GLOBAL JOURNAL OF GEOLOGICAL SCIENCES VOL. 2, NO. 2, 2004: 235 - 242
COPYRIGHT(C) BACHUDO SCIENCE CO. LTD. PRINTED IN NIGERIA. ISSN 1596 - 6798

GEOPHYSICAL SURVEY, GEOCHEMICAL AND MICROBIOLOGICAL INVESTIGATION OF GROUND AND WELL WATER IN ADO-EKITI NORTH-EAST, SOUTH-WESTERN NIGERIA.

A. O. OYINLOYE and G. O. JEGEDE

(Received September, 2003; Revision Accepted 13 February, 2004)

ABSTRACT

Geophysical survey for ground water chemical measurements and microbiological examination of hand-dug well water have been carried out in Ado-Ekiti northeast and presented here. Geophysical (Vertical Electrical Sounding, VES) survey of stations VES-1 and VES -2 indicates that the area of study shows an irregular weathering front. Possible aquifer zone in the area is a lateritic clayey or fracture zone which vary from 6.5m in VES-1 to about 47m at VES-2. The weathered clayey zone at VES-2 extends to about 60m. This makes VES-2 station a potential high yielding source of groundwater in the study area. Fifteen well water samples from five hand-dug wells were analysed for HCO_3^-, Cl^-, SO_4^{2-}, SiO_2, Na^+, K^+, Ca^{2+} and Mg^{2+}. The concentrations of these ions and molecule in the well water analysed when compared with their corresponding standard values of World Health Organisation (WHO) reveal that the well water in Ado-Ekiti northeast is safe for human consumption. However, microbiological study carried out on the well water samples reveals presence of bacteria in the water. These can be removed by boiling and chlorination to make the well water potable.

Key words: aquifer, weathering front, presumptive, hardness, chlorination.

INTRODUCTION

Water no doubt is one of the most essential needs of human beings. Because of this importance, the World Health Organisation (WHO) had set up a standard quality which water should attain before it can be safe for human consumption. Water though not scarce in Ekiti-State because of its geographical location in the rain forest, potable water is sparsely distributed. In Ado-Ekiti the State Capital, there is an acute shortage of potable water especially in the northeastern part of the city which is the study area for this paper (Fig 1). The Ekiti State Housing Estate is situated in the part of Ado-Ekiti where this study was carried out. Here, people depend on hand-dug well water mostly for their domestic use including drinking.

Ado-Ekiti is in the basement complex of southwestern Nigeria. Water here like other places in the southwestern Nigeria is confined to springs, rivers and streams. Groundwater occurs in the subsurface in the weathered rocks which cover up the basement complex. In the basement complex areas, water can also accumulate as groundwater in faults, fracture and joint zones. Adegoke et al., (1984) studied the aquifers for groundwater in Ado-Ekiti area. These authors presented information on the distribution and orientation of faults, fractures and joints which may serve as reservoirs for well and groundwater in this area. Aina (1995) worked on the quality of well water in terms of microbial content at Iworoko area close to Ado-Ekiti. This study focuses on geophysical survey to determine possible aquifer at VES-1 and VES-2 at the Ekiti State Housing Estate, (Ado-Ekiti northeast) chemical and microbiological analyses of well water samples to determine its suitability or otherwise for human consumption by comparing with the World Health Organisation's (WHO's) standards.

GEOLOGICAL SETTING

The geology of Ado-Ekiti area is dominated by crystalline and schistose rocks which belong to the southwestern Nigerian basement complex. The geology of this area has been studied and documented in literature (e.g. Hubbard 1968, Cooray 1972, 1975, Olarewaju 1981, Tubosun et al., 1984 and Olarewaju 1987). The lithology in Ado-Ekiti area is made up of migmatite-gneiss, granite gneiss, charnockite, older granite and metasediments which are quartzite - muscovite schists, (Fig. 1). Field study shows that the charnockite and granite are closely associated in time and space, (Olarewaju 1987). According to Rahaman (1981) both granites and charnockites are contemporaneous or the charnockites formed shortly after the emplacement of the older granites. The older metasediments occur as ridges and mica schists and this constitutes part of the schist belts in Nigeria (cf. Bruguier et al., 1994).

In Ado-Ekiti area, the charnockite rocks have been distinguished into coarse grained, fine grained and gneissic types, (Tubosun 1984 and Olarewaju 1987). Other rocks are porphyritic biotite-hornblende older granite and quartzite – muscovite schists, (Fig. 1). Strike directions of foliated rocks in Ado-Ekiti area are to the northwest, and most of the rocks dip to the west, (Fig. 1). The study area, lies in a gneissic charnockitic terrain (Fig. 1). The streams here drain part of this area. During the rainy seasons, springs produce water in this area but these fail during the dry seasons. The basement rocks in Ado-Ekiti area have undergone a

A. O. OYINLOYE, Department of Geology, University of Ado-Ekiti, P M B. 5363, Ado-Ekiti, Nigeria
G. O. JEGEDE, Department of Applied Geology, Federal University of Technology, Akure, Nigeria

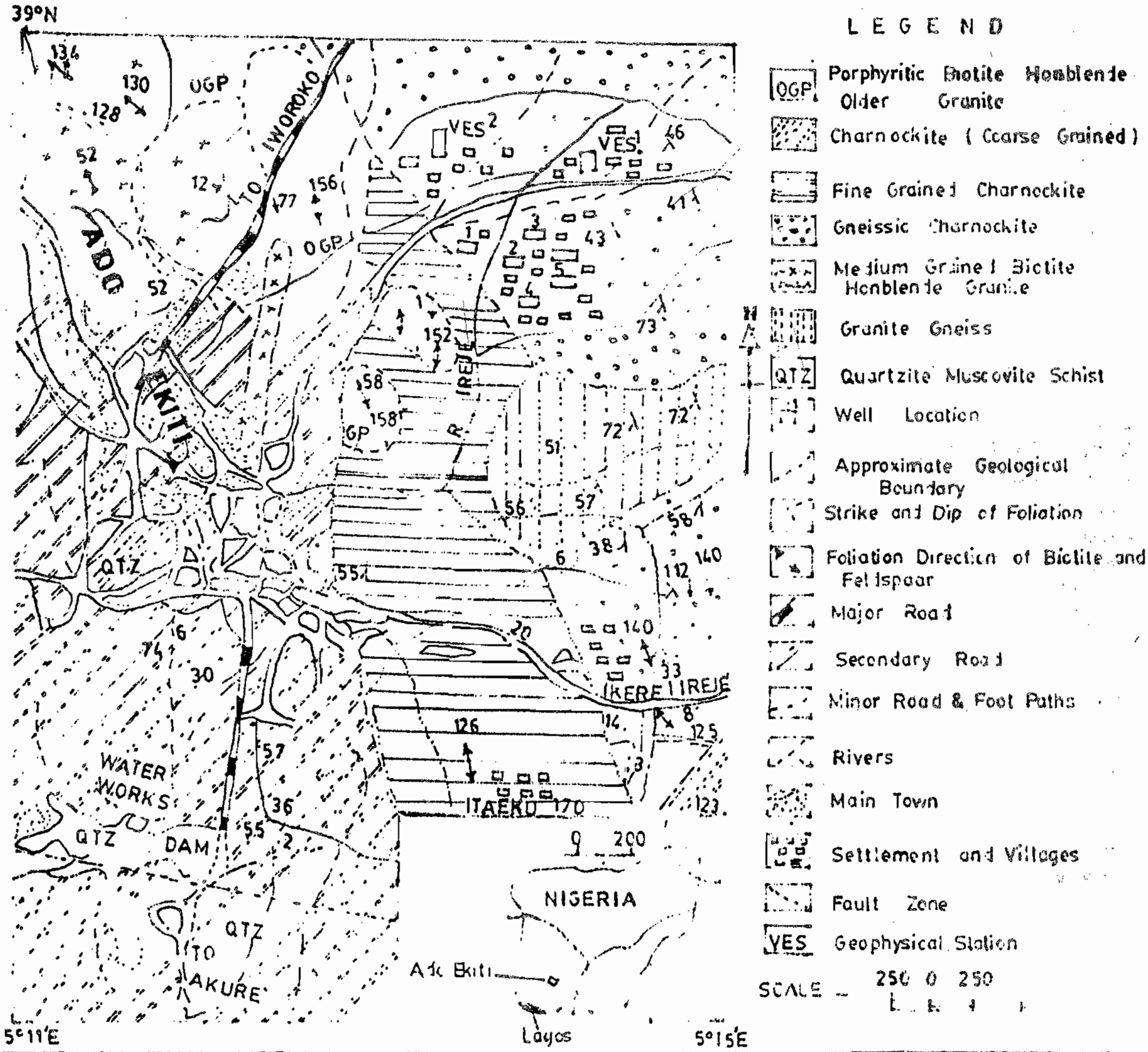

Fig. 1: Geological map of Ado Ekiti Area, Southwestern Nigeria

polycyclic metamorphic deformation like the other parts of the Nigerian basement complex (cf. Oyinloye 1995, Dada 1998). This area has also suffered tropical weathering resulting in accumulation of sediments covering up the basement complex rocks. Outcrops are low lying and sparsely distributed. Elsewhere outcrops occur as deformed hills with remnant rock debris and boulders on top of the hills.

Geophysical survey carried out in this study shows that the area of study has an irregular weathering front, i.e. depth to the fresh bedrock varies rapidly within a very short interval of space. The aquifer here is a weathered clayey or fractured material.

MATERIALS AND METHOD OF STUDY

Schlumberger electrode array configuration was used in the geophysical survey. The traverse lines were established along the 320°-140° azimuthal direction. ABEM terrameter SAS 300B was used in taking measurements. Two stations were investigated. For the chemical analysis, 15 water samples were taken from 5 wells during the dry season. Samples were treated using the conventional method and kept in clean plastic containers. These were preserved with 5ml concentrated HNO_3 acid per litre of the sample after the pH and temperature of water have been recorded. The total hardness (Ca^{2+}, Mg^{2+}) of the well water was determined using the complexometric titration unit 0.0lm Ethelene Diamine Tetra Acetic Acid (EDTA). Na^+, K^+, and Ca^{2+} contents of the well water were determined for each sample using the Coning 405 Flame Photometer. Chlorides were determined by titrimetric and Atomic Absorption Spectrometric methods. All measurements are recorded in ppm mg^{-1} $litre^{-1}$ and shown in Table 1.

Bacteriological tests were carried out to further determine the potability of the well water under investigation. Four (4) water samples from each well (20 in all) were cultured using the appropriate reagents. Colonies of bacteria were counted with the aid of colour displayed by each colony. This was followed by presumptive and confirmatory tests to establish bacteria presence in the well water studied. The result of the microbiological tests are recorded in Tables 2,3,4,5 and 6, and compared with the World Health Organisation's (WHO) maximum standard of bacteria tolerance level in potable water.

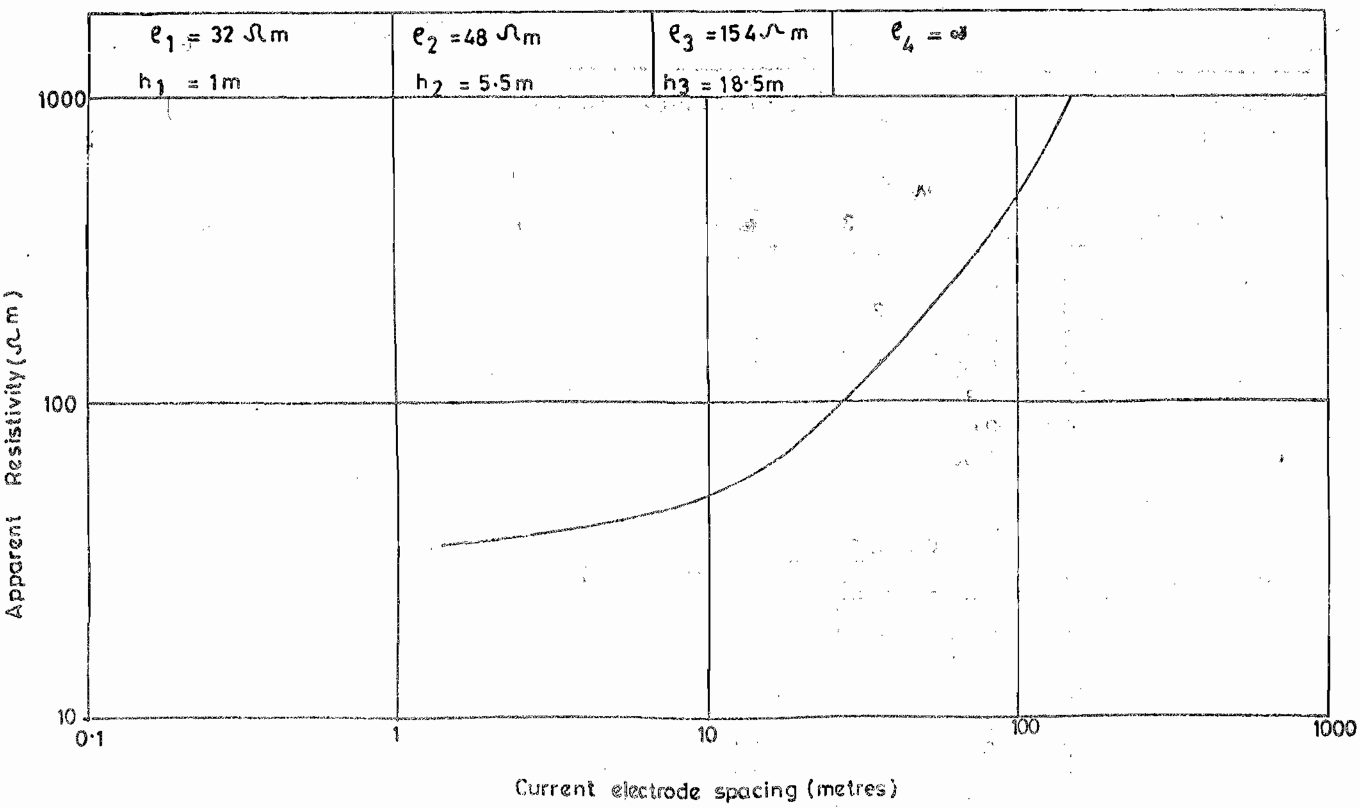

Fig. 2: Geoelectric curve of VES 1

RESULTS AND DISCUSSION

Geophysical survey involving Vertical Electrical Sounding (VES) was carried out at two stations in the study area. General geomorphological, hydrological and geological appraisal of the area carried out dictated the choice of VES points located. The processed field data are presented as geo-electric curves in Figures 2 and 3. The curves are interpreted as geo-electric sections in Figures 4 and 5.

Station VES – 1

At VES-1, the top soil which is about 1m thick is underlain by a lateritic clayey material having a thickness of about 5.5m. Weathered material having an appreciable thickness of about 18.5m underlies this clayey horizon extending to the 25m depth. Below the horizon of weathering is the fresh gneissic charnockite bedrock. At this point depth to fresh and hard bedrock is about 25m while the total overburden thickness is about 6.5m. Considering the fact that a massive hilly outcrop is only about two hundred metres away there is the need for a deeper depth of weathering and or fracturing more than the 25m present before this point can store substantial quantity of groundwater. However a hand-dug well may produce water from this point if only seasonally.

Station VES – 2

At VES-2, the top soil is about 0.9m thick and this is followed by a horizon of lateritic clayey material which extends to about 13m. Underlying this clayey horizon is a zone of fairly weathered material which is suspected to be either sandy or well fractured. This weathered zone extends down to a depth of about 60m. Below this zone is the fresh crystalline gneissic charnockitic bedrock. At this point, the geo-electric layer made up of 47m column of weathered material appears as a good source of substantial quantity of groundwater. The depth of about 60m at which this horizon terminates is good enough for reasonable borehole yield in a basement terrain like the one here. A borehole here at this point (VES-2) may not require any sump or screen if it can penetrate down to the 60m depth. As at the time of writing, a borehole had been sunk at VES-2. A hand-dug well had also been sunk close to the VES-2 station. The borehole is a high yielding one which provides water all the year round to the inhabitants close by.

WELL WATER GEOCHEMISTRY

The chemical data for the 15 samples anaysed in this study are shown in Table 1, with the WHO's standard. In wells 1-5, all the samples analysed showed that the well water in this area contain an average of 6.10 ppm mg^{-1} $litre^{-1}$ HCO_3^{-1} which although higher than the WHO's minimum standard, is lower than WHO's maximum standard of 7.00 ppm mg^{-1} $litre^{-1}$. Except in well 2, (Table 1) all other wells contain an average of between 2.66 and 3.00ppm mg^{-1} $litre^{-1}$ Cl^- which is a little higher than the WHO's maximum standard (Table 1). SO_4^{2-} content of the well water in this area is far less than the WHO's maximum standard of 7.6 ppm mg^{-1}

Table 1 Chemical Data of Well Water in Ado-Ekiti Northeast (Ekiti State Housing Estate). In ppm mg^{-1} $litre^{-1}$

	WELL 1				WELL II			
SAMPLES	1	2	3	MEAN	1	2	3	MEAN
PH	7.30	7.40	7.50	7.30	7.20	7.20	7.20	7.20
HCO_3^-	6.10	6.10	6.10	6.10	6.10	6.10	6.10	6.10
Cl^-	3.00	3.00	3.00	3.00	0.70	0.60	0.50	0.63
SO_4^{2-}	0.50	0.40	0.60	0.50	1.00	1.00	1.00	1.00
SiO_2	8.00	8.00	8.00	8.00	10.60	10.70	10.80	10 70
Na^+	0.20	0.30	0.20	0.23	0.95	0.95	0.95	0.95
K^+	0.60	0.60	0.60	0.60	0.62	0.63	0.64	0.63
Ca^{2+}	0.90	1.00	0.90	0.93	0.40	0.40	0.40	0.40
Mg^{2+}	0.10	0.20	0.10	0.13	0.12	0.12	0.12	0.12

	WELL 1II				WELL IV			
SAMPLES	1	2	3	MEAN	1	2	3	MEAN
PH	7.70	7.70	7.70	7.70	7.60	7.50	7.50	7.53
HCO_3^-	6.10	6.20	6.30	620	6.10	6.10	6.10	6.10
Cl^-	3.00	3.00	3.00	3.00	3.00	4.00	3.00	3.33
SO_4^{2-}	0.40	0.30	0.40	0.30	0.60	0.50	0.70	0.60
SiO_2	9.00	8.50	7.50	8.33	8.50	8.40	8.60	8.50
Na^+	0.50	0.90	0.80	0.73	0.80	0.90	0.70	0.80
K^+	1.00	1.00	1.00	1.00	0.65	0.64	0.66	0.65
Ca^{2+}	0.70	0.70	0.60	0.67	1.00	2.00	1.00	1.33
Mg^{2+}	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30

	WELL V				W. H. O	
SAMPLES	1	2	3	MEAN	MIN	MAX.
PH	7.50	7.40	7.30	7.40	-	
HCO_3^-	6.10	6.10	6.10	6.10	3.00	7.00
Cl^-	3.00	2.00	3.00	2.67	0.20	1.70
SO_4^{2-}	0.50	0.60	0.50	0.53	3.70	7.60
SiO_2	8.00	7.00	7.00	7.33	10.00	10.0
Na^+	0.20	0.30	0.30	0.27	0.00	0.40
K^+	0.60	0.50	0.60	0.57	0.00	0.60
Ca^{2+}	1.00	2.00	1.00	1.33	0.00	1.40
Mg^{2+}	0.10	0.20	0.10	0.13	0.20	1.20

MIN = **MINIMUM**
MAX = MAXIMUM

$litre^{-1}$. Na^+ in wells 1 and 5 has concentrations which are slightly less than the WHO's maximum standard value of 0.4ppm mg^{-1} $litre^{-1}$, (Table 1). In other wells Na^+ contents are slightly above the WHO's maximum standard. K^+ content of well 3 (Table 1) is about 0.4ppm mg^{-1} $litre^{-1}$ higher than the WHO's maximum standard. However K^+ content of water in other wells are about the same in value with the WHO's maximum standard value of 0.60 ppm mg^{-1} $litre^{-1}$, (Table 1). Ca^{2+} concentrations in all the wells are a little lower than the WHO's maximum standard value of 1.4 ppm mg^{-1} $litre^{-1}$ (Table 1). The well water in this area also contains Mg^{2+} values which are less than the WHO's maximum standard value of 1.2 ppm mg^{-1} $litre^{-1}$. All the water samples analysed from the five wells contain SiO_2 in concentrations that are normal when compared with the WHO's standard.

Considering the chemical data discussed above and taking into consideration the margin of the unestimated experimental error in these analyses, none of the well water samples contains any of the ions and molecule calculated in concentrations that can be detrimental to human health if consumed. Again these water samples were taken during the dry season.

The coliform counting test result, (Table 2) shows that there were significant bacteria colonies in samples 3 and 4 in well I, 5 and 8 in well II, 16 in well IV,

During the rainy seasons, water levels and volume will increase. This would lead to dilution of chemical contents especially the chlorides, and this may further reduce the concentrations of these compounds in the well water here. Bacteriological quality analysis of the well water samples studied was undertaken to establish its potability as discussed below.

18 and 19 in well V. A presumptive test was carried out on these samples and the result recorded in Table 3.

Table 2: Results of coliform counting test on well water samples.

Sample No		No of colony/100ml	W. H. O's Maximum 5 colonies per 100ml
WELL I	1	2	
	2	3	
	3	8	
WELL II	4	10	
	5	15	
	6	06	
	7	02	
WELL III	8	06	
	9	02	
	10	00	
	11	02	
WELL IV	12	00	
	13	00	
	14	00	
	15	03	
WELL V	16	20	
	17	02	
	18	03	
	19	12	
	20	02	

Table 3: Result of Presumptive test on well water samples

Sample Location		Acid Produced	Gas Produced	Remark
Well I	3	-ve	-ve	-
	4	+ve	-ve	-
Well II	5	+ve	-ve	-
	8	+ve	+ve	+ve
Well IV	16	+ve	+ve	+ve
Well V	18	-ve	-ve	-
	19	+ve	+ve	+ve

Table 4: Morphological appearance of the bacteria colonies

Sample	Colour	Shape	Size	Surface
8	Greenish metallic	Regular	0.3 micron	Smooth
16	Greenish metallic	Regular	0.4 micron	Smooth
19	Greenish metallic	Regular	0.4 micron	Smooth

Table 5: Gram-staining test results

Samples	Gram +ve	Gram-ve
8		-ve
16		-ve
19		-ve

Table 6: **Motility Test Results**

Samples	Motile	Not motile
8	√	
16	√	
19	√	

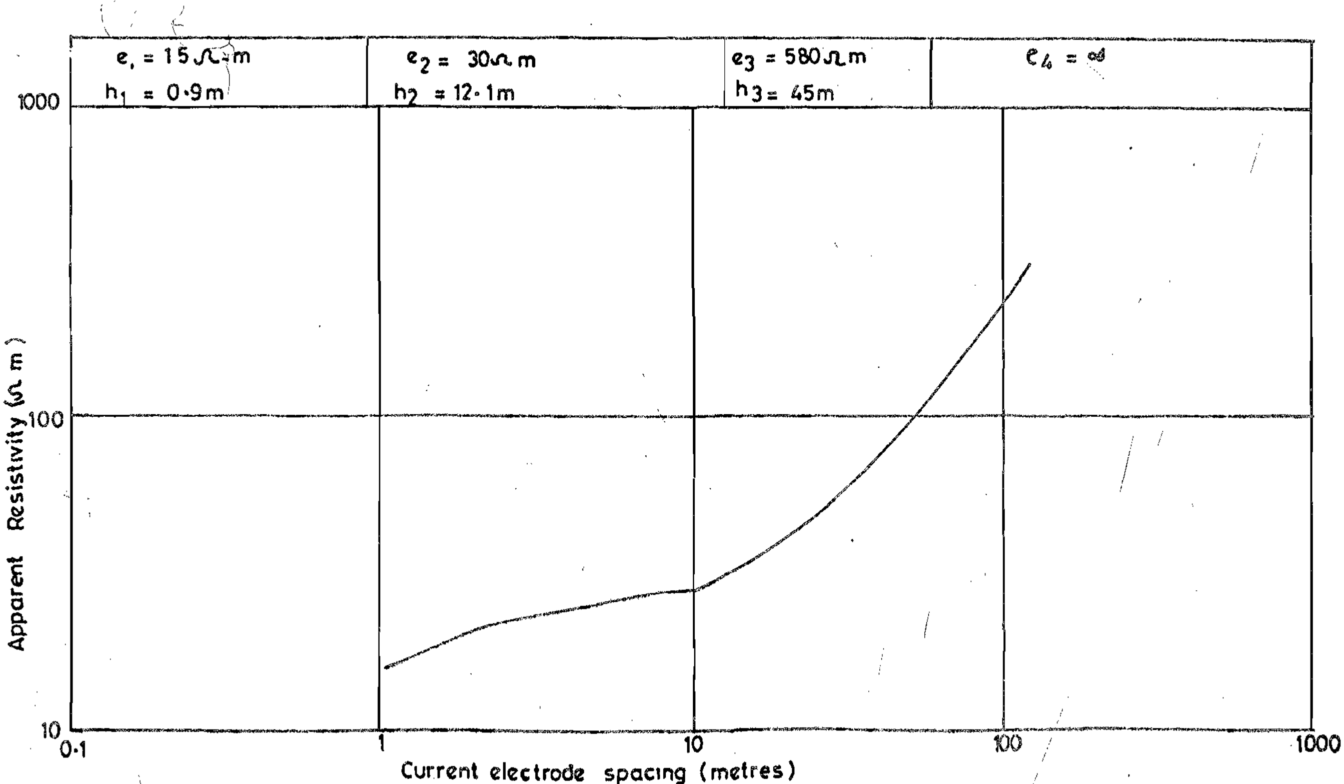

Fig. 3: Geoelectric curve of VES 2

The above result indicate the presence of microbiological colonies in samples 8 in well II, 16 in well IV, and 19 in well V. These samples were used for the confirmatory test, by sub- culturing for 24hrs. at 37^0C.

Gram-staining of the developed colonies was carried out as well as motility test. The morphological appearances of the colonies, gram-staining and motility test results are shown in Tables 4,5, and 6.

The results of the morphological appearances i.e greenish metallic colour, regular shape and smooth surfaces formed confirm the presence of bacterial colonies in the well water samples studied. Negative Gram-staining test result also indicates presence of bacteria in the well water. Motility test results above indicate that the bacteria present in the well water are motile i.e mobile in nature. From the above results, it is evidendent that many of the well samples contain probable coliform count which is less than W. H. O's standard of 5 colonies per 100ml.

However, probable coliform counts higher than 5 per 100ml (WHO's standard) were recorded in 7 samples (of the 20 studied) spread over 4 of the 5 wells studied. Presumptive and confirmatory tests go further to confirm presence of motile bacteria in 3 samples from 3 of the 5 wells.

CONCLUSIONS

Geophysical survey carried out in this study reveals that the area in Ado-Ekiti northeast has an irregular weathering front. The sections examined contain thin top soil followed by varying depths of clayey lateritic materials which may serve as the aquifer in this area. The geo-electric layer of 47m at VES-2 makes it a good location for a high yielding borehole. Chemical analysis of the well water carried out reveals that the well water in this area contains chemical compounds in concentrations which compare favourably well with the WHO's standard values. This makes the well water suitable for human consumption although the need for a little scientific treatment cannot be ruled out.

Microbiological data obtained in this study reveal that majority of the water samples contain bacterial population lower than the W. H. O's standard of maximum of 5 colonies per 100ml. However presence of significant number of bacteria colonies were recorded in 80% of the wells sampled. Therefore well water from this

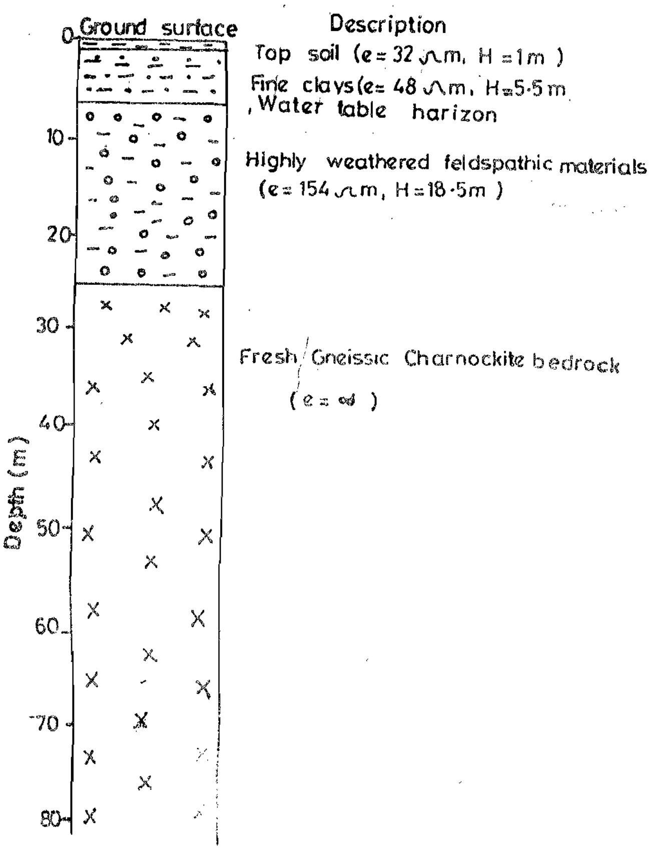

Fig. 4: Geoelectric Section of VES 1

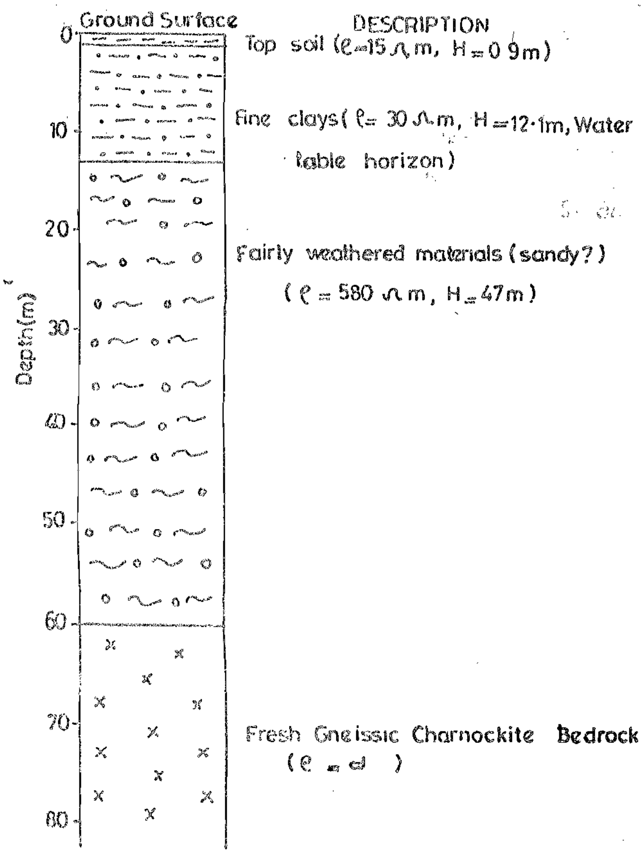

Fig. 5: Geoelectric Section of VES 2

part of Ado-Ekiti can be made more potable by boiling and chlorination to remove bacteria from the water.

ACKNOWLEDGEMENTS

The technical assistance rendered by Messrs O. Z. Ajayi and Tope Akingbade of Department of Geology University of Ado-Ekiti, Ado-Ekiti is gratefully acknowledged. The Water Sanitation Project (WATSAN) Ekiti State is acknowledged for assisting in the chemical analysis of the well water samples. Dr. Ayo Asiwaju-Bello of the Department of Applied Geology Federal University of Technology Akure is acknowledged for his field and technical assistance. Mr. Amos Afolayan of the Department of Microbiology, University of Ado-Ekiti, Ado-Ekiti is gratefully acknowledged for the assistance rendered in the microbiological analysis of the well water samples investigated.

REFERENCES

Adegoke S. O., Ako B. D., Rahaman M. A., Jeje L. K., Ocan O. O., and Falomo O. A., 1984. Geotechnical Survey of the Ondo State University Ado-Ekiti, Unpublished Technical Report 19-33.

Aina R., O., 1995. The Assessment of Well Water Quality in Iworoko-Ekiti; Unpublished B. Sc. Dissertation, Department of Geology Univeristy of Ado-Ekiti. 38p.

Bruguier O. Dada S. S. and Lancelot J. R; 1994. Early Archean Component (>3.5 Ga) within a 3.05 Ga Orthogneiss from Northern Nigeria: U-Pb Zircon Evidence, Earth Planet. Sci. Lett. 125: 89-103.

Cooray P. G. 1972. Note on the Charnockites of the Akure- Ado-Ekiti area, Western Nigeria. In African Geology (Dessauvagie T. F. and Whiteman A. J. eds), University Press, Ibadan 45-63.

Cooray P. G. 1975. The Charnockitic Rocks in Nigeria, Pichamuthu Volume, 50-73, Bangalore University, India.

Dada S. S. 1998. Crust-forming Ages and Proterozoic Crustal Evolution in Nigeria: A reappraisal of current interpretations, Precamb. Res. 87, 65-74

Hubbard F. H. 1968. The Association of Charnockite and Older Granite in Southwestern Nigeria, Journ. Min. Geol. Nigeria 3: 25-32.

Olarewaju V. O. 1981. Geochemistry of the Charnockitic and Granitic rocks of the Basement Complex around Ado-Ekiti-Akure S. W. Nigeria, Ph.D. Thesis (Unpublished) University of London U. K.

Olarewaju V. O. 1987. Charnockite-Granite Association in SW Nigeria: Rapakivi Granite Type and

Charnokitic Plutons in Nigeria? Jour. Afric. Earth Sci. 6 (1): 67-77.

Oyinloye A. O., 1995. Geochemistry of the Iperindo Primary Gold alteration selvages in Ilesha Area Southwestern Nigeria, Afric. Jour. Sci. Tech. 7 (2): 36-42

Rahaman M. A. 1981. Recent Advances in the Study of the Basement Complex of Nigeria Proc. 1st Symp. Precamb. Geol. of Nigeria, Kaduna.

Tubosun I. A., Lancelot, J. R., Rahaman M. A. and Ocan O. 1984. U-Pb Pan-African Ages of two Charnockite Granite Associations from S. W. Nigeria Contrib. Mineral Petrol