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INVESTIGATIGATION OF FRESH BASEMENT TOPOGRAPHY USING GEO-ELECTRIC SOUNDING METHOD AT SARDAUNA MEMORIAL COLLEGE KADUNA, KADUNA STATE NORTH- WESTERN NIGERIA

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ABSTRACT
Geo-electric sounding method is mostly used for engineering studies. 25 sounding points along the five profiles was carried out at Sardauna Memorial College Kaduna. This is an attempt to investigate the basement topography of the area. The Ohmega resistivity meter was the principal instrument used. The Schlumberger Electrode configuration was used in the data collection. The method consist of expanding AB (distance between the current electrodes) while MN (distance between the potential electrodes) is kept fixed. The VES curves were interpreted using IPI2Win Resistivity computer software. The results of the interpreted VES data showed an irregular distribution of the basement layer, with resistivity values ranging from 1000Ωm to 83422Ωm. The basement layer is predominantly fresh Granite Rocks. The overburden thickness ranges from 2.8m to 63.8m with an average depth of 17.98m. Clay constituents are needed to be excavated at an average depth of 8m from the topsoil before laying any foundation.

Keywords: Resistivity, Topography, Geo-electric, Schlumberger Configuration

INTRODUCTION
Geophysical methods are commonly used in engineering-geological survey to provide reliable information on the nature of subsurface, geologic structures and sequence. These methods offer fast, cheap and cost effective technique of investigating subsurface formation that provide valuable information that normally assist civil engineer, builder and town planner in the design and construction of an engineering structures especially heavy and high rising buildings. Also, information about the basement complex rock of the region is important for safety of the structure (Ademila 2015). Electrical and electromagnetic methods among others are valuable tools for geo-engineering investigations to confirm the competence of groundwork beneath the earth structures and is a vital step from which groundwork stability response is required for the design and construction of sustainable civil engineering works (Oluwafemi and Oladunjoye 2013; Ademila 2015). The understanding of the properties and parameters beneath the earth materials such as soil or rocks from measurements made at the surface of the earth provide subsurface information in solving engineering infrastructural problems (Falea, 2014, Niederliethinger, *et al*., 2015). Numerous investigation works have been carried out in recent time with the use of electrical resistivity methods in delineating the structural formation.

Ango et al., (2019) carried out geophysical survey on application of 2D and 3D imaging for hydrological and engineering site investigation at Kaduna state university, Kaduna. North western Nigerian with the aim of determines the competency of the side for engineering purposes as a result of rapid growth of the university. They concluded that the results from both 2D and 3D resistivity module show that the study area is characterized by the presence of low resistivity values <100 ohm-m from the depth of 4.99m down to 13.7m indicating various degree of weathering in the weathered profile with thickness of more than 6m. The results of both 2D and 3D images revealed that the study area is resistive at depth beyond 6m and highly affected by weathering process. This means that the site is structurally incompetent for high rising engineering work but has high ground water potentials.

Abdullahi N.K., *et al.*, (2016) Carried out geophysical investigation for engineering at the convocation square of Kaduna State University (KASU) using vertical electrical sounding (VES) with Schlumberger array. The result show three lithologic units comprising of topsoil, characterized by sandy/lateritic materials, weathered basement and fresh bedrock. The iso-resistivity maps of the weathered basement, overburden and the bedrock with respect to subsurface competency constructed from the VES data revealed that the study area is competent to permit construction of engineering work.

Aboh, H.O. *et al.*, (2016). Carried out geophysical survey using very low frequency (VLF) method and vertical electrical sounding (VES), in parts of Karuga Area, Chikun L.G.A of Kaduna State with aim of evaluating the geotechnical parameters in the study area. The interpretation of geo-electric data show that the area is underlain by three to five subsurface layers. The competency of the soil and rock materials was found to be high and moderate. The identified high competent regions where the basement material are highly resistivity (300Ωm - 900Ωm) was observed to dominate most part of the area and where the depth are as appropriate are suggested as probably good zones for sitting construction work such as high rise building and road but part of the section along the north-central and southeast with resistivity (<300Ωm) could be regarded as weak zone.

Olayinka, L.A. *et al.*, (2019) Carried out integrated geophysical survey using very low frequency electromagnetic (VLF-EM) And 2D Electrical resistivity method for foundation studies at Ahmadu Bello University phase II , Zaria .The 2D imaging profile of the VLF-EM highly correlates with resistivity profile and the 2D VLF-EM and resistivity profiles revealed the conductive zone and resistive zones respectively. These zones are suspected to be geological features (dyke, faults and fracture). From interpretation the geological feature such as fracture zone was filled with an earth's materials which are probably sandy clay and mottled clay, and these materials are highly undesirable for the foundation of building structures due to its characteristics of swelling and contracting during rainy and dry season respectively. Thus, undesirable materials should be excavated and be refilled with suitable materials for the foundation of super-structure and also, geological bodies should be avoided when the foundation of the structure is to be erected.

Ayanninuola O. S., et-tal., (2022).Carried out geophysical survey using Vertical Electrical Sounding (VES) at site in Kukwaba District, Abuja to examine the geophysical parameters that can be used to evaluate the structural competence of the subsurface for foundation. The results revealed maximum of five layers, the topsoil, the laterite, weathered layer, fractured basement and fresh basement. The resistivity value of the topsoil ranges between 85.1Ωm to 2416Ωm which is typical clay, clayed, sand, sandy clay and laterite with laterite being the most competent and clay being lest competent. From Geo-electric section, it is observed that the top layer resistivity of VES point 3, 11 and 15 with resistivity value less than 100Ωm are characterized by clay with high moisture content and therefore not competent, while VES point 12 and 14 are lateritic in nature; thus very competent and good for high rising building, while VES point 1, 2, 4, 5, 6, 7, 8, 9, 10, and 13 are moderately competent and can with stand small engineering construction.

MATERIALS AND METHOD

Materials used for this study were Ohmega resistivity meter, Electrode (current and potentials electrodes), Rechargeable battery, Measuring Tape, Cables, Hammer, Global positioning system (GPS), Recording Sheet.

The OHMEGA resistivity meter is a high quality portable earth resistance meter capable of accurate measurement over a wide range of conditions. It has a maximum power output of 36 watts, manual selection of current in steps up to 200mA, a choice of sample time/Signal length averaged and three frequency settings. The receiver incorporates automatic gain steps, which provide a range of measurements from 0.001 ohms to 360 kilo ohms.

Plate 1: Ohmega resistivity meter

Data Collection

Vertical Electrical Sounding (VES) was employed in the study area on five (5) profiles of length two hundred meters. Five VES point were sounded in each profile making a total of twenty five (25) VES point. The central electrodes (potential electrodes) were kept fixed while the current electrodes are expanded. The wider spacing the deeper information as possible of the surface structure and lithological disposition of the area. The resistances values are obtained from the Ohmega (Ω) resistivity meter by multiplying it with geometric factor K which was the function of the electrodes spacing to obtain the apparent resistivity values. The electrode array use to obtain these values is the Schlumberger array. The location coordinates of each VES point was also recorded using GPS.

SITE LOCATION

The research project was conducted at Sardauna Memorial College, Kaduna State. It is located between latitude $10^0346.0$N &$10^0347.4$N, longitude 72^0 658.87E & 72^0 658.00E. The specific location where the survey was done is an open field within the school premises. The satellite image of the study area shown in plate: 2 below.

Plate2:.Satellite image showing the study area Sardauna Memorial College Kaduna

ELECTRICAL RESISTIVITY SURVEY

The Electrical Resistivity(ER) survey methods are used for locating and mapping groundwater sources, natural groundwater flow paths, groundwater contamination, and archeological remnants. These methods measure voltages associated with electric currents flowing in the ground. These currents may be currents introduced into the earth through electrodes or they may be natural currents due to earth processes. This type of testing is use full in detecting changes in apparent resistivity or apparent conductivity both laterally and vertically to map an area for lateral changes vertical change of resistivity with depth. These two techniques are often used in conjunction to fully understand the information about the subsurface (Dahlin and Zhou, 2004; Loke et al., 2013).

THEORY OF ELECTRICAL RESISTIVITY METHODS

The physical quantities measured in the determination of field resistivity are the current **I** flowing between two electrodes, the potential difference ΔV between two measuring point M and N and the distance between the various electrodes.

$$\rho = \frac{2\pi\Delta V}{I} = \frac{\Delta V}{I} k \text{-- (2.1)}$$

Thus, by measuring ΔV and I, and knowing the geometric factor (K), the apparent resistivity ρ will be obtain.

RESULT AND DISCUSSION

The table1: below showing the profile, the VES points along each profile, the resistivity of the basement rocks and the depth to basement which is also known as overburden thickness. The result obtained from the geophysical survey was used to produce the basement topography curve along the five profiles at the survey area.

TABLE 1: RESULTS

PROFILES/VES POINTS	BASEMENT RESISTIVITY(Ωm)	DEPTH TO BASEMENT(m)
P1V1	9267	32.2
P1V2	21949	13.7
P1V3	1555	10.3
P1V4	1795	2.8
P1V5	7687	18.4
P2V1	83422	21.6
P2V2	12000	7.74
P2V3	74069	53.18
P2V4	4204	7.84
P2V5	1176	8.77
P3V1	3059	32.2
P3V2	3917	15.2
P3V3	28402	19.8
P3V4	2776	6.44
P3V5	75643	23.9
P4V1	1753	9.49
P4V2	57690	8.2
P4V3	1491	5.17
P4V4	7958	20.1
P4V5	3392	22.5
P5V1	62525	18.2
P5V2	2276	7.54
P5V3	1440	11.5
P5V4	27846	63.8
P5V6	1000	8.87

Profile 1: Basement Topography

Five VES points were sounded along profile one. The depth to basement (overburden thickness) at VES 1, VES2, VES3, VES4 and VES5 were found to be 32.20m, 13.70m, 10.30m, 2.80m and 18.40m respectively with an average depth to basement of 15.50m. The maximum thickness was found to be located at VES1 and a shallow depth at VES4. The basement topography along profile one is shown in Fig.1below.

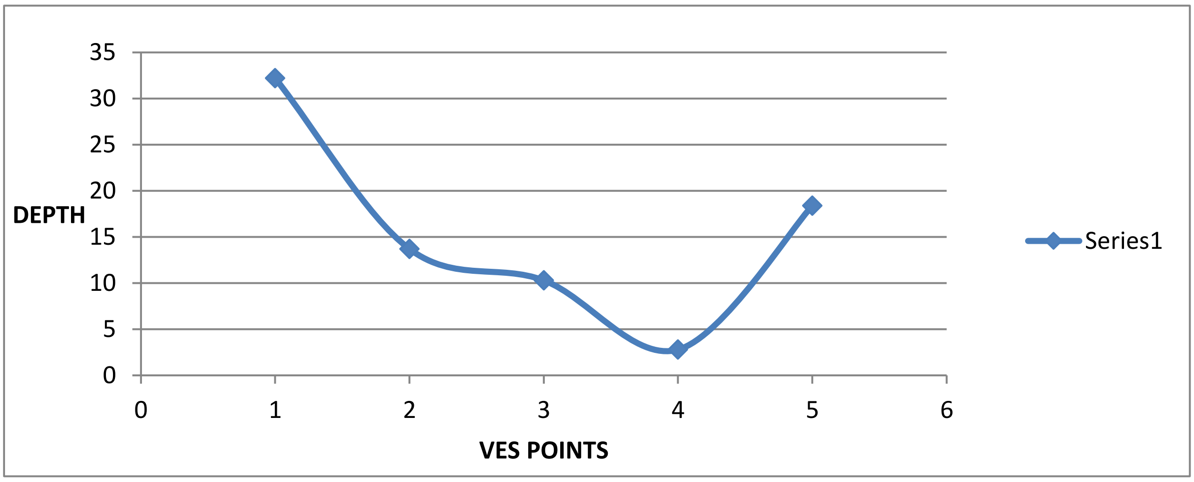

Figure1: Basement Topography along profile 1

Profile 2: Basement Topography

Five VES points were sounded along profile two. The depth to basement (overburden thickness) at VES 1, VES2, VES3, VES4 and VES5 were found to be 21.60m,7.74m,53.18m,7.84m and 8.77m respectively. The thickness varied from 7.74m to 53.18m with a mean value of 19.83m.The maximum thickness was found to be located at VES3 and shallow depths at VES2, VES4 and VES5. The basement topography along profile two is shown in Fig 2: below.

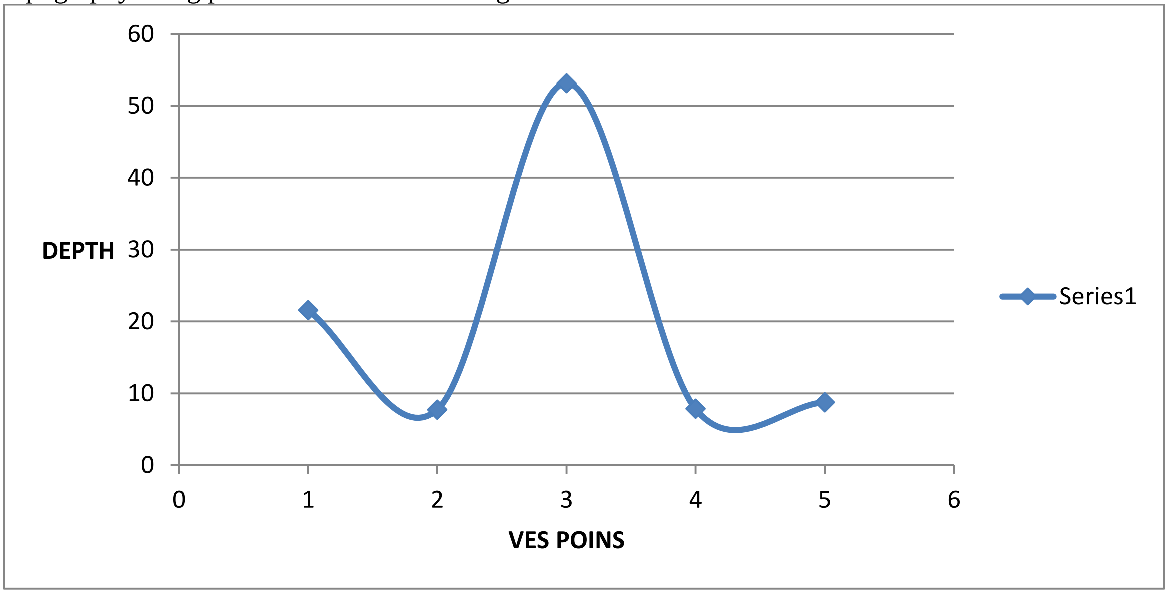

Figure 2: Basement Topography along profile 2

Profile 3: Basement Topography

Five VES points were sounded along profile three. The depth to basement (overburden thickness) at VES 1, VES2, VES3, VES4 and VES5 were found to be 32.20m,15.2m,19.80m,6.44m and 23.90m respectively. The thickness ranging from 6.44m to 32.20m with an average value of 19.51m.The maximum thickness was found at VES1 and shallow depths at VES4. Highly resistive rocks with shallow depth are competent for civil engineering structure especially heavy and high rising building therefore VES4 is a competent VES point. The basement topography along profile three is shown in Fig 3: below.

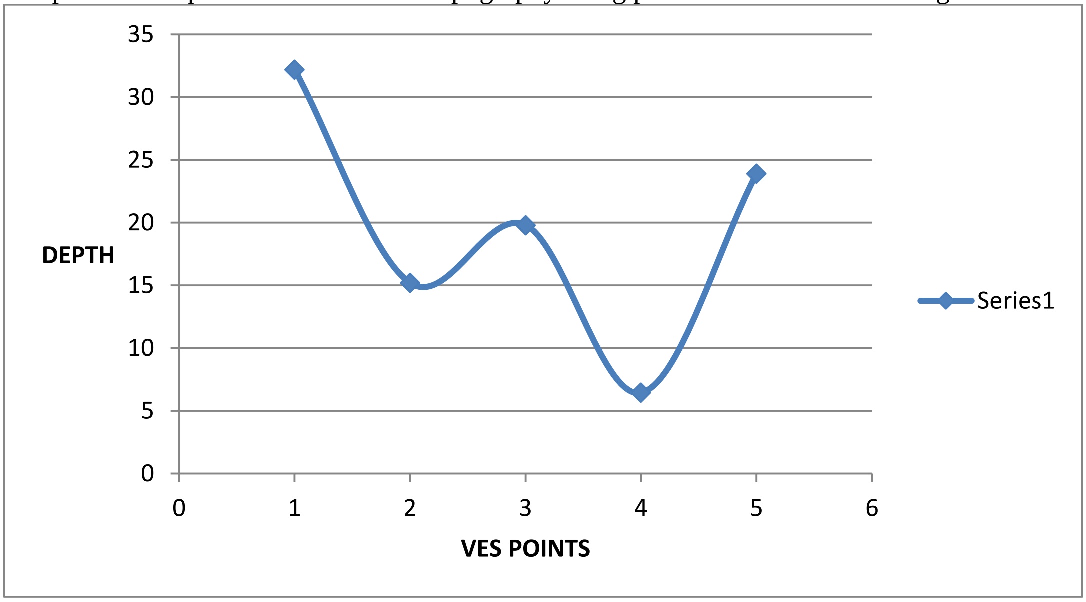

Figure 3: Basement Topography along profile 3

Profile 4: Basement Topography

Five VES points were sounded along profile four. The depth to basement (overburden thickness) at VES 1, VES2, VES3, VES4 and VES5 were found to be 9.49m,8.20m,5.17m,20.10m and 22.50m respectively. The thickness varied from 5.17mm to 22.50m with an average value of 13.10m.The graph show that the overburden thickness for profile four increasing toward VES4 and VES5. The basement topography along profile four is shown in Fig 4: below.

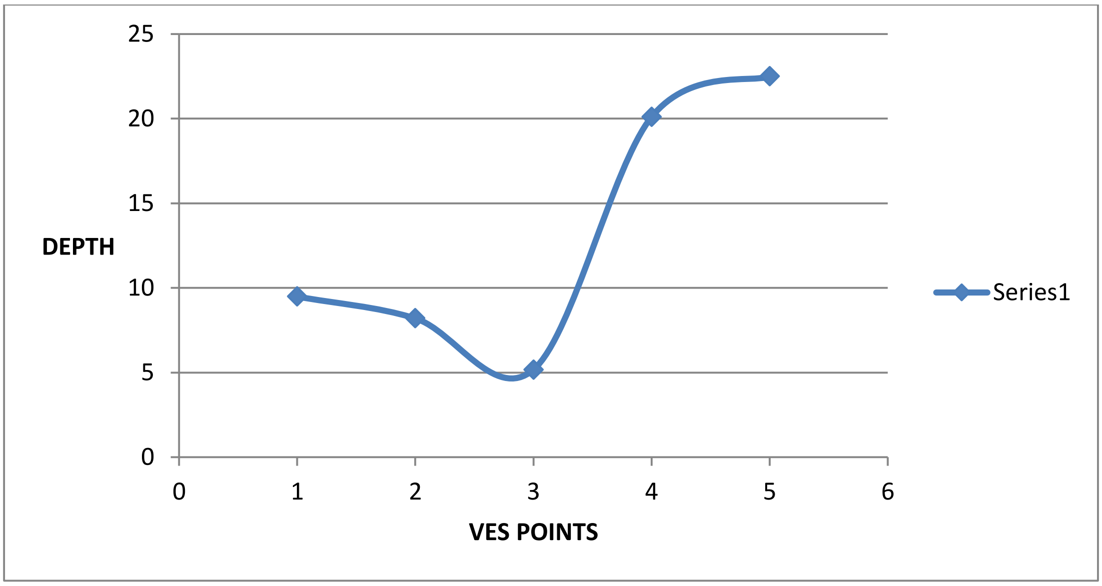

Figure 4: Basement Topography along profile

Profile 5: Basement Topography

Five VES points were sounded along profile five. The depth to basement (overburden thickness) at VES 1, VES2, VES3, VES4 and VES5 were found to be 18.20m,7.54m,11.5m,63.8m and 8.87m respectively. The thickness along this profile ranging from 7.54 at VES2 to 63.8m at VES4 with an average value of 21.98m and VES1, VES2 VES3 and VES5 is shallow except VES4 which is deeper as shown in fig 5 below

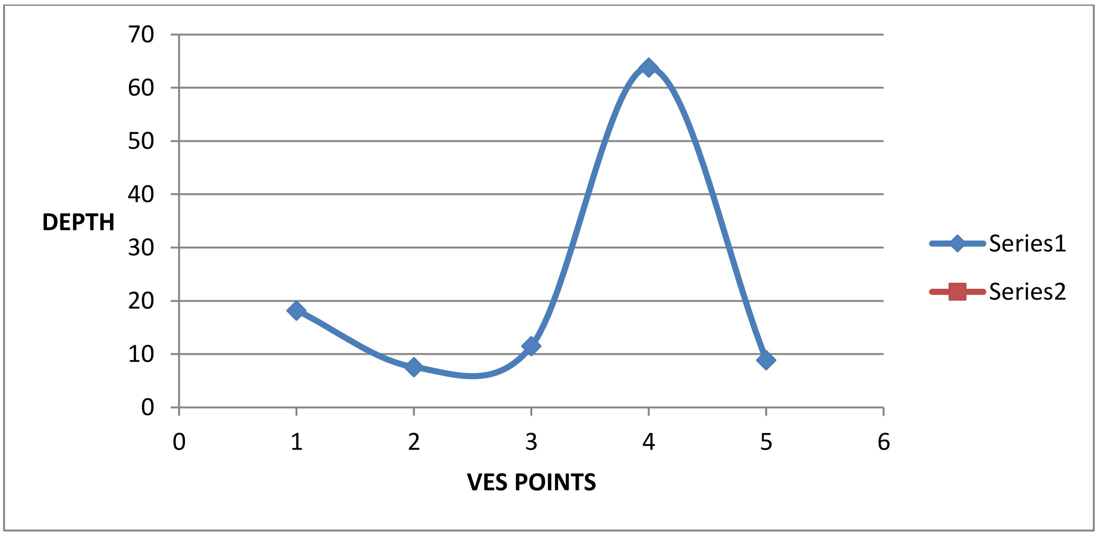

Figure 5: Basement Topography along profile 5

The overburden thickness map of the study area

The Fig 6: below show the overall depth to basement map (overburden thickness) of the study area. The VES points fall within the extreme end of the profiles have maximum thickness while other part is shallow depth which occupy the large portion of the study area and is competent for any civil engineering structure especially heavy and high rising building.

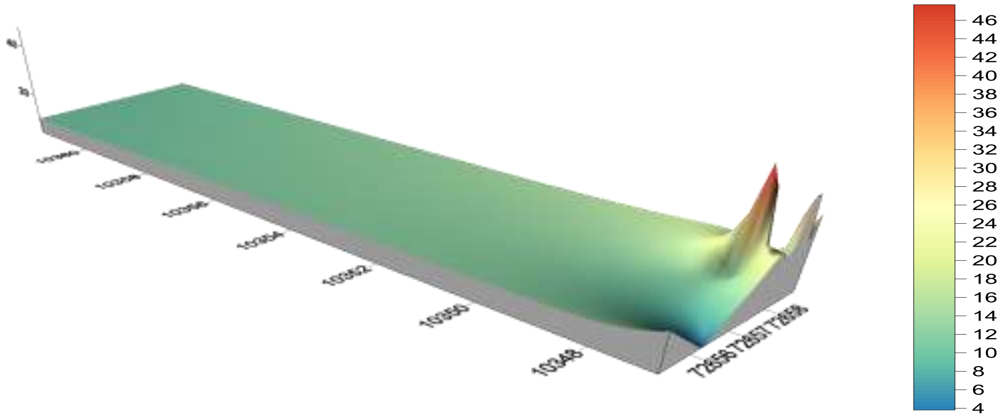

Fig 6: overburden thickness map

CONCLUSION AND RECOMMENDATION

After the completion of the survey, 25 VES points along the five profile produce were investigated at the study area. The depth to basement varied between 2.8m at VES4 of profile one (1) to 63.8m at VES4 of profile five (5). The overall average depth to basement was found to be 17.98m.The basement topography showed an irregular distribution of the subsurface structure with resistivity values ranging from 1000Ωm to 83422Ωm of fresh Granite rocks of the earth material.

Geo-electrical survey using the Vertical Electrical Sounding method is highly recommended for investigation of the subsurface. This is recommendable for any proposed of heavy or high rising building. The soil constituent of the survey area is mostly clay. Hence, clay constituents should be excavated before laying any foundation

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