GEOPHYSICAL INVESTIGATION FOR THE ESTIMATION OF DEPTH TO TOP OF LIMESTONE DEPOSIT, ILARO, OGUN STATE, NIGERIA

CLIENT: NAME WITHELD FOR PRIVACY

CONSULTANT: MUKOLAK GEOCONSULT NIG. LTD.

APRIL, 2025

LIST OF PARTICIPANTS

(1)	Prof. K.A.N. Adiat	Chief Consultant
(2)	Dr. M. Bawallah	Geophysicist/Technologist
(3)	Mr. S.A. Mudashiru	Geophysicist/Report Author
(4)	Mr. A.O. Olatunji	Geophysicist

EXECUTIVE SUMMARY

Geophysical investigation was conducted at Ogun State, Nigeria for the possibility of limestone quarry development. The investigation engaged the Electrical Resistivity Geophysical Method utilizing Vertical Electrical Sounding (VES) employing Schlumberger Electrode Configuration for the acquisition of the VES data. The interpretation of the VES data showed that, curve types KQH, HA, HK and HA curve types were delineated at VES locations 1, 2, 3 and 4 respectively thereby implying that 5 geoelectric layers can be inferred for VES 1 whereas 4 geoelectric layers can be inferred for VES 2, 3 and 4.

Further interpretation of the VES data obtained at the four VES locations V1, V2, V3 and V4 classified the area into four and five geo-electric layers. At V1, the area is underlain by Topsoil, Lateritic, Sandy, Unsaturated Clay and Clayey Sand whereas at V2, V3 and V4, the area is underlain by Topsoil, Highly Saturated Clay Layer, Unsaturated/Slightly Saturated Clay Layer and Clayey Sand/Plastic Clay Layer. In addition, at V2, V3 and V4, the Topsoil resistivity value ranges from (7 – 12 Ohm-m) with thickness range (0.9 – 1.1m), the Highly Saturated Clay Layer has resistivity value ranging from (2 – 4 Ohm-m) with thickness range (5.0 – 7.5m), the Unsaturated/Slightly Saturated Clay Layer has resistivity value ranging from (15 – 32 Ohm-m) with thickness range (11.7 – 24.1m) whereas the last layer delineated has Clayey Sand/Plastic Clay has resistivity range (15 – 74 Ohm-m) with infinite thickness. **The geoelectric parameters from the VES data at the four VES locations revealed that, the overburden materials at the mining site are very thick suggesting deeper depth of limestone occurrence if there will be any occurrence of the limestone formation. In addition, the underestimation of depth of penetration even at maximum half current electrode spreading of 325m at VES locations 3 and 4 was due to attenuation of electric current by the thick conductive overburden. Furthermore, judging by the recorded resistivity data, there is no indication of occurrence of limestone deposit at the observed VES locations and even if there will be possibility of occurrence, it will be at a much deeper depth of approximately more than 90m posing tremendous difficulty in excavation of such deeper depth occurring deposit.**

It should however be pointed out that all inferences were made based on the interpretation of the acquired VES data, and therefore, a Geophysicist's role is to make inferences based on the acquired geophysical data. Consequently, the quantity and quality of information derived are inherently limited by the depth of investigation, resolution, and the geophysical contrast of subsurface materials.

1.0 INTRODUCTION

The use of surface geophysics in estimating the depth to top of occurrence of solid mineral deposit (e.g. limestone) in an area is important not only because it offers non-invasive and cost effective approach but also because it helps to aid decision–making prior to final acquisition of the mining site as well as drilling/excavation of the site. Therefore, the following objectives are the highlight of the employed geophysical investigation;

(i) **carry out electrical resistivity geophysical survey employing vertical electrical sounding (VES) utilizing Schlumberger configuration;**

(ii) **delineate the geoelectric sequence/subsurface geology of the site from the data obtained in (i);**

(iii) **estimate/infer the probable depth to top of occurrence of the limestone deposit from the geoelectric parameters obtained in (ii);**

(iv) **make inference on the investment suitability of the mining site based on (i), (ii) and (iii)**

2.0 SITE DESCRIPTION

The study area is located within the Egbado/Yewa North Local Government Area of Ogun State bordering Benin Republic (Figure 1).

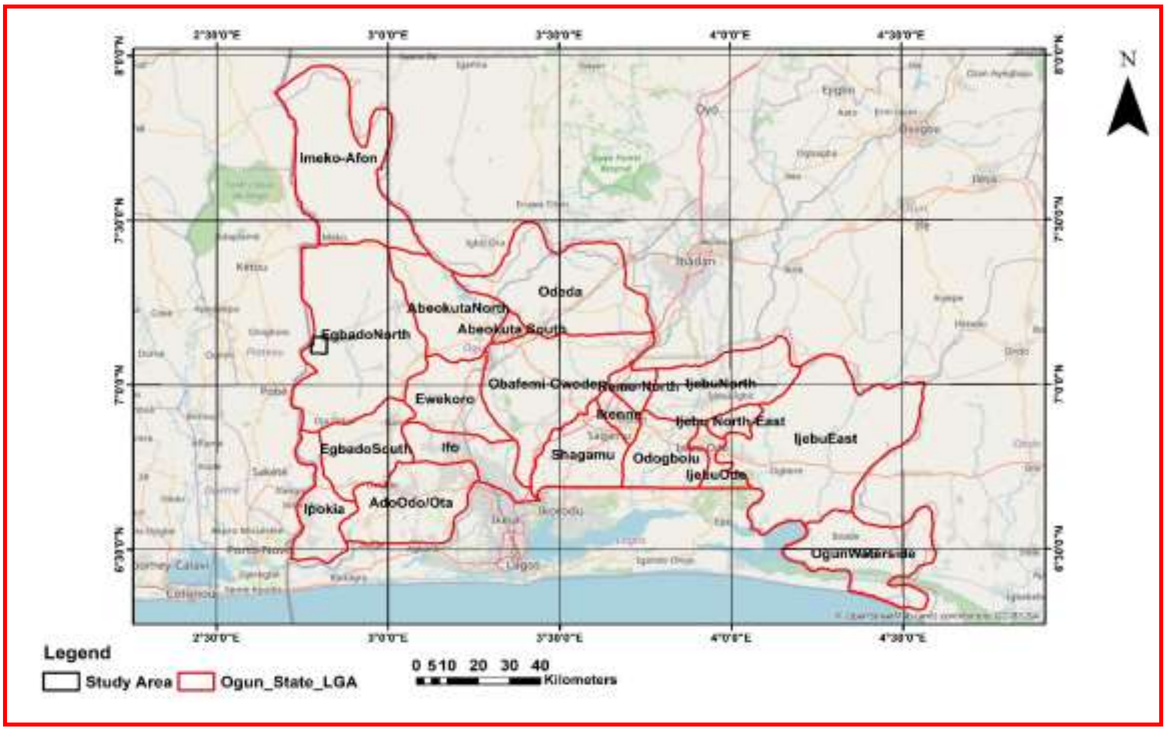

Fig. 1: Study area location

3.0 GEOLOGY AND GEOMORPHOLOGY

The study area falls within the Ewekoro formation which is one of the geologic formation in Ogun State (Figure 2). Ewekoro Formation is a well-known Paleocene sedimentary unit within the Dahomey Basin of southwestern Nigeria. According to the work of Badmus and Ayolabi (2006), Ewekoro formation is characterized with thick overburden (which can be lateritic layer or clay layer) overlying the limestone deposit. As such, limestone deposit within Ewekoro formation have been recorded to occur at much deeper depth rather than at shallow depth.

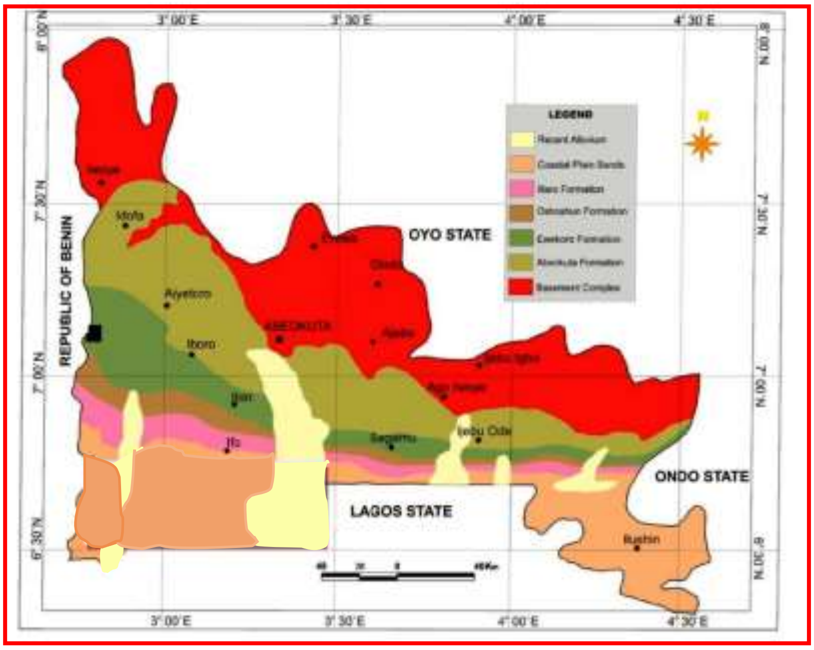

Fig. 2: The Study Area (In Black Shade) Falling within Ewekoro Formation in the Georeferenced Geologic Map of Ogun State

4.0 GEOPHYSICAL INVESTIGATION

The geophysical investigation employed the Vertical Electrical Sounding (VES) technique utilizing the normal Schlumberger array (Fig. 3a). In the VES approach employing Schlumberger configuration, with the potential electrodes located within the current electrodes, the half current electrode (AB/2) spreading starting from 1m and reaching a maximum spread of 325m was adopted. Although, only two (i.e. VES 3 and 4) of the four acquired VES data fall within the block of interest in the mining site, the results of these data within the Ewekoro formation (Fig. 3b) are enough to make inference on the entire block since sedimentary geologic regions (i.e. Ewekoro Formation) to which the mining site falls into normally exhibit similar resisitivity data response. Furthermore, PASSI earth resistivity meter was used as the geophysical measuring equipment and the whole processes adopted were geared towards good and accurate data acquisition.

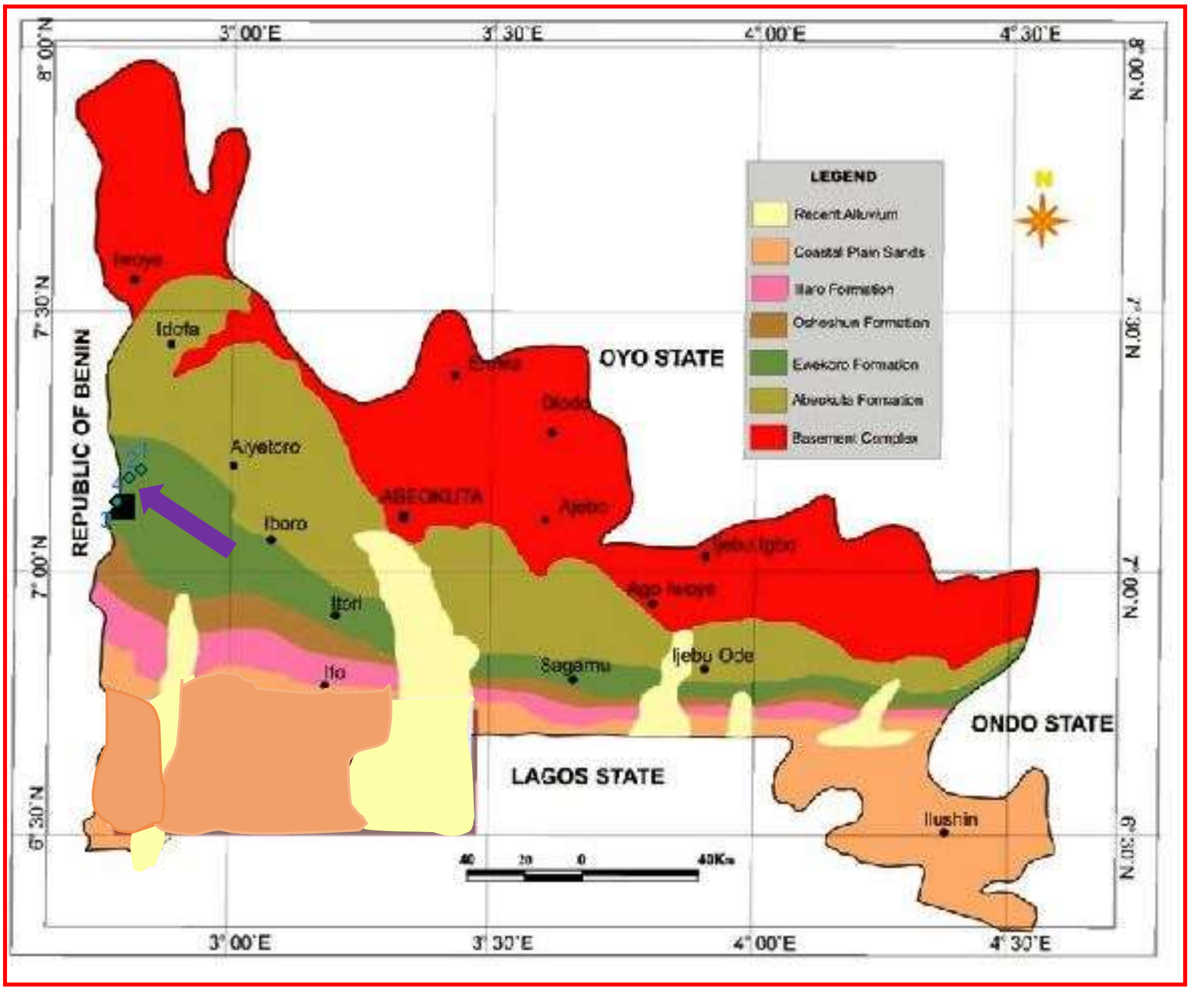

Fig. 3b: VES location (In Green Dot) posted on the georeferenced geologic map

5.0 DATA PRESENTATION AND INTERPRETATION

Geophysical data can be presented in the form of depth sounding curves, profiles, maps, sections and tables. For this study, the use of profile, depth sounding curves and tables in discussing and establishing the relevant subsurface layers and the top to limestone deposit were adopted. The sounding data are plotted and presented as sounding curves (Figs.4a, b, c and d) and are interpreted quantitatively. The results of the VES quantitative interpretation are shown in Tables 2a, b, c and d as geoelectric parameters.

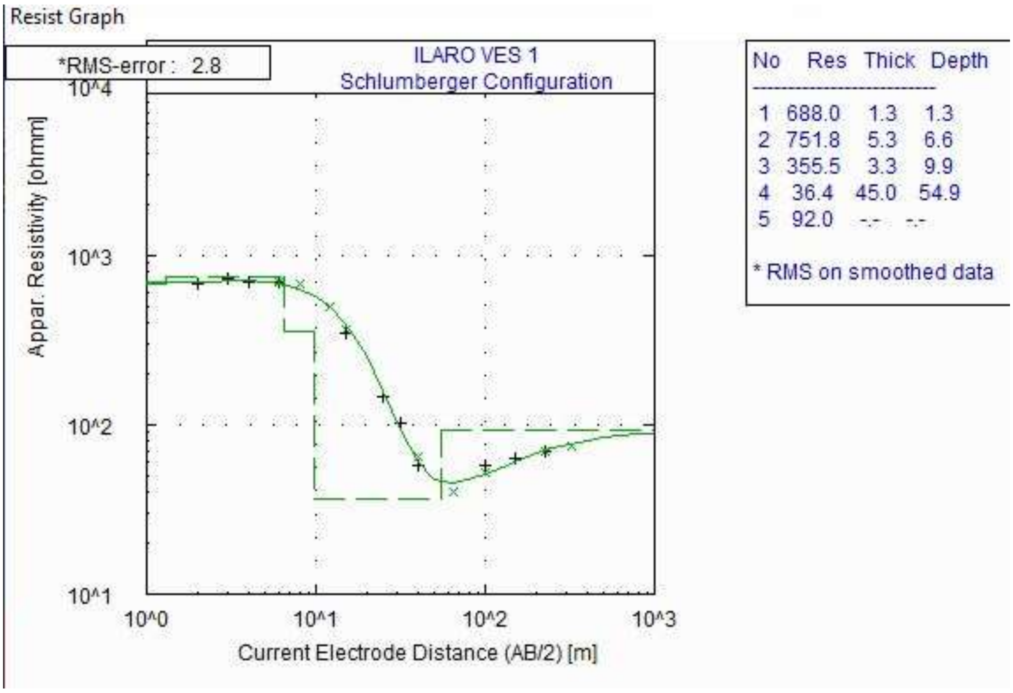

Fig. 4a: Depth sounding curve for VES 1

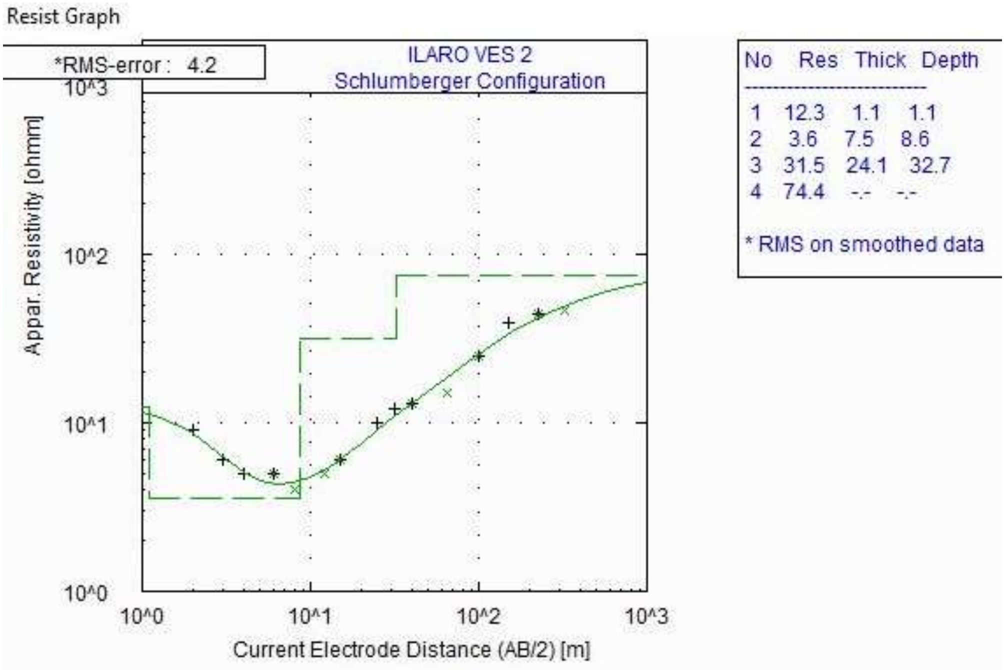

Fig. 4b: Depth sounding curve for VES 2

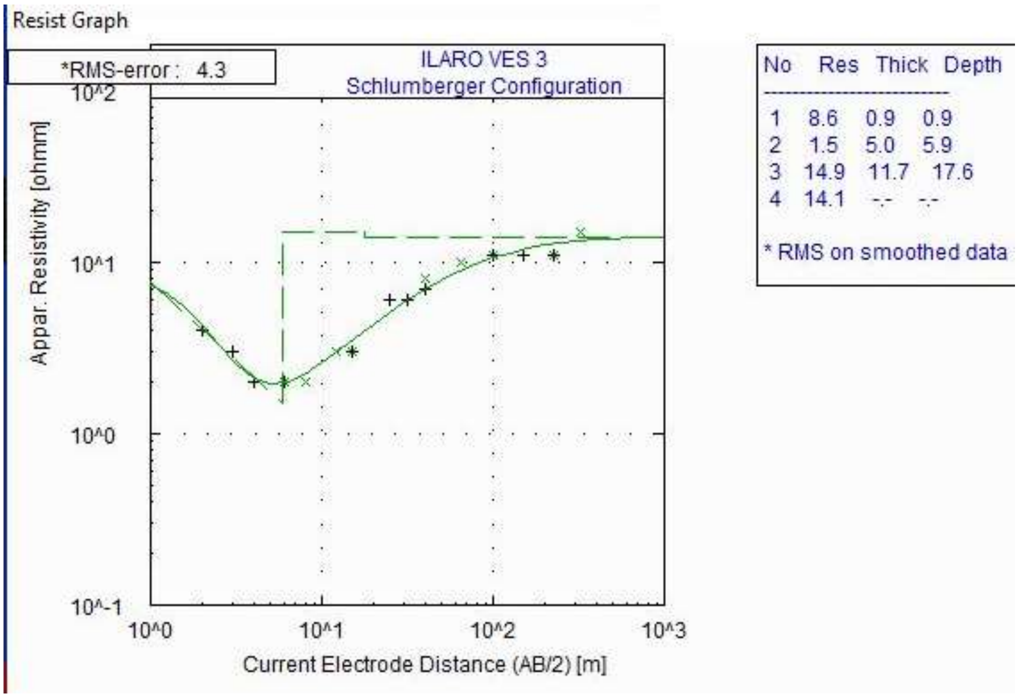

Fig. 4c: Depth sounding curve for VES 3

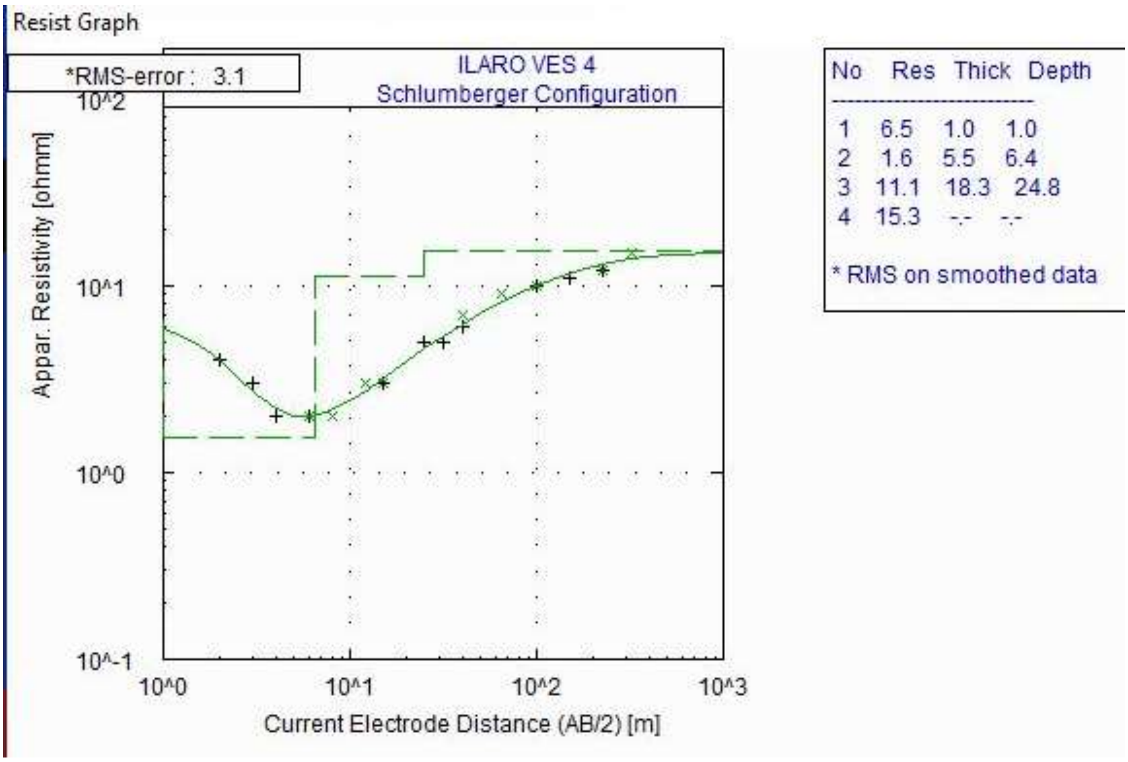

Fig. 4d: Depth sounding curve for VES 4

Table 2a: VES Interpreted Results (V_1)

S/N	Resistivity (Ωm)	Thickness (m)	Depth (m)	Lithologic Equivalence
1	688	1.3	1.3	Topsoil
2	752	5.3	6.6	Lateritic layer
3	356	3.3	9.9	Sand
4	36	45	54.9	Clay
5	92	-	-	Clayey sand

Table 2b: VES Interpreted Results (V_2)

S/N	Resistivity (Ωm)	Thickness (m)	Depth (m)	Lithologic Equivalence
1	12	1.1	1.1	Topsoil
2	4	7.5	8.6	Highly saturated clay
3	32	24.1	32.7	Unsaturated clay
4	74	-	-	Clayey sand

Table 2c: VES Interpreted Results (V_3)

S/N	Resistivity (Ωm)	Thickness (m)	Depth (m)	Lithologic Equivalence
1	9	0.9	0.9	Topsoil
2	2	5.0	5.9	Highly saturated clay
3	15	11.7	17.6	Slightly saturated clay
4	14	-	-	Plastic clay

Table 2d: VES Interpreted Results (V_4)

S/N	Resistivity (Ωm)	Thickness (m)	Depth (m)	Lithologic Equivalence
1	7	1.0	1.0	Topsoil
2	2	5.5	6.4	Highly saturated clay
3	11	18.3	24.8	Slightly saturated clay
4	15	-	-	Plastic clay

From Tables 3a, b, c and d, the geo-electric parameters obtained from depth sounding at the four VES locations V1, V2, V3 and V4 classified the area into four and five geo-electric layers. At V1, the area is underlain by Topsoil, Lateritic, Sandy, Unsaturated Clay and Clayey Sand whereas at V2, V3 and V4, the area is underlain by Topsoil, Highly Saturated Clay Layer, Unsaturated/Slightly Saturated Clay Layer and Clayey Sand/Plastic Clay Layer. In addition, at V2, V3 and V4, the Topsoil resistivity value ranges from (7 – 12 Ohm-m) with thickness range (0.9 – 1.1m), the Highly Saturated Clay Layer has resistivity value ranging from (2 – 4 Ohm-m) with thickness range (5.0 – 7.5m), the Unsaturated/Slightly Saturated Clay Layer has resistivity value ranging from (15 – 32 Ohm-m) with thickness range (11.7 – 24.1m) whereas the last layer delineated has Clayey Sand/Plastic Clay has resistivity range (15 – 74 Ohm-m) with infinite thickness. **The geoelectric parameters from the VES data at the four VES locations revealed that, the overburden materials are very thick. In addition, the underestimation of depth of penetration even at maximum half current electrode spreading of 325m at VES locations 3 and 4 was due to attenuation of electric current by the thick conductive overburden. Furthermore, judging by the recorded resistivity data, there is no indication of occurrence of limestone deposit at the observed VES locations and even if there will be possibility of occurrence, it will be at a much deeper depth of approximately more than 90m posing tremendous difficulty in excavation of such deeper depth occurring deposit.**

INVESTMENT EVALUATION OF THE STUDY SITE

The absence of very high resistivity values (i.e. > 5kΩm - 10 kΩm) typical of clean and compact limestone formation (i.e. required for limestone exploration or quarry development) at either shallow or deeper depth across all the VES locations suggests low economic viability of the site for limestone mining site development. The lack of these very high resistivity values implies that the limestone horizon may either be deeply buried beyond the maximum investigation depth or the limestone formation may have been embedded within the clay formation making it impure and therefore reducing its economic worth. Additionally, the dominance lower resistivity values recorded especially at VES locations 3 and 4 falling within the study area suggests plastic clay nature of the overburden which are less valuable in commercial terms and may even pose geotechnical challenges for core drilling processes.

CONCLUSION

The most economically viable site for any solid mineral (e.g. limestone) mining development is the site that has a shallower depth occurrence (i.e. 20 - 30m) of the target solid mineral thereby supporting open pit mining. Since the assessed site do not show resistivity value compatible with limestone formation even at deeper depths of penetration, the site do not show any indication of limestone occurrence. In addition, even if the limestone occurred at a much deeper depth than the depth of penetration, deeper mining methods which are usually not only more expensive to carry out but geotechnical difficult in a thicker conductive overburden materials typical of the assessed site will need to be done to mine such occurrence. Thus, the assessed site do not show any indication of being economically viable for limestone quarrying development.

RECOMMENDATION

It is therefore recommended that the site do not show any indication of occurrence of limestone deposit and even if such deposit would occur, it is at a much deeper depth unattained at the maximum half electrode spreading adopted in the VES investigation. Furthermore, it is therefore suggested that the site do not show any indication of being economically viable for limestone quarry development.