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HYDROGEOLOGICAL SIGNIFICANCE OF GEOELECTRIC SOUNDING AT IJEBU-ODE AREA, SOUTHWEST NIGERIA

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ABSTRACT

Twenty eight (28) Vertical Electrical Resistivity Soundings have been carried out in three selected areas of Ijebu-ode (Ijebu-ode, Igbeba and Ikangba) with maximum current electrode separation (AB) of 500m.
The geoelectric deductions show that Ijebu-ode is underlain by the sedimentary rock of Abeokuta formation and consist of one major groundwater aquifer unit suitable for sustainable industrial development. This unit is composed of coarse sand in Ijebu-ode area with resistivity ranging from 733 to 1394Ωm and thickness of 45 to 81m while at Igbeba the aquifer unit is composed of fine-medium sand and sandy clay layer with resistivity ranging from 59 to 446Ωm and thickness of 20 to 104m. Depth to bedrock in these areas vary from 70 to 163m. The existence of thick highly compacted and highly resistive clay formation at general depth of about 3 – 56 m delineated may be responsible for the failure of hand dug wells and some boreholes in these areas.
At Ikangba, a shallow and relatively thin aquifer unit composed of sandy clay and fine-medium sand with resistivity ranging from 57 to 523Ωm and thickness of 1 to 15m was delineated while the depth to bedrock vary from 2 to 30m. This area is suspected to be a transition between the basement complex rock and the sedimentary rock of Abeokuta formation. Thus for Ijebu-ode and its environs, a thorough geophysical survey is required before citing a borehole to guide against failure or dry hole.

KEY WORDS: Aquifer, Coarse sand, Resistivity, Compacted Clay, Borehole.

INTRODUCTION

Ijebu-ode is an important city in Ogun state located Southwest Nigeria. The city have witnessed some socio-economic transformation in the recent years coupled with population increase. However, the problem of water shortage that has bedeviled the city remain unsolvable partly because of non-continuous functioning of pipe borne water supply and the reported cases of borehole/hand dug well failure (Ojelabi et al 2001).

Electrical resistivity method of geophysical investigation has been found useful in the area of ore prospecting, groundwater investigation, depth to bedrock determination, sand and gravel exploration and structural trends determination (Zohdy et al, 1974; Ojo et al 1990; Olorunfemi and Okhue 1992) as it provides a quick method of obtaining the details about location, depth and resistivity of subsurface formations.

The underlying principles subsurface variation using electrica. method is that when an electric current is u. through the ground, the resulting potential differences are measured at the surface. Anomalous conditions or inhomogeneities within the ground, such as electrically better or poorer conducting layers, are inferred from the fact that they deflect the current and distort the normal potentials (Sharma 1997). Vertical electrical sounding is based on the fact that the current penetrates continuously deeper with increasing separation of the current electrodes and thereby reflects information about the resistivity variation with depth and as such this method have been employed in this study with a view of understanding the hydrogeological setting of ijebu-ode and its environs and thus provides information about the depth to bedrock and its structural disposition, the possible geological formations and possible depths of good quality groundwater suitable for industrial development. The validity or otherwise of the possible causes of hand dug well / borehole failures in these areas as reported by Ojelabi et al, 2001 would also be considered.

LOCATION OF THE STUDY AREA

The study area (Ijebuode, Ikangba and Igbeba) falls within Ogun state (fig. 1) Southwest Nigeria.

GEOLOGY OF THE STUDY AREA

The geology of Ogun state in general (fig. 2) comprises of sedimentary rocks that cover

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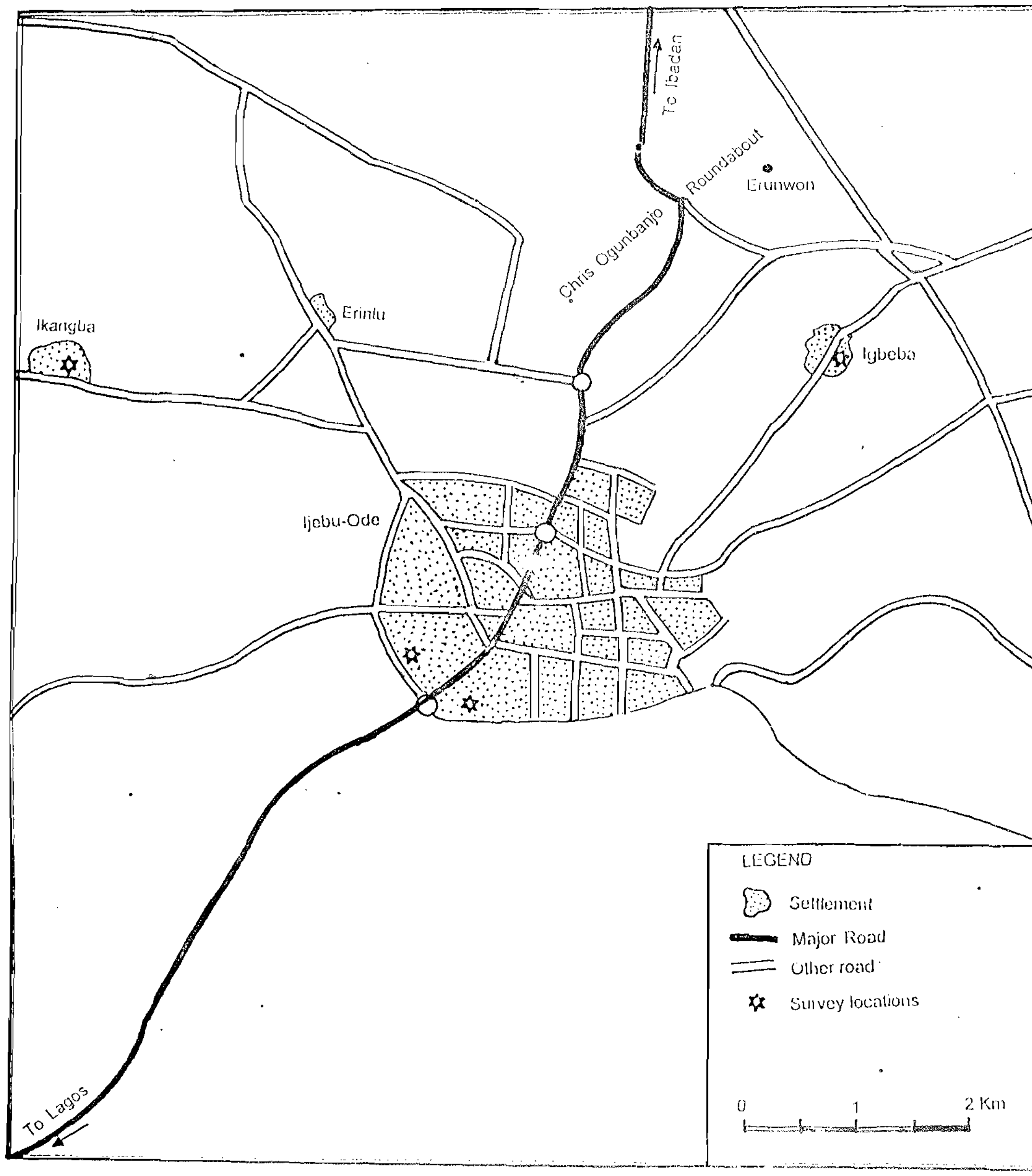

Fig. 1: The Map of the Survey area

approximately three quarters of the whole surface area stretching from the Northwest to the Southwest and the basement complex rock which underlay the remaining one-quarter of the surface area of the state. The sedimentary rock units consist of the Abeokuta formation lying directly above the basement complex. This is in turn overlain by the Ewekoro, Oshosun and Ilaro formations, which are themselves overlain by the coastal plain sands (Jones and Hockey 1964).

The Ijebuode township falls within the sedimentary rock of Abeokuta formation. The subsurface lithology from a borehole drilled to the basement about 4km North – East of Ijebuode is composed of the following materials from top to basement (~55.5m).

First Layer (0.61m thick) - Red earth;
Second Layer (14.33m thick) - Clay, red, yellow, brown, sandy;
Third Layer (35.37m thick) - Sand, white and variegated, fine-medium and coarse-grains;
fourth Layer (0.304m thick) - Clay, pink, silty;

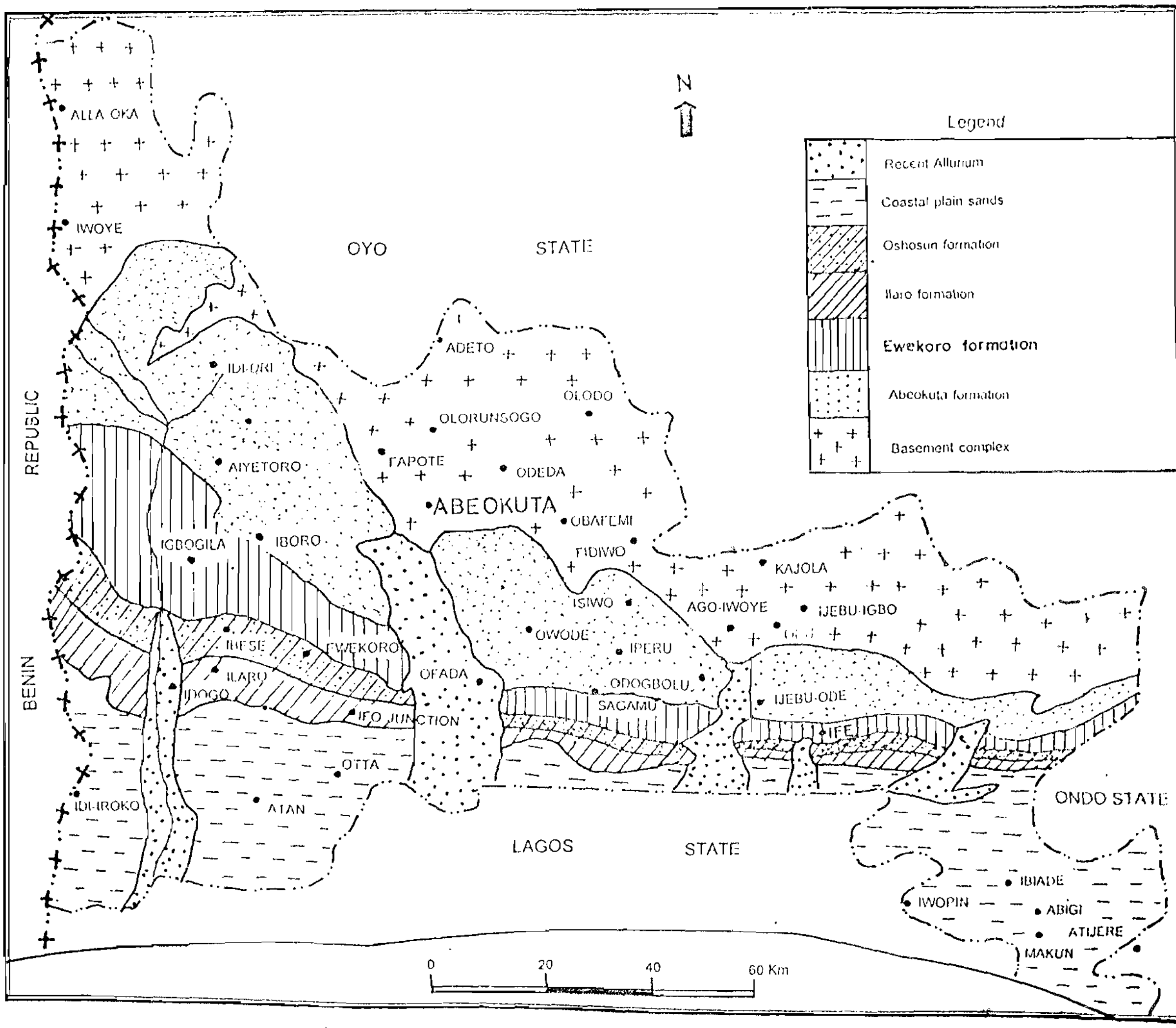

Fig. 2: GEOLOGY OF OGUN STATE

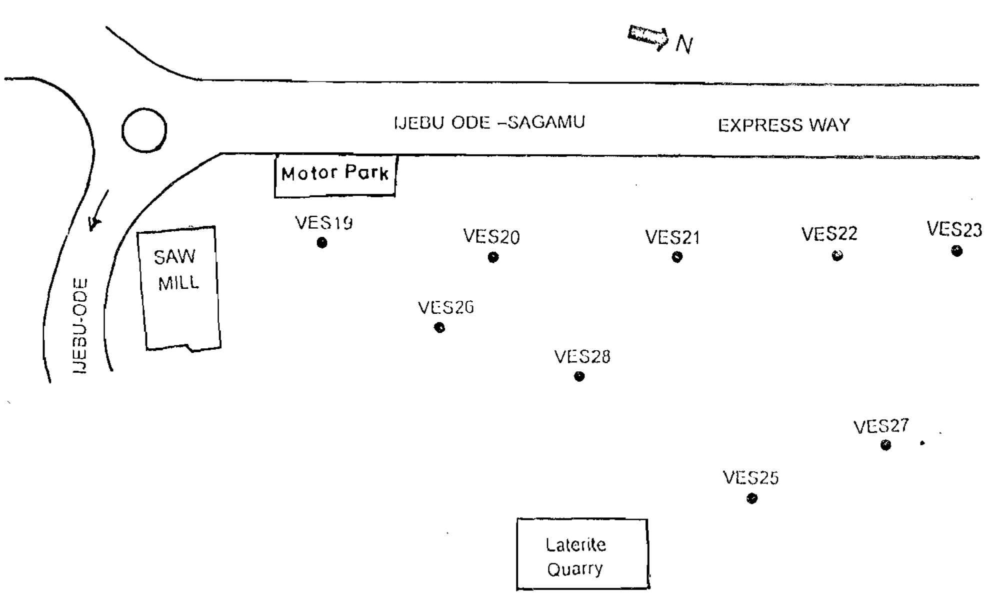

Fig 3a Data acquisition sketch map at Ijebu-Ode

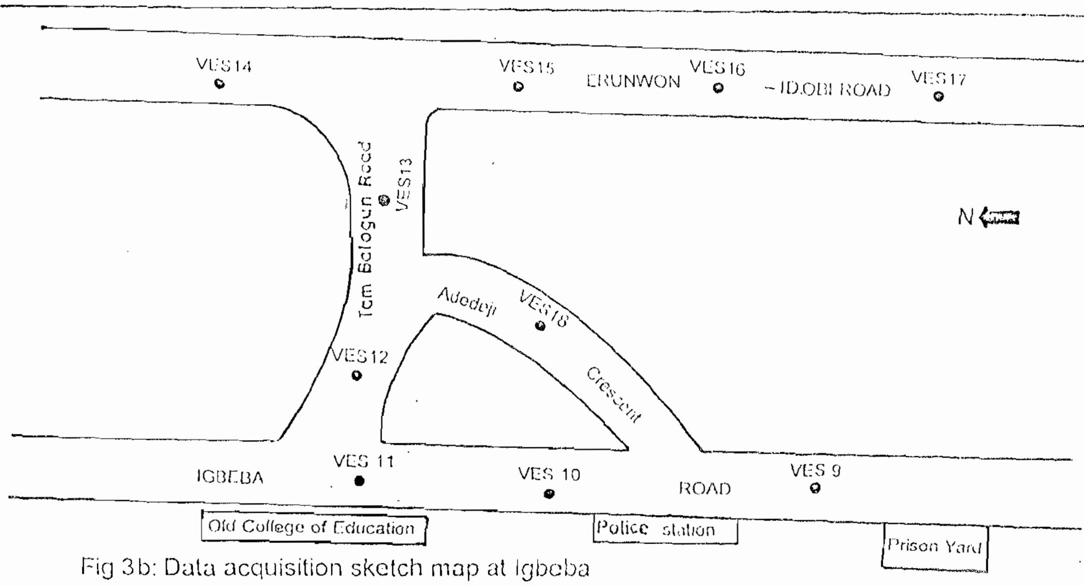

Fig 3b: Data acquisition sketch map at Igbeba

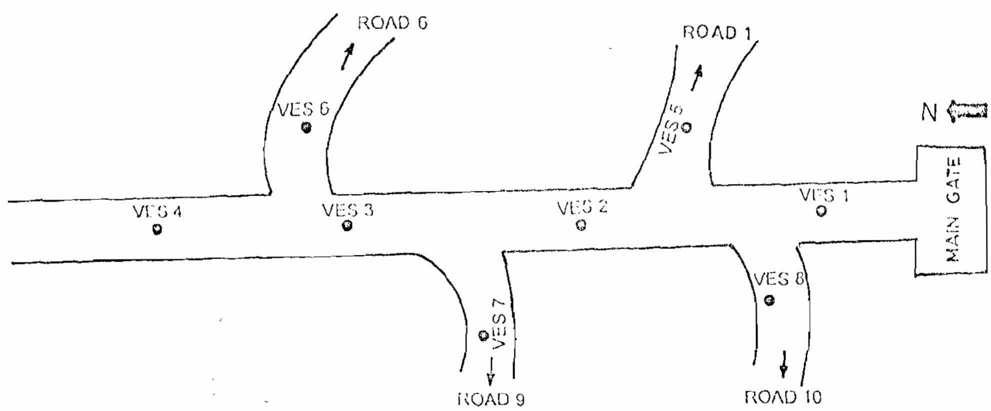

Fig 3c: Data acquisition sketch map at Ikangba

Fifth Layer (4.88m thick) - Sand, white and variegated, fine-medium and coarse grained;
Sixth Layer - Crystalline basement.

A similar section was penetrated in a borehole drilled to basement at *Imushin* about 8km East – South – East of Ijebu-ode and provide the following section from top to basement (~74m);

First Layer (3.05m thick) - Red earth;
Second Layer (14.33m thick) - Clay, red, sandy;
Third layer (6.10m thick) - Clay, variegated, very sandy;
Fourth Layer (40.55m thick) - sand, variegated, mostly coarse grained, sometimes pebbly, ill-sorted, clayed;
Fifth Layer (1.52m thick)- Gravel, sub-angular with coarse grained sand and white clay;
Sixth Layer (0.61m thick)- Shale variegated sandy;
Seventh Layer (7.93m thick) - sand, pale and variegated coarse-grained clayey;
Eight Layer - Crystalline basement (Jones and Hockey; 1964).

DATA ACQUISITION AND ANALYSIS

A total of 28 Vertical electrical soundings (VES) were carried out fig.3 (10 at Ijebu-ode after the sawmill along Ijebu-ode Sagamu express way, 8 at Ikangba within Ikangba housing estate and 10 at Igbeba within Igbeba housing estate), using the Schlumberger electrode array, with a maximum current electrode separation (AB) of 500m. Digital averaging equipment ABEM Terrameter SAS 300C for direct current resistivity was used for this work. The instrument displays the resistance which is converted by appropriate geometric factor to obtain the apparent resistivity.

The apparent resistivity obtained from the field data was plotted against half of the current electrode spacing on a log-log graph scale. The sounding curves obtained at Ikangba are characterized by QH, KH, H and AKH types (fig.4) reflecting the presence of three to five geoelectric layers. In each of these curve types, the last layer show an asymptotic increase in resistivity characteristics of an highly resistive bedrock. At

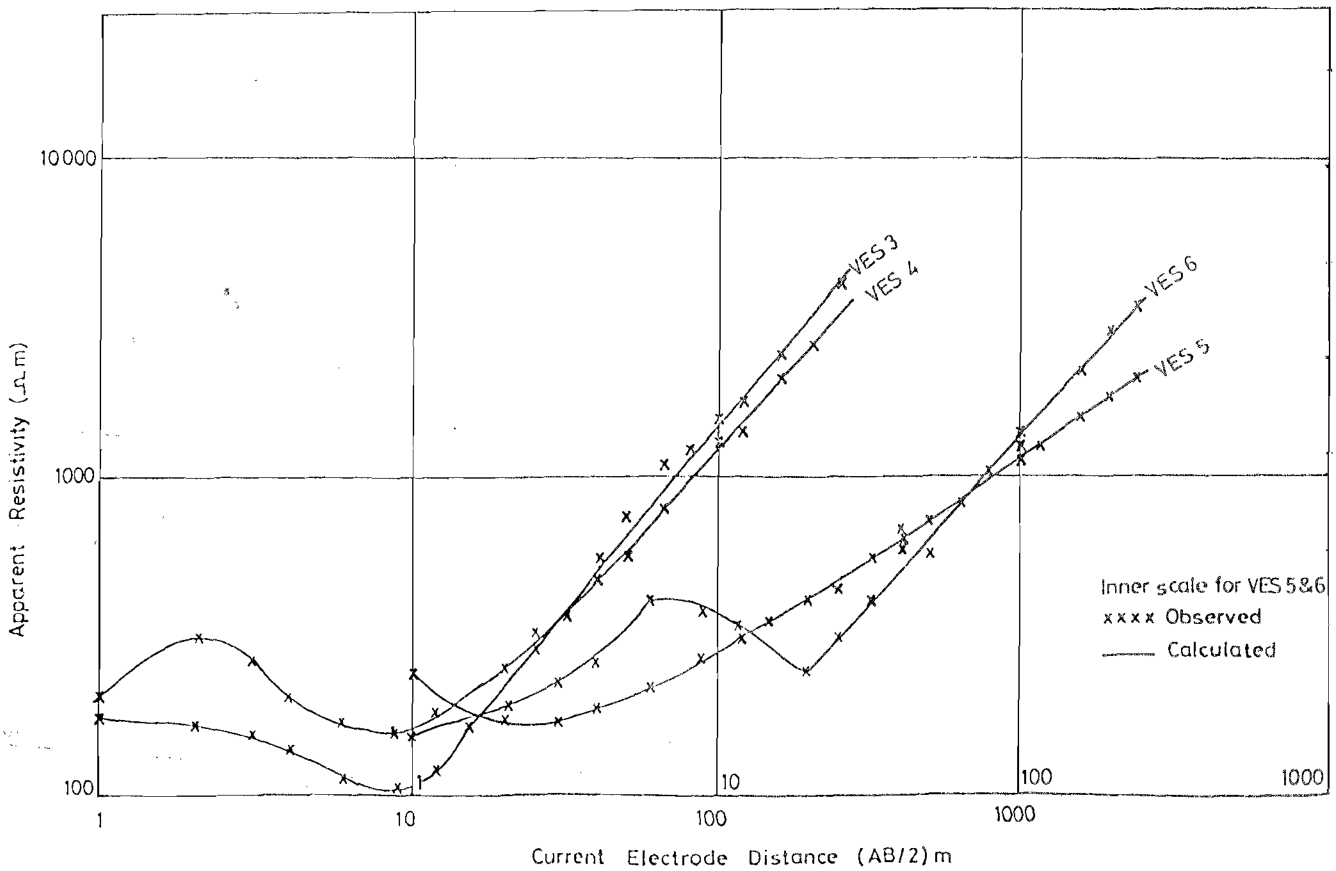

Fig. 4: VES Curve types obtained at Ikangba

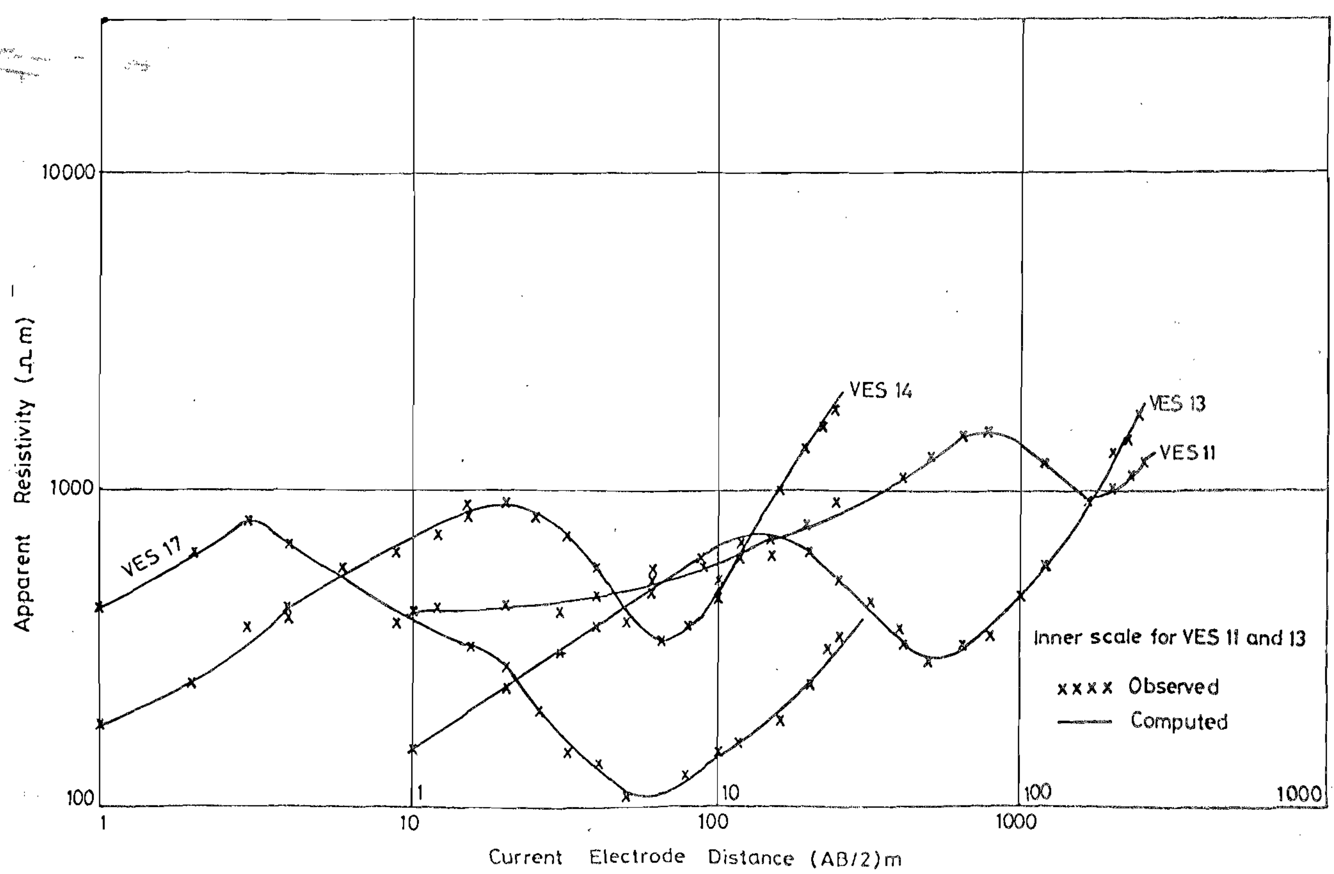

Fig. 5: VES Curve types obtained at Igbeba

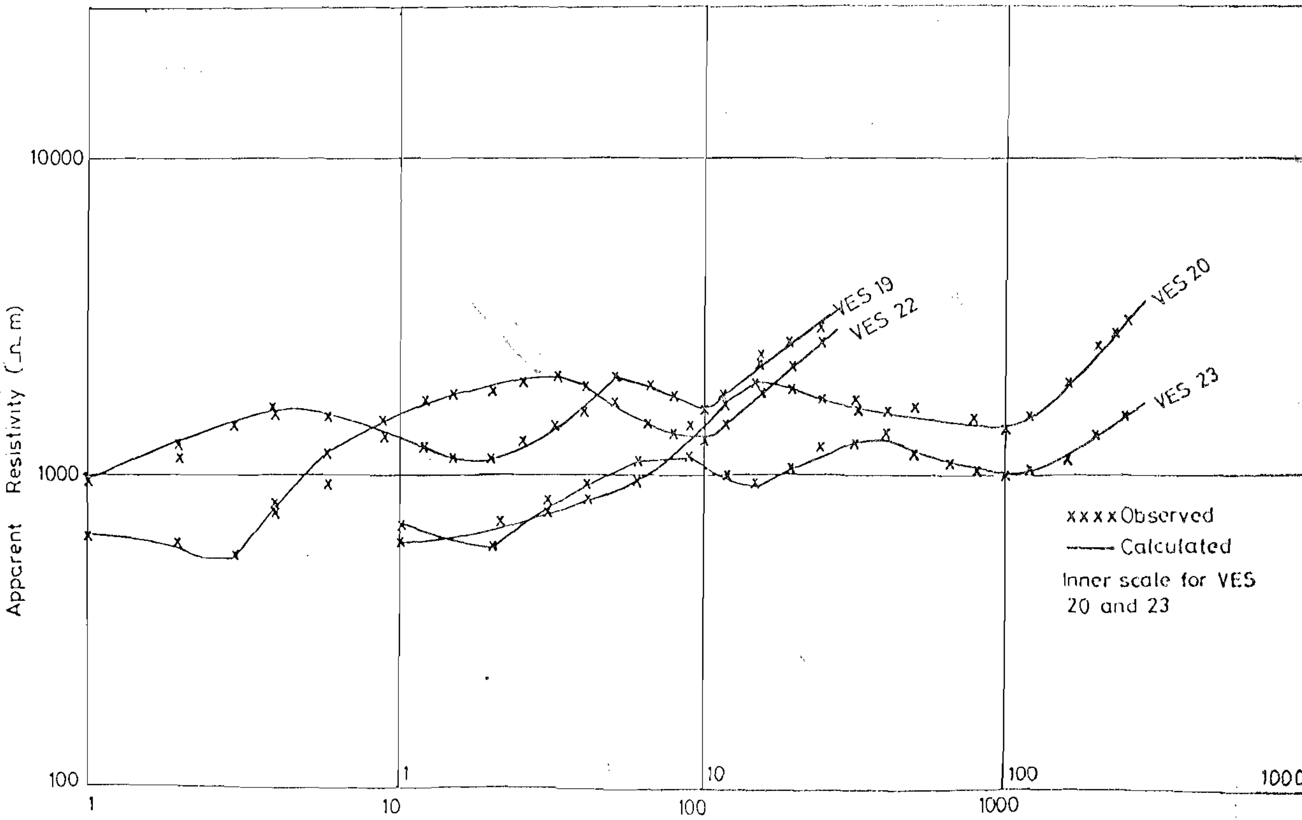

Fig. 6 : VES Curve types obtained at Ijebu - Ode

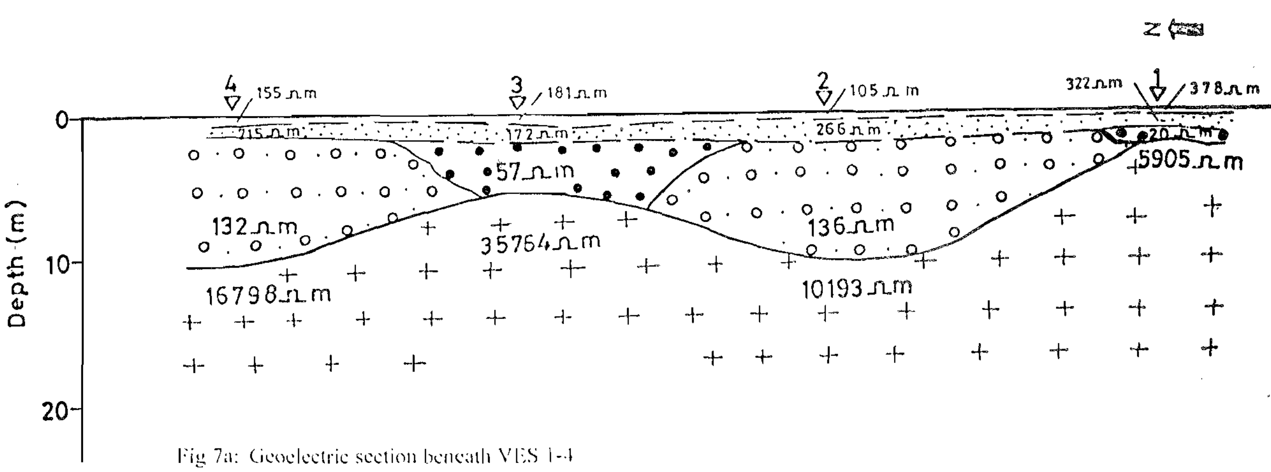

Fig 7a: Geoelectric section beneath VES 1-4

Igbeba, the sounding curve types AKH, AAKH, and KQH (fig.5) were obtained with five to six geoelectric layers while at Ijebu-ode KH, KHK, HKH, AKH, HKQ, KHKH, HKHKH and AKHKH (fig.6) were obtained having four to seven geoelectric layers.

Preliminary interpretation of the data was carried out using partial curve matching technique (Zohdy, 1965; Zohdy et al, 1974; Bhattacharya and Patra 1968). This gave an initial estimate of the resistivities and thicknesses for the various geoelectric layers obtained. These were inturn used as starting models for a fast computer iterative interpretation technique (RESIST) to obtain a quantitative interpretation.

The results obtained from the computer modeling are presented in form of geoelectric sections figs 7 to 9, while the summary of the VES curve types, aquifer thickness, resistivity and lithology are presented in Table 1.

DISCUSSION OF RESULTS

At Ikangba area, the vertical electrical sounding data show an asymptotic increase characteristics of the crystalline basement bedrock (fig.4). Three to five geoelectric layers consists of topsoil, clayed sand, sandy clay, fine-medium sand and the bedrock were obtained. The geoelectric section beneath the VES points in this area (figs. 7 a-c) show that the depth to bedrock vary from 2.4 to 29.7m. This area is suspected to be a transition zone between the crystalline basement rock and the sedimentary rock of Abeokuta formation. Appreciable groundwater yield for sustainable industrial development may not be feasible in this area particularly where we have thin overburden (figs 4a & b). However beneath VES 7 (fig. 4c) the fourth geoelectric layer which is composed of fine-medium sand of resistivity 317Ωm and thickness 15.3m was delineated. The

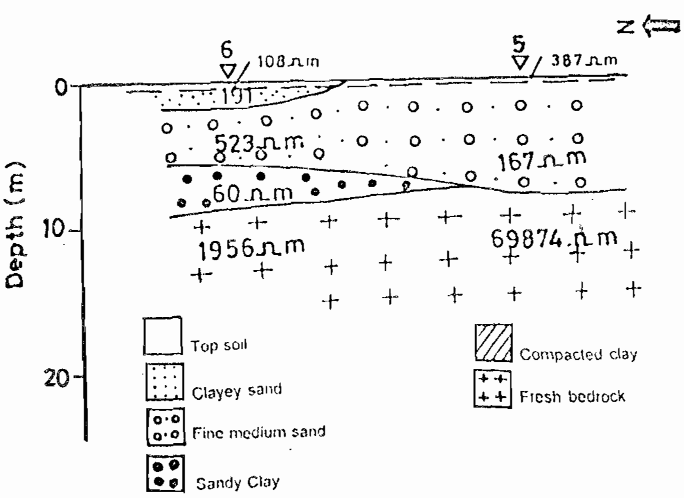

Figure 7b Geoelectric section beneath VES 6 and 5

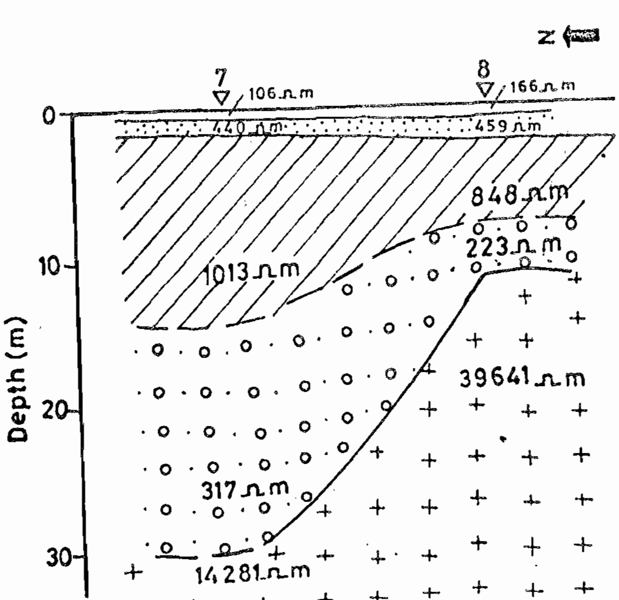

Figure 7c Geoelectric section beneath VES 7 and 8

Table 1: Summary of VES Curve Types, Aquifer Thickness, Resistivity and Lithology

Locality	Type Curve	Frequency Of Occurrence	Depth To Bedrock (m)	Thickness Of Groundwater Aquifer (m)	Resistivity of Aquifer unit (Ωm)	Possible Lithology	Inferred Geological Formation
Ikangba	QH	2	2.4 – 5.3	1.3 – 3.4	20 – 57	Sandy Clay	Transition Between Basement Complex Rock And Abeokuta Formation
	KH	2	10.2	8.1 – 8.9	133 – 136	Fine-Medium Sand	
	H	1	8	7.7	167	Fine-Medium Sand	
	AKH	3	8.7 – 29.7	3.5 – 15.3	223 – 523	Fine-Medium Sand	
Ijebuode	KHKH	2	80 – 82.2	46.1 – 53.8	775 – 916	Coarse Sand	Abeokuta Formation
	AKH	2	70.2 – 92.8	52 – 82	917 – 1130	Coarse Sand	
	HKH	1	77.7	45.1	733	Coarse Sand	
	HKHKH	1	99.4	70	811	Coarse Sand	
	HKQ	1	Not delineated	Not delineated	1110	Coarse Sand	
	AKHKH	1	101.1	80.6	815	Coarse Sand	
	KHK	1	Not delineated	Not delineated	1394	Coarse Sand	
	KH	1	Not delineated	Not delineated	-	-	
Igbeba	AKH	6	29.3 – 161.7	19.6 – 101.9	137 – 332	Fine-Medium Sand	Abeokuta Formation
	AAKH	2	150.7 – 163.2	81.3 – 104.3	141 – 416	Fine-Medium Sand	
	KQH	2	33.7 – 51.6	29.8 – 40.8	59 – 65	Sandy Clay	

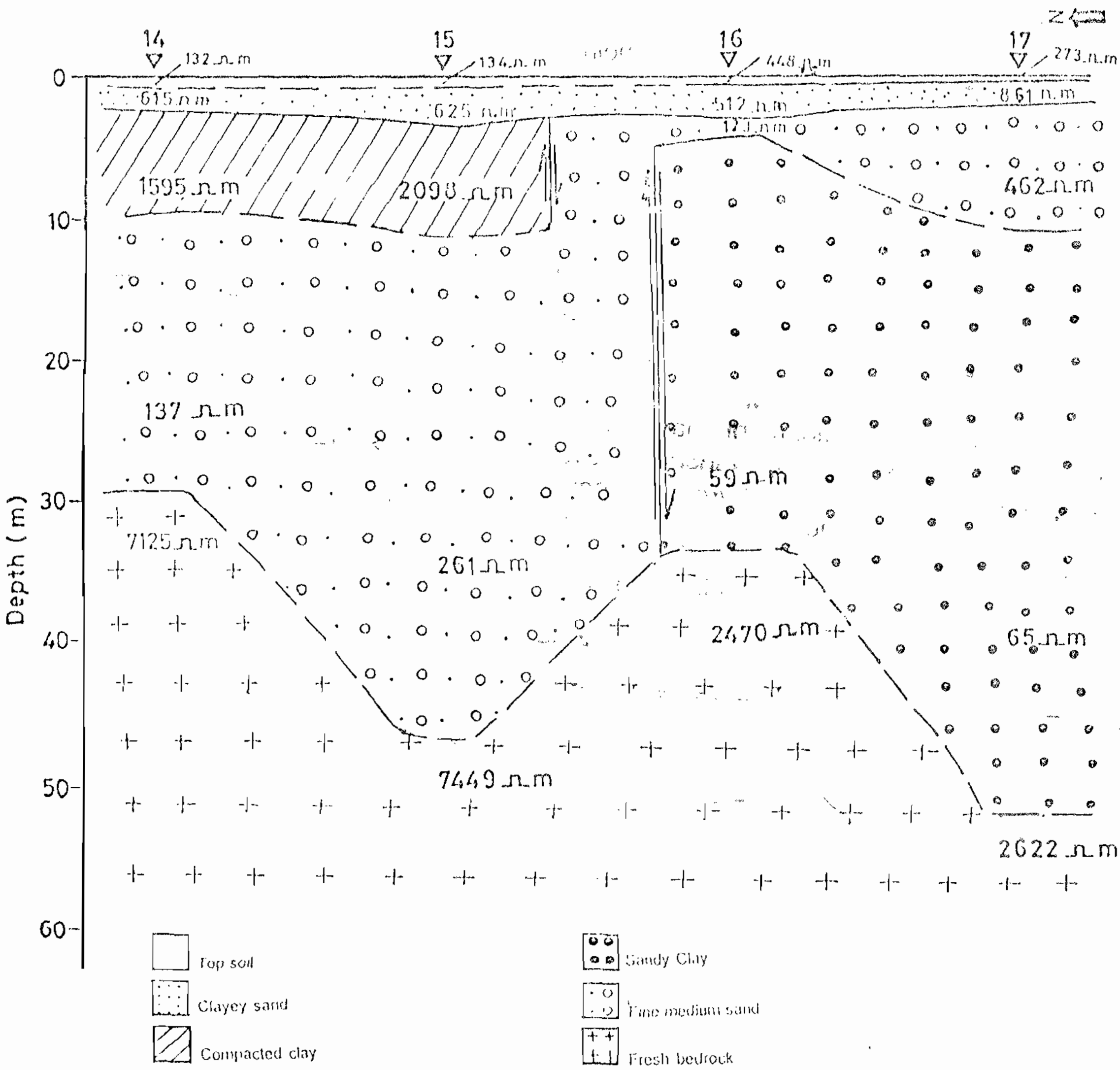

Figure 8a Geoelectric section beneath VES 14 - 17

bedrock in this area appears to be close to the surface as earlier deduced by Ojelabi et al; 2001.

At Igbeba, the VES data show a minimum of five and maximum of six geoelectric layers composed of topsoil, clayed sand, compacted clay, sandy clay, fine-medium sand and bedrock. The third geoelectric layer (figs 8 a-d) in this area composed of compacted clay layer of resistivity ranging from 787 to 2708Ωm and thickness of between 6 to 49m. This thick and highly resistive compacted clay layer may have been responsible for the abortive or failure of hand dug wells and some borehole in this area. This third geoelectric layer was interpreted as bedrock intrusion by Ojelabi et al (2001) as maximum current electrode separation of 200m used made it impossible for any other layer to be delineated. However in this study, available borehole data show that this layer is composed of compacted clay while the increase in current electrode separation to 500m enable us, to delineate the fourth and fifth/sixth geoelectric layer and thus determining the depth to bedrock Table 1. The fourth/fifth geoelectric layer delineated in this area is composed of sandy clay and fine-medium sand with resistivity ranging from 59 to 446Ωm and thickness of about 20 to 104m, this offer a good potential for the extraction and exploitation of groundwater capable of sustainable industrial development.

At Ijebu-ode, around the sawmill along Ijebuode – Sagamu express way, the VES data show a minimum of four geoelectric layer and maximum of seven geoelectric layer figs 9a & b. The third geoelectric layer in this area is similar to the one at Igbeba area, that is, it consists mainly of highly resistive (986 – 3346Ωm) and highly compacted thick

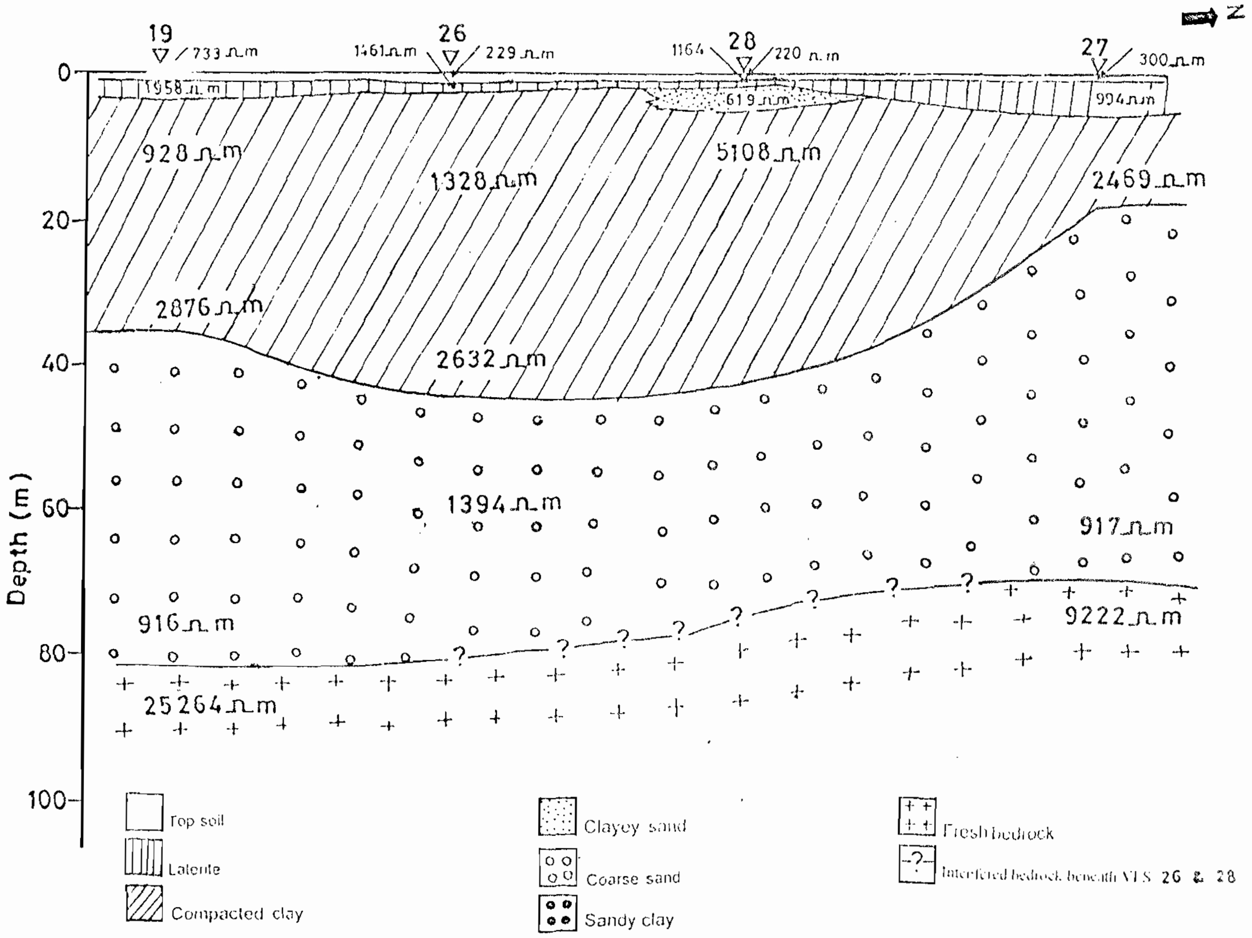

Fig 9a: Geoelectric Section beneath VES 19, 26, 27 and 28

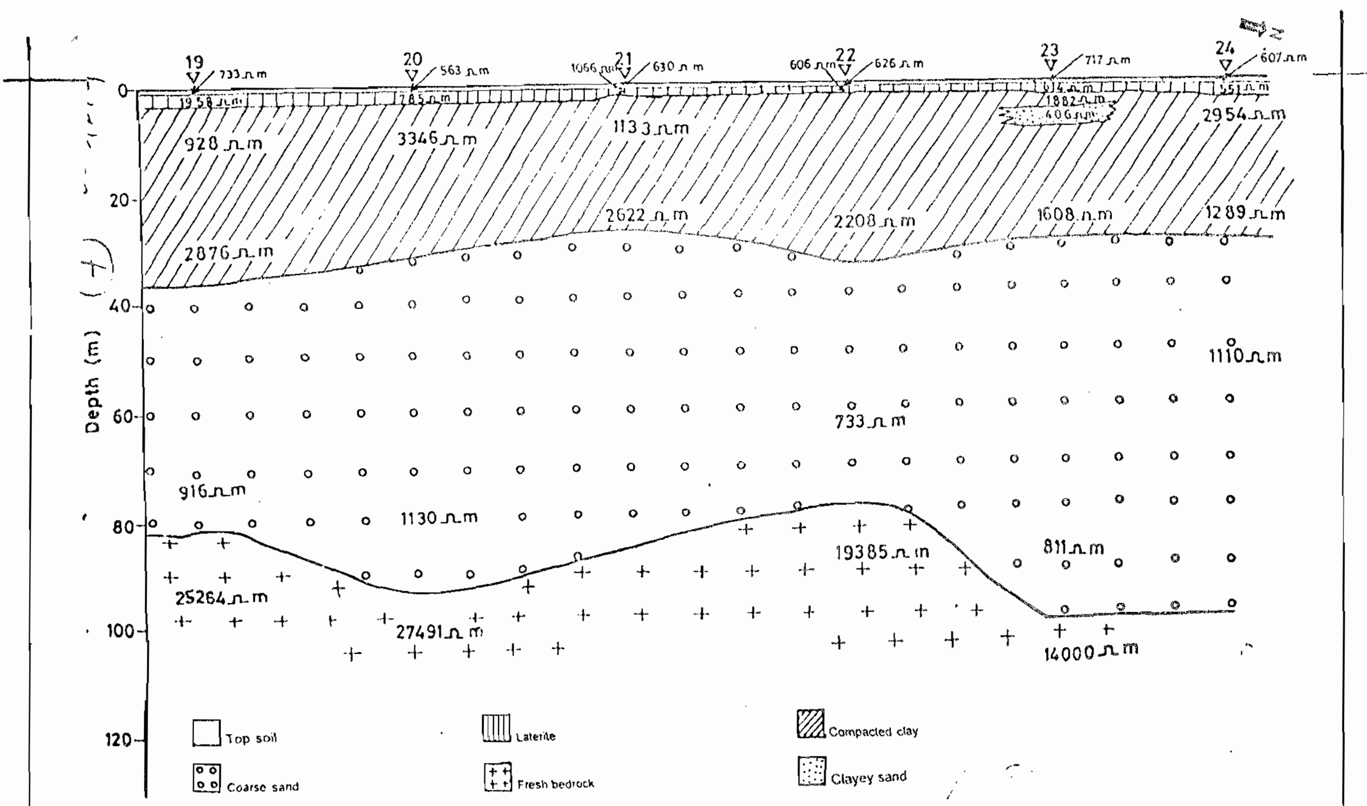

Fig 9b: Geoelectric Section beneath VES 19 – 24

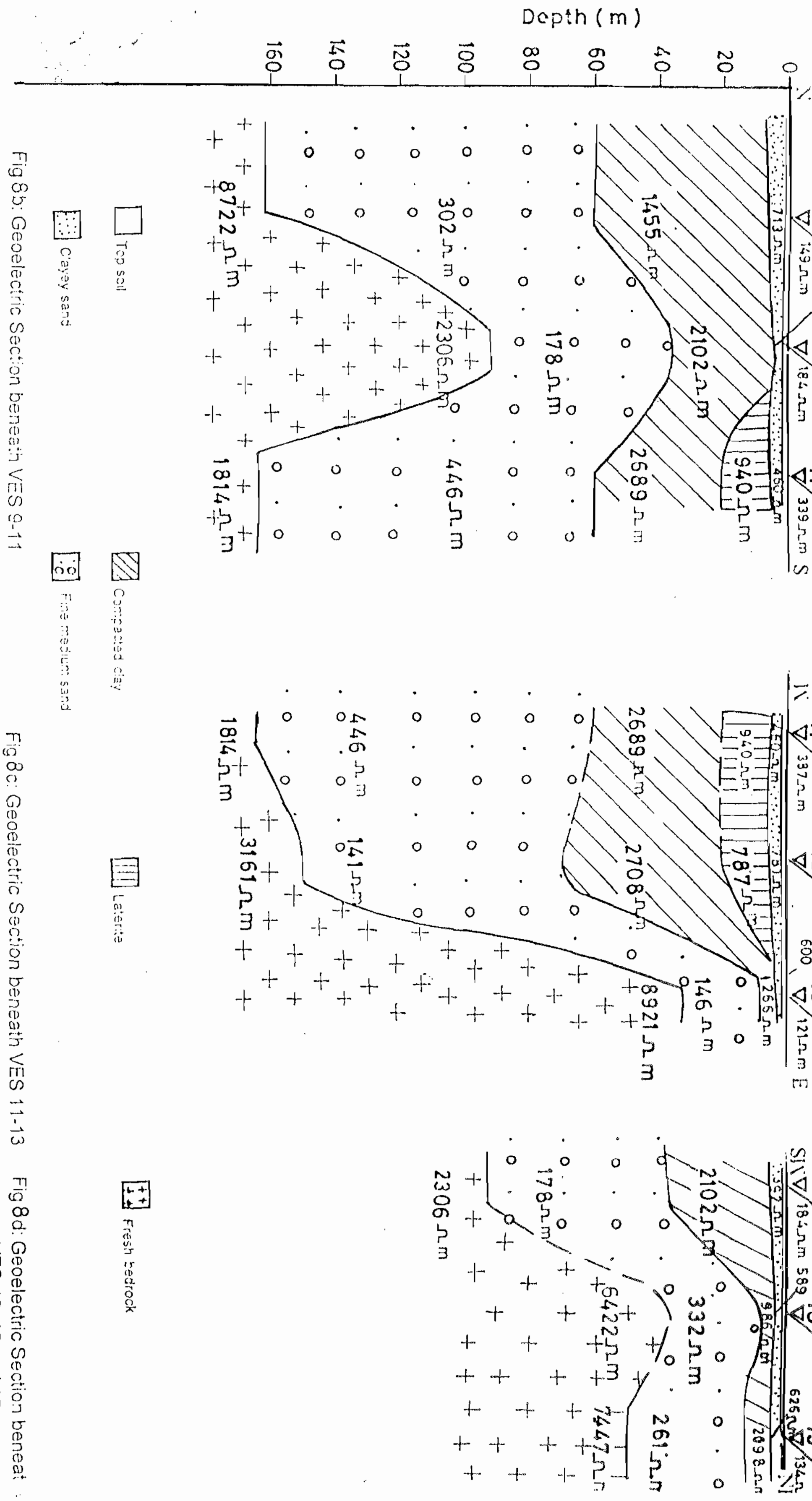

Fig 8b: Geoelectric Section beneath VES 9-11

Fig 8c: Geoelectric Section beneath VES 11-13

Fig 8d: Geoelectric Section beneath VES 10, 18 and 15

(12.0 – 43.0m) clay layer, which is largely responsible for abortive well or dry hole in this area. The fourth geoelectric layer compose of coarse sand of resistivity 733 – 1394Ωm and thickness of about 45 – 81m form the aquifer unit in this area which is a good potential for groundwater exploitation and exploration for sustainable industrial development.

CONCLUSION

The result of the VES analysis shows that Ijebu-ode and Igbeba area fall within the sedimentary rock of Abeokuta formation while Ikangba area is a transition zone between the basement complex rock and the Abeokuta formation. The causes of abortive hand dug well and borehole failure in this area is attributable to the existence of a thick highly resistive and compacted clay layer. Thus thorough geophysical investigation is required before drilling a borehole in this area.

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