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Geophysical investigation of the aquiferous layers, in Uhunmwode local government area, Edo State, Nigeria

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ABSTRACT

The purpose of the geophysical survey was to investigate the subsurface geologic parameters of the aquifer layers. ABEM 1000C Terrameter with an inbuilt booster was used for the study. Vertical Electrical Sounding (VES) in eighty selected locations were sounded with the Schlumberger array. The geo-location data of VES sites were obtained with the GPS map 76csx. The maximum current electrodes spacing was 1,362 m, except in VES 13, (510 m), VES 14, (430 m) and VES 17, (928 m). The investigation showed that the study area is made of 5-8 earth layers with various thicknesses, (13.7 m-181.6 m), depths, (38.9 m-198.6 m) and resistivities, (115 Ωm-18,111.8 Ωm) respectively. The curves were of the types; HAAKQ, AAK, AAAK, AKQH, KQQH, AAKH, AKQ, AKQQ, AAKQ, HAKQH, AAKQH and HKHAKQ. Most of the curves have the ascending A-type, an indication of a horizontally stratified homogenous earth.

Key word: VES, Geoelectric section, Aquifer, Resistivity and curve type.

INTRODUCTION

The greatest benefits of geophysical methods come from using them early in the site characterization process since they are typically nondestructive, less risky, cover more area spatially and volumetrically, and require less time and cost than using monitoring wells. On the other hand, great skill is required in interpreting the data generated by these methods, and their indirect nature creates uncertainties that can only be resolved by use of multiple methods and direct observation. Consequently, preliminary site characterization by geophysical methods will usually be followed by direct observation through the installation of monitoring wells. Geophysical techniques can be used for a number of purposes in ground-water contamination studies: Geologic characterization, including assessing types and thicknesses of strata and the topography of the bedrock surface below unconsolidated material, and generating fracture mapping and paleochannels.

Over the years Electrical Geophysical Prospecting Method has been used for geologic mapping. Using electrical resistivity method, one may measure potential, current and electromagnetic fields that occur naturally or are introduced artificially into the ground. It is the enormous variation in electrical resistivity found in different rocks and materials that makes these techniques possible (Telford et al. 1976). The advantage of the geoelectric method over others in the mapping of the subsurface is further buttress by the work of (Pulawaski and Kurht, 1977).

Geology of the study area

The study area, Uhunmwode Local Government, (Figure 1) lies north of Benin City, Edo state, within longitudes 5º45´E and 6º00´E and latitudes 6º15´N and 6º45´N. Geologically, the study area is basically sand witched between the Niger-Delta basin and Anambra basin. It lies within the aquiferous Benin formation of the Niger-Delta basin and aquiferous Ogwashi-Asaba formation of the Anambra basin (Aigbogun 2010). The Niger-Delta basin has been simplified and divided into three rock units (Short and Stauble, 1967 and Reyment, 1965).

1. The Akata formation (Imo shale) – Which is the lowermost and consists of marine sediments of shale and clays. The top is deepest occurrence of deltaic sandstone beds.
2. The Agbada formation (Ogwashi-Asaba/Ameki) - which overlies the Akata, and consists of paralic sediments of shale and sandstones. The top is highest occurrence of shale with brackish water to marine fauna.
3. The Benin formation (Coastal plain sands) – which is uppermost and consists of thick Continental sands.

The Benin formation extends from the west across the whole Niger delta area and southward beyond the present coastline (figure 2).

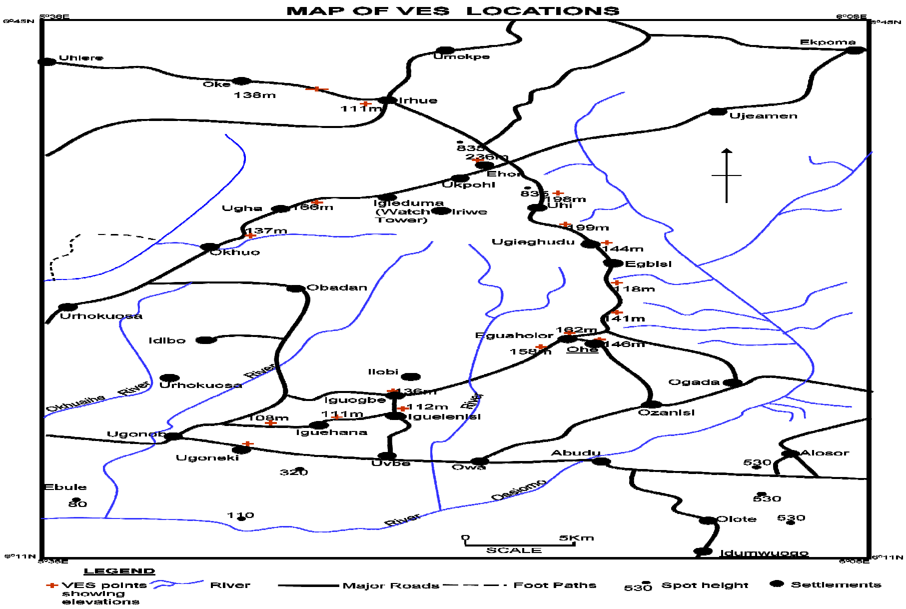


Figure 1: Map of the study Area

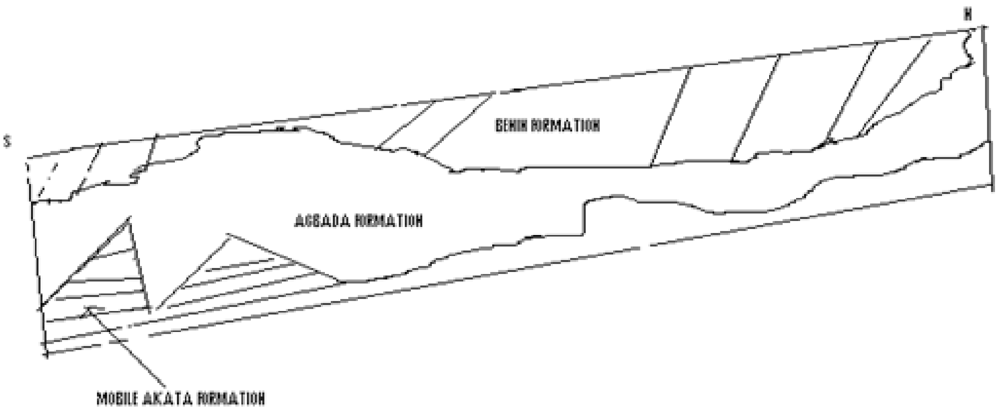


Figure 2: The Benin Formation

Topography
Edo State is a low lying area, except in the north, that is Akoko Edo area where it is characterized by undulating hills rising to a pick of about 572 metres. The area under study is within the Benin lowlands. A sandy plain, marked with rivers, generally running towards the southwest. There are few hills to the east and the lands are drains with by the Rivers Ikpoba and Ossiomon.

Climate
Edo State has a tropical climate, characterized by two distinct seasons, the wet and dry seasons. The wet season last from April to November and the dry season from December to March. Rainfall intensity decreases from the south to the north. In the south, average annual rainfall is 152-254 cm (60"-100") and in the north, average annual rainfall 127-152 cm (50"-60"). The dry season sets in as a result of the influence of the north-east trade wind. The temperature averages about 25°C in the rainy season and 28°C in the dry season.

MATERIALS AND METHODS

The materials used for this research are the ABEM 1000C Terrameter with an inbuilt booster to ensure deeper penetration of current. This equipment has the capacity of displaying computed apparent resistivity of the subsurface depending on the parameters of the array used as input. The GPS map was used to geo-locate the VES points. Resistivity method was adopted using Schlumberger configuration. Electrical method involves the application of different principles, but each is based on the electrical properties of the medium (Egbai and Asokhia, 1998; Egbai, 2011). Quantitative measure of the conductivity properties of the subsurface can be used to find depth and thickness of layers in the earth with anomalously high or low conductivities. The irregularities in the earth conductivity below affect the relation between the current and potential drop at the surface. For the Schlumberger array configuration that was used in this research figure 3, where ***a*** is the potential electrodes separation and ***r*** is half current electrodes spacing. For accurate results ***a*** should be less than one fifth of ***r***. The apparent resistivity at the centre of Schlumberger array is:

$$\rho_a = \pi \left[\frac{r^2}{a} - \frac{a}{4}\right] . \frac{\Delta V}{I} \qquad [1]$$

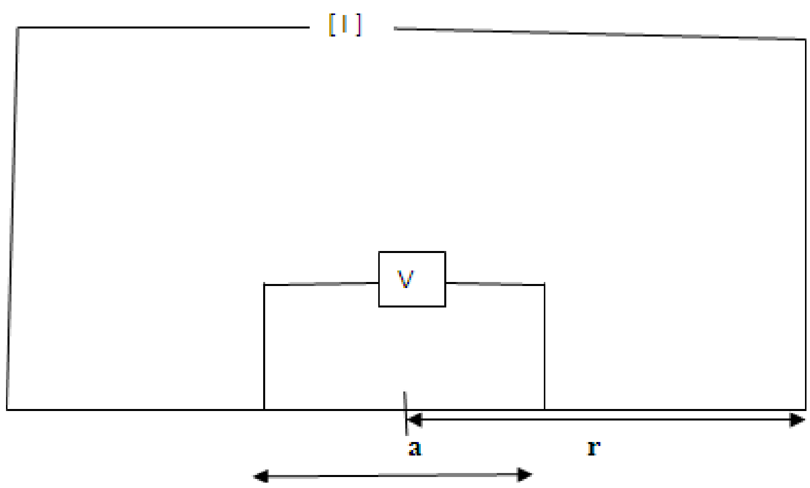


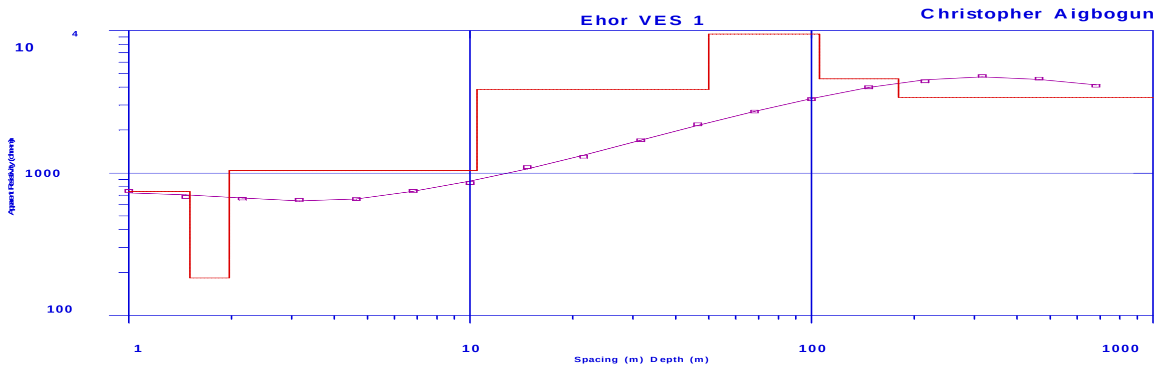
Figure 3: Schlumberger Array

RESULTS AND DISCUSSION

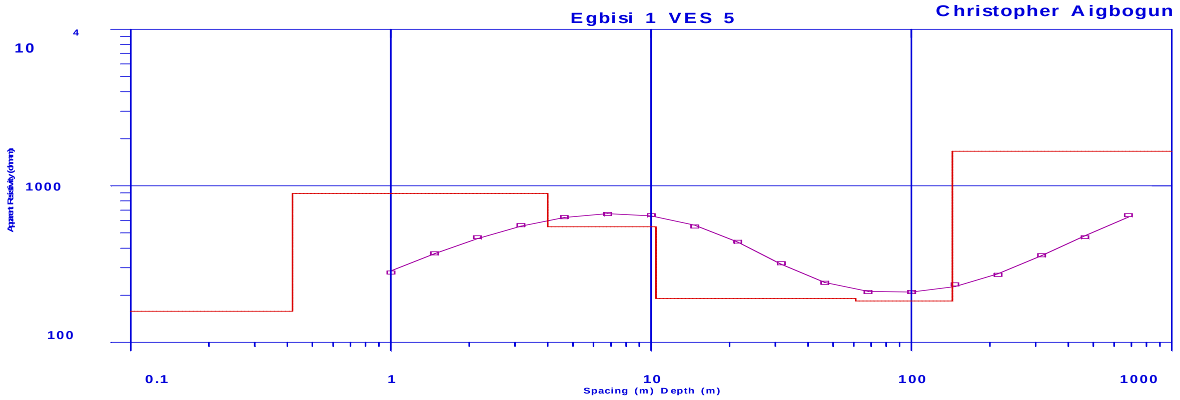
Table 1: Showing Aquifer parameters and Curve Types

VES	Locations	Resistivity (Ωm)	Thickness (m)	Aquifer Depth (m)	Lat (Deg)	Lon (Deg)	Elevation (m)	Curves Types
1	Ehor	4570.4	74.2	179.8	6.63	5.99	236	$\rho_1>\rho_2<\rho_3<\rho_4<\rho_5>\rho_6>\rho_7$ HAAKQ
2	Uhi	9544.1	58.8	72.9	6.66	6.00	198	$\rho_1<\rho_2<\rho_3<\rho_4>\rho_5$ AAK
3	Ugieghudu 1	18111.8	65.7	98.6	6.54	6.03	199	$\rho_1<\rho_2<\rho_3<\rho_4<\rho_5>\rho_6$ AAAK
4	Ugieghudu 2	216.3	85.1	168.9	6.52	6.04	144	$\rho_1<\rho_2<\rho_3>\rho_4>\rho_5<\rho_6$ AKQH
5	Egbisi 1	183.6	82.6	143.7	6.5	6.05	118	$\rho_1<\rho_2>\rho_3>\rho_4>\rho_5<\rho_6$ KQQH
6	Egbisi 2	115.5	121.1	163.4	6.49	6.05	141	$\rho_1<\rho_2>\rho_3>\rho_4>\rho_5<\rho_6$ KQQH
7	Ohe	287.4	144.0	173.4	6.45	6.04	162	$\rho_1<\rho_2<\rho_3<\rho_4>\rho_5<\rho_6$ AAKH
8	Eguaholor	3734	42.4	100.4	6.43	6.02	158	$\rho_1<\rho_2<\rho_3>\rho_4>\rho_5$ AKQ
9	Ilobi/Iguobge	786.6	48.1	118.1	6.36	5.96	138	$\rho_1<\rho_2<\rho_3<\rho_4>\rho_5<\rho_6$ AAKH
10	Iguelenisi	4492	47.7	136.2	6.34	5.94	112	$\rho_1<\rho_2<\rho_3>\rho_4>\rho_5>\rho_6$ AKQQ
11	Iguehana 2	2085.9	44.4	93.3	6.33	5.91	111	$\rho_1<\rho_2<\rho_3>\rho_4>\rho_5$ AKQ
12	Iguehana 1	982.6	45.7	129.7	6.32	5.90	108	$\rho_1<\rho_2<\rho_3<\rho_4>\rho_5>\rho_6$ AAKQ
13	Ugoneki	986.5	30.1	38.9	6.31	5.88	81	$\rho_1<\rho_2<\rho_3<\rho_4>\rho_5<\rho_6$ AAKH
14	Oke	544.1	45.8	87.7	6.70	5.90	138	$\rho_1<\rho_2<\rho_3>\rho_4>\rho_5>\rho_6$ AKQQ
15	Irhue	2466.5	13.7	46.8	6.39	5.94	211	$\rho_1>\rho_2<\rho_3<\rho_4>\rho_5>\rho_6<\rho_7$ HAKQH
16	Ugha 1	3803.7	24.7	112.6	6.54	5.88	137	$\rho_1<\rho_2<\rho_3<\rho_4>\rho_5>\rho_6<\rho_7$ AAKQH
17	Ugha 2	2040	63.8	124.4	6.55	5.88	166	$\rho_1>\rho_2<\rho_3<\rho_4<\rho_5>\rho_6>\rho_7$ HAAKQ
18	Ugha 3	2070.3	181.6	198.6	6.55	5.88	166	$\rho_1>\rho_2<\rho_3>\rho_4<\rho_5<\rho_6>\rho_7>\rho_8$ HKHAKQ

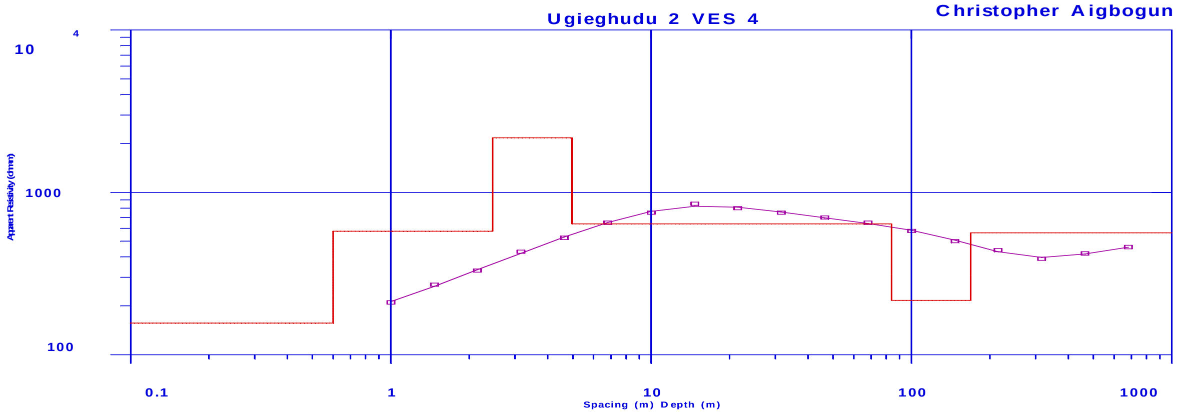
The various type curves as observed in the area of study are as shown in table 1. The field data acquired was adjusted and curve-matched before computer iteration, using the Interpex Ix1Dv2 software. The geoelectric sections of all the VES points indicate that the different aquifer layers have the following characteristics: The resistivity range from (115.5-1811.8) ohm-m; while the thickness varies from (30.1-144.0) m and depth has the range of (38.9-198.6) m. The curves were of the types; HAAKQ, AAK, AAAK, AKQH, KQQH, AAKH, AKQ, AKQQ, AAKQ, HAKQH, AAKQH and HKHAKQ. Most of the curves have the ascending A-type, as shown in Figure 4(a-f), an indication of a horizontally stratified homogenous earth (Keller and Frischknecht, 1966), (Bhattacharya and Patra, 1968) and (Aigbogun, et. al, 2010). The results also show that the confined aquifers have thick layers and also relatively deep which indicates that the study area has a good potential for ground water utilization for domestic, agriculture and industrial purposes. The aquifer depth contour map and bedrock resistivity image map which allow us at a glance to view the information of the study area are shown in figures 4 and 5 respectively.


Ehor VES 1
Christopher Aigbogun
10
4
1000
100
1
10
100
1000
Spacing (m) Depth (m)

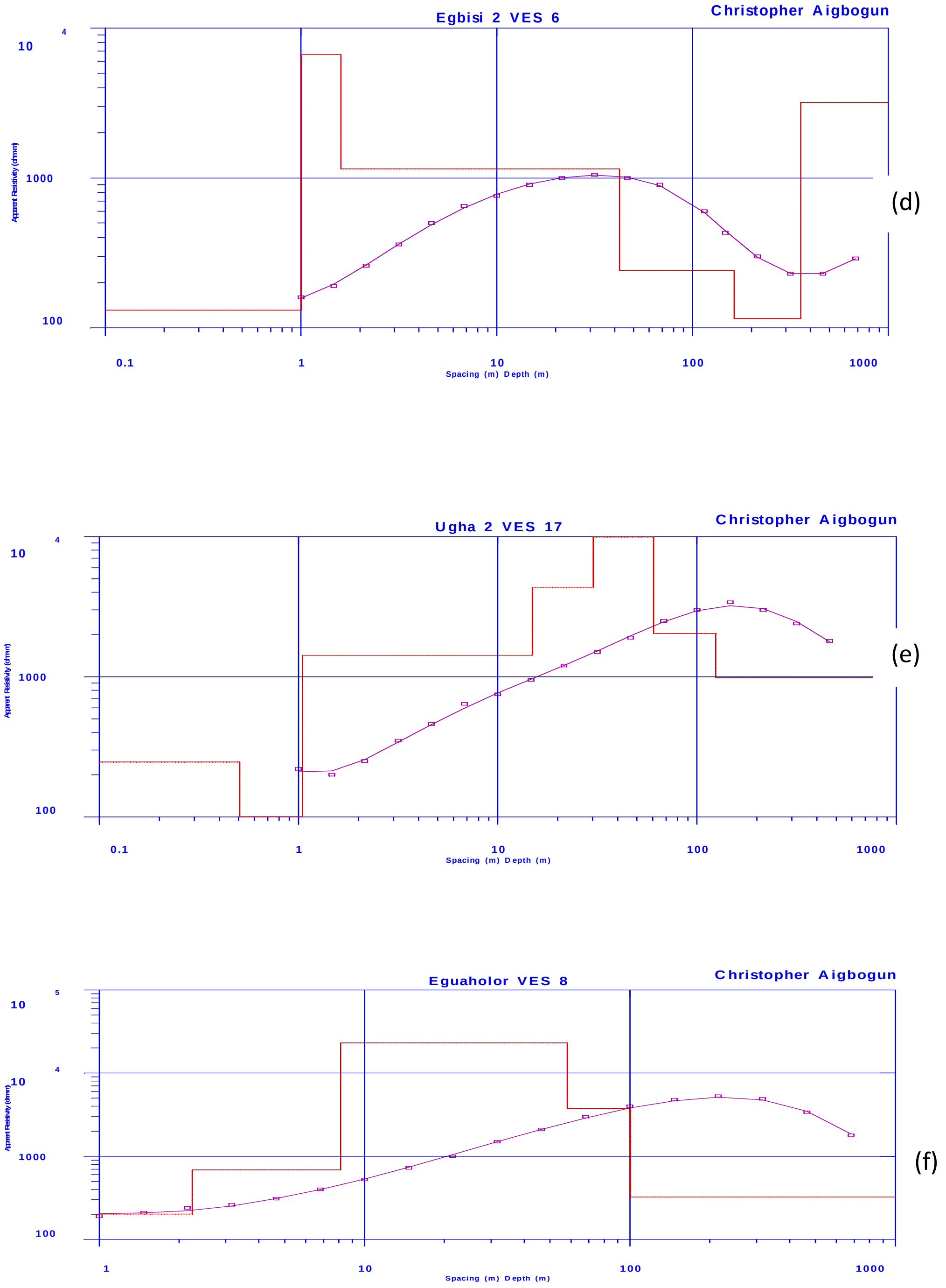
(a)


Egbisi 1 VES 5
Christopher Aigbogun
10
4
1000
100
0.1
1
10
100
1000
Spacing (m) Depth (m)

(b)


Ugieghudu 2 VES 4
Christopher Aigbogun
10
4
1000
100
0.1
1
10
100
1000
Spacing (m) Depth (m)

(c)



Figures 4(a-f): Some of the VES Curves

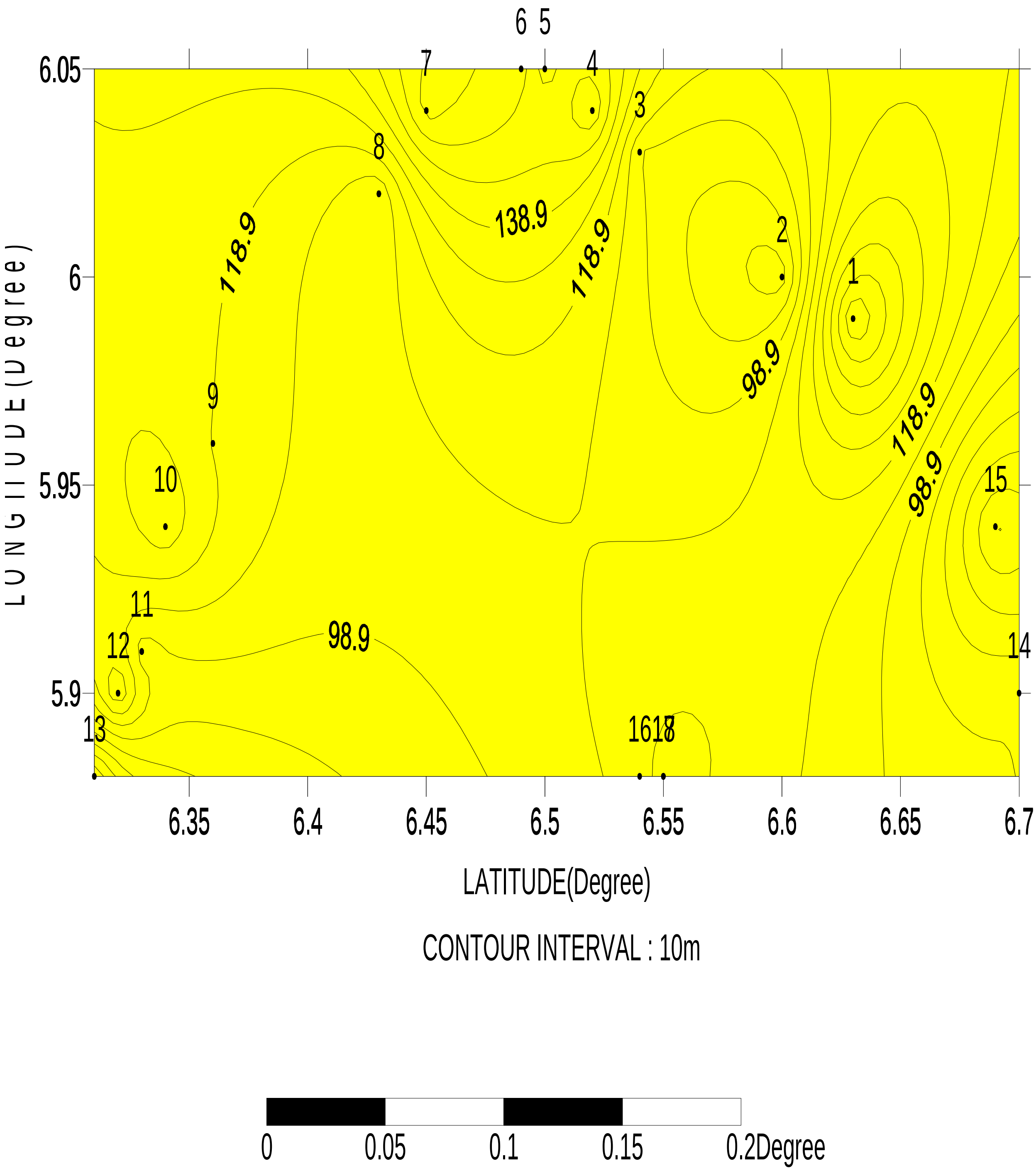


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Figure 5: Aquifer Depth Contour Map

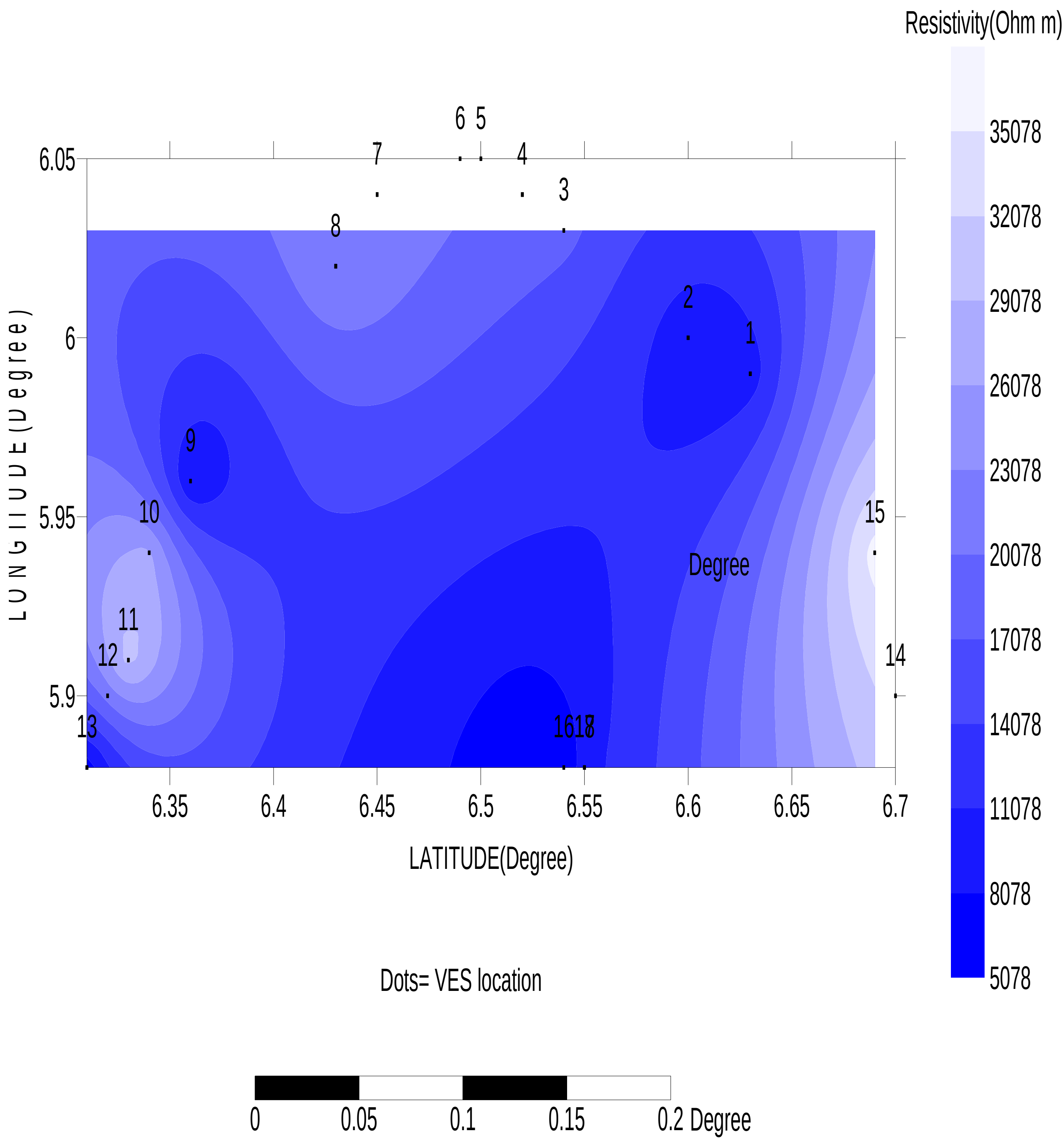

Figure 6: Bedrock Resistivity Image Map

CONCLUSION

After the analysis of the acquired field data, the result show that the study area is made of 5-8 earth layers with various thicknesses, (13.7 m-181.6 m), depths, (38.9 m-198.6 m) and resistivities, (115 Ωm-18,111.8 Ωm) respectively. The curves were of the types; HAAKQ, AAK, AAAK, AKQH, KQQH, AAKH, AKQ, AKQQ, AAKQ, HAKQH, AAKQH and HKHAKQ. The investigation also reveal that the confined aquifers have thick layers and also relatively deep which indicates that the study area has a good potential for ground water utilization for domestic, agriculture and industrial purposes.

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