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Electromagnetic and Electrical Geophysical Investigation of Groundwater Potential at Dangote Cement Depot, Ilokun, Ado-Ekiti, Southwestern Nigeria

***[1]Adeoye, A.S., [1]Ajayi, C.A., & [2]Ikubuwaje, C.O.**
[1]Department of Geology, Ekiti State University, Ado Ekiti, Nigeria
[2]Department of Minerals and Petroleum Resources Engineering Technology, Federal Polytechnic, Ado-Ekiti, Nigeria

***Corresponding author email**: aderemi.adeoye@eksu.edu.ng

Abstract

Geoelectric investigation of groundwater occurrence around Dangote Cement Depot, Ilokun, Ado-Ekiti, South-western Nigeria was carried out. Vertical Electrical Sounding Array was chosen for the work. Four traverses with a total length of 105 m were established around the building to locate best position for groundwater development. The results were presented as field curves and geoelectric section. A total spread of 200 to 300 m was employed. Seven VES was carried out to produce four geoelectric sections around the study area. This was used to delineate six geoelectric layers which are; topsoil, weathered layer, fractured basement, partly fractured basement and fresh basement with resistivities: 223 to 2095, 29.7 to 254, 299 to 1141, 134 to 1206, 496 to 2400 and 504 to 34016 ohm-m respectively. Clay formations were delineated very near the surface down to a depth of over 35 m. The clay constitutes major path along the traverse lines as weathered zones. Some parts of the building show fractured zones that can accommodate the formation of groundwater. VES 1, VES 4 and VES 5were promising locations for the drilling of boreholes judging from the thickness of their weathered and fractured zones. VES 5 is the most appropriate for groundwater development.

Keywords: Groundwater, Geoelectric Section, Weathered Zone, Vertical Electrical Sounding, Cement Depot

Introduction

The availability and accessibility to a sustainable groundwater supply is an issue within the study area. Basic understanding of the hydrogeological properties and subsurface structures is limited, hindering effective groundwater resource management and development within the study area; this is as result of unyielding approach set in motion to investigate the aquiferous zones within the study area. Due to common occurrences of failed or abortive boreholes within the area, there is need for proper geophysical investigation which can serve as template for future groundwater development in the community (Adepelumi et al., 2018). The dipole-dipole geoelectric resistivity technique has proven to be effective in revealing subsurface geological structure which could serve as aquifers for groundwater accumulations (Ajayi et al., 2022). The geoelectric investigation of groundwater occurrence at Ilokun in Ado-Ekiti, southwestern Nigeria, is a significant research study conducted to assess the groundwater resources in the area. This type of investigation gives important knowledge of the subsurface characteristics and that of groundwater availability, which is crucial for sustainable water resource management and development plans in the region. To conduct the research, geoelectric survey methods were employed in order to obtain subsurface information. Geoelectric techniques involve the measurement and interpretation of electrical properties of the subsurface materials. These properties can provide information about lithology, groundwater presence, and hydrogeological characteristics of the area under consideration.

Aim and Objectives

This work aims at utilizing electrical resistivity imaging and electromagnetic approaches for groundwater investigations around Dangote Cement Depot in Ilokun Ado-Ekiti, Southwestern Nigeria to determine appropriate location for groundwater development.

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The objectives are to:

i. conduct hydrogeological review of the study area.
ii. adopt electrical resistivity and electromagnetic geophysical methods to delineate the subsurface condition of the study area.
iii. use vertical electrical sounding and dipole-dipole techniques for the electrical resistivity imaging; and gradient array for the impact method of electromagnetic approach to evaluate conductive zones within the study area.
iv. analyze the geoelectric and electromagnetic data collected in (i-iii) to visualize the subsurface structures and differentiate the overburden materials characterizing the subsurface materials.
v. use (iv) to reveal the subsurface formations such as topsoil, weathered zone, fractured basement and fresh basement for the analysis of plausible groundwater productive locations within the study area.

Description of the location

The investigated area is within Ilokun community of Ado-Ekiti, along Iworoko road. The area is geographically located between latitude 7^0 3' and 7^0 49' north of the equator and longitude $5^0$7' and 5^0 27' east of the Greenwich Meridian (Figure 1). Ilokun is nestled in a lush landscape, surrounded by scenic hills and valleys. The area features a tropical climate. The mean annual rainfall is approximately 1,200/mm, with the wettest months usually between April and July. The temperature ranges from 20°C to 35°C throughout the year. Ilokun is predominantly an agrarian community, with farming being the primary economic activity. The area is blessed with fertile soil, suitable for cultivating various crops such as yam, cassava, maize, cocoa, and palm produce. Agriculture plays a vital role in the local economy, providing employment and sustenance to the majority of the population. In terms of infrastructure, Ilokun has basic amenities like schools, healthcare centers and markets to cater to the needs of the residents.

Groundwater Occurrence in the Area

Groundwater occurrence at Ilokun, Ado-Ekiti has been studied by various researchers to understand the hydrogeological characteristics of the area. One of the prominent studies on groundwater occurrence in this region is the research conducted by (Okwueze et al., 2015). The study area populace has been facing difficulties about groundwater production. The terrain is a basement complex zone with water productivity majorly depends on weathered basement rock and the geologic structure. The people around the area rarely have good supply of water during the dry season.

Geology of the Study Area

Ilokun, Ado-Ekiti is within the southwestern Nigeria, specifically in Ekiti State. The region falls within the geological framework known as the Basement Complex, which forms the foundation of the Nigerian landscape. The Basement Complex is composed of several crystalline rocks, including gneisses, schists, granite, and migmatites (Olasunkanmi et al., 2018). The area around Ilokun is characterized by ancient rock formations that date back to the Precambrian era, approximately 2.5 to 4 billion years ago. These rocks have undergone extensive metamorphism and deformation over geological time, resulting in their current complex and folded nature (Olasunkanmi et al., 2018). It is located within the migmatite rock of Ado-Ekiti basement rock terrain.

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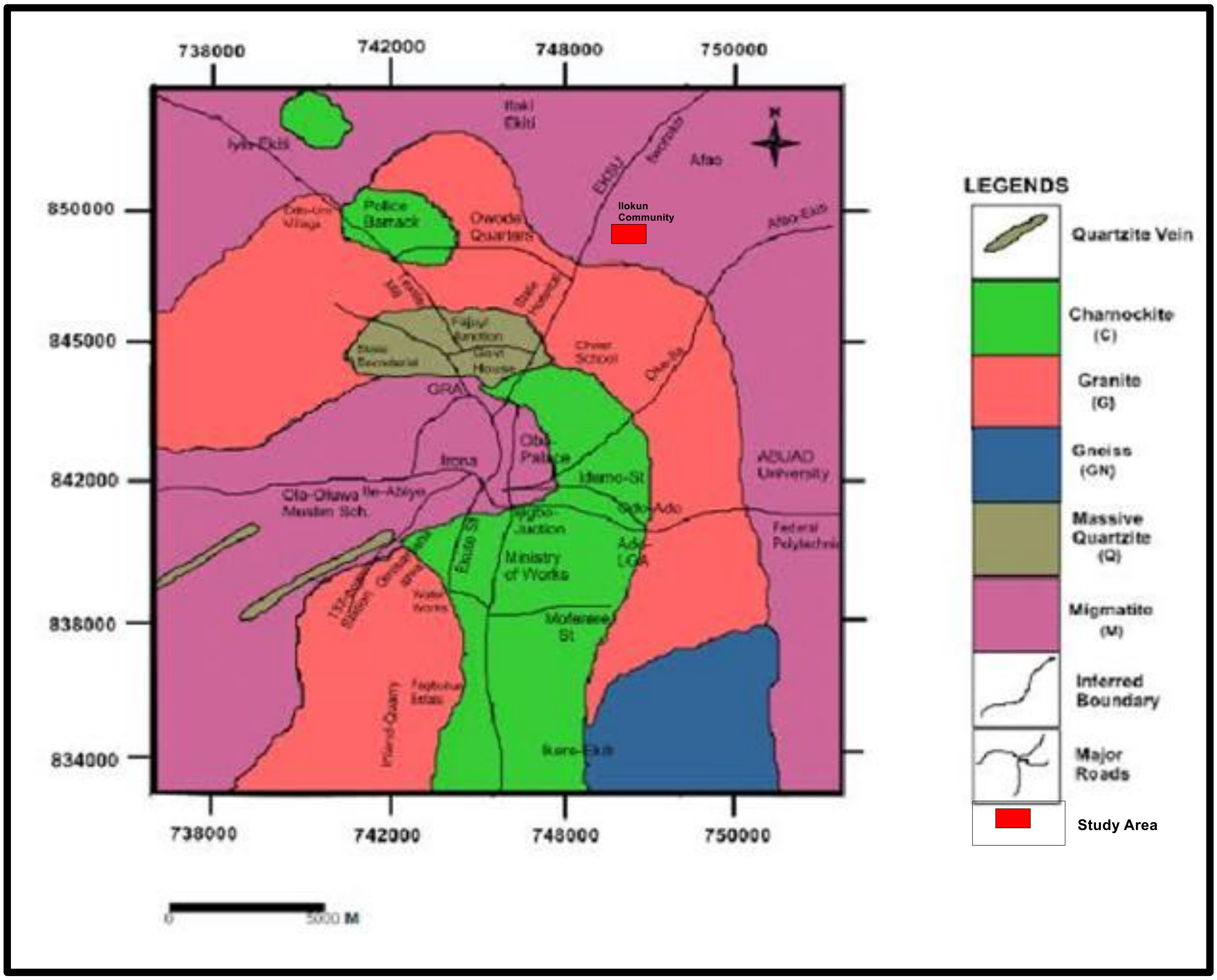

Figure 1: Geological Map of the Study Area (Modified after Ajayi *et al.*, 2022).

Materials and Methods

Electrical resistivity and electromagnetic methods were utilized to probe the subsurface within the study area. Four traverses were established within the study area with a total length of 105 m each (Figure 2). 7 VES were conducted around the study area with total spread ranging from 200 to 300 m using Omega Campus Resistivity Meter SAS 1000. The interpretations of the data collected were done by both partial curve matching and iterated computer package called WinResist used only for VES data. This equipment adequately delineates conductive zones like weathered layer and fractured/faulted zones which can serve as a good aquifer for groundwater accumulation. The results of the VES was used to delineate four to five geoelectric layers which are; topsoil, weathered layer, partly weathered/Partly fractured zone, fractured zone and fresh basement. This is an Impact Electromagnetic Method of geophysics where two rods were being utilized. The equipment operates with frequency domain by selecting natural electric field at varying frequencies. The responses are now picked by the instrument and stacked together by the the instrument computerised/programmed processor to generate a 2D-Image of existing electromagnetic resistance as a function of the materials that characterises the subsurface. The instrument named PQWT Water Detector Power Point is a geophysical instrument developed by integrating four methods consisting of more data filters for analyzing data and filtering errors. The basic principle of the instrument is to measure an existing natural electromagnetic resistance of the resultant fields generated by the earth. The theory of natural occurring current flowing within earth surface exhibits electrical field potential, this field component were the primary source for PQWT geological equipment where the varied frequencies of electromagnetic field transmitted over the geologic body are recorded as data after being received by the equipment through the second rod. The sensitivities of the equipment to measure the potential field along the line demonstrates a distortion along the subsurface structure within the host rock.

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Four traverse lines were established for the data measurement at E-W and N-S direction, about 21 points were marked by the equipment which were later changed to electrode spacing of the MN =10m, station =2m, the midpoint between MN is the probable location within the surface. Tap 10 meter distance to mark the start place of 0m, The MN two copper electrode connecting cable and transducer bar where equidistance of 10m , both MN increase with 2m distance after each completed reading.

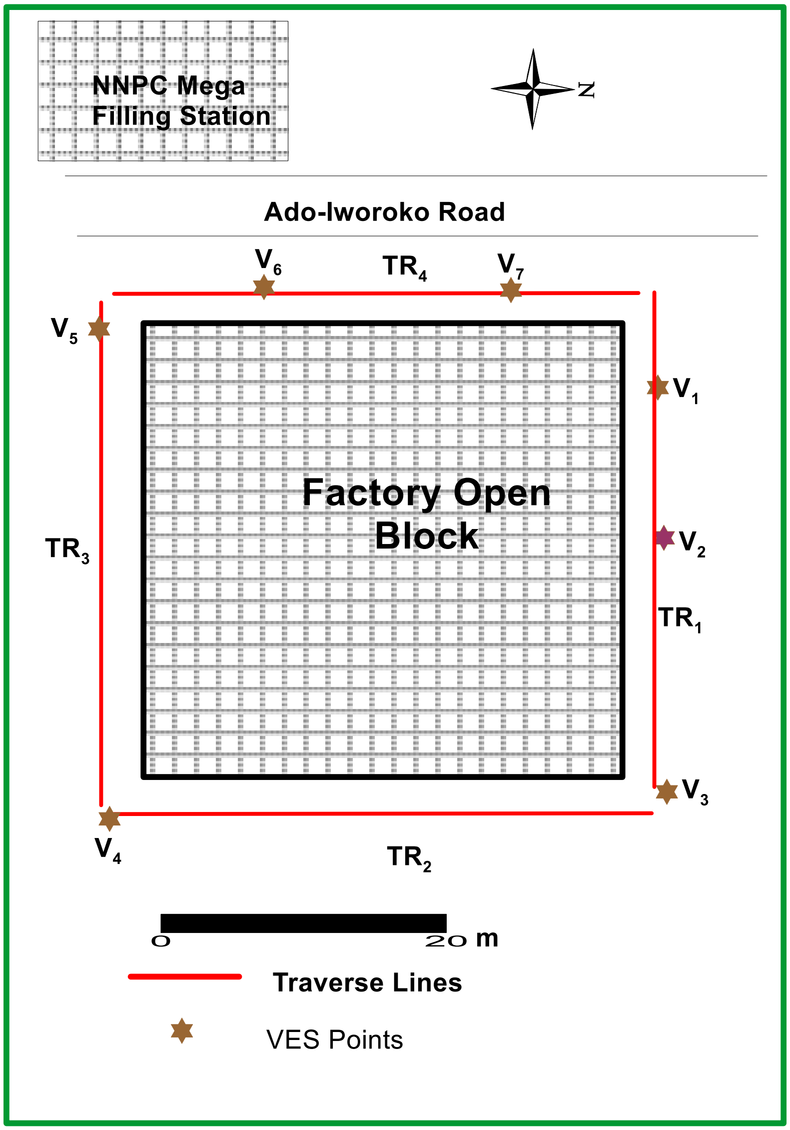

Figure 2: Data Acquisition Map at Ilokun, Ado-Ekiti

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Basic Principle

Tap 10 meter distance to mark the start place of 0m, The MN two copper electrode connecting cable and transducer bar where equidistance of 10m , both MN increase with 1m distance after each completed reading (Figure 3).

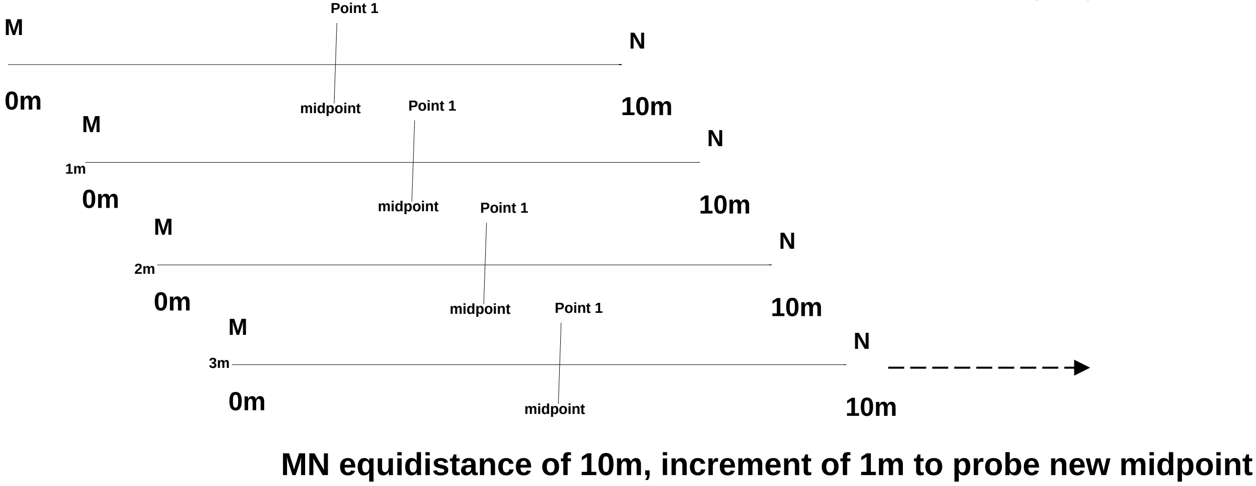

Figure 3: Data Acquisition Procedure

Results

Electrical Method

The geophysical method employed for this study is the Electrical Resistivity method using Schlumberger and dipole-dipole arrangement for the data acquisition. The results were presented as figures, tables and geoelectric sections. The Vertical Electrical Sounding interpretation results are presented in Table 1. Figure 3(a-g) represents the result of the VES investigations for VES 1, VES 2, VES 3, VES 4, VES 5, VES 6 and VES 7. The following curve types were represented in the study; HAA, HKHKH, HA, HKQH, and HKH, having 16%, 28%, 28%, 14% and 14% respectively. Figure 4 a-d shows the geoelectric section of the study area of Traverse 1, Traverse 2, Traverse 3 and Traverse 4. Different formations were delineated according to the result of the analyzed data obtained from the VES stations. These formations are topsoil, weathered layer, partly weathered, fractured, partly fractured, and fresh basement; with resistivity values ranges from 223.0-2095.3Ωm, 29.7-254.8Ωm, 299.4-1141.1Ωm, 134.0-1206.7Ωm, 496.2-2400.6Ωm, 504.0-34016.4 Ωm and thickness ranges 0.6-2.4m, 1.2-11.7m, 21.7-44.7m, 5.9-40.9, 2.1-20.1 respectively. (Table 1).

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Table 1: Summary of Interpreted VES Curves

	Resistivity (Ωm)	**Thickness (m)**	**Depth**	**Curve Type**	**No. of Layers**	**Remark**
1	581.6	1.4	1.4			Lateritic Topsoil
	29.7	11.7	13.1			Clayey Layer
	243.7	22.2	35.2			Weathered Layer
	299.4	44.7	80.0	HAA	5	Partly Weathered Basement
	504.0	------	------			Fresh Basement
2	807.3	0.6	0.6			Lateritic Topsoil
	254.8	1.2	1.8			Weathered Layer
	1386.4	2.4	4.2			Fresh Basement
	134.0	5.9	10.1			Fractured Basement
	1726.9	18.2	28.3	HKHKH	7	Fresh Basement
	165.8	40.9	69.2			Fractured Basement
	496.2	------	-----			Partly Fractured Basement
3	437.5	1.7	1.7			Lateritic Topsoil
	30.5	1.8	3.5			Clayey/Weathered Layer
	5184.4	5.5	9.0	HA	5	Fresh Basement
	2400.6	2.1	11.2			Partly Fractured Basement
	34016.4	-----	-----			Fresh Basement
4	1255.5	2.4	2.4			Lateritic Topsoil
	267.8	10.4	12.7			Weathered Layer
	1141.1	21.7	34.5	HA	4	Partly Weathered Basement
	11373.2	------	------			Fresh Basement
5	2095.3	1.5	1.5			Lateritic Topsoil
	107.7	3.8	5.2			Clayey/Weathered Layer
	1291.9	13.1	18.4			Fresh Basement
	1206.7	15.5	33.8		6	Partly Fractured Basement
	515.4	14.9	48.7	HKQH		Fractured Basement
	1049.6	-----	-----			Fresh Basement
6	223.0	1.7	1.7			Topsoil
	24.8	1.4	3.0			Clayey Layer
	702.6	6.5	9.5	HKH	5	Fresh Basement
	189.3	13.7	23.2			Fractured Basement
	5594.9	-----	-----			Fresh Basement
7	957.2	1.4	1.4			Lateritic Topsoil
	234.7	2.0	3.3			Weathered Layer
	1568.5	2.9	6.3			Fresh Basement
	257.8	17.8	24.0			Fractured Basement
	1081.9	14.1	38.1	HKHKH		Partly Fractured Basement
	1081.1	20.5	58.6			Partly Fractured Basement
	1768.3	------	-----		7	Fresh Basement

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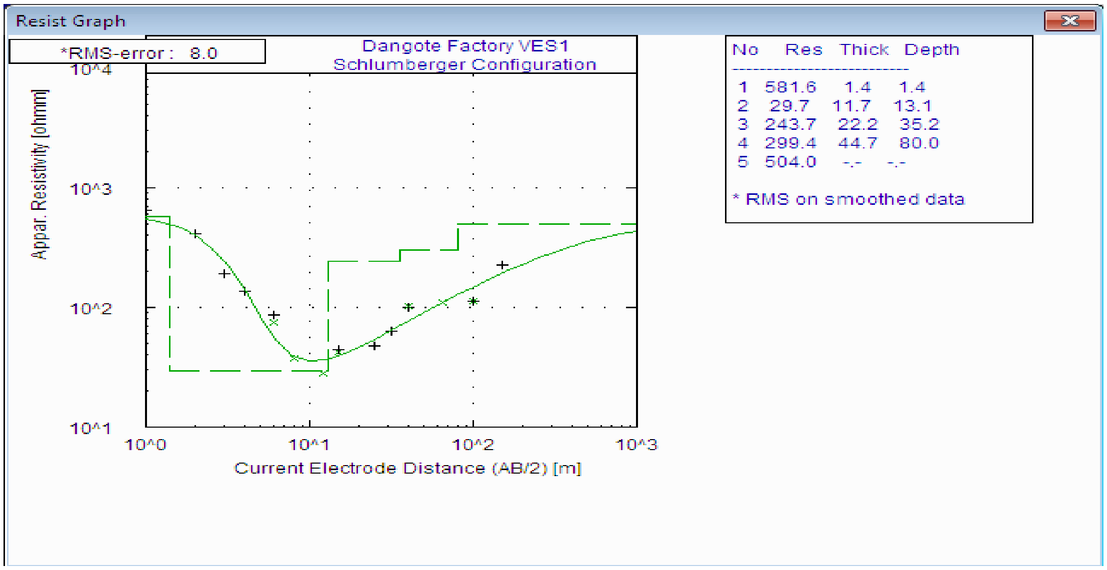
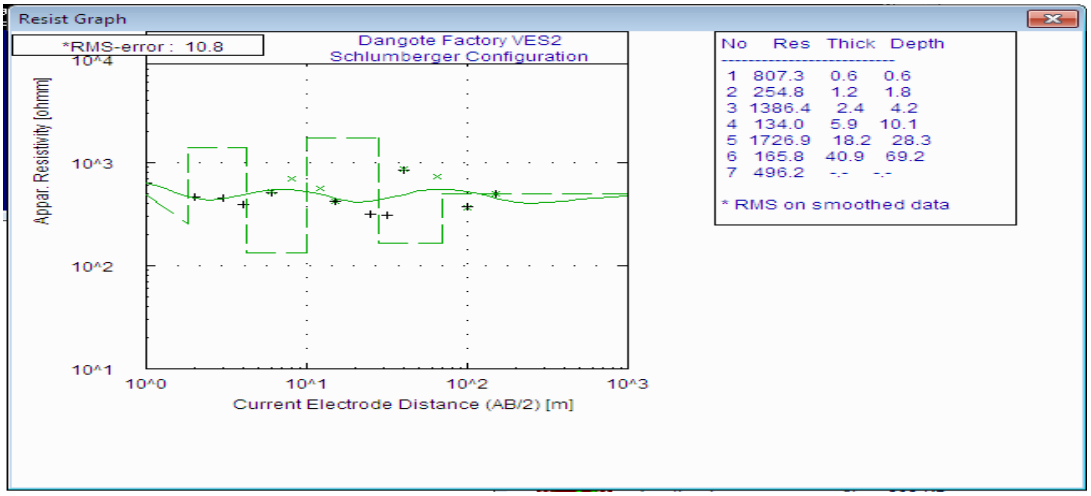


```
*RMS-error :  8.0

No    Res   Thick  Depth
----------------------------
 1  581.6    1.4    1.4
 2   29.7   11.7   13.1
 3  243.7   22.2   35.2
 4  299.4   44.7   80.0
 5  504.0    -.-    -.-

* RMS on smoothed data
```

Figure 3a: Sounding curve for VES 1



```
*RMS-error :  10.8

No    Res   Thick  Depth
----------------------------
 1  807.3    0.6    0.6
 2  254.8    1.2    1.8
 3 1386.4    2.4    4.2
 4  134.0    5.9   10.1
 5 1726.9   18.2   28.3
 6  165.8   40.9   69.2
 7  496.2    -.-    -.-

* RMS on smoothed data
```

Figure 3b: Sounding curve for VES 2

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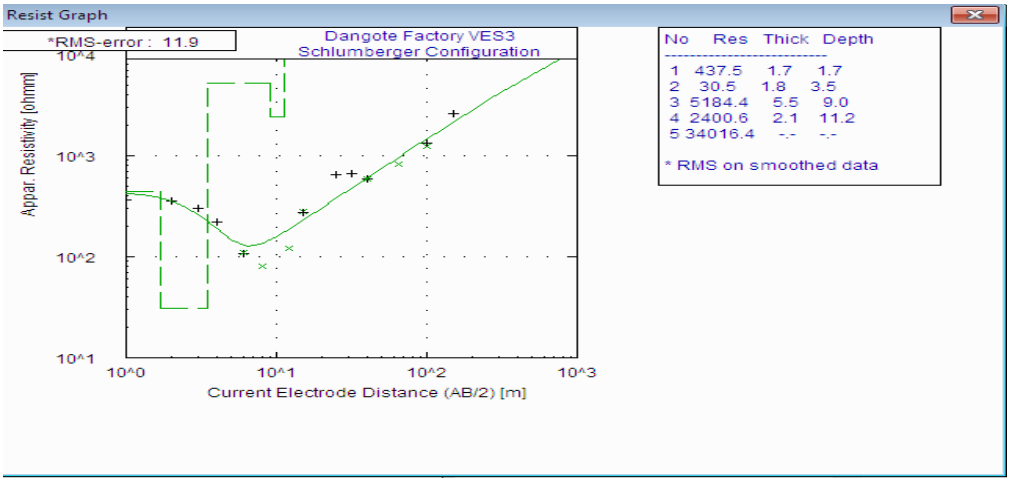

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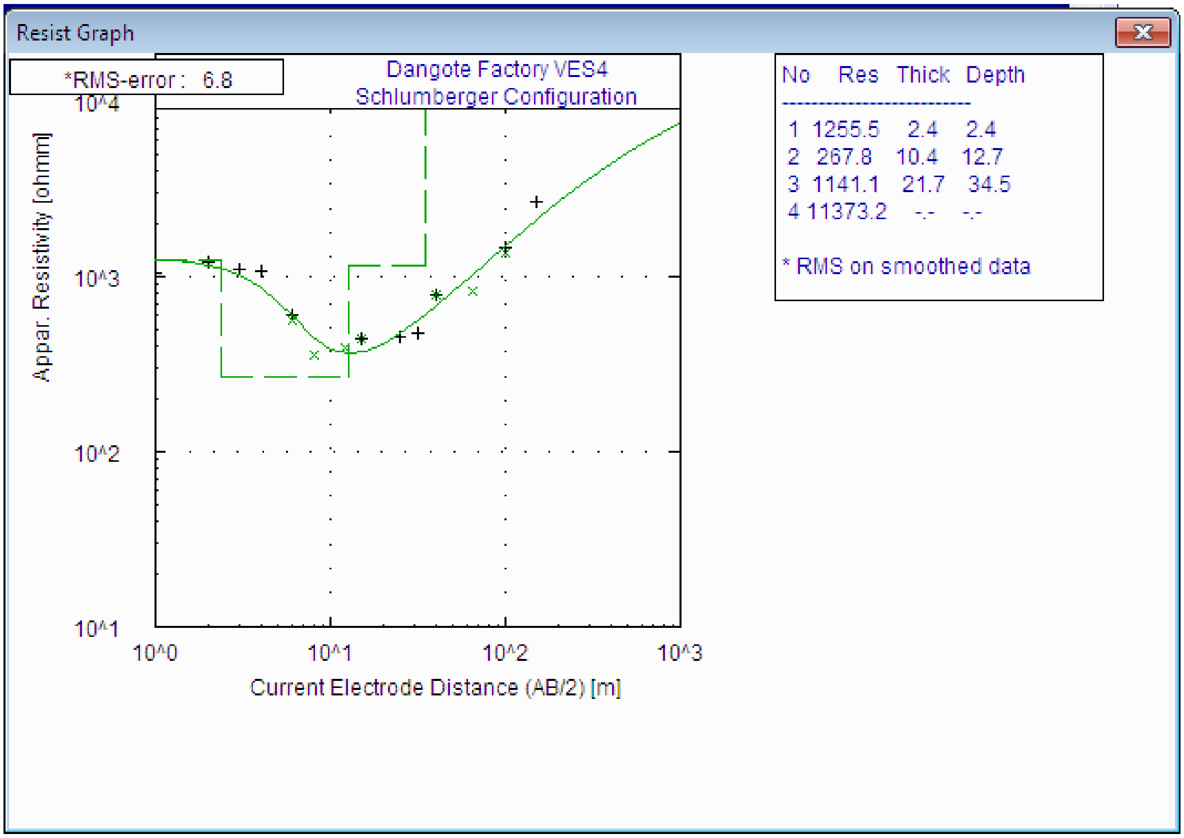
*RMS-error :  11.9

No    Res   Thick  Depth
---------------------------
 1   437.5    1.7    1.7
 2    30.5    1.8    3.5
 3  5184.4    5.5    9.0
 4  2400.6    2.1   11.2
 5 34016.4    -.-    -.-

* RMS on smoothed data
```

Figure 3c: Sounding curve for VES 3



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*RMS-error :  6.8

No    Res   Thick  Depth
---------------------------
 1  1255.5    2.4    2.4
 2   267.8   10.4   12.7
 3  1141.1   21.7   34.5
 4 11373.2    -.-    -.-

* RMS on smoothed data
```

Figure 4.1d: Sounding curve for VES 4

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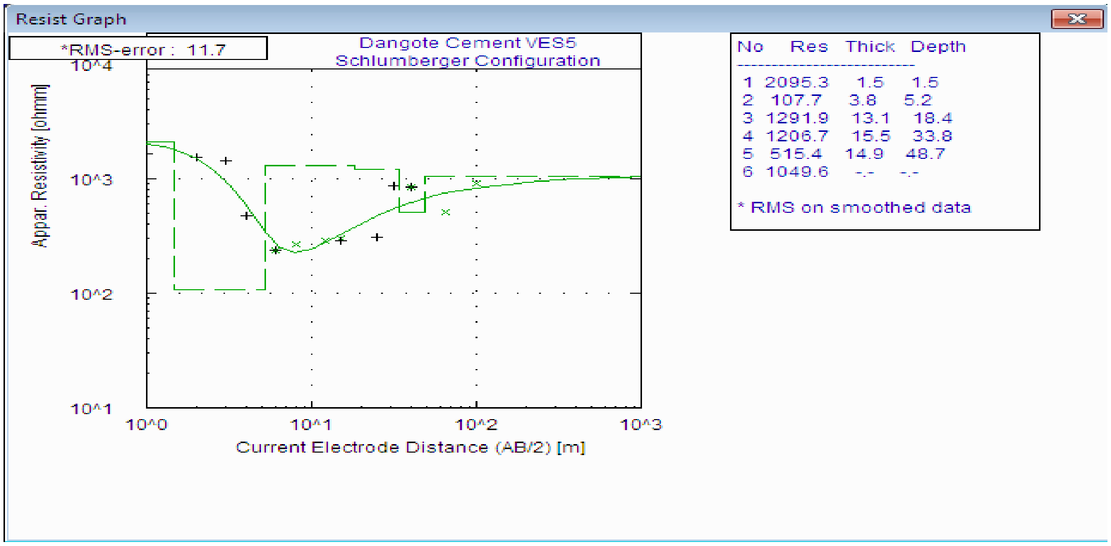


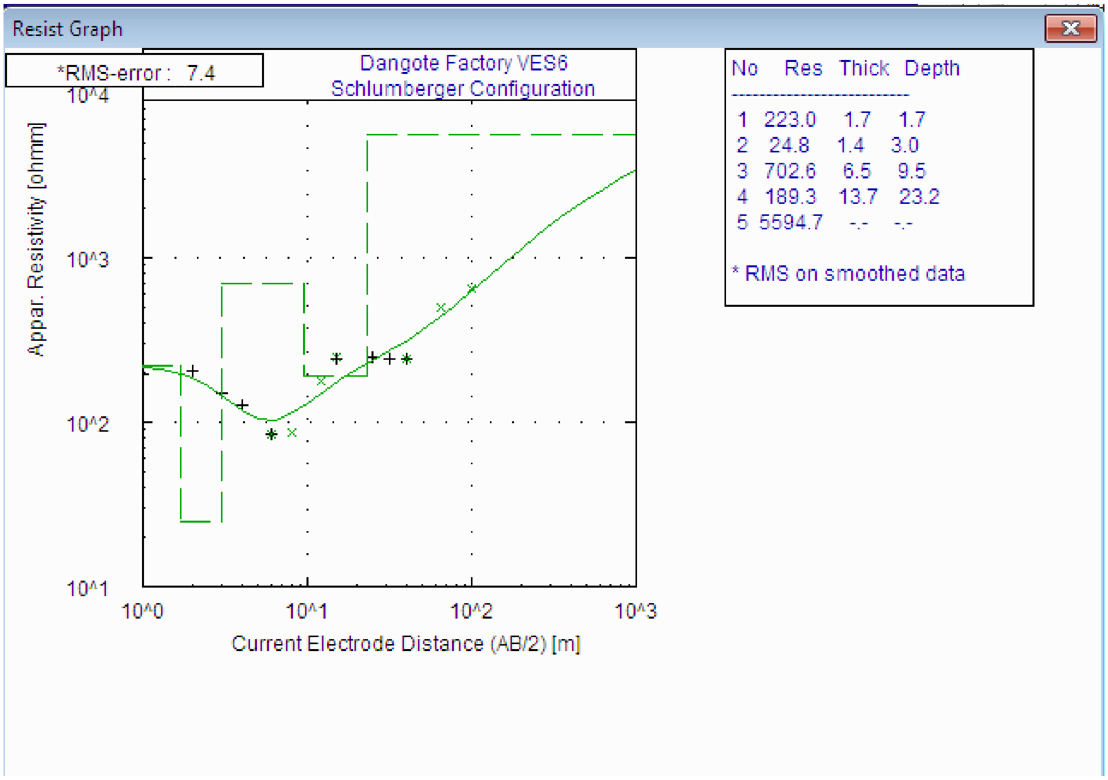
*RMS-error : 11.7

Dangote Cement VES5
Schlumberger Configuration

```
No    Res    Thick   Depth
--------------------------
1  2095.3    1.5     1.5
2   107.7    3.8     5.2
3  1291.9   13.1    18.4
4  1206.7   15.5    33.8
5   515.4   14.9    48.7
6  1049.6    -.-     -.-

* RMS on smoothed data
```

Figure 4.1e: Sounding curve for VES 5



*RMS-error : 7.4

Dangote Factory VES6
Schlumberger Configuration

```
No   Res   Thick  Depth
-----------------------
1  223.0   1.7    1.7
2   24.8   1.4    3.0
3  702.6   6.5    9.5
4  189.3  13.7   23.2
5 5594.7   -.-    -.-

* RMS on smoothed data
```

Figure 3f: Sounding curve for VES 6

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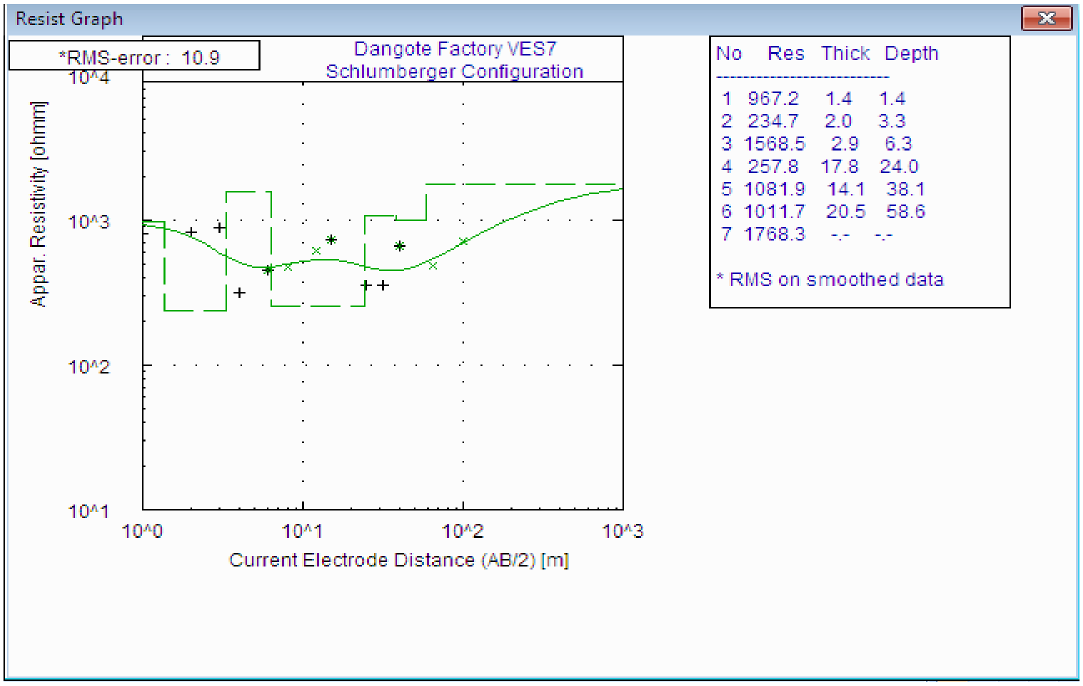

```
*RMS-error :  10.9
```

```
No    Res   Thick  Depth
---------------------------
 1   967.2    1.4    1.4
 2   234.7    2.0    3.3
 3  1568.5    2.9    6.3
 4   257.8   17.8   24.0
 5  1081.9   14.1   38.1
 6  1011.7   20.5   58.6
 7  1768.3    -.-    -.-

* RMS on smoothed data
```

Figure 3g: Sounding curve for VES 7

Figures 4 (a-d) shows the geoelectric section of the study area with the following formations; topsoil, clayey/weathered, partly weathered,, fractured basement and fresh basement; with resistivity values range of 223-2095, 28-244, 299-1141, 106-515, 504-11,373 Ohmmeter (Ωm), and thickness range of 1.4-1.7, 1.2-22.2, 14.1-44, 13.7-40.9 and 2.4 to infinity in meter (m) respectively. Along Traverse 1, VES 1 is more promising to groundwater development judging from the thickness of weathered formation to a depth of 80m. Also along Traverse 2 (Figure 4a), VES 4 is the best location for good borehole because of the thickness of the weathered formation to a depth of around 35m from the surface (Figure 4b). On Traverse 3, VES 5 is better for drilling because it possess good aquifer with thick weathered formation (35m) coupled with thick fractured zone (15m) (Figure 4c). Traverse 4 also confirms VES 5 to be the best location for siting a borehole for water production (Figure 4d).

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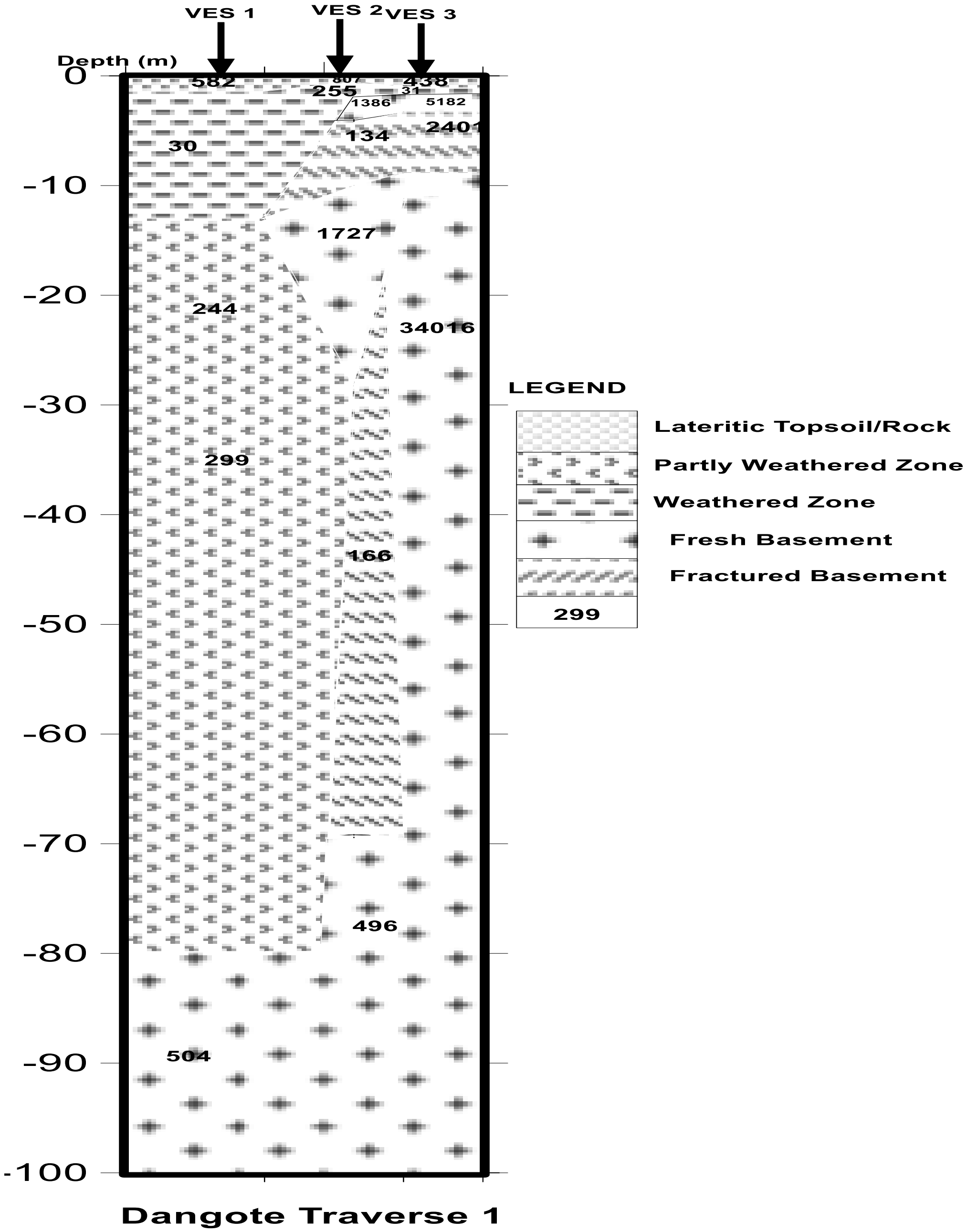

Figure 4a: Geoelectric section of Traverse 1

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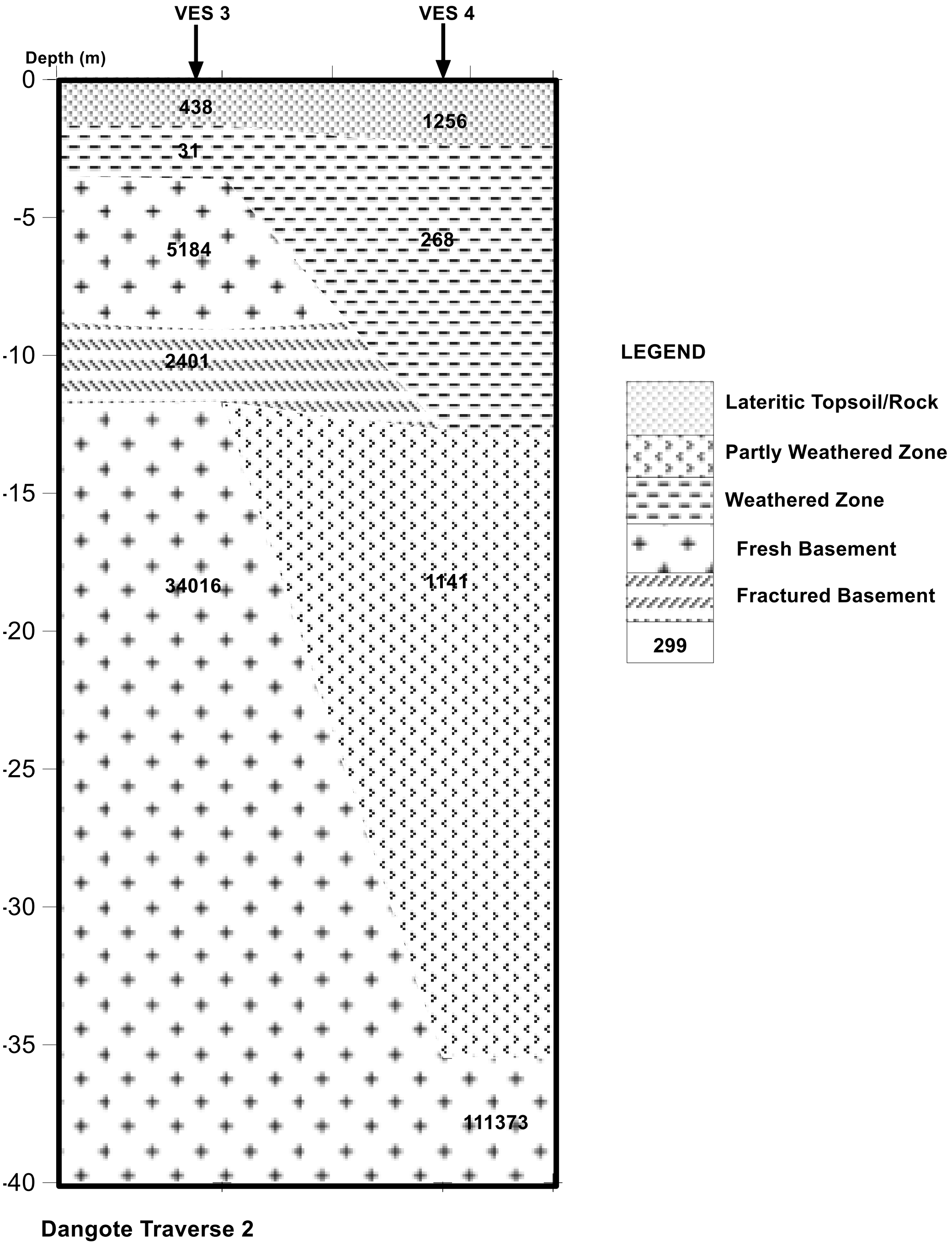

Figure 4b: Geoelectric section of Traverse 2

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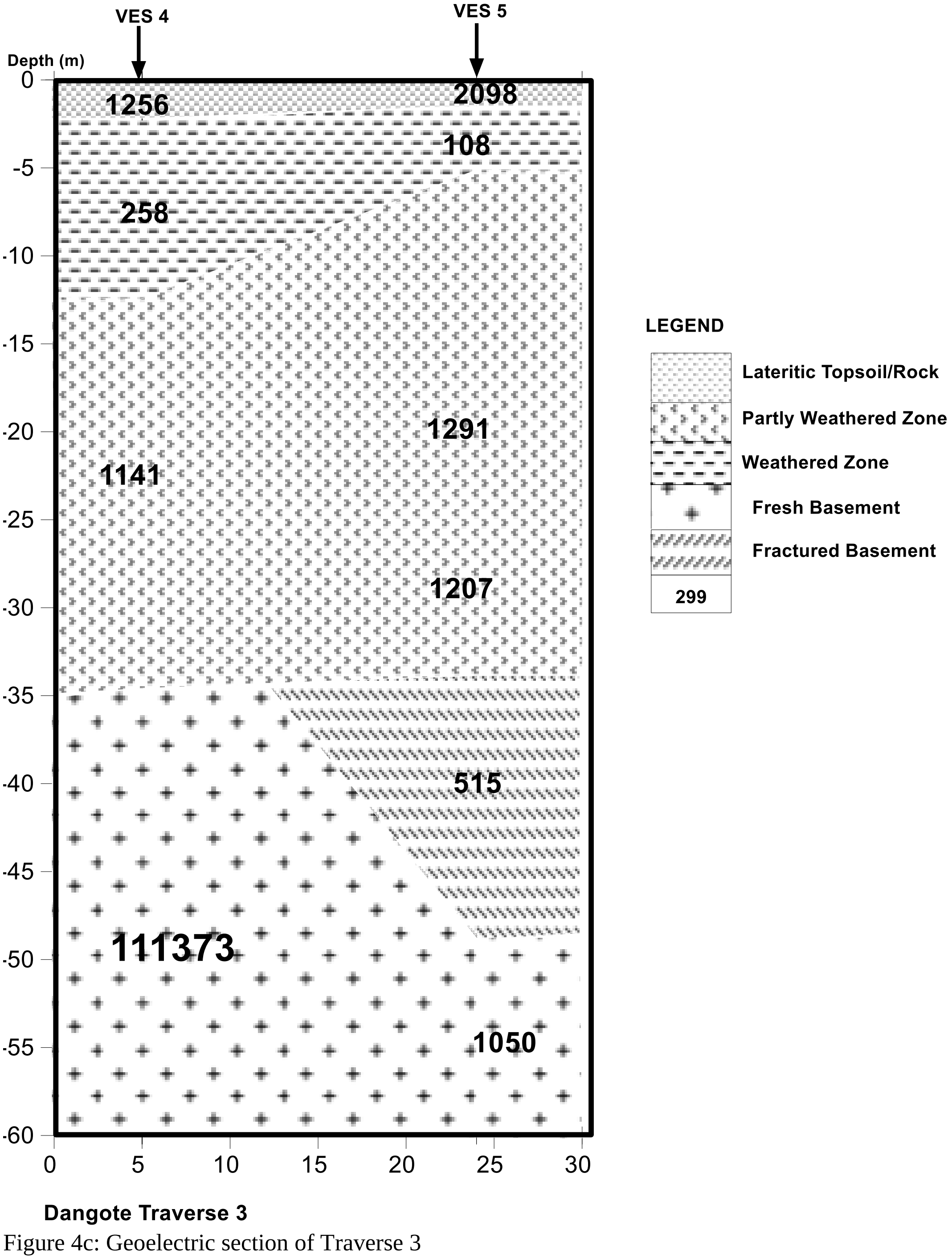

Figure 4c: Geoelectric section of Traverse 3

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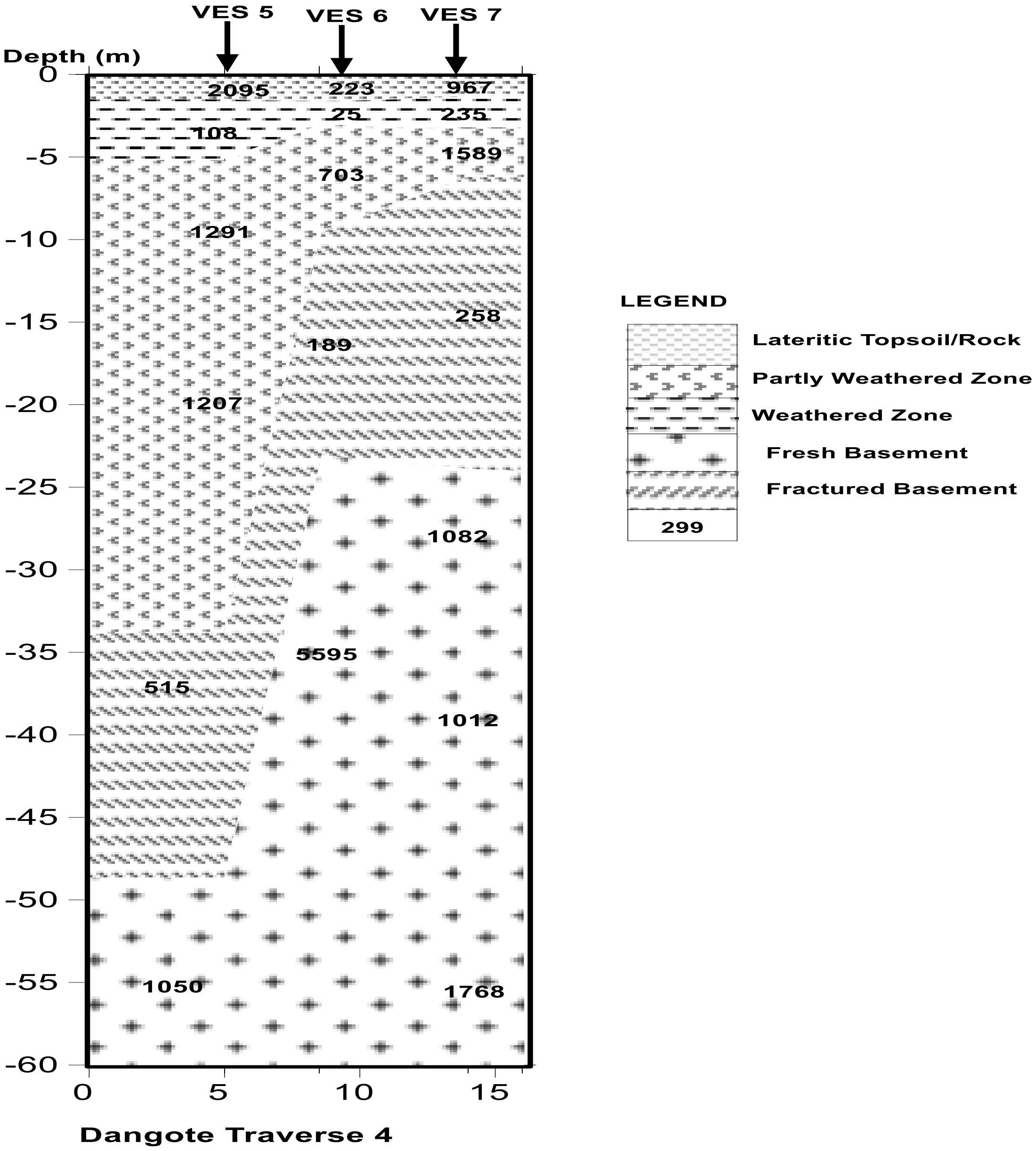

Figure 4d: Geoelectric section of Traverse 4

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Electromagnetic method

A brand-new geophysical exploration tool known as PQWT was used to measure the natural electric field in the research region. The groundwater detector model utilized in this study is the PQWT-TC150, a new model produced by China's Hunan Puqi Geologic Exploration Equipment Institute. Since the natural electric field serves as its source, this device is sometimes referred to as a natural electric field frequency selection system (Hunan, 2017). By identifying variations in the conductivity characteristics of subterranean geological formations, the PQWT-TC150 functions. It monitors the electrical fluctuations at various frequencies and depths of the Earth's magnetic field. Nuclear magnetic resonance (NMR), magnetotelluric, and induced polarization are integrated geophysical techniques that are used to locate subsurface features. These techniques form the basis of PQWT technology. This geodynamo mechanism is the main natural source of the magnetic field, upon which other sources rely. In this mechanism, fluid movement in the core interacts with an existing magnetic field to create an electric current, which in turn generates a secondary magnetic field (Heilig et al., 2018). PQWT technology utilizes the phenomenon of nuclear magnetic resonance, where nuclei respond to weak oscillating magnetic fields by producing an electromagnetic signal with a frequency characteristic of the magnetic field at the nucleus. Depending on a number of variables, including the strength of the static magnetic field and the characteristics of the isotope in question, this resonance happens when the oscillation frequency equals the intrinsic frequency of the nuclei (Legchenko et al., 2002). Magnetic or electric fields have historically had an impact on Earth radiation that originates from rock minerals, bodies, underground water, and other geological features. When these radioactive emissions travel across charged plates or a magnetic field, gamma rays are produced. Gamma rays are electromagnetic waves without charge and remain unaffected as they pass through the field. The natural electromagnetic field is created by this process, and its electric field component can be measured to find the subsurface material's resistivity characteristics. PQWT-TC150 takes into account fluctuations in the subsurface electromagnetic field's frequencies, which range from 0 to 30 KHz, to study the underground field and address challenging geological issues (Harinah, 2020).

The automated built-in software creates a curve graph and profile map following data collection and synchronizations. It then uses these tools to identify the weak anomalous zone, which is prominently displayed on the LED screen, reverse the curves to locate the (V) measuring point, display regular numbers of falling curves, lower potential difference data, and mark the position number. First Layer 1 is the V shape falling curve on the profile maps with a very low potential differential data value of highly weathered Sandy-Clay materials which indicate possible proximity water. Second Layer is the light bluish zone stand for the first low resistivity data which indicates the presence of Highly Weathered/Fractured rock zone with high proximity for water. The Deep bluish zone is the fractured zone indicating a high accumulation of water. While the third Layer the Yellowish colour stands for the moderately low resistivity data; which indicates the presence of partly-weathered rock formation and suggested low water accumulation. Fourth Layer with the reddish zone is the fresh basement zone.

Traverse one exhibits highly thick fracture zone along the east west direction at distances 15–25 m, 35–60 m and 70–85 m; with depth range of 45 to 150 m and above (Figure 5a). This also corresponds to the flat long profile lows in the profile map below the 2D-section. Therefore, portions identified along this traverse shows good promise for groundwater production. The orientation of traverse 2 along S/W direction revealed that the formation majorly contain fresh basement with slight occurrence of fractures and weathered basement zones. The fractures as geologic structures occur at distances 10, 35, 45-50 m at depth range of 35–150m with small thicknesses. Travers 3 is similar to 2 but it show the occurrence of fracture distance 15 m only; while Traverse 4 shows that the weathered layer occurs within the depth range of 0 to 45 m (Figure 5d). These zones with high thicknesses have highly weathered/fractured zones can be developed to generate large production of water.

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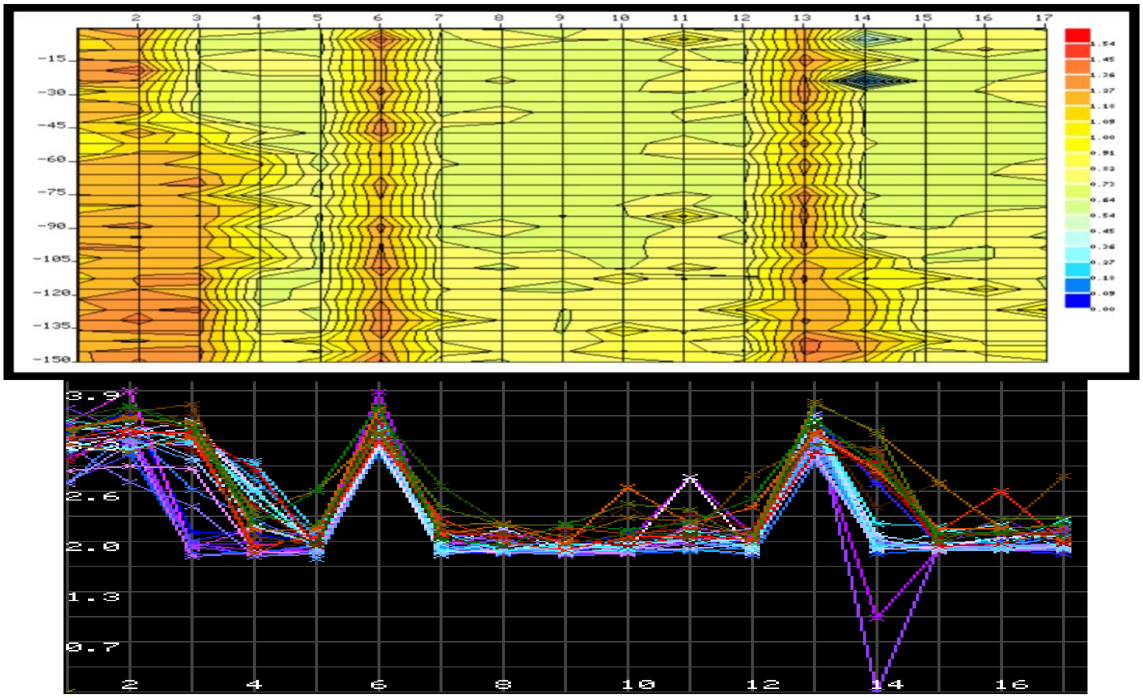

Figure 5a: Figure 5: 2D-EM Frequency Effect Percentage Survey along Traverse 1

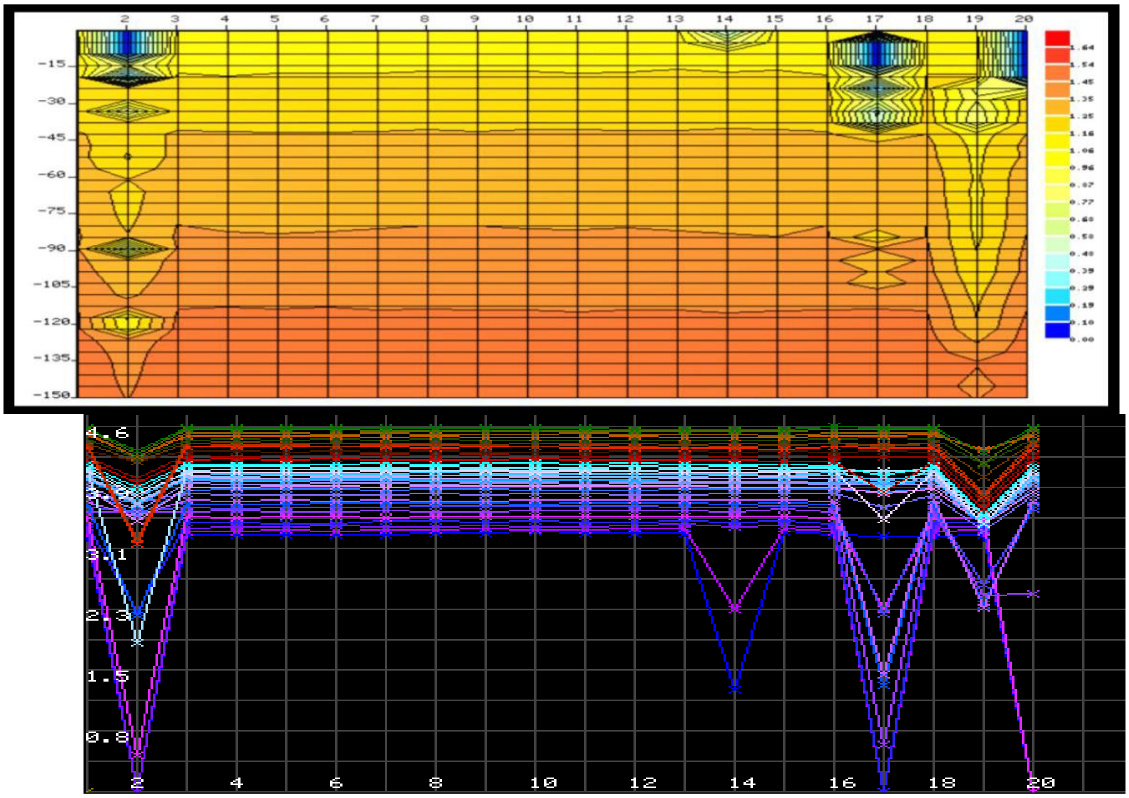

Figure 5b: Figure 5: 2D-EM Frequency Effect Percentage Survey along Traverse 2

Cite this article as:
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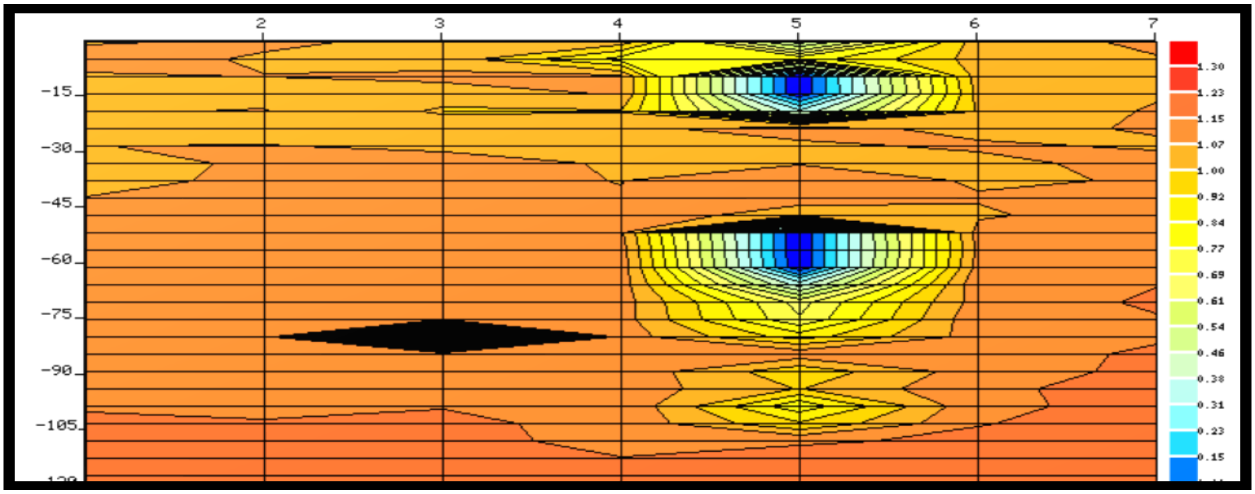


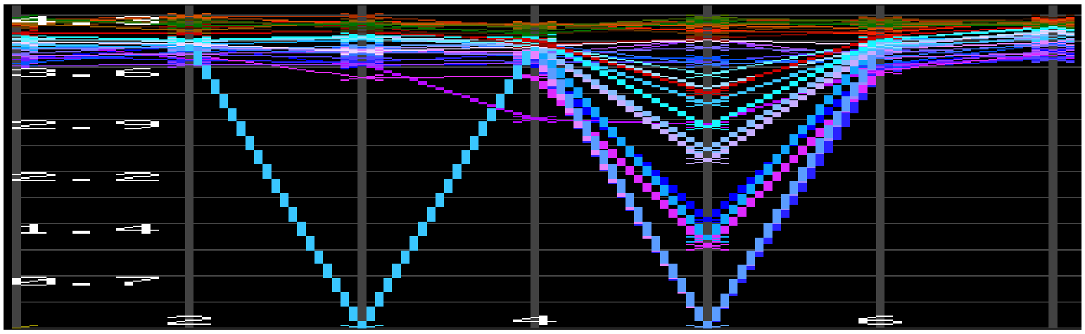
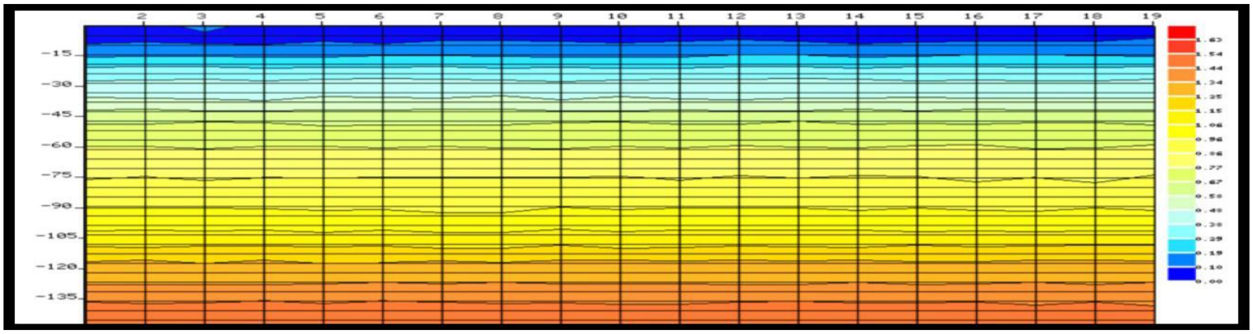


Figure 5c: Figure 5: 2D-EM Frequency Effect Percentage Survey along Traverse 3



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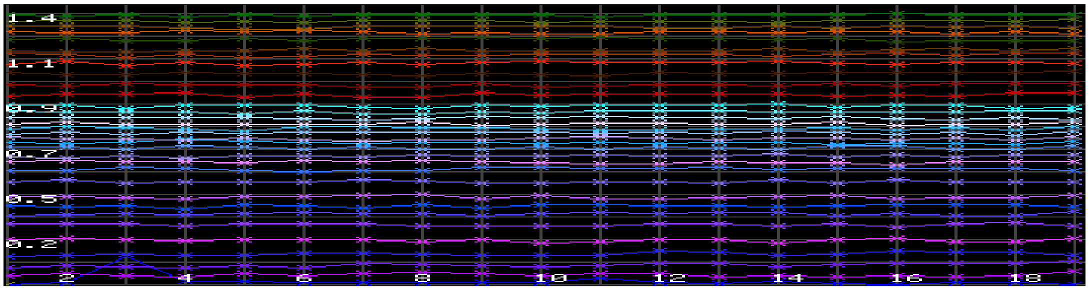


Figure 5d: Figure 5: 2D-EM Frequency Effect Percentage Survey along Traverse 4

Conclusion

Electrical resistivity method of geophysics using vertical electrical sound of schlumberger and configuration has been used to determine locations that are good for groundwater development. Gradient Array technique was adopted for the electromagnetic approach for probing the conductive zones of the subsurface. A total of seven (7) VES has been carried out to delineate different formations which are topsoil, weathered, partly weathered, fractured and fresh basement. The weathered and fractured formations are the aquiferous zones of target for groundwater development. VES 1 and VES 4 are the two best locations along the four traverses for groundwater production judging from the thick weathered and fractured zones. The thickness values of 80 and 35m of weathered formations on Traverse 1 and 4 respectively with thick fractured formation of 13.7m delineated on VES 5. VES 1 is recommended for drilling as the best location for the borehole while VES 4 and VES 5 can also be drilled if more water needed around the Ilokun community. The result of the EM exploration reveal that Traverses 1 and 4 which contains fracture and weathered layers shows possible good water production.

Recommendation

VES 1 is recommended for drilling as a result of thick overburden and fractured zones. However, two or three boreholes can be considered (VES 4 and 5 as addition) if the demand for water by the industry is enormous.

Induced Polarisation and Spontaneous Potential methods can also be adopted to support the two approaches.

References

Adepelumi, A. A., Olorunfemi, M. O., Ogungbesan, G. O., & Ako, B. D. (2018). Integrated geophysical and hydrogeological investigations of the groundwater prospects of a basement complex terrain, southwestern Nigeria. *Journal of African Earth Sciences*, *138*, 121-133.

Ajayi, C. A., Adeoye A. S., Ilugbo, S. O., Adebo, B. A. and Adewumi, O. A. (2022). Geophysical Post-Foundation Studies of Ministry of Justice Building, Ekiti-State Secretariat, Ado-Ekiti, Ekiti-State. *Nigeria. Geological Behavior (GBR). 6*(2), page 88-92.

Harinah, (2020). Introduction PQWT Groundwater detector PQWT-TC series, http://pqwtcs.com/newsDetail.aspx?nid=3675 accessed on 20th Nov.,2020.

Heilig, B., Lichtenberger, J., Beggan, C., (2018): Natural sources of geomagnetic field variations, CERN Report No. CERN-ACC-2018-0033; CLIC-Note-1083

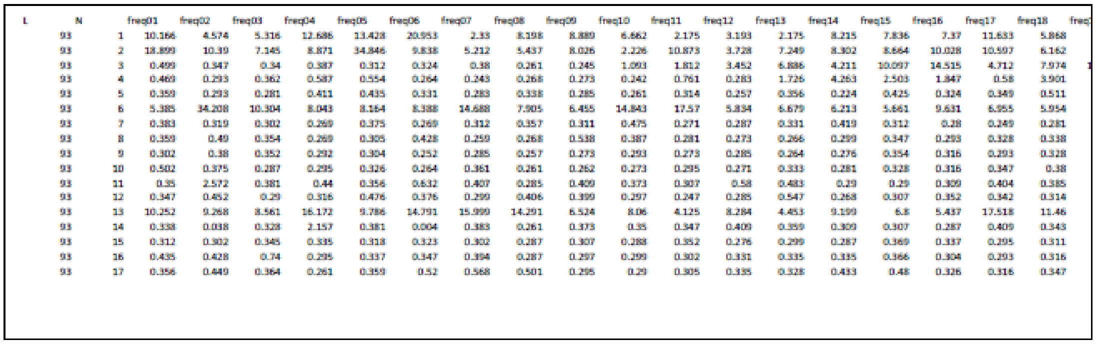
Hunan, P. (2017): Development History and Practical application of Geophysical prospecting instrument for Natural Electric field, Geologic Exploration Equipment Institute China.

Legchenko, A., Baltassat, J., Beauce, A., & Bernard, J. (2002). Nuclear magnetic resonance as a geophysical tool for hydrogeologists. *Journal of Applied Geophysics, 50,* 21-46.

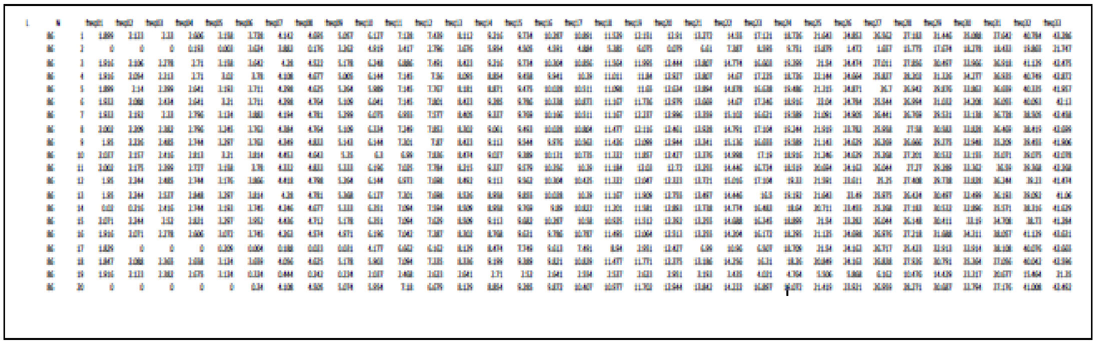
Okwueze, E. E., Olatunji, A. S., and Olatunde, S. O. (2015). Hydrogeological and geophysical investigation of groundwater potential in Ado-Ekiti, southwestern Nigeria. Journal of African Earth Sciences, 112, 141-149.

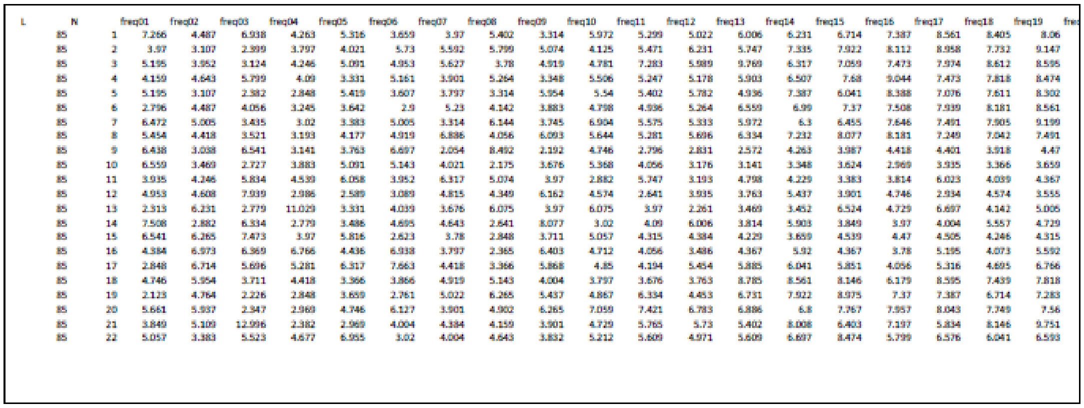
Olasunkanmi, A. S., Ojo, G. O., & Apatemon, O. I. (2018). Petrological and geochemical studies of selected migmatite-gneisses in Ijero-Ekiti, southwestern Nigeria. *International Journal of Advanced Geosciences, 6*(3), 274-283.

APPEDIX



L	N	freq01	freq02	freq03	freq04	freq05	freq06	freq07	freq08	freq09	freq10	freq11	freq12	freq13	freq14	freq15	freq16	freq17	freq18	freq
93	1	10.166	4.574	5.316	12.686	13.428	20.953	2.33	8.198	8.889	6.662	2.175	3.193	2.175	8.215	7.836	7.37	11.633	5.868	
93	2	18.899	10.39	7.145	8.871	34.846	9.838	5.212	5.437	8.026	2.226	10.873	3.728	7.249	8.302	8.664	10.028	10.597	6.162	
93	3	0.499	0.347	0.34	0.387	0.312	0.324	0.38	0.261	0.245	1.093	1.812	3.452	6.886	4.211	10.097	14.515	4.712	7.974	1
93	4	0.469	0.293	0.362	0.587	0.554	0.264	0.243	0.268	0.273	0.242	0.761	0.283	1.726	4.263	2.503	1.847	0.58	3.901	
93	5	0.359	0.293	0.281	0.411	0.435	0.331	0.283	0.338	0.285	0.261	0.314	0.257	0.356	0.224	0.425	0.324	0.349	0.511	
93	6	5.385	34.208	10.304	8.043	8.164	8.388	14.688	7.905	6.455	14.843	17.57	5.834	6.679	6.213	5.661	9.631	6.955	5.954	
93	7	0.383	0.319	0.302	0.269	0.375	0.269	0.312	0.357	0.311	0.475	0.271	0.287	0.331	0.419	0.312	0.28	0.249	0.281	
93	8	0.359	0.49	0.354	0.269	0.305	0.428	0.259	0.268	0.538	0.387	0.281	0.273	0.266	0.299	0.347	0.293	0.328	0.338	
93	9	0.302	0.38	0.352	0.292	0.304	0.252	0.285	0.257	0.273	0.293	0.273	0.285	0.264	0.276	0.354	0.316	0.293	0.328	
93	10	0.502	0.375	0.287	0.295	0.326	0.264	0.361	0.261	0.262	0.273	0.295	0.271	0.333	0.281	0.328	0.316	0.347	0.38	
93	11	0.35	2.572	0.381	0.44	0.356	0.632	0.407	0.285	0.409	0.373	0.307	0.58	0.483	0.29	0.29	0.309	0.404	0.385	
93	12	0.347	0.452	0.29	0.316	0.476	0.376	0.299	0.406	0.399	0.297	0.247	0.285	0.547	0.268	0.307	0.352	0.342	0.314	
93	13	10.252	9.268	8.561	16.172	9.786	14.791	15.999	14.291	6.524	8.06	4.125	8.284	4.453	9.199	6.8	5.437	17.518	11.46	
93	14	0.338	0.038	0.328	2.157	0.381	0.004	0.383	0.261	0.373	0.35	0.347	0.409	0.359	0.309	0.307	0.287	0.409	0.343	
93	15	0.312	0.302	0.345	0.335	0.318	0.323	0.302	0.287	0.307	0.288	0.352	0.276	0.299	0.287	0.369	0.337	0.295	0.311	
93	16	0.435	0.428	0.74	0.295	0.337	0.347	0.394	0.287	0.297	0.299	0.302	0.331	0.335	0.335	0.366	0.304	0.293	0.316	
93	17	0.356	0.449	0.364	0.261	0.359	0.52	0.568	0.501	0.295	0.29	0.305	0.335	0.328	0.433	0.48	0.326	0.316	0.347	





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85	1	7.266	4.487	6.938	4.263	5.316	3.659	3.97	5.402	3.314	5.972	5.299	5.022	6.006	6.231	6.714	7.387	8.561	8.405	8.06	
85	2	3.97	3.107	2.399	3.797	4.021	5.73	5.592	5.799	5.074	4.125	5.471	6.231	5.747	7.335	7.922	8.112	8.958	7.732	9.147	
85	3	5.195	3.952	3.124	4.246	5.091	4.953	5.627	3.78	4.919	4.781	7.283	5.989	9.769	6.317	7.059	7.473	7.974	8.612	8.595	
85	4	4.159	4.643	5.799	4.09	3.331	5.161	3.901	5.264	3.348	5.506	5.247	5.178	5.903	6.507	7.68	9.044	7.473	7.818	8.474	
85	5	5.195	3.107	2.382	2.848	5.419	3.607	3.797	3.314	5.954	5.54	5.402	5.782	4.936	7.387	6.041	8.388	7.076	7.611	8.302	
85	6	2.796	4.487	4.056	3.245	3.642	2.9	5.23	4.142	3.883	4.798	4.936	5.264	6.559	6.99	7.37	7.508	7.939	8.181	8.561	
85	7	6.472	5.005	3.435	3.02	3.383	5.005	3.314	6.144	3.745	6.904	5.575	5.333	5.972	6.3	6.455	7.646	7.491	7.905	9.199	
85	8	5.454	4.418	3.521	3.193	4.177	4.919	6.886	4.056	6.093	5.644	5.281	5.696	6.334	7.232	8.077	8.181	7.249	7.042	7.491	
85	9	6.438	3.038	6.541	3.141	3.763	6.697	2.054	8.492	2.192	4.746	2.796	2.831	2.572	4.263	3.987	4.418	4.401	3.918	4.47	
85	10	6.559	3.469	2.727	3.883	5.091	5.143	4.021	2.175	3.676	5.368	4.056	3.176	3.141	3.348	3.624	2.969	3.935	3.366	3.659	
85	11	3.935	4.246	5.834	4.539	6.058	3.952	6.317	5.074	3.97	2.882	5.747	3.193	4.798	4.229	3.383	3.814	6.023	4.039	4.367	
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85	13	2.313	6.231	2.779	11.029	3.331	4.039	3.676	6.075	3.97	6.075	3.97	2.261	3.469	3.452	6.524	4.729	6.697	4.142	5.005	
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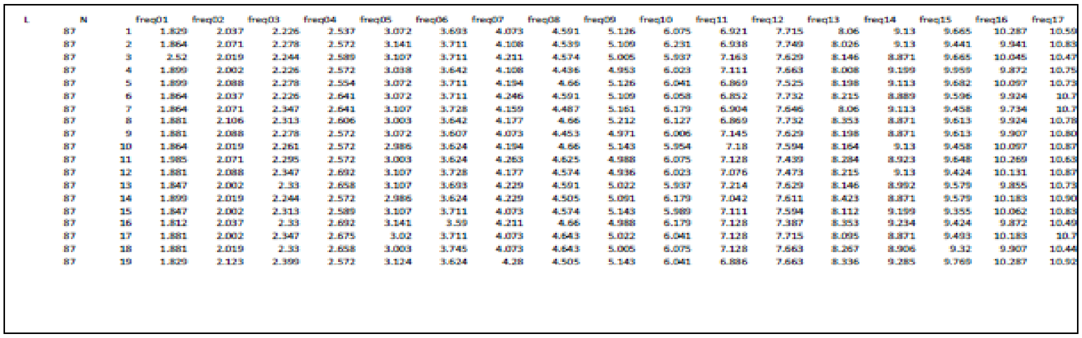
85	19	2.123	4.764	2.226	2.848	3.659	2.761	5.022	6.265	5.437	4.867	6.334	4.453	6.731	7.922	8.975	7.37	7.387	6.714	7.283	
85	20	5.661	5.937	2.347	2.969	4.746	6.127	3.901	4.902	6.265	7.059	7.421	6.783	6.886	6.8	7.767	7.957	8.043	7.749	7.56	
85	21	3.849	5.109	12.996	2.382	2.969	4.004	4.384	4.159	3.901	4.729	5.765	5.73	5.402	8.008	6.403	7.197	5.834	8.146	9.751	
85	22	5.057	3.383	5.523	4.677	6.955	3.02	4.004	4.643	3.832	5.212	5.609	4.971	5.609	6.697	8.474	5.799	6.576	6.041	6.593	



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87	2	1.864	2.071	2.278	2.572	3.141	3.711	4.108	4.539	5.109	6.231	6.938	7.749	8.026	9.13	9.441	9.941	10.83
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87	4	1.899	2.002	2.226	2.572	3.038	3.642	4.108	4.436	4.953	6.023	7.111	7.663	8.008	9.199	9.959	9.872	10.75
87	5	1.899	2.088	2.278	2.554	3.072	3.711	4.194	4.66	5.126	6.041	6.869	7.525	8.198	9.113	9.682	10.097	10.73
87	6	1.864	2.037	2.226	2.641	3.072	3.711	4.246	4.591	5.109	6.058	6.852	7.732	8.215	8.889	9.596	9.924	10.7
87	7	1.864	2.071	2.347	2.641	3.107	3.728	4.159	4.487	5.161	6.179	6.904	7.646	8.06	9.113	9.458	9.734	10.7
87	8	1.881	2.106	2.313	2.606	3.003	3.642	4.177	4.66	5.212	6.127	6.869	7.732	8.353	8.871	9.613	9.924	10.78
87	9	1.881	2.088	2.278	2.572	3.072	3.607	4.073	4.453	4.971	6.006	7.145	7.629	8.198	8.871	9.613	9.907	10.80
87	10	1.864	2.019	2.261	2.572	2.986	3.624	4.194	4.66	5.143	5.954	7.18	7.594	8.164	9.13	9.458	10.097	10.87
87	11	1.985	2.071	2.295	2.572	3.003	3.624	4.263	4.625	4.988	6.075	7.128	7.439	8.284	8.923	9.648	10.269	10.63
87	12	1.881	2.088	2.347	2.692	3.107	3.728	4.177	4.574	4.936	6.023	7.076	7.473	8.215	9.13	9.424	10.131	10.87
87	13	1.847	2.002	2.33	2.658	3.107	3.693	4.229	4.591	5.022	5.937	7.214	7.629	8.146	8.992	9.579	9.855	10.73
87	14	1.899	2.019	2.244	2.572	2.986	3.624	4.229	4.505	5.091	6.179	7.042	7.611	8.423	8.871	9.579	10.183	10.90
87	15	1.847	2.002	2.313	2.589	3.107	3.711	4.073	4.574	5.143	5.989	7.111	7.594	8.112	9.199	9.355	10.062	10.83
87	16	1.812	2.037	2.33	2.692	3.141	3.59	4.211	4.66	4.988	6.179	7.128	7.387	8.353	9.234	9.424	9.872	10.49
87	17	1.881	2.002	2.347	2.675	3.02	3.711	4.073	4.643	5.022	6.041	7.128	7.715	8.095	8.871	9.493	10.183	10.7
87	18	1.881	2.019	2.33	2.658	3.003	3.745	4.073	4.643	5.005	6.075	7.128	7.663	8.267	8.906	9.32	9.907	10.44
87	19	1.829	2.123	2.399	2.572	3.124	3.624	4.28	4.505	5.143	6.041	6.886	7.663	8.336	9.285	9.769	10.287	10.92