International Journal of Recent Engineering Science (IJRES) Volume 6 Issue 1, 14-20, Jan-Feb 2019
ISSN: 2349 – 7157 / doi: 10.1445/23497157/IJRES-V6I1P104

Determination of Stratigraphic Sequence of Rocks Using Vertical Electrical Sounding: In Federal University Wukari, Taraba State, Northeast Nigeria

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Abstract

The quest for mineral exploration, search for water, and pre-construction surveys have become so prevalent in our society today. Structures that host some of the minerals are found in or within the striatal components of layers. The geo-electrical investigation involving the electrical resistivity method was carried out within the premises of Federal University Wukari to generate the surface and subsurface geologic information that was used in determining the stratigraphic sequence in the study area. Eleven (11) vertical electrical sounding points were conducted. The data obtained were interpreted by the computer iteration process. This was done to observe the variability in a layered structure concerning resistivity. Analysis of result reveals that layer one has a resistivity range from 48.96Ωm-9374.4Ωm, layer two has 47.32Ωm-721.7Ωm, layer three 0.573Ωm-787.76Ωm, layer four has 0.034Ωm-3172Ωm, and layer five has 0.487Ωm-6914.9Ωm. they corresponding thickness ranges from 0.28m-4.89m, 0.424m-15.05m, 1.04m-30.5m and 2.18m-33.56m respectively. The analysis also reveals four to five lithological units comprising top lateritic soil, sandstone, silt, sandy shale, shale, and intercalation of clay-shaley materials.

Keywords: Geo-electric Section, Geology, Resistivity, StratigraphicSequence, Variations,

I. Introduction

The stratigraphic sequence is the study of sediments and sedimentary rocks in repetitively arranged facies and associated strata geometry [9, 7]. It is a technique that can be traced back to the work of [8] on interregional unconformities, but it became systematized only after the advent of seismic stratigraphy.

Stratigraphic sequence, therefore, is a methodology that provides a framework for the element of depositional setting [4, 5]. This framework ties changes in striatal stacking patterns to the response of varying accommodation and sediment supply through time [8]. Striatal stacking patterns enable the determination of how strata were laid down and explain the geometric relationships and architecture of sedimentary strata.

The geophysical method like the vertical electrical sounding will serve as an alternative to the seismic method in that it determines variation in stratigraphic sequence by observing changes in lithological resistivity [1, 5, 6, 9]. Based on this, eleven vertical electrical soundings (VES) points were conducted in Federal University Wukari with the view of delineating stratigraphic sequences.

Federal University, Wukari, which is located along Wukari-Zakibiam Road in Wukari Local Government Area of Taraba State, North-eastern Nigeriafalls within longitudes 9°46'30''E and 9°46'10''E and latitudes 7°50'32''N and 7°50'39''N (Fig 1), with an estimated area of 4 Km^2 at an elevation of 153 meters above sea level.

This study aims to determine the stratigraphic sequence using vertical electrical sounding in Federal University Wukari, Taraba State. Geologically, Federal University Wukari is located within the Mid-Benue Trough. The middle Benue Trough is the central segment of the Nigerian Benue Trough, a Northeastern-Southwestern trending sedimentary basin, with an approximate length of about 800 km and bounded on its southwestern and northeastern ends by the Niger Delta and the Chad Basin, respectively. The area comprises three major groups of rocks commonly found in northeastern Nigeria, namely, the Precambrian Basement Complex, Cretaceous Sediments, and Tertiary/Quaternary volcanic rocks [2].

II. Data Acquisition/ Interpretation

Eleven (11) Schlumberger vertical electrical soundings (VES) were carried out using ABM SAS 300CTerrameter and 12 volts universal DC/AC frequency of5HZ. During the field procedure carried out in July 2018, the Schlumberger array of AB/2 = 68m was used, while the vertical electrical sounding method was adopted. In the vertical electrical sounding, the goal is to observe the variation of resistivity with depth. The technique is best adopted to determine depth and resistivity for flat-lying layered rock structures, such as sedimentary beds, or the depth to the water table.

The Schlumberger array is most commonly used for vertical electrical soundings (VES) investigation. During the field procedure, the array's mid-point was kept fixed while the distance between the current electrodes was progressively increased. This causes the current lines to penetrate to even greater depths, depending on the vertical distribution of conductivity.

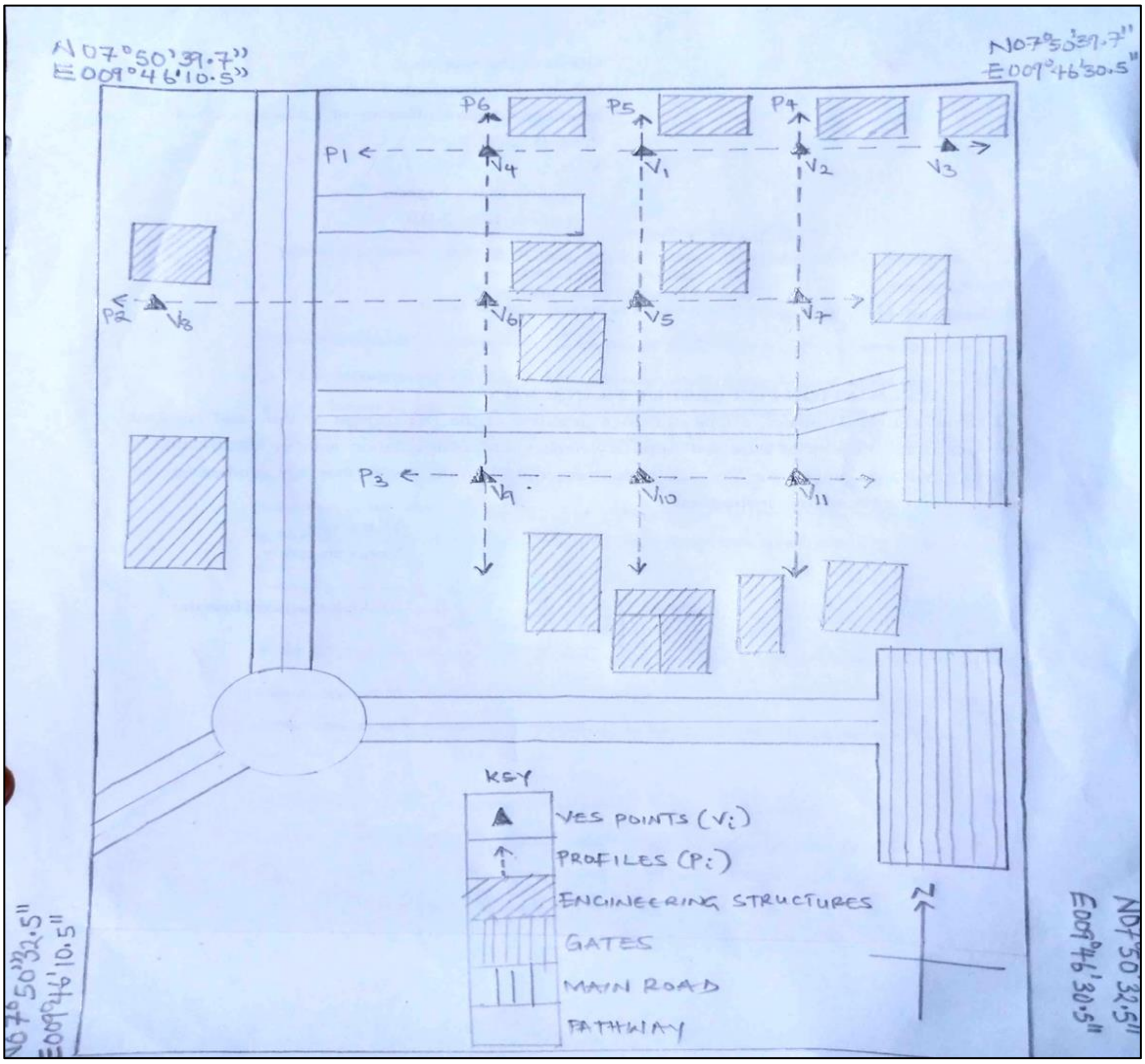

Figure 1: Layout of the study area showing VES locations/profiles.

The apparent resistivity obtained from the field was plotted against half of the current electrode spacing AB/2 on a log-log graph scale.

Based on this preliminary interpretation, an estimate of resistivity and thickness of various geoelectric layers was obtained. These were later used as starting models for a computer programmed [12].

III. Discussion of Results

The results of the computer analysis obtained from the ten (11) VES points are presented in Table 1. The table consists of depths/thickness of various lithological layers with their corresponding resistivity and their description.

From the interpretation result in Table 1, the first layer (top lateritic soil) has an average resistivity of 1,121.175Ωm with an average thickness of 1.667m and at a mean depth of 1.667m. The second layer (sandstone) has an average resistivity value of 175.255Ωm at an average depth of 5.757m. The third layer, mainly clay, has an average resistivity of 111.043Ωm at an average depth of 10.172m. The fourth layer and the fifth layer (which occurs only for VES 3, 4, and 10) possess mean resistivity values of 696.176Ωm and 2,331.809Ωm respectively, at depths below 10.172m. Electrical methods primarily reflect variations in ground resistivity. The electrical resistivity contrasts existing between lithological sequences in the subsurface are often adequate to enable the delineation of geoelectric layers (Fig 2 -6) are presented as profiles 01, 02, 03, 04, 05, and 06.

IV. PROFILES

Profile 01 (Fig 2) below, consisting of VES 4, 1, 2, and 3, is underlain by five (5) distinguishable stratigraphic units. The first layer, top lateritic soil, has a resistivity value ranging from 48.960Ωm - 4376Ωm at an average depth of 1.625m. The second layer, which is silt, has a resistivity value ranging from 64Ωm - 314Ωm with thickness ranging from 0.420m – 9.400m at an average depth of 6.223m. The third layer, which is clay, has resistivity values ranging from 3.020Ωm – 787.760Ωm at a depth of 2.570m – 20.000m. The fourth layer, shale-clay, has a resistivity value of 19Ωm while the fifth layer has resistivity values of 31.72Ωm and 272Ωm, respectively. The layers are not lateral in extension and exhibit nonuniformity.

Profile 02(Fig 3) below, consisting of VES 6, 5, and 7, is underlain by five distinguishable stratigraphic units. The first layer, top lateritic soil, has a resistivity value ranging from 148.82Ωm - 401Ωm at an average depth of 2.377m. The second layer, which is lateritic, has a resistivity value ranging from 677Ωm. The third layer, which is siltstone, has resistivity values ranging from 65Ωm - 721Ωm at a depth of 15m. It can be observed that shale is in between siltstone and sandstone and has a resistivity value of 10Ωm - 51Ωm at a depth of 31.57m, while sandstone lies below the shally bed and has a resistivity of 1371Ωm - 2555Ωm.

Profile 03 (Fig 4) below, consisting of VES 9, 10, and 11, is underlain by four (4) distinguishable stratigraphic units, except for VES 10, which has a high resistive (6,914.900Ωm) fifth layer (sandstone). The first layer, top lateritic soil, has a resistivity value ranging from 190.100Ωm – 546.150Ωm at an average depth of 0.918m. The second layer (shale/clayey materials) has a resistivity value ranging from 13.320Ωm – 89.435Ωm with thickness ranging from 0.445m – 7.636m at an average depth of 4.914m. The third layer (clay/sandstone) has resistivity values ranging from 0.573Ωm – 306.790Ωm at a depth of 2.680m – 27.418m. The fourth layer (shale)has resistivity values ranging from 27.530Ωm – 58.590Ωm at depths below 2.680m.

Profile 04 (Fig 5) below, consisting of VES 2, 7 &11, is underlain by four distinguishable stratigraphic units. The first layer, top lateritic soil, has a resistivity value ranging from 196.30Ωm-677.300Ωm at an average depth of 1.432m. The second layer, which consists of silty materials (siltstone), has a resistivity value ranging from 13.320Ωm-112.400Ωm with thickness ranging from 0.445m-8.4m at an average depth of6.94m. The third layer, which is shale-clay, has resistivity values ranging from 4.7Ωm-306.79Ωm at a depth of 2.68m-26.46m. The fourth layer comprises of sandstone/shale with resistivity values of (0.034Ωm-222.8Ωm). These layers do not have uniformity and lateral extent as the thickness varies with depth.

Profile05 Fig 6 comprises four geo-stratigraphic sequences comprising of laterite, silt, shally-clay, and sandstone. The first sequence, which is mainly laterite, has resistivity values of 89Ωm-9376Ωm at a depth of2.2m. The second layer, which is silty, has resistivity values of 314Ωm and 721Ωm with a corresponding thickness of 2.2m to 9.0m, respectively. The third layer depicts a shally-clay unit that ranges in thickness from 9.0m to 24m. It is observed that the layer is not uniform but appears to have been deformed.

Profile 06 consists of VES 4, 6, and 9 and is underlain by four distinguishable stratigraphic units. The first layer, top lateritic soil, has a resistivity value ranging from 132Ωm-190Ωm at an average depth of 2.3m. The second layer, which is siltstone, has resistivity values ranging from 47Ωm-65Ωm with a thickness that ranges from 3.8m-16m. The third layer (shally-clay) has resistivity values ranging from 10Ωm-19Ωm at a depth of 3.3m-33m. The fourth layer, the main shale, has resistivity values from 31Ωm, 80Ωm, and 255Ωm, respectively. The layers are not generally uniform in thickness and depth.

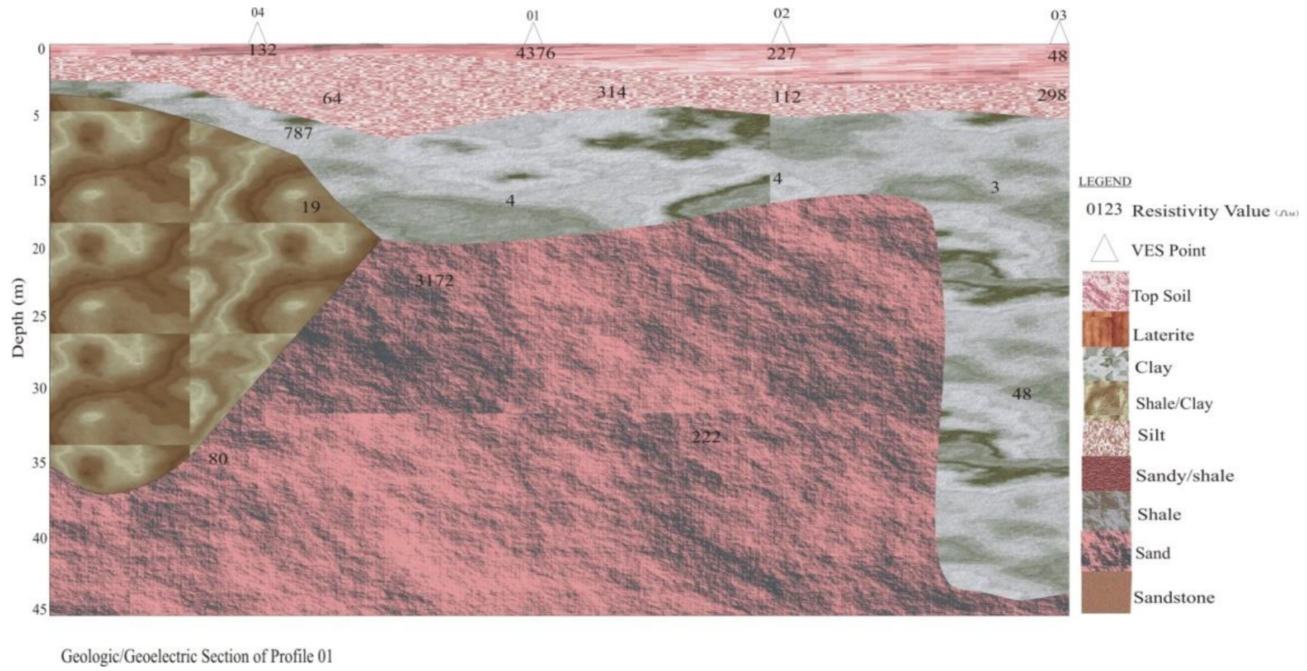

Figure 2: Geologic/Geo-electric Section of profile 01

Table 1.Summary of Result Obtained from Computer Interpretation of 11 VES Points.

Ves	Location	Layers	Resistivity(Ωm)	Thickness(m)	Depth(m)	Lithology
1	7^{0}50’40’’n 9^{0}46’28’’e	1	9,376.4	0.38	0.380	Topsoil
		2	314.11	8.38	5.900	Sandstone
		3	4.02	8.76	14.660	Shale/clay
		4	3,172	-	-	Sandstone
2	7^{0}50’41’’n 9^{0}46’34’’e	1	227.4	3.2	3.200	Topsoil
		2	112.4	9.5	12.600	Sandstone
		3	4.7	7.4	20.000	Shale/clay
		4	222.8	-	-	Sandstone
3	7^{0}50’45’’n 9^{0}46’31’’e	1	48.96	1.95	1.950	Top lose soil
		2	298.95	3.75	5.000	Sandstone
		3	3.02	1.04	6.060	Clay
		4	48.2	33.56	39.600	Shale
		5	0.487	-	-	Clay
4	7^{0}50’39’’n 9^{0}46’28’’e	1	132.5	0.97	0.970	Topsoil
		2	64.11	0.424	1.390	Clay
		3	787.76	1.176	2.570	Sandstone
		4	19.611	30.16	32.730	Shale/clay
		5	80.04	-	-	Shale
5	7^{0}50’39’’n 9^{0}46’24’’e	1	401.47	1.96	1.960	Topsoil
		2	721.7	1.02	2.980	Sandstone
		3	51.82	17.47	20.450	Shale
		4	37.42	-	-	Clay
6	7^{0}50’37’’n 9^{0}46’20’’e	1	148.82	4.89	4.890	Topsoil
		2	65.829	15.05	19.950	Shale
		3	10.140	16.94	36.880	Clay
		4	2,555.4	-	-	Sandstone
7	7^{0}50’33’’n 9^{0}46’29’’e	1	677.3	0.28	0.280	Lateritic soil
		2	86.835	6.686	6.966	Silt material
		3	25	30.5	37.460	Shale
		4	0.034	-	-	Clay
8	7^{0}50’38’’n 9^{0}46’18’’e	1	387.52	1.949	1.949	Topsoil
		2	113.8	6.525	8.470	Sandstone
		3	15	8.02	16.490	Shale
		4	1,485	-	-	Sandstone
9	7^{0}50’30’’n 9046’22’’e	1	190.1	1.142	1.142	Topsoil
		2	47.319	7.636	8.778	Shale
		3	12.65	18.639	27.418	Clay
		4	31.35	-	-	Shale
10	7^{0}50’31’’n 9^{0}46’29’’e	1	546.15	0.796	0.796	Lateritic soil
		2	89.435	3.906	4.703	Shale
		3	0.573	0.527	5.230	Clay
		4	58.59	2.18	7.411	Shale
		5	6,914.9	-	-	Sandstone
11	7^{0}50’34’’n 9^{0}46’35’’e	1	196.3	0.815	0.815	Topsoil
		2	13.32	0.445	1.260	Clay
		3	306.79	1.42	2.680	Sandstone
		4	27.53	-	-	Shale

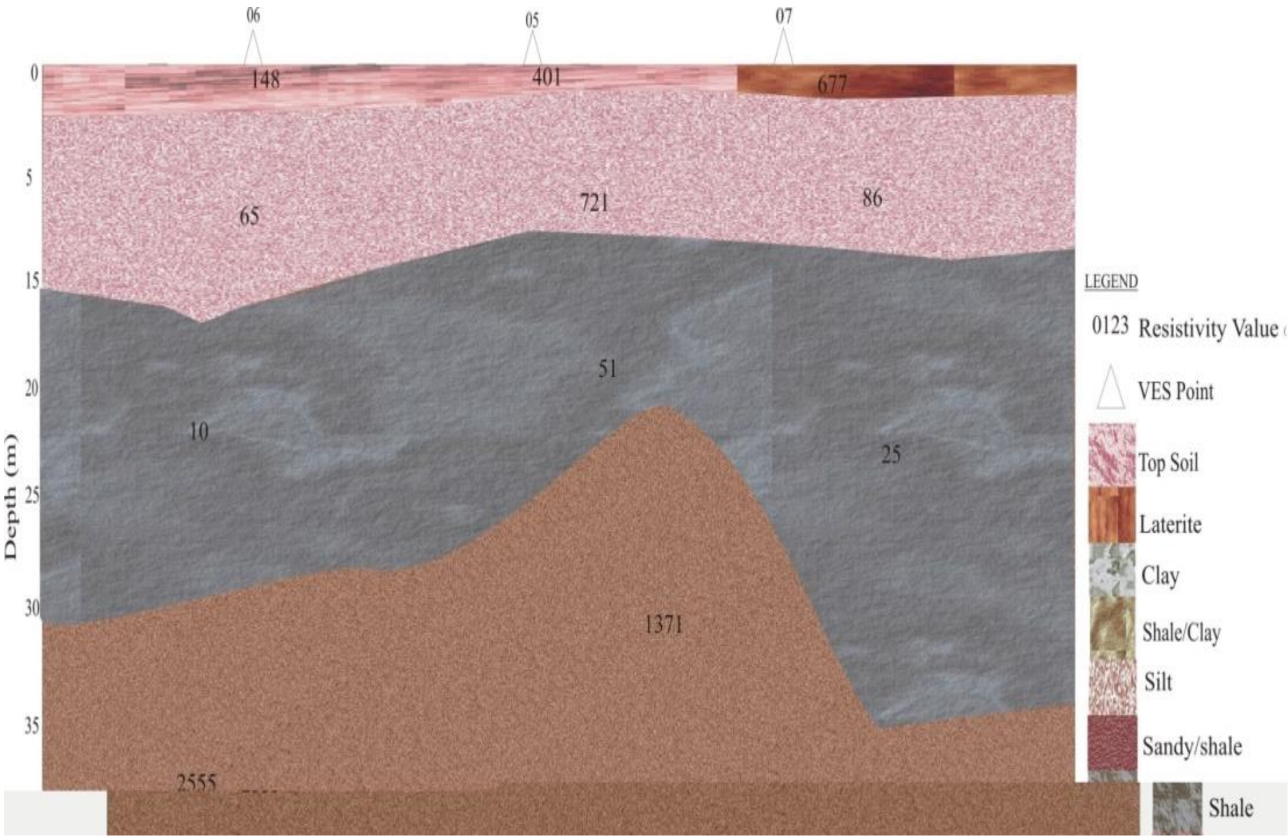

Figure 3: Geologic/Geo-electric Section of profile 02

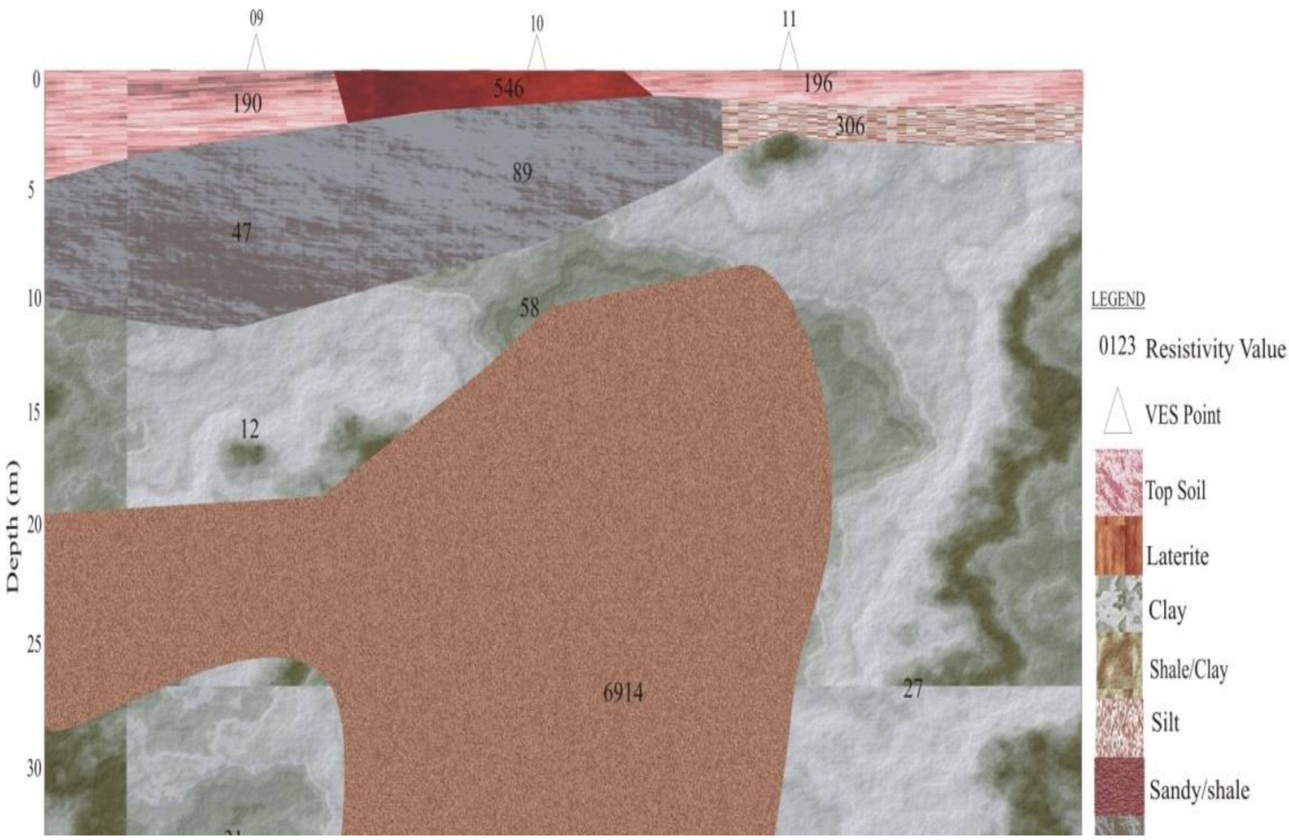

Figure 4: Geologic/Geo-electric Section of profile 03

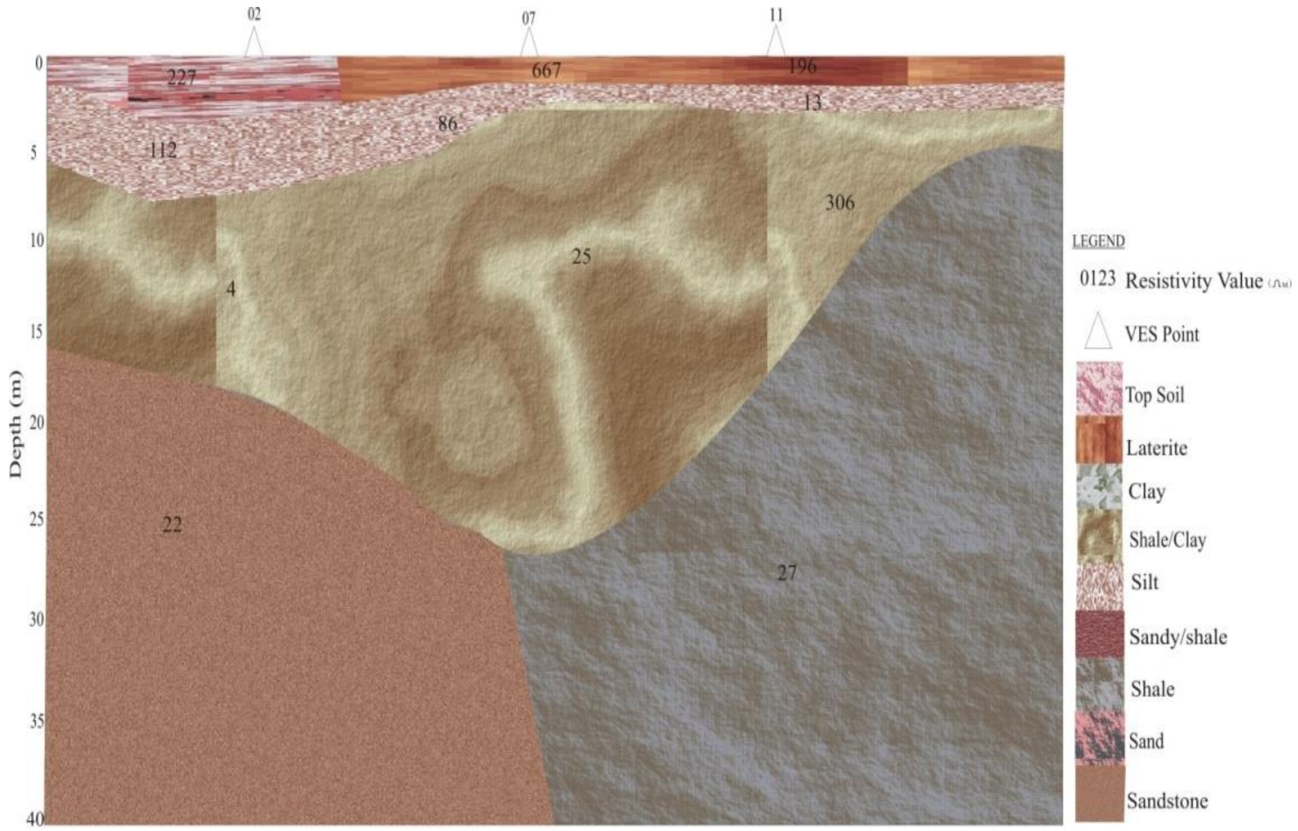

Figure 5: Geologic/Geo-electric Section of profile 04

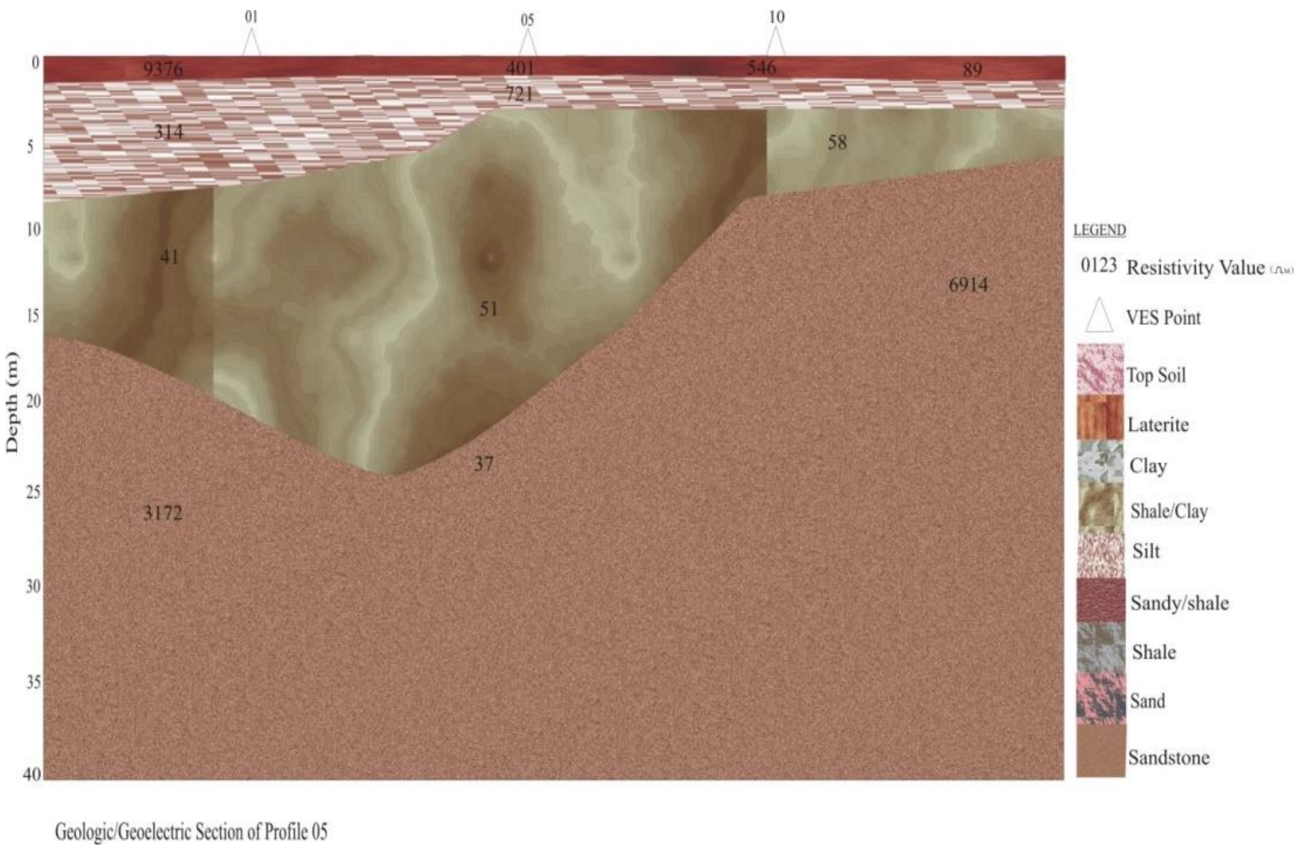

Figure 6: Geologic/Geo-electric Section of profile 05

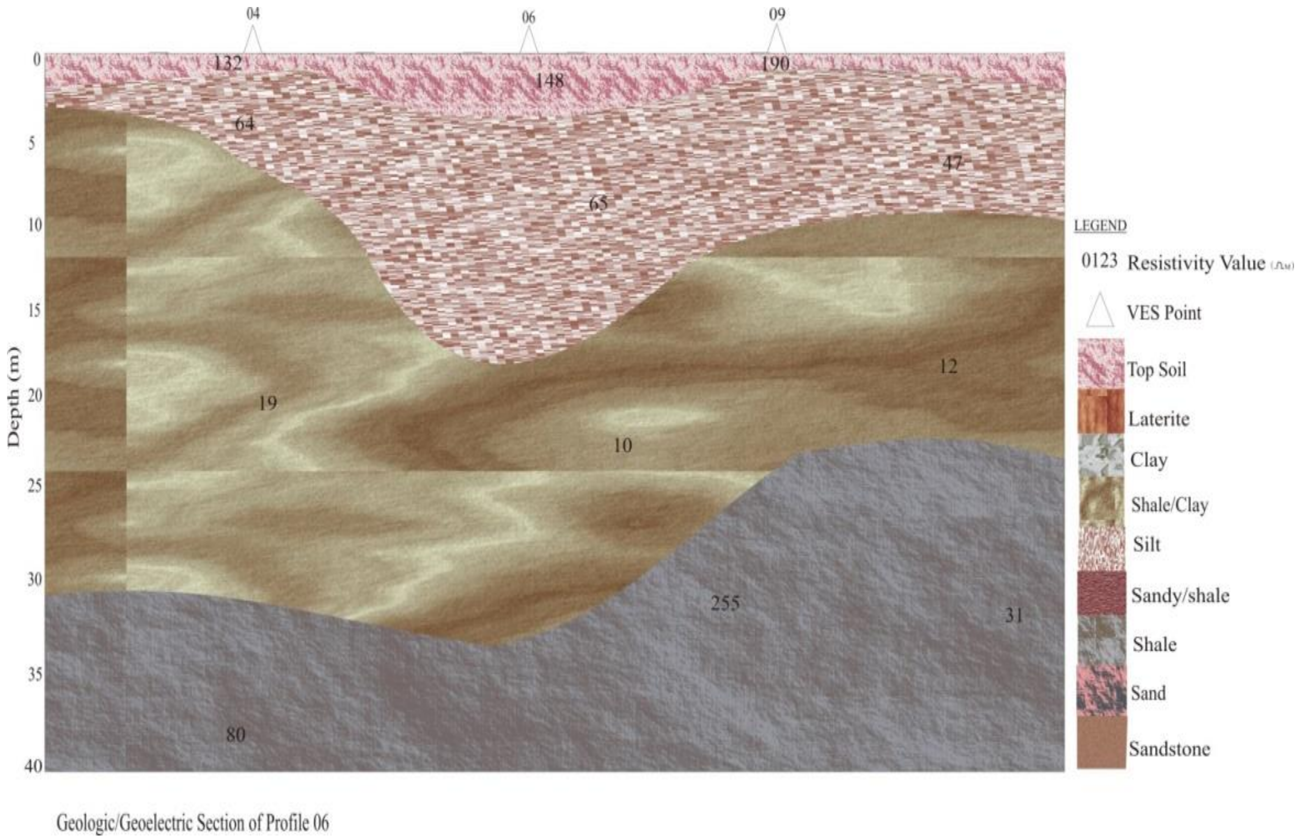

Figure 7: Geologic/Geo-electric Section of profile 06

V. Conclusion

The subsurface investigation using vertical electrical sounding in Federal University Wukari, Taraba State revealed that the stratigraphic sequence consists of four to five layers. Based on the results of the interpreted resistivity measurement, geoelectric and geologic sections have inferred that range from top lateritic soil, silt, clay, shally clay, shale, and sandstone. These studies, therefore, provide a guideline for generating stratigraphic sequences from available data acquired by electrical sounding and profiling. In this work, we showed that the stratigraphic sequence interpolated from the data is not uniform in thickness and lateral extent.

VI. Acknowledgement

The authors are grateful to Taraba State Rural Water Supply and Sanitation Agency for providing them with the ABEM 300C Terrameter, which they used in acquiring the data use for this work.

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