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Application of Dar Zarrouk parameters to evaluate aquifer transmissivity in Ekpoma, Edo State, Nigeria.

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Abstract

The evaluation of the aquifer transmissivity in Ekpoma area of Edo State, Nigeria, was carried out by the application of the Dar Zarrouk Parameter (DZP). The Schlumberger array configuration in electrical resistivity survey was adopted in acquiring the data. The geoelectric parameters were obtained from the interpretation of the data by the Schlumberger automatic analysis. The average electrical properties of each unit in layered geoelectric section were described by the Dar Zarrouk Parameter and a coefficient of anisotropy λ. From the evaluation, the study showed that the aquifer transmissivity in the location gives T_{r1}: T_{r2}: T_{r3}: = $K\delta(2.341 \times 10^6)$: $K\delta(2.705 \times 10^6)$: $K\delta(2.400 \times 10^6)$ = (2.341×10^6): (2.705×10^6): (2.400×10^6).

Keywords
Dar Zarrouk Parameters, Aquifer, Transmissivity, Resistivity, Evaluation

1.0 Introduction

The ability of a formation as a whole to transmit water is a function of its bulk permeability multiplied by the saturated thickness of the formation: this is known as the transmissibility (or transmissivity) of the formation. The rate at which water is transmitted depends also on the local hydraulic head, which is the difference in elevation between the source and the point of measurement. The vertical head difference (effectively the pressure) divided by the distance over which the difference is measured is known as the hydraulic gradient; this is the driving force for groundwater movement.

Permeability, transmissibility and hydraulic gradient are analogous to resistance, current and voltage in electrical theory and are also related to rate of flow in the aquifer. In the case of water flow, the relationship is expressed by Darcy's law. This analogous relationship can be used to construct two-dimensional analogue models of aquifer characteristics, substituting electrical inputs, resistances, etc. for the estimated actual values. Measurement of the flow of electrical current through the model gives an indication of the pattern of groundwater flow in the real aquifer.

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However, with the advent of low cost computers, analogue models have given way to digital modeling of groundwater movement; finite element and finite difference techniques have become widely available in software packages for solving resource and flow problems on both the micro and macro scale form, for example, calculating the groundwater flow into a civil engineering excavation for a building project. It can also be used for generating regional water resource models for predicting water supply and demand.

2.0 Methodology and theory

In this research work, the Schlumberger array in electrical resistivity survey was adopted in acquiring the data. The interpretation of the data was carried out by the Schlumberger automatic analysis. The Dar Zarrouk function, introduced by Maillet [1], is based on the external equivalence between isotropic and anisotropic media. The Dar Zarrouk curve is a graph of pseudo-resistivity (ρ_{mj}) against pseudo-depth (L_{mj}), where:

$$\left.\begin{aligned} \rho_{mj} &= \left(\frac{T_j}{S_j}\right)^{\frac{1}{2}}, T_j = \sum_{i=1}^{j} T_i \\ L_{mj} &= \left(T_j S_j\right)^{\frac{1}{2}}, S_j = \sum_{i=1}^{j} S_i \end{aligned}\right\} \qquad (1.1)$$

where T_j is the total transverse unit resistance, S_j is the total longitudinal unit conductance, S_j is the longitudinal unit conductance, and T_j is the transverse unit resistance

For a model of a layer which is represented as a branch and point (L_m, $\rho_{m,}$), represents the thickness and resistivity respectively of that single isotropic layer which may replace all overlying layers. Note that, unlike the apparent resistivity curve, each point on the Dar Zarrouk curve is independent of any underlying layers. The importance of the Dar Zarrouk function is that it is uniquely related to the apparent resistivity function. The Dar Zarrouk function is easier to calculate for an assumed model and bears a close graphical resemblance to a resistivity curve, except that the segments are angular. The basic mathematics and procedures for graphical construction of Dar Zarrouk curves are given by Orellana [2] and Zohdy [3].

Now that computers are used to simulate sounding curves over horizontal models, the use of the Dar Zarrouk curve has become optional. But Dar Zarrouk curves are useful in analyzing equivalence because they may be inverted to give true layer resistivities and thickness Zohdy [3]:

$$h_j = \rho_j \left[\frac{L_{mj}}{\rho_{mj}} - \frac{L_{m,j-1}}{\rho_{m,j-1}}\right] \qquad (2.2)$$

$$j = 2,3,\cdots,n \qquad (2.3)$$

$$\rho_j = \left[\frac{L_{mj}\rho_{mj} - L_{m,j-1}\rho_{m,j-1}}{L_{mj}/\rho_{mj} - L_{m,j-1}/\rho_{m,j-1}}\right]^{1/2} \qquad (2.4)$$

$$h_1 = L_{m1} \qquad (2.5)$$

$$\rho_1 = \rho_{m1} \qquad (2.6)$$

where h_j is the thickness.

After an initial interpretation, an equivalent segment may be redrawn by introducing up to 10% error and then the entire curve may be-inverted to give a new sequence of resistivities and thickness which should set limits on equivalence. Also, the Dar Zarrouk curve may be smoothed before inversion to reduce the number of layers in an interpretation, or the reverse may be done to force geological constraints on the solution. Zohdy [4] has used Dar Zarrouk inversion as the basis of a method of automatic interpretation of resistivity sounding curves.

The geometrical arrangement of the interstices in the rock has less effect but can make the resistivity anisotropic, which is having different magnitudes for current flow in different directions. Anisotropy is characteristic of stratified rock which is generally more conductive in the bedding plane. Anisotropy is the ratio of maximum to minimum resistivity which may be as large as two in some graphitic slates and varies from 1 to 1.2 in rocks such as limestone, shale and rhylite Telford, *et al* [5]. Many rocks are anisotropic in nature and errors can arise in the interpretation if neglected. The resistivity measurement is usually affected if in a layered earth, current flow parallel to the direction of stratification is different from that perpendicular to it. Generally the coefficient of anisotropy for layered rocks is usually of the order 1.10 to 1.30. Dar Zarrouk parameters are derived from the exact resistivity distribution of the given medium. In electrical method of exploration, the consideration of electrical properties should be averaged over a large volume of rock which may not be homogeneous. The average electrical properties of each unit in layered geoelectric section are described by three parameters which are longitudinal unit conductance S, transverse unit resistance T and a coefficient of anisotropy λ, defined by the square root of the ratio of transverse resistivity to longitudinal resistivity which is unity for isotropic layer. Geoelectric layer is mostly described by resistivity ρ_i and thickness h_i, where i = 1, 2, 3… other parameters derived from these includes: longitudinal unit conductance S_i, transverse unit resistance T_i, longitudinal resistivity ρ_L, transverse resistivity ρ_t and anisotropy λ which are given as:

$$S_i = \frac{h_i}{\rho_i}, \tag{2.7}$$

$$T_i = h_i \rho_i, \tag{2.8}$$

$$\rho_L = \frac{h_i}{S_i}, \tag{2.9}$$

$$\rho_t = \frac{T_i}{h_i}, \tag{2.10}$$

and

$$\lambda = \sqrt{\frac{\rho_t}{\rho_L}}. \tag{2.11}$$

For isotropic layers, $\rho_t = \rho_L$ and $\lambda = 1$. These secondary parameters are important when used to describe geoelectric section consisting of several layers Zohdy [6], Onwuka and Amadi [7]. Thus for n layers, total longitudinal unit resistance is

$$S = \sum_{i=1}^{n} \frac{h_i}{\rho_i} = \frac{h_1}{\rho_1} + \frac{h_2}{\rho_2} + \frac{h_3}{\rho_3} + \ldots + \frac{h_n}{\rho_n} \tag{2.12}$$

While the total transverse unit resistance is $T = \sum_{i=1}^{n} h_i \rho_i = h_1\rho_1 + h_2\rho_2 + h_3\rho_3 + \ldots + h_n\rho_n$ (2.13)

The average longitudinal resistivity is

$$\rho_i = \frac{\sum_i^n h_i}{\sum_i^n \frac{h_i}{\rho_i}} \tag{2.14}$$

The average transverse unit resistance is $$\rho_i = \frac{\sum_i^n h_i \rho_i}{\sum_i^n h_i} \quad (2.15)$$

And the anisotropy is $$\lambda = \sqrt{\frac{\rho_t}{\rho_L}} \quad (2.16)$$

The parameters S, T, ρ_L, ρ_t and λ are derived from consideration of a column of unit square cross-sectional area cut out of a group of layers of infinite lateral extent. If the current flows vertically only through the column, then the layers in the column will behave as resistors connected in series and the total resistance of the column of unit cross-sectional area will be

$$R = R_1 + R_2 + R_3 + \ldots + R_n, \quad (2.17)$$

or $$R = \rho_1 h_1 + \rho_2 h_2 + \ldots + \rho_n h_n = \sum_i^n \rho_i h_i = T \quad (2.18)$$

The symbol T is used instead of R to indicate that the resistance is measured in a direction transverse to the bedding and also because the dimensions of these unit resistance are usually expressed in ohm-m^2 instead of ohms. If the current flows parallel to the bedding, the layers in the column will behave as resistors connected in parallel and the conductance will be

$$S = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots + \frac{1}{R_n} \quad (2.19)$$

or $$S = \frac{h_1}{\rho_1} + \frac{h_2}{\rho_2} + \frac{h_3}{\rho_3} + \ldots + \frac{h_n}{\rho_n} \quad (2.20)$$

S and *T* are called the Dar Zarrouk parameters and were introduced by Maillet [1]. The importance of the Dar Zarrouk parameters is that it is uniquely related to the apparent resistivity function. The Dar Zarrouk parameters are easier to calculate for an assumed earth model. Besides being useful in the definition of aquifer geometry, we can also infer on the aquifer transmissivity and storativity.

3.0 Results

Observed Ves: 1a **L.G.A.: Esan West**
Location: AAU Ekpoma I **Weather: Hot**
State: Edo

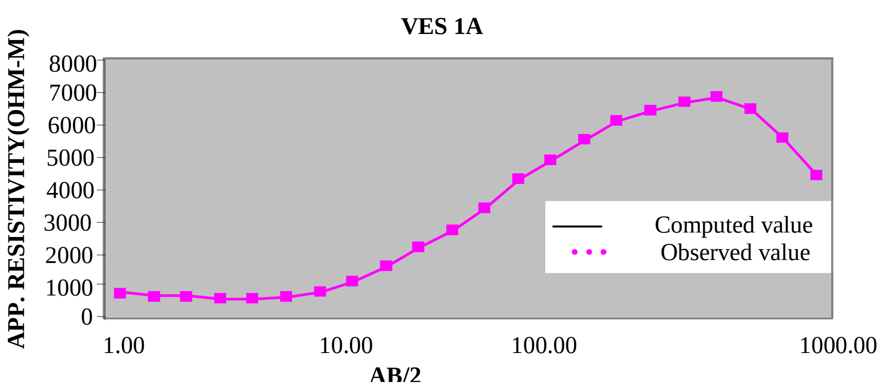

Figure 3.1: Plate 1a

Table 3.1: Observed (field) and computed (theoretical) data

$AB/2(m)$	$\rho_a(ohm-m)$ Observed value	$\rho_a(ohm-m)$ Computed value
1.00	1150.00	1109.62
1.47	1085.92	1020.04
2.15	1016.39	1016.06
3.16	1078.77	890.00
4.64	1245.47	890.00
6.81	1341.87	950.00
10.00	1501.04	1100.00
14.70	1485.00	1400.00
21.50	1582.05	1890.00
31.60	3136.28	2500.00
46.40	3152.12	3000.00
68.10	3787.25	3666.27
100.00	471.19	4600.00
147.00	6247.42	5160.00
215.00	7260.49	5800.00
250.00	5678.89	6370.00
300.00	4567.90	6680.00
400.00	3447.89	6950.00
500.00	3400.67	7110.00
600.00	3045.87	6740.00
700.00	2789.56	5840.00
800.00	2568.32	4680.00

RMS Error (%): 1.57

Model Parameters

Geoelectric Layer	Resistivity (ohm-m)	Thickness(m)	Cumulative Thickness(m)
1	1602.00	3.10	3.10
2	3129.00	13.10	16.20
3	4954.00	53.30	69.50
4	25471.00	100.70	170.20
5	1159.00	164.70	334.90
6	37466.00	infinity	Infinity

Observed Ves: 1b **L.G.A.: Esan West**
Location: AAU Ekpoma II **Weather: Hot**
State: Edo

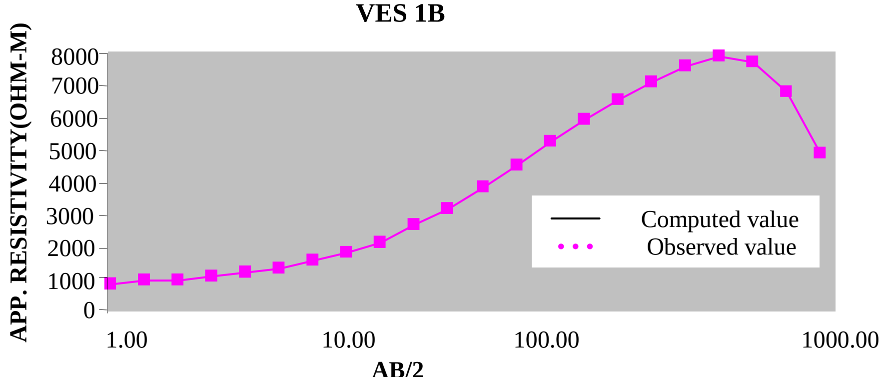

Figure 3.2: Plate Ib

Table 3.2: Observed (field) and computed (theoretical) data

$AB/2(m)$	$\rho_a(ohm-m)$ Observed value	$\rho_a(ohm-m)$ Computed value
1.00	1150.00	890.00
1.47	1085.92	1010.00
2.15	1016.39	1014.00

$AB/2(m)$	$\rho_a(ohm-m)$ **Observed value**	$\rho_a(ohm-m)$ **Computed value**
3.16	1078.77	1100.00
4.64	1245.47	1210.00
6.81	1341.87	1342.00
10.00	1501.04	1530.00
14.70	1485.00	1740.00
21.50	1582.05	2005.00
31.60	3136.28	2491.00
46.40	3152.12	2899.00
68.10	3787.25	3500.00
100.00	471.19	4050.00
147.00	6247.42	4680.00
215.00	7260.49	5260.00
250.00	5678.89	5800.00
300.00	4567.90	6260.00
400.00	3447.89	6680.00
500.00	3400.67	6950.00
600.00	3045.87	6812.00
700.00	2789.56	6000.00
800.00	2568.32	4370.00

Model parameters

Geoelectric Layer	**Resistivity (*ohm-m*)**	**Thickness(*m*)**	**Cumulative Thickness(*m*)**
1	1736.00	3.10	3.10
2	2859.00	13.50	16.60
3	5576.00	53.00	69.60
4	29493.00	119.00	188.60
5	1357.00	167.00	355.60
6	24240.00	infinity	Infinity

Observed Ves: 1c

RMS Error (%): 1.56

Location: AAU Ekpoma III **Weather: Hot**

State: Edo

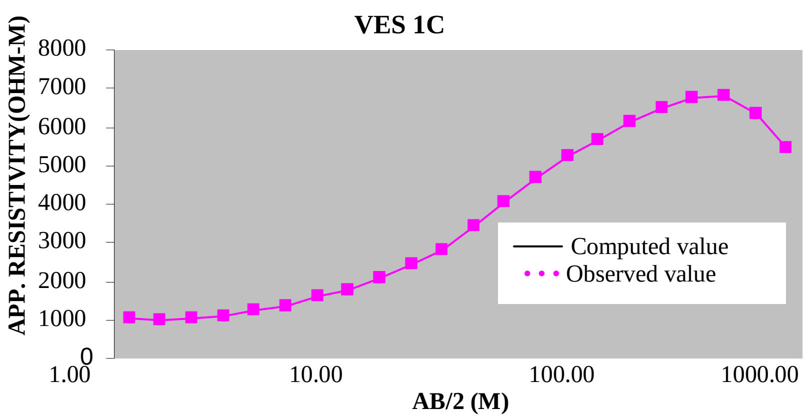

Figure 3.3: Plate Ic

Table 3.3: Observed (field) and computed (theoretical) data

$AB/2(m)$	$\rho_a(ohm-m)$ **Observed value**	$\rho_a(ohm-m)$ **Computed value**
1.00	1110.00	1014
1.47	1115.92	1006
2.15	1017.39	1050
3.16	1078.78	1112
4.64	1235.47	1241

$AB/2(m)$	$\rho_a(ohm-m)$ **Observed value**	$\rho_a(ohm-m)$ **Computed value**
6.81	1351.87	1326
10.00	1511.04	1588
14.70	1475.00	1744
21.50	1582.55	2100
31.60	3136.67	2440
46.40	3152.89	2799
68.10	3687.25	3410
100.00	4071.19	4050
147.00	6247.42	4691
215.00	7160.49	5250
250.00	5578.89	5660
300.00	4467.90	6106
400.00	3347.89	6490
500.00	3405.76	6750
600.00	3065.77	6800
700.00	2799.87	6340
800.00	2668.23	5450

Model Parameters

Geoelectric Layer	Resistivity (*ohm-m*)	Thickness(*m*)	Cumulative Thickness(*m*)
1	1743	3.30	3.30
2	2795	13.60	16.90
3	5559	52.80	69.70
4	24927	123.60	193.30
5	1402	155.00	348.30
6	21775	Infinity	Infinity

RMS Error (%): 1.55

4.0 Computation of the Dar Zarrouk parameters in the study area.

4.1 The Dar Zarrouk parameters

Computing the Dar Zarrouk parameters for the locations in the study area using the equations above, we obtain the following:

Table 4.1: DZP for VES 1A

Geoelectric layers	Geoelectric Parameters		Dar Zarrouk Parameters	
	Resistivity ρ_i **(ohm-m)** $i = 1, 2, 3, \ldots$	**Thickness** $h_i\,(m)$ $i = 1, 2, 3, \ldots$	**Longitudinal Unit Conductance** $S_i = \frac{h_i}{\rho_i}\,(\Omega^{-1})$	**Transverse Unit Resistance** $T_i = h_i\rho_i\,(\Omega m^2)$
1	1602.00	3.10	1.94×10^{-3}	4966.20
2	3129.00	13.1	4.19×10^{-3}	40989.90
3	4954.00	53.30	10.76×10^{-3}	264048.20
4	25471.00	100.70	3.95×10^{-3}	2564929.70
5	1159.00	164.70	142.12×10^{-3}	190887.30
TOTAL =		334.90	162.96×10^{-3}	3.066×10^{6}

For the second VES we have

Table 4.2: DZP for VES 1B

Geoelectric layers	Geoelectric Parameters		Dar Zarrouk Parameters	
	Resistivity ρ_i **(ohm-m)** $i = 1, 2, 3, \ldots$	**Thickness** $h_i\,(m)$ $i = 1, 2, 3, \ldots$	**Longitudinal Unit Conductance** $S_i = \frac{h_i}{\rho_i}\,(\Omega^{-1})$	**Transverse Unit Resistance** $T_i = h_i\rho_i\,(\Omega m^2)$
1	1736.00	3.10	1.79×10^{-3}	5381.60
2	2859.00	13.50	4.72×10^{-3}	38596.50

Geoelectric layers	Geoelectric Parameters		Dar Zarrouk Parameters	
	Resistivity ρ_i **(ohm-m)** ***i* = 1, 2, 3,…**	**Thickness *h*$_i$ (*m*)** ***i* = 1, 2, 3, …**	**Longitudinal Unit Conductance** $S_i = \frac{h_i}{\rho_i}\,(\Omega^{-1})$	**Transverse Unit Resistance** $T_i = h_i \rho_i\,(\Omega m^2)$
3	5576.00	53.30	9.56×10^{-3}	297200.80
4	29493.00	119.00	4.04×10^{-3}	3509667.00
5	1357.00	167.00	123.07×10^{-3}	226619.00
TOTAL =		355.90	143.18×10^{-3}	4.076×10^{6}

For the third VES we have

Table 4.3: DZP for VES 1C

Geoelectric layers	Geoelectric Parameters		Dar Zarrouk Parameters	
	Resistivity ρ_i **(*ohm-m*)** ***i* = 1, 2, 3, …**	**Thickness *h*$_i$ (*m*)** ***i* = 1, 2, 3, …**	**Longitudinal Unit Conductance** $S_i = \frac{h_i}{\rho_i}\,(\Omega^{-1})$	**Transverse Unit Resistance** $T_i = h_i \rho_i\,(\Omega m^2)$
1	1743	3.30	1.89×10^{-3}	5751.90
2	2795	13.60	4.87×10^{-3}	38012.00
3	5559	52.80	9.50×10^{-3}	293515.20
4	24927	123.60	4.96×10^{-3}	3080977.20
5	1402	155.60	110.56×10^{-3}	217310.00
TOTAL =		1748.30	131.78×10^{-3}	3.64×10^{6}

4.2 Anisotropic estimation

Considering the estimation from the first VES in the location, we have as follows

Table 4.4: Anisotropic estimation for VES 1A

Thickness *h*$_i$ (*m*) ***i* = 1, 2, 3,…**	**Longitudinal Unit Conductance** $S_i = \frac{h_i}{\rho_i}\,(\Omega^{-1})$	$\rho_L = \frac{h_i}{S_i}$	**Transverse Unit Resistance** $T_i = h_i \rho_i\,(\Omega m^2)$	$\rho_t = \frac{T_i}{h_i}$	$\lambda = \sqrt{\frac{\rho_t}{\rho_L}}$
3.10	1.94×10^{-3}	1.60×10^{3}	4960.00	1600.19	1.0001
13.1	4.19×10^{-3}	3.13×10^{3}	40989.90	3129.00	1.0000
53.30	10.76×10^{-3}	4.95×10^{3}	263835.00	4950.00	1.0000
100.70	3.95×10^{-3}	25.54×10^{3}	2571878.00	2554.00	1.0000

Table 4.5: Anisotropic estimation for VES 1B

Thickness *h*$_i$ (*m*) ***i* = 1, 2, 3, …**	**Longitudinal Unit Conductance** $S_i = \frac{h_i}{\rho_i}\,(\Omega^{-1})$	$\rho_L = \frac{h_i}{S_i}$	**Transverse Unit Resistance** $T_i = h_i \rho_i\,(\Omega m^2)$	$\rho_t = \frac{T_i}{h_i}$	$\lambda = \sqrt{\frac{\rho_t}{\rho_L}}$
3.10	1.79×10^{-3}	1.73×10^{3}	5363.00	1730.00	1.0000
13.50	4.72×10^{-3}	2.86×10^{3}	38596.50	2859.00	1.0000
53.30	9.56×10^{-3}	5.59×10^{3}	297947.00	5590.00	1.0000
119.00	4.04×10^{-3}	29.46×10^{3}	3565740.00	29460.30	1.0000
167.00	123.07×10^{-3}	1.36×10^{3}	227120.00	1360.00	1.0000

Table 4.6: Anisotropic estimation for VES 1C

Thickness h_i (m) i = 1, 2, 3,	**Longitudinal Unit Conductance** $S_i = \frac{h_i}{\rho_i} (\Omega^{-1})$	$\rho_L = \frac{h_i}{S_i}$	**Transverse Unit Resistance** $T_i = h_i \rho_i (\Omega m^2)$	$\rho_t = \frac{T_i}{h_i}$	$\lambda = \sqrt{\frac{\rho_t}{\rho_L}}$
3.30	1.89×10^{-3}	1.75×10^{3}	5775.00	1750.00	1.0009
13.60	4.87×10^{-3}	2.79×10^{3}	38012.00	2795.00	1.0009
52.80	9.50×10^{-3}	5.56×10^{3}	293568.00	5560.00	1.0000
123.60	4.96×10^{-3}	24.92×10^{3}	3080112.00	24920.00	1.0003
155.00	110.56×10^{-3}	1.40×10^{3}	217000.00	1400.00	1.0007

Table 4.7: Summary of the Dar Zarrouk Parameters (DZP)

Location (AAU Ekpoma)	***.Transverse Resistance*** $T = h\rho\ (\Omega m^2)$	***Longitudinal Conductance*** $S = \frac{h}{\rho} (\Omega^{-1})$	$\lambda = \sqrt{\frac{\rho_t}{\rho_L}}$
VES A	2.341×10^{6}	131.68×10^{-3}	1.0003
VES B	2.705×10^{6}	126.52×10^{-3}	1.0002
VES C	2.400×10^{6}	128.49×10^{-3}	1.0007

5.0 Discussion

From the analytical relationship according to Niwas and Upadhyay (1981) [8], we have that $T_r = K\sigma T = \frac{KS}{\sigma}$ Let T and S for the VES stations in the locations be denoted by (T_1, S_1), (T_2, S_2), (T_3, S_3)…, then their corresponding transmissivity values are given by T_{r1}, T_{r2} and T_{r3}, respectively. From A, B and C locations in AAU Ekpoma, we have that;

$$(T_1,S_1) = (2.341 \times 10^6)\ (131.68 \times 10^{-3})$$
$$(T_2,S_2) = (2.705 \times 10^6)\ (126.52 \times 10^{-3})$$
$$(T_3,S_3) = (2.400 \times 10^6)\ (128.49 \times 10^{-3})$$

$T_r = K\sigma T = \frac{KS}{\sigma}$. Therefore $K\sigma T = \frac{KS.S}{\sigma}$. For T_{r1}, T_{r2} and T_{r3}, we have that;

T_{r1} = $K\sigma$ (2.341 v 10^6) = $\frac{K}{\sigma}$ (131.68 x 10^{-3}), T_{r2} = $K\sigma$ (2.705 v 10^6) = (126.52 x 10^{-3}), T_{r3} = $K\sigma$ (2.400$v10^6$) = $\frac{K}{\sigma}$ (128.49 × 10^{-3}) where (T_1, S_1), (T_2, S_2), (T_3, S_3) implies the respective Transverse Resistance and Longitudinal Conductance for the VES stations in the locations and their corresponding transmissivities are Tr_1’ T_{r2} and T_{r3}, respectively

$K\sigma$ and $\frac{K}{\sigma}$ are not varying (constants).

Taking the ratio, we have that;

T_{r1}: T_{r2}: T_{r3}: = $K\delta$ (2.341 × 10^6) : $K\delta$ (2.705 × 10^6) : $K\delta$ (2.400 × 10^6) = (2.341 × 10^6): (2.705 × 10^6): (2.400 × 10^6)

The Dar Zarrouk parameters, that is, Longitudinal Unit Conductance $S_i = \frac{h_i}{\rho_i}(\Omega^{-1})$ and Transverse Unit Resistance $T_i = h_i \rho_i (\Omega m^2)$ were evaluated to be able to estimate the anisotropic values $\lambda = \sqrt{\frac{\rho_t}{\rho_L}}$ as presented in Tables (4.1, 4.2 and 4.3). Geoelectric layer is mostly described by resistivity ρ_i and thickness h_i and were obtained as presented in Plate Ia, Plate Ib and Plate Ic. From Table 4.3: Summary of the Dar Zarrouk Parameters (DZP) computation, we have the anisotropic values to be 1.0003, 1.0002 and 1.0007. These values are approximately equal to one which implies the equality of anisotropy and isotropy in the location. Therefore, the assumption of isotropic homogeneous formation is tenable in the location of the area of study. From the evaluation we have the aquifer transmissivity in the location as:

T_{r1}: T_{r2}: T_{r3}: $= K\sigma$ (2.341×10^6): $K\sigma$ (2.705×10^6): $K\delta$ (2.400×10^6) = (2.341×10^6): (2.705×10^6): (2.400×10^6). This implies $T_{r1} < T_{r2}$ ($T_{r1} < T_{r2} > T_{r3}$) and $T_{r1} < T_{r3}$. But $T_{r2} > T_{r3.}$ This means that the aquifer transmissivity in the first VES is lower than the aquifer transmissivity values of the second and third. But the aquifer transmissivity of the second VES is higher than the third. This will definitely influence the water flow pattern in the area. It tends to flow from the direction of the second VES towards the direction of the first and the last VES.

6.0 Conclusion

The study has been able to validate the computation of the Dar Zarrouk parameters to evaluate aquifer transmissivity. The average electrical properties of each unit in layered geoelectric section were described by the Dar Zarrouk Parameter and a coefficient of anisotropy λ was computed and found out that the anisotropic values are approximately equal to one which implies the equality of anisotropy and isotropy in the location. The study therefore confirms the assumption of isotropic homogeneous formation in the location of the study area. The study showed from the evaluation of the transmissivity that it will definitely influence the water flow pattern in the area which tends to flow from the direction of the second VES towards the direction of the first and the last VES. This gives better information of a proper location of a productive borehole installation in the area.

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