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INVESTIGATION OF GROUND WATER CAPACITY OF OKADA AND ITS ENVIRONS USING ELECTRICAL ESISTIVITY METHOD IN ACQUIFER POTENTIAL MAP

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ABSTRACT

Electrical resistivity survey was carried out to investigate the groundwater capacity of Okada, an urban sedimentary area with the oldest Cretaceous rocks (sandstones and shales) which are of Albian age. The equipment used for the survey include, ABEM terrameter (SAS, 300C), four electrodes, hammer, four reels of wires, connecting cords, measuring tapes and global positioning system (GPS). This geological study was carried out in three different locations. The field layout employed was the Wenner-schlumberger array. The result of the survey shows that the average resistivities are 1337.8Ωm for the first layer, 5914. 34 Ωm for the second layer, 1277. 59 Ωm for the third layer, 189. 65 Ωm for the fourth layer and 695.78 Ωm for the fifth layer with probable lithologic interpretations as lateritic over-burden for the first layer,and highly compact clay stone for second layer, fissile dry shale, splintery shale(wet) and saturated and pyritised silty shale (wet) for the other three layers, respectively. The result indicates that potential groundwater is found in the fourth layer of the study area.

I. Introduction and Theory

Groundwater occurs in many types of geological formations; those known as aquifers are of utmost importance. An aquifer is a formation that contains sufficient saturated permeable material to yield significant amount of water to wells and springs. Aquifers are generally extensive and may be overlain or underlain by a confining bed [1]. They could be porous rocks, unconsolidated gravels or fractured rocks. They are reservoirs storing large amount of water.

Detailed and comprehensive study of ground water and the condition under which it occurs can only be made by subsurface investigation through geological explorations. Whether the information needed concerns its location, thickness, composition, permeability or yield, quantitative data can be obtained from geophysical exploration. The various geophysical methods that can be employed.

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These include electromagnetic (E.M), electrical resistivity, gravity and magnetic methods [2]. Of all these methods, the resistivity method is preferably used for groundwater studies because of accuracy and reliability of results. For groundwater studies in Okada particularly, the resistivity method has been selected because of its outstanding peculiarities and hydrogeology of the area. Owing to the geology of Okada, it is difficult to detect aquiferous rocks, using geological techniques and this has been the cause of abortive wells. However, with the use of electrical resistivity method, the problem of abortive wells is solved. The resistivity method, nevertheless seems to be the commonest method of geophysical prospecting that has been utilized in the study area by previous researchers. The Edo state rural water supply and sanitation agency (ED-RUWASSA) has done some works with this method in many parts of the state [3]

Electrical resistivity method was used with Wenner- Schlumberger configuration of electrodes. The result showed that the first layer from the surface of the earth has resistivity of 1821.15 Ωm and thickness of 1.8m, which was interpreted to be lateritic overburden, the second layer has resistivity of 147.62 Ωm and a thickness of 12.7m. This was interpreted as ferrugnised clay with concretion. The third layer has resistivity of 1284.59 Ωm and a thickness of 16.8m and was interpreted as wet limestone while the fourth layer whose base was not reached has a resistivity of 311.07 Ωm and was interpreted to be hard fissile shales (likely fractured and wet).

a. Field Procedure

The study area is Okada, urban area of Edo state, Nigeria. It is located within longitudes 8^0 5' 8^0 10^1E and latitudes $6^0 17^1$ -$6^0 20^1$N and has an area of about 81km^2 [4].

The geology of the study area is quite interesting as it has the oldest rock in the world. It is situated within the anticlinorium which occurred as a result of tectonic movement during the Albian transgression which also gave rise to the Edo basin and (Edo state) syncline.

The stratigraphic succession consists basically of the lower Cretaceous (Albian) sediments which occur as a result of the folding and uplifting of the Usen fold belt in the Santonian stage which produced the Usen basin. The basin is predominantly filled with clastic sediments constituting several distinct lithostragraphic units deposited from upper Campanain to recent time. The lithostratigraphic units have a thickness of up to 2,500m [5]. The study area is characterized by pyroclastics, dolerites, dark gray shales and other magmatic formations. The formations are poorly fossilized [6].

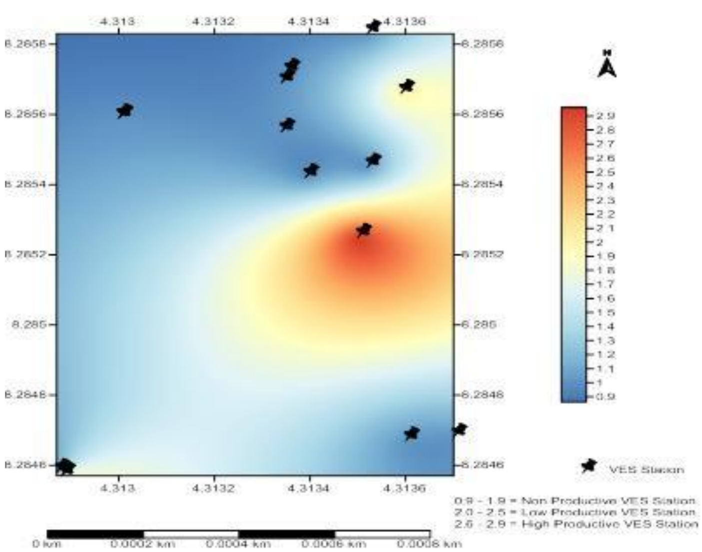

Fig.1 Ground water potential map of study Area.

The Okeluse River group has folded during the tectonism that occurred at the early part of the Turonian stage. This activity gave rise to the Okada anticlinorium with sediments that are gently warped along widely spaced axes which trend in a N-E direction and pitch at a low angle to the S-W. This brought about fissures, cracks and joints within the consolidated sediments. Probably following major tectonic activities were igneous activities and a consequent lead zinc mineralization of the adjourning rocks. Tectonism in the area seems to have continued up till the Cenozoic Era when some basic intrusions (mainly dolerites) were emplaced [7]

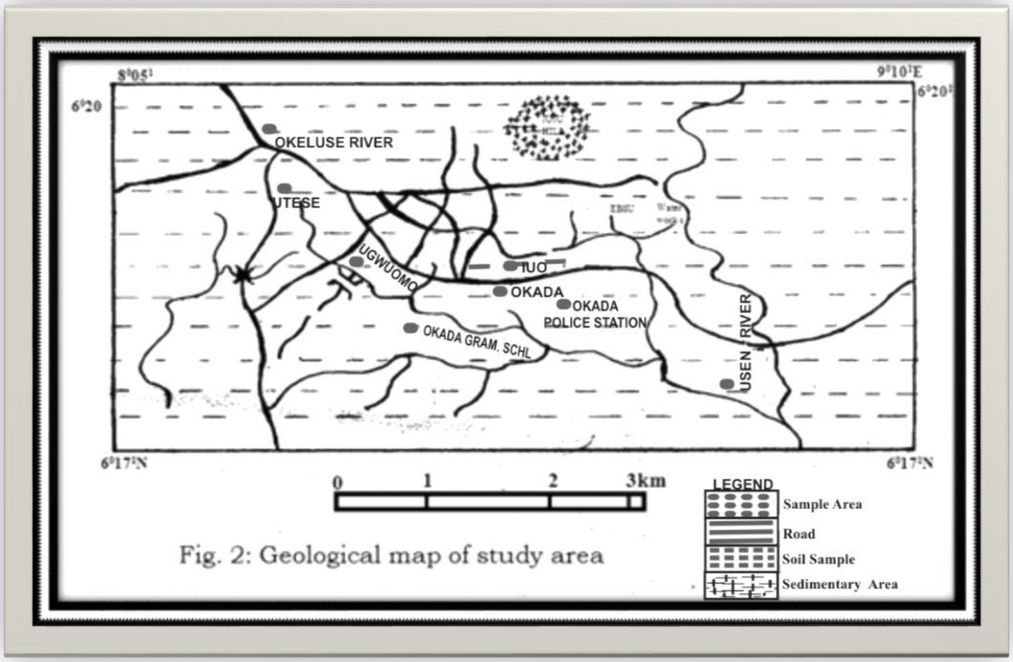

Fig.2. Geological map of study area

b. Data Acquisition and Processing

Resistivity survey equipment are designed to measure the resistance of the earth layers to a very high degree of accuracy[6]. The resistance obtained from the field and the spacing of the electrodes are used to calculate the resistivity (apparent resistivity, ρa). In general, the materials needed for electrical resistivity survey for water include a terrameter for the measurement of potential difference when a current of low frequency is introduced, otherwise called resistivity meter, electrodes, cables, connecting cords, tapes, battery, hammer and global positioning system. These were utilized in this work [7].

II. Materials and Method

The electrodes array used, was the Wiener-Schlumberger type, which consists of two pairs of electrodes viz the potential and the current pairs. The potential pair was the inner electrodes wile the current pair constituted the outer electrodes in the array. The survey was carried out by choosing the best traverse line. The mid-point of the array on the line of traverse was determined and the tetrameter placed there [8]. The potential electrodes were initially separated by 0.2m and the current electrodes by 1m. Although the survey involved vertical electrical soundings (VES), several lateral movements of the current electrodes were made while the potential electrodes spacing remained relatively fixed. However, the potential electrodes spacing were altered at some points in order to minimize noise [8]. See Fig. 3 below.

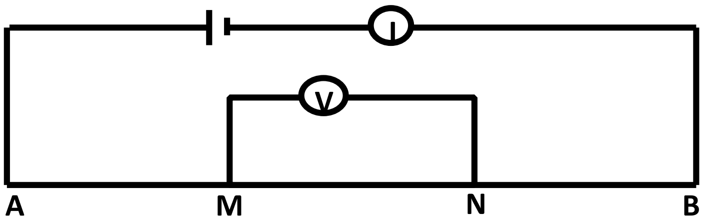

Fig 3: Schematic diagram of Wiener-Schlumberger array with potential (V) electrodes, M, N, inner and current electrodes, A, B. Since the Wiener- Schlumberger configuration was used for the survey, the apparent resistivity ρ_a was computed by multiplying the geometric factor k, by the resistance, R [9] That is:

ρ_a=k x R , Where AM= na , AN = a+an , BM = a + an , BN = na

And Geometric factor, K = $\frac{2\pi}{Q} = 2\pi Q^{-1}$, where Q = $[\frac{1}{AM} - \frac{1}{BM} - \frac{1}{AN} + \frac{1}{BN}]^{-1}$

Thus, geometric factor K = $2\pi\ [\frac{1}{na} - \frac{1}{a+an} - \frac{1}{a+an} + \frac{1}{na}]^{-1}$, K= $(n+1)$,

Where a= Electrode Spacing = (n +2)

Therefore, K = $\pi a(\text{n} + 1)(n+2)$.

c. Field Measurement: The data used in this work were obtained from three different locations within the study area which includes Ogwuomo junction, Okada Grammar School, , and Central police station. The azimuths of the traverses were measured to be 036^{0}NE for Eguebeh street junction, 043^{0}NE for central police station and 070^{0}NE at Okada Grammar School. [10]

The longitudes and latitudes of Utese junction were measured to be 06.44524^{0}E and 007.96178^{0}N respectively. For Okada Grammar School they were 06.44871^{0}E and 007.96672^{0}N respectively. The third location, Central police station had longitudes and latitudes of 06.44367^{0}E and 007.96459^{0}N respectively;. The altitudes of the locations were determined to be 133m, 129m and 118m for the first, second and third locations, respectively.

III. Data Presentation and Interpretation of Results

Since the resistivity of the earth's subsurface layers seldom changes, the resistivity values and depth measured which have fairly very close range of values were grouped together as one layer resulting in a maximum of five layers for Igbinoba street junction, five layers for Okada Grammar School ,Usen and four layers for central police station. The grouping of these layers involved taking the average of resistivity values for a given range presumed to have fairly close range of resistivity [11]

After a careful interpretation of the log-log curves of Figs 4-6 above, and the equivalence plots from the computer software Excel, version 2.1, the following tables (Tables 1 to 3) were obtained which presents the deduced results in the form of stratigraphic units alongside their resistivity and thickness values [12]

Table 1: Interpretation of result from location 1

Layer	Depth(m)	Thickness(m)	Resistivity ρ**a** (Ω	Lithology
1	1.80	1.80	834.46	Loose Lateritic earth with over burd
2	10.9	9.1	9420.81	Ferruginised and high compact claystone(dry)
3	26.3	15.4	935.12	Fissile shale (well compacted (dry)
4	36.7	9.6	152.67	plintery shale with clay bands (wet a saturated)
5	Based not reached		906.22	Pyritized silty shale (wet)

Table 2: Interpretation of result from location 2

Layer	Depth (m)	Thickness (m)	Resistivity ρ**a** (Ωm)	Lithology
1	2.1	2.1	1357.38	Over-burden (dry and laterlic)
2	12.9	10.8	8174.58	Ferrugnisied and high compact claystone (damp)
3	27.9	14.4	1614.06	Fissile shale (well compact (dry)
4	40.1	12.8	106.21	Splintery shale with clay bands (wet and saturated)
5	Base not reached		485.33	Pyritized silty shale (wet)

Table 3: Interpretation of result from location 3

Layer	Depth (m)	Thickness (m)	Resistivity ρ**a** (Ωm)	lithology
1	1.8	1.8	1821.15	Lateritic over burden (including the dry top soil)
2	14.4	12.6	147.62	Ferrugnisied clay with concertions)
3	16.7	16.7	1283.58	Limestone (damp)
4	Base not reache		310.07	Hard fissile shale (likely Fractured and wet).

From Fig.4 to Fig 6, the average apparent resistivities and thicknesses of the subsurface layers of Okada were estimated to be 1337.80Ωm and 1.9m for the first layer, 5914.34 Ωm and 10.8m for the second layer, 1277.59Ωm and 15.5m for the third layer, 189.65 Ωm and 11.0m for the fourth layer respectively [13]

The average depth to each of the layers in the surveyed area from the earth's surface are 1.9m, 12.7m, 28.2m and 39.20m for the first four layers. And these layers are interpreted to be lateritic over-burden, ferrugnisied clay, fissile dry shale, splintery wet shale.

The fourth layer of Okada with average resistivity and thickness of 189.65Ωm and 11.0m respectively and which is interpreted as splintery wet shale is likely to substantially yield water to wells when exploited. It is therefore suspected to be the aquifer of the study area. The fifth layer whose base was not reached has average resistivity of 695.78 Ωm [14]

IV. Discussion of Results

The data obtained from measurements include the resistance reading of the terrameter at various survey points within each location and the corresponding current and potential electrode spacing measured from the array. The apparent resistivities ρ**a** (Ωm) were evaluated and plotted against half-current electrode spacing AB/2 on a log-log graph using computer modeling. The resulting VES curves for the three locations surveyed are shown in Figs 4-6 below [15].

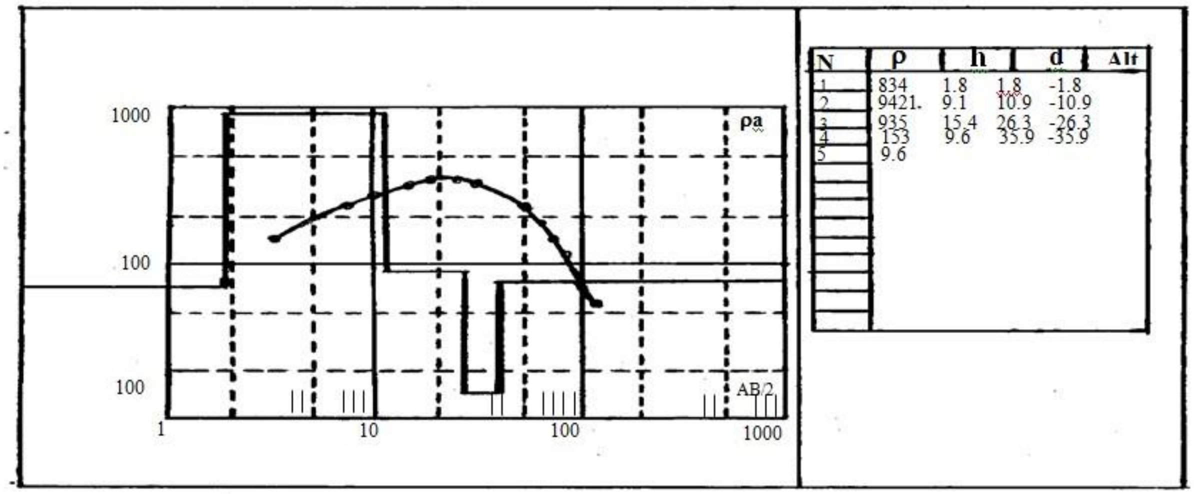

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Fig 4 VES curve for resistivity data obtained at location 1

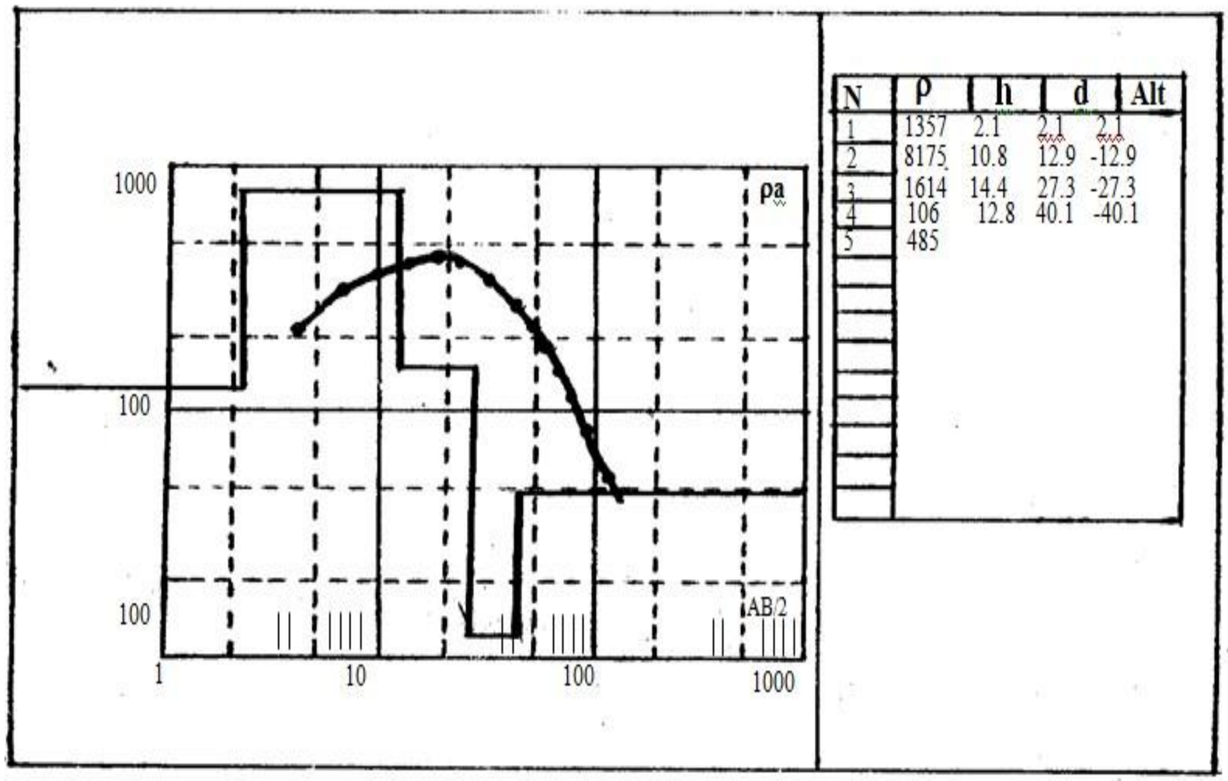

Fig 5. VES curve for resistivity data obtained at location 2

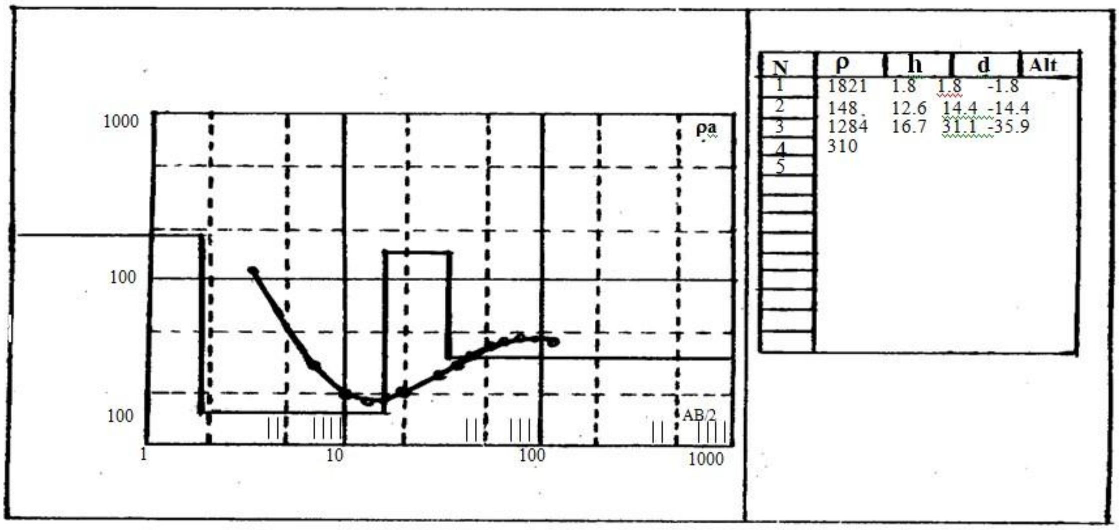

Fig 6. VES curve for resistivity data obtained at location 3

V. Recommendation

It is recommended that other geophysical methods such as the seismic refraction method, very-low frequency Electromagnetic method, Spontaneous Potential method, Induced Polarization method etc. should be used for complimentary investigation in the study area so as to confirm these findings.

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