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GROUNDWATER EXPLORATION IN A TYPICAL BASEMENT COMPLEX TERRAIN, SOUTHWESTERN, NIGERIA

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ABSTRACT: *Previous researches shows that resistivity values are not sufficient in adequately and correctly delineating aquiferous zone or areas of high groundwater yield in crystalline basement terrain, a complementary has been recommended, the aim of this study is to delineate fractured zones and area of groundwater potential from reflection coefficient and overburden thickness above the bedrock. Geoelectric measurements using the vertical electrical sounding (VES) method were carried out in Alakia, Ibadan Oyo State, Nigeria. Eight profiles were carried out using the Schlumberger array configuration. The data was interpreted using the method of curve matching and computer iteration (WinResist Software). Results showed that four to six geologic layers were identified in the study area and they include the topsoil, clayey, clayed sand, sandy soil, lateritic soil, weathered/highly fractured basement. The values of the reflection coefficient ranges from 0.16 to 0.78, the low values imply the study area is well fractured while the overburden thickness varies between 8.1 and 59.4m. 88% of the study area has overburden thickness that is greater than 30m, while all the VES points have reflection coefficient that is less than 0.8. The result revealed that the area is well fractured and the groundwater prospect within the area is very high.*

KEYWORDS: reflection coefficient, overburden thickness, aquifer potential, electrical resistivity, fractured rock, Alakia

INTRODUCTION

The resistivity of a geological formation in a basement terrain cannot be solely relied on to identify areas of promising aquifer within the terrain because the rocks in this terrain lack primary porosity and permeability (Olayinka, 1996; Abiola et al, 2009) but fracturing and weathering activities of basement complex rocks may lead to appreciable secondary porosity and permeability of the rocks, thereby making them suitable aquifers (Dan-Hassan and Olorunfemi 1999). The reflection coefficient is a measure of the degree of fracture in an area, such that areas of low reflection coefficient value have high water potentials (Olayinka et al 2000: Anudu et al 2011). Reflection coefficient should be consider as a complementary factor in evaluating the groundwater potential of a basement complex area because it show the degree of fracturing of the underlying basement better than depending solely on the resistivity values. Overburden refers to earth materials other than the hard rocks that overlie the basement rocks, this includes the topsoil, weathered layer, and partly weathered basement (Abiola et al 2009). It can also be defined as loose, unconsolidated materials resting on bed rock, the overburden in assumed to include all materials above the presumably fresh basement. Generally, areas with thick overburden and low percentage of clay in which intergranular flow is dominant are known to have high groundwater potential particularly in basement complex terrain (Okhue and Olorunfemi, 1991). In the basement terrain, good aquiferous zones are usually characterized by relatively thick overburden and low reflection coefficient (Olorunfemi and Fasuyi, 1993). These two properties are complementary in delineating aquiferous zone in hard rock terrain or in evaluating the groundwater potential (Meju et al. 1999; Omosuyi, 2000; Lenkey et al., 2005: Nicholas et al 2016; Bayewu et al 2018) .Vertical electrical sounding (VES) is a geophysical method for the estimating the electrical conductivity or resistivity of a geological medium. The estimation is performed based on the measurement of voltage of electrical field induced by the grounded current electrodes. Etu-Efeotor et al. (1998) carried out an assessment of the near surface underground water resources potential within the eastern Niger Delta, Nwankwo et al., (2013) also carried out a Geophysical investigation for ground water development in a basement rock region; Akobo - Ibadan. This research therefore is based on the use of Electrical Resistivity for mapping underground water potential of Alakia, Ibadan.

SITE DESCRIPTION AND GEOLOGY

The study area (Figure 1)is located in Alakia, Ibadan, Oyo state and lies within latitude 7° 23' 04.5 '' N to7° 23 ' 09.2" N, and longitude 3° 58’ 37.8" E to 3° 58' 37.2 " E. The area lies within the Basement Complex of Nigeria and the area is also underlained by the Precambrian Basement rocks of southwest Nigeria (Rahaman and Ocan 1978).These rocks can be grouped into major and minor rock types. The major types are quartzite of the Meta sedimentary series and the migmatite complex comprising banded gneiss, augen gneiss and magnetite, while the minor rocks types are pegmatite, quartz, aplite, diorites, amphibolites and xenoliths. The type of rock in an area is an important factor governing the characteristics of its groundwater. Basement complex rocks, composed mainly of metamorphic and igneous rocks types are relatively low in groundwater production in comparison with sedimentary rock. These rocks lack primary porosity, occurrence of groundwater is due largely to the development of secondary porosity and permeability by weathering and fracturing of the parent rocks (Acworth, 1987; Olorunfemi and Fasuyi, 1993; Olayinka et al., 1997. It has an equatorial climate with dry and wet seasons and relatively high humidity. The dry season lasts from November to March while wet season starts from April and ends in October. The average annual rainfall is 150mm daily and the average daily temperature ranges between 25 °C and 35 °C almost throughout the year.

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MATERIAL AND METHOD

The field survey involved the application of electrical resistivity method to acquire the vertical electrical sounding (VES) data using the Schlumberger array or configuration.
The field data was processed using method of Partial curve matching and computer iteration technique. The overburden thickness was calculated from the iteration results and the reflection coefficient R was determine using equation 1

$$\mathbf{R} = \frac{\rho_n - \rho_{n-1}}{\rho_n + \rho_{n-1}} \qquad 1$$

Where ρ_n is resistivity of nth layer and ρ_{n-1} is the resistivity of (n-1) th layer, while the number of layers from the surface to the top of the bedrock varies from i= 1 to n.

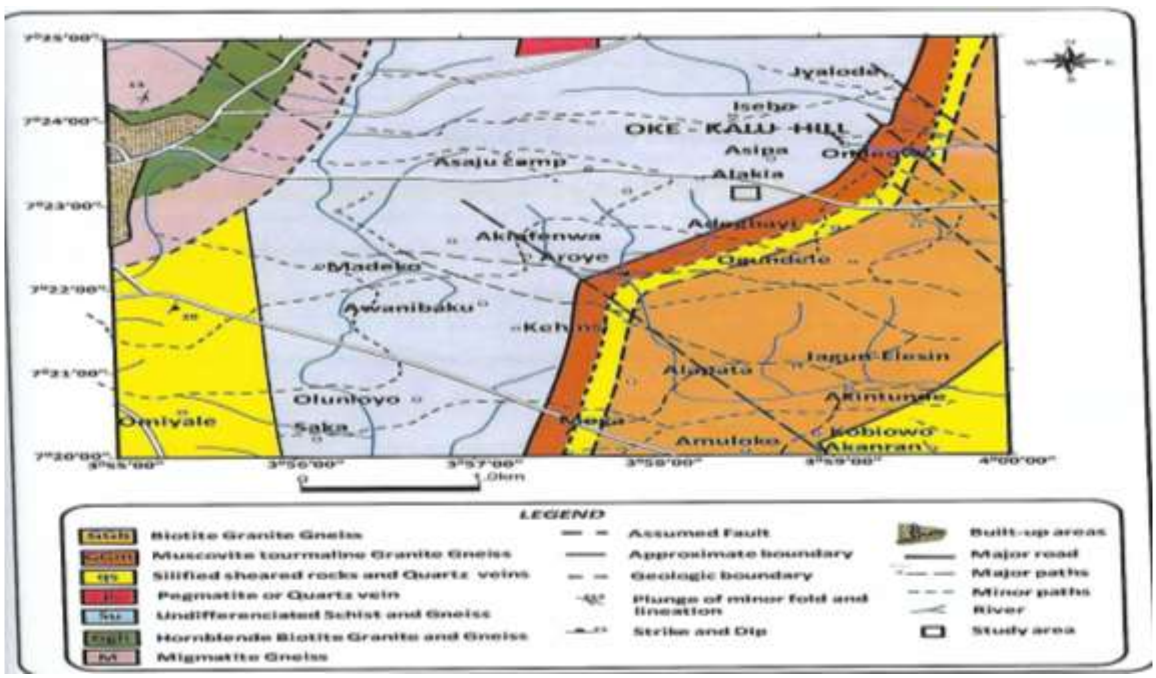

Fig 1: Geological map showing the study area

RESULTS AND DISCUSSION

Eight VES curves were obtained from the study area, resistivity curves are classified under the following types of curves namely; A-type curve when $\rho_1 < \rho_2 < \rho_3$, Q-type curve when $\rho_1 > \rho_2 > \rho_3$, H-type curve when $\rho_1 > \rho_2 < \rho3$ and K-type curve when $\rho1 < \rho_2 > \rho_3$.
Table 1 showed that VES 1, 6 and 7 are AK type, VES 2 is HKH type, VES 3 is HA type and VES 4 is HAKH type, VES 5 and 8 are KH type. The apparent resistivity curve shows that the most dominant type is AK type followed by KH type. Four to six geologic layers were identified in the study area and they include the topsoil, clayey, clayed sand, sandy soil, lateritic soil, weathered/highly fractured basement.

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Reflection coefficient was used to determine if the bedrock in the area is fractured or not, the values of the reflection coefficient ranges from 0.16 to 0.78 this low values implies the study area is well fractured while the overburden thickness varies between 8.1 and 59.4m which is relatively similar to the thickness range 4.0 to 79.2 obtained to by Okhue and Olorunfemi 1991. Area with low reflection coefficient and high overburden thickness are regarded as having high groundwater potential. VES 1 and 4 have low reflection coefficient which is evidence that the area has been fractured and an aquiferous layer of thickness 4.3m was delineated in that area but the overburden thickness is very thin, but this area cannot be recommended because the aquifer is very vulnerable to pollution due to the thin overburden thickness.VES 2, 3, 5, 6, 7, 8 are good aquiferous zones or areas with high groundwater potential because of their low reflection coefficient values, high overburden thicknesses and a high thickness of aquiferous layers of 20.4m to 22.1m were delineated within these zones, this implies high volume of groundwater that is less vulnerable to pollution.

Table 2: Results and Interpretation

Station	Layer	Apparent Resistivity Value(m)	Layer thickness(m)	Curve Type	Overburden Thickness(	Reflection Coefficient
VES 1	1	46.6	1.5	AK	8.1	0.23
	2	79.9	2.3			
	3	198.9	4.3			
	4	124.1				
VES 2	1	59.6	2.2			
	2	22.9	13.0	HKH	59.5	0.16
	3	107.4	22.1			
	4	18.4	22.2			
	5	25.5				
VES 3	1	46.2	1.4			
	2	37.8	7.9	HA	31.4	0.43
	3	44.3	22.1			
	4	110.8				
VES 4	1	204.1	0.5	HAKH	38.4	0.56
		55	0.8			
		165.1	2.5			
	4	1005.2	7.8			
	5	43.2	26.8			
	6	153.3				
VES 5	1	145.7	1.2	KH	52.4	0.51
		305.3	3.9			
		150.1	47.3'			
	4	459.1				
VES 6	1	58.7	1.6	AK	31.6	0.31

	-	67.4	2.5			
		117.9	27.5			
	4	62.6				
VES 7	1	137.5	4.3	AK	30	0.78
	2	152.8	5.3			
	3	314.7	20.4			
	4	39.3				
VES 8	1	351.9	7.3	KH	47.4	0.31
	2	541.1	10.5			
	3	91.8	29.6			
		174.8				

CONCLUSION

The reflection coefficient ranges from 0.16 to 0.78 this low values implies the study area is well fractured while the overburden thickness varies between 8.1 and 59. Area with low reflection coefficient and high overburden thickness implies high groundwater potential. 88% of the study area has overburden thickness that is greater than 30m , these is greater than the values obtained by Olorunfemi and Okhue, 1992, Olayinkaet al, 1997, while all the VES points have reflection coefficient that is less than 0.8. The result revealed that groundwater prospect within study the area is very high.

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