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HYDROGEOPHYSICAL INVESTIGATION OF UNDERGROUND WATER IN SABON KAURA COMMUNITY, BAUCHI, NIGERIA

Mohammed Musa Musa[1], Samuel Osarenren Osaghae[2]

and Sanni Eshovo Blessing[3]

[1]Geosolve Consultant Limited, Bauchi, Nigeria

musa84648@gmail.com

[2]Geological Technology Department, Auchi Polytechnic, Auchi, Edo, Nigeria

sammyosaghae@gmail.com

[3]Geological Technology Department, Auchi Polytechnic, Auchi, Edo, Nigeria

blessingeshovo@gmail.com

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ABSTRACT: *Hydrogeophysics is the investigation of underground formations to understand the hydrologic cycle using geophysical techniques, which aids to understand the groundwater quality and type of aquifer. One of the surface geophysical methods is the Vertical Electrical Sounding; it is effective in the investigation of layer resistivity and thicknesses of layers at various depths of interest as well as aquifer thickness. Twenty (20) VES points were sounded with maximum spread AB/2 of 60 m. The VES data was processed using IPI2 win and sounding curves obtained at most combinations which include HA, QH, KHK, KHA, A and H. The sounding curves were observed to have five layers at most: the first layer resistivity and thickness ranges (53.1–606 Ωm, 0.545–6.24 m) followed by the second layer ranging (7.7–730 Ωm, 2.17–20.4 m) and the third layer act in most of the VES as the aquiferous zone which ranges from (19–160000 Ωm, 17.2–20.1 m); jiggling was also observed within the fractured-fresh crystalline basement which represents fractures. The recommended depth of drilling ranges from 50–60 m over granite/bauchite where extensive weathering and fracturing is observed and over migmatite and gneiss 70–80 m as only fracturing was observed at deeper depth. The yield anticipated in the recommendation is moderate-high with a very low or low yield from the non-recommended VES.*

KEYWORD*s:* VES, Rock Type, Basement, Geoelectric Section and Potential Zones.

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INTRODUCTION

The research is aimed at conducting geoelectric investigations (VES) in Sabon Kaura community, Bauchi, Northeastern, Nigeria in order to determine the electrical resistivity parameters of the area in preparation for groundwater exploitation. The study's goals are to evaluate the lithology of the study area, its aquifer protective capacity, and some aquifer parameters of the subsurface rocks in the area in order to delineate the subsurface layers for groundwater potential zones in the area. This was prepared to figure out what was responsible for rampant cases of failed/abortive boreholes in the area.

Due to the rate of growth of the population in recent years in the study area and water being an essential part of human beings, the need to search for more sources of water has become a mandatory issue as the water supply is not reaching the demand of the settlement/community. The area constitutes rocks which hand dug wells cannot be sufficient for the masses and dries off as soon the raining season is past. The search for groundwater has become imperative and has led to the need for more intensive studies of the geometry and properties of aquifers to explore and exploit.

Figure 1: Map of Sabon Kaura with VES Points

Geology and Hydrology of Bauchi

The study area lies in Bauchi on longitude 10.28741□N and latitude 9.78767□E. The geology of Bauchi is generally subdivided in to three units. Bauchi State is basically underlain by crystalline rocks of Nigeria basement complex. Quartz diorite occurs as veins and dykes within the migmatites and granites. The dykes vary in thickness from 10cm to as much as 100cm and

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are also about 1km across. They generally cut across the structure in the host rock having sharp contact with them; the quartz diorite is grained melanocratic rock (Koebe, 1987).

Fayalite bearing charnokitic rocks (Bauchite) and quartz diorite occur widely in the older granite complexes of Bauchi area. The Bauchite are larger bodies up to 10km across with gradation boundaries whereas the quartz diorite is small discrete intrusion up to about 1 km across or dyke close to or intruding into Bauchite (Oyawoye, 1961). Bauxite was described as coarse grained augite syenite by Falcon (1911) and later Bain (1926). The distinctive features of quartz-diorite and Bauxite were first described by Oyawoye (1961) who named them Bauxite. Fresh samples of Bauxite are dark green due to the green or brown color of feldspar (Rahman, 1971).

The pegmatites are found crosscutting the country rocks within the area of interest. They can be divided into concordant and discordant. The concordant pegmatites are those found parallel to the pre-existing structure while discordant are those truncating the pre-existing structure in the rock. The pegmatite is made up of coarse quartz and feldspar, mostly potassium feldspar with little biotite.

Bauchi is a basement terrain; the weathered zone forms an aquifer with limited resources. The fractured zones occurring within the fresh basement on the other hand constitute the richer aquifer with water yield which tends to be constant depending on the rock type. Since the thickness of the weathered and fractured layer forming the aquifer determines the size of its water bearing capacity, therefore, the maximum groundwater potential in these basements complex part of the state is to be found along the fracture and fissured lines which constitute the preferential flow paths of groundwater.

MATERIALS AND METHODS

This research involved the use of a geophysical method called the electrical resistivity technique using schlumberger array configuration; the instruments used are OMEGA terrameter and accessories to delineate the groundwater potential zones. This is an active technique in electrical methods where current is injected to the subsurface through a pair of current electrodes, one serving as source and the other as sink, and the resultant potential is also measured across another pair of electrodes known as the potential electrodes. The current moves through the subsurface hemispherical from current electrode 1 (source) to electrode 2 (sink) and it is approximately calculated that the depth of penetration is equal to the half current electrode separate. A third-party software package IPI2Win was used for the resistivity data processing.

Geoelectric section plotting is the process of determining the extent to which the depth of a particular portion of the rock with different resistivity values varies. It can be done using the interpretation software which includes surfers. In order to have a good understanding of the subsurface geology of the study area, geoelectric section was obtained for some of the location in the study area.

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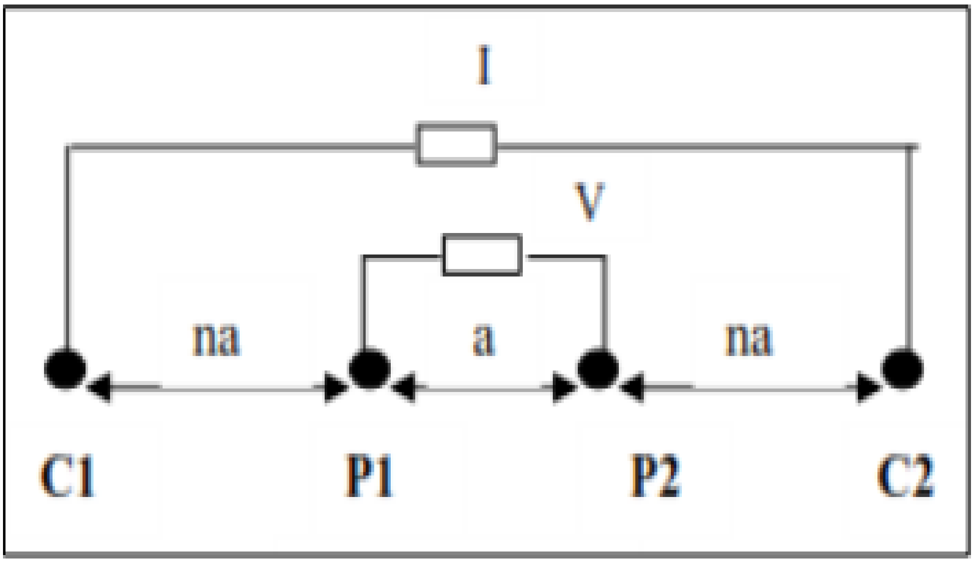

Figure 2: Schlumberger Configuration (Telford, 1990)

RESULTS AND DISCUSSION

Based on the geological mapping conducted/reconnaissance survey in the area, it was found that the rock type of the study area is mostly granite that occupies large portion within the study area, and some parts of the study area are dominated by metamorphic rocks based on this research, two lithologies were observed for granitic and metamorphic rocks with a coarse-fine grain.

From the observed interpreted curves (as illustrated below), it shows that the geo-electrical layers from the sounding points are mostly of H-type, HA-type, A-type, and KHA-type curves. The H-type curves are VES 01, 03, 04, 07, 09, 11, 13, 14, 16, 17 and 18; the A-type curves are VES 19 and 20, HA-type curves are VES 06, 08, 10, 12 and VES 15, only 1 VES is with KHA type of curve and VES 02 as HAA- type of curve. The A-type curves are usually known for groundwater reserves not being feasible since $\rho_1 < \rho_2 < \rho_3$ indicating that the resistivity of the upper geoelectric layer ρ_1 is lower than that of the intermediate layer ρ_2 and the intermediate resistivity is also lower than that of the lowest layer. The H-type and that of HA-type curves are usually known to contain good water reserve as$\rho_1 > \rho_2 < \rho_3$. The VES points with the H- or HA-type curves can only be recommended for sitting of borehole if the aquifer(s) or intermediate layers' resistivity has sufficient thickness and is/are found to be at least deeper so as to avoid surface water infiltration.

The figures below show different types of resistivity layers, in some areas (3 layers of the rock) were obtained and the other part of the study area has about 4 layers geoelectrical. The layers also show different resistivity values ranging from low, medium and high resistivity values respectively; this brings about the differences in thickness of the rock layers. The layers can be inferred as top soil with high-low resistivity value followed by the weathered basement with low-medium resistivity then fractured rock with almost medium resistivity value, and finally to the fresh basement with the highest resistivity value.

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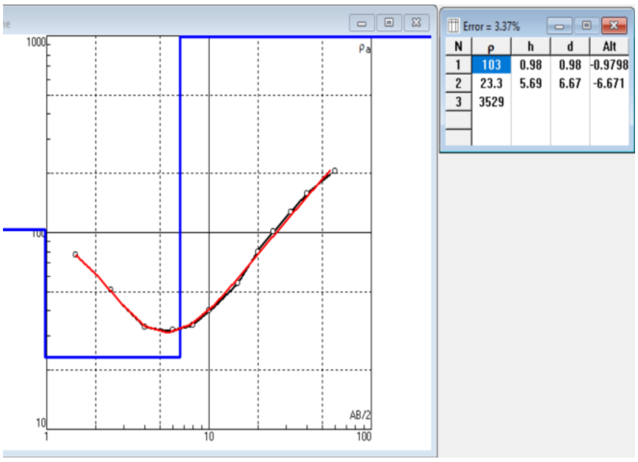
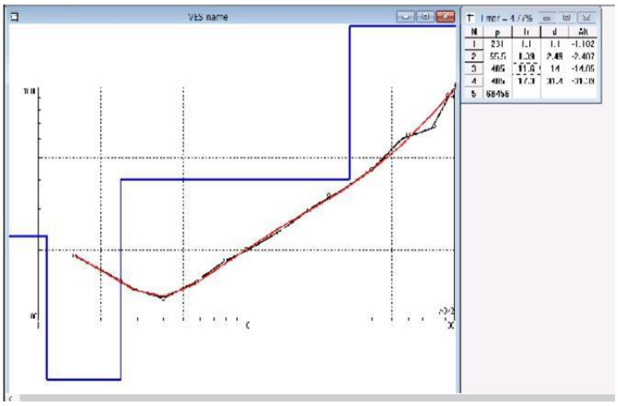
Electrical resistivity data and the computer-generated curves for VES 1 - 20.

VES 1



VES 2



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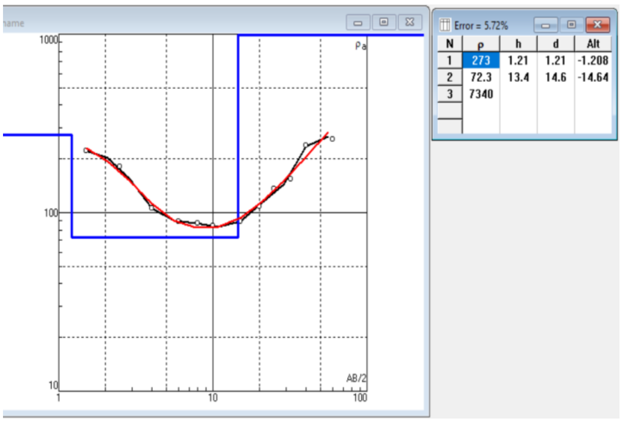

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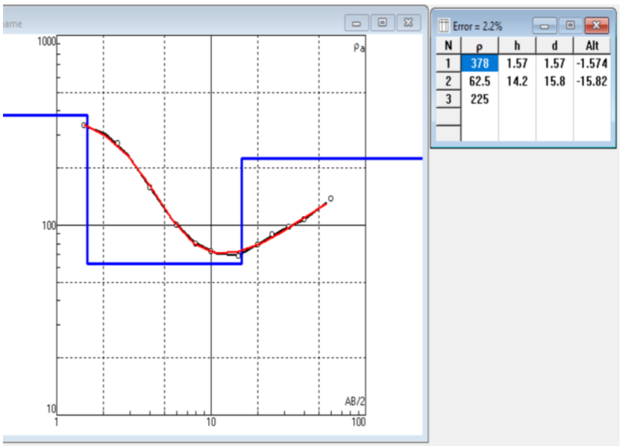
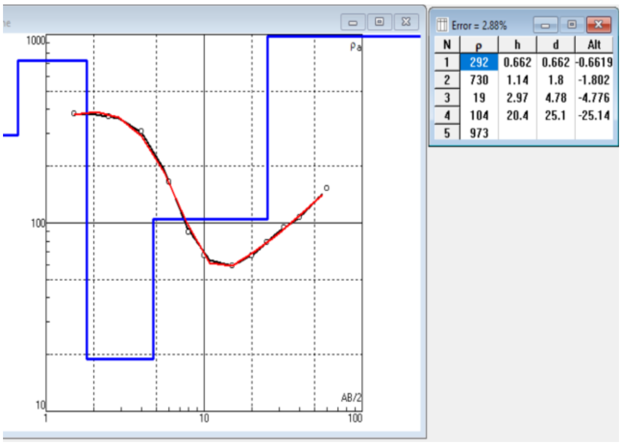
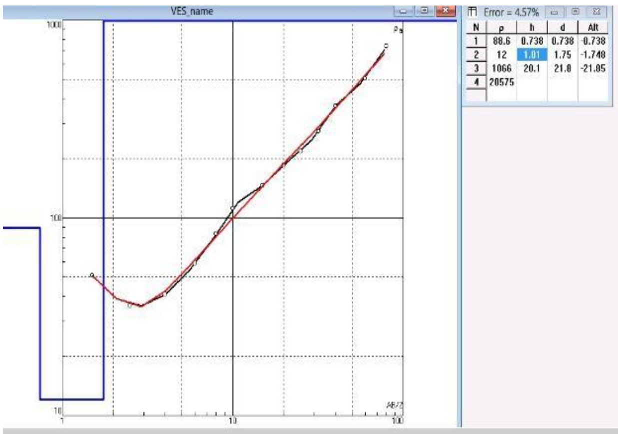
VES 4



VES 5



VES 6



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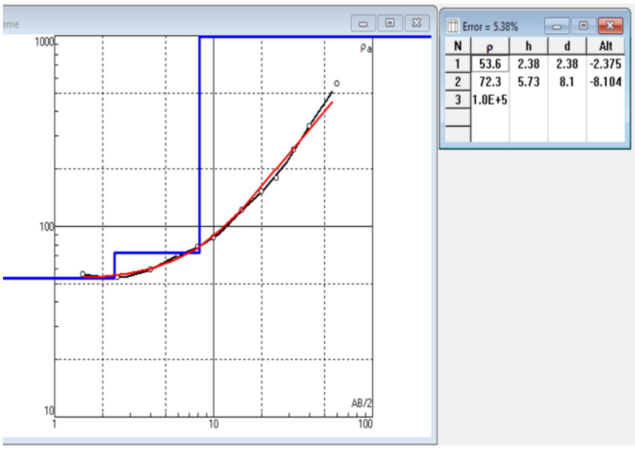
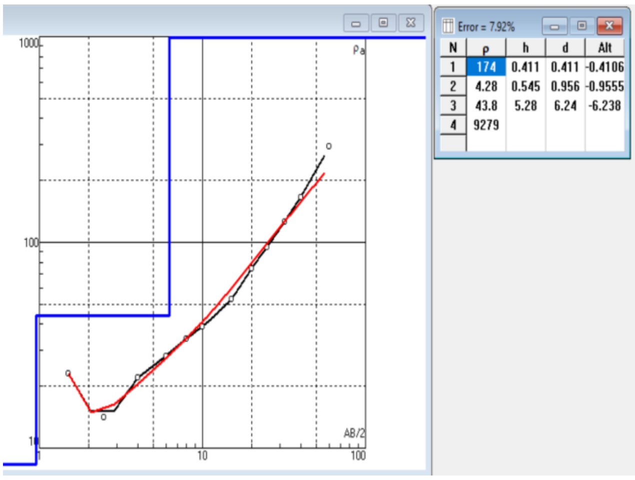
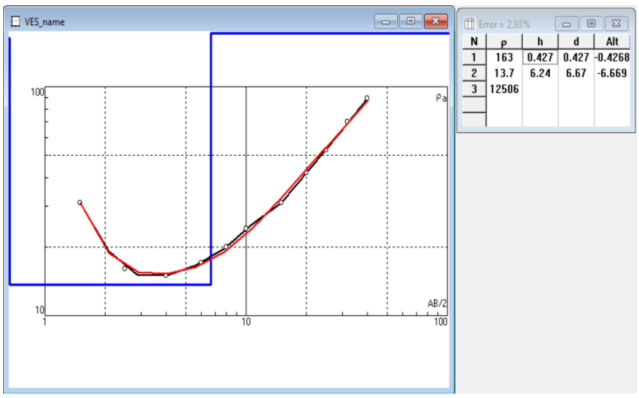
VES 7



VES 8



VES 9



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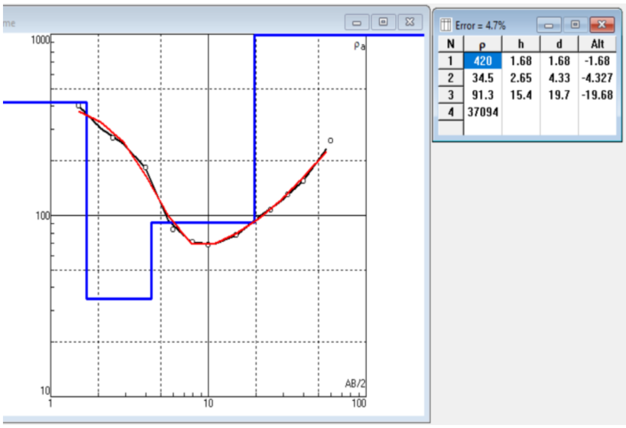
VES 10



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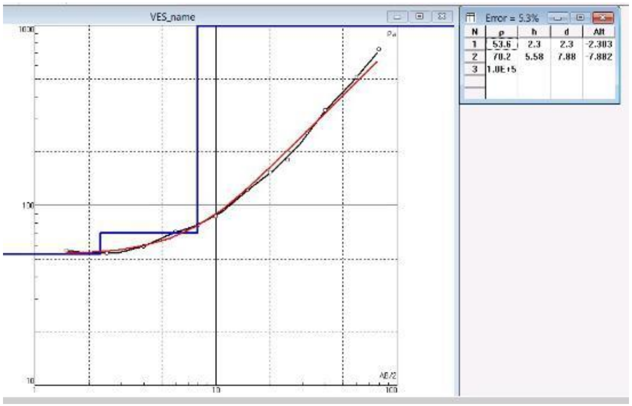
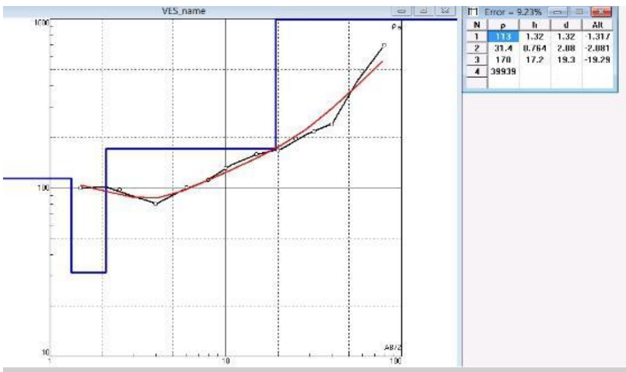


VES 12



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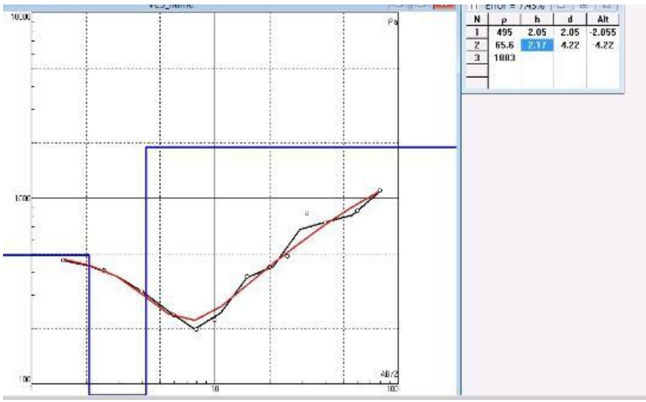
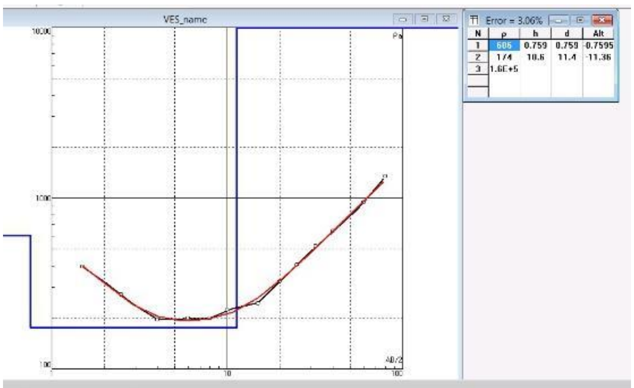
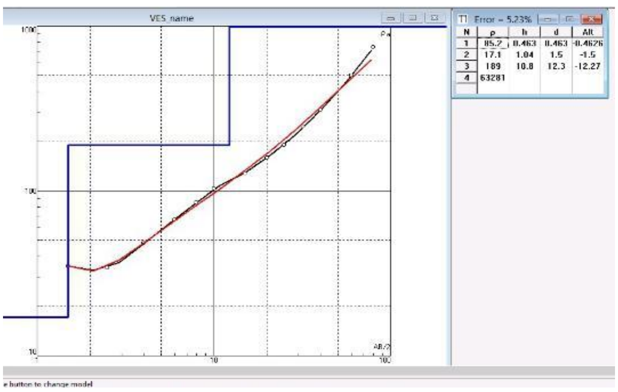
VES 13



VES 14



VES 15



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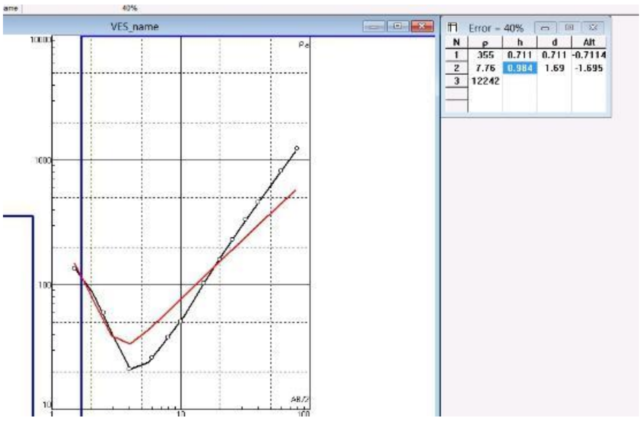
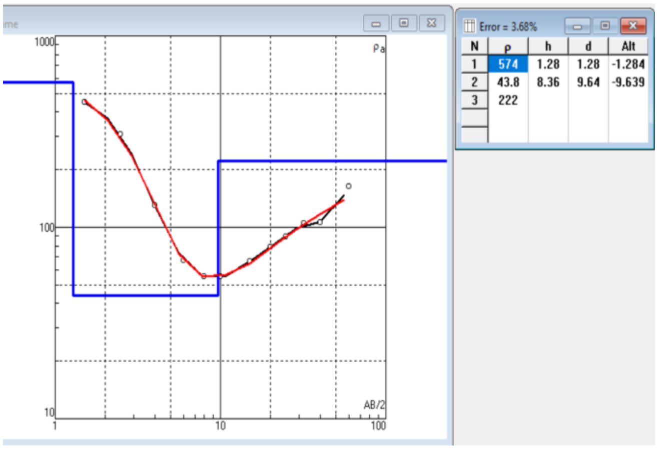
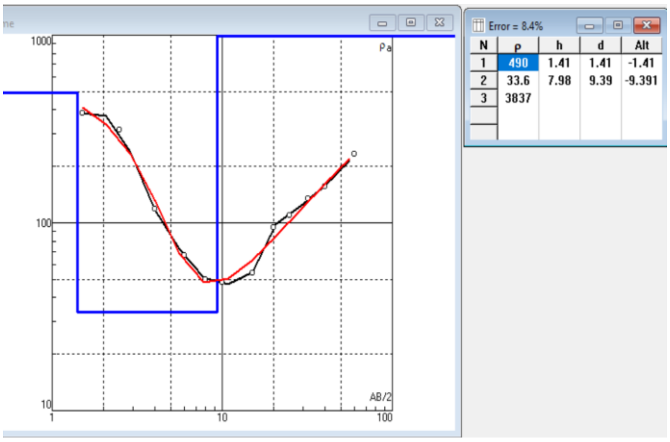
VES 16



VES 17



VES 18



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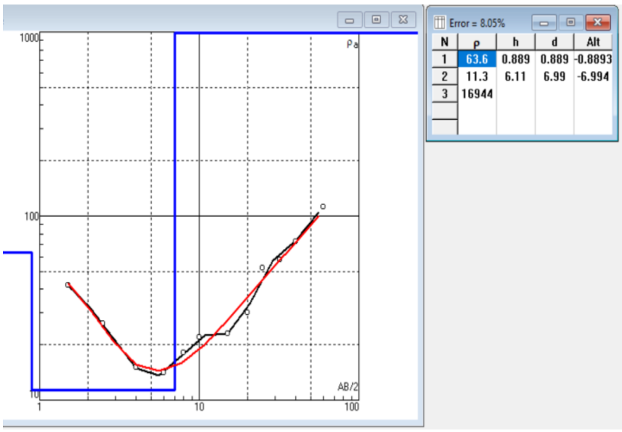
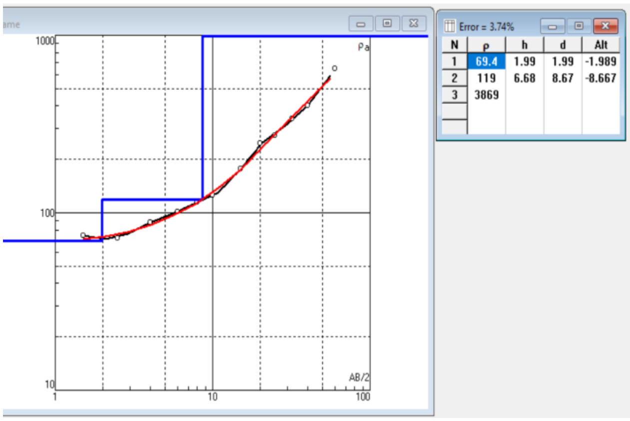
VES 19



VES 20



Categorically, different curve types from the interpreted data give different zones which include the aqua-ferrous zones (zone with porosity and permeability sufficient enough to yield high amount of water); these zones can be referred to the fractured rocks; zones with depths moderately have lower values of apparent resistivity and were inferred to be potential water bearing zones; this zone can be referred to as weathered rock while those that have exceptionally high values of apparent resistivity were inferred to be zones of non-water bearing zone or (dry fractures), impervious or fresh basement. Certain parameters were observed carefully and were logically deduced until the whole sounding points were scrutinized. The common curve types observed in the study area are A, H, and HA types. The geoelectric cross-section shows that the top soil mostly ranges from 0.411–1.99 m, weathered rocks ranges from about 0.545–10.6 m and the fractured basement ranges from 5.28–20.4 m. This zone is very important to provide a great zone for groundwater accumulations, whereas 25–30 m mark the top of fractured-fresh basement or fresh basement with less or no fractures.

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CONCLUSION

Based on the geological mapping conducted in the study area, it was found that the rock type of the area was mostly older granite and metamorphic rocks. Based on this work, two lithologies were observed: granitic and metamorphic rock with a coarse-fine grain granite.

The results of vertical electrical sounding (VES) in the study area have revealed generally 3–4 geoelectric layers. These were inferred to correspond to the topsoil (lateritic, clayed or sandy soil), decomposed basement, and fractured-fresh crystalline basement units respectively. The weathered/fractured basement may constitute the main aquifer in the study area with appreciable permeability and transmissivity to be a potential site for successful boreholes that can supply sufficient amounts of water to the community. In the above interpreted curves, VES 2, 6, 7, 9, 11, 12, 15, 16 and 20 were not recommended for drilling.

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