Delineation Of The Aquifer In The South-Western Part Of The Nupe Basin, Kwara State, Nigeria

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ABSTRACT: A geophysical study using the Vertical Electrical Soundings (VES) techniques has been used to investigate the sub-surface layering in the southwestern part of the Niger Basin in order to determine the nature, characteristics and spatial extent of the components of the aquifer underlying the region. The results of the interpreted VES data suggest that the layering in the region range from three to five layers. The geologic sections derived from the analyzed geoelectric section suggest that the alluvial deposits of sand, sandy clay, medium to coarse sandstones, as well as the weathered and fractured basement constitute the aquifer found in this sedimentary region. Furthermore the results of the interpretation of the VES data indicate that the thickness values of the aquifer vary from 6.01 m to 58.60 m. The geoelectric section generated also suggest that the resistivity values of the aquifer components range from 4.2 Ω-m to 106.7 Ω-m for the alluvial deposits; 33.7 Ω-m to 108.6 Ω-m (weathered basement); and 345.7 Ω-m to 564.0 Ω-m for the fractured basement rocks. [Academia Arena, 2009;1(3):38-46]. ISSN 1553-992X.

Key words: Delineation, Aquifer, Vertical Electrical Soundings (VES), Nupe Basin.

INTRODUCTION

Water supply problems are very common in most localities in Kwara State just like in most tropical areas; the situation is really disturbing in tropical areas like in the study area of this work. In most cases, water required for domestic and agricultural uses are obtained from rivers, streams and shallow hand-dug well. Moreover, most of these rivers and streams are often situated at great distances from the villages they serve. The surface water sources are usually ephemeral/seasonal and prone to contamination by human beings and animals. The consequences of these pathetic situations on the water supply systems of the people in this region are the prevalence of such water-borne diseases like guinea worm, cholera and typhoid fever. According to United Nations International Children Education Fund's Rural Water Sanitation, UNICEF-RUWATSAN Project (1988), more than one million people are yearly affected by guinea worm. A prevention of the scourge of such water-borne diseases could have saved a lot of scarce resources spent on health care facilities. There is no gainsaying the fact that substantial losses in man-hours required for productive ventures associated with the sick and their relatives who care for them could have been saved and channeled to other productive sources. In view of this scenario, the provision of sustainable potable water for the people should be the main priority of any government which is serious in eradicating poverty and enhancing the socio-economic status of its people. Moreover, according to the United Nations, one of the cardinal programmes of the Millennium Development Goals (MDG) is the provision of potable water to every community so that the impoverishment of the rural folks in most especially, the tropics and the least developed countries (LDCs) can be wiped out from the global road map of economic development. As a contribution to the improvement and development of the water resources in this region, this work was aimed at identifying the nature, extent and spatial distribution of the components of the aquifer in the southwestern/south-central part of the Lower Niger Basin. It is hoped that the results of this study could also be used to determine the groundwater potentials of the study area.

PHYSIOGRAPHY, GEOMORPHOLOGY, GEOLOGY AND HYDROGEOLOGY

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Physiography and Geomorphology

The project area lies within the Cretaceous-to-Upper Maestrichtian Nupe (Bida or Niger) Basin, Niger trough or better still Middle Niger Valley just south of the River Niger between longitude $4^0$45'E and $6^0$10'E and latitudes $9^0$10'N and $8^0$47'N (Figure 1). It covers an area of about 4870 km^2. According to Idachaba (1982), this study area which is part of the former Edu Local Government Area (LGA) of Kwara State and now split into Edu and Pategi LGAs is a sparsely populated region with an estimated population density of about 34 persons per square kilometer, and is mainly dependent on subsistence agriculture and fishery. The dominant topographic feature is the peneplain of the Niger River Trough which stretches from Jebba to Eggan in such a way that the topography is relatively flat-lying near the River Niger, and rises to the crystalline uplands in the south to an elevation of less than 150m above mean sea level (msl). Vegetation is of the Guinea Savannah type, which according to Udo (1982) has a characteristic mean annual temperature or 29°C and mean annual rainfall of 300mm. The River Niger and its tributaries control the course of most of the rivers in this area. Such rivers like Oro, Oyi, Oyun, Ebba existing in this region have a North-Northeasterly flow towards the River Niger.

Geology and Hydrogeology

This Basin is an approximately NW-SE trending trough filled with mainly Santonia to Maestrichtian sediments of sandstones, siltstones and superficial alluvial deposits (Adeleye, 1976, Ajibade, 1980). Borehole log reports from UNICEF-RUWATSAN project (1988) show that primary porous and permeable formations of the Nupe Sandstones Group predominate the northern and central parts of the Edu and Pategi LGA. The lithology of these formations, according to Idornighie and Olorunfemi (1992) and, Mallam and Ajayi (2000), are alluvium, weathered laterite, sandy clay and clayey sand. The southern part of the study area is characterized by formations with secondary permeabilities with the following lithologies: weathered laterite, sandy clay/ clayey sand, fractured basement and fresh basement rocks. Generally the rock units in this region are suggested to be highly characterized by intercalations of claystone, siltstone, silt, clay and weathered bedrock (Biwater Shellabear, 1985; UNICEF-RUWATSAN Project, 1988). These geological materials are usually liable to form aquitard and permeable zones to the bedrocks in both the sedimentary terrain and the crystalline basement complex existing in this area. In areas underlain by crystalline rocks, presence of structures like fractures, fissures, veins, joints and such other structural deformations of the basement complex control the flow of groundwater and also influence the rate of recharge and discharge of the main aquiferous units (Biwater Shellabear, 1985). Fig. 2 shows the existence of minor fractures with approximate NW-SE trends. These structures intrude the basement complex rock in the southern and eastern part of Edu LGA and create relatively thick highly weathered overburdens.

VES DATA COLLECTION AND INTERPRETATION

Collection of VES data

Twenty-two (22) Vertical Electrical Soundings (VES) data using Schlumberger array were carried out by UNICEF-RUWATSAN Project team based in Ilorin, Kwara state at twenty-two (22) communities in Edu and Pategi LGAs. The VES data were collected and their corresponding borehole logs were collected for quantitative analyses in order to basically determine the subsurface layering, thickness of the surface layers, thickness of the overburden and thickness of the aquiferous or saturated ground water layer beneath each of the studied VES sites.

Interpreting the VES data

The sets of VES data collected at each VES site were plotted to obtain the apparent resistivity, ρ_i against half the current electrode spacing, AB/2 on a bi-logarithmic graph sheet, as resistivity, ρ_a field curve. The field curves were interpreted using the conventional curve matching technique (Keller and Frischnecht, 1966) and empirical method (Van Nostrand and Cook, 1966; Shiftan, 1970) as well as computer modelling which make use of interactive program written and published by Mooney (1980). Fig. 3 shows the results of the interpretation of the VES data collected for a VES site and a drilled borehole in Shonga Village. The shape of the curve suggests that three or four geoelectric layers of various lithologies were sampled at the VES site. As can be seen in the figure, the third layer has a moderate resistivity of 60. Ωm and the highest estimated thickness value of 30.7 m the third layer is thus taken to comprise or the saturated groundwater zone at this VES site. The procedure described above for determining the aquiferous zone was repeated to analyze the nature and characteristics of the aquifer beneath the 22 VES data collected for the various VES sites in the study area of this work.

RESULTS AND DISCUSSIONS

The results of the interpretation of the VES data and information obtained from the borehole logs collected for this work have been used to produce the geoelectric sections and geologic sections associated with each of the VES sites investigated.

Geoelectric and Geologic Sections

These sections were derived in order to know and understand the geological components of the aquifers beneath each VES site and determine the possible hydrogeophysical/hydrogeological parameters of thickness and resistivity characterizing each aquifer. Interestingly, in this study, a good knowledge and understanding of the geological formations below each VES point studied, were obtained from the borehole logs even before the set of VES data were interpreted. These are unlike what obtains in most previous related works reported by for example, Worthington (1977), Van Overmeeren (1989), Olayinka (1990), Ajayi and Hassan (1990), Idornighie and Olorunfemi (1992), and Shemang (1993). In all these geophysical studies, electrical resistivity data were interpreted using generalized geological information obtained for the areas studied and/or using geological data from areas similar to these study areas. This means, such interpreted VES data gives generalized geological information from their interpreted geoelectric data. However, in this study, we have available borehole logs to serve as control on the interpretation of the corresponding VES data for each site.

Figures 4 (a) - (d) show typical geoelectric sections obtained from the interpreted VES data and the geologic sections derived from the borehole logs collected for some of the investigated VES sites. The analyses of the 22 pairs of the sections obtained for this work suggest that the storage elements for ground water in the south western part of the Middle Niger Basin are mostly the Recent to Tertiary alluvial deposits of sandy clay/clayey sand, lateritic clay and gravelly clay; Nupe Sandstone Group consisting of quartzose gravel, conglomerates, brecciated conglomerate, clayey sandstones, as well as clayey weathered basement and fractured basement rocks of the Precambriam Basement complex. The result of this work revealed that the components of the aquiferous zone existing in the northern and central part of the study area are mainly the Nupe Sandstone Group formations. On the other hand, the weathered basement and fractured basement rocks constitute the aquifers in the southern part of the study area. Specifically, fractured basement rocks predominate the areas around Gbagota, Macha, Bishewa and Ndanaku. The results of the interpretation of the VES data studied suggest that this sedimentary region is underlain by three to five geoelectric layers. Furthermore, the information obtained from the borehole logs and the interpreted VES data results suggest that the thickness of the aquifers varies from 6.10m to 75.10m. The geoelectrically interpreted VES data result indicate that the value of the resistivity of the aquifer range from 4.2 Ω-m to 564.0 Ω-m. The result of this investigation also suggest that the alluvial deposit in the northern part of the study area comprise of aquifers which are associated with low to medium resistivity values of 4.2 Ω-m to 106.72 Ω-m. On the other hand in the southern part of the area studied, it was found that the weathered basement aquifers are characterized by resistivity values in the range of 33.7 Ω-m to 180.6 Ω-m, while resistivity values of 345.7Ω-m to 564.0Ω-m are associated with the aquifers of the fractured basement rocks. The average specific yield capacity value for the aquifer within the sedimentary terrain of the study area was 0.2158 l/s/m while the corresponding value estimated for the basement area aquifers was found to be 0.1799 l/s/m. Hence in agreement with the report of Idornighie and Olorunfemi (1992), this study shows that the aquifers derived from the Nupe Sandstone Group are more productive than the weathered basement aquifers which exist within the southern fringe of the Niger Basin.

In order to have an insight to the groundwater potentials of the study area, a preliminary aquifer resistivity map (fig. 5) was produced from the interpreted VES data results of this work. The map is considered preliminary as a result of the fact that the VES stations used in this work are not uniformly spread across the two LGAs studied. The map is therefore, produced for preliminary deductions pending future detailed work in the project area. The resistivity value of the aquifers at each VES site location was plotted and contoured al 25 Ω-m to give the preliminary resistivity of the aquifer map for the study area of Edu and

Patagi LGA (fig. 5). The map was produced in order to delineate the fresh water–bearing areas and the saline water–bearing zone. As shown on the map, the resistivity value of the aquifer is highest (about 225 Ω-m) in the north central part (around Sakpata and Dumaji) and southern part (around Wariku) of the study area. The high resistivity value associated with the aquifers in the northern part is possibly due to the presence of loose sand and sandy formations which corresponds to the local geology of the area (Biwater Shellabear, 1985). The aquifer thickness values in the northern part have also been determined from the interpreted geoelectric and geologic sections to be quite high. These therefore, suggest that the Nupe Sandstone Group aquifer component around Shonga and Sakpata as well as the weathered/fractured basement aquifers around Wariku and Macha are probably saturated with freshwater-bearing horizons. On the other hand, the less than 25 Ω-m associated with the aquifer in the entire west end of the study area is probably due to the presence of highly weathered and/or clayey nature of the aquifer. It is also most likely that the groundwater in the western part of the Edu and Pategi LGAs is salty (saline) or it contains high content of ferruginised particles derived from the thick laterite cappings which, according to Wigwe (1974) and Offodile (1992), predominate the area. However, information obtained from the borehole logs collected for the well site drilled in the southwestern part of Edu LOA suggest the existence of thick aquifers in these areas and the aquifers possibly lie at moderate depth below the ground. The low resistivity value of the aquifers in the western part of Edu LGA is also most probably due to the high level of saturation of the aquifer in this part of the area studied.

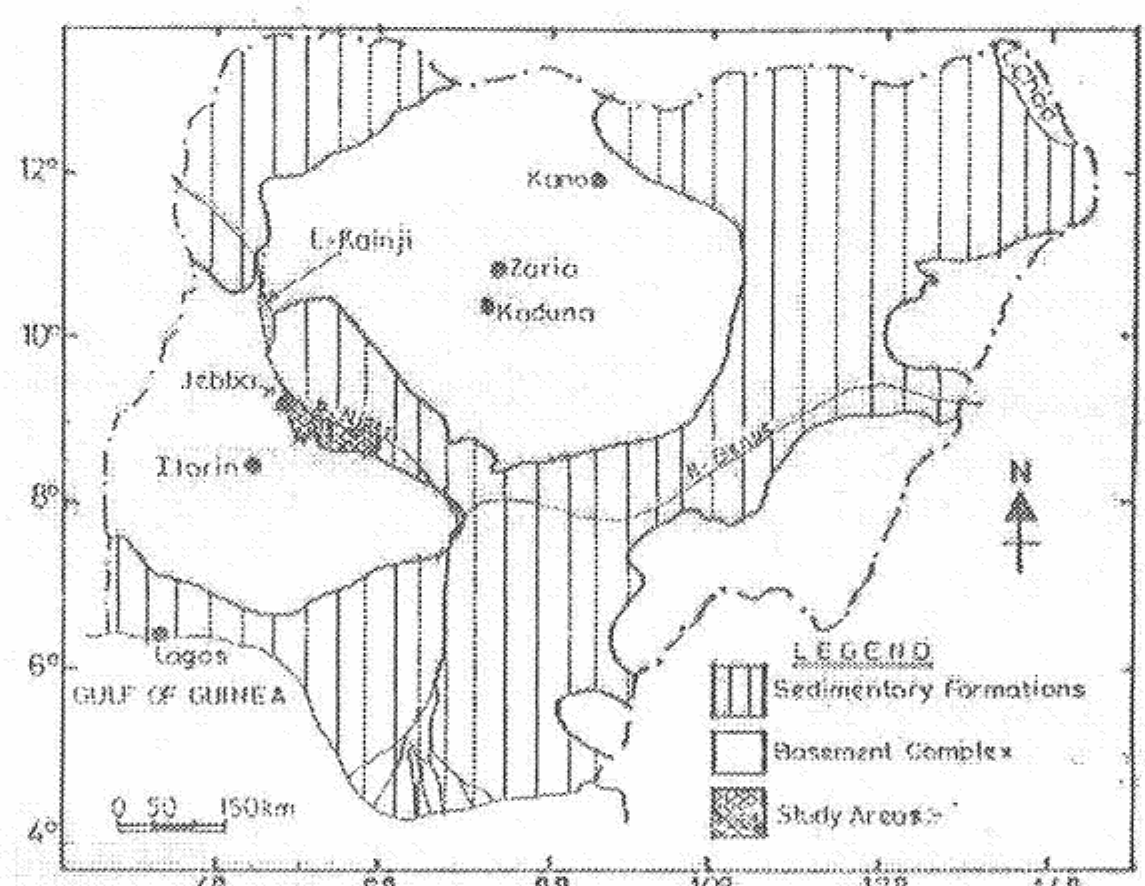

fig.1

FIG-1:SIMPLIFIED GEOLOGICAL MAP OF NIGERIA SHOWING THE TWO LOCAL GOVERNMENT AREAS STUDIED (Courtesy of GSN)

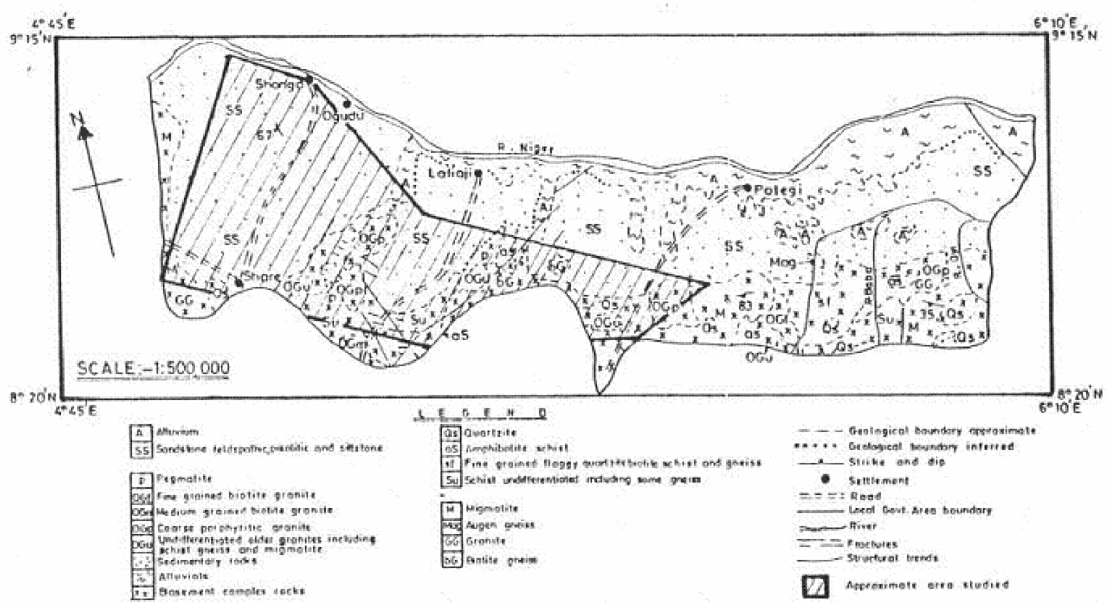

FIGURE 2: GEOLOGICAL MAP OF EDU AND PATEGI LOCAL GOVERRNMENT AREAS OF KWARA STATE (COURTESY G.S.N, ILORIN)

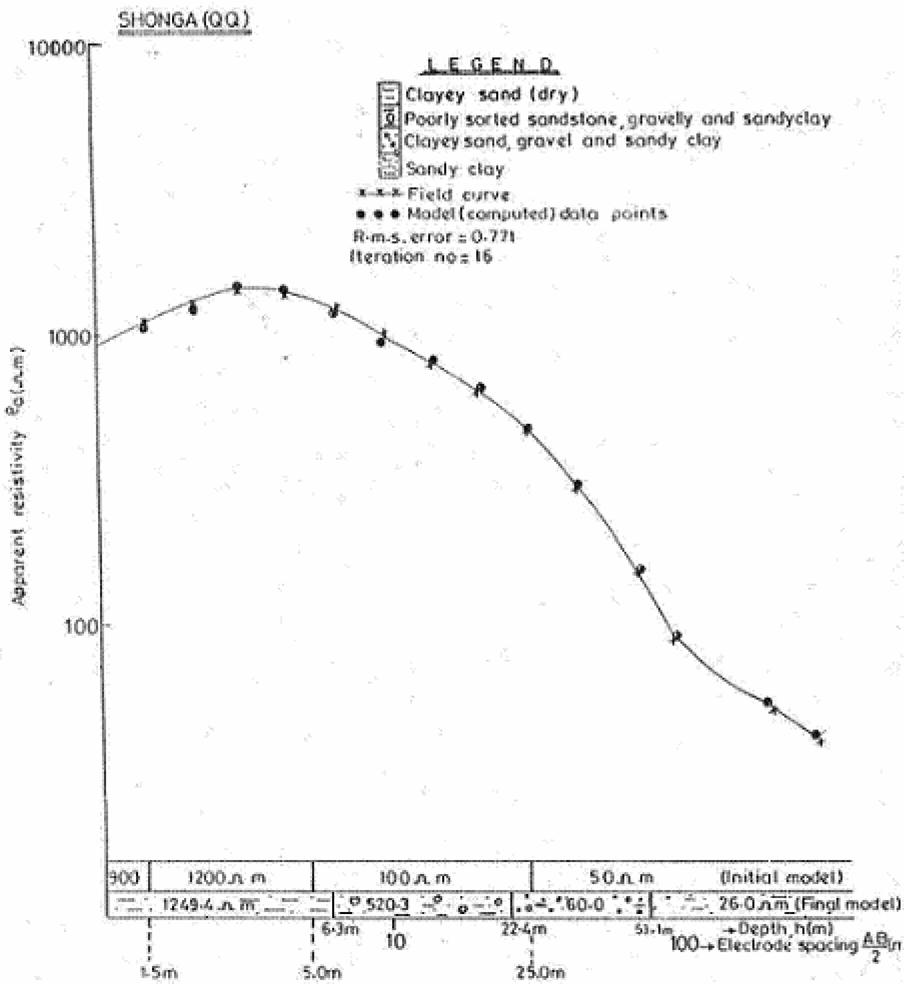

FIG.30: TYPICAL INTERPRETATION OF THE VES DATA FOR THE VES STATION IN SHONGA, EDU LGA.

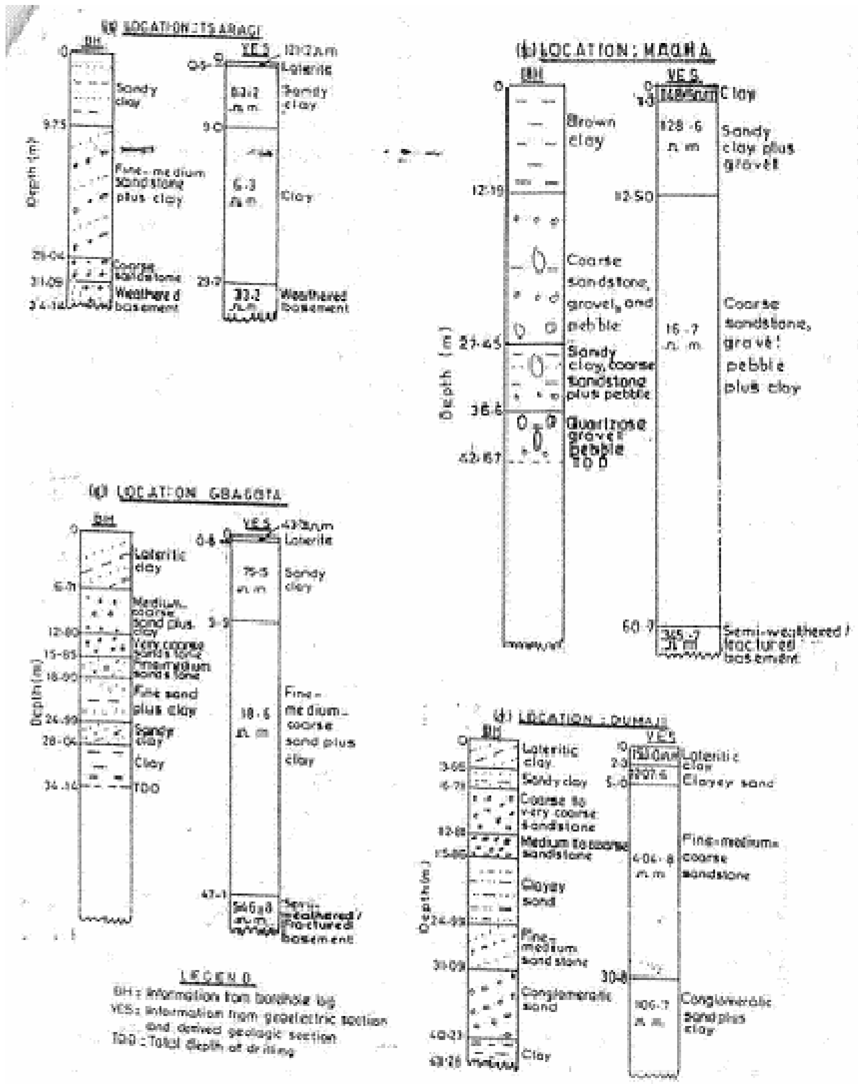

FIG.4 : TYPICAL GEOLOGIC SECTIONS (BH) AND GEOELECTRIC SECTIONS (VES) DERIVED FOR THE STUDY AREAS.

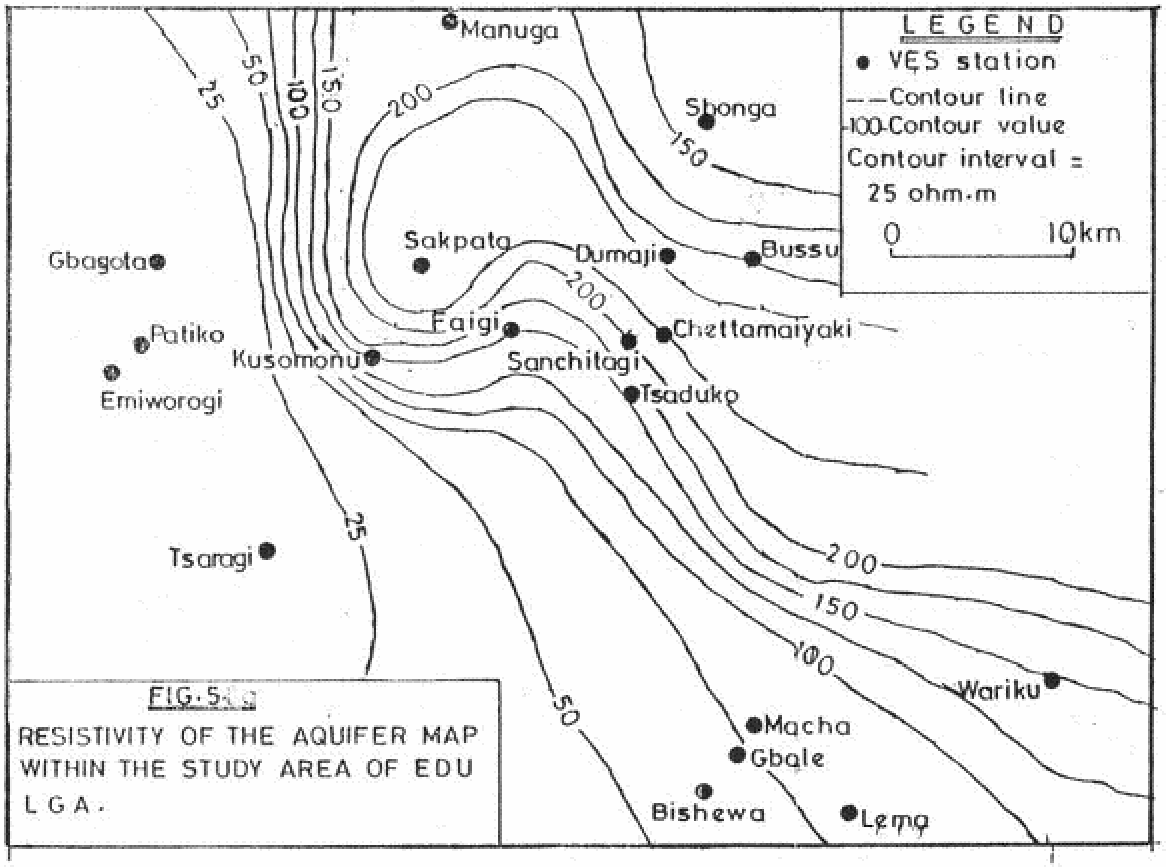

FIG.5
RESISTIVITY OF THE AQUIFER MAP WITHIN THE STUDY AREA OF EDU LGA.

CONCLUSION

From the interpreted VES data results and analyses of the borehole logs collected for each VES site drilled for productive water wells, the following conclusions could be drawn:

I. For the studied area within the southwestern end of the Niger Basin in Edu and Pategi LGA, the alluvial deposits of sand, sandy clay, clayey sand, clay and gravel as well as the medium-to-coarse sandstones of the Nupe Sandstone Group, and the weathered/fractured basement rocks constitute the main aquifer component in this sedimentary region.

2. The thickness values of the aquifers vary from 6.10m to 58.6m. The aquifer resistivity values range from 4.2Ω-m to 282.5Ω-m for the Nupe Sandstone Group aquifer. The resistivity value of the aquifer derived from the weathered basement rocks vary from 10.3Ω-m to 345.7Ω-m while the resistivity values of the fractured basement aquifers range from 345.7Ω-m to 566.0Ω-m.

3. The preliminary deductions from the resistivity of the aquifer map produced for the study area suggest that the north-central part of Edu LGA and the south-eastern part of Edu LGA, which coincides with the south-western part of Pategi LGA have the best prospects for groundwater production in this region. The area around the western part of the study area, that is, Gbagota, Patiko and Emiworogi have the least groundwater potentials in this sedimentary region.

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