# GEOTECHNICAL INVESTIGATION OF THE SUBSURFACE FORMATIONS USING ELECTRICAL RESISTIVITY METHOD IN NORTHERN PART OF PAIKO TOWN, NIGER STATE, NIGERIA

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**Abstract**

Vertical electrical sounding (VES) was carried out in the study area, using Abem Terrameter model SAS 4000. The study was carried out with a view to determine the subsurface layer parameters (resistivity, depth, thickness and lithologies) which were employed in delineating the sites for building construction. Six transverses with ten VES stations along each traverse, having separation of 50 m apart were investigated. It has a maximum current electrode separation (AB/2) of 100 m. Three to four distinct geoelectric layers were observed namely; Top layer which consist of gravel, sand, laterite and alluvial, weathered/fractured layer consist of clay and laterite, and fresh basement layer that consist of granite, gneiss and igneous rock. The observed frequencies in curve types include 21.6% of H, 0.6% of HA, 2.4% of K, 0.6% of A, 3.6% of KH, 6% of QA and 1.2% of HK. Sixteen VES stations were delineated for building construction, having depths to fresh basement varying between 2.18 m and 3.93 m with fresh basement resistivity ranged between 1038 Ωm and 194453 Ωm

**Key words**: Building construction, vertical electrical sounding, resistivity, depth, geoelectric layer, bedrock, Abem Terrameter

**Introduction**

The study area is located in the north central part of Nigeria. The population of Paiko is increasing rapidly as a result of people migrating from rural areas to urban towns to earn a living. As such, there is need for more estate development to accommodate the growing population of the area. However, presently in Nigeria there are several cases of building collapse and cracking of walls as a result of poor foundation and lack of site investigation (Alhassan *et al*., 2015). There is need to search for the areas where the consolidated basement is shallow and can provide strong base for building construction. Therefore, the aim of this work is to employ geophysical method to determine sites where the fresh basement is intruded close to the surface that can support foundations to buildings. Among several geophysical methods employed in determining depth to bedrock (electrical resistivity, gravity, seismic, magnetic, remote sensing, and electromagnetic), the electrical resistivity method is the most effective (Kearey *et al*., 2002; Alhassan *et al*., 2017). It is an effective and a reliable tool in slicing the earth into geoelectric layers. It has the advantage of non-destructive effect on the environment, cost effective, rapid and quick survey time and less ambiguity in interpretations of results when compared to other geophysical survey methods (Todd, 1980). The vertical electrical sounding (VES) technique provides information on the vertical variations in the resistivity of the ground with depth (Ariyo, 2005; Alhassan *et al*., 2015; Obiora *et al*., 2016). It is used to solve a wide variety of problems, such as; determination of depth, thickness and boundary of aquifer (Asfahani, 2006; Bello and Makinde, 2007).

**GEOLOGY OF THE STUDY AREA**

The study area is located within the north central Nigerian basement complex. It has an elevation of 304 m above sea level with population of about 736,133 people as at 2006 census. It is bounded by latitudes 9° 25′N and 9° 27′N and longitudes 6 ° 37′E and 6 ° 39′E. Generally, the area mapped forms part of the Minna- granitic formation that consists of Metasediment `and metavolcanics. The Metasediment include quartzites, gneisses and the metavolcanics are mainly granites. Among the main rock groups are granites which occur at the central and northern parts of the area, while on the south and east, cobbles of quartzite are found especially along the channels and valley. However, the other bodies like pegmatites and quartz veins also occur within the major rock types (Figure 1). The rocks are mainly biotite –granites with medium to coarse grained, light colored rocks with some variation in biotite content. The mineral constituents are leucocratic to mesocratic. However, the biotite minerals are thread like and are arranged rough parallel streak, although some are disoriented in the groundmass. The feldspar minerals occur as fine to medium grained, though grains are cloudy as a result of alteration mostly along the twin planes, while the quartz minerals are constituents of the granitic rocks which show strong fracturing in the granitic rocks of the area (Ajibade, 1980).

The area is therefore, underlain by four lithological formations as it is evident from the rocks in the area. The rock types in this region include granites, gneisses quartzite as well as laterites while most of the granites are older granites and this distinguishes them from the younger granites found in Jos area. From field observation, granitic rocks are the most abundant and they are widely distributed in the study area, as well characterized by hills with relative low lands and slightly drained by streams of intermittent and ephemeral types and also some tributaries. The area mapped is underlain by coarse to medium grained granite. These rocks are well exposed at the southern and eastern parts of the area. In hand specimen they have a coarse texture. The outcrops are all light in colour and the major minerals contained are quartz, feldspar and biotite as revealed under the thin section studies by the use of a petrological microscope.

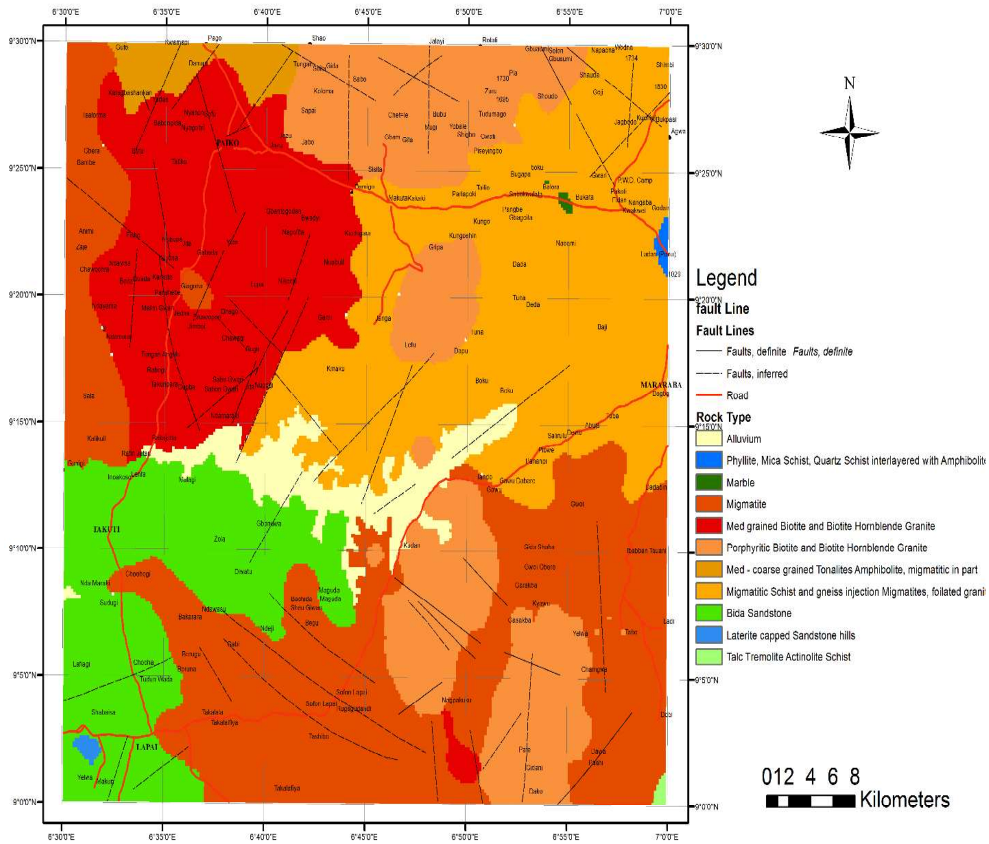


Figure 1: Geological Map of Paiko area (Modified after NGSA 2010).

## METHODOLOGY

This research has utilized the electrical resistivity method in delineating the shallow consolidated basement of the study area. Sixty vertical electrical soundings were carried out using SAS 4000 model Terrameter and its accessories. The conventional Schlumberger array pattern with half electrode spacing (AB/2) varying from 1 m to a maximum of 100 m was adopted. The apparent resistivity was computed using equation 1

$$\rho_a = KR \quad (1)$$

Where $\rho_a$ is an apparent resistivity and the earth resistance (R) is given as

$$R = \frac{\Delta V}{I} \quad (2)$$

The geometric factor, K, is expressed as

$$K = \pi\left(\frac{\left(\frac{AB}{2}\right)^2 - \left(\frac{MN}{2}\right)^2}{MN}\right) \quad (3)$$

The apparent resistivity values obtained from equation (1) were plotted against the half current electrode separation spacing using IPI2WIN software. From these plots, vertical electrical sounding curves were obtained (Figure 2) and qualitative deductions such as resistivity of the layers, the depth of each layer, the thickness of each layer, number of layers, curve types and geologic cross section of the area were made.

## RESULTS AND DISCUSSION

The summary of the interpreted electrical resistivity survey is presented in Tables 1, 2, 3 and 4. Table 1 consists of VES stations $G_1$to $I_{10}$ while table 2 comprised of VES stations $J_1$ to $L_{10}$. The tables 3 and 4 show the depth to consolidated basement. From the plot of apparent resistivity versus half current electrode spacing, geoelectric sections were produced (figure 2), where resistivity of the layers, the depth of each layer, the thickness of each layer, and number of layers, were obtained.

The geologic cross section (Figure 3a-f) reveals that the area is characterized by 3 to 4 geologic subsurface layers. Six profiles with sixty VES stations were covered and their subsurface geologic cross sections were presented in figure 3. The geologic cross section shows the layers in vertical sequence with colorations differentiate one layer from another layer (figure 3a-f). From the figure, 3- layer type occurring more and are characterized by H curve type. Some are characterized by A and K curve types. The 3- layer geologic sections are generally made up of topsoil, weathered/fractured layer and fresh basement rock from top to the bottom with variable depths, thicknesses and resistivities. The 4- layer geoelectric sections are characterized by HA, KH and HK curve types. The observed frequencies in curve types include 21.6 % of H, 3.0 % of HK, 4.2 % of HA, 3.6 % of A, 2.4 % of K, and 1.2 % of KH

The 4- layer geoelectric section is made up of topsoil, weathered layer, fractured layer and fresh basement rock. Generally, the topsoil of the area is made up of loose sand, gravels, sandy clay, laterite and clay. In a basement complex terrain, areas with fresh basement layer depth less or equal to 4 m are favorable and good for building construction (Alhassan *et al*., 2015).

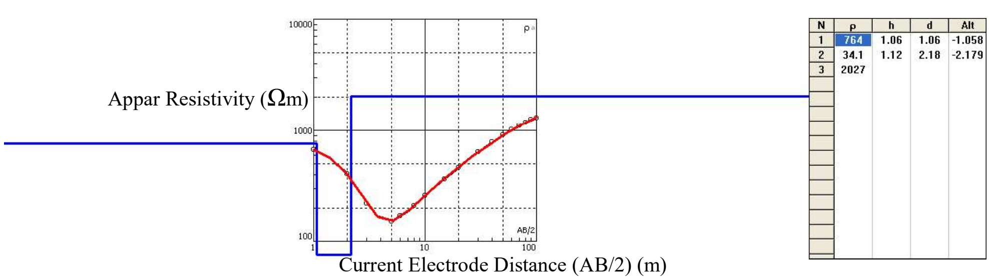

**Figure 2a: VES Curve $I_7$**

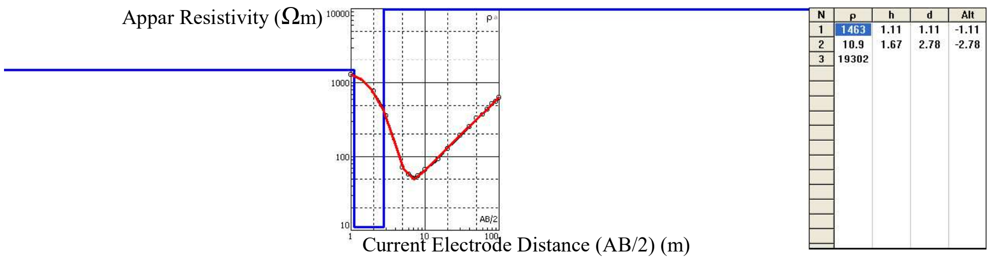


**Figure 2b: VES Curve $I_{10}$**

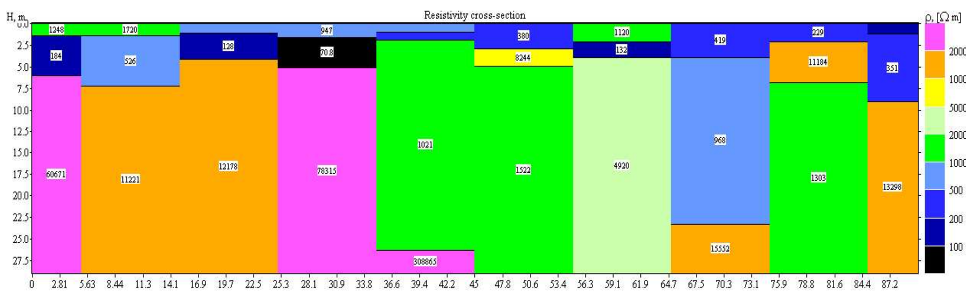


Figure 3a: Geologic Cross-Section of Profile G

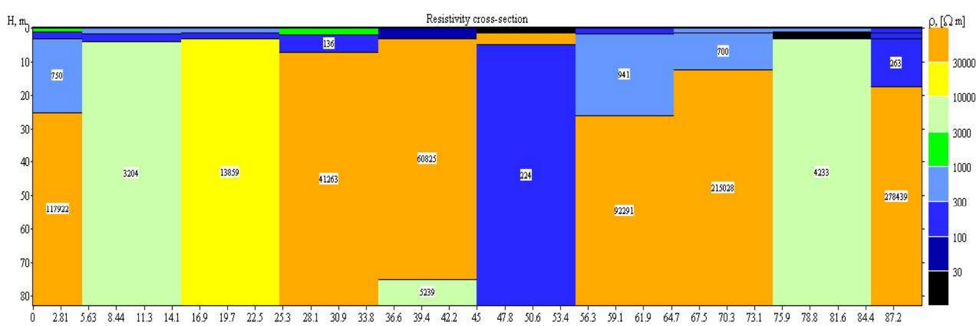


Figure 3b: Geologic Cross-Section of Profile H

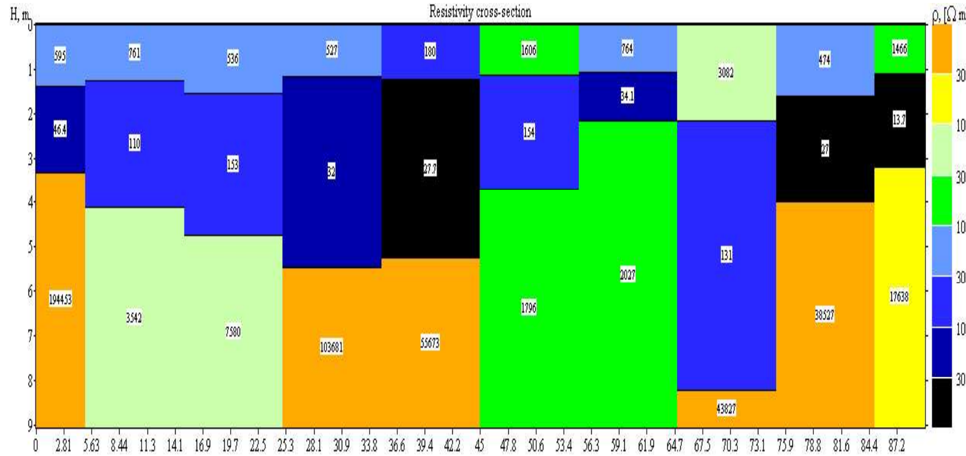


Figure 3c: Geologic Cross-Section of Profile I

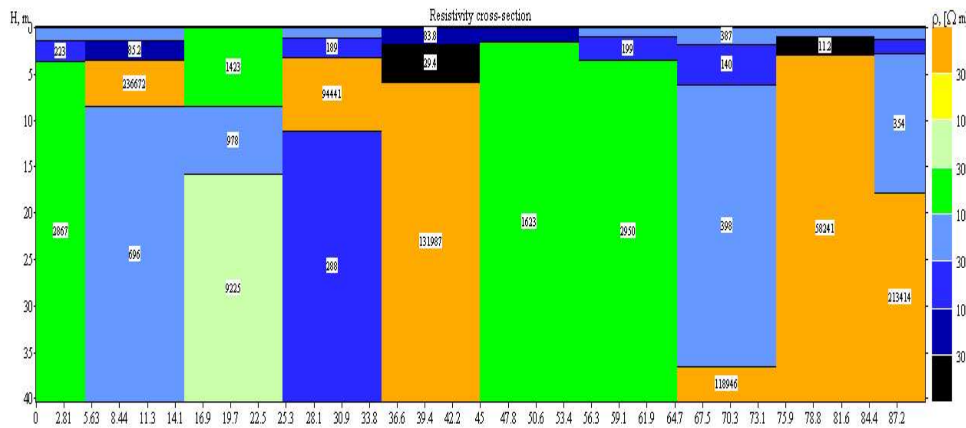


Figure 3d: Geologic Cross-Section of Profile J

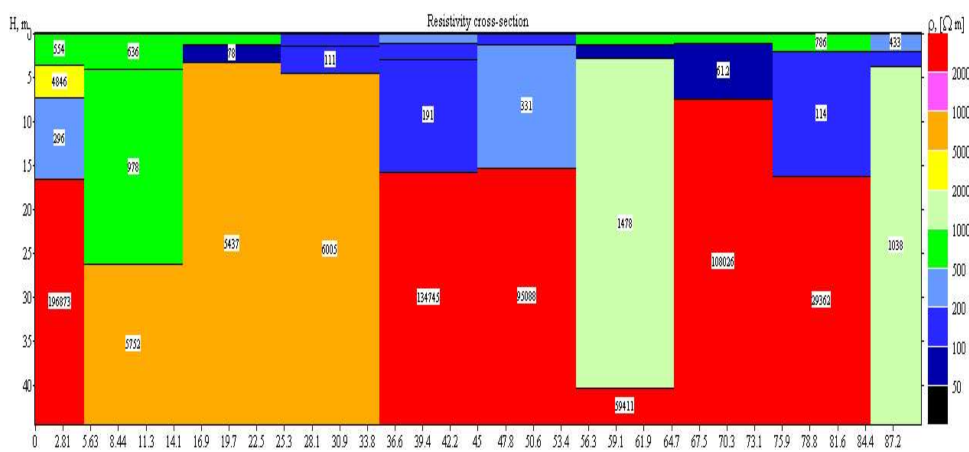


Figure 3e: Geologic Cross-Section of Profile K

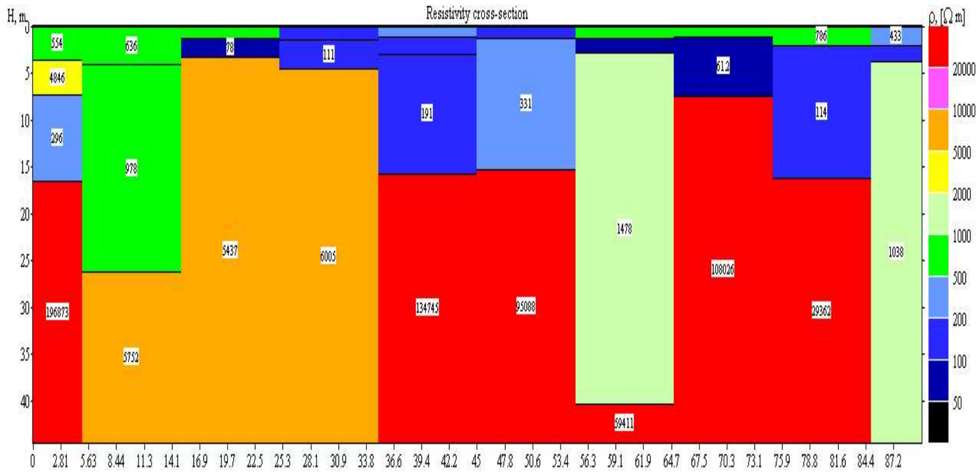


Figure 3f: Geologic Cross-Section of Profile L

In investigating the continuous variation of resistivity with depth, iso-resistivity maps using Golden software (Surfer 11.0) version were obtained for the layers (Figure 4). It shows the color range corresponding to resistivity range of the earth materials. The iso-resistivity map of the first layer reveal that blue represent gravels, sky blue represent sand, green correspond to laterite and yellow represent alluvial deposits (Figure 4a).

The iso-resistivity map of the second layer shows that blue color corresponds to clay and sky blue represent laterite (Figure 4b). Third layer iso-resistivity maps reveal that blue represent granite, sky blue represent gneiss, green correspond to igneous rock, and yellow represent gabbro rock (Figure 4c).

The depth to consolidated basement map shows the depth distribution within the area (figure 5). From the map, the area with blue coloration corresponds to the shallow depth to fresh basement with high resistivity values and therefore be the suitable areas delineated for building construction.

**Table 1: Layers resistivity, depth, thickness and curve types**

| VES station | No of Layer | Layer resistivity (Ωm) | | | | Layer depth (m) | | | | Layer Thickness (m) | | | | Curve type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $\rho_1$ | $\rho_2$ | $\rho_3$ | $\rho_4$ | $d_1$ | $d_2$ | $d_3$ | $d_4$ | $h_1$ | $h_2$ | $h_3$ | $h_4$ | |
| $G_1$ | 3 | 1248 | 184 | 60671 | | 1.40 | 6.00 | ∞ | | 1.40 | 4.60 | ∞ | | H |
| $G_2$ | 3 | 1720 | 526 | 11221 | | 1.38 | 7.27 | ∞ | | 1.38 | 5.89 | ∞ | | H |
| $G_3$ | 3 | 667 | 126 | 12178 | | 1.14 | 4.07 | ∞ | | 1.15 | 2.92 | ∞ | | H |
| $G_4$ | 3 | 947 | 70.80 | 78315 | | 1.63 | 5.11 | ∞ | | 1.63 | 3.47 | ∞ | | H |
| $G_5$ | 4 | 820 | 247 | 1021 | 308865 | 1.04 | 1.88 | 26.30 | ∞ | 1.04 | 0.85 | 24.40 | ∞ | HA |
| $G_6$ | 3 | 380 | 8244 | 1522 | | 2.87 | 4.91 | ∞ | | 2.07 | 2.04 | ∞ | | K |
| $G_7$ | 3 | 1120 | 132 | 4920 | | 2.07 | 3.93 | ∞ | | 2.07 | 1.06 | ∞ | | H |
| $G_8$ | 3 | 419 | 968 | 15552 | | 3.91 | 23.30 | ∞ | | 3.91 | 19.40 | ∞ | | A |
| $G_9$ | 3 | 229 | 11184 | 1303 | | 2.11 | 6.87 | ∞ | | 2.11 | 4.75 | ∞ | | K |
| $G_{10}$ | 3 | 117 | 351 | 13298 | | 1.18 | 9.07 | ∞ | | 1.19 | 7.88 | ∞ | | A |
| $H_1$ | 4 | 1490 | 152 | 750 | 117922 | 1.18 | 3.21 | 25.40 | ∞ | 1.18 | 2.03 | 22.10 | ∞ | HA |
| $H_2$ | 3 | 415 | 124 | 3204 | | 1.69 | 3.93 | ∞ | | 1.69 | 2.24 | ∞ | | H |
| $H_3$ | 3 | 308 | 130 | 13859 | | 1.42 | 3.28 | ∞ | | 1.42 | 1.86 | ∞ | | H |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $H_4$ | 3 | 1114 | 136 | 41263 | | 1.93 | 7.16 | ∞ | | 1.93 | 5.23 | ∞ | H |
| $H_5$ | 3 | 39.90 | 60825 | 5239 | | 3.07 | 75.10 | ∞ | | 3.07 | 72.00 | ∞ | K |
| $H_6$ | 3 | 1070 | 80368 | 224 | | 1.38 | 4.81 | ∞ | | 1.38 | 3.43 | ∞ | K |
| $H_7$ | 3 | 243 | 941 | 92291 | | 1.85 | 26.10 | ∞ | | 1.05 | 24.30 | ∞ | A |
| $H_8$ | 3 | 457 | 700 | 215028 | | 1.45 | 12.40 | ∞ | | 1.45 | 10.90 | ∞ | A |
| $H_9$ | 3 | 550 | 28 | 4233 | | 1.12 | 3.30 | ∞ | | 1.12 | 2.17 | ∞ | H |
| $H_{10}$ | 4 | 191 | 106 | 263 | 278439 | 1.43 | 3.03 | 17.60 | ∞ | 1.43 | 1.60 | 14.60 ∞ | HA |
| $I_1$ | 3 | 595 | 46.40 | 194453 | | 1.37 | 3.34 | ∞ | | 1.37 | 1.96 | ∞ | H |
| $I_2$ | 3 | 761 | 110 | 3542 | | 1.25 | 4.10 | ∞ | | 1.25 | 2.86 | ∞ | H |
| $I_3$ | 3 | 536 | 153 | 7580 | | 1.52 | 4.75 | ∞ | | 1.52 | 3.23 | ∞ | H |
| $I_4$ | 3 | 527 | 32 | 103681 | | 1.16 | 5.47 | ∞ | | 1.16 | 4.31 | ∞ | H |
| $I_5$ | 3 | 180 | 27.70 | 55673 | | 1.22 | 5.23 | ∞ | | 1.22 | 4.02 | ∞ | H |
| $I_6$ | 3 | 1606 | 154 | 1796 | | 1.12 | 3.72 | ∞ | | 1.12 | 2.60 | ∞ | H |
| $I_7$ | 3 | 764 | 34.10 | 2027 | | 1.06 | 2.18 | ∞ | | 1.06 | 1.12 | ∞ | H |
| $I_8$ | 3 | 3082 | 131 | 43827 | | 2.15 | 8.22 | ∞ | | 2.15 | 6.06 | ∞ | H |
| $I_9$ | 3 | 474 | 27 | 38527 | | 1.61 | 3.97 | ∞ | | 1.61 | 2.36 | ∞ | H |
| $I_{10}$ | 3 | 1463 | 10.90 | 19302 | | 1.11 | 2.78 | ∞ | | 1.11 | 1.67 | ∞ | H |

VES-vertical electrical sounding; ρ-layer resistivity; d- layer depth; h – layer thickness; m-metre

**Table 2: Layers resistivity, depth, thickness and curve types**

| VES station | No of Layer | Layer resistivity (Ωm) | | | | Layer depth (m) | | | | Layer Thickness (m) | | | | Curve type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $\rho_1$ | $\rho_2$ | $\rho_3$ | $\rho_4$ | $d_1$ | $d_2$ | $d_3$ | $d_4$ | $h_1$ | $h_2$ | $h_3$ | $h_4$ | |
| $J_1$ | 3 | 841 | 223 | 2867 | | 1.36 | 3.61 | ∞ | | 1.36 | 2.25 | ∞ | | H |
| $J_2$ | 4 | 439 | 85.20 | 236672 | 696 | 1.35 | 3.53 | 8.57 | ∞ | 1.35 | 2.18 | 5.04 | ∞ | HK |
| $J_3$ | 3 | 1423 | 978 | 9225 | | 8.53 | 15.70 | ∞ | | 8.53 | 7.20 | ∞ | | H |
| $J_4$ | 4 | 985 | 189 | 94441 | 288 | 1.05 | 3.27 | 11.20 | ∞ | 1.05 | 2.22 | 7.93 | ∞ | HK |
| $J_5$ | 3 | 83.80 | 29.40 | 131987 | | 1.86 | 5.86 | ∞ | | 1.86 | 3.99 | ∞ | | H |
| $J_6$ | 2 | 62.20 | 1623 | | | 1.56 | ∞ | | | 1.56 | ∞ | | | A |
| $J_7$ | 3 | 982 | 199 | 2950 | | 0.95 | 3.54 | ∞ | | 0.95 | 2.59 | ∞ | | H |
| $J_8$ | 4 | 387 | 140 | 398 | 118946 | 1.86 | 6.09 | 36.60 | ∞ | 1.86 | 4.22 | 30.50 | ∞ | HA |
| $J_9$ | 3 | 620 | 11.20 | 58241 | | 1.00 | 3.00 | ∞ | | 1.00 | 2.00 | ∞ | | H |
| $J_{10}$ | 4 | 571 | 124 | 354 | 213414 | 1.30 | 2.73 | 17.80 | ∞ | 1.30 | 1.43 | 15.10 | ∞ | HA |
| $K_1$ | 4 | 554 | 4846 | 296 | 196873 | 3.57 | 7.19 | 16.40 | ∞ | 3.57 | 3.61 | 9.22 | ∞ | KH |
| $K_2$ | 3 | 636 | 978 | 5752 | | 4.06 | 26.20 | ∞ | | 4.06 | 22.10 | ∞ | | A |
| $K_3$ | 3 | 517 | 78 | 5437 | | 1.17 | 3.22 | ∞ | | 1.17 | 2.05 | ∞ | | H |
| $K_4$ | 3 | 178 | 111 | 6005 | | 1.42 | 4.47 | ∞ | | 1.42 | 3.05 | ∞ | | H |
| $K_5$ | 4 | 469 | 117 | 191 | 134745 | 1.07 | 3.00 | 15.70 | ∞ | 1.07 | 1.93 | 12.70 | ∞ | HA |
| $K_6$ | 3 | 198 | 331 | 95088 | | 1.30 | 15.20 | ∞ | | 1.30 | 13.90 | ∞ | | A |
| $K_7$ | 4 | 776 | 61.30 | 1478 | 59411 | 1.21 | 2.76 | 40.30 | ∞ | 1.21 | 1.54 | 37.50 | ∞ | HA |
| $K_8$ | 3 | 712 | 61.20 | 108026 | | 1.06 | 7.45 | ∞ | | 1.06 | 6.39 | ∞ | | H |
| $K_9$ | 3 | 786 | 114 | 29362 | | 2.02 | 16.10 | ∞ | | 2.02 | 14.10 | ∞ | | H |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $K_{10}$ | 3 | 433 | 113 | 1038 | | 2.02 | 3.62 | ∞ | | 2.02 | 1.60 | ∞ | | H |
| $L_1$ | 4 | 300 | 196 | 27962 | 79.90 | 2.69 | 7.93 | 15.30 | ∞ | 2.69 | 5.23 | 7.41 | ∞ | HK |
| $L_2$ | 4 | 620 | 154 | 38600 | 130 | 1.18 | 3.24 | 8.02 | ∞ | 1.18 | 2.06 | 4.78 | ∞ | HK |
| $L_3$ | 4 | 625 | 132 | 113317 | 303 | 1.28 | 3.03 | 6.78 | ∞ | 1.28 | 1.75 | 3.75 | ∞ | HK |
| $L_4$ | 3 | 1052 | 232 | 172184 | | 1.24 | 12.70 | ∞ | | 1.24 | 11.40 | ∞ | | H |
| $L_5$ | 3 | 656 | 289 | 4230 | | 1.49 | 13.60 | ∞ | | 1.49 | 12.10 | ∞ | | H |
| $L_6$ | 3 | 85 | 15.20 | 78682 | | 1.13 | 5.26 | ∞ | | 1.13 | 4.13 | ∞ | | H |
| $L_7$ | 3 | 584 | 156 | 2853 | | 1.18 | 3.73 | ∞ | | 1.18 | 2.55 | ∞ | | H |
| $L_8$ | 3 | 1003 | 59.80 | 31877 | | 2.54 | 7.28 | ∞ | | 2.54 | 4.75 | ∞ | | H |
| $L_9$ | 3 | 546 | 43.20 | 107599 | | 1.42 | 7.54 | ∞ | | 1.42 | 6.12 | ∞ | | H |
| $L_{10}$ | 3 | 420 | 170 | 110943 | | 2.31 | 14.40 | ∞ | | 2.31 | 12.10 | ∞ | | H |

VES-vertical electrical sounding; ρ-layer resistivity; d- layer depth; h – layer thickness; m-metre

**Table 3: Depths to Fresh Basement of the Area**

| VES STATION | Latitude (degrees) | Longitude (degrees) | Elevation (m) | Depth to Basement (m) |
|---|---|---|---|---|
| $G_1$ | 09.46521 | 006.63871 | 320 | 6.00 |
| $G_2$ | 09.46500 | 006.63832 | 312 | 7.27 |
| $G_3$ | 09.46463 | 006.63797 | 307 | 4.07 |
| $G_4$ | 09.46435 | 006.63756 | 311 | 5.11 |
| $G_5$ | 09.46410 | 006.63720 | 310 | 26.30 |
| $G_6$ | 09.46379 | 006.63683 | 313 | 4.91 |
| $G_7$ | 09.46360 | 006.63642 | 307 | 3.93 |
| $G_8$ | 09.46330 | 006.63602 | 306 | 23.30 |
| $G_9$ | 09.46294 | 006.63575 | 308 | 6.87 |
| $G_{10}$ | 09.46264 | 006.63533 | 312 | 9.07 |
| $H_1$ | 09.46567 | 006.63856 | 313 | 25.40 |
| $H_2$ | 09.46538 | 006.63799 | 305 | 3.93 |
| $H_3$ | 09.46502 | 006.63739 | 299 | 3.28 |
| $H_4$ | 09.46469 | 006.63698 | 304 | 7.16 |

| | | | | |
|---|---|---|---|---|
| $H_5$ | 09.46443 | 006.63658 | 307 | 75.10 |
| $H_6$ | 09.46413 | 006.63629 | 307 | 4.81 |
| $H_7$ | 09.46382 | 006.63595 | 310 | 26.10 |
| $H_8$ | 09.46353 | 006.63560 | 305 | 12.40 |
| $H_9$ | 09.46279 | 006.63505 | 303 | 3.30 |
| $H_{10}$ | 09.46278 | 006.63501 | 305 | 17.60 |
| $I_1$ | 09.46609 | 006.63838 | 309 | 3.34 |
| $I_2$ | 09.46596 | 006.63795 | 313 | 4.10 |
| $I_3$ | 09.46572 | 006.63758 | 310 | 4.75 |
| $I_4$ | 09.46551 | 006.63718 | 305 | 5.47 |
| $I_5$ | 09.46535 | 006.63672 | 305 | 5.23 |
| $I_6$ | 09.46510 | 006.63634 | 306 | 3.72 |
| $I_7$ | 09.46483 | 006.63597 | 306 | 2.18 |
| $I_8$ | 09.46458 | 006.63562 | 305 | 8.22 |
| $I_9$ | 09.46424 | 006.63528 | 308 | 3.97 |
| $I_{10}$ | 09.46383 | 006.63491 | 296 | 2.78 |

**Table 4: Depths to Fresh Basement of the Area**

| VES STATION | Latitude (degrees) | Longitude (degrees) | Elevation (m) | Depth to Basement (m) |
|---|---|---|---|---|
| $J_1$ | 09.46655 | 006.63817 | 312 | 3.61 |
| $J_2$ | 09.4663 | 006.63778 | 311 | 8.57 |
| $J_3$ | 09.46610 | 006.63736 | 310 | 15.70 |
| $J_4$ | 09.46587 | 006.63693 | 303 | 11.20 |
| $J_5$ | 09.46569 | 006.63650 | 291 | 5.86 |
| $J_6$ | 09.46538 | 006.63613 | 301 | 3.00 |
| $J_7$ | 09.46520 | 006.63573 | 305 | 3.54 |
| $J_8$ | 09.46494 | 006.63538 | 304 | 36.60 |
| $J_9$ | 09.46465 | 006.63501 | 303 | 3.00 |
| $J_{10}$ | 09.46429 | 006.63460 | 303 | 17.80 |
| $K_1$ | 09.46704 | 006.63790 | 316 | 16.40 |
| $K_2$ | 09.46672 | 006.63721 | 311 | 26.20 |
| $K_3$ | 09.46640 | 006.63688 | 301 | 3.22 |
| $K_4$ | 09.46617 | 006.63649 | 302 | 4.47 |
| $K_5$ | 09.46588 | 006.63613 | 300 | 15.70 |
| $K_6$ | 09.46560 | 006.63574 | 301 | 15.20 |
| $K_7$ | 09.46533 | 006.63533 | 302 | 40.30 |
| $K_8$ | 09.46504 | 006.63494 | 303 | 7.45 |
| $K_9$ | 09.46473 | 006.63451 | 298 | 16.10 |
| $K_{10}$ | 09.46443 | 006.63412 | 305 | 3.62 |

| | | | | |
|---|---|---|---|---|
| $L_1$ | 09.46746 | 006.63768 | 314 | 15.30 |
| $L_2$ | 09.46734 | 006.63724 | 310 | 8.02 |
| $L_3$ | 09.46703 | 006.63681 | 314 | 6.78 |
| $L_4$ | 09.46677 | 006.63638 | 312 | 12.70 |
| $L_5$ | 09.46650 | 006.63600 | 313 | 13.60 |
| $L_6$ | 09.46621 | 006.63557 | 306 | 5.26 |
| $L_7$ | 09.46585 | 006.63514 | 299 | 3.73 |
| $L_8$ | 09.46552 | 006.63486 | 296 | 7.28 |
| $L_9$ | 09.46529 | 006.63436 | 304 | 7.54 |
| $L_{10}$ | 09.46497 | 006.63390 | 314 | 14.40 |

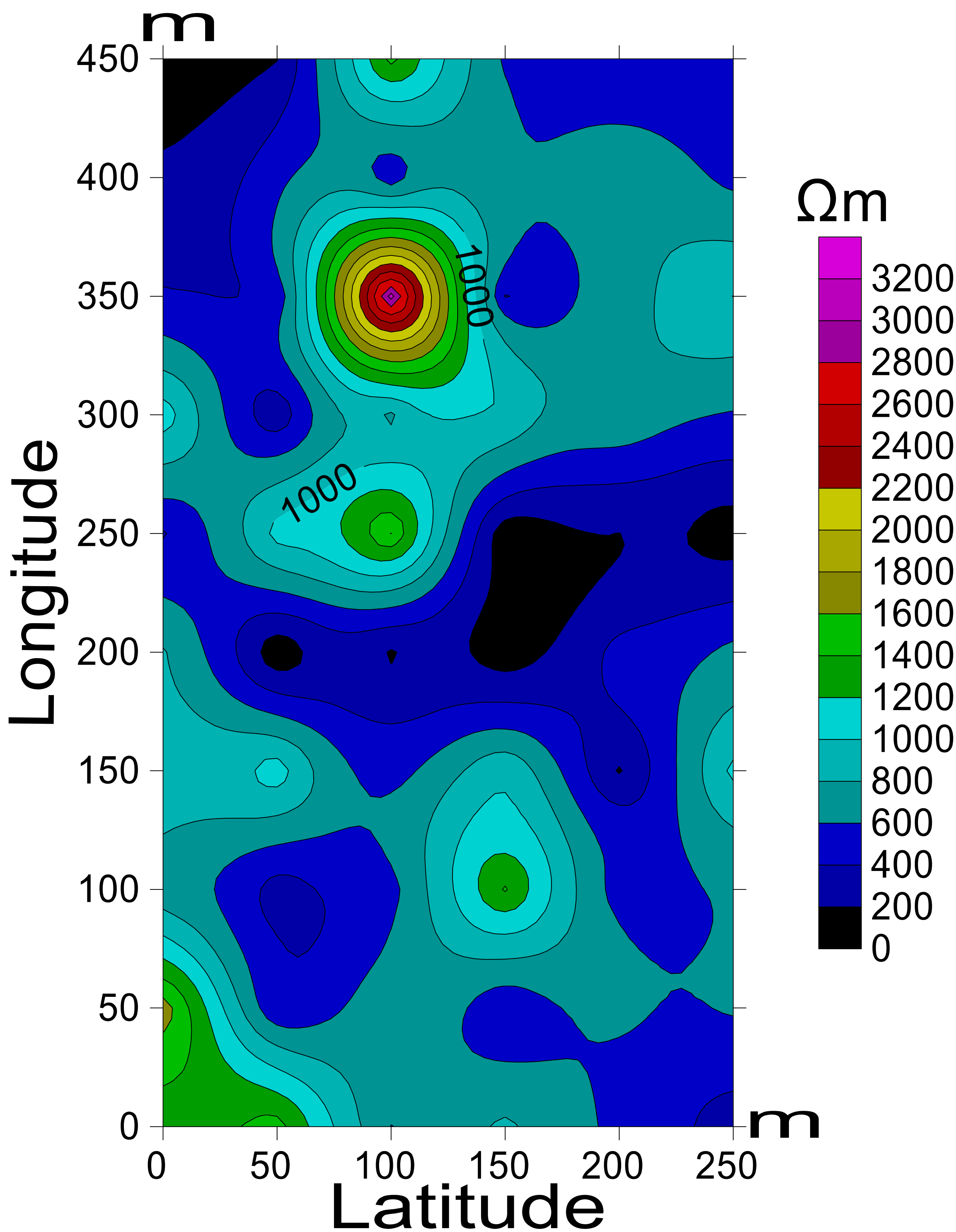



**Figure 4a: Iso resistivity Map of the First Layer**

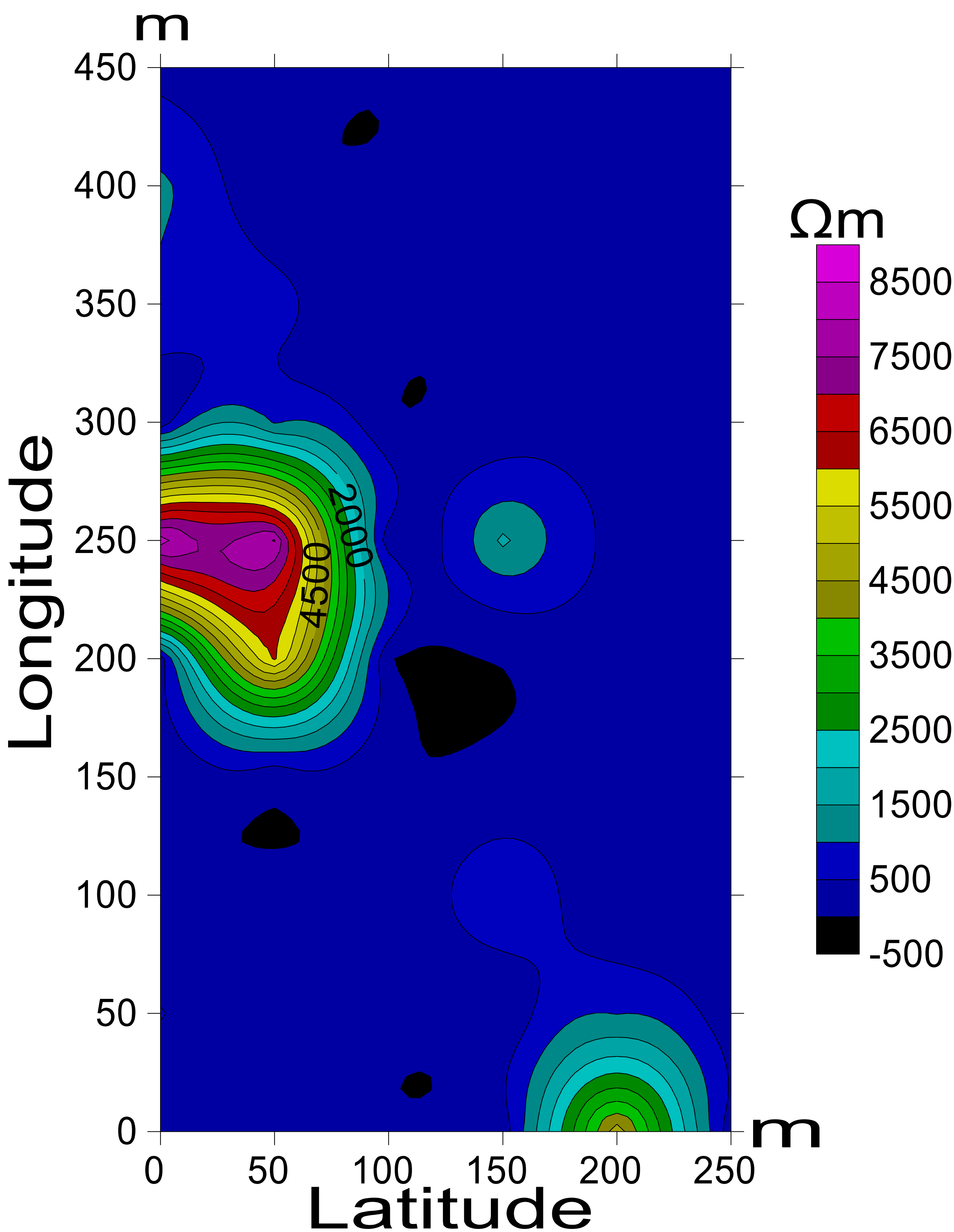



**Figure 4b: Iso resistivity Map of the Second Layer**

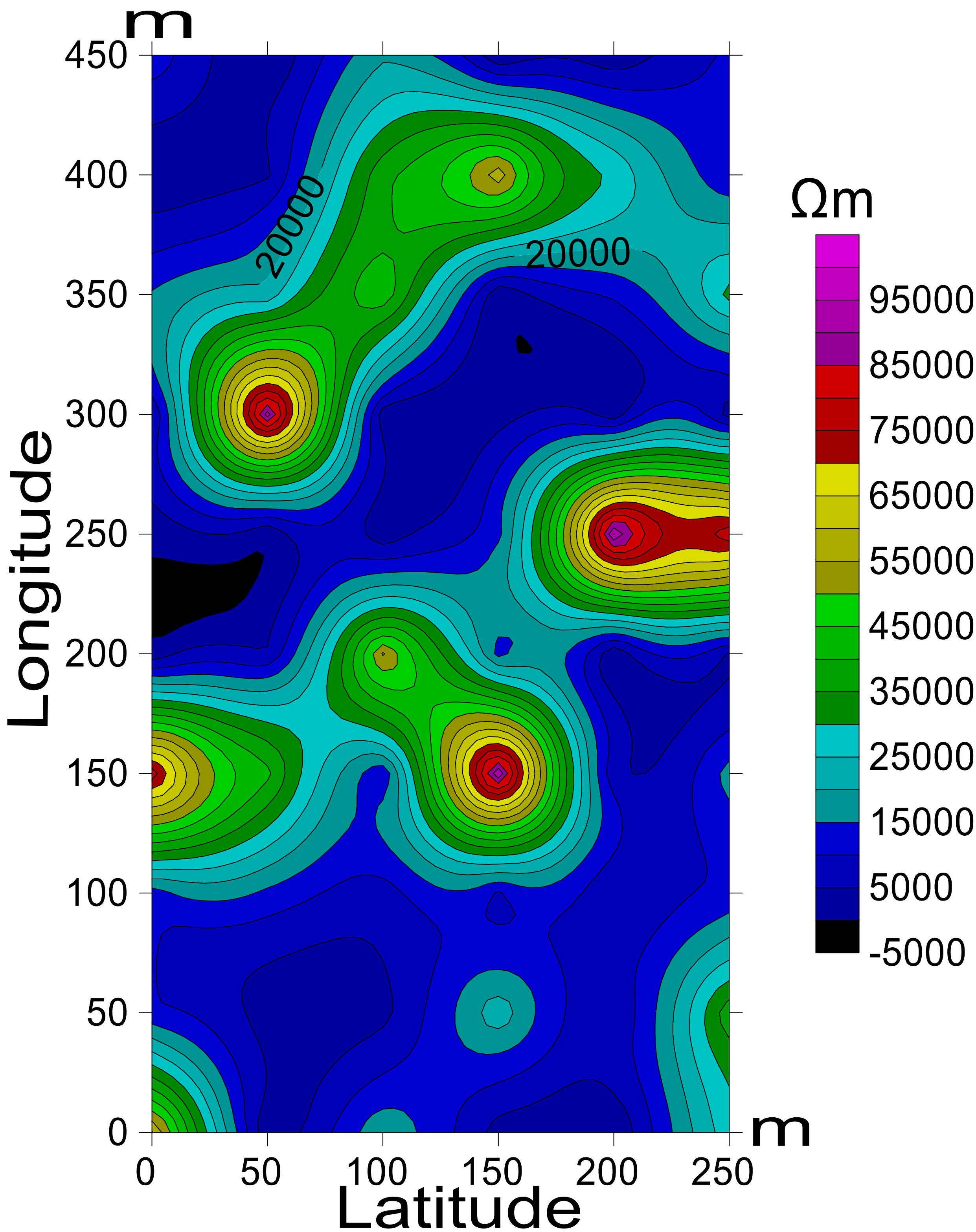
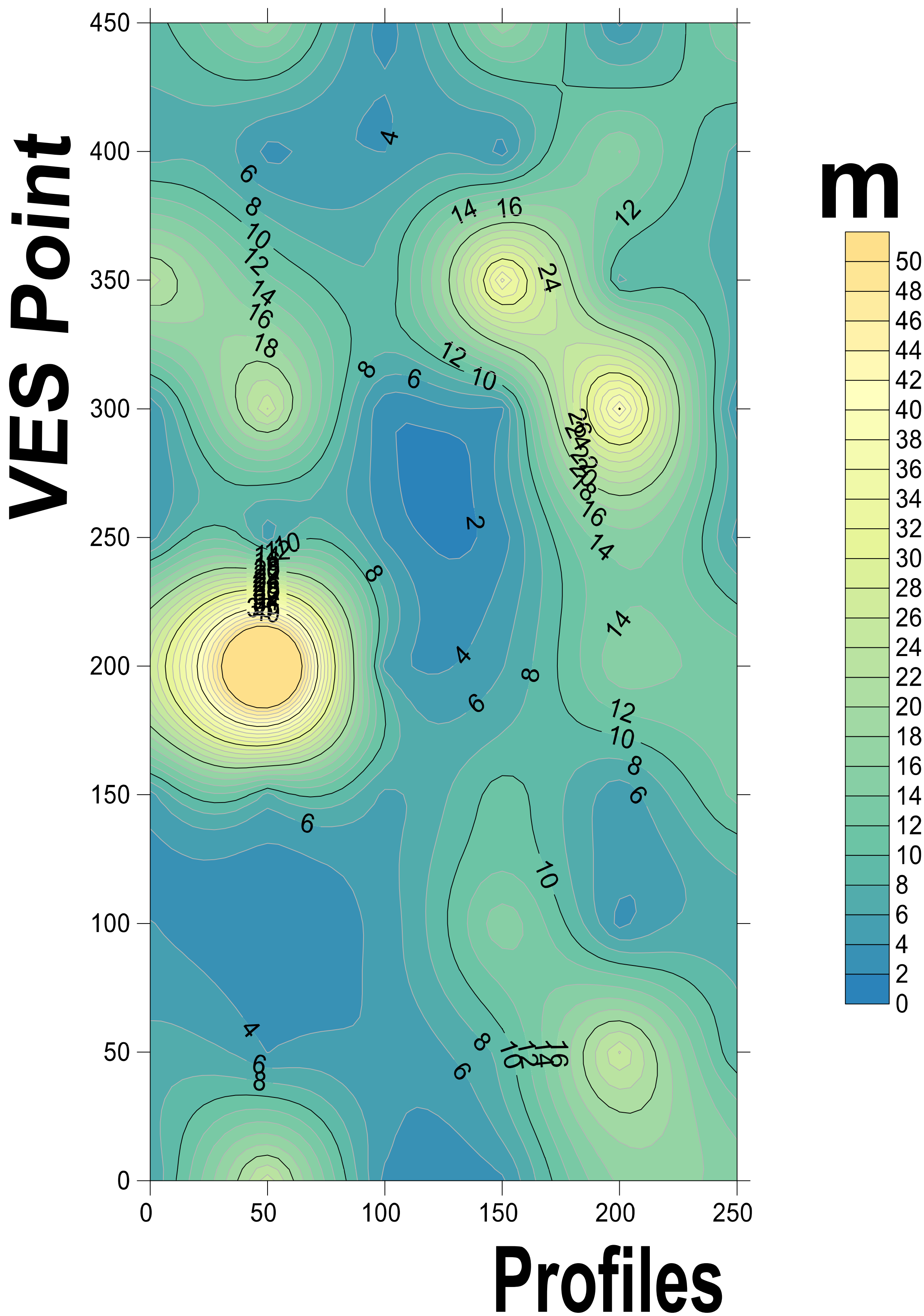

m
450
400
350
300
250
200
150
100
50
0
Longitude
20000
20000
0
50
100
150
200
250
m
Latitude
Ωm
95000
85000
75000
65000
55000
45000
35000
25000
15000
5000
-5000

**Figure 4c: Iso resistivity Map of the Third Layer**



VES Point
Profiles
m

**Figure 4d: Depths to Fresh Basement Contour Map**

**Table 5: Areas Delineated for Building Construction**

| VES STATION | Latitude (degrees) | Longitude (degrees) | Elevation (m) | Depth to Basement (m) |
|---|---|---|---|---|
| $G_7$ | 09.46360 | 006.63642 | 307 | 3.93 |
| $H_2$ | 09.46538 | 006.63799 | 305 | 3.93 |
| $H_3$ | 09.46502 | 006.63739 | 299 | 3.28 |
| $H_9$ | 09.46279 | 006.63505 | 303 | 3.30 |
| $I_1$ | 09.46609 | 006.63838 | 309 | 3.34 |
| $I_6$ | 09.46510 | 006.63634 | 306 | 3.72 |
| $I_7$ | 09.46483 | 006.63597 | 306 | 2.18 |
| $I_9$ | 09.46424 | 006.63528 | 308 | 3.97 |
| $I_{10}$ | 09.46383 | 006.63491 | 296 | 2.78 |
| $J_1$ | 09.46655 | 006.63817 | 312 | 3.61 |
| $J_6$ | 09.46538 | 006.63613 | 301 | 3.00 |
| $J_7$ | 09.46520 | 006.63573 | 305 | 3.54 |
| $J_9$ | 09.46465 | 006.63501 | 303 | 3.00 |
| $K_3$ | 09.46640 | 006.63688 | 301 | 3.22 |
| $K_{10}$ | 09.46443 | 006.63412 | 305 | 3.62 |
| $L_7$ | 09.46585 | 006.63514 | 299 | 3.73 |

Sixteen VES stations were delineated for building construction having depths to fresh basement varying between 2.18 m and 3.93 m and resistivity values ranged between 1038 Ωm and 194453 Ωm, where consolidated basement is shallow as indicated in table 5.

**Conclusion**

The use of various electrical resistivity parameters (resistivity of the layer, depth of the layer, thickness of the layer) were employed to determine the suitable site for building construction. Three to four distinct geoelectric layers were observed namely; Top layer, weathered layer, fractured layer, and fresh basement layer. The observed frequencies in curve types include 21.6% of H, 4.2% of HA, 2.4% of K, 3.6% of A, 1.2% of KH, and 3% of HK. Sixteen VES stations were delineated for building construction, having depths to fresh basement varying between 2.18 m and 3.97 m and fresh basement resistivities ranged from 1038 Ωm to 194453 Ωm. Government and estate developers in the area are encouraged to make use of the results of this study for building construction site selection to reduce the problem of building collapse and cracking of walls. More research work in this area would contribute to solving the problem of collapse of building completely.

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