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*RESEARCH ARTICLE*

# APPLICATION OF STATISTICAL ANALYSIS ON THE DYNAMICS OF FOUNDATION STUDIES USING GEOPHYSICAL PARAMETERS IN A TYPICAL SEDIMENTARY ENVIRONMENT, SOUTH SOUTH NIGERIA

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**ABSTRACT**

A statistic is found useful in many applications of science where data and analysis are used for illustration and description for better understanding and justification of the data sets. Therefore in an attempt to achieve a better understanding and illustration of the dynamics of foundation integrity and vulnerability of failure, which often remain a major challenge to mankind, especially in Nigeria where foundation failures remain a major concern to both the Government and citizen. In this present study, a statistical approach was carried out on the Geophysical parameters in Issele-Mkitim area, South South Nigeria, to evaluate the dynamic factors that affect foundation integrity and vulnerability of subsurface lithologies. Very Low Frequency Electromagnetic (VLF-EM), Magnetic, and Electrical Resistivity Methods were used in this study. The Electrical Resistivity Method involved Lateral Horizontal Profiling (LRP) utilizing Wenner configuration. The three (3) methods correlated in terms of statistical prediction and understanding of the geologic dynamics natured associated with foundation failure and integrity. It was deduced that profiles one to six has high tendency of weak geological material which can easily lead to subsidence if any engineering construction is erected on it. However, proper consideration must be put in place to avoid future differential settlements. All the methods give useful information about the dynamics of the geological trends from the preliminary data analysis and interpretations, and a better understanding of the geodynamics nature of the soil as well as the region of a weak and competent zone in terms of engineering constructions.

**KEYWORDS**

Integrity, Vulnerability, Magnetic, VLF-EM, LRP

## 1. INTRODUCTION

Statistics is not only modern science but a scientific knowledge that is as old as the World Itself. It is a very useful tool with its applications in every aspect of human activities, vis-à-vis, commerce, industry, space science, ground research, technological data analysis, simulations, forecasting, and predictions (Bawallah *et al.,* 2021a). Within the context of this study, the foundation has been assessed from the angle of using Geophysical parameters to study (Aigbedion et al., 2021) and define geologic dynamics, resulting in volcanic activities (Adebiyi et al., 2018; Aigbedion et al., 2019a; Adebo et al., 2021; Ajayi et al., 2022a; 2022b). It ultimately affects soil stratification and stability, which are mostly accountable for foundation integrity or vulnerability (Oke, 2011; Adebo et al., 2019; Magawata et al., 2020; Oyedele et al., 2020). Therefore, within the context of stress and strains, under load bearing capacity of the soil or soil strata (Bawallah et al., 2019a) which are factors of geologic tectonic activities leading to such formations as the case (Aigbedion et al., 2019b; Bawallah et al., 202b1), subsequently using Geophysical approach to evaluate subsurface parameters that may be under stress and strains and based on their intrinsic geologic properties (Ilugbo et al., 2018a; Ozegin et al., 2019a; Bawallah et al., 2019b) which often accounts for the load bearing capacity of soil strata, which is majorly responsible for foundation integrity (materials of high strength) or weak founding materials (weak founding materials) (Ilugbo et al., 2018b; Ozegin et al., 2019b; Bawallah et al., 2020). Vulnerability refers to weak Geologic materials causing engineering structures to fail, while Integrity is the competent geologic materials with high load-bearing capacity preventing engineering construction to fail (Bawallah *et al.,* 2021a). Because of the growing concerns among researchers, particularly in an attempt to provide solutions to the dynamics of foundation integrity and possible reasons for high vulnerability and frequent construction failures, that do occur especially in the sedimentary environment. Therefore, a statistical approach was carried out on the Geophysical parameters with a special focus on the Issele-Mkitim area, South South Nigeria to evaluate the dynamic factors that affect foundation integrity and vulnerability of engineering constructions.

### 1.1 Site Description and Geology of the Study Area

Issele-Mkpitime falls within the northern flank of the Niger Delta basin and localities where the lithofacies of Anambra basin extends and Ogwashi-Asaba Formation which are lateral equivalent of the Upper Agbada Formation of the Niger Delta (Figure 1). The Issele- Mkpitime Lake, a large

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body of relatively still water surrounded by land is a freshwater lake, covering a large expanse of land near the Igbodo border. The lake rises during the rainy season and almost dry in the dry during the season and thus, is considered a 'mysterious' pool. The geology of the Niger Delta has been extensively documented by various workers including; (Rayment, 1965; Allen, 1965; Burke et al., 1971; Murat, 1972) and others. The Niger Delta Basin consists of three diachronous, siliciclastic, or lithostratigraphic units: the deep marine pro-delta Akata Formation, the shallow-marine delta-front Agbada Formation, and the continental delta-top Benin Formation. The study falls within Bendel Ameki formation.

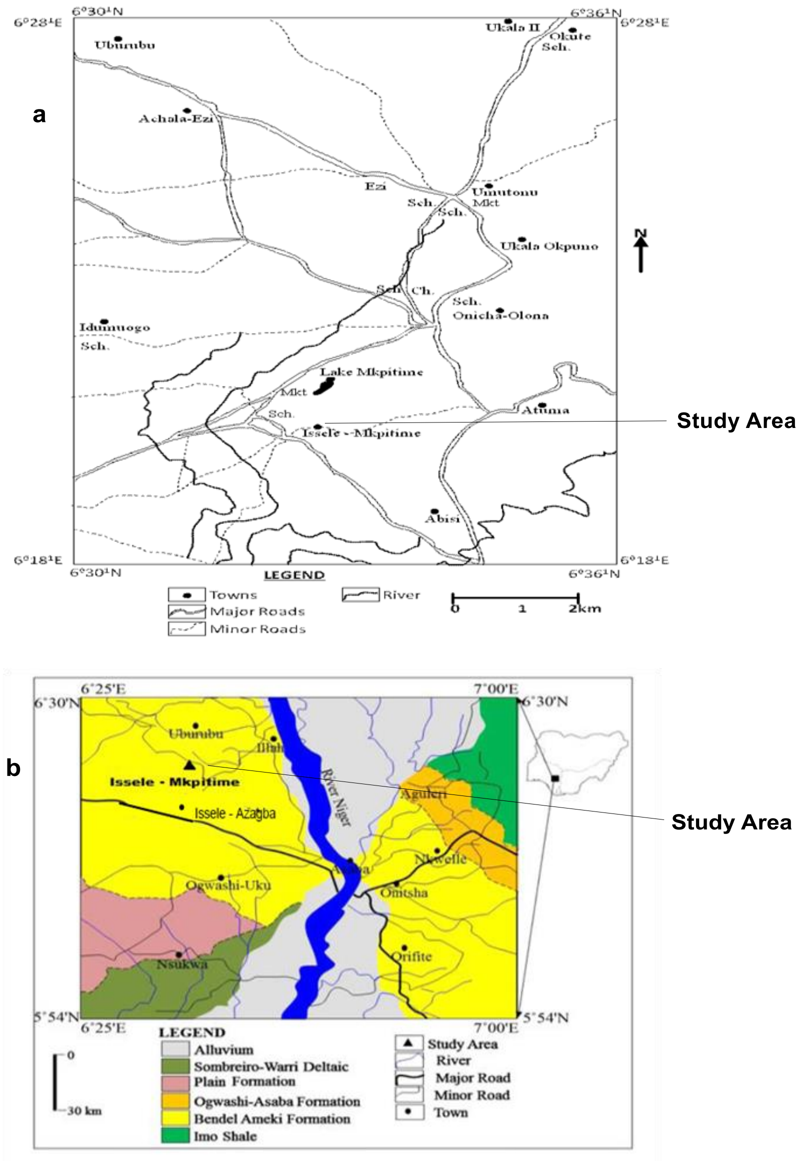


**Figure 1:** (a) Location Map of the Study Area (b) Geological Map of Niger Delta Showing the Study Area

## 2. Material and Methods

This research utilized three methods involving Magnetic, VLF-EM, and Electrical Resistivity method. Six traverse lines were established in approximately E-W direction and the seventh traverse was cut across the profiles which serve as a control (Figure 2). The Very Low Frequency electromagnetic data was acquired using ABEM WADI VLF equipment. Seven (7) traverses were used for the data acquisition and station interval of 20 m on each traverse of varying lengths. The frequency of operation was 18.0 kHz for the traverses. The parameters measured are raw real, filtered real, raw imaginary, and filtered imaginary components of the electromagnetic field. Magnetic reading involves measurements of the direction, gradient, or intensity of the Earth's magnetic field and interpretation of variation in these quantities over the areas of investigation. However, the ground magnetic study is used for detail mapping to understand the subsurface geology of an area, and was measured using a Proton Precession Magnetometer (Geometrics 856). While the survey direction and station locations were determined using the Garmin Global Positioning System (GPS) navigational equipment and measurements were taken at an interval of 10 m along seven profile lines (1-7) of length ranging from 180 – 260 m trending in the East-West (W-E) direction and perpendicular to the geologic strike and the lake. The Electrical Resistivity method employed Lateral Horizontal Profiling using the Wenner array. Wenner data measurements were taken at electrode spacing of 10 m and using the ABEM SAS 1000 Terameter. The VLF data, i.e. (real and imaginary components) of the EM fields measured was subjected to Fraser (1969) filtering to increase the signal-to-noise ratio of the data set and enhance the anomaly signature. The Fraser Filter (Q) was computed using a filter operator as shown in the following relation:

$$Q = (Q_4 + Q_3) - (Q_2 + Q_1)$$

Where Q is EM data and the subscript are station positions. This was applied to the real component VLF data to transform the data set to the filtered real VLF data (Karous and Hjelt, 1983), then plotted using an excel word spreadsheet. The results of the magnetic method involved plotting the relative magnetic intensity against station positions and the corresponding geomagnetic sections were generated using the excel worksheet. The Wenner array was plotted using an excel worksheet. The Geophysical results obtained from VLF-EM, Magnetic, and Lateral Resistivity Profiles (LRP) were further subjected to statistical analysis, as a percentage and ratios, and statistical medications using the equations below. This enables a better understanding of the dynamic factors that affect foundation integrity and vulnerability to failures in the study. And also the intricacies of foundation integrity and vulnerability factors that often bring about failures.

Where $\frac{X2+X1}{2}$ = Threshold

i.e. maximum anomaly + minimum anomaly divided by (2) i.e. midpoint between the peak and trough of the anomaly = Threshold

The region of high integrity ($V_T$) anomaly

$x = (x_1 - x_0) + (x_2 - x_1) + (x_3 - x_2) + (x_4 - x_3) + \ldots\ldots\ldots$

Region of Weak anomaly ($V_{Ti}$)

$x = (x_5 - x_4) + (x_6 - x_5) + (x_7 - x_6) + (x_8 - x_7) + \ldots\ldots\ldots\ldots\ldots$

Comparing the ratio between $V_T : V_{Ti}$

The ratio between $V_T$ and $V_{Ti}$ is used to determine the competence and weakness of the geological nature of the study.

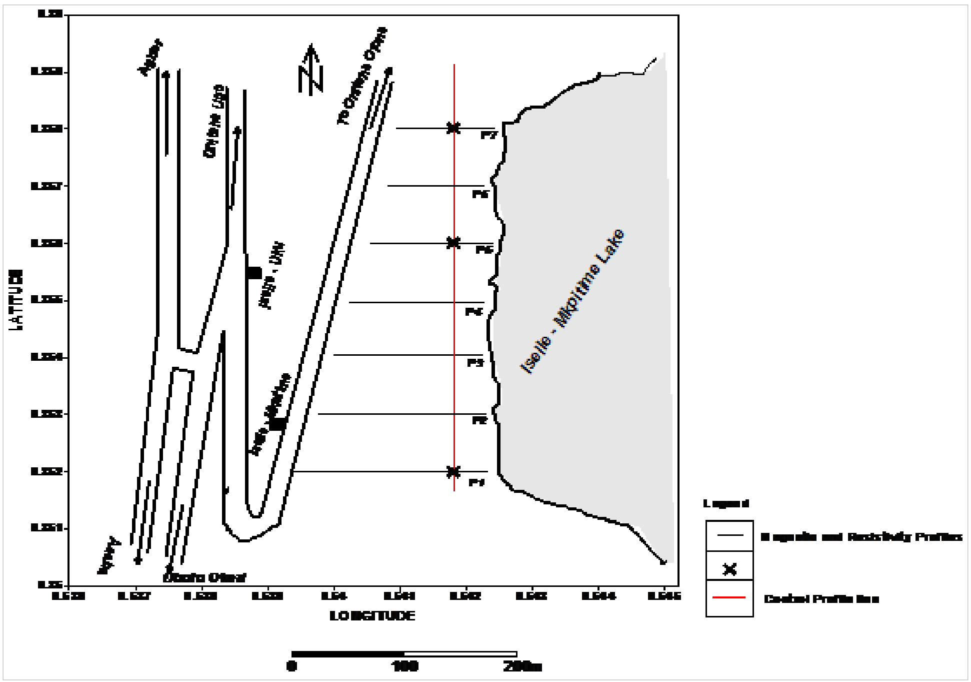


**Figure 2:** Acquisition Map of the Study area

## 3. Results and Discussion

### 3.1 VLF-Electromagnetic Method

#### *3.1.1 Profile One*

The VLF-EM profile along Transverse one covers a distance of 500 meters with three anomalous zones of interest of peak and trough of the positive and negative anomaly (Figure 3a) is denoted with x, and the Threshold of this profile remains at zero and x; varies from $x_1$ to maximum of $x_6$ covering both the peak and the trough of the anomalous zone with the positive peak anomaly, indicative of conductive/weak geologic materials while the negative (trough) anomaly is indicative of the non-conductive/resistive zone, characteristics of stable/high integrity geologic materials.

Thus the analysis, in this case, is such that; the vulnerability Threshold ($V_T$)/integrity Threshold ($I_T$) is zero being a sinusoidal graph.

For conductive (positive) anomaly

$= (120 - 0) + (280 - 200) + (500 - 400) = {}^{300}/_{500} \text{ x } 100 = 60\%$

60% conductive/weak zones; characteristics of weak geologic materials

whereas for the negative analysis;

$(200 - 120) + (400 - 280) = {}^{200}/_{500} \text{ x } 100 = 40\%$

40% non-conductive/competent zones; characteristics of competent geologic materials

Comparing the ratio between $V_T : V_{Ti}$ = 40/60 = 2:3

The ratio of competent to weak zones along the profile is 2:3 indicative of a high percentage of weak geologic materials which could lead to differential settlement if the proper measure is not taken along the weak zones.

#### *3.1.2 Profile Two*

The $V_T/V_{Ti}$ (Threshold) of the anomaly zero and x varies from $x_1$ to $x_{14}$ for both positive and negative anomalies (Figure 3b).

For positive anomaly i.e. conductive/weak zone ($V_i$)

$=(80 - 50) + (120 - 100) + (190 - 180) + (210 - 190) + (280 - 240) + (320 - 300) + (400 - 370)$

= 30 + 20 + 10 + 20 + 40 + 20 + 30 = 170

$= {}^{170}/_{400} \text{ x } 100 = 42.5\%$

Whereas for the negative anomaly, i.e. Resistive zone/high integrity zone ($V_T$);

$= (40 - 0) + (90 + 70) + (170 - 110) + (240 - 210) + (300 - 280) + (360 - 320)$

= 40 + 20 + 60 + 30 + 20 +60 = 230

Therefore ${}^{230}/_{400}\ x\ 100 = 57.5\%$

Comparing the ratio between $V_T : V_{Ti}$ = 57.5/42.5 = 2.3:1.7

The ratio of competent to weak zones along profile two is 2.3:1.7 indicative of a high percentage of competent geologic materials but proper measures should be taken along the weak zones.

#### *3.1.3 Profile Three*

The $V_T/V_{Ti}$ (Threshold) of the anomaly zero and x varies from $x_1$ to $x_{14}$ for both positive and negative anomalies (Figure 3c).

For positive anomaly i.e. conductive/weak zone ($V_i$)

$=(160 - 100) + (260 - 220) + (350 - 320) + (440 - 400) + (510 - 490) + (600 - 560)$

$= 40 + 40 + 30 + 60 + 20 + 40 = {}^{230}/_{600}$

$= {}^{230}/_{600}\ x\ 100 = 38.3\%$

Whereas for the negative anomaly, i.e. Resistive zone/high integrity zone ($V_T$);

$= (20 - 0) + (80 - 20) + (200 - 140) + (320 - 270) + (400 - 370) + (470 - 420) + (540 - 500)20 + 60 + 60 + 50 + 30 + 50 + 60 = {}^{330}/_{600}\ x\ 100 = 55\%$

Comparing the ratio between $V_T : V_{Ti}$ = 1.44:1

The ratio of competent to weak zones along the profile is 1.44:1 indicative of a high percentage of competent geologic materials but proper measures should be taken along the weak zones.

### *3.1.4 Profile Four*

The $V_T/V_{Ti}$ (Threshold) of the anomaly zero and x varies from $x_1$ to $x_{14}$ for both positive and negative anomalies (Figure 4a).

For positive anomaly i.e. conductive/weak zone ($V_i$)

$= (150-0)+(450-300)+(600-540)$

$= 150+150+60 = {}^{450}/_{600}\ x\ 100 = 75\%$

Whereas the x for the negative anomaly i.e. resistive/zone of high integrity ($V_T$)

$= (300-150)+(550-460)$

$= 150 + 90$

$= {}^{240}/_{600}\ x\ 100 = 40\%$

Comparing the ratio between $V_T : V_{Ti} = 1:1.8$

The ratio of competent to weak zones along the profile is 1:1.8 indicative of a high percentage of weak geologic materials but proper measures should be taken along the weak zones.

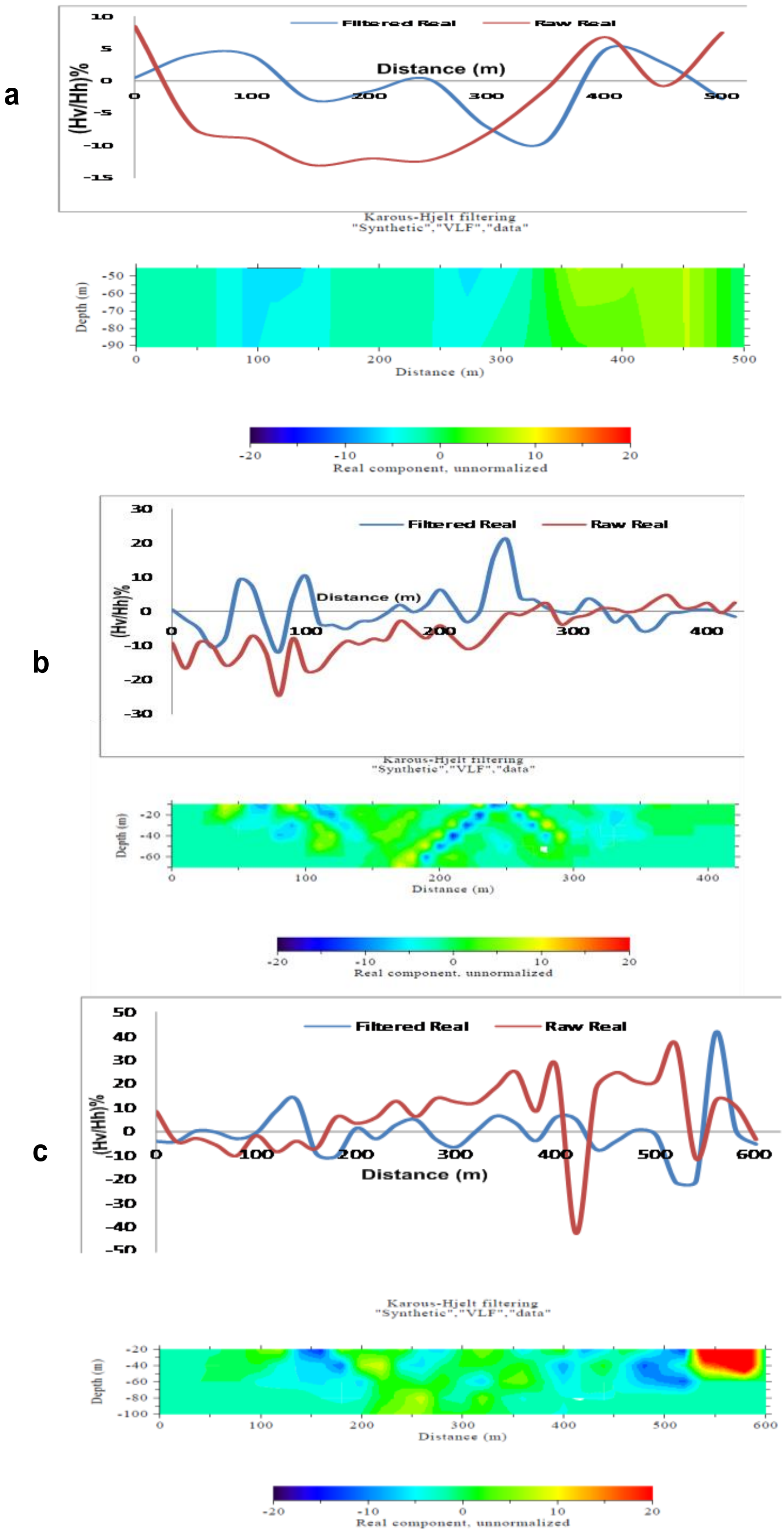


**Figure 3:** VLF-EM Along Profile (a) One (b) Two (c) Three

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### 3.1.5 Profile Five

The $V_T/V_{Ti}$ (Threshold) of the anomaly zero and x varies from $x_1$ to $x_{14}$ for both positive and negative anomalies (Figure 4b).

For positive anomaly i.e. conductive/weak zone ($V_i$)

$= (50 - 150) + (250 - 180) = 50 + 70 = 120$

$= {}^{120}/_{250}\ x\ 100 = 48\%$

Whereas the x for the negative anomaly i.e. resistive/zone of high integrity ($V_T$)

$= 180 - 50 = 130/250\ x\ 100 = 52\%$

Comparing the ratio between $V_T : V_{Ti} = 1.1:1$

The ratio of competent to weak zones along the profile is 1.1:1 indicative of a moderate percentage of competent geologic materials but proper measures should be taken along the weak zones to prevent differential settlement of any construction along the profile.

### 3.1.6 Profile Six

The Interpretation of VLF – EM along profile six follows the same pattern with a total distance of 400 m (Figure 4c).

For positive anomaly i.e. conductive/weak zone ($V_i$)

$= (120 - 80) + (180 - 150) + (340 - 290) = 40 + 30 + 50$

$= {}^{120}/_{400}\ x\ 100 = 30\%$

Whereas the x for the negative anomaly i.e. resistive/zone of high integrity ($V_T$);

$= (80 - 0) + (150 - 100) + (250 - 160) + (400 - 350)$

$= 80 + 50 + 100 + 50 = {}^{280}/_{400}\ x\ 100 = 70\%$

Comparing the ratio between $V_T : V_{Ti} = 2.3:1$

The ratio of competent to weak zones along the profile is 2.3:1 indicative of a high percentage of competent geologic materials but proper measures should be taken along the weak zones.

### 3.1.7 Profile Seven

The VLF- EM along Profile Seven (7) covers a distance of 280m (Figure 4d).

For positive anomaly i.e. conductive/weak zone ($V_i$)

$x = (140 - 0) + (280 - 260) = {}^{160}/_{280}\ x\ 100 = 57.1$

Whereas for the negative anomaly i.e. resistive/zone of high integrity ($V_T$); = 39.3%

Comparing the ratio between $V_T : V_{Ti} = 1:1.5$

Hence, partial failure was observed along the portion of the road.

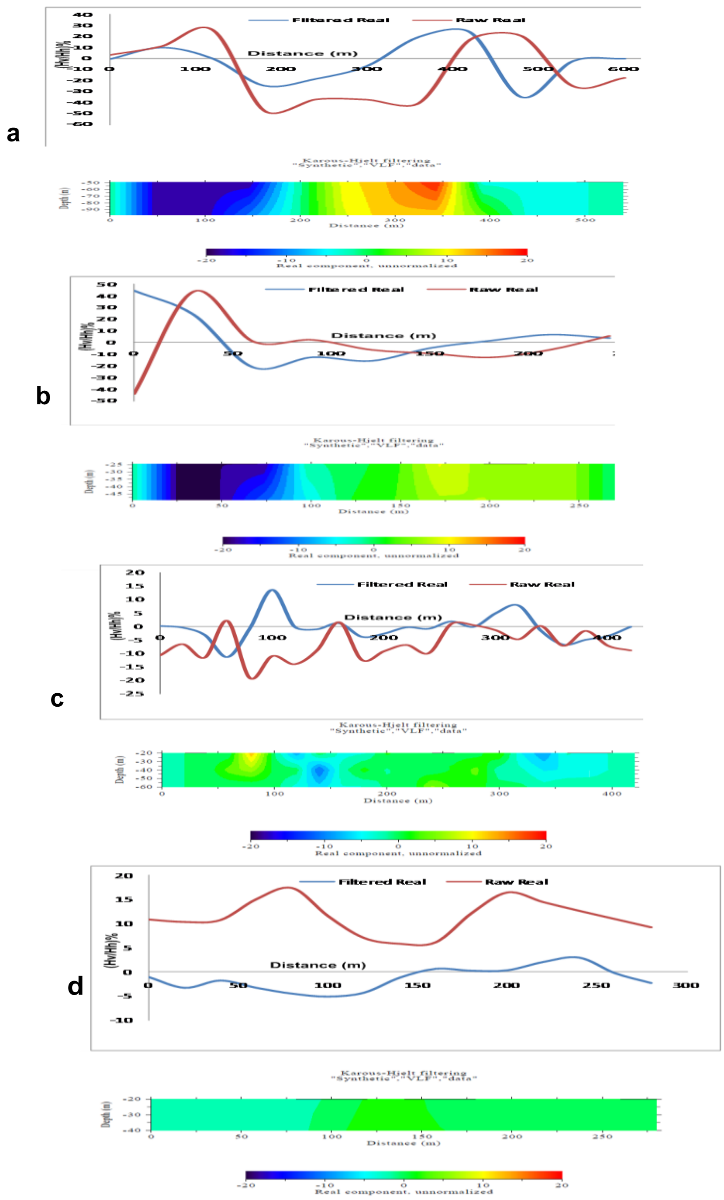


**Figure 4:** VLF-EM Along Profile (a) Four (b) Five (c) Six (d) Seven

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### 3.2 Summary of EM – Profiles

Figure 5 shows the summary of the percentage ratio of all seven profiles in form of a histogram. It can be inferred that when $V_T > V_{Ii}$ the foundation is expected to be moderate/high integrity while $V_T < V_{Ii}$ the foundation is highly vulnerable to failure. And when $V_T \neq V_I$, it is a fifty/fifty chance for failure/stability

## 4. MAGNETIC

### 4.1 Profile One

Profile 1 uses the same approach adopted for VLF – EM (Figure 6a).

Since the graph is not taking off from zero origin

$\therefore = \frac{33150+33130}{2} = 33140$

i.e. midpoint between the peak and trough of the anomaly = Threshold

The entire magnetic profile is characterized by low susceptibility (weak zones), then the result will be interpreted in terms of moderately low and very low susceptibility.

For moderately low ($V_T$) anomaly using the Threshold value as a middle point;

$= (190 - 110) + (380 - 250) + (450 - 40)$

$= 80 + 130 + 50 = {}^{260}/_{600}\ x\ 100 = 40.3\%$

For very low susceptibility/highly vulnerable ($V_{Ti}$)

$= (50 - 0) + (120 - 50) + (280 - 160) + (420 - 370) + (500 - 450)$

$= 50 + 70 + 120 + 50 + 50 = {}^{340}/_{600}\ x\ 100 = 56.7\%$

Therefore the ratio of moderately low to very low vulnerability = $V_T : V_{Ti}$ = 1:1.4

Hence, the region is highly vulnerable.

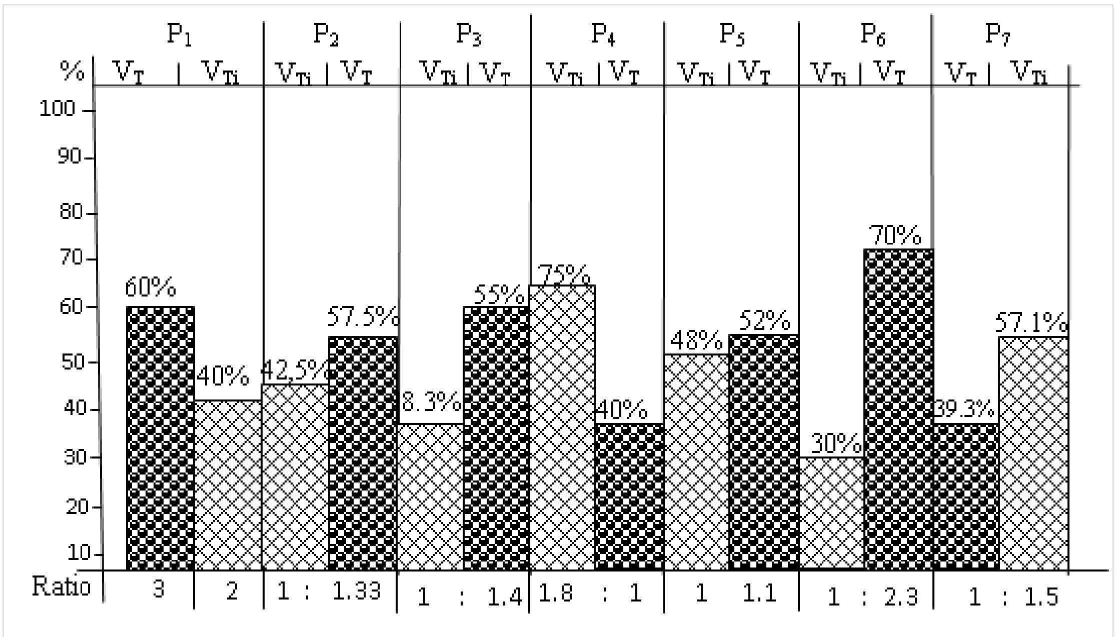


**Figure 5:** Histogram Analysis of Ratio $V_T : V_{Ti}$.

### 4.2 Magnetic Profile 2

Interpretation of Magnetic Profile 2 (Figure 6b)

The interpretation was considered based on the principle adopted for the geological dynamics of magnetic profile 1, as the entire profile was characterized by moderately low/very low magnetic susceptibility; where the Threshold was determined using the midpoint between the peak and trough of the anomaly divided by two. The entire magnetic profile is characterized by low susceptibility (weak zones), then the result will be interpreted in terms of moderately low and very low susceptibility.

Threshold = 33135

For moderately low ($V_T$) anomaly;

$= (50 - 0) + (100 - 50) = 50 + 50 = 100 = 100/500\ x\ 100 = 20\%$

For very low susceptibility/highly vulnerable ($V_{Ti}$)

$= (200 - 90) + (280 - 200) + (280 - 200) + (380 - 280) + (400 - 350) + (450 - 400) = 10 + 110 + 80 + 100 + 50 + 50 = 400/500\ x\ 100 = 80\%$

Comparing the ratio between $V_T : V_i$ = 1:4

It is highly vulnerable to failure.

### 4.3 Interpretation of Magnetic Profile 3

$\therefore$ Threshold = 3305

For moderately low ($V_T$) anomaly

$= (50 - 0) = 50/400\ x\ 100 = 12.5\%$

For very low susceptibility/highly vulnerable ($V_{Ti}$)

$= (110 - 50) + (200 - 110) + (320 - 220) + (400 - 320)$

$= 60 + 110 + 100 + 80 = 350 = 350/400\ x\ 100 = 87.5\%$

Comparing the ratio between $V_T : V_{Ti}$ = 1:7

It implies highly susceptible to foundation failure resulting from the dynamics of very weak geologic materials (Figure 6c).

### 4.4 Interpretation of Magnetic Profile 4

Threshold = 33118

The region of Weak anomaly ($V_{Ti}$)

$= (80 - 50) + (230 - 200) + (300 - 250) + (400 - 300)$

$= 30 + 30 + 50 + 100$

$= 210/400\ x\ 100 = 52.5\%$

While the region of high integrity ($V_T$) anomaly

$= (50 - 0) + (200 - 90) + (280 - 250)$

$= 50 + 110 + 30 = 190$

$= 190/400\ x\ 100 = 47.5\%$

Comparing the ratio between $V_T : V_{Ti}$ = 1:1.1

Hence, the region is moderately low vulnerable to failure (Figure 6d).

### 4.5 Interpretation of Magnetic Profile 5

Threshold = 33114

While the region of high integrity ($V_T$) anomaly

$= (50 - 0) = 50/350\ x\ 100 = 14.3\%$

The region of Weak anomaly ($V_{Ti}$)

$= (75 - 50) + (125 - 75) + (200 - 125) + (250 - 200) + (300 - 250) + (350 - 300)$

$= 25 + 50 + 75 + 50 + 50 + 50 = 300/350\ x\ 100 = 85.7\%$

Comparing the ratio between $V_T$:$V_{Ti}$ = 1:6

Hence, the region is high vulnerable to failure (Figure 6e).

### 4.6 Interpretation of Magnetic Profile 6

Magnetic anomaly Threshold ($T$) = 33105

The region of high integrity ($V_T$) anomaly

$= (20 - 0) + (100 - 70)$

$= 50/250\ x\ 100 = 20\%$

While the region of Weak anomaly ($V_{Ti}$)

$= (70 - 20) + (250 - 100)$

$= 50 + 150 = 200/250\ x\ 100 = 80\%$

Comparing the ratio between $V_T$:$V_{Ti}$ = 1:4

Hence, the region is highly vulnerability to failure (Figure 6f).

### 4.7 Interpretation of Magnetic Profile 7

Where Magnetics anomaly Threshold ($T$) = 33089

The region of high integrity ($V_T$) anomaly

$= (20 - 0) + (75 - 25) + (120 - 75) + (175 - 150) + (250 - 200)$

= 20 + 50 + 45 + 25 + 50 = 190/250 x 100 = 76%

While the region of Weak anomaly ($V_{Ti}$)

$= (30 - 20) + (150 - 130) + (220 - 190)$

$= 10 + 20 + 30 = 60/250\ x\ 100 = 24\%$

Comparing the ratio between $V_T$:$V_{Ti}$ = 3:1

Hence, the region is moderately competent but the weak zones must be put into consideration to prevent differential settlement (Figure 6g)


**Figure 6:** Magnetic Profile Along Profile (a) One (b) Two (c) Three (d) Four (e) Five (f) Six (g) Seven

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### 4.8 Summary of Magnetic Profiles

Figure 7 shows the summary of the percentage ratio of all seven profiles in form of a histogram. It can be predicted that failure will mostly occur along profiles one to six, except profile seven with the ratio of 3:1 which has a measurable competent material but the weak zones must be considered to avoid differential settlement.

### 4.9 Lateral Resistivity Profile (LRP)

#### *4.9.1 Interpretation of (LRP) Profile 1*

The anomaly Threshold $= 800\ \Omega m$

Where the $V_T$ represents as a zone of high integrity) and $V_{Ti}$ represents as a weak zone.

Therefore, for the region of high integrity ($V_T$) anomaly (Figure 8a)

$= (50 - 0) + (100 - 50) + (140 - 100) + (180 - 140)$

$= 50 + 50 + 60 + 40 = 200/400\ x\ 100 = {}^{1}/_{2}\ x\ 100 = 50\%$

While for the region of Weak anomaly ($V_{Ti}$)

$= (230 - 280) + (300 - 200) + (350 - 300) + (400 - 380)$

$= 30 + 100 + 50 + 20 = 200/400\ x\ 100 = {}^{1}/_{2}\ x\ 100 = 50\%$

Comparing the ratio between $V_T:V_{Ti} = 1:1$

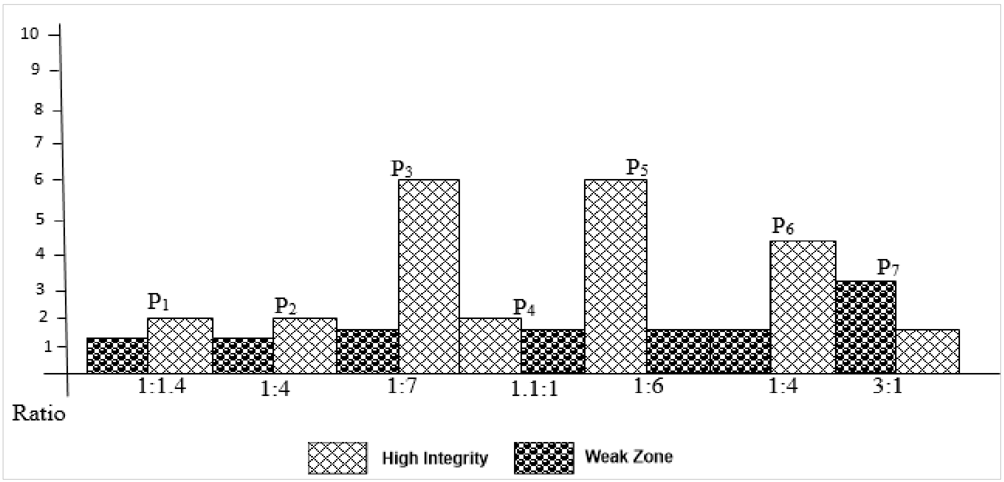


**Figure 7:** Histogram Analysis of Ratio $V_T$: $V_{Ti}$

#### *4.9.2 Interpretation of LRP profile 2*

The threshold $= 700\ \Omega m$

Any value above 700 Ωm is considered as the zone of integrity $V_T$ while below is considered as a region of vulnerability to failure ($V_{Ti}$) ($Figure\ 8b$).

Therefore, the region of high integrity ($V_{T1}$) anomaly

$= (40 - 0) + (190 - 60) + (230 - 210)$

$= 40 + 130 + 20 = 190/400\ x\ 100 = 47.5\%$

While the region of weak anomaly ($V_{Ti}$)

$= (60 - 50) + (310 - 180) + (380 - 230) + (400 - 380)$

$= 10 + 30 + 90 + 150 + 20 = 210/400\ x\ 100 = 52.5\%$

Comparing the ratio between $V_T:V_{Ti} = 52.5: 47.5 = 1.1: 1$

#### *4.9.3 Lateral Resistivity Profile 3*

Threshold = 800Ω, any value above 800 Ωm is considered as the zone of integrity $V_T$ while below is considered as a region of vulnerability to failure ($V_{Ti}$) ($Figure\ 8c$).

Therefore, for the region of high integrity ($V_{T1}$) anomaly

$= (40 - 0) + (200 - 60) + (240 - 210)$

$= 40 + 140 + 30 = 210 = 210/400\ x\ 100 = 52.5\%$

While for the region of Weak anomaly ($V_{Ti}$)

$= (50 - 40) + (205 - 195) + (380 - 220) + (400 - 380)$

$= 10 + 10 + 160 + 10 = 190 = 190/400\ x\ 100 = 47.5\%$

Comparing the ratio between $V_T:V_{Ti} = 1: 1.1$

#### *4.9.4 Lateral Resistivity Profile (LRP) of Profile 4*

Threshold = 2125 $\Omega m$, any value above 2125 Ωm is considered as the zone of integrity $V_T$ while below is considered as a region of vulnerability to failure ($V_{Ti}$) ($Figure\ 8d$).

Therefore, for the region of high integrity ($V_{T1}$) anomaly

$= (50 - 0) = {}^{50}/_{400}$ x 100 = 12.5

While for the region of Weak anomaly ($V_{Ti}$)

$x = (x_2 - x_1) = (400 - 50) = {}^{350}/_{400}$ x 100 = 87.5

Comparing the ratio between $V_T:V_{Ti} = 1: 7$

#### *4.9.5 Lateral Resistivity Profile (LRP) of Profile 5*

Threshold = 2000 Ωm, any value above 2000 Ωm is considered as the zone of integrity $V_T$ while below is considered as a region of vulnerability to failure ($V_{Ti}$) (Figure 8e).

Therefore, for the region of high integrity ($V_{T1}$) anomaly

$= (50 - 0) = 50 = {}^{50}/_{400}$ x 100 = 12.5%

While for the region of Weak anomaly ($V_{Ti}$)

$= (400 - 50)$

$= {}^{350}/_{400}$ x 100 = 87.5%

Comparing the ratio between $V_T:V_{Ti} = 1: 7$

#### *4.9.6 Lateral Resistivity Profile (LRP) of Profile 6*

Threshold = 1750 Ωm, any value above 1750 Ωm is considered as the zone of integrity $V_T$ while below is considered as a region of vulnerability to failure ($V_{Ti}$) (Figure 8f).

Therefore, for the region of high integrity ($V_{T1}$) anomaly

$= (50 - 0) = {}^{50}/_{400}$ x 100 = 12.5%

While for the region of Weak anomaly ($V_{Ti}$)

$= 400 - 50 = {}^{350}/_{400}$ x 100 = 87.5%

Comparing the ratio between $V_T: V_{Ti} = 1: 7$

#### *4.9.7 Lateral Resistivity Profile (LRP) of Profile 7*

Threshold = 2250 Ωm, any value above 2250 Ωm is considered as the zone of integrity $V_T$ while below is considered as a region of vulnerability to failure ($V_{Ti}$) (Figure 8g).

Therefore, for the region of high integrity ($V_{T1}$) anomaly

$= (90 - 30) + (300 - 280)$

$= (60 + 20) = {}^{80}/_{300} \times 100 = 26.7\%$

While for the region of Weak anomaly ($V_{Ti}$)

$= (30 - 0) + (270 - 90)$

$= (40 - 0) + (270 - 90) = 40 + 180 = {}^{220}/_{300} \times 100 = 73.3\%$

Comparing the ratio between $V_T$:$V_{Ti}$= 1: 2.4

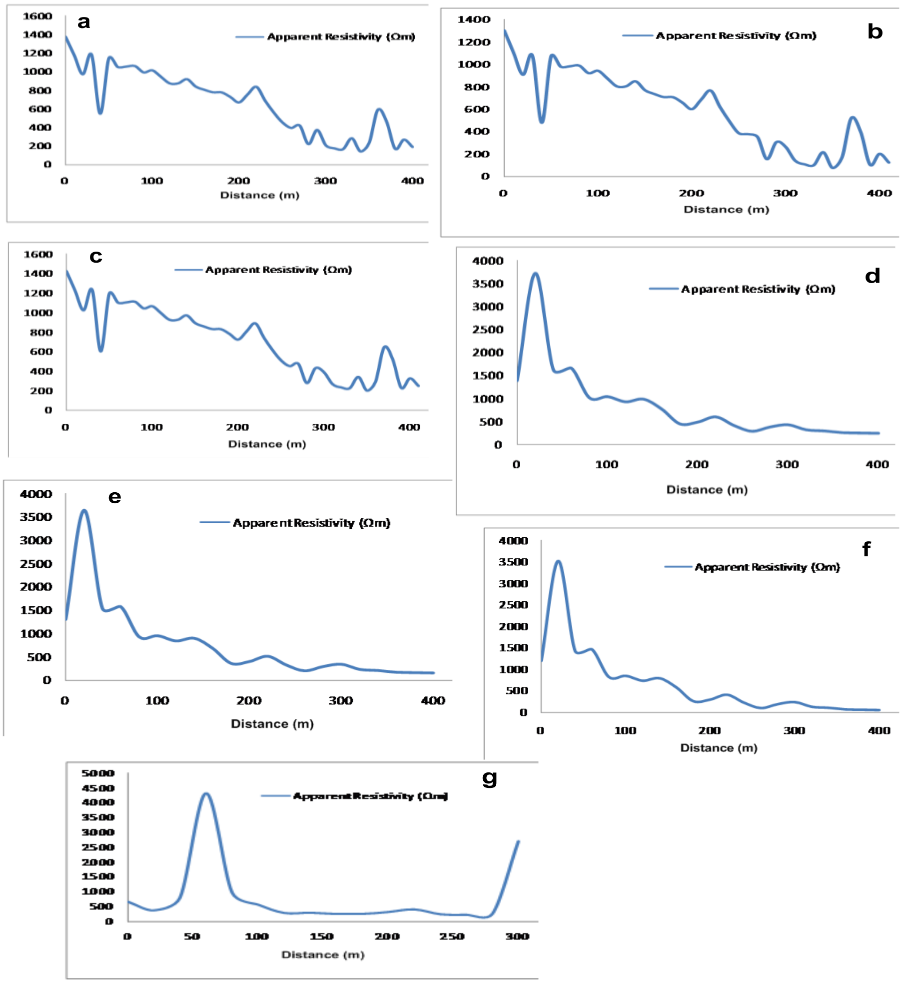


**Figure 8:** Wenner Horizontal Profiling Along Profile (a) One (b) Two (c) Three (d) Four (e) Five (f) Six (g) Seven

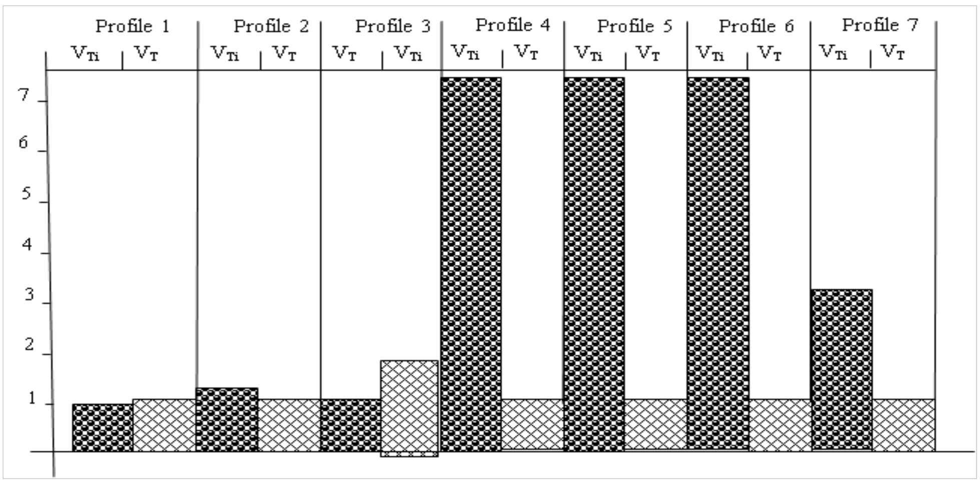


**Figure 9:** Histogram Analysis of ratio $V_T$:$V_{Ti}$

### 4.10 Summary of Lateral Horizontal Profiles

Figure 9 shows the summary of the percentage ratio of all seven profiles in form of a histogram. Statistical Prediction under similar geologic conditions and geodynamic factors; it can be rightly inferred nor predicted from the histogram that profile 1, 2, and 3 are of moderate integrity and may not easily suffer major vulnerability. However, profiles 4, 5, and 6 are highly vulnerable to failure due to the high presence of weak geological materials within the region, while profile seven (7) has high degree of vulnerability to fail

### 4.11 General Summary

The three (3) methods correlated in terms of statistical prediction and understanding of the geologic dynamics natured associated with foundation failure and integrity. It was deduced that profiles one to six has high tendency of weak geological material which can easily lead to subsidence if any engineering construction is erected on it. However, proper consideration must be put in place to avoid future differential settlements.

## 5. Conclusion

This study has justified the usefulness of the statistical approach, illustration, and description at enhancement and a better understanding of Geophysical data sets and their attendant implications of the dynamics of foundation integrity and vulnerability, along with possible reasons for foundation failures in a typical sedimentary environment of Nigeria.

## References


Ajayi C.A., Ilugbo S.O., Bayode S., Aderemi S.A., Adebo B.A., Talabi A.O.., Ojo O.F. and Talabi J.I. (2022a). Assessment of Probable Foundation Problems Using Geophysical and Remotely Sensed Data in A TypicalBasement Complex, Southwestern Nigeria. Earth Sciences Pakistan, 6(2): 65-75.

Ajayi C.A., Aderemi S.A., Ilugbo S.O., Adebo B.A. and Adewumi O.A. (2022b). Geophysical Post-Foundation Studies of Minisrty of Justice Building, Ekiti-State Secretariat, Ado Ekiti, Ekiti-State, Nigeria, Geological Behaviour 6(2): 65-69.

Adebo, B.A., Layade, G.O., Ilugbo, S.O., Hamzat, A.A, and Otobrise, H.K., 2019. Mapping of Subsurface Geological Structures using Ground Magnetic and Electrical Resistivity Methods within Lead City University, Southwestern Nigeria. Kada Journal of Physics 2(2), Pp. 64-73.

Adebo B.A., Makinde E.O., Ilugbo S.O. 2021. Application of Electrical Resistivity Method to Site Characterisation for Construction Purposes at Institute of Agriculture Research and Training Moor Plantation Ibadan. Indonesian Journal of Earth Sciences, 1 (2), Pp. 49-62

Adebiyi, A.D., Ilugbo, S.O., Ajayi, C.A., Ojo, A.O., and Babadiya, E.G., 2018. Evaluation of pavement instability section using integrated geophysical and geotechnical methods in a sedimentary terrain, Southern Nigeria. Asian Journal of Geological Research 1 (3), Pp. 113.

Aigbedion I., Bawallah M., Ilugbo S., Osaigbovo A.D., Diana E.K., Ihewkwumere C., Igbinoba C., Patrick P.U., Amagbamwan E. 2019a. Geophysical Investigation for Post Foundation Studies at Ikekogbe Primary School, Ekpoma, Edo State, Nigeria. American Journal of Environmental and Resource Economics. 4(2), 73-83. doi: 10.11648/j.ajere.20190402.14

Aigbedion, I., Bawallah, M.A., Ilugbo, S.O., Abulu, F.O., Eguakhide, V., Afuaman, E.W., and Ukubile, B., 2019b. Geophysical Investigation for Pre-Foundation Studies at RCCG, Calvary Love Parish 2, Ukpenu, Ekpoma, Edo State, Nigeria. International Journal of Research and Innovation in Applied Science 4 (5), Pp. 39-45.

Aigbedion I., Bawallah M.A., Ilugbo S.O., Ozegin K.O, ThankGod A., Atama J., Nwankwo B., Oladi O.O., Oladeji JF., and Alabi S.K. 2021. Environmental Impact Assessment of Structural Defects Using Geophysical and Geotechnical Methods in Parts of Ekpoma, Southsouthern Nigeria. International Journal of Earth Sciences Knowledge and Applications, 3(2), Pp. 124-133,

Allen, J. R. L. 1965. Late Quaternary Niger Delta and Adjacent Areas: Sedimentary Environments and Lithofacies. Bulletin American Association of Petroleum Geology vol. 49(5), pp. 547–600.

Bawallah M.A., Ilugbo S.O., Adebo B.A., Adedapo J.O., Ofomola M.O., Oladeji J.F., Raji I., Chinyem F.I., Hadiza M.B., Bello K. and Imolore M.O. (2021a). Application of Vulnerability Determination for Foundation Parameters: A Case Study of Issele Mkpitime Area of Delta State, Nigeria. Pakistan Journal of Geology, 5(1), 73-90.DOI: 10.2478/pjg-2021-0009

Bawallah M.A., Ilugbo S.O., Ozegin K.O., Adebo B.A., Aigbedion I., Salako K.A., 2021b. Electrical Resistivity and Geotechnical Attributes and The Dynamics of Foundation Vulnerability. Indonesian Journal of Earth Sciences, 1(2), Pp. 84-97

Bawallah, M.A., Ayuks, M.A., Ilugbo, S.O., Ozegin, K.O., Oyedele, A.A., Aigbedion, I., Aina, A.O., Whetode, J.M., & Ladipo, K.O., 2019a. Geodynamics and its implications to environmental protection: A case study of Aule area, Akure, Ondo State, Southwestern, Nigeria. Applied Journal of Physical Science 1 (3), Pp. 37-53,

Bawallah, M.A., Ilugbo, S.O., Aigbedion, I., Aina, A.O., and Oyedele, A.A., 2019b. Modeling of subsurface integrity using Dar Zarrouk parameters: A case study of Ikekogbe UBE Primary School, Ekpoma, Edo State, Nigeria. Journal of Geography, Environment and Earth Science International 22 (1), Pp. 1-17.

Bawallah, M.A., Oyedele, A.A., Ilugbo, S.O., Ozegin, K.O., Ojo, B.T., Olutomilola, O.O., Airewele, E., and Aigbedion, I., 2020. Evaluation of structural defects and the dynamic of stress and strain on a building along Oluwole Area, Southwestern Nigeria. Applied Journal of Physical Science 2 (2),Pp. 23-37.

Burke, K., Dessauvagie, T.F.J., Whiteman, A.J. 1971. Opening of the Gulf of Guinea and Geophysical History of the Benue Depression and Niger Delta Basin. University of Ibadan Press, Ibadan, Nigeria, 233: 51-53pp.

Fraser, D.C. 1969. Contouring of VLF-EM data. Geophysics, vol.34, 958-967.

Ilugbo, S.O., Adebiyi, A.D., Olaogun, S.O., and Egunjobi, T., 2018a. Application of Electrical Resistivity Method in Site Characterization along Ado–Afao Road, Southwestern Nigeria. Journal of Engineering Research and Reports 1(4), Pp. 1-16.

Ilugbo, S.O., Adebo, A.B., Ajayi, O.A., Adewumi, O.O., and Edunjobi, H.O., 2018b. Geophysical and geotechnical studies of a proposed structure at Akure, Southwestern Nigeria. Journal of Engineering Research and Reports 2 (2), Pp. 1-12.

Karous M, Hjelt S.E, 1983. Linear-filtering of VLF dip-angle measurements. Geophysics. Prospecting., 31: 782-894.

Magawata U.Z., Gulma M.Y., Bawallah M.A and Ilugbo S.O., 2020. Geotechnical Investigation of Sub-Base and Sub-Material of Kali Collapsed Dam Aliero, Northwest Nigeria, Using Laboratory Investigations. Science Journal of Advanced and Cognitive Research, 1(1); Pp. 61-75.

Murat, R. C. 1970. Stratigraphy and Paleogeography of the Cretaceous and Lower Tertiary in Southern Nigeria: In African Geology. University of Ibadan Press, 635-648

Oke, A., 2011. An examination of the causes and effects of building coollapse in Nigeria. Journal of Design and Built Environment. 9, Pp. 37-47

Oyedele, A.A., Bawallah, M.A., Ozegin, K.O., Ilugbo, S.O., Ajayi, C.A., and Aigbedion, I., 2020. Probability functions of road failures in a typical basement complex region, Southwestern Nigeria: A case study of Akure - Oba Ile Airport Road. International Journal of Water Resources and Environmental Engineering 12 (2), Pp. 10-21.

Ozegin, K.O., Bawallah, M.A., Ilugbo, S.O., Oyedele, A.A., and Oladeji, J.F., 2019a. Effect of geodynamic activities on an existing dam: A case study of Ojirami Dam, Southern Nigeria. Journal of Geoscience and Environment Protection 7 (9), Pp .200-213.

Ozegin, K.O., Bawallah, M.A., Ilugbo, S.O., Olaogun, S.O., Oyedele, A.A., and Iluore, K., 2019b. Susceptibility test for road construction: A case study of Shake Road, Irrua, Edo State. Global Journal of Science Frontier Research: H Environment and Earth Science 19 (1), Pp. 45-53.

Reyment, R. A. 1965. Aspects of the Geology of Nigeria. University of Ibadan Press, Ibadan.132pp

Vander Velpen, B. P. A., 2004. RESIST Version 1.0. M.Sc. Research Project, ITC, Delft Netherland.

William J. S. and Ted D., 2004. Engineering Site Characterization and Electrical Resistivity Surveys, North-America Society for Trenchless Technology (NASTT) Bulletin, New Orleans, March 22-24, Louisiana.


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