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Ground Water Exploration using Geoelectrical investigation in Bafia Area, Cameroon

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Abstract

Fifty Schlumberger electrical soundings were carried out in the centre region of Cameroon in Bafia subdivision. These were done using a maximum current electrode spacing AB/2 of 83 m in order to show the vertical distribution of structures directly below measurement stations. The field data were smoothened and interpreted using IP2WIN computer software. This software converts the apparent resistivity (as a function of electrode spacing) to the true resistivity as a function of depth. The depth and resistivity of the subsurface layers were determined. Also, the isoapparent resistivity maps for two depth levels (according to AB/2 range of about 4.4m and 58m), discharge map, hydraulic conductivity and transmissivity maps are drawn. The results from the interpretation of VES data reveal the presence of following terrains models' types: three layers (Q, A, H and K), four layers (KH, QH, AK and KQ) and five layers (KHK, HKH, KQH, and KHA) models. The following geoelectrical layers are: (1) the top layer with resistivity ranging from 6.5 to 301.3 Ω.m and thickness ranging from 0.1 to 6.6 m. (2). The second layer has resistivity varying from 0.1 to 4100 Ω.m while the thickness varies from 0.2 to 63.8 m. It is composed of cracked granites and gneiss, or clay sandy or clayey soil which contributes to the development of groundwater.(3) The third layer, characterized by electrical resistivity value ranging from 0.2 to 2965 Ω.m in most parts of the area and with depth ranging between 0.6 and 41.4m. This layer corresponds probably to shaly layer or confined aquifer. (4) The forth geoelectrical layer, which may constitute the bedrock, has resistivity values ranging from 14.16 to 11189 Ω.m and depth ranging from 17 to 79.4m.

The high resistivity is probably caused by existing gneisses and granites. In addition, the relationship between discharge, hydraulic conductivity and transmissivity is used to determine zones with high yield potential for groundwater exploitation in the area.

Keywords: VES (vertical electrical sounding), groundwater exploration, Schlumberger configuration, resistivity, aquifer, Bafia.

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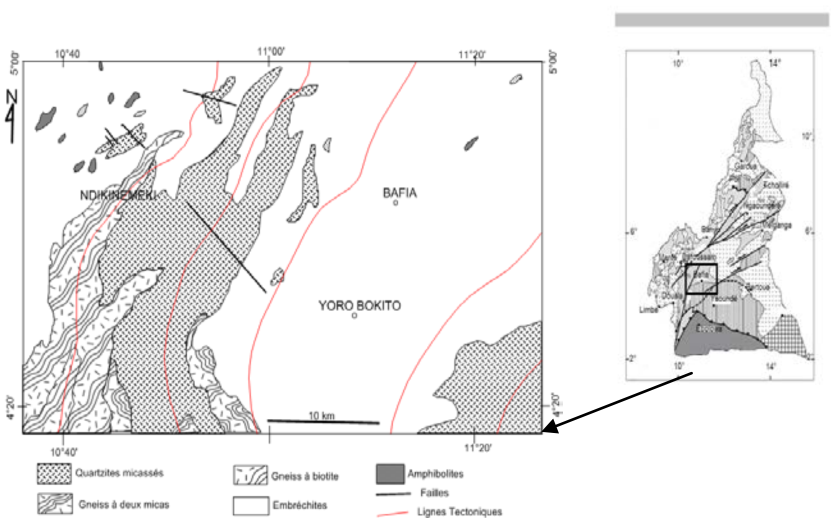
1 Introduction

The Bafia area experiences scarcity of potable water, due on one hand, to inadequate knowledge of the basement aquifer potentialities, mainly the characteristics of the latter, and on the other hand the aggressive exploitation of water. It is therefore of deep interest to first bring out the existence of such aquifers and regulate their utilization among the available population, i.e, make the found resources equally useful for the whole population. However, there are many handicaps and drawbacks in modelling new groundwater development projects, where the most prominent is the limited information on aquifer properties, such as permeability and transmissivity, due to the limited number of test boreholes. Errors in the design of the groundwater model mainly originate from the extrapolation and estimation of aquifer properties for other parts of the aquifer from the few existing boreholes. For example, surface resistivity methods have been used routinely by engineers and hydrologists since the late 1960 s to obtain quantitative aquifer information, such as yields, hydraulic conductivity, and transmissivity [1].The best positive correlation between surface resistivities and well’s yield are obtained [2], but the correlation between resistivity and hydrogeology was not taken into consideration. An inverse correlation between corrected formation factor and intergranular permeability is reported and the relation between permeability and formation factor is developed [3] .The estimation of transmissivity from boreholes resistivity measurements and vice-versa relationship is used. In Italy electrical soundings to estimate transmissivities has been used [4, 5, 6]. Nevertheless, there are new Geophysical methods, particularly those involving resistivity, which can efficiently contribute to increase the accuracy of the groundwater model, not only by delineating the aquifer extension and marking structural features, but also by linking geoelectrical and hydrogeological parameters. Surface geophysical survey, as a veritable tool in ground water exploration, has the basic advantage of saving cost in boreholes construction by locating target aquifer before drilling is embarked upon [7]. In this study, the geolelectrical method is used before draining boreholes in the interest area. The Vertical Electrical Sounding (VES) is applied for the groundwater exploration in the Bafia area. Geological facts are correlated to the VES data inversion.



area is a Cameroonian piece of the North Equatorial Fold Belt (NEFB) bounded north and south, by the Adamaoua and Sanaga lineaments respectively; and south west by the Kribi lineament. Reconnaissance studies in the Bafia region distinguished two broad types of rocks: ectinites represented by gneisses and quartzites, and, biotite and/or amphibole migmatites.
The deformation history revealed that the study area underwent four major tectonic phases D1-D4 [8] as the whole Yaoundé series. Imprints in the rocks from the area highlight a three-step deformation corresponding at the regional scale, to the D2 and D3 phases. The D2 ductile phase is characterized by a maximal NE-SW stretching and a NW-SE minimal lengthening of structures. The D3 phase is a brittle tectonics induced by two compression trends NW-SE to NE-SW and E-W to NW-SE along with C3 shear planes. This three-step deformation history is followed by another brittle D4 phase characterized by mega-, meso- and microscaled fractures which appertains in the whole Panafrican fold belt. Previous geophysical studies [9] have shown evidence of some buried faults directed W-E and have confirmed tectonic napes with a southern vergency.
The climate of the area is an equatorial type, and the annual mean rainfall measured is 1600mm. Many rivers, tributaries flow in the area and many spring exceptionally in Nyambaye site.

3 Data Acquisition and Methods

3.1 Data Acquisition

The field data were collected along the Schlumberger array, using the Terrameter SAS 303 resistivimeter. Measurements were taken at increasing current electrodes spacing such that, the injected electric current should be penetrating at greater depths. Direct current or low frequency alternating current is injected into the ground, and the voltage between two points is measured. Variations in resistance to the current flow at depth cause distinctive variations in voltage measurements which provide information on subsurface structure and materials. Details of the operational efficiency of the involved equipment have been documented in previous researchers' works [10].
In general, VES method with Schlumberger array assumes considerable importance in the field of groundwater exploration because of its ease of operation, low cost and its capability to distinguish between saturated and unsaturated layers. Thus this technique has been used in this case study.
Field data were recorded in a computer for further processing using specialized software *IP2WIN*.
Discharge, hydraulic conductivity and transmissivity parameters were obtained by pumping test.

3.2 Geoelectrical Method

The apparent resistivity ρ is obtained according to the relation:

$$\rho = K\,\Delta V/I \qquad (1)$$

ΔV, I and K being respectively the voltage in volts, the electric current in Ampere and K is the geometric factor which depends on the electrodes array used. For the schlumberger array, four electrodes were placed along a straight line on the surface such that the current electrodes distance AB is equal to or greater than five times the potential electrode distance MN [11], the geometric factor K is computed as

$$K = \pi \left[(AB-MN)(AB+MN)/2MN \right] \quad (2)$$

Where AB is the current electrodes spacing, MN stands for the potential electrodes spacing in meter, and π is equal to 22/7.
The apparent resistivity values are plotted versus the half current spacing AB using a log-log sheet. These plots represent the field curves, which were immediately interpreted qualitatively in the field and later subjected to computer assisted iterative interpretation using the IP2WIN package. The resulting set of layer parameters were interpreted in terms of their lithological equivalent in relation with Cameroon's geological formations.
When the thickness (h) and resistivity (ρ) of an aquifer are known, its transverse resistance (R) and longitudinal conductance (S) can be easily calculated also. [12] Was the first to give the concept of these parameters and subsequently called them the Dar-Zarrouk variable (R) and Dar-Zarrouk function (S).

$$R=\rho h \quad (3)$$

$$S = h/\rho \quad (4)$$

Transmissivity as a hydraulic characteristic of aquifer is widely used for hydrogeological investigation. This parameter is defined as the product of its conductivity and the thickness of layer.

$$T = Kih \quad (5)$$

Where, T is the transmissivity and Ki is the hydraulic conductivity. Combining equation (3) and (5) gives:

$$T = Ki/\rho R \quad (6)$$

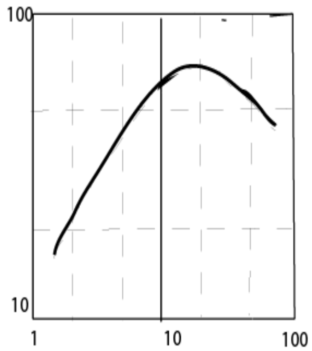
This relationship is suitable for the determination of aquifer transmissivity, as the ratio K_i/ρ is assumed to be constant in areas with similar geological setting and water quality.

4 Results and Discussion

The results obtained within the case study come both from quantitative interpretation (Vertical electrical sounding) and qualitative interpretation (isoapparent resistivity maps, discharge, hydraulic conductivity and transmissivity maps). It is assumed that these results could also be used to determine the groundwater potentials of the study area.

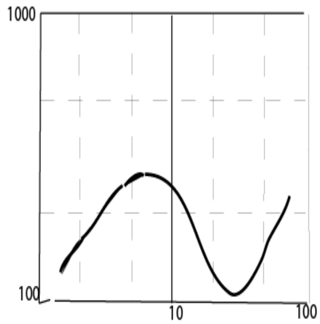
4.1 Sounding curves

The interpretation of sounding curves from the study area shows the existence of many geoelectrical models:



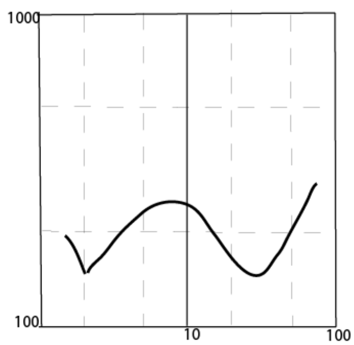
N	Rho	H (m)	Depth	altitude
1	62.1	0.4853	0.4853	-0.4853
2	992.6	11.04	11.53	-11.53
3	372.3			

Figure 2a: Three layered model



N	Rho	H (m)	Depth	altitude
1	43.98	0.4736	0.4736	-0.4736
2	1946	1.034	1.507	-1.5073
3	14.84	4.6	6.108	-6.1076
4	11189			

Figure 2b: four layered model



N	Rho	H (m)	Depth	altitude
1	2470	0.3468	0.3468	-0.34683
2	56.86	0.716	1.063	-1.0629
3	1024	1.683	2.746	-2.746
4	79.07	19.15	21.89	-21.892
5	17634			

Figure 2c: five layered model

Four types of terrains models with three layers Q, A, H, K (24); four types of terrain models with four layers KH, QH, AK, KQ (21); and four types of terrain models with five layers KHK, HKH, KQH, KHA (5). These main twelve major curve types were identified as shown in **Table 1** and **Fig. 2** (**a, b and c**) illustrate, respectively, those major types.

Table 1: types of curves

Types of curves	**A**	**H**	**K**	**Q**	**AK**	**KQ**	**QH**	**KH**	**KHK**	**HKH**	**KQH**	**KHA**
Locations of curves	Batanga Bitang1 Etoundou1 Etoundou2	Bigindé Bongando1 Biamese2 Bognoumousou Djoro Essende2 Kedia Mouko Ombessa Mougo2 Mouko2	diomar	Mouko1 Bafia Biamese1 Bongando 2 Boyaba Essende1 Yaro-bokito	Mougo 1 Nyamzon2	Eloa2	Biabezock1 Rufon	Babetta1 Babetta2 Bamoko 1 Bitang 2 Eloa 1 Eloa 2 Nyamzon1 Ndekalend1 Ndekalend2 ,nekon1 Nekon2, nyambaye1 Nyambaye2 nyamsong1 nyamsong2 tsekane1 tsekane2	bamoko2 bassolo1	Bakoa	Bassolo2	Biabezock 2,
Numbers of curves	**4**	**11**	**1**	**7**	**2**	**1**	**2**	**17**	**2**	**1**	**1**	**1**

The apparent resistivity curves reveal a dominant curve type KH with 34%, H with 22% and type Q with 14% over the entire area. The dominance of these curve types shows a homogenous subsurface succession, and, in most sounding curves the same layers were found; showing typical geoelectrical curves representative of the curve types A, H, AK and KH respectively [13].

Three to four geoelectrical layers were shown **(table 2)**: - The top layers with an average resistivity value of 74.60 Ω.m and a thickness between 0.1 and 6.6 m; - The second layer may be partly made up of clay within sandy or clayey soil with an approximate resistivity average of 914.09 Ω.m and thickness ranging between 0.9 and 48 m. This second layer contributes into the development of groundwater, because it enables the infiltration of surface water to the underlying fractured migmatitic layer; - The fractured migmatitic layer (gneisses and granites) has a thickness ranged between 0.4 and 80 m. It corresponds to a horizontal aquifer with a mean resistivity value of 249.4 Ω.m. this layer overly the bedrock. The structures above the water table are in the ventilation zone. The topsoil generally consists of three parts: the belt of soil water at the top, the intermediate vadose zone, and the capillary fringe at the bottom. The difference in compaction of the clayey materials sand is responsible of the variation in the resistivity values [14].

Stations from Babetta, Bakoa, Bamoko, Bassolo (1), Biabezock (2), Eloa, Mougo (1), Ndekalend, Nekon I, Nyambaye, Nyamzon (1) and Tsekane show an acceptable thickness for the aquifer. These stations may be the recommendable locations for groundwater exploitation because they have the highest thickness between both weathered zones (76 m). The rocks in these zones are well consolidated with no permeability and not water bearing, except where these rocks are fractured. Fractured zones are good for groundwater storage and they have a recharge capability. However, because of the presence of a consolidated rock above the aquifer, it may be difficult to drill. Thus, mechanized boreholes can only be realized there.

Table 2: Recap of lithology layers

N° Ves Station	*Resistivity (Ω.m)* $\rho_1 / \rho_2 / \rho_3 / \rho_4 / \rho_5$	*Thickness (m)* $h_1 / h_2 / h_3 / h_4 / h_5$	*Llithology*	*Type Courbe*
Ves 1 Babetta Stn1	85.4/3029/136.5/2713	0.9/1/19.2	Top soil/Granite/ Granite*/ Granite	KH
Ves 2 Babetta Stn2	93.4/961.9/213.9/472.2	0.9/1.2/10	Top soil /Granite*/ Granite*/ Granite*	KH
Ves 3 Bafia centre Stn	22.6/1.8/0.2	0.8/10.8/9.6	Top soil / clay */Sand	Q
Ves 4 Bakoa Stn	2470/56.9/1024/79.1/1763	0.3/0.7/1.7/19	Top soil /clay/ Gneiss*/ Gneiss*/Gneiss	HKH
Ves 5 Bamoko Stn1	115/1986/73.6/439	0.6/0.7/12	Top soil /Granite/ Granite*/ Granite*	KH
VES 6 Bamoko Stn2	81.8/1111/66.2/820/6.7	0.4/0.6/2.4/17	Top soil /Granite/ Granite*/ Granite*	KHK
VES 7 Bassolo Stn1	36.41/1238/14.68/461.2/18.96	0.2/1.1/2.2/79.4	Top soil /Gneiss/ Gneiss*/ Gneiss*	KHK
VES 8 Bassolo Stn2	111.8/4216/348.4/83.7/287.5	2.1/0.7/1.1/12.6	Top soil /Gneiss/ Gneiss*/ Gneiss*/ Gneiss*	KQH
VES 9 Batanga Stn	69.3/3489/2965	6.6/45	Top soil /Gneiss/ Granite	A
VES 10 Biabezock Stn1	543.7/245/124.6/1165	0.4/1.2/6.8	Top soil /Granite*/ Granite*/ Granite*	QH
VES 11Biabezock Stn2	143.6/1893/32.8/5234.2/6873	0.4/0.9/0.6/28.5	Top soil / Gneiss*/ Gneiss*/ Gneiss/Gneiss	KHA
VES 12Biamesse Stn1	77.3/2.3/0.9	0.6/2.5	Top soil / clay */Sand	Q
VES 13Biamesse Stn2	43/4/15.4	0.9/3	Top soil / clay */ Granite*	H
VES 14Biginde Stn	36.9/0.4/1.6	1/12.4	Top soil / clay */ clay	H
VES 15 Bitang Stn1	38.8/481.5/2871	0.5/70.9	Top soil /Gneiss*/ Gneiss	A
VES 16 Bitang Stn2	97.4/881.7/102.6/1174	0.8/1.3/30.1	Top soil /Granite*/ Granite*/ Granite	KH
VES 17 Bogando Stn1	7.6/0.1/2.1	1.7/47.6	Top soil /Sand/ clay	H
VES 18 Bogando Stn2	93.8/6.3/0.6	0.4/2	Top soil / clay / clay *	Q
VES 19 Bognoumoussou Stn	85.2/3.7/24.1	0.8/2.9	Top soil / clay */ clay	H
VES 20 Bongando Stn	8.2/1.4/1.8	1/ 4.7	Top soil / clay / clay	H
VES 21 Bongando Stn1	9.6/0.4/2.1	1.3/17.6	Top soil /clay*/clay	H
VES 22 Boyaba Stn	47.7/4.9/1.1	0.8/2.8	Top soil / clay / clay *	Q
VES 23 Diomar Stn	62.1/992.6/372.3	0.5/11	Top soil /Granite/ Granite*	K
VES 24 Djoro Stn	34.4/1.23/7.95	0.9/4.6	Top soil / clay */ Granite*	H
VES 25 Eloa Stn1	6.5/1086.7/30.2/7067	0.3/0.8/5	Top soil /Gneiss/ Gneiss*/Gneiss	KQ

VES 26 Eloa Stn2	13.2/5708/3412/77.5	0.5/0.7/0.6	Top soil /Gneiss/ Gneiss/ Gneiss*	KQ
VES27 Essende Stn1	24.6/0.7/0.3	0.8/4.4	Top soil / clay / clay *	Q
VES 28 Essende Stn2	20.2/1.1/74.8	0.9/3.9	Top soil / clay /Granite*	H
VES 29 Etoundou Stn1	138.1/145.6/285.8	4/7	Top soil /Granite*/ Granite*	A
VES 30 Etoundou Stn2	112.4/293.8/27528	0.5/38.4	Top soil /Gneiss*/ Gneiss	A
VES 31 Kédia Stn	47.9/0.9/33.2	3.1/18.9	Top soil / clay */ Granite*	H
VES 32 Mougo Stn1	25.4/307.8/2500/14.16	1.6/63.8/5.7	Top soil /Gneiss*/Gneiss/Gneiss*	AK
VES 33 Mougo Stn2	301.3/79.7/767.3	0.9/5.5	Top soil /Gneiss*/Gneiss*	A
VES 34 Mouko Stn1	65.2/2.1/1.4	0.5/4.2	Top soil / clay / clay *	Q
VES 35 Mouko Stn2	8.6/0.5/1	0.7/5.9	Top soil /Sable/Sable	H
VES 36 Ndekelend Stn1	87.1/2194/224.9/450.1	0.6/0.4/1.2	Top soil /Granite/ Granite/ Granite*	KH
VES 37 Ndekelend Stn2	274.8/3087/439.5/28873	1.2/0.2/41.4	Top soil /Granite/ Granite*/ Granite	KH
VES 38 Nekon I Stn1	176/1313/126.1/1216	0.8/2.1/36.4	Top soil /Granite/ Granite*/ Granite	KH
VES 39 Nekon I Stn2	48.7/2405/108.3/7496	0.3/1.2/31.4	Top soil /Gneiss/ Gneiss*/Gneiss	KH
VES 40 Nyambaye Stn1	130.7/4101/192.1/3937	0.9/1.2/16.7	Top soil /Granite/ Granite*/ Granite	KH
VES 41 Nyambaye Stn2	164/2759/169.6/3259	0.5/0.9/24.3	Top soil /Granite/ Granite*/ Granite	KH
VES 42 Nyamsong II Stn1	81.5/726/162/867	0.2/4.1/24.4	Top soil /Granite*/ Granite*/ Granite*	KH
VES 43 Nyamsong II Stn2	38.7/616.9/29.8/6180	0.1/9.4/4.9	Top soil /Granite*/ Granite*/ Granite	KH
VES 44 Nyamzon Stn1	64.6/3365/27.4/3131	0.4/1.06/5.17	Top soil /Granite/ Granite*/ Granite	KH
VES 45 Nyamzon Stn2	111.4/883.4/2038/7.6	4.7/7.4/9.4	Top soil /Granite*/ Granite/ Granite*	AK
VES 46 Ombessa Stn	34.4/0.9/7.9	1/21.1	Top soil / clay */ Granite*	H
VES 47Rufon Stn	42/3.7/0.2/18.5	0.8/2.6/25.5	Top soil / clay */ Granite*	QH
VES 48 Tsekane Stn1	44/1946/14.8/11189	0.4/1/4.6	Top soil /Granite/ Granite*/ Granite	KH
VES 49 Tsekane Stn2	23/9064/27.8/21019	0.5/0.9/5.7	Top soil /Granite/ Granite*/ Granite	KH
VES 50 Yaro-Bokito Stn	95.32/3.3/1.2	1.2/4.1	Top soil / clay / clay *	Q

clay * = clay sandy or clayey soil; Gneiss* = Cracked gneiss; Granite* = Cracked granite

Locations favorable to the implantation of artisanal boreholes may be Bafia, Bassolo (2), Biginde, Bitang, Bogando (2), Diomar, Etoundou, Mougo, Nyamsong II, Ombessa, Kédia

and Yaro-Bokito. These locations have quite thick aquifers at accessible depth.
Locations where boreholes setting are not recommendable because of the high conductivity and high porosity of layers are mainly Biamesse, Bogando (1), Bognoumoussou, Bong-Ando, Boyaba, Essende, Djoro and Rufon. These locations are essentially constituted by clay and sand. This can be ecologicaly frail or weak and contaminated by infiltration. However they cannot be characterized like secured fresh groundwater.

4.2 Isoapparent Resistivity Maps

The resistivity maps reflect the lateral variation of the apparent resistivity over a horizontal plane at a given depth. In other words, these maps indicate the distribution of apparent resistivity in the area versus the current electrodes spacing. Based on the depth of current penetration, the isoapparent resistivity map for AB/2= 4.4 m **(figure 3a)** correlates with depth of about 3 m and approximately reflects the surface layer in the total area. The resistivity map for AB/2= 58 m **(figure 3b)** correlates with depth of about 40 m and reflects water-bearing layer in the whole area.
Generally, the apparent resistivity values in **figure 3a** are greater than those in **3b**. This difference is caused by the electrolytical pore fluids conduction (in the satured layers) and also on surface, by the effective surface of minerals in the dry layers [16].

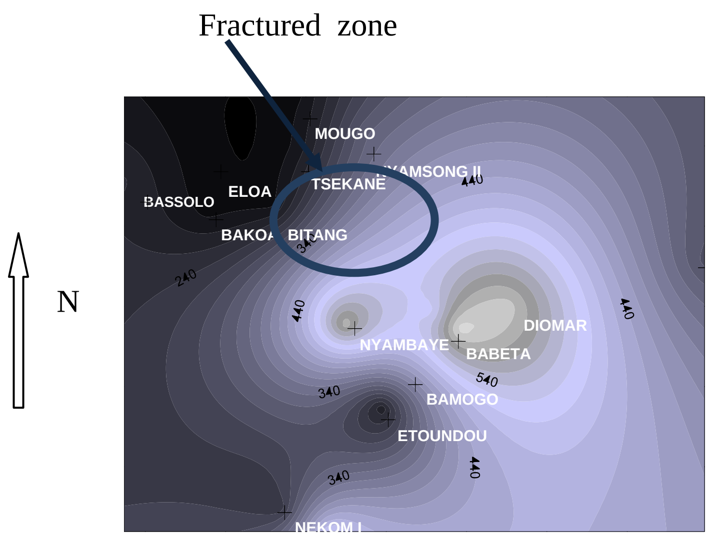


Figure 3a: Resistivity map for AB/2 = 4.4 m

Thus, the high values of apparent resistivity observed for AB/2= 4.4 m (**figure 3a)** are attributed to the presence of an unconsolidated and dry layer at the depth of 3 to 4 m. The apparent resistivity contours with AB/2 = 58 m **(figure 3b)** show relatively low apparent resistivity values because of the presence of water saturated zones.

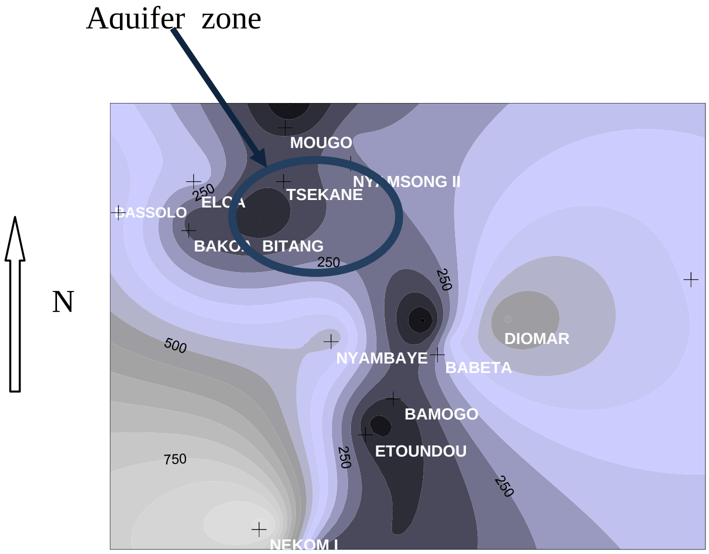


Figure 3b: Resistivity map for AB/2 = 58 m

Furthermore, the resistivity map indicates the presence of a low resistive zone reflecting the southern vergence of the aquifer, with a strike oriented N-S to NE-SW; hence the recharge area is concentrated in the middle of the study area. Tsekane, Diomar, Bakoa and Babetta localities and neighborhoods have low resistivities and they are located near the fractured zone. This proves that these are the places where the two best aquifers of the study area are sited.

4.3 Discharge, Hydraulic Conductivity and Transmissivity Maps

These parameters were obtained by pumping tests shown in **table 3**. Discharge, hydraulic conductivity and transmissivity are hydraulic characteristics of aquifers widely used in hydrological investigation.

Table 3: Properties of the aquifer

Locality	Long	Lat	Alt	NS	h	Q	T	K	S	Q/S	D
Babeta	539133	727176	648	3,2	644,8	8	4,2E-05	3,9E-0	0,24	33,3	12
Bamogo	535684	729555	568	7,88	560,1	1,2	8,8E-06	7,4E-07	0,15	8	8
Bitang	515937	742524	517	8,85	509,1	6	8,6E-05	7,3E-06	9,5	0,6	8
Eloa	508660	747247	458	3,54	460,4	8	3,5E-06	3E-07	7,1	1,1	4
Mougo	519181	756125	461	5,4	455,6	3	5,9E-05	5E-06	1,3	2,3	8
Nekom I	516769	704771	863	3	860	1,1	2E-05	1,1E-06	0,71	1,5	8
Nyamsong	527233	751733	507	14,4	492,6	1,5	8,5E-06	1,9E-06	4,3	0,3	8
Tsekane	519078	749945	484	8,2	475,8	6	0,00027	2,3E-05	3,15	1,9	8
Bakoa	507627	741782	453	0	453	6	0,00023	2E-05	1,29	4,6	4
Bassolo	497374	745704	438	9,57	848,4	4	5,2E-05	4,4E-06	6,8	0,5	8
Diomar	545257	730036	610	4	606	5	0,00011	9,2E-06	1,8	2,7	8
Etoundou	529434	717287	691	6,46	684,5	1,5	2E-05	1,2E-06	0,89	1,6	8
Ndekaleng	522862	701931	905	20,4	884,6	1	4,6E-06	2,6E-07	0,11	9,0	8
Nyambaye	524824	727763	668	8,89	659,1	1	4,1E-06	3,5E-07	0,17	5,8	8
Nyamzon	569629	735703	662	12,68	649,3	2,5	1E-04	8,5E-06	0,17	14,7	8

The **figure 4** (**a, b, c**) shows three maps (respectively discharge, hydraulic conductivity and transmissivity maps) that present in locations like Tsekane, Diomar, Babetta and Bakoa high values of the three physical parameters cited above.

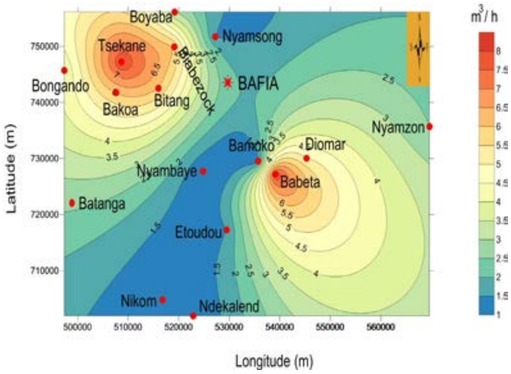


Figure 4a: Discharge map

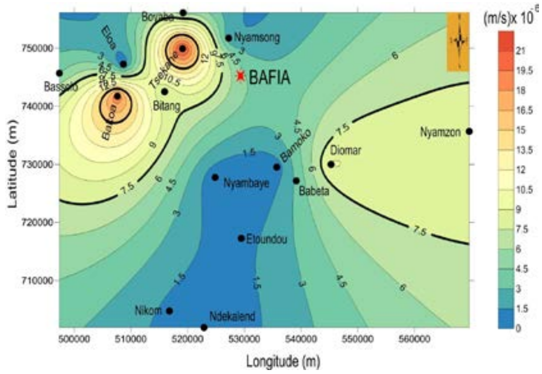


Figure 4b: Hydraulic conductivity

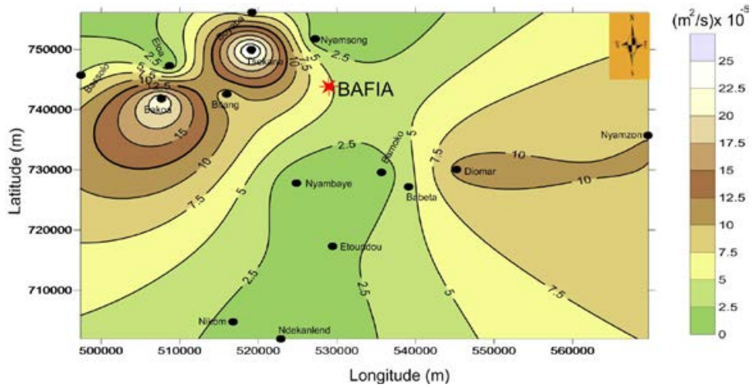


Figure 4c: Transmissivity map

These informations allow us to notice that the study area has two adjacent aquifers separated by a global N-S channel. These parameters are relatively poor at Nyamsong, Bafia, Nyambaye, Etoundou, Ndekaleng, Nekon. The sizes of these aquifers, the discharge and their transmissivity show that they can supply the needs of the population in drinkable water whose access is currently difficult.
The discharge map **(figure 4a)** shows that the aquifer located in Tsekane have a wide area of 20000 m^2. This information can allow us to suggest this location as the best for boreholes in groundwater exploration tests.

7 Conclusion

The geoelectrical investigation showed that there are three to four geoelectrical layers in twelve major curve types. These layers correspond to the top layer, clay or sandy or clayey layer, shaly layer or confined aquifer and the bedrock.
The depth values and the isothickness map of aquifer reveal that aquifer thickness varies from 50 to 75m with and the bedrock depth lies between 50.4 and 80 m.

The sounding at Tsekane and Diomar are located on the fractured zone (resistivity maps), the discharge hydraulic conductivity and transmissivity maps exhibit lower values. Considering the relationship between the resistivity and aquifer transmissivity, the yield potential in these areas is low. But the high thickness value, high resistivity values and the lack of wells, the advisable location for well drilling in this area, is suggested to be in Tsekane.

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