GEOELECTRICAL APPRAISAL OF LOKO GOMA AND ENVIRONS, PART OF JEMAA SHEET 188SW, KOKONA LOCAL GOVERNMENT AREA OF NASARAWA STATE, NIGERIA.

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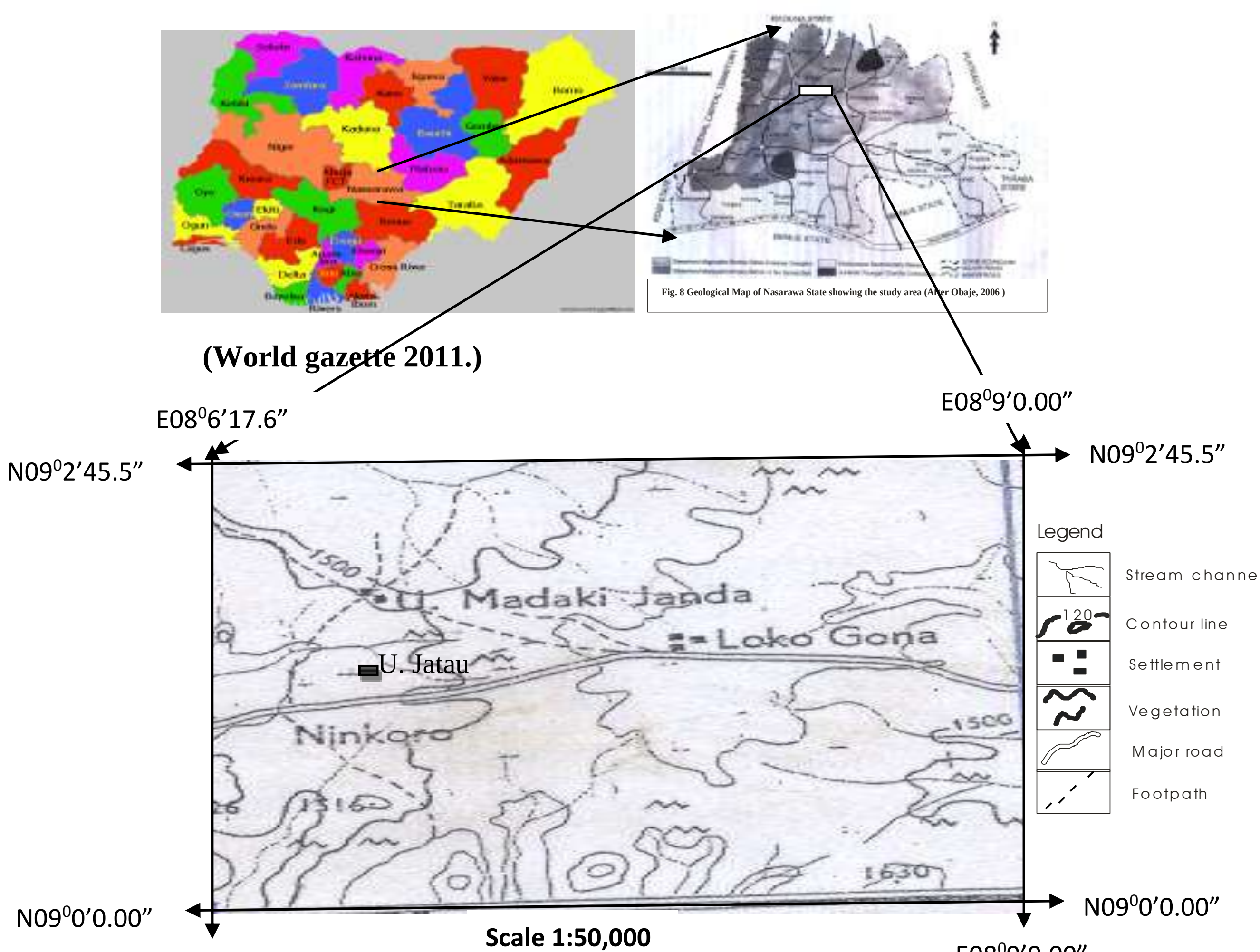
ABSTRACT: *Geophysical investigation was carried out in Loko Goma and its environs, with the aim of studying the groundwater potential of the study area in Kokona Local Government Area of Nasarawa state, Central Nigeria and lies between latitudes 9^0 $00'$ $0.00''$ to 9^0 $02'$ $45.9''$ and longitudes 8^0 $06'$ $17.6''$ to -8^0 $9'$ $0.00''$. The study area covers an area extent of 25km^2. The area is underlain by the Basement Complex of the North Central Nigeria. Ten (10) Vertical Electrical Sounding (VES) were carried out in the study area. Interpreted data shows a dominance of A and H type curve. The quantitative and qualitative interpretations revealed some good degree weathered and fracture basement. Iso-resistivity of the true aquifer, depth to basement, basement resistivity and, piezometric maps were delineated. Out of the ten VES, three (VES 1,8 and 10) have been delineated as the most viable locations for good water potentials and moderate at VES7,4,5 and 9, while the least expected yield lies are VES 3,2 and 6. The two types of aquifer, which are weathered basement and fractured basement, have been delineated. This study will serve as useful guide for groundwater exploration in the study area.*

KEYWORDS: Geoelectrical, Groundwater Potential, Curve Types, True Aquifer, Piezometric and Basement Maps.

INTRODUCTION

The study area covers an area extent of 25km^2, bounded by latitudes N^{o}09 $0'$ $0.0''$ to 09^0 $2'$ $45.9''$ and longitudes E^0 $08^06'$ $17.6''$ to $08^09'$ $0.00''$ south of Jemaa sheet 188, on a scale of 1:12,500. Sources of water supply in the area come from streams, rivers, hand dug wells and a borehole sunk in high weathered and fractured basement rocks. Fractures in the basement rocks are due to multiple deformational processes in the basement rocks. The major source of recharge of this surface water is by precipitation (rainfall). However, the streams or rivers flow only in the rainy season and early parts of the dry season thus making the supply very scarce in the dry season, and limiting water access to groundwater. The surface water is obvious that it is harnessed only during the rainy season in streams and shallow dug wells at the stream bank.



rface Map of the study area (Extracted and modified from topographical map sheet 188 Jemaa, Federal Survey 1972)

Physiography
The area is characterized by steep escarpments which are associated with the granitic intrusion, separating the high level (N,NE) areas from lower areas (S,SW) (Figs.1-2) . It has an undulating surface with high altitude in the north and lower latitude to the south. Elevations in the area are about 520m, 508m, and 420m. The entire area has a dentritic pattern of drainage (Fig.3).

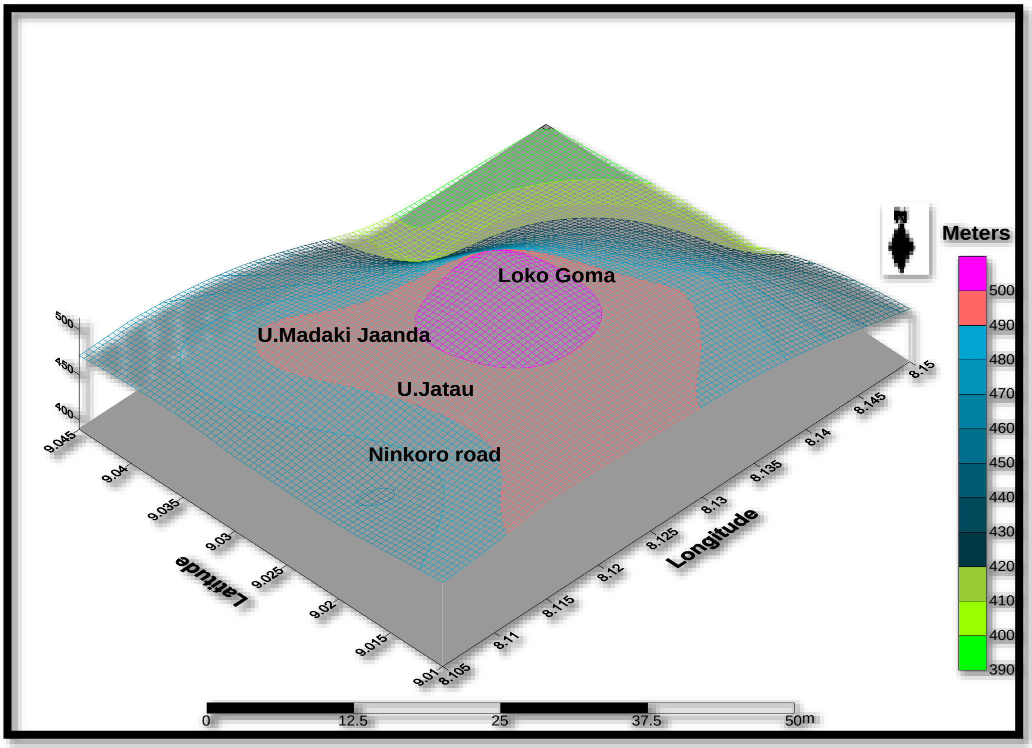
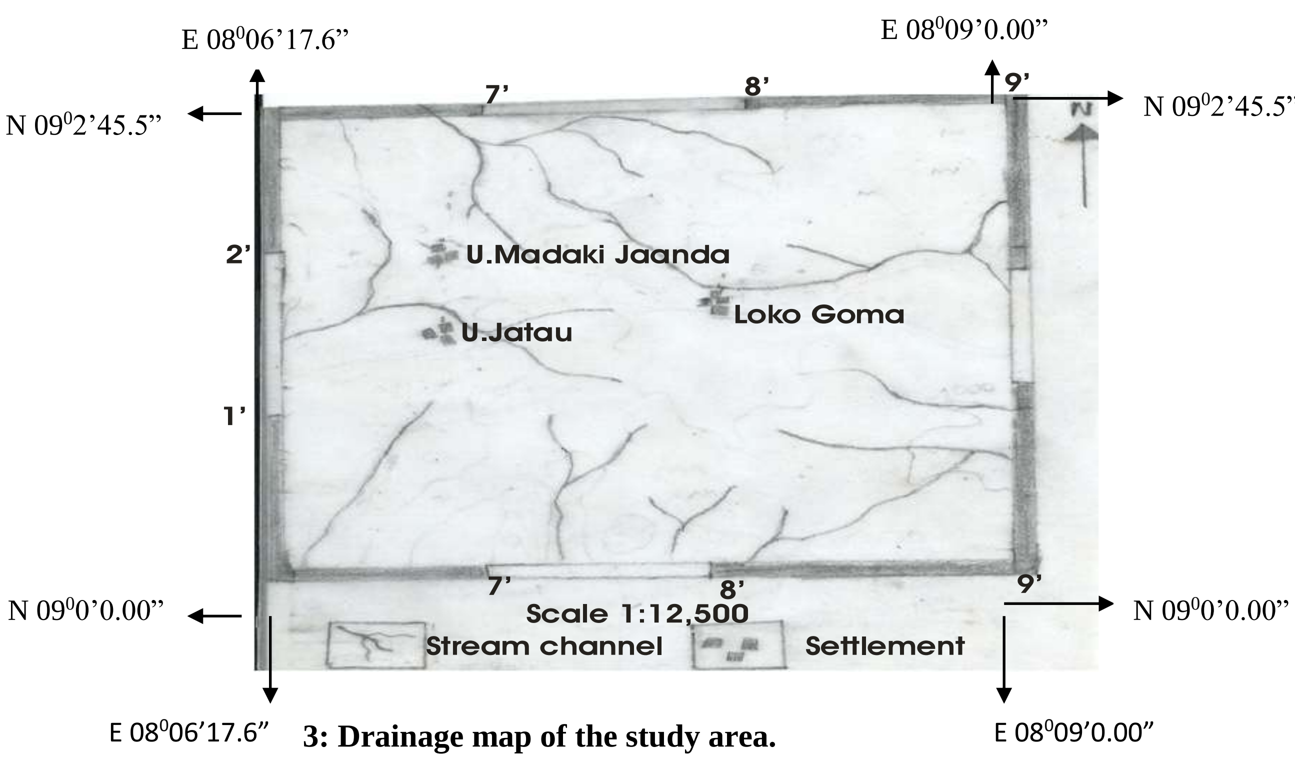


Fig. 2: Surface map of the study area showing its relief.



3: Drainage map of the study area.

The mean annual rainfall range from; 14.2mm to 229.4mm with the highest in August and lowest in April, The mean annual temperature of the area in a year range from 19.3^{0}C to 23.8^{0}C. The annual mean humidity varies from 32% to 86 %.(NMA, Lafia 2013)

GEOLOGY OF THE STUDY AREA

Loko Goma falls within the Basement Complex on the Nigerian geology, which lies in the extensive region east of the West African Craton and northwest of the Congo Craton which is believed to be among the Pan Africa Mobile belt (600Ma) (Ajibade et al, 1987; Ajibade and Woakes, 1976) Evidence from the eastern and northern margins of the West African Craton indicates that the Pan African Belt evolved by plate tectonics process which involves the collision between the passive continental margin of the West Africa Craton and the Active continental margin (Pharusian belt) of the Tuareg Shield about 600Ma ago (Wright et. al., 1970). It also falls within the Lower Benue River basin of the Nigerian Hydrological province, and the crystalline or Basement rocks of Nigeria (Dan Hassan and Olorunfemi, 1999; Offodile, 1983; Offodile, 2002.). Generally, the areas are located on high relief in which run-off is high with low infiltration rates and the natures of the rocks are hard with low permeability and porosity (Offodile, 1983, Jatau et al, 2013). The Study area falls within the Migmatite Gneiss Complex of the North central Nigerian, which consists of gneiss, quartzite, schist, coarse grained granite and rhyolite. The gneiss which is the oldest is intruded by a NW-SE and NE-SW trending quartzo-feldspathic rocks, granite and the NE-SW trending rhyolite. The structural analyses revealed a NW-SE and E-W trend which is in correspondence to the general trend of the Nigerian basement (Fig.4).

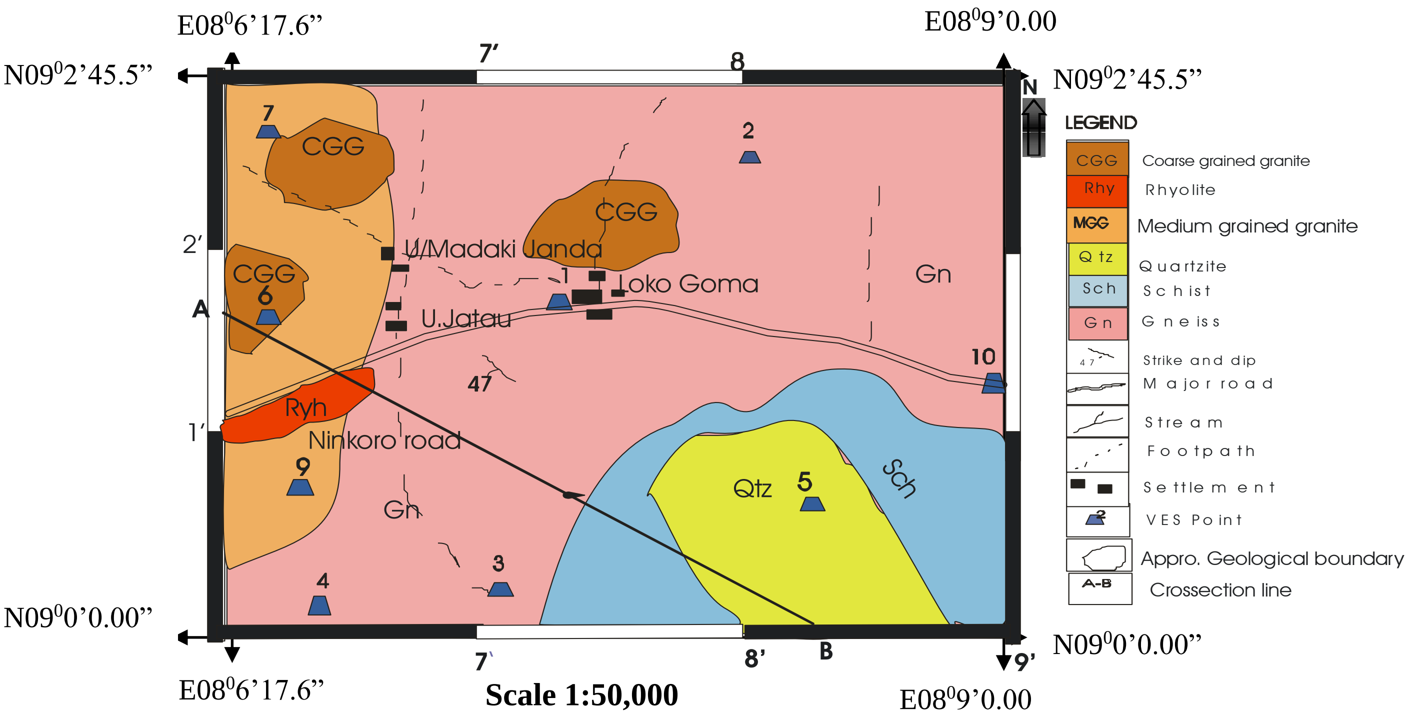


Fig.4: Geologic map of the study area showing the VES points (1-10).

METHOD AND MATERIALS

Ten (10) Vertical Electrical Sounding (VES) points out of cultural interference were selected and L and R resistivity meter was used for data collection in Loko Goma and environs. Field curves were subjected to curve matching exercise and then interpreted quantitatively using IXIP software and surfer 8 for the qualitative interpretations.

RESULT AND DISCUSSION

Table 1 Interpreted model geoelectric parameters and curve types of the study area.

VES Location/ G.P.S Point.		**VES1** (N,09^{0}01'30.4") (E,08^{0}07'45.0")	**VES 2** (N,09^{0} 02'5.5") (E,08^{0} 08'10.0")	**VES 3** (N,09^{0} ^{0}0'4.1") (E,08^{0} 07'45.5")	**VES 4** (E,09^{0}00'23.8") (E.08^{0}07'50.5")	**VES5** (N,09^{0}00'50.5") (E, 08^{0}08'39.2")	**VES 6** (N,09^{0}01'35.5") (E,08^{0}06'17.6")	**VES 7** (N,09^{0}02' 50.6") (E,08^{0}06' 36.6")	**VES 8** (N,09^{0}01' 30.9") (E,08^{0}07' 20.9")	**VES 9** (N,09^{0}00' 50.8") (E,08^{0}06' 44.8")	**VES 10** (N,09^{0}01' 15.5") (E,08^{0}09 '00.0")
Layer Thickn-ess(m)	**1**	0.534	0.519	0.650	0.319	1.11	0.895	1.39	1.40	0.797	0.265
	2	2.24	8.63	2.96	3.71	2.64	1.62	2.84	2.41	4.17	1.5
	3	7.07	8.02	5.47	7.53	4.25	5.00	5.61	7.40	5.58	8.1
	4	18.79	6.35	13.87	12.80	16.66	11.57	17.04	18.30	7.24	17.28
	5	7.94	-	10.39	-	9.13	7.08	-	-	19.10	7.84
	6	-		-		-	-			-	-
Layer Resisti-vity (Ωm)	**1**	778.6	300.4	296.8	291.0	1210.9	384.7	389.1	105.3	236.5	778.5
	2	5261.4	1329.6	685.3	518.8	863.9	606.7	203.7	294.1	225.1	2327.9
	3	2116.9	1774.1	2436.8	911.7	6682	1924.7	694.0	1627.2	203.9	1739.6
	4	514.7	3370.0	600.2	1843.9	1160.7	364.3	1232.5	449.2	888.4	293.8
	5	681.1	7040.2	1259.6	11733.2	506.5	910.1	1293.3	2240.5	1030.9	1335.4
	6	998.8		5707.7		2261.0	2800.5			7207.4	2184.4
No. of Layer		6	5	6	5	6	6	5	5	6	6
Curve Type		KH	A	AH	A	QH	AH	H	A	H	KH

Table 2: Interpreted geoelectric log of a six layer case of the study area.

S/N	Layer No.	Layer resistivity (Ωm)	Layer thickness(m)	Suggested/inferred geoelectric layer (Lithology)
1	1	105.3-1210.1	0.534-1.40	Top soil (sand, sandy soil, laterite clay and laterite.
2	2	203.0-5261.4	1.62-4.17	Sandy soil, lateritic clay, and fresh laterite.
3	3	668.2-2116.0	4.25-8.1	Partially weathered basement, and fresh basement in some cases.
4	4	514.0-3370.0	7.24-8.79	Fractured basement and fresh basement.
5	5	293.8- 600.0	7.09-19.10	Weathered and fractured basement.
6	6	998.8 – 5707.7	Infinity	Fresh basement

Table 3 Interpreted geoelectric log of a five layer case of the study area.

S/N	Layer No.	Layer resistivity(Ωm)	Layer thickness(m)	Suggested/inferred geoelectric layer (Lithology)
1	1	105..1 – 300.4	0.319 – 1.40	Top soil, sand, sandy clay, and clayey soil.
2	2	203.7 – 1326.6	2.41 – 8.63	Sand, clayey soil, sandy clay, hard pan
3	3	694.0 -1140.0	5.61 – 8.02	Weathered / Fractured basement
4	4	449.2 – 3370.0	6.35 – 18.30	Fractured basement and fresh basement
5	5	1295.5 - 11733.2	Infinity	Fresh basement

Geoelectric Parameter Interpretation

Resistivity measurements separate the sub-surface into different layers based on their resistivity values. The field curves are dominantly A, K and HA types (Keller and Frischknecht, 1966).

Geoelectric interpreted parameters of the study area is summarized in Table 1.The various sounding points were modeled from 1-D inversion algorithm software which record their layers resistivity and thicknesses. The semi-qualitative analyses of the data studied, revealed a six-five layer cases (Tables1-3). VES 1, 3, 5, 6, 9 and 10 revealed a six layer case, while VES 2, 4, 7, and 8 revealed a five layer case. The type of lithology revealed are Top soil, weathered basement, fractured basement and fresh basement. The summary of the layers interpretation based on lithology is shown in Tables 2 and 3. The inferred lithology to each layer were based on probability, geological and inferences of previous work carried out in the same Jemaa Sheet 188 North central and South Eastern area (Jatau 2013, Dan Hassan and Olorunfemi 1999).

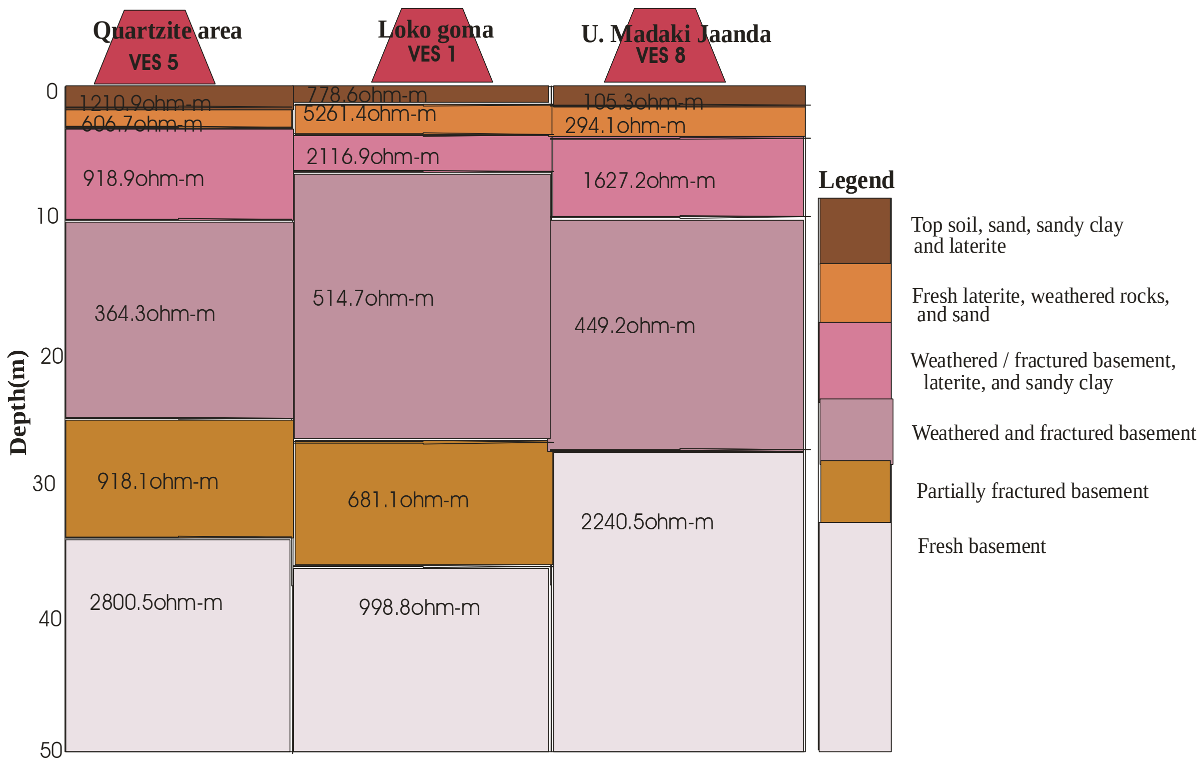


Fig. 5: Geoelectric sections of some of the VES location (VES 5, 1 and 8)

Iso-Apparent resistivity Map

The individual true aquifer resistivities of the study area obtained from the processed data quantitative analysis (Table 1) and was plotted and contoured as shown in (Fig.6). The contour map reveals a NW-SE trend similar to that of the depth to basement (Fig.8). The purple coloured contour lines reveal a high resistivity values and the lowest resistivity in green colour. The North–western trend reveals a good aquiferous zone in Loko goma, U/Madaki Jaanda, VES 7 and VES 5 (Fig.5) which record the lowest resistivity; this reveals a probable weathered and fractured basement.

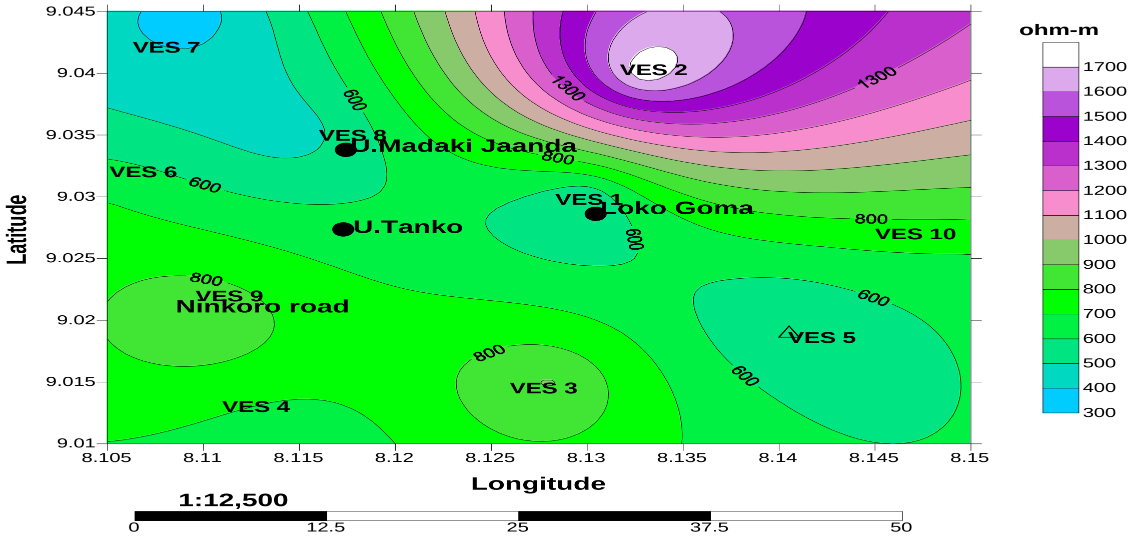


Fig.6: Contour map of the true aquifer resistivity map of Loko Goma and environs

Piezometric Map of Loko Goma and environs

The piezometric map was obtained by subtracting the field spot elevation by the depth of the overburden thicknesses for each location. This help in determining the direction of flow of aquifer water in the study area. The direction of groundwater movement can be understood in the fact that groundwater always flows in the direction of decreasing head. The piezometric map of studied area reveals three depressions in the north with an E-W, NE-SW and E-W trends (Fig.7). The purple intensity of the purple colour shows a high piezometric spot and the light blue to the green colour recording the lowest piezometric spot. This also confirms that the flow of the streams lies within the basement depression.

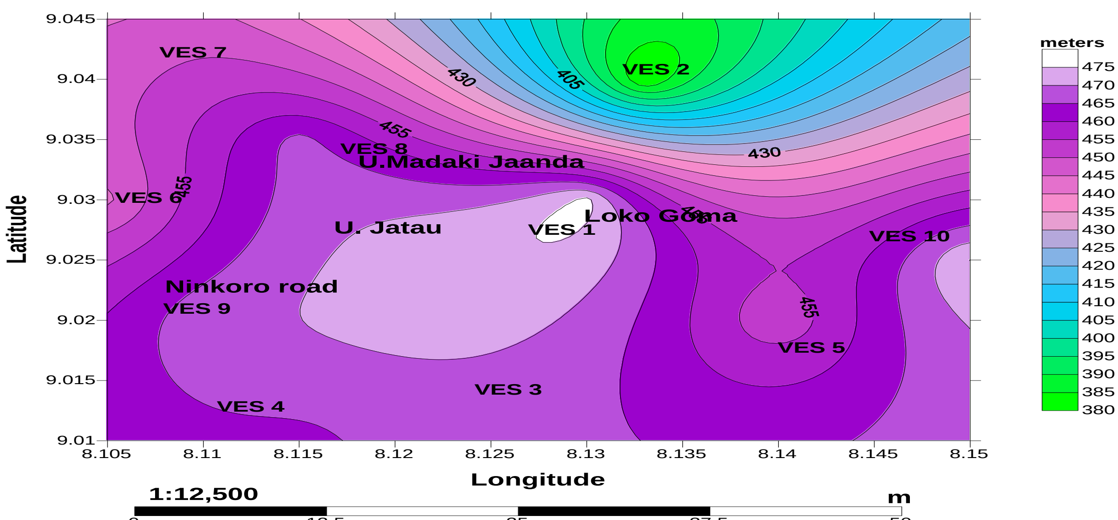


Fig7: Piezometric Map of Loko Goma and environs.

Depth to Basement

This is the depth to the basement rock beneath the surface. The depth to fresh basement rocks beneath the sounding point was rounded up to the nearest whole number as obtained from the quantitative interpretation (Table 1.). The depth to basement rocks ranges from 9m-28m. The basement is deeper at the central portion of the study area. Generally, the depth to the basement decreases northward, eastward, southward and westward from the central portion. This makes the central portion a groundwater receptacle zone, since groundwater will flow down topography to it. The result is in close range with the other research work carried out in the North-central Nigeria (Dan Hassan and Olorunfemi 1999) that predicted 4.3m – 64m and Jatau (2013) 15m- 49m. The study area map reveals shallow overburden areas where the depth to basement is shallow. Two depressions were revealed in the western areas and the south with a NW-SS trend, and also two ridges was also revealed in Loko goma and Ninkoro axis showing a NE-SW (Fig.8). Areas of thick overburden, less percentage of clay and good degree of porosity and permeability may have relatively good groundwater yield.

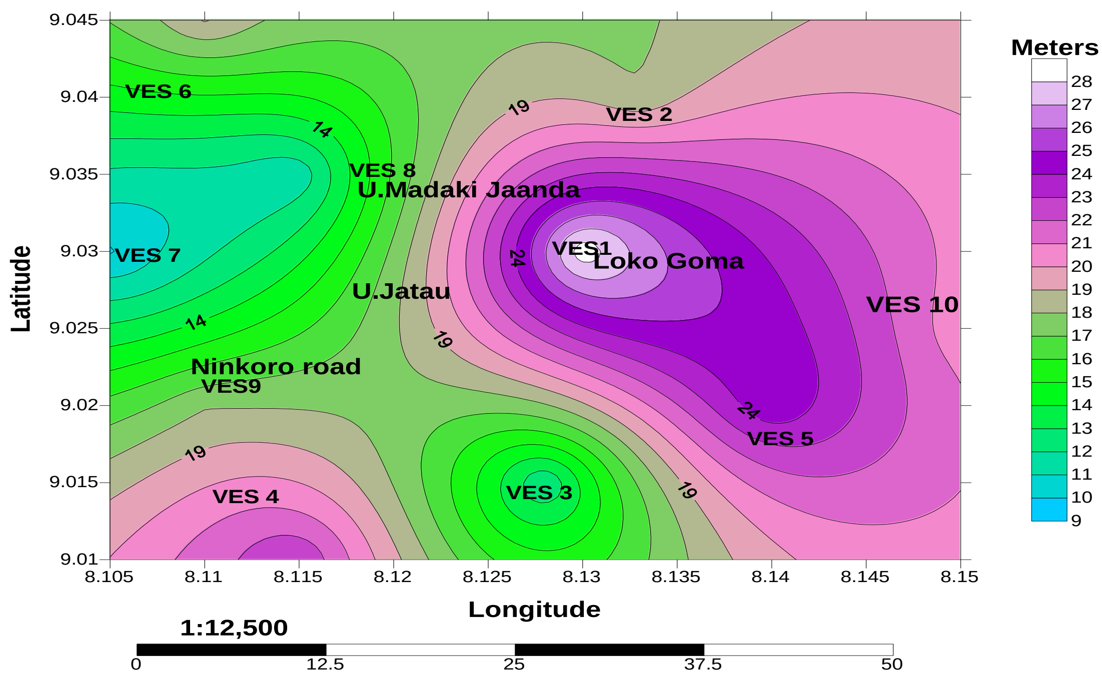


Fig8: Depth to basement of the study area

Basement Resistivity

The basement resistivity for each sounding point was obtained from the interpreted geoelectrical data (Table.1). The basement resistivity was recorded as the last layer resistivity. The basement resistivity of the sounding point defines the type, nature and character of the layer. In the study area, the contour map shows a NW-SE and E-W trend which are controlled by structures (fractures and weathered). Resistivities values >1000 revealed a fresh basement granitic rock and values <1000 revealed the weathered/fractured quartzite and granite. The basement resistivities in the southern areas in purple colour revealed a low potential area due to the rocks nature (Fig.9).

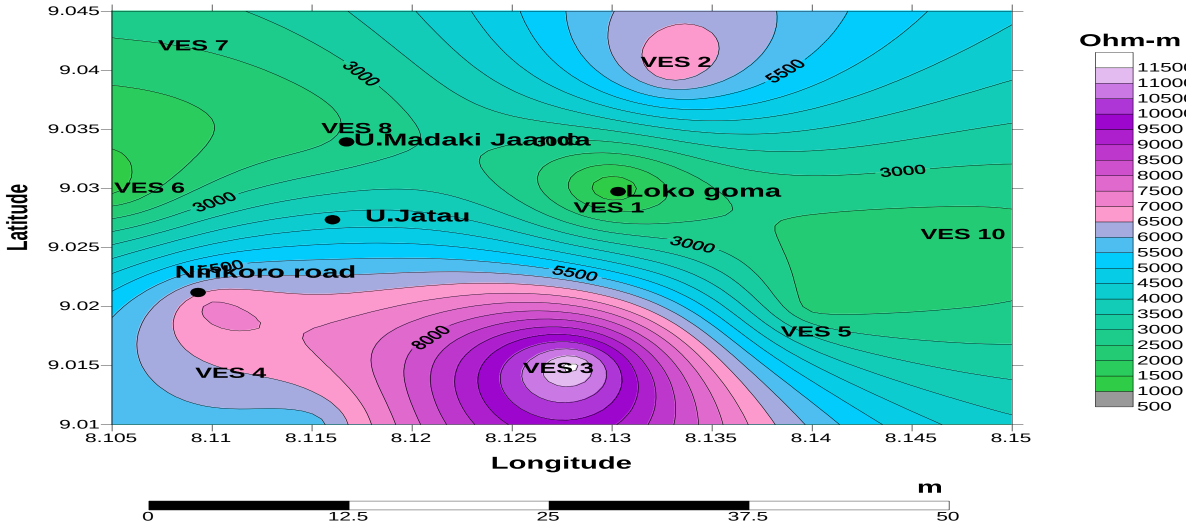


Fig. 9: Basement resistivity map of the study area.

The True Aquifer Depth

The depth of the true aquifers in the study area was obtained by subtracting the field spot elevation and the true aquifer spot elevation. The summation of the overburden layer thicknesses to the aquifer layer gives the depth to the true aquifer (Table 1). The contour map of each sounding point's of the true aquifer depth shows a NW-SE trend, similar to the Iso-resistivity map (Fig.7) with two ridges in the direction of the trend (NW-SE) and three depression in the south and North in green to light blue colour. The depth of the aquifer is shallow in the southern areas, around VES 3, 4, 9, 2; range from 8-18m, while areas like Ungwar Madaki Jaanda, Loko Goma and VES5 (Quartzite area) has deeper depth range from 22-33m (Fig.10).

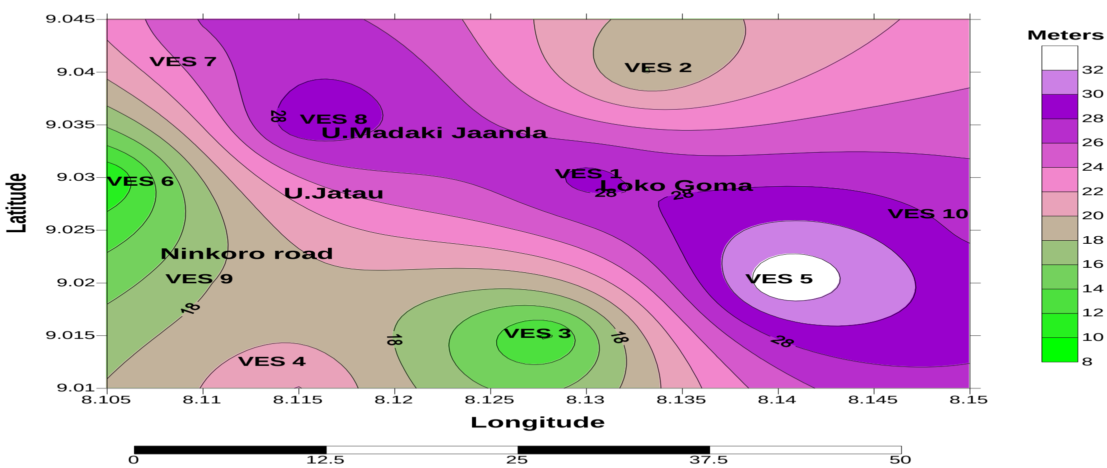


Fig.10: Contour map of true aquifer depth of Loko Goma and environs.

True Aquifer depth or thickness

The aquifer thickness of the VES locations were contoured (Fig.11). The thickness of the aquifer varies within the study area revealing a NW-SE and E-W trend. The thickness of the aquifer in the study area is thicker in areas which are represented by white spot, and light purple colour; Loko Goma (VES 1), U/ Madaki Jaanda (VES 8), and VES 10, which record 15-19m thick, while thinner region represented by green and light violet colour are revealed along Ninkoro road, (VES 9), VES 4, VES 6 and VES 2. The thickly moderate aquifer represented by light blue colour areas is revealed in the quartzite area (VES 5). The thickness of an aquifer controls the water potential of the aquifer itself, more so, the thicker and broader the aquifer, the greater the chances of having a good water potential (high prospect for groundwater).

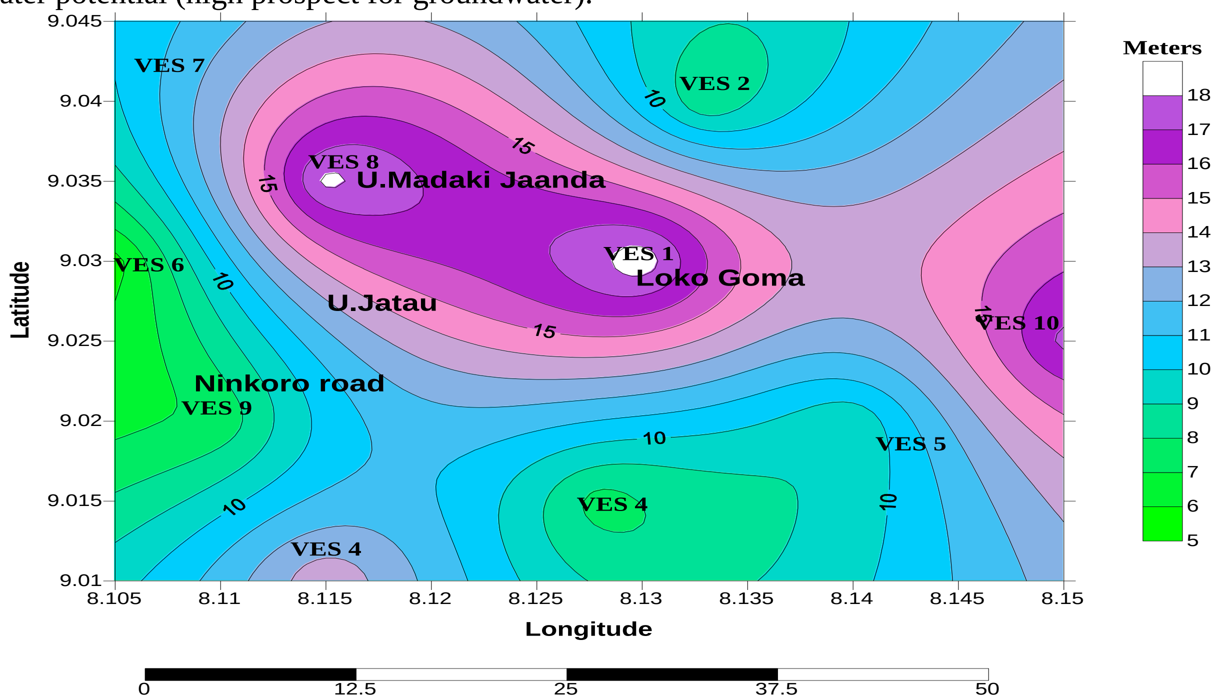


Fig.11: True aquifer thickness of Loko Goma and Environs

CONCLUSION

The geoelectric studies revealed a five-six (5-6) layer case, in which the weathered and fracture basement is believed to be the main aquifers. The piezometric map of the study area range between 380-475m, the true aquifer depth range 6-18m, basement resistivity 900-5707Ωm, depth to basement 9-23m, and the true aquifer resistivity range between 294-700Ωm. The groundwater potential area varies with high potential around Loko Goma (VES 1), VES 5, VES 9, VES 7 with true aquifer resistivity value from 294-700 Ωm overburden thickness range from 10-28m, this is followed by the VES 2 and 9 has a moderate – low potential. Their true aquifer resistivity ranges from 800-1000Ωm with overburden thicknesses from 8-18m. The area has a viable groundwater potential especially in Loko goma, U/Madaki Jaanda, U/Jatau, Ninkoro and the western southwestern area.

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