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THE USE OF ELECTRICAL RESISTIVITY SURVEY TO DETERMINE WATER-BEARING STRUCTURES, GA EAST AND LA-NKWANTANANG-MADINA MUNICIPALITIES, GHANA

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Abstract

Hydrogeological investigations to delineate water-bearing zones had successfully been carried used using ABEM Terrameter SAS 3000C for electrical resistivity profiling and vertical electrical sounding along traverses in 9 communities in Ga East and La-Nkwantanang-Madina Municipalities. Three, 4 and 5-layer resistivity subsurface structures with A, K H, AK, KH, HK, QH, HKH, KHK as resistivity curve types were delineated. While 3, and 4-layer resistivity structures are located within the Dahomeyan Supergroup and the Togo Structural Unit, the 5- layer structures are only restricted to the Togo Structural Unit. For a particular vertical Electrical sounding point, modeled results that show intermediate layer characterized by highest electrical conductivity with corresponding appreciable thickness exceeding 8.5 m shows the presence of weathered and fracture zone capable of hosting groundwater structures. Also, low bedrock apparent resistivity showed the presence of weathered zones, fractured zones and fractured bedrocks capable of hosting groundwater structures that can be exploited for water supply in most communities. Most often, bedrock rock apparent resistivity not exceeding 1000 Ωm host water-bearing structures. Anomalous points in communities that have subsurface structures capable of being exploited for water supply include C 50 at Adenkrebi, B 20 and A 194 (shallow well) at Kponkpo; A 58, A 20, B 55, and A 75 at Oyarifa; A220, B160 and B 222 at Akporman. Others are A 10, A 48, and B 53 at Atomic Energy Quarters; A 20, A 100, B 80, and B 180 at Kweiman; B 2 and B 18 for Adoteiman, B 56 for Taifa Burkina. Three-layer structures at A 38 and A 75 (Kwabenya Village) and B 15 (Taifa Burkina) showed no water-bearing structure to be developed for water supply. The results therefore show the capability of using electrical resistivity to determine water-bearing zones for water supply in the area.

Keywords: Water-bearing Structures, Vertical Electrical Sounding, and Bedrock Apparent Resistivity.

Introduction

In Accra, the capital of Ghana, existing housing units near commercial centres had gradually been converted into commercial facilities. Most residents in these areas are gradually relocating to new areas outskirt these commercial hubs. One such areas where residents are gradually migrating to are communities in Ga East and La Nkwantanang -Madina Municipal Assemblies. However, residents in these new settlements lack potable water and are confronted to depend on ephemeral streams, untreated rainwater from roofs, unprotected hand dug wells. The result is that water-borne diseases particularly typhoid fever and dysentery topped most of the hospital attendant cases in the area. Where residents do not want to depend on the unsafe drinking water for their domestic purposes, they depend on water vendors who provide pipe-borne water obtained from other districts. Even water from these vendors may not be safe due to possible contamination of the resource along the supply chain. What make matters worse was the uncoordinated private individual housing units rapidly springing up in one place or another without taking into account the availability of potable water in these areas. Furthermore, the government is not able to extend existing pipelines to catch up with the rapidly expanding private housing units around these areas The risk associated with the use of such unsafe water necessitate the need to investigate the presence of any water-bearing zones in the area that can exploited in 9 water-stressed communities. In this paper, attempt had been made to use electrical resistivity survey to identify the existence of any water-bearing zones in 9 communities in parts of Ga East and La-Nkwanta Municipal Assemblies.

Study Area

The study area lies within the Ga East Municipal Assembly which is bounded by latitudes 05˚46.770'N and 05˚40.101'N and longitudes 0˚15.168'W and 0˚09.071'W and covers an area of 166 Km^2. Taifa Burkina Market, Atomic Energy Staff Quarters, Kwabenya Village Adenkrebi, Oyarifa, Kponkpo, Kweiman, Adoteiman, and Akporman are the list of nine research communities (Fig. 1.0). Vegetation in this area is Guinea Savanna Grassland. One dry season and two wet seasons are experienced in the area. The dry season starts in late September or early October and ends in February. The major wet season starts in March and ends in July with peak rain in June. The minor rainy season starts in August and ends in early October. Within the dry season, the area experiences a strong northeast trade wind known as Harmattan which affects the entire country (Dickson and Benneh, 1980). Mean Annual Temperature in the area varied from 28˚C to 31˚C. The hottest month is February while the coolest month is August. The ephemeral Onyasia River is the main dendritic drainage system in the area with Labor, Dakobi and Ado as the main tributaries that feed the stream. Geologically, the area is covered by Togo Structural Unit underlain by the Dahomeyan Supergroup along the eastern fringes of the Togo Structural Unit. While the Togo Structural Unit belongs to Neoproterozoic Era with sandstones, quartzites, quartzitic sandstone, schist, and shale as the principal rock types, the Dahomeyan Supergroup belongs to Eburmain Era with granitic gneiss as the main rock type. Generally, the rocks of the Togo Formation thin out towards the eastern section of the study area. There exist several water-bearing structures within the Togo Structural Unit compared to the Dahomeyan Supergroup. This is because apart from the individual rocks type having their inherent fracture systems, the contacts between any two rock types serve as conducts for infiltration of rainfall for groundwater accumulation and storage. Existing boreholes show depth of boreholes not exceeding 100 m. Yields varied from 20 litres per minute to 145 litres per minute. Several boreholes drilled in some private homes especially within the Togo Structural Unit showed appreciable levels of iron and manganese exceeding World Health Organization upper limit (WHO, 2011) for drinking water. Some of these boreholes have undergone treatment before being used for domestic purposes.

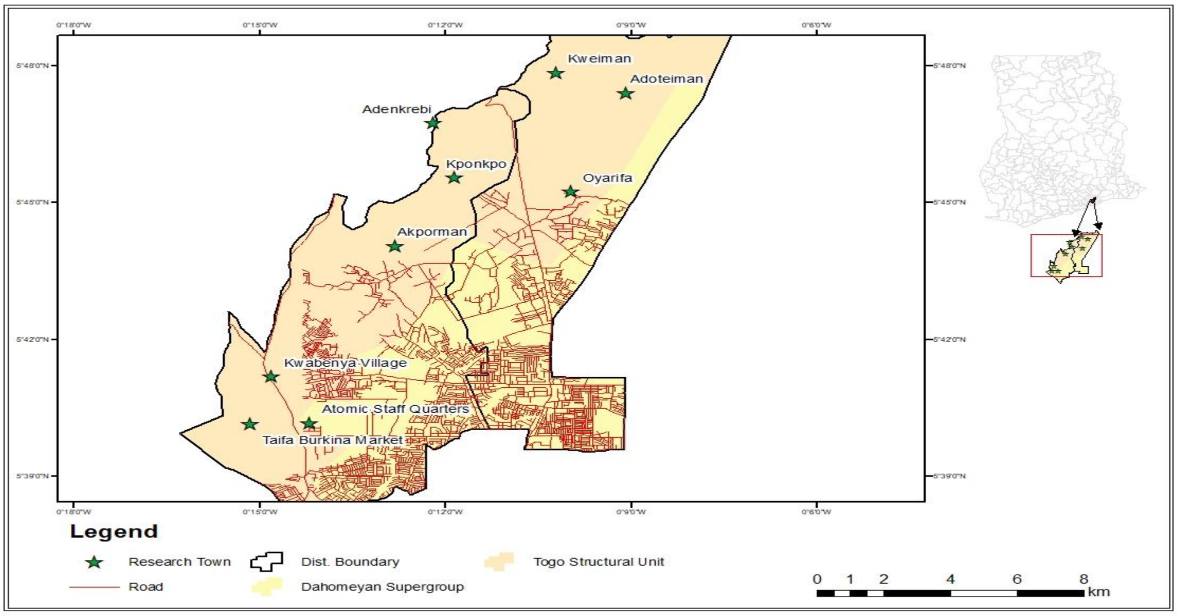


Fig.1.0: Research communities in Ga East and La-Nkwantanang Municipal Assemblies.

Method and Material.

Electrical resistivity survey is one of the near-surface geophysical methods for subsurface investigations (Nath, 2000; Sharma, 2000; Telford et al, 1994) and had been used for groundwater exploration (Patil et al, 2015; Gupta et al, 2014; Ewusi and Kumah, 2011; Ahilan and Kumar, 2011; George et al, 2011; Nwankwo et al, 2011; Armada et al, 2009; Oyolabi et al, 2009; Reddy and Raju, 1997; Hazel et al, 1992; Caruthers and Smiths,1992; Giddo et al, 1992; Barker et al, 1981). It had been used to determine groundwater potential (Alabi et al, 2016; Joshua et al, 2011; Nejad, 2009) and to determine groundwater salinity (Holdlur, 2010; Van Overmeeren, 1989). Gupta et al, (2014) also used it to characterize saline water and freshwater interface. Furthermore, it had been used to characterize aquifers (Quadif et al, 201; Majumdar et al, 2011; Tizro, et al, 2010; Onu, 2003; Urish and Frohlich, 1990). The successful use of the method widely in the water industry, makes the method an effective geophysical method for locating of sites for boreholes (Hazel et al,1992; Caruthers and Smiths,1992; Oyolabi et al, (2009).

In Ghana, it is the most popular and most effective means for groundwater exploration and extensively used for more than 2 decades. In an attempt of detecting water-bearing zones per objective of this research, the method was selected because of its simplicity, straight-forwardness, ease of use, availability of the equipment, low operational cost associated with its usage. Furthermore, area under consideration has different rock types sandstone, shale, quartzites, gneiss) and the wide range of resistivity values of earth materials (e.g. Telford et al, 1994) makes the method versatile in locating groundwater contained in the different rock types within the area. To determine water-bearing zones in the communities, electrical resistivity survey was carried out along traverses in the communities. The Schlumberger electrode arrays with electrode separations given as (AB/2, MN/2): (19 m, 0.5 m) and (40 m, 5 m) for electrical resistivity profiling at two depths of investigation and for vertical electrical sounding. The (19 m, 0.5 m) array was for shallow depths while the (40 m, 5 m) was used for investigating the bedrock. Profiling along traverses were done at 2 m, 5 m, and 10 m intervals. The ABEM Terrameter SAS 300C was used for resistivity profiling and Vertical Electrical Sounding to obtain the resistivity of the point at the depth of investigation. When the resistivity value for the profiling or sounding is obtained, the product of the measured electrical resistivity with a corresponding multiplying factor per electrode spread is used to obtain corresponding apparent resistivity. On identification of anomalous point(s), electrical resistivity profiling at 2 m interval were carried out across the identified point(s) for final selection of point(s) for Vertical Electrical Soundings for 5 m and 10 m profile intervals.

For vertical electrical soundings, the Schlumberger array with expanding electrode procedure was used. Minimum current electrode spread was 1.5 m while 83 m was for maximum current electrode spread. Potential electrode spread changed from 0.5 m to 5 m. Measured resistivity values obtained were plotted as VES was in progress with the best line of fit so as to obtain the resistivity boundaries of the subsurface conditions. The final VES apparent resistivity values for each sounding points were imported into ‘Resist’ Software Program for modeling. Iterations and curve smoothening of the imported data were done to ensure minimum root mean square (r. m. s) errors and best lines of fits were obtained. For this work, minimum root means squares not exceeding 3.08 % was used. The modeled results gave quantitative values of apparent resistivities with corresponding layers and depths or thickness of their layers. The modeled results were put in a tabular form with L, R and T representing layer, modeled apparent resistivity and thickness of the subsurface layer respectively. Based on the quantitative results, appropriate interpretations were made based on identified conductive zone(s) and the apparent resistivity of the bedrock) for each point. The conductive zones of the various resistivity layers, and the bedrock apparent resistivity values were use as basis to identify water-bearing zones within the communities.

Results and Discussion

Summary Statistics for Electrical Resistivity Profile

Table 1.0 provides the summary statistics of electrical resistivity profiling data along selected traverses in the communities. With the exception of 3 traverses at Adenkrebi, two traverses were profiled in each of the remaining eight communities. Length of traverse varied depending on accessibility for profiling and availability of public land. Total profile length was 2409 m. Least and highest traverse length of 24 m and 250 m occurred at Adoteiman and Akporman respectively. A wide range of apparent resistivity values exist along the selected traverses in the communities. Generally high resistivity values were recorded along traverses in Adenkrebi and Kwabenya Village, moderate in Taifa Burkina, Adoteiman, Kweiman, Akporman and Kponkpo and low at Oyarifa and Atomic Energy Quarters. The high standard deviations of electrical resistivity for each traverse in communities suggest the heterogenous nature of resistivity values within the subsurface. Highest standard deviation occurred along traverse B in Adenkrebi while least standard deviation occurred on traverse B at Atomic Energy Quarters.

Table 1.0: Summary Statistics of Profiling Results in Communities

Community	Traverse	Minimum (Ωm)	Maximum (Ωm)	Mean (Ωm)	Median (Ωm)	Standard Deviation	Traverse (m)
Adenkrebi	A	558.36	2598.75	1393.92	1418.17	652.83	170
	B	1103.85	5613.30	3347.96	3059.10	1275.66	130
	C	509.36	2866.05	1409.00	1188.00	707.76	140
Kponkpo	A	184.14	468.27	287.71	266.31	83.87	220
	B	210.37	369.27	260.97	255.66	43.75	170
Oyarifa	A	31.68	237.60	59.29	49.99	42.87	100
	B	35.14	49.50	47.71	43.80	11.54	75
Akporman	A	94.54	213.84	141.83	141.32	28.96	250
	B	85.63	232.65	147.39	139.83	30.90	250
Atomic Energy Quarters	A	19.80	75.24	50.41	48.51	18.71	60
	B	41.58	75.73	57.52	54.70	9.89	65
Kweiman	A	76.72	173.25	130.94	137.11	26.26	160
	B	62.37	161.86	122.66	127.21	23.59	200
Adoteiman	A	127.21	332.64	240.65	223.24	62.98	60
	B	101.47	336.10	222.10	233.64	81.96	24
Taifa Burkina Market	A	384.12	1039.50	752.34	837.54	206.86	80
	B	214.83	467.28	356.96	356.40	79.36	95
Kwabenya Village	A	1683.00	3687.75	2627.86	2663.10	572.15	80
	B	1514.70	3529.35	2491.59	2588.85	568.68	80

Vertical Electrical Sounding and Modeled Results

Modeled graphs of 12 anomalous points had been indicated in Fig. 2 a -l while the numerical values of modeled results of the Vertical Electrical Soundings points identified are displayed (Table 2.0). On the basis of resistivity curve-type, A, H, K, AK, KH, HK, QH, KHK, and HKH formed 9 different types identified in the study. H-type is the most dominant and constitutes approximately 35.71 % while A, K AK and QH formed the least (3.57 %). Modeled results showed 3, 4 and 5-layers of apparent resistivities with corresponding thicknesses within the communities. Out of twenty-eight (28) VES points, 12 are 3-layer models, 14 are 4-layer models while 2 depict 5-layer subsurface structures. This makes the 4 –layer subsurface structure to be the dominant subsurface structure within the study area, followed by 3 -layer structures and 5-layer structures.

For 3-layer structure, apparent resistivity for first layer varied from 14.2 Ωm at Taifa Burkina Market to 517.2 Ωm at Kweiman. Intermediate layers varied from 9.0 Ωm with corresponding thickness of 8.6 m at Oyarifa to 362.4 Ωm with corresponding thickness of 56.7 m at Kwabenya Village. The most extensive (24.8 m) conductive zone among the 3-layer structures occurred at Kweiman (B 180). Bedrock apparent resistivity changed from 87.2 Ωm at Oyarifa (A 20) to 7340.9 Ωm at Kponkpo (A 194).

For the 4-layer models, apparent resistivity of the first layer varied from 14.9 Ωm at Atomic Energy Quarter (A10) to 370.6 Ωm at Akporman (A 220). The apparent resistivity of the second layers changed from 30.6 Ωm to 780.8 Ωm at Taifa Burkina (B 56 and B 85). Apparent resistivity of the third layer changed from 12.5 Ωm at Atomic Energy Quarters (A 10) to 910.4 Ωm at Adenkrebi (C 50). The most extensive thickness (27.5 m) of the third layer which occurred at Atomic Energy Quarters (A48) occurred on the same traverse that the least apparent resistivity of the third layer occurred (Atomic Energy Quarters: A10). It is worth noting that for any 4-layer structure, the third layer has the most extensive thickness. The moderate apparent resistivities and extensive thicknesses of the third layers are therefore indications of good conductive zones for groundwater occurrence and accumulation. The apparent resistivity of the bedrock of the 4-layer models varied from 76.1 Ωm at Atomic Energy Quarters (A10) to 92913.9 Ωm at Kwabenya Village (A75).

For the 5-layer structures, apparent resistivity for first layer are 149.4 Ωm and 914.2 Ωm, 2510.9 Ωm and 53.3 Ωm for second layer, 771.7 Ωm and 1776.2 Ωm for third layer, 440.7 Ωm and 2061.6 Ωm for the fourth layer and 924.1 Ωm and 530.4 Ωm as bedrock apparent resistivities at Kponkpo (B20) and Ademkrebi (A100) repectively. The medium apparent resistivity of the fourth layer at Kponkpo (B20) occurring at depth between 20.1 m and 32.1 m is a conductive zone and /or contact between two rocks which can be considered for groundwater exploitation.

At Adenkrebi, bedrock apparent resistivity varied from 145.2 Ωm at C 50 to 744.7 Ωm at A 40. C 50 has the least bedrock apparent resistivity suggesting the presence of possible fracture system within the bedrock at this point. A 40 and A 100 have higher bedrock apparent resistivity which implied the decreasing fracture system or conductive zone at increasing depth. On the basis of apparent resistivity and corresponding thickness of the subsurface layers, C 50 contained structures that host the presence of groundwater.

At Kponkpo, B 20 can be considered to contain structures capable of producing groundwater. The lowest apparent resistivity of the bedrock at B 20 and the appreciable thickness 12 m of a fourth layer conductive zone accounts for this. Point A 194 may be considered as another point because of the conductive of the intermediate layer with resistivity thickness of 16.1 m but the highest bedrock apparent resistivity at this point implied shallow well could be made available upon exploitation.

At Oyarifa, all the intermediate layers are the most conductive parts at each anomalous point. All the points have low bedrock apparent resistivities suggesting the presence of possible conductive or fracture system within the bedrock. The low apparent resistivities of the intermediate layers and their appreciable layer thickness varying from 8.6 m to 12 m are also indications of presence of groundwater. Thus, all the three points contained potential groundwater structures capable of producing wells for water supply. The difference lies in the differences among the points. We therefore expect point A 20 to have a better water-bearing structure within its bedrock than B 55 followed by A 75 because A 20 has the least bedrock apparent resistivity followed by B 55 and then by A 75.

At Akporman, besides A 58 which show a 3-layer structure with the least bedrock apparent resistivity, all other points identified displayed alternating low-high resistivity structures. These alternating high-lows apparent resistivity depicts fracture system provided one rock type exist at each point or intercalation of rock types for different multiple rock types in the area. For the same rock type existing at each point suggest the presence of groundwater as fracture systems are the main aquifer zone for bedrock aquifers in crystalline rocks. Where multiple rocks exist, the contact of these rock could serve as conducts for weathering and hence, accumulation and storage of infiltrated water from rainfall as groundwater. Also, A 58 has the least bedrock apparent resistivity suggesting a possible conductive zone within the bedrock at this location. We therefore expect the presence of groundwater at A 58, A 220, B 222, and B 160 for exploitation.

At Kwabenya Village, A 75 is characterized by the highest bedrock apparent resistivity within the study. It has a thin 6.7 m third layer up to a depth of 10.7 m approximately. The thin intermediate conductive zone at shallow depth and the highest bedrock apparent resistivity at shallow depth implies the presence of surface water accumulation at depth between 4 m to 10.7m and absence of fracture or conductive zone at depth beyond 10.7 m. At A 35, there is no much difference between the second and the third layer. Such small difference suggests the absence of major conductive zone within the bedrock for groundwater exploitation. Thus, 2 anomalous points identified is not suitable for groundwater exploitation.

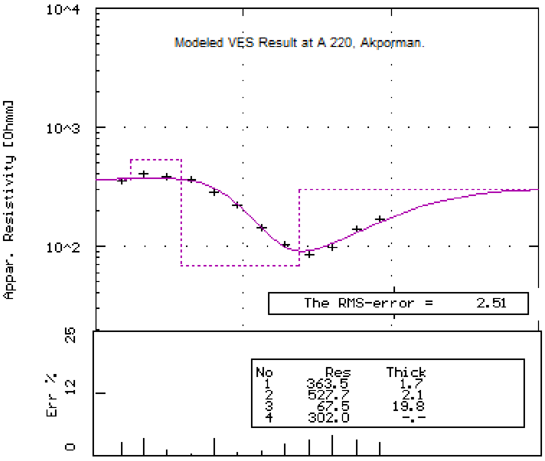


Fig. 2a: Modeled graph at A 220, Akporman.

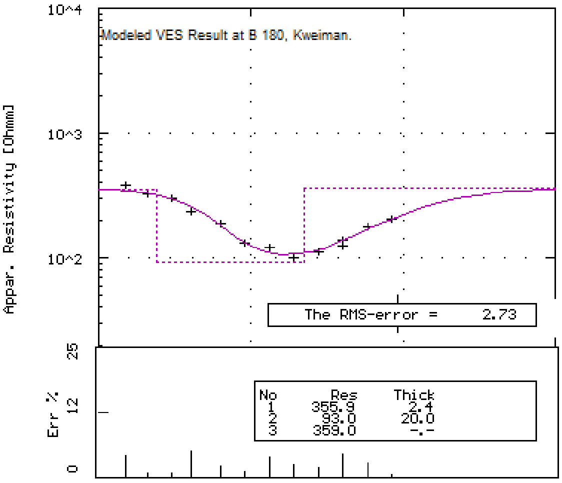


Fig.2b: Modeled graph at B 180, Kweiman.

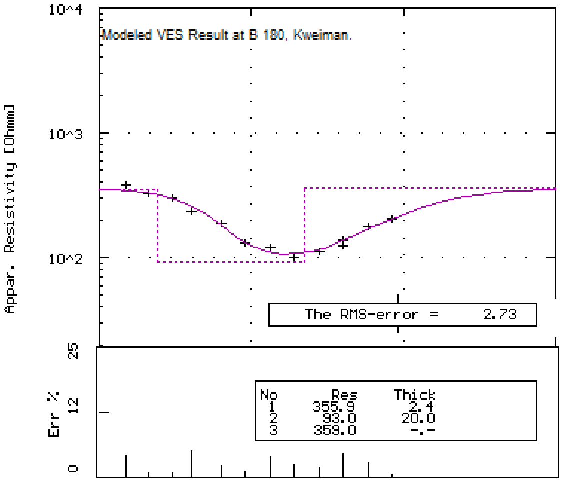


Fig.2b: Modeled graph at B 180, Kweiman.

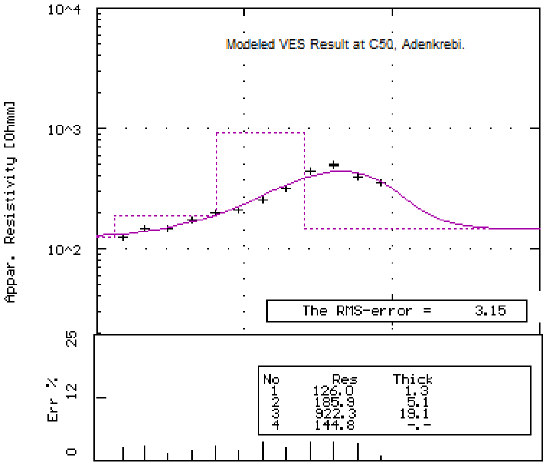
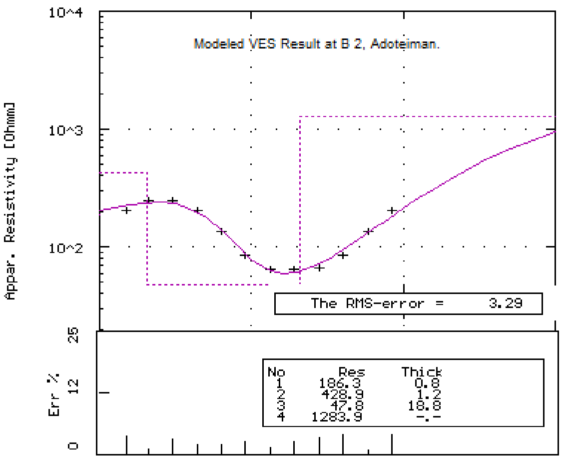


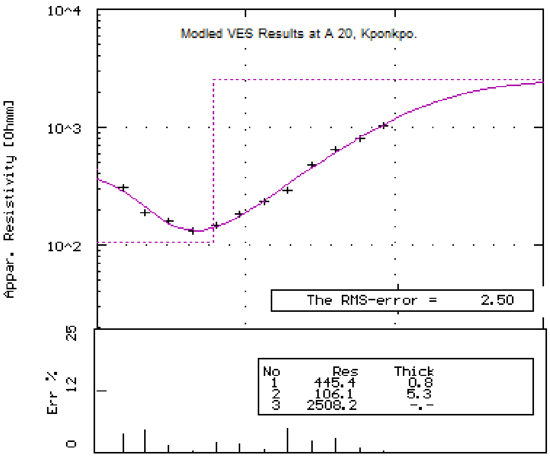
Fig. 2c: Modeled graph at C 50, Adenkrebi.



```
The RMS-error =     3.29

No      Res     Thick
 1    186.3       0.8
 2    428.9       1.2
 3     47.8      18.8
 4   1283.9       -.-
```

Fig. 2e: Modeled graph at A 20, Oyarifa Site 1.



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The RMS-error =     2.50

No      Res     Thick
 1    445.4       0.8
 2    106.1       5.3
 3   2508.2       -.-
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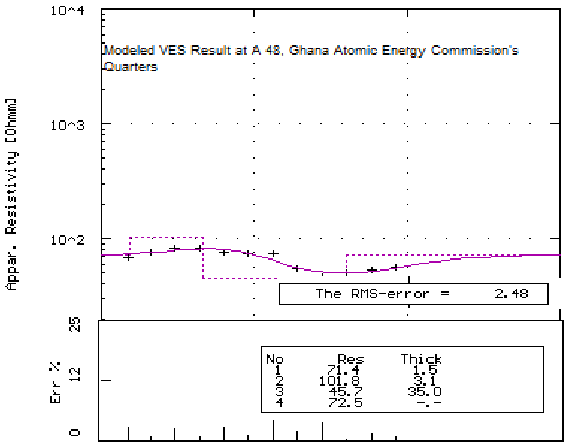
Fig. 2f: Modeled graph at A 20, Kponkpo.



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The RMS-error =     2.48

No      Res     Thick
 1     71.4       1.5
 2    101.8       3.1
 3     45.7      35.0
 4     72.5       -.-
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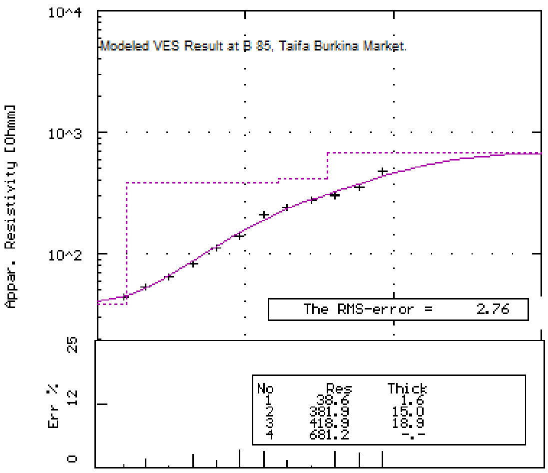
Fig.2g: Modeled graph at A 46, Atomic Energy.



```
The RMS-error =     2.76

No      Res     Thick
 1     38.6       1.6
 2    381.9      15.0
 3    418.9      18.9
 4    681.2       -.-
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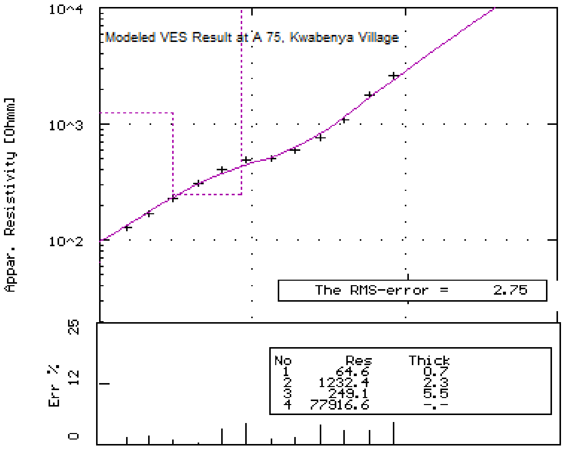
Fig. 2h: Modeled graph at B 85, Taifa Burkina.



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The RMS-error =     2.75

No      Res     Thick
 1     64.6       0.7
 2   1232.4       2.3
 3    249.1       5.5
 4  77916.6       -.-
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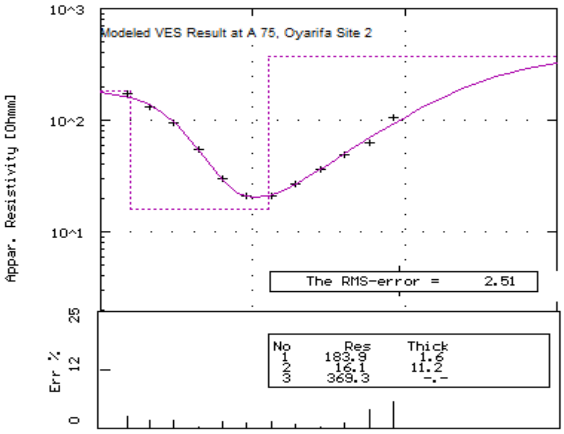
Fig.2i: Modeled graph at A 75, Kwabenya Village.



```
The RMS-error =     2.51

No      Res     Thick
 1    183.9       1.6
 2     16.1      11.2
 3    369.3       -.-
```

Fig. 2j: Modeled graph at A 75, Oyarifa Site 2.

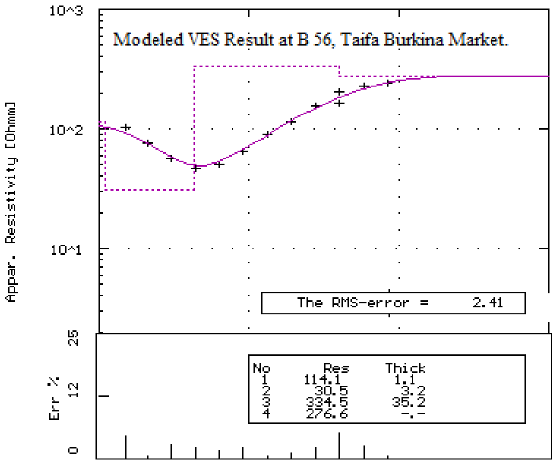


Fig. 2k: Modeled graph at B 56, Taifa Burkina.

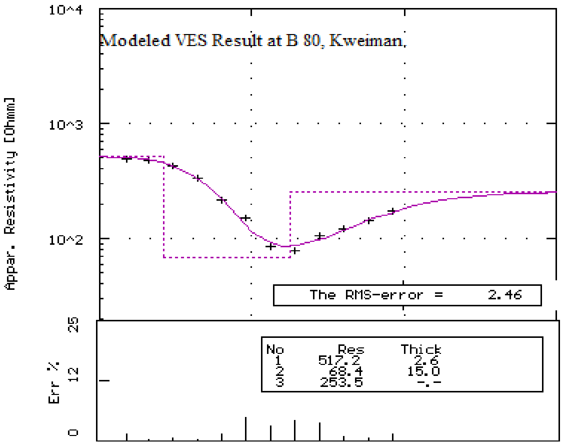


Fig. 2l: Modeled graph at B 80, Kweiman.

Table 2.0: Modeled results of anomalous points in research communities.

Community	VES Point	Modeled Results			Curve Type	r.m.s value (%)	Comments/GPS
		L	R	T			
Adenkrebi	C50	1	126.1	1.3	AK	2.40	Conductive zones exist at depth
		2	184.8	5.2			beyond 25.3 m approximately.
		3	910.4	18.8			05°46.742’N, 0°12.183’W, 323 m
		4	145.2				
	A40	1	629.5	1.6	H	2.16	Conductive zone at shallow depth
		2	258.4	8.1			of approximately 9 m.
		3	744.7				05°46.694’N, 0°11.952’W, 345 m
	A100	1	914.2	0.8	KHK	2.74	Alternate layers of conductive zones
		2	2510.9	1.7			at depths of 8m and beyond 14 m.
		3	771.7	5.5			05°46.740’N, 0°11.937’W, 334 m
		4	2061.6	6.7			
		5	530.4				
Kponkpo	B20	1	149.4	1.1	HKH	2.79	Conductive zones suspected to be
		2	53.3	3.0			between 20m and 32 m.
		3	1776.2	16.1			05°45.545’N, 0°11.846’W, 91 m
		4	440.7	12.0			
		5	924.1				
	A20	1	437.9	0.8	H	2.51	Shallow conductive zone at depth
		2	104.1	5.2			of 6 m.
		32501.9					05°45.542’N, 0°11.880’W, 93 m
	A194	1	289.1	0.8	H	2.63	Conductive zone at depth of 16 m
		2	97.4	16.1			05°45.616’N, 0°11.802’W, 91 m
		3	7340.9				
Oyarifa	B55	1	162.0	0.7	H	2.47	Conductive zone at 12m
		2	12.5	12.0			05°45.220’N, 0°09.947’W, 211 m
		3218.8					
	A20	1	19.4	0.9	H	2.24	Conductive zone at 9.4m
		2	9.0	8.6			05°45.244’N, 0°09.971’W, 210 m
		3	87.2				
	A75	1	189.8	1.6	H	2.48	Conductive zone at 12.5m
		2	15.8	10.9			05°45.244’N, 0°09.946’W, 211 m
		3	300.1				
	A58	1	87.9	1.1	H	2.96	Conductive zone encountered at
		2	42.0	4.3			shallow depth of 5.4m

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Akporman		3	150.9				05°43.970’N, 0°12.766’W, 172.2 m
	A220	1	370.6	1.9	KH	2.53	Conductive zone encountered at
		2	514.8	2.0			depth between 4m to 24m.
		3	68.9	19.9			05°44.016’N, 0°12.691’W, 190.2 m
		4	290.7				
	B222	1	154.7	1.4	KH	1.79	Conductive zone inferred at depth
		2	198.8	2.8			between 5m to 30m.
		3	97.9	22.2			05°44.053’N, 0°12.806’W, 192 m
		4	175.6				
	B160	1	25.4	1.3	KH	2.45	Conductive zone encountered
		2	90.7	9.8			between 11m to 24m.
		3	56.5	13.3			05°44.021’N, 0°12.801’W, 187.2 m
		4	188.4				
Kwabenya Village	A75	1	103.9	0.9	KH	2.96	Conductive zone encountered at
		2	960.4	3.1			10.7 m.
		3	218.1	6.7			
		4	92913.9				05°41.184’N, 0°14.808’W, 107 m.

Table 2.0: Continued.

Community	VES Point	Modeled Results			Curve Type	r.m.s value (%)	Comments/GPS
		L	R	T			
Kwabenya Village	A38	1	78.9	1.7	K	2.47	Shallow conductive zone at depth
		2	362.4	56.7			of 2.0 m approximately
		3	350.4				05°41.189’N, 0°14.794’W, 107 m.
Atomic Staff Quarters	A10	1	14.9	2.0	KH	2.51	Thick conductive zone encountered
		2	50.2	6.5			possibly beyond 10m
		3	12.1	20.5			05°40.171’N, 0°14.156’W, 112.8 m
		4	76.1				
	A48	1	68.1	1.6	KH	2.52	Thick conductive zone encountered
		2	123.1	3.7			just beyond 5.3 m
		3	36.2	27.5			05°40.175’N, 0°14.178’W, 106.8 m
		4	93.3				
	B53	1	16.0	1.2	KH	3.08	Conductive zone at shallow depth of
		2	87.9	1.4			approximately 11 m
		3	13.6	8.1			05°40.193’N, 0°14.176’W, 115.8 m
		4	102.9				
Kweiman	B180	1	362.9	2.4	H	2.47	Thick conductive zone encountered
		2	97.5	24.8			at shallow depth
		3	459.2				05°47.843’N, 0°10.415’W, 113 m
	B80	1	517.2	2.6	H	2.46	Thick conductive zone encountered
		2	68.4	15.0			at shallow depth
		3	253.5				05°47.603’N, 0°10.394’W, 112 m
	A100	1	159.5	1.1	QH	2.43	Thick conductive zone encountered
		2	94.5	3.5			at shallow depth
		3	48.8	14.2			05°47.846’N, 0°10.210’W, 115 m
		4	375.7				
	A20	1	153.3	2.4	H	2.45	Thick conductive zone encountered
		2	39.3	16.7			at shallow depth
		3	227.8				05°47.614’N, 0°10.121W, 112 m
Adoteiman	A35	1	156.2	0.8	KH	2.51	Shallow conductive zone
		2	495.1	1.7			encountered at about 9m
		3	74.6	7.1			05°47.402’N, 0°09.068’W, 201 m
		4	1058.0				
	B2	1	197.8	0.9	KH	2.51	Shallow conductive zone
		2	418.1	1.3			encountered at 18m approximately.

		3	49.4	15.8			05˚47.410’N, 0˚09.071’W, 196.2 m
		4	709.4				
	B18	1	200.8	1.4	KH	2.50	Shallow conductive zone
		2	230.2	2.8			encountered at 12m approximately
		3	130.4	5.5			05˚47.414’N, 0˚09.064’W, 190.2 m
		4	372.1				
Taifa Burkina Market	B 56	1	113.8	1.1	HK	2.24	Conductive zone encountered at
		2	30.6	3.2			depth beyond 39m approximately.
		3	352.4	35.3			05˚40.149’N, 0˚15.144’W, 122 m
		4	270.7				
	B15	1	14.2	1.1	A	2.37	Conductive zone at shallow depth of
		2	301.4	8.8			approximately 1 m.
		3	363.5				05˚40.149’N, 0˚15.168’W, 122 m
	B 85	1	41.0	1.9	KH	2.79	Conductive zone at depth between
		2	780.8	7.7			10 m and 29 m approximately.
		3	179.6	19.4			
		4	2288.3				05˚40.149’N, 0˚15.128’W, 122 m

Anomalous points identified at Atomic Energy Quarters showed similar trends like Akporman. All VES points have low bedrock apparent resistivities that varied from 76.1 Ωm to 102.9 Ωm. Each point with the highest conductive zone is the third layer with appreciable thickness of 8.1 m, 27.5 m and 20.5 m for B 53, A 48 and A 10 respectively. The low bedrock apparent resistivities are indications of water-bearing structures at each point. Also, the alternating low-highs apparent resistivities as well as the highest conductivities of third layers are possible indications of groundwater presence at each point. It therefore possible to exploit groundwater at all the points in the community.

At Kweiman, bedrock apparent resistivities varied from 227.8 Ωm to 459.2 Ωm; the highest conductive layer is the intermediate or second layer for the three-layer resistivity structures (A 20, B 80 and B 180) while the third layer is the highest conductive layer for 4-layer structure (A 100). All four VES points have appreciable thickness of the layer with the highest conductivity (least apparent resistivity). These with appreciable bedrock resistivities not exceeding 459.2 Ωm are indications for the possibility of exploiting groundwater at these locations.

Modeled VES results at Adoteiman, showed 4-layer structure at each point. Bedrock apparent resistivity spanned from 372.1 Ωm to 1058 Ωm. Third layers have the highest conductivities with 7.1 m, 15.8 m and 5.5 m as corresponding thicknesses for A 20, B 2 and B 18 respectively. B 2 has the highest conductivity as its third layer, highest resistivity thickness of 15.8 m and an intermediate bedrock apparent resistivity. These make the point suitable for groundwater exploitation. B 18 has least bedrock apparent resistivity which suggest the possibility of water-bearing zones within the bedrock. A35 has highest bedrock apparent resistivity at this location suggesting decreasing fracture or conductive zone with increasing depth and can be considered for hand-dug well or borehole which may require hydro-fracturing should low yield be encountered.

VES points at Taifa Burkina showed wide variation despite the small size of the area investigated. B15 show increasing apparent resistivity with increasing depth which suggest absence of water-bearing zone at the point. B 56 depicts conductive zone within the bedrock at depth beyond 39.6 m approximately. B 85 showed highest conductive zone possible for holding structure that may contain groundwater within its third resistivity layer. However, its high bedrock apparent resistivity suggests that the presence of any water-bearing structures at the point may be at shallow depth. Thus, while B 56 and B 85 are potential points for groundwater exploitation, B 15 cannot support the exploitation of groundwater.

Conclusions

From the study, twenty-eight (28) anomalous points were identified along most traverses within the communities. Wide variations exist in modeled results with 3, 4, 5-layer as structures identified. The 3-layer resistivity structure is the dominant constituting 42.85 % of subsurface structures. Nine (9) different types of resistivity structures: A, H, K, AK, HK, KH, QH, HKH, and KHK were identified. Water-bearing structures are characterized principally by an intermediate layer with the highest electrical conductivity with appreciable resistivity thickness most often exceeding 10 m and low bed apparent resistivity values most often not exceeding 1000 Ωm. For a series of VES points in a community, the VES point with the least bedrock apparent resistivity suggest the presence of fracture system within the bedrock capable of being exploited for groundwater. With the exception of two points (A 75 and A 38) at Kwabenya Village, there exist at least a point in 8 communities that host water-bearing structure that can be exploited. On the basis of bedrock apparent resistivity values, the apparent resistivity values of the highest electrical conductivity of intermediate layers with corresponding thickness exceeding 8.9m, C50 at Adenkrebi, B20 at Kponkpo, A75 for Oyarifa, A220 for Akporman, A48 for Atomic Energy Quarters, A20 for Kweiman, B2 for Adoteiman, and B56 for Taifa Burkina are points containing groundwater structures. Other potential points that could be considered include A 20 and A 194 at Kponkpo for shallow wells; B 55 and A 20 at Oyarifa; B 222, A 58, and B 160 for Kponkpo; A 10 and B 53 at Atomic Energy Quarters; A 100, B 80 and B 180 for Kweiman; B 18, and . B 85 for shallow well for Taifa Burkina. Points A 75 and A 38 at Kwabenya Village and B 15 at Taifa Burkina do not display significant conductive zone for the existence of water-bearing zones. Thus, water-bearing structures varied within the study. While a community can have all anomalous points considered to host groundwater structures, others may not. Thus, the potential for groundwater exploitation can be described as low to through moderate to high within the study.

6.0 References

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