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INTEGRATED GEO-ELECTRICAL AND ELECTROMAGNETIC INVESTIGATION OF GRID PART OF FELELE CAMPUS, FEDERAL UNIVERSITY LOKOJA, NIGERIA

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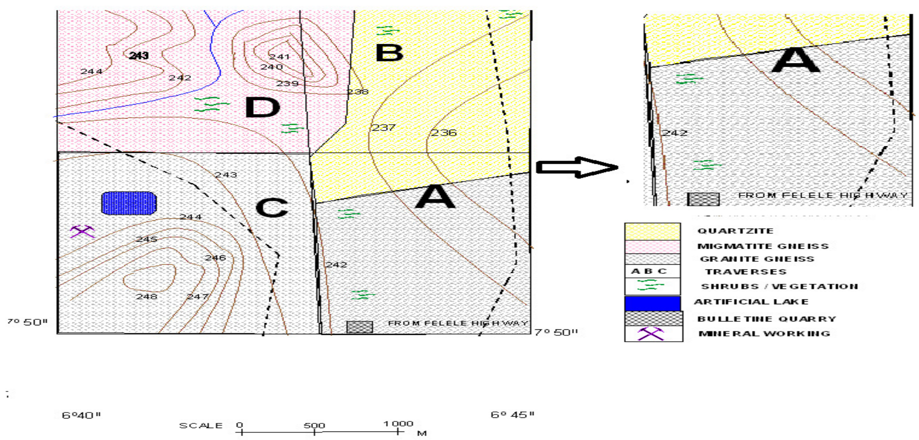
ABSTRACT
Geophysical investigation involving the use of vertical electrical sounding (VES) on grid-A part of Felele campus, Federal University Lokoja, Nigeria with objectives to delineating depth to fresh basement, fractured zones in the study area for potential groundwater exploration within the crystalline basement rocks. The area is underlain by the Crystalline Basement rocks composed of granite gneiss, quartzite and intrusions. PASI Terrameter was used and the symmetrical Schlumberger configuration adopted. A total of four (4) Vertical Electrical Sounding (VES) stations were established. Preliminary input data from the field were inputed into the WINRESIST software to generate real resistivities and depths to geoelectric layers. Three (3) geoelectric layers were interpreted, the first layer is the top soil made up of resistivity values ranging from 141 Ωm - 486.1 Ωm and depth to weathered basement of 1.2-2.5m. It is inferred that this layer does not consist of the same material across the entire length of the profile. The second layer is made up of resistivity values ranging from 37.9Ωm to 85.6Ωm and depth to fresh basement of 11.2 – 16.1m. Its inferred to composed mostly of fractured and unconsolidated rocks, loose gravel, sandy soil and clayey. The resistivity value within this layer indicates that is it good for groundwater exploration and the third layer has the highest resistivity values ranging from 821.2 Ωm - 2695Ωm with an infinite depth. It's entirely composed of fresh basement rock which is possibly of the gneissic suite.
Keywords: *Basement rocks, Fractures, Geoelctric layers, ground water, lokoja, schlumberger*

INTRODUCTION

Geoelectrical investigation techniques are been widely employed in groundwater exploration, depth to bedrock determination and basement rock characterization (Zohdy et al., 1974; Beck, 1981; Olorunfemi and Okhue, 1992). Geoelectric investigation of the area was carried out with a view to understanding the subsurface lithology and hydrogeological setting of the area. However, interpretation of geophysical data can be ambiguous if clear correlations are not established between the geophysical attributes and the geologic properties coupled with the stratigraphic properties of the subsurface (Koster and Harry, 2005). Given the usual sparsity of core and geophysical logs, establishing such correlations is often problematic. As good alternative, geophysical studies of outcrops strata in basement complex terrain are often used (Wolfe and Richard, 1996; Hubbard and Rubin, 2000). The permanent site of Federal University Lokoja (study area) is a developing area located at Felele - Lokoja, Kogi State, Nigeria, off Lokoja-Okene road. It is at the north western part of mount Patti, it lies between mount Patti and Agbaja plateau at latitude 07 °50' 05" N to latitude 07° 54' 04" N and longitude 06° 40' 22" E to longitude 06° 42' 02" E. The permanent site of Federal University Lokoja is dominantly underlain by the Precambrian basement complex and part of the area is underlain by cretaceous sediments which uncomfortably over lay the basement complex. The study area is composed of the following; fieldspathic sand stone and siltstones, biotite hornblende, quartzite, gneiss and migmatite. The climatic data from the Nigeria metrological agency (NIMET, 2011) indicates that the study area falls within the tropical climate characterized by two distinct seasons; rainy season (April to October) and dry season (November to march). Mean annual temperature oscillates between 26°c (July or August) to 35°c in February or March while relative humidity ranges from 50- 63% (NIMET, 2011). The vegetation in the study area is classified as guinea savanna grassland characterized by shrubs with scattered orchard bush. The area is generally drained into river Niger due to the moderate sloping nature of the land.

Geology of the Study Area

The area of study is located within Lokoja in Kogi State in the North-central part of Nigeria. It is situated at the extreme eastern part of the south-western Nigeria Basement Complex and the Mid-Niger Basin otherwise known as the Bida basin or the Nupe basin. Its coordinate lies within latitudes 070 45′0″N to 070 51′0″N and longitudes 0060 42′0″E to 0060 45′0″E. The basement rocks in the area had regionally been described in the past by previous workers; Jones and Hockey (1964) Grant et al (1972), Odigi et al (1993), Pearce and Gale (1977). The area is made up of Basement Complex rocks which include migmatite gneiss (augen gneiss or porphyroblastic granite and biotite gneiss) intruded by the NE-SW trending pegmatite dykes and covered by the Cretaceous – Recent coarse-medium grained sands to the East forming the bank of River Niger. Field observations and a study of the rock samples collected indicate that the rocks belong to the migmatite – gneiss complex of the south-western Nigeria Basement Complex. The area is underlain predominantly by migmatite, augen gneiss, biotite gneiss as well as minor occurrences of pegmatite and quartzo – feldspathic veins. Petrographic and chemical analyses of the rock samples from this area show the migmatites to generally consist of quartz, feldspar (plagioclase, microcline and orthoclase), biotite and a few accessory minerals like epidote and zircon. The chemical analysis data and petrographic details suggest an igneous parentage for the migmatites. However, with their uncomplicated mineralogical composition, these migmatites differ from those of the near-by north-eastern part of Lokoja which are of pelitic rock parentage. Consequently, it is suggested that a deformational episode occurred along with the metamorphism of the various rocks of the mapped area and its environs resulting in varied metamorphic derivatives ranging from the amphibolite facies to higher metamorphic facies condition. These migmatites may have been formed from the metamorphism and metasomatism of



fractionated igneous bodies during tectonism. The segregation and migration of the melting minerals such as quartz and feldspar during regional metamorphism resulted in the banding of the leucosome and melanosome minerals. The map in (figure 2.0) shows the general basement of study area.

Figure 2: Geological map of the study Area

METHODOLOGY

In each sounding point, four (4) electrodes were hammered into the ground via which the electric current was transmitted into the ground and the potential difference was detected and measured by the Terrameter. The schlumberger electrodes array was employed to generate the field data. The two (inner) potential electrodes (M and N) were initially placed at 0.5m from the central reference point. Similarly, the two current electrodes (A and B) were placed at 1M from the reference point, all lying symmetrical to each other. The Terrameter was connected to the electrodes via conducting wires. After making all the necessary connections, the readings were displayed on the LCD screen of the terrameter and readings were recorded in the field note book. The current electrodes were shifted to 2m, 3m and 6m with the potential electrodes fixed at 0.5m. The potential electrodes were changed to 1m for electrode spacing 6m, 8m and 12m. This technique was repeated for the rest of the VES points and stations in the study area.

RESULT AND DISCUSSION

The results of the data obtained from the field are presented as tables, geoelectric section and graphs. The geoelectric profile shows that the area of investigation constitutes three layers which include the top soil, weathered basement and the fresh basement. More so, the qualitative interpretation of the depth sounding curves enabled the classification of the VES data into the curve types. The classification ranged from one to 2- curves type(s) arising from the layer resistivity combination.

DATA PROCESSING AND RESULT

Vertical Electrical Sounding (VES)

The data obtained was subjected to computer assisted iterative interpretation using WIN-RESIST software. This programme was used to perform quantitative analysis and inter-pretation of the field curves. The software requires that the operator provide the apparent resistivity values, the corresponding electrode spacing and the number of the subsurface layers. The theoretical curve for the initial input parameters is compared with the measured data. The starting model and its corresponding resistivity are transformed, refined or modified by the programme to obtain a best fit relation to the field data. The process of iteration was performed until fitting error between field data and synthetic model curve becomes least and constant. Thus, the software yields the number, thickness and resistivity of the various layers. The field curves obtained within the study area are the H-type. The typical VES curve type are shown in (Fig. 20) and it is obtained from the processed data. The VES curve obtained has given a graphical view of the layers from top to bottom comprising of top soil, weathered basement, fresh basement respectively; and the thickness of the top soil, weathered and fresh basement.

Fig. 20 (a) to (d) is a typical H-type curve indicating that the soundings successfully penetrated three (3) layers in the subsurface. These curve types are generally obtainable in hard rock terrains which consist of dry top soil, weathered rock layer and fresh bedrock. The resistivity in each case falls to minimum and rises again to maximum indicating that the intermediate layer is of lower resistivity than the top and bottom layers, thus indicating the presence of possible water bearing formation(s) in the subsurface.

Electromagnetic Method

The E.M data acquisition machine used performs duo function of acquisition and pro-cessing by an automated mechanism through a simple command to profile. The machine automatically plots and presents result in 3D as shown in (F.g 22) below. The PQWT Geological prospecting equipment mainly tell the underground geological structures, like fractures and cracks.

Self Potential

The SP data obtained was plotted similarly like the HEP data. The data obtained was subjected to a software assisted process of graphical exposure of the fluctuation

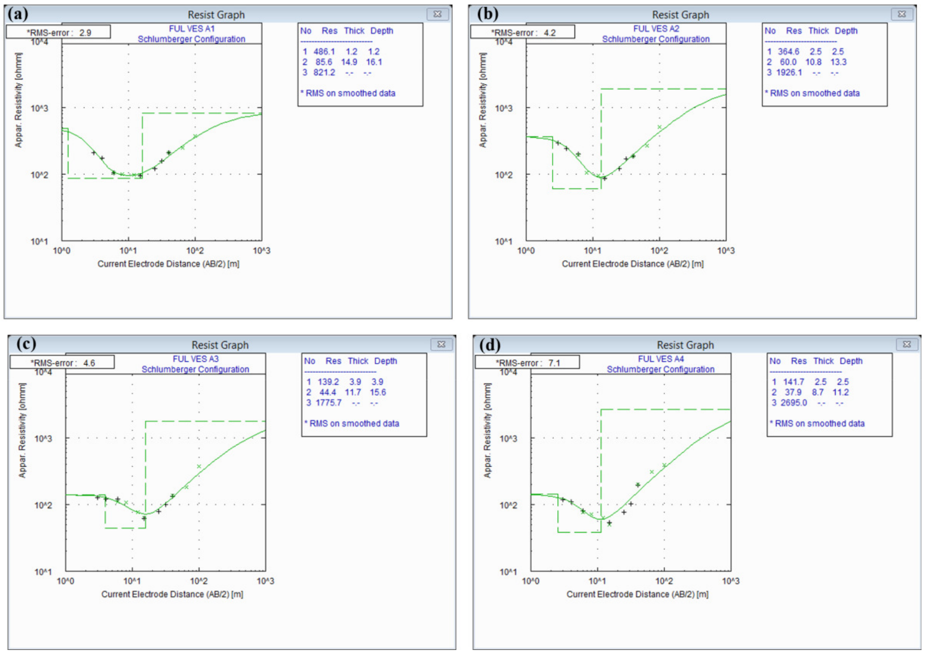


Figure 3: (a), (b), (c) and (d) are typical H-type curve indicating that the soundings successfully penetrated three (3) layers in the subsurface.

In potential value. Suitable plotting software was used to show the graphical variation of earth's potential by plotting SP values against spread with which you can infer the mineralization at each distance across. The software requires that the operator provide the SP values and the corresponding electrode spacing.

DISCUSSION

Vertical Electrical Sounding

The plots in Fig 3 (a) to (d) are the four different curves are typically H-type, indicating that the soundings successfully penetrated three (3) layers in the subsurface. These curve types are generally obtainable in hard rock terrains which consists of dry top soil, weath-ered rock layer and fresh bedrock. The resistivity in each case falls to minimum and rises again to maximum indicating that the intermediate layer is of lower resistivity than the top and bottom layers, thus indicating the presence of possible water bearing formation(s) in the subsurface. The geoelectric section in fig.8 shows the 3D representation of the 4 VES points. The result presented in the previous chapter shows that the investigated area consists of three layers; the first layer is the top soil made up of resistivity values ranging

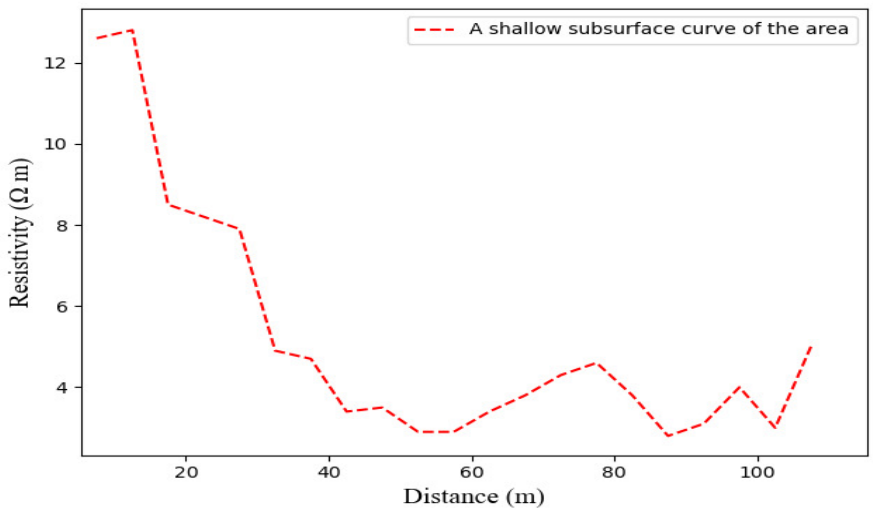


Figure 4: The H.E.P curve showing a shallow subsurface curve of the area.

From 141 Ωm -486.1 Ωm and depth to weathered basement of 1.2-2.5m. It is inferred that this layer does not consist of the same material across the entire length of the profile.

The second layer is made up of resistivity values ranging from 37.9 Ωm to 85.6 Ωm and depth to fresh basement of 11.2m – 16.1m. Its inferred to composed mostly of fractured and unconsolidated rocks, loose gravel, sandy soil and clayey. The resistivity value within this layer indicates that is it good for groundwater exploration. The third layer has the highest resistivity values ranging from 821.2 Ωm - 2695 Ωm with an infinite depth. It's entirely composed of fresh basement rocks which is possibly of the gneissic suite.

Horizontal Electrical Profiling (H.E.P)

The H.E.P curve shows a shallow subsurface curve of the area. Areas on the curve with high resistivity represent zones of highly compacted rock types. Low resistivity areas on the plot represent zones of penetrated fractured rocks. It is obvious from the data set and graph that; most of the shallow subsurface rocks at the surveyed site are loosed top soil showing possible absence of outcrop within the survey area, however, between 0-5M, the resistivity value increased appreciably showing possible presence of a crystalline rock beneath shallow subsurface. The legend attached to the right hand side of the plot (fig. 5) gives the interpretation of the profile maps in terms of color. The red stand for high value and probability for high density rocks with the orange color showing contact zone between high density rock to low density rock. The yellow stands for the middle value, high probability for rocks. All of the above indicates possible absence of water. The green color represents contact zone between rock mass to low values like wet rock portion and dry some times. The blue stands for low value and high probability for water.

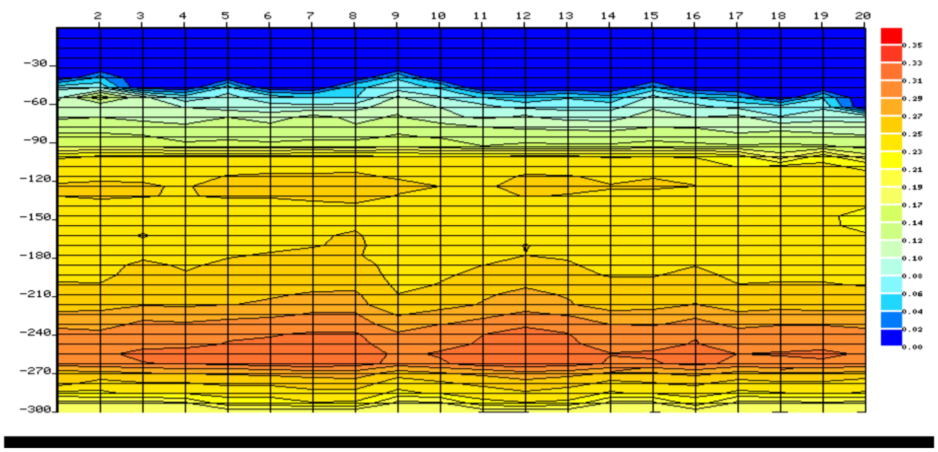


Figure 5: The interpretation of profile map

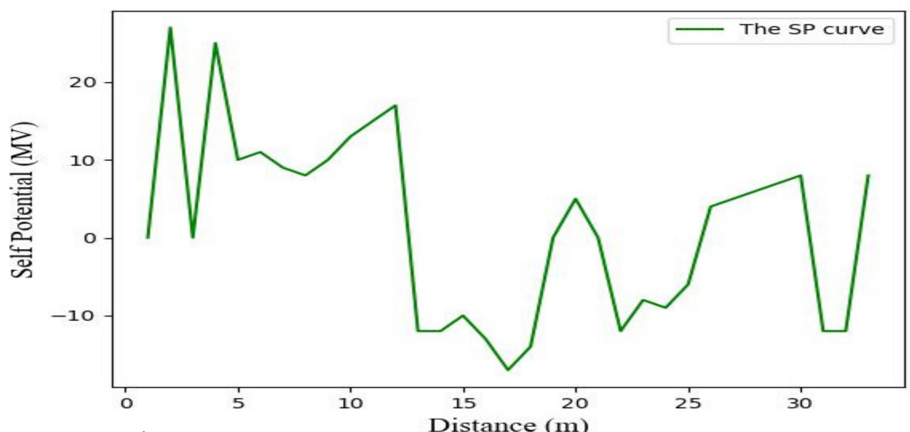


Figure 6: The SP curve

SUMMARY

The Summary of the Geoelectric Parameter of Vertical Electrical Sounding (VES) curve obtain on the field is presented in (fig. 7) and (fig. 8). The field curves obtained within the study area is a typical 3 layered curve type. The field curves obtain within the study area is an H type. Generally, the result of the four Vertical Electrical Sounding (VES) conducted in the area of investigation reveals three Geoelectric layers. The Geoelectric section along Profile 1, 2, 3 and 4 are shown in (fig. 8). According to (Aku M. O and Gani L. I.,2015), the section shows that the area is predominantly made of the Top soil layers, Lateritic clay layers, Weathered basement layers and Fresh basement layers. Taken. The EM profile map (fig. 22) shows that the area of investigation is relatively rugged at a deeper depth with fractures and weathering of the top layer and possible water bearing layer.

Fig. 7 is the summary of the VES data of the various points on the field. The HEP – resistivity profile (fig.4) shows that the top soil is more loose than crystalline basement. The overburden thickness (fig.7) shows that the depth to basement is thin and it will reduce the cost of excavating the overburden before possible mining of the crystalline rock is done. Based on the result of geophysical investigation, the mineralization potential wasn't convincing but with further investigation, the reserve could be estimated and recommended for mining.

CONCLUSION

The field data was gotten by obtained by the geophysical investigation involving Vertical Electrical Sounding (VES), horizontal electrical profiling, Self-potential and electro-magnetic investigation was carried out to obtain the depth to basement, ground water potential, structures and mineralization within the study area. The interpretation of the geo-electric resistivity to obtain the overburden thickness and the variation of the soil profile which shows the ranges of the thickness to be between 1.2m to 3.9m. The entire study area is comprised of three layers namely; Top soil, weathered basement, Fresh basement respectively. The basement rock is mostly fresh. When the shallow overburden thickness around the vicinity of rock outcrop is put into consideration, it is expected that less material will be excavated before blasting of the rock.

The following are recommended;

(1) Drilling for water is highly recommended,

(2) Continuous mapping and prospecting for possible mineralization is very important as this will help us to estimate reserve and recommend for mining of the minerals within.

(3)Blasting of rock within the area of investigation should not be more than depth of 50m to avoid discomfort around the area.

(4)Construction of appropriate drainage especially along the stream channel to enhance easy passage of water should be highly noted. It is important in order to avoid unnecessary flooding in the site.

Figure 7: The summary of the VES data of the various points on the field.

Station	Type of geo-electric model	Layer	Depth	Thickness	Resistivity	Inferred lithology
VES 1	H-Curve	Three(3)	1.2	1.2	486.1	Top soil
			16.1	14.9	85.6	Weathered basement
			---	---	821.2	Fresh basement
V ES 2	H-Curve	Three(3)	2.5	2.5	364.2	Top soil
			13.3	10.8	60.0	Weathered basement
			---	---	1926.1	Fresh basement
VES 3	H-Curve	Three(3)	3.9	3.9	139.2	Top soil
			15.6	11.7	44.4	Weathered basement
			---	---	1775.7	Fresh basement
VES 4	H-Curve	Three(3)	2.5	2.5	141.7	Top soil
			11.2	8.7	37.9	Weathered basement
			---	---	2695.0	Fresh Basement

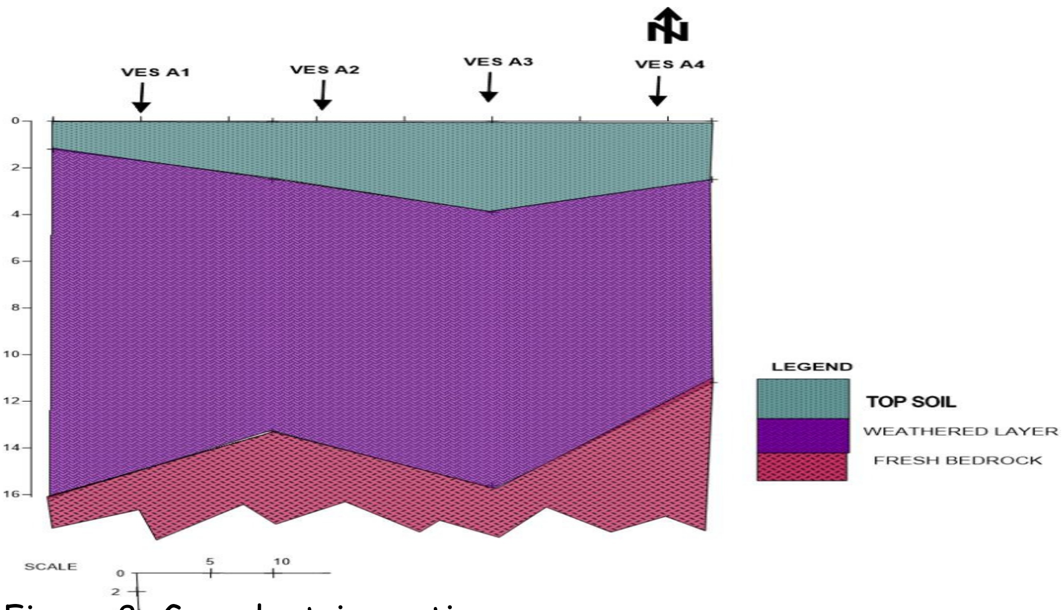


Figure 8: Geo-electric section.

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