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Full Length Research Paper

Geoelectric investigation of groundwater in Obaretin – Iyanomon locality, Edo state, Nigeria

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Geoelectric investigation for underground water in Obaretin – Iyanomon and its environ was done using the Vertical Electrical Sounding (VES) method. Three vertical electrical sounding (VES 12, 14 and 28) data were acquired within the locations in the study area. Borehole data were also acquired. These were used in delineating the geoelectric sections. The study was carried out using the Schlumberger electrode configuration and the Res1Dinv method of interpretation was adopted. The interpretation of the resistivity curves over the study area within geologic terrain often referred to as sedimentary environment indicates that the area have underground water potential. The experiment conducted over the area showed a total depth of 85.80 and 89.36 m respectively which corroborated with borehole data acquired from the study area. The geologic section of a nearby location termed VES 14 was delineated and its total depth was found to be 95.37 m. This also corroborated with the borehole data in the area.

Key words: Geoelectric, investigation, underground water, lithology, borehole section.

INTRODUCTION

The advent of technology has made the quest for water for all purpose in life to drift from ordinary search for surface water to prospecting for steady and reliable subsurface or ground water from boreholes. In Nigeria, presently, boreholes have rescued the citizenry from acute shortage of water.

Underground water is characterized by a certain number of parameters which are determined by geophysical methods such as electrical resistivity methods, seismic methods, magnetic methods, gravity methods etc. But for this research work, the application of electrical resistivity survey method was used. The most usual parameters are the porosity, the permeability, the transmissivity and the conductivity. Electrical resistivity method in geophysical exploration for groundwater in a sedimentary environment has proven reliable (Emenike, 2001). Records show that the depths of aquifers differ from place to place because of variational geo-thermal and geo-structural occurrence (Ekine and Osobonye, 1996; Okwueze, 1996). Electrical resistivity method is one of the most useful techniques in underground water geophysical exploration because the resistivity of rock is very sensitive to its water content. In turn, the resistivity of water is very sensitive to its ionic content.

The geology of the study area reveals that the entire area is underlain by sedimentary rocks. These rocks are of ages between Paleocene to recent. The sedimentary rock contains about 90% of sandstone and shale intercalation. It is coarse grained locally fine grained in some areas, poorly sorted, sub- angular to well rounded and bears lignite streaks and wood fragment (Kogbe, 1989). The sedimentary rock of the study area constitutes the Benin formation. This has an important groundwater reservoir.

Emenike (2001) carried out a geophysical exploration for groundwater in a sedimentary environment: A case study from Nanka over Nanka Formation in Anambra Basin, South-Eastern Nigeria. In his work, the interpretation of five resistive curves over Nanka town within geologic terrain often referred to as Nanka formation in Anambra Basin indicates that the area has high level of groundwater potential. A correlation of the curves with the lithologic log from a nearby borehole suggests that the major lithologic units penetrated by the

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sounding curves are laterite, sandstone and clay. The sandstone unit, which is the aquifer zone, has a resistivity range of between 500 and 960 ohm-m and thickness in excess of 200 m. The work reveals that the depth to the water table is 100 m. Ujuanbi (2000) carried out the investigation of clay deposits in the northern part of Edo state using electrical resistivity methods.

Olorunfemi et al. (1995) carried out a Pre-drilling geophysical investigation for groundwater development in the Proterozoic basement of the northern rural part of Kaduna state, Nigeria, using electromagnetic and resistivity methods. The VES was carried out with both the Wenner and Schlumberger arrays. A total of 150 VES stations were occupied in 76 rural areas. The quantitative interpretation of the VES data involved partial curve marching and computer iteration. They concluded that the EM method is sensitive to shallow water bearing, unconfined sheet-like fractures. It is not amenable to the delineation of confined fractures that are concealed by infinitely resistive, fresh, Precambrian basement rocks.

Asokhia et al. (2000) use a simple computer iteration technique for the interpretation of vertical electrical sounding. A preliminary finding of the groundwater resource potentials from a regional geoelectric survey of the Obudu basement area of Nigeria has been done (Okwueze, 1996). Oyedele (2001) carried out a geo-electric investigation of groundwater resources at Onibode area, near Abeokuta South-West of Nigeria.

Reinhard (1994) carried out a combined geo-electrical and drill-hole investigation for detecting fresh-water aquifers in Northern Western Missouri. Application of surface geophysics to groundwater investigation has been carried out (Zohdy et al., 1974). Zohdy (1974) did a work on automatic interpretation of Schlumberger sounding curves. Alile (2008) carried out a geophysical investigation for underground water in the southern and central senatorial districts of Edo State, Nigeria, using electrical resistivity survey and seismic refraction survey methods.

Karous and Pernu (1985) carried out a combined use of sounding profiling resistivity measurement with electrode arrays. They showed that the combination of resistivity sounding and profiling measurements can be used to obtain the maximum information about distribution of resistivities in the earth and that resistivity data from such measurements can be presented as electrical normal sounding curve. They concluded that with three electrode arrays, thin conductors and contact lithological units of different resistivities can be accurately located. Direct current probing of the subsurface earth for water bearing layer in Oredo Local Government Area, Edo State, Nigeria, has been carried out (Alile and Amadasun, 2008). Chilton and Forster (1995) researched into hydrogeological characterization and water supply potentials of basement aquifers in tropical Africa.

This study tends to explore the use of geoelectric method to investigate the water bearing layer in Obaretin, Iyanomon and the nearby locality.

METHODOLOGY

This method responds favourably to measurable parameters that can easily distinguish the aquifer from other formations. The conductivity (resistivity reciprocal) variations of formations will enable one delineate different layers using the ABEM Terrameter. Electrical resistivity varies with rock or sediment type, porosity and the quality and quantity of water and is a fundamental property of earth materials. Electricity can be conducted in the earth electrolytically by interstitial fluids (usually water) and electronically by certain materials, such as clay minerals, by cation exchange. As a result, poorer quality ground water (that is water with higher concentrations of dissolved solids) or sediments with higher clay content are usually more conductive (Zohdy et al., 1974). Resistivity is expressed in ohm-meters, and is an estimate of the earth resistivity calculated using the relationship between resistivity, an electric field, and current density (ohm's law), and the geometry constant, spacing of the current and potential electrodes. Where the earth is not homogeneous and isotropic, this estimate is called the apparent resistivity, which is an average of the true resistivity in the measured section of the earth.

In this research work, the Schlumberger array in electrical resistivity survey was adopted. The basic field equipment for this study is the ABEM Terrameter SAS 300B which displays apparent resistivity values digitally as computed from ohm's law. It is powered by a 12.5 V DC power source. Other accessories to the terrameter includes the booster, four metal electrodes, cables for current and potential electrodes, harmers (3), measuring tapes, walking, phones for very long spread. In this configuration, the four electrodes are positioned symmetrically along a straight line, the current electrodes on the outside and the potential electrodes on the inside. To change the depth range of the measurements, the current electrodes are displaced outwards while the potential electrodes in general, are left at the same position.

When the ratio of the distance between the current electrodes to that between the potential electrodes becomes too large, the potential electrodes must also be displaced outwards otherwise the potential difference becomes too small to be measured with sufficient accuracy (Koefoed, 1979). One of the major advantages this method has over other methods is that only the current electrodes need to be shifted to new position for most readings while potential electrodes are kept constant for up to three or four readings (Reinhard, 1974). During the field work, taking a sounding, the ABEM Terrameter SAS 300B (Self Averaging System) performs automatic recording of both voltage and current, stacks the results, computes the resistance in real time and digitally displays it. (Dobrin and King, 1976).

RESULTS AND DISCUSSION

The first step in the interpretation of a resistivity sounding survey is to classify the observed apparent resistivity curves into types. This classification is primarily made on the basis of the shapes of the curves, but at the same time it is related to the geological situation in the subsurface. The shapes of a VES curve depend on the number of layers in the subsurface and the thickness of each layer. Model parameters estimated from the data were used for computer iterative operations to interpret the data. In the iterative interpretation method used in this study, the field data were compared with the data derived from a layer model obtained by curve matching. If the agreement between the two sets of data is unsatisfactory, then the parameters of the layer model are adjusted. This

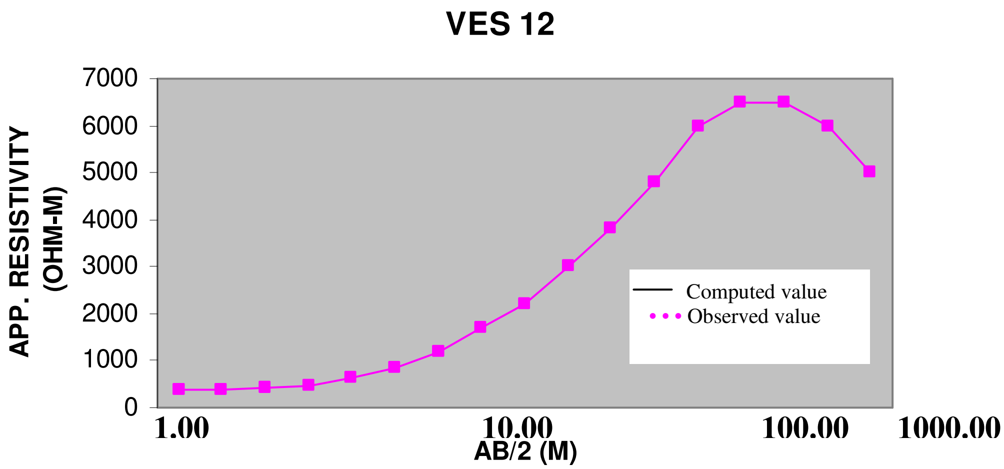

Figure 1. Observed VES: 12; Local Government Area: Ikpoba Okha; Location: Obaretin; Weather: Hot; State: Edo.

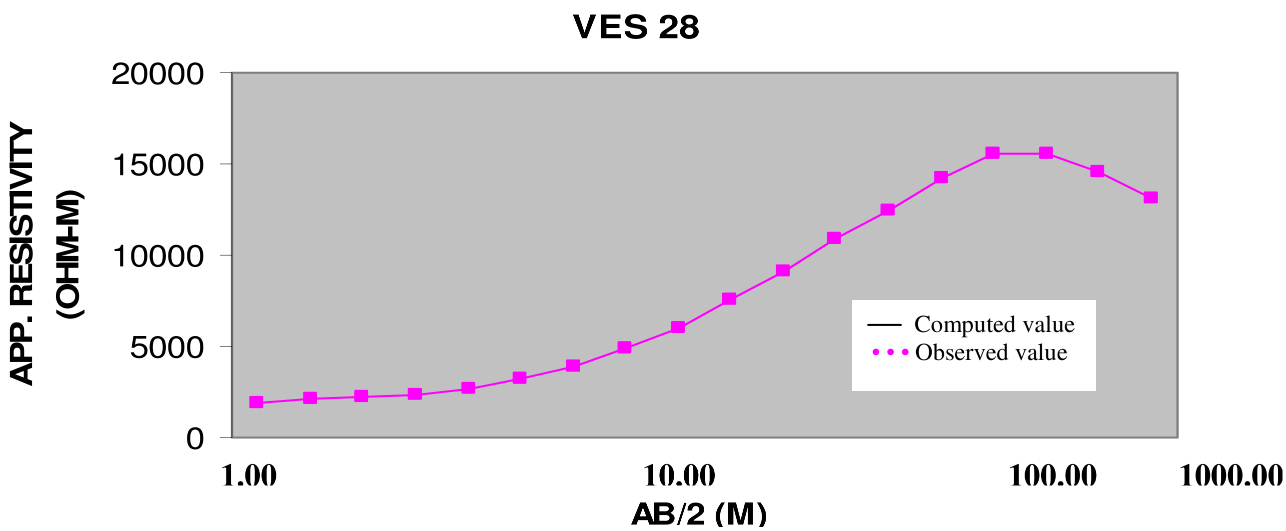

Figure 2. Observed VES: 28; Local Government Area: Ikpoba Okha; Location: Iyanomon; Weather: Hot; State: Edo.

procedure was repeated until a sufficient agreement between the model data and the field data was obtained. Therefore the model parameters, observed data and computed data as well as the theoretical curves for the area covered in this study are used in delineating the geoelectric sections and the geologic sections respectively.

From the results as shown in the Figures 1, 2 and 3, six geoelectric layers were encountered with resistivities as shown in the Tables 1a and 1b; 2a and 2b; 3a and 3b in the study area. These six geoelectric layers gives a better and detail information of the geologic formation of the subsurface earth than a fewer geoelectric layers. The VES curves are HAKQ-curve type ($\rho_1 > \rho_2 < \rho_3 < \rho_4 > \rho_5 > \rho_6$).

The geologic sections are presented in Figure 4. At Obaretin, Iyanomon and Orionmwonbor, the total depth obtained are 85.80, 95.37 and 95.37 m. There is a high correlation with the borehole section at Iyanomon (Figure 5). This study showed a clear support or proof of the depth to aquifer in the study area.

Conclusion

This research has provided information on the depth to the groundwater and probably the thickness of the aquifer unit in the study area. This information is going to be relevant to the development of an effective water scheme for the area and possibly beyond other areas underlain by the formation.

The experiment conducted over the area showed a total depth of 85.80 and 89.36 m respectively. This in line with the borehole data acquired from the study area,

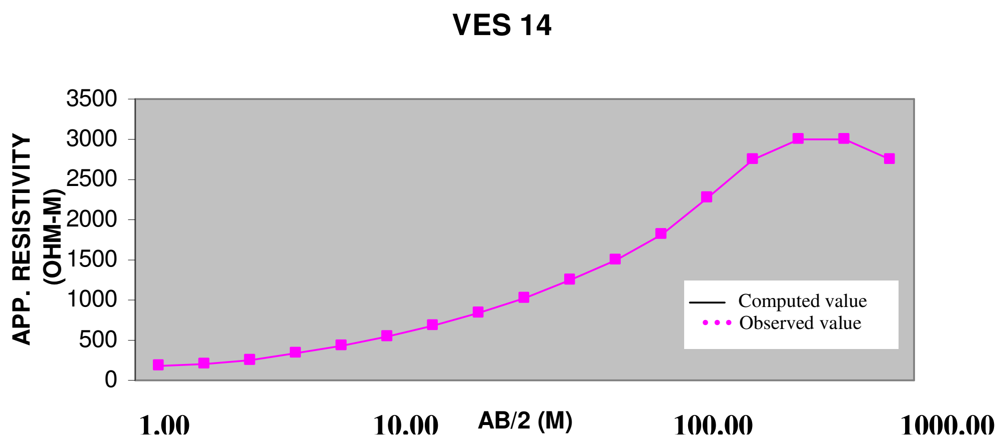

Figure 3. Observed VES: 14; Local Government Area: Ikpoba Okha; Location: Orionmwonbor; Weather: Hot; State: Edo.

Table 1a. Observed (field) and computed (theoretical) data.

$\frac{AB}{2}(m)$	$\rho_a(ohm-m)$ **Observed value**	$\rho_a(ohm-m)$ **Computed value**
1.00	1478.66	400.00
1.47	1515.80	400.00
2.15	1464.37	420.00
3.16	1476.27	480.00
4.64	1533.75	650.00
6.81	1301.30	850.00
10.00	1215.42	1200.00
14.70	1017.12	1800.00
21.50	946.40	2200.00
31.60	1913.13	3000.00
46.40	2535.22	3800.00
68.10	2767.61	4800.00
100.00	1256.51	6000.00
147.00	11540.20	6500.00
215.00	15973.87	6500.00
250.00	14564.67	6000.00
300.00	14325.23	5000.00

Table 1b. Model parameter.

Geoelectric layer	Resistivity (ohm-m)	Thickness (m)	Cumulative thickness(m)
1	3300.00	3.70	3.70
2	10500.00	15.30	19.00
3	5160.00	15.60	34.60
4	6060.00	25.20	59.80
5	5045.00	26.00	85.80
6	4500.00	Infinity	Infinity

RMS error (%): 1.51.

there is a high correlation. The geologic section of a nearby location termed VES 14 was delineated and its total depth was found to be 95.37 m. This also corroborated with the borehole data in the area. Therefore geoelectric

Table 2a.Observed (field) and computed (theoretical) data.

$\frac{AB}{2}(m)$	$\rho_a (ohm-m)$ **Observed value**	$\rho_a (ohm-m)$ **Computed value**
1.00	1450.64	1910.00
1.47	1456.23	2110.00
2.15	1464.37	2200.00
3.16	1486.27	2300.00
4.64	1543.77	2680.00
6.81	1311.35	3260.00
10.00	1225.45	3930.00
14.70	1127.14	4880.00
21.50	956.45	6000.00
31.60	1923.16	7600.00
46.40	2535.25	9100.00
68.10	2867.66	10910.00
100.00	1556.51	12400.00
147.00	11640.20	14170.00
215.00	15983.88	15510.00
250.00	14564.77	15600.00
300.00	14315.56	14550.00
400.00	13877.87	13120.00

Table 2b. Model parameter.

Geoelectric layer	Resistivity (ohm-m)	Thickness (m)	Cumulative thickness(m)
1	8050.00	6.20	6.20
2	11500.00	15.36	21.56
3	5260.00	15.60	37.16
4	6260.00	26.00	63.16
5	5012.00	26.20	89.36
6	3000.00	Infinity	Infinity

RMS error (%): 1.50.

Table 3a. Observed (field) and computed (theoretical) data.

$\frac{AB}{2}(m)$	$\rho_a (ohm-m)$ **Observed value**	$\rho_a (ohm-m)$ **Computed value**
1.00	340.99	180.00
1.47	313.01	200.00
2.15	310.70	260.00
3.16	364.11	347.14
4.64	329.95	428.70
6.81	504.29	537.61
10.00	639.28	671.57
14.70	809.63	835.02
21.50	718.45	1024.64
31.60	2559.21	1250.00

Table 3a. Contd.

46.40	1892.96	1491.53
68.10	3131.76	1812.82
100.00	5026.05	2263.10
147.00	12252.98	2740.00
215.00	21201.68	3005.10
250.00	2345.56	3000.00
300.00	2255.89	2750.00

Table 3b. Model parameters.

Geoelectric layer	Resistivity (ohm-m)	Thickness (m)	Cumulative thickness(m)
1	800.00	5.90	5.90
2	1790.00	18.40	24.30
3	7440.00	20.00	44.30
4	1530.00	25.06	69.36
5	1050.00	26.01	95.37
6	980.00	Infinity	Infinity

RMS error (%): 2.60.

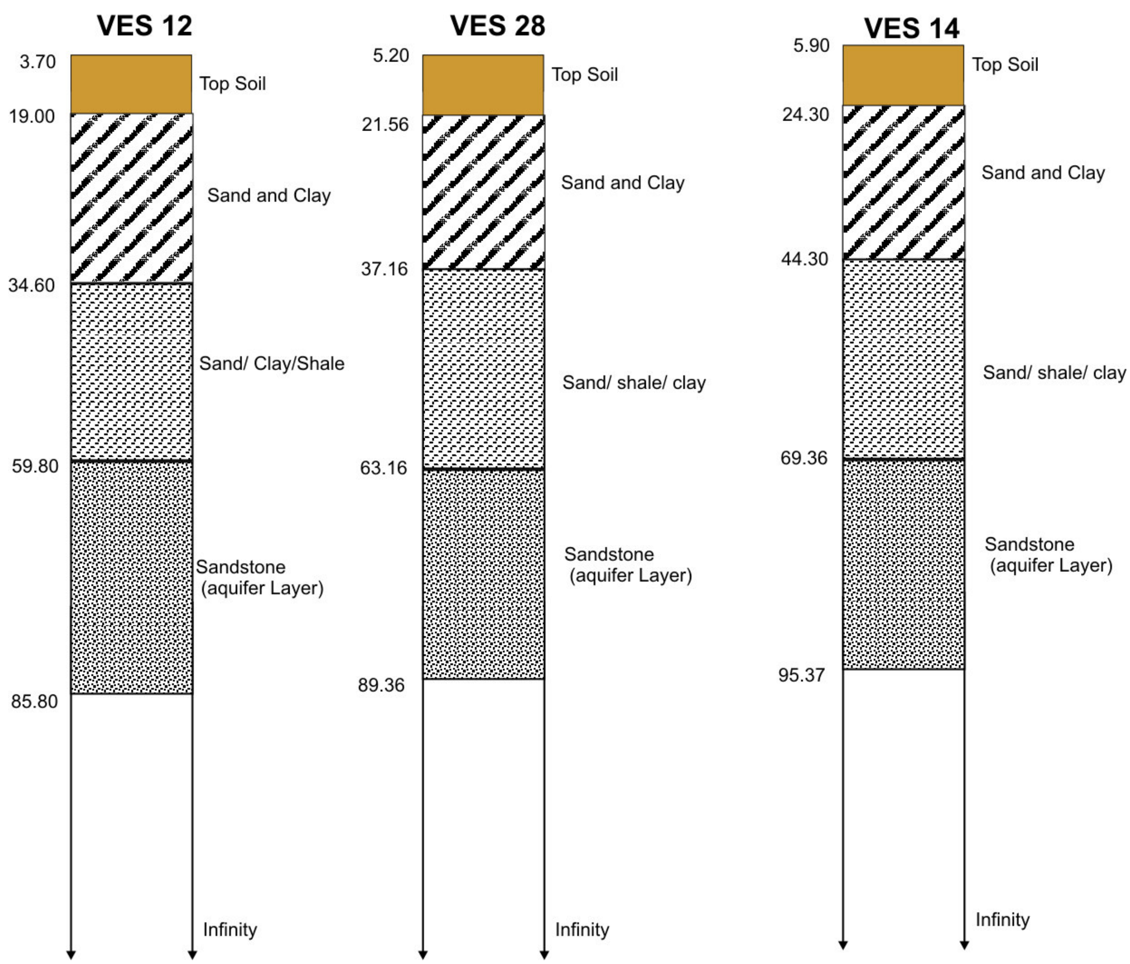

Figure 4. Geologic sections of Obaretin, Iyanomon and Orhionmwonbor locations.

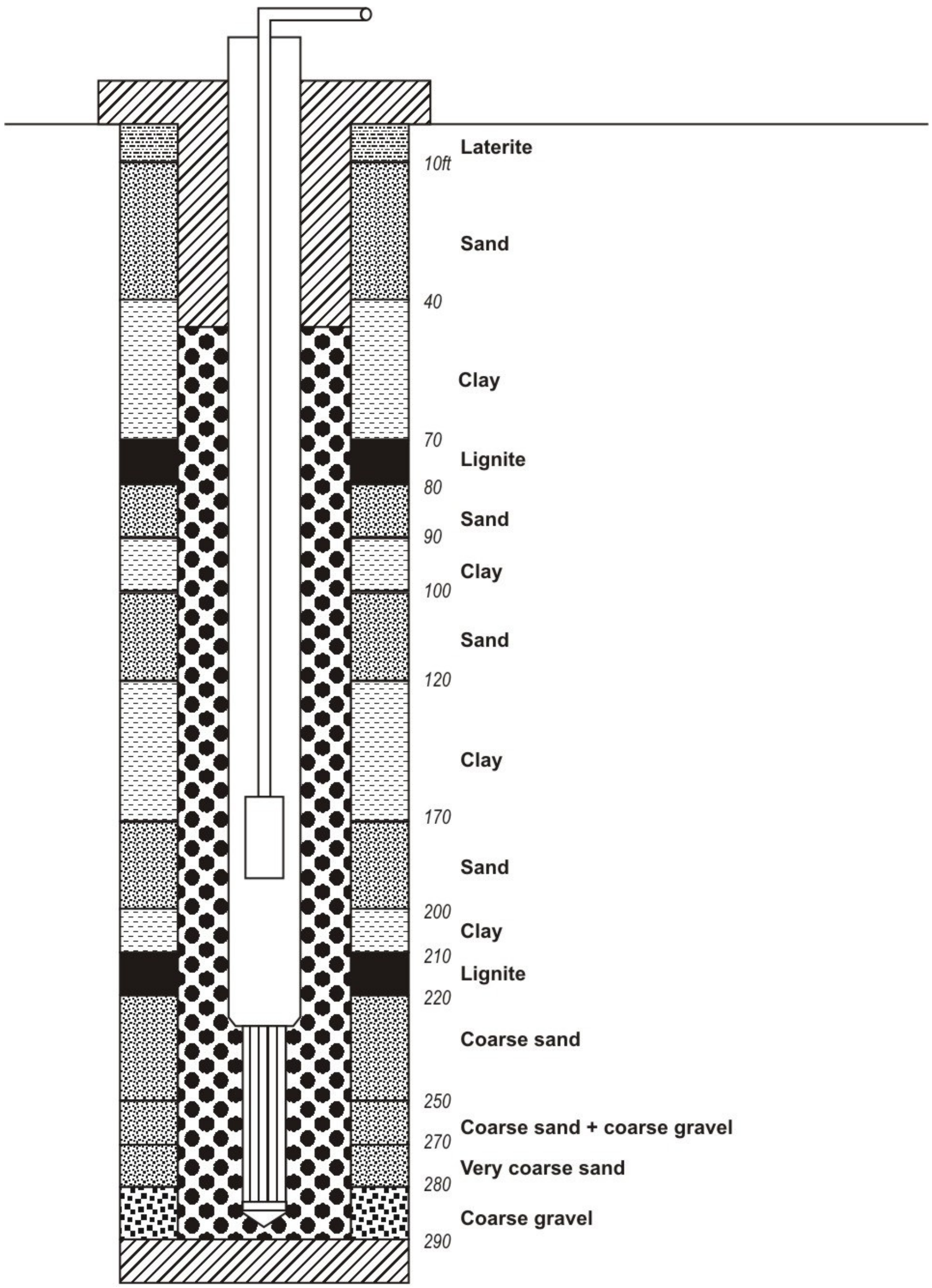

Figure 5. Iyanomon borehole section.

investigation for groundwater study has proved reliable in the study area.

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