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Geo-electric probe for Groundwater in Giri, Nigeria

By Dikedi, P. N.
University of Abuja, Gwagwalada, Nigeria

Abstract - This project report focuses on the relevance of electrical resistivity method in ground water investigations; past research works on the use of this method are mentioned. Geology and hydrogeology of the study area are investigated, an adapted version of the national verification form for provision of potable water, schematic of the Federal Capital Territory (FCT), maps of the drainage pattern, hydro geology, geology of the study area and other relevant maps are presented. ABEM terameter 300c and other geophysical equipments are employed in measuring resistivity readings over a region of 900 000m2 within the university of Abuja permanent site. This region is characterised by rock outcrops of various sizes, predominantly granites and quartz. Wener array is employed in this survey; it is well established from past research work (Leoflinch, 2001) that depth of fractured rock was 24.5m-VES 1. Current dipoles separation must be three times this depth i.e. 75m; hence electrode separation of 25m is adopted. Ten parallel traverses, each of length 1000m, separated from each other by 100m are marked out, over which readings are taken at intervals of 25m. From field data, apparent resistivity maps are drawn by employing 3d field software; low resistivity zones of well fractured rocks—which delineated the productive from the unproductive zones—are observed as potential harbours for ground water.

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Strictly as per the compliance and regulations of :

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Introduction, Materials and methods, Results, discussion, Acknowledgements, References

I. Introduction

a) General introduction

The final relocation of government from Lagos to Abuja in 1991 brought about a massive influx of people into the Gwagwalada area council of which Giri is a part. The population grew from 150 000 to 500 000 between 1991 and 2004 (Uzodinma, 2004). There are 63 boreholes which supplies potable water to 29 communities in Gwagwalada (Table 1). The facility often breaks down causing shortage in water Supply; they are reticulated. Within Giri, there is an intake structure at river Wuye with a package treatment plant which draws water at $50m^3/h$. There are two bore holes and pumps. Due to the increasing population in this region and inadequate supply of water in Gwagwalada, there is the need to seek for other source of water to meet the people's demand. It is in this light that the research work was conducted within the University of Abuja permanent site in Gwagwalada. The main objective is to delineate locations within the survey which have potential for groundwater. The region of interest is located within basement complex with fractures and faults. This complex is composed of enclosed aquifers within the weathered overburden and structures like faults, joints and features (Enslin, 1961)

The use of electrical resistivity method dates back to 1970 in mineral and ground water exploration. Reputed for its success ((Emenike, 2001; Okwueze and Ezeanyim, 1991; Okwueze, 1996), this method was employed for ground water investigation in Barkumbo valley, Gudun hill area and Tambari valley, very close to Bauchi state, from which highly weathered basement materials were revealed, leading to the suggestion that parts of the Barkumbo valley are best suited for a borehole programme (Shemang et al, 1994). Resistivity measurements of upper aquifer was conducted around Lake Alau area in Maiduguri; Results of this study showed that water table of upper aquifer system is the source for ground water being tapped from hand dug wells in the region (Alkali, 1995). Geoelectric investigations of ground water resources were conducted at Onibode area, near Abeokuta, south western Nigeria; delineated aquifer units, observed beneath the weathered layer and beneath the fractured basement rocks were identified as probable drilling zones of water supply boreholes. This method was utilized to determine the possibility of sinking a mechanised borehole in Gwagwalada area council secretariat (Leoflinch, 2001)

The outcome of Geo-electric investigation of groundwater resources by Oyedele, (2000) in which two aquifer units were delineated and conclusion by Olayinka, (1990)-cited by the former-that resistivity range of $10\Omega m$ to $200\Omega m$ harbours weathered zones, are favourably pertinent to this research; thereupon, impact–wise, ambiguities and enigmas normally associated with geophysical data, are reasonably improved, meaning conferred reliability on result of this survey is enhanced. The main objective of this investigation is to delineate locations within the survey area which have potential for groundwater. The outcome of this result will hopefully address the water supply problem of the University's permanent site; this research will also assist ground water development in the region.

Author : Department of Physics, University of Abuja, Gwagwalada, Nigeria. E-mail : pdikedi@yahoo.co.uk

S/N	Name of Community	Number of boreholes	Number of hand pumps	Number of taps	Remarks
1	Tungan Maje	1	2		
2	Paikon Kore	4	3		
3	Dobi	6	3	10	
4	Zuba	6	4	10	
4a	Zuba Market	1		40	
5	Pmasso	3	2	20	
6	Anagada	2	2	30	
7	Machada	2	2	10	
8	Pagnada	2	2		
9	Dukwa	3	3		
10	Wuna	2	2		
11	Chitumu	1	1		
12	Gurfata	2	2		
13	Kutunku	2	2		
14	Dadabiri	2	2		
15	Pabeyi	1	1		
16	Yimi	1	1		
17	Giri	2	2		
18	Tungan Gayan	1	1		
19	Ungwan Dodo	1	1		
20	Rafin Zurfi	1	1		
21	Gwako	2	2		
22	Tsauni	2	2		
23	Shenagu	1	1		
24	Ikwa	2	2		
25	Ibwa	2	2		
26	Gwoi	1	1		
27	Kutun Sarki	3	3		
28	Kaida	2	2		
29	Dagiri	2			ongoing project

Table 1 : National data verification form for provision of potable water in Gwagwalada

b) Location of survey site

The survey site is located within the University of Abuja permanent site, 1200m from Giri junction and 150m from Giri Airport road. It is located within longitude 7009’54’’E and 7010’38”E and latitudes 8059’13”N and 8059’49”N (Figure 1).

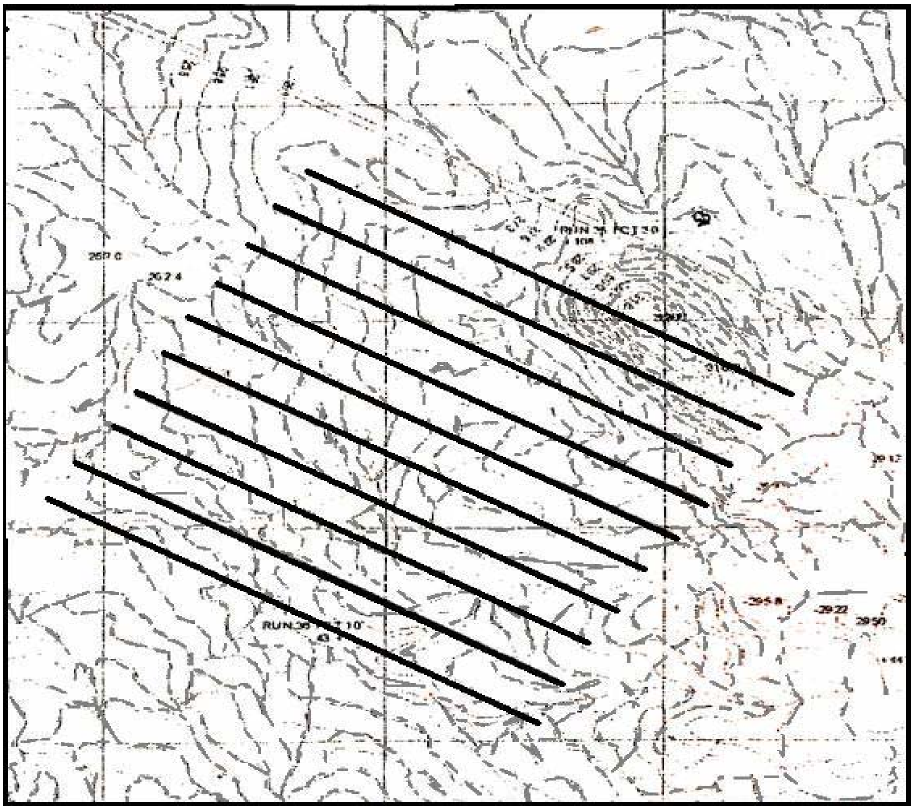

Figure 1 : Location map of the surveyed area

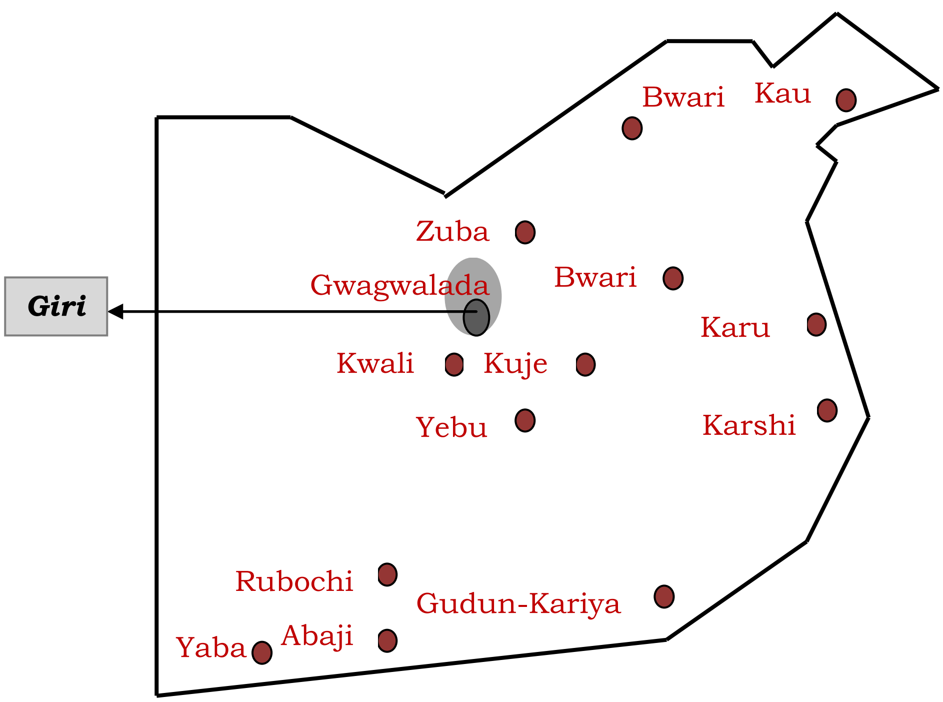

Figure 2 : A schematic of the FCT map

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c) Geology

Abuja, the Federal Capital Territory (FCT), lies within the longitude 6027'00''E and 7023'24''E and the latitude 8015'00''N and 9012'00''N (Ideh and Sanni, 1998). It covers 8000km2 area, more than twice the area of Lagos state. Underlying the FCT, almost predominantly are, high grade metamorphic and igneous rocks of the Precambrian age (Mamman and Oyebanji, 2000). Generally the North North East (NNE) and South South West (SSW) of the FCT are made of gneiss, migmatites and granites which characterize the Northern Nigeria. The out crop of schist belt is found along the Eastern margin of the area. This belt broadens as one moves south wards and maximum size is found to the South Eastern region of the FCT.

The geology of the FCT is same as that of Gwagwalada and Giri. The area like most Northern Nigerian region is underlain by basement complex.

The rocks found in Gwagwalada consist of granite, gneiss, diorites, horn blende schist, mica schist, feldspathic quartz schist and migmatites (Figure 2).

While some rock outcrops are found in various places around, some are concealed by a thin weathered layer.

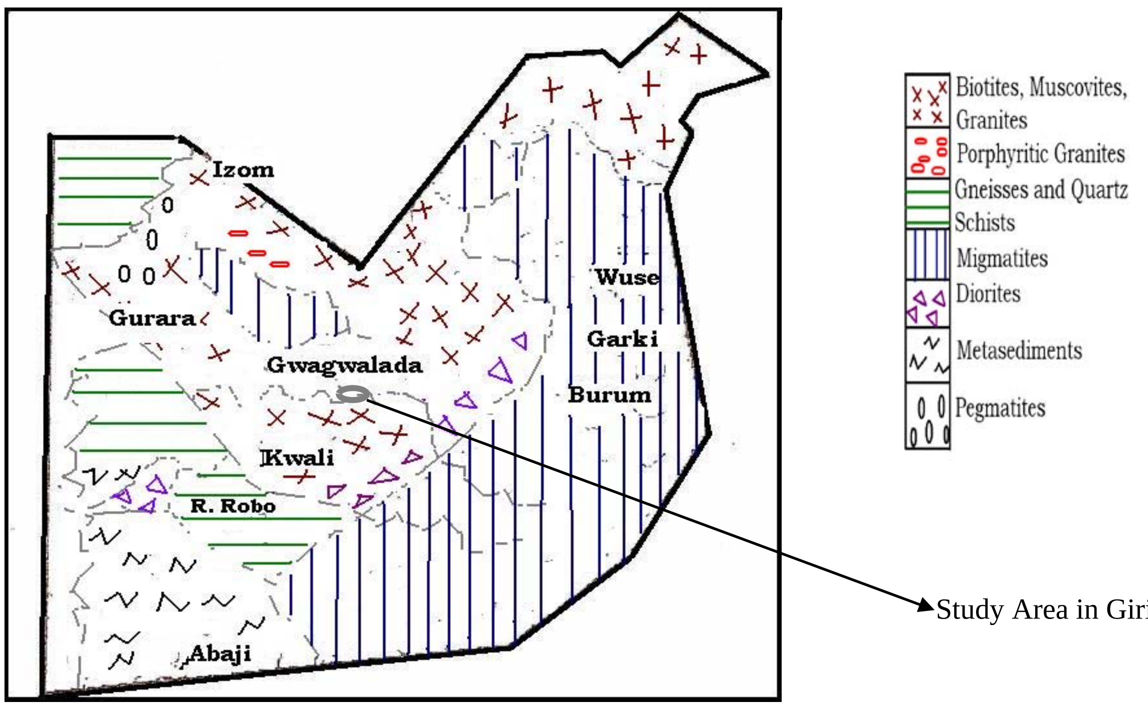

Figure 2 : The Geologic map of the Federal Capital Territory

The granites vary from medium to coarse-grained types. They are grey coloured, massive and homogeneous. The survey site reveals various rock outcrops, consisting of grey coloured granites, scattered and isolated in some regions and also appearing as bands in some other regions.

These granite outcrops are most numerous within streams and rivers.

There are also small fragments of quartz rock spread around the region as well as granites, which are compacted into the soil. They are noticed around high vegetation zone. The shrub savannah occurs extensively in rough terrain close to hills and ridges. The hills are in clusters or long range, with the Wuna range located North of Gwagwalada. There are also small fragments of quartz rock spread around the region as well as granites, which are compacted into the soil. They are noticed around high vegetation zone.

d) Hydrogeology

Water bearing rocks compose of aquifers and they consist either of unconsolidated deposits or consolidated rocks.

Consolidated rocks are made of rocks and mineral particles of various sizes and shapes welded together by heat and pressure or chemical reaction into a rock mass (Gunn and Childress, 1998);

Aquifers made of consolidated rocks-granite as an example- are found in the Gwagwalada regions; water flows through these rocks through fractures, gas pores and other openings in them.

Most unconsolidated deposits consist of material gotten from the disintegration of consolidated rocks. Some or all of the following materials in various combinations are examples of unconsolidated deposits. They are soil-like materials, gravel sand, silt clay and fragments of shell of marine organisms.

Worth mentioning is the fact that physical properties of aquifer materials and aquifer themselves, that is thickness and depth are important in determining how quickly ground water will move and what channel it will take as it moves through the aquifer. This is because the thicker and deeper the aquifer the less porous the aquifer is and it will take some time for groundwater to move and assume the direction where pores and fractures are located. This knowledge helps in deciding how best to get water out of the ground for drinking. In the basement complex, ground water is highly localised and aquifers develop from the secondary weathering, usually induced by fracturing and other tectonic activities (Offodile, 1988). The greatest amount of water flows through joints.

e) Rivers and drainage pattern

In Giri, there is an intake structure at River Wuye with a package treatment plant which draws water at 50m3/h.

River Wuye is one major river in the Giri region which is surrounded by tributaries. It flows into River Usuma. River Usuma is a tributary of River Gurara (Figure 3); the river is 8000m from the survey region. Rivers are good surface water resources. Ground water within this region of interest is recharged by surface precipitation-lateral flow from the above-mentioned rivers and tributaries.

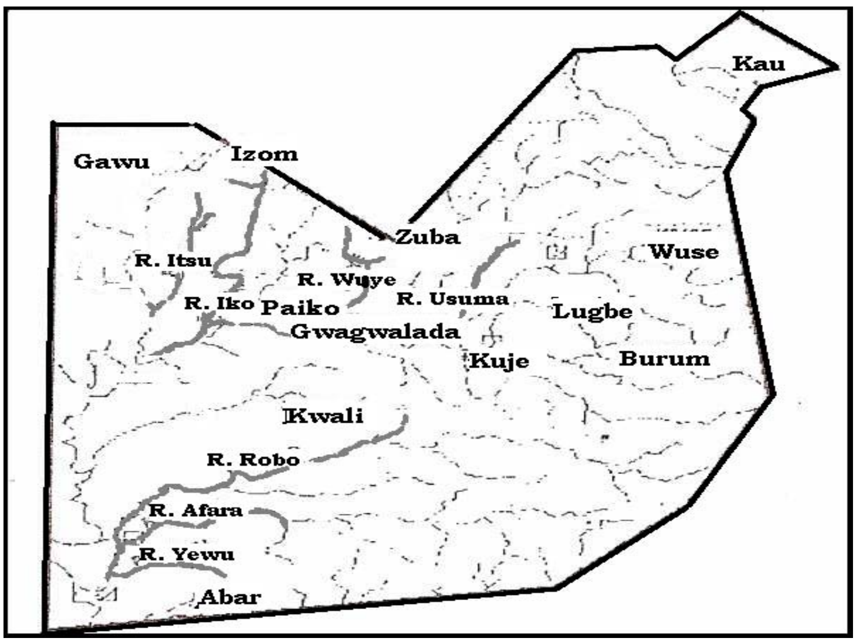

Figure 3 : River /drainage pattern of the Federal Capital Territory

f) Rainfall

In Gwagwalada, there are two prevalent seasons namely, the rainy and dry seasons. The rainy season falls within the period of April and October; the dry season falls within November and March (Physical setting, 2003). The temperature drops from 950F (350C) during the dry season to 770F (250C) during rainy season due to dense cloud cover. The relative humidity rises in the afternoon to 50%. The annual range of rainfall for the federal capital territory is in the order of 1100mm to 1600mm.

Gwagwalada enjoys higher rainfall total than the more southerly regions of the FCT. The FCT experiences heavy rainfall occurrence during the months of July, August and September. These three months contribute about 60% of the total rainfall in the region (Dawam, 2000)

One of the past works is the report of geophysical investigation of Leoflinch house at phase 1, behind university of Abuja male hostel. The result showed overburden thickness of between 10m to 12m (Leoflinch 2001).

The lithology of formation is given as:

Top soil (0.77m thick), ferrogenised sandstone (3.3m), highly weathered rock (21.5m), and fractured rock (24.5m)-VES 1

Top soil (0.83m), ferrogenised sand stone (2.8m), sand stone formation (3.0m) and weathered/fractured rock (23m)-VES 2

Four distinct strata were identified within the subsurface; these were the overburden, weathered, fractured and bed rock.

Deep-rooted fracture zone is envisaged between 36 to 50m which will further enhance the bore yield. Total depth of borehole is 50 to 55m (Leoflinch 2001).

II. Materials and Method

a) Electrical resistivity method

The electrical resistivity method was employed in this survey for ground water. It measures the apparent resistivity of soils and rocks as a function of depth or position (Geovision, 2000). Resistivity of soil is function of porosity, permeability, ionic content of pore fluids and clay mineralisation. Current flow is always perpendicular to equipotential lines when the ground is uniform; however when inhomogeneity is present, resistivity changes with electrode configuration and the value derived is "apparent resistivity ". Wener array was employed in this survey.

Current density and voltage

For current I, flowing into ground via current dipoles over some hemispherical shell, we have, Current density:

$$J = \frac{I}{2\pi r^2} \qquad (1)$$

Where current density, J decreases as distance r, increases during dissipation of current I. Voltage change across a hemispherical sphere of radius r and thickness δr is expressed as:

$$\delta v = -\rho \delta r I \frac{\rho \delta r I}{2\pi r^2} = -\rho J \delta r \qquad (2)$$

Voltage at an arbitrary point r is given by:

$$V_r = -\int dv = -\int \rho J \delta r = -\int \rho \frac{\rho I}{2\pi r^2} dr \qquad (3)$$

The above expression leads on, to the expression for the apparent resistivity for wener array (Figure 5):

$$\rho_a = 2\pi a R = RG \qquad (4)$$

where G—referred to as geometric factor, for wener array—is given by $2\pi a$;

The most probable single but important factor controlling resistivity of rocks –sedimentary rocks- is the resistivity of pore fluid as explained by Archie's law. In 1942, Archie expressed the effective resistivity, ρ, of rocks as:

$$\rho = a\emptyset^{-m} S^{-n} \rho_w \qquad (5)$$

$$F = \frac{\rho}{\rho_w} \qquad (6)$$

Where a, m and n are empirically determined constants in which we take $0.5<a<2.5$, $1.3<m<2.5$ and $n\approx 2$; $\emptyset$ is the porosity, S is the volume fraction of pores with water and ρw is the resistivity of the solution in the pores—electrolyte or water--of the rock.

In his review, Slater (2007), expounded the permeability equation defined by

$$k = \frac{\emptyset(r^2)}{aT} \qquad (7)$$

$$k = \frac{c l_c^2}{F} \qquad (8)$$

The four parameter Cole-Cole model was also considered, given by

$$\sigma^*(\omega) = \sigma_0 [1 + m_g (\frac{(i\omega\tau)^c}{1+(i\omega\tau)^c(1-m_g)})] \qquad (9)$$

All stated parameters in 5, 6, 7, 8 and 9 are pertinent to resistivity values of earth sample—they control these values.

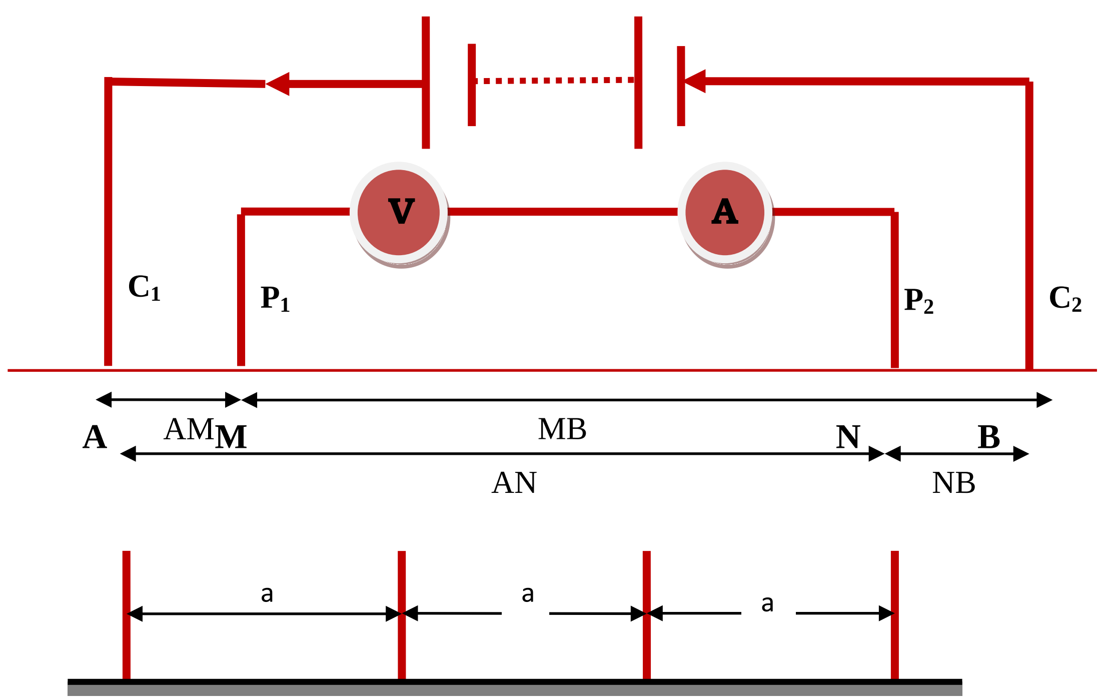

Figure 5 : Wener array electrode configuration

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Where ω is frequency, σ_0 is the dc conductivity, $\sigma^*(\omega)$ is the frequency dependent electrical response of soils—or complex electrical conductivity, m_g is global changeability given by $m_g = 1 - \sigma_0/\sigma_\infty$, where σ_∞ is the conductivity at high frequency, time constant τ, l_c is the percolation threshold length—scale controlling fluid flow, ρ_a is the ground apparent resistivity, ρ is the effective resistivity of rocks, k is the permeability, μ is the fluid dynamic viscosity,$\emptyset$ is the porosity, g is gravitational acceleration, $i = \sqrt{-1}$, F is the cementation factor and c=1/226

b) Instrumentation

The ABEM terameter SAS 300C was employed during the survey to measure resistance values; these values were displayed on the visual display unit. Multiple values showed up initially but a single value was retained with time; this electronic device measures ground resistivity in mΩ, Ω or kΩ. The product of every single resistance value and an appropriate geometric factor gave values of apparent resistivity. A specially built battery supplied some voltage to the terameter.

c) Field procedure

The survey conducted, stretched through an area of 900 000m^2. Grasses and shrubs along the profile were mowed with the cutlass. Thereafter, the field was divided into ten traverses or profiles; each profile was 1000m long and inter-profile spacing was 100m. 41 holes, separated by 25m, one from the other, were dug along each traverse; 41 wooden pegs were driven into them with the mattock hammer.

Four electrodes were co linearly planted in the ground alongside each peg. The first and last electrodes were the current electrodes and the second and third electrodes were the potential electrodes. With the aid of banana plugs and sockets of 4mm, crocodile clips and a pair of cables of black and red coloured insulation, all four electrodes were connected to the terameter. Current was injected through current electrodes into the subsurface, once the terameter was switched on; following this potential difference between the second and third electrodes was measured through potential electrodes. 41 ground resistance values were measured per profile and 410 values were recorded for the entire survey. To derive apparent resistivity values, each ground resistance value was multiplied by geometric factor of 157.1m (wener array).

d) Electrode separation

Electrode separation of 25m was adopted based on past geophysical report (Leoflinch, 2001); the result showed overburden thickness of 10m to 12m. The lithology of formation showed thicknesses of top soil (0.77m), ferrogenised sandstone (3.3m), weathered rock and fractured rocks (46m). The target depth for wener array equals electrode separation. Only 30% of current flow beneath this depth, therefore to energise a target, electrode separation typically needs to be 2 to 3 times its depth, hence current dipole separation of 75m was adopted which implied electrode separation of 25m.

III. Conclusion

a) Data acquisition

Table 2 is a collection of resistance values for profile 1 to 10 for 41 probe points with inter-probe separation of 25m. Table 3 is a collection of corresponding apparent resistivity values for profiles 1 to 10 with inter-probe separation of 25m meters. These apparent resistivity values were derived by multiplying each resistance value by geometric factor 'G'=2πa=157.1m.

b) Data analysis, interpretation and results

Table 2 : Resistance values in ohms for profiles 1 to 10

Point probe	Distance in meters	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
1	0	3.19	3.96	3.46	2.52	3.07	3.93	3.47	3.54	2.69	2.34
2	25	3.51	5.89	1.39	2.61	4.57	5.84	1.39	5.27	2.96	2.42
3	50	3.70	4.37	3.37	3.33	3.39	4.33	3.38	3.91	3.12	2.16
4	75	4.47	3.38	3.45	2.68	2.62	3.35	3.46	3.02	3.77	2.48
5	100	5.23	0.21	3.28	2.44	0.16	0.21	3.29	0.18	4.41	2.26
6	125	4.72	3.82	3.23	2.25	2.96	3.79	3.24	3.41	3.98	2.55
7	150	5.41	3.17	5.00	3.49	2.46	3.14	5.02	2.84	4.57	3.23
8	175	5.79	2.64	7.82	3.16	2.05	2.62	7.85	2.36	4.89	2.93
9	200	6.95	2.67	2.64	3.94	2.07	2.65	2.65	2.39	5.86	3.65
10	225	10.63	0.14	2.8	2.60	0.12	0.14	2.18	0.14	8.97	2.41

11	250	7.66	1.78	2.82	5.54	1.38	1.76	2.83	1.59	6.46	5.13
12	275	8.43	0.16	4.49	2.49	0.13	0.16	4.51	0.15	7.11	2.31
13	300	7.26	2.90	3.99	1.97	2.25	2.88	4.00	2.6	6.13	1.82
14	325	6.29	3.50	5.86	2.35	2.71	3.47	5.88	3.13	5.31	2.18
15	350	5.87	3.66	5.93	2.96	2.85	3.65	5.95	3.29	4.95	2.74
16	375	4.89	2.99	6.41	3.27	2.26	2.89	6.43	2.61	4.13	3.03
17	400	4.98	3.22	6.90	3.03	2.50	3.19	6.92	2.88	4.2	2.81
18	425	5.58	3.68	7.03	2.55	2.85	3.65	7.05	3.29	4.71	2.36
19	450	6.03	3.40	8.14	4.52	2.64	2.50	4.48	3.04	5.02	4.22
20	475	9.50	3.67	6.54	4.55	1.34	3.64	10.54	1.55	8.02	4.22
21	500	2.36	2.38	6.23	5.24	1.41	3.16	6.21	1.62	1.99	4.86
22	525	3.76	2.87	4.94	6.76	1.32	2.85	4.96	1.52	4.46	6.26
23	550	4.74	2.04	4.37	5.97	1.46	3.08	4.38	3.48	4.00	7.00
24	575	6.33	2.88	4.12	7.77	3.26	2.86	4.13	3.76	3.68	7.20
25	600	6.73	2.58	4.40	8.44	2.00	2.56	4.41	3.75	5.54	7.82
26	625	7.06	5.19	3.83	3.15	2.50	5.15	3.84	2.88	8.35	2.92
27	650	8.25	5.09	3.32	16.5	2.14	5.05	3.38	2.85	10.37	15.29
28	675	7.92	5.41	4.80	5.29	4.01	5.37	4.82	4.63	9.39	4.90
29	700	8.42	13.85	3.93	9.27	2.28	13.7	3.94	2.63	9.98	8.59
30	725	10.93	7.74	3.27	8.25	5.65	7.68	3.28	6.52	12.95	8.11
31	750	9.73	18.27	5.31	6.32	10.3	13.2	5.33	11.9	11.53	5.86
32	775	16.93	7.58	2.78	8.72	5.95	7.62	2.79	6.86	20.06	8.08
33	800	4.72	6.84	3.73	1.15	5.30	6.78	8.74	6.11	5.59	1.06
34	825	8.76	4.92	3.74	4.97	3.81	4.88	3.75	4.39	10.38	4.61
35	850	11.91	5.68	5.35	4.18	4.4	5.63	5.37	5.07	10.05	3.87
36	875	6.26	3.09	4.12	3.03	3.81	3.06	4.13	4.39	5.28	2.81
37	900	9.23	0.38	4.59	1.74	0.30	0.38	4.60	0.35	7.79	1.61
38	925	9.45	4.93	5.26	2.79	3.82	4.89	5.28	4.41	7.97	2.59
39	950	5.44	5.51	3.98	2.37	4.27	5.46	3.99	4.92	4.59	2.20
40	975	5.29	4.53	4.78	2.81	3.51	4.49	4.80	4.05	4.46	2.60
41	1000	3.80	4.19	3.98	11.79	3.25	4.16	3.91	3.75	3.21	10.93

Table 3 : Apparent resistivity values for profiles 1 to 10

Probe point	Distance in meters	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
1	0	501	622	544	396	482	617	545	556	423	360
2	25	551	925	218	410	718	917	218	828	465	380
3	50	581	686	529	366	533	680	531	614	490	336
4	75	702	531	542	421	412	526	544	474	592	392
5	100	822	33	515	383	25	33	517	28	693	333
6	125	741	600	597	432	465	595	509	536	625	400
7	150	850	498	785	548	386	493	789	446	718	500
8	175	909	415	1228	496	322	412	1233	371	768	460
9	200	1092	419	415	619	325	416	416	375	920	570
10	225	1670	22	440	408	19	22	441	22	1409	378

11	250	1280	279	443	870	217	276	445	250	1015	800
12	275	1324	26	705	391	20	25	798	24	1117	30
13	300	1140	456	627	309	393	452	628	408	963	286
14	325	988	550	920	169	426	545	924	492	834	342
15	350	922	578	931	465	448	573	935	517	778	430
16	375	768	457	1007	514	355	354	1010	410	649	470
17	400	782	506	1084	476	393	501	1081	452	660	44
18	425	877	578	1104	401	448	573	1107	512	714	371
19	450	947	534	1279	710	415	393	704	478	800	658
20	475	1490	576	1027	715	211	573	1651	243	1260	663
21	500	371	374	979	823	221	497	975	254	313	763
22	525	591	451	776	1062	207	448	779	239	701	983
23	550	745	320	686	281	230	484	688	547	628	1100
24	575	994	452	647	1221	512	449	649	590	578	1131
25	600	1057	405	691	1326	314	402	693	589	870	1228
26	625	1109	815	602	495	393	809	603	452	1315	459
27	650	1296	800	529	2592	379	793	531	448	162	2402
28	675	1244	850	754	831	630	843	757	727	1475	770
29	700	1323	2176	617	1456	358	2158	619	413	1568	1349
30	725	1717	1216	514	1304	888	1206	515	1024	2034	1274
31	750	1928	2084	834	993	1616	2067	837	1865	1811	920
32	775	2659	1206	437	1320	935	1197	438	1078	3151	1269
33	800	741	1074	586	180	833	1065	587	960	878	167
34	825	1376	773	581	781	598	767	889	686	1530	724
35	850	1872	882	840	652	691	884	844	796	1529	608
36	875	983	485	647	476	592	481	649	690	829	441
37	900	945	60	764	271	47	60	723	55	1224	253
38	925	1484	774	826	438	600	768	829	693	1252	402
39	950	855	866	625	372	671	858	627	773	721	346
40	975	831	712	751	441	551	705	754	636	701	408
41	1000	597	658	625	1852	511	653	614	589	504	1717

Interpretation is qualitative; apparent resistivity values versus distance are plotted on profile maps and drawn as contours. As cited by Wyatt et al, ward (1990) suggests that wenner method is effective in terms of: high signal to noise ratio with good resolution of horizontal layers, moderate rating for the resolution of steeply dipping structures and moderate sensitivity to surface inhomogeneity; based on these, it is well established (Leoflinch, 2001; Telford, 1990) that the sharp drop in resistivity values which is indicative of some sort of discontinuity within two zones 550m and 850m respectively from the Giri-Airport road, may suggest the presence of faults or fault zones—zones having potential for ground water. Contour map was generated using 3D field software. The raw field data was first smoothened, before contours were drawn. Areas of interest are those situated within low resistivity zones.

IV. Discussion of Results

Resistivity values on profile maps (Figure 6) generally undulates west wards and rises steeply eastwards; peak values are observed between 600 and 800 Ωm for most profiles. Information on profile maps have been translated to apparent resistivity contour map (Figure 7).

At 625m from the east end, three zones of resistivity range of 1200 Ωm to 2000 Ωm are observed, according to figure 2. These zones are observed as peak points of the wiggles drawn on the profile maps in figure 1. The first zone is located within longitudes of $7^0$10'21''E and $7^0$10'38"E; and latitudes of $8^0$59'31"N and $8^0$59'35"N respectively. The second zone is located within longitudes $7^0$10'21"E and $7^0$10'38"E; and latitudes $8^0$59'28"N and $8^0$59'29"N. The third zone is located within longitudes $7^0$10'21"E and $7^0$10'38"E; and latitudes

8059’13”N and 8059’19”N. These zones are rich in massively bedded rocks as well as fresh crystalline rocks. Between these three zones are two isolated spots having resistivity values peaking at 800 Ωm; there are possibilities of granite and quartz.

Two isolated zones each of 200 Ωm peak resistivity value are spotted between the 5th and 6th profile; and 8th and 9th profile; these two regions marked as productive, are delineated away from the unproductive region, defined by resistivity values acquired during investigation. The first and second zones are 550m and 850m respectively, away from the Giri-Airport highway. The first zone is located within longitudes $7^0$10’00”E and $7^0$10’11”E and latitudes $8^0$59’29”N and $8^0$59’33”N. The second zone is located within longitudes $7^0$09’57”E and $7^0$10’16”E and latitudes $8^0$59’41”N and $8^0$5945”N. These zones are granitic fault zones, with presence of weathered granite, weathered and fractured rock.

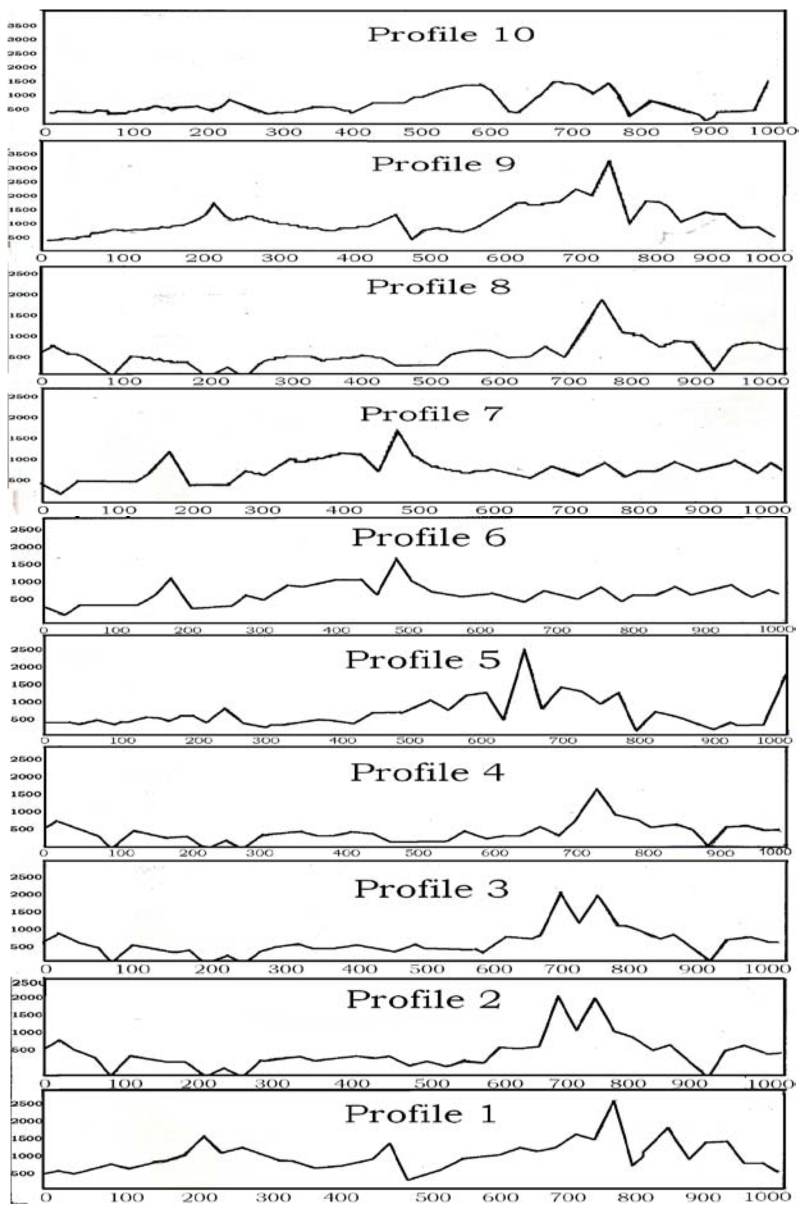

Figure 6 : Resistivity Profile map, showing profiles 1 to 10; it indicates resistivity versus distance

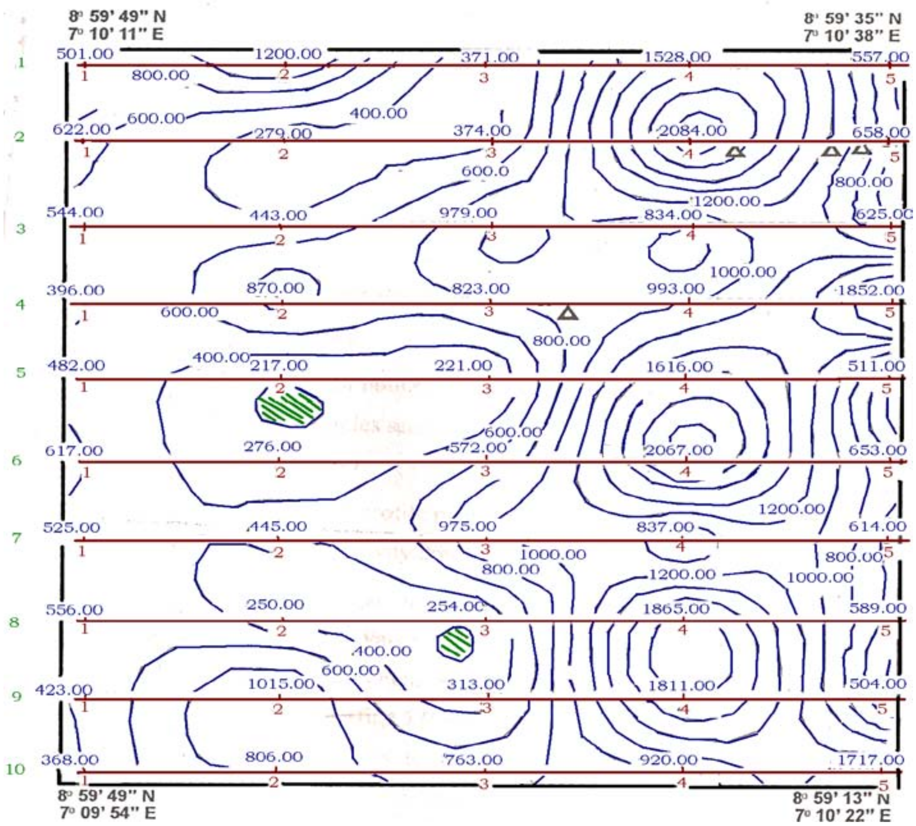

Figure 7 : Apparent resistivity map of the area under survey

a) Conclusion

Past investigations which employed electrical resistivity method have been mentioned, data of ongoing potable water projects for Gwagwalada have been presented and with the aid of a geologic map, the geology of the study area have been described; hydrogeology of this region have also been explained; additionally, field procedure have been described and a suitable electrode separation of 25m have been adopted. Ground resistance and apparent resistivity data of the study area have been acquired; data have also been analysed.

Two isolated zones 550m and 850m respectively from the Giri-Airport highway are identified as having potential for ground water, based on resistivity values of present report with peak value as 200 Ωm and past geophysical report by Leoflinch.

These zones are identified to harbour faults, fractured zones and weathered rocks. The first zone is located within longitudes $7^0$10'00"E and $7^0$10'11"E and latitudes $8^0$59'29"N and $8^0$59'33"N. The second zone is located within longitudes $7^0$10'16"E and $7^0$09'57"E and latitudes $8^0$59'41"N and $8^0$59'45"N.

Further work must be directed at employing multiple geophysical techniques such as Magnetic, Seismic and Microgravity techniques for enhanced precision in the acquired results; it is expected that the use of multiple techniques will infer that faults will be well mapped and the geometry of the zone of interest will be well delineated.

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