Investigation For Groundwater In Abuja Technology Village, Using Vertical Electrical Sounding (VES)

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INVESTIGATION FOR GROUNDWATER IN ABUJA TECHNOLOGY VILLAGE, USING VERTICAL ELECTRICAL SOUNDING (VES)

BY

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A THESIS SUBMITTED TO GEOLOGY PROGRAM, ABUBAKAR TAFAWA BALEWA UNIVERSITY, BAUCHI IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF DEGREE OF BACHELOR OF TECHNOLOGY (B.TECH) IN APPLIED GEOLOGY.

MAY, 2008

APPROVAL PAGE

This is to certify that DAKAT LYNDA NANFE carried out this research work in partial fulfillment of the requirement for the award of the degree of Bachelor of Technology (B.Tech) in Applied Geology, in Abubakar Tafawa Balewa University, Bauchi.

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DEDICATION

This work is dedicated to the Almighty God, Jehovah.

ACKNOWLEDGEMENT

My unreserved and wholehearted appreciation goes to Jehovah God through Christ Jesus who directly and through my fellow humans lovingly drove this research work to its successful conclusion.

A lot of hands have been instrumental to the success of this work humanly speaking. Most important of these are members of my family, especially my mother, Mrs Liberty Dakat; Mr. Samson Dakat; Aunt Nanre and Nanpon Dakat . There is no possible way I can repay them for their support and encouragement especially during the tumultuous period of this project.

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ABSTRACT

The geophysical method of Vertical Electrical Sounding (VES) using Schlumberger array was used in determining the groundwater potentials of the Abuja Technology Village, Abuja and the results showed that boreholes can be drilled on VES9, VES11, VES16, VES21 and VES31 which displayed a good degree of weathering and fracturing. This method also picked up structures, (such as faults and/or fractures), and their lateral depth from the surface. The trend of the structures in the study area was also related to the general trend of established structures in the Central Basement Complex of Nigeria. It was found that the trend of these structures is concurrent with the general trend of lineaments in the Central Basement Complex of Nigeria. This was achieved through comparism of resistivity readings with the Satellite Image (Landsat 7 ETM) of the study area.

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CHAPTER ONE: Introduction

1.0 The Background Information

The geophysical investigation for ground water in Abuja Technology Village is divided into two. The first part took three days to complete. The second part which has to do with the actual borehole drilling is not covered in this research work. A reconnaissance survey was carried out using satellite imagery. This revealed the drainage pattern and lineament pattern in the region.

1.1 Objectives of Work

The objective of the present study is to carry out a geophysical investigation for ground water in Abuja Technology. The study entails the determination of:

1. The subsurface layering of the Abuja Technology Village Site
2. Determination of the depths to basement or the thicknesses of the overburden within the site

3. Determination of the groundwater potentials of the area and delineating the zones into high, medium and low ground water zones

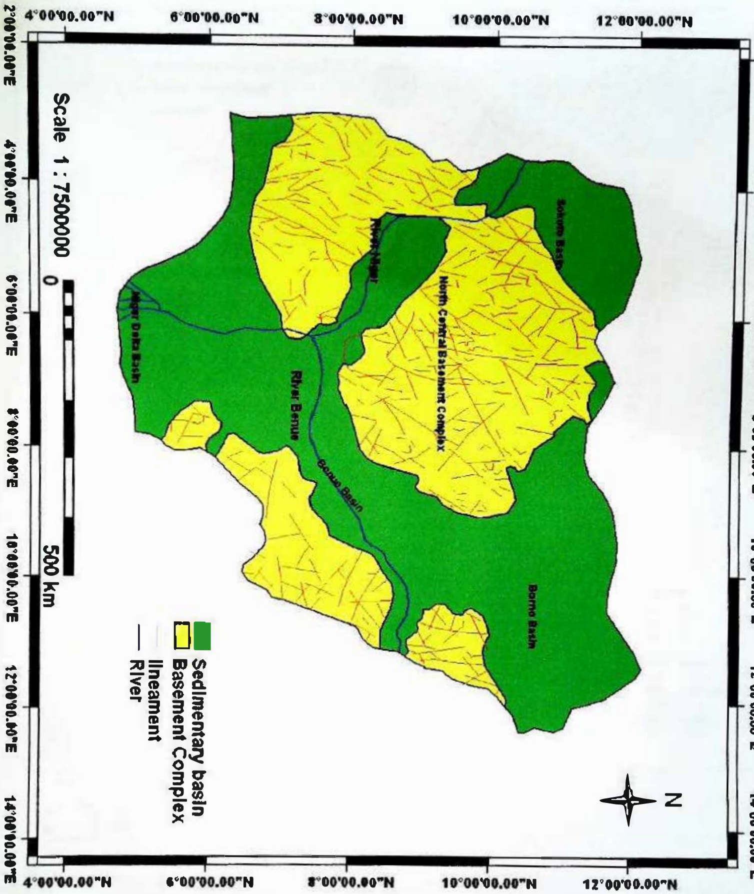
4. Determination of the subsurface geophysical structures, such as faults /and fractures, and their extent, depth and continuity

5. Determination of the possible engineering problems the structures could cause to infrastructures.

1.2 Scope of Work

The work is basically a geophysical investigation using geo-electrical resistivity sounding method (Schlumberger technique). It was done using SAS 1000 ABEM Terrameter and the total spread of AB/2 values is 120m wide and this gives a penetration depth of 42 m, and the total area covered is about 2 Km by 1Km

1.3 Location



Source: Modified from precambrian Geology of Nigeria (National Center For Remote Sensing, Jos)

Fig1: Map of Nigeria showing the Basement and Sedimentary terrains

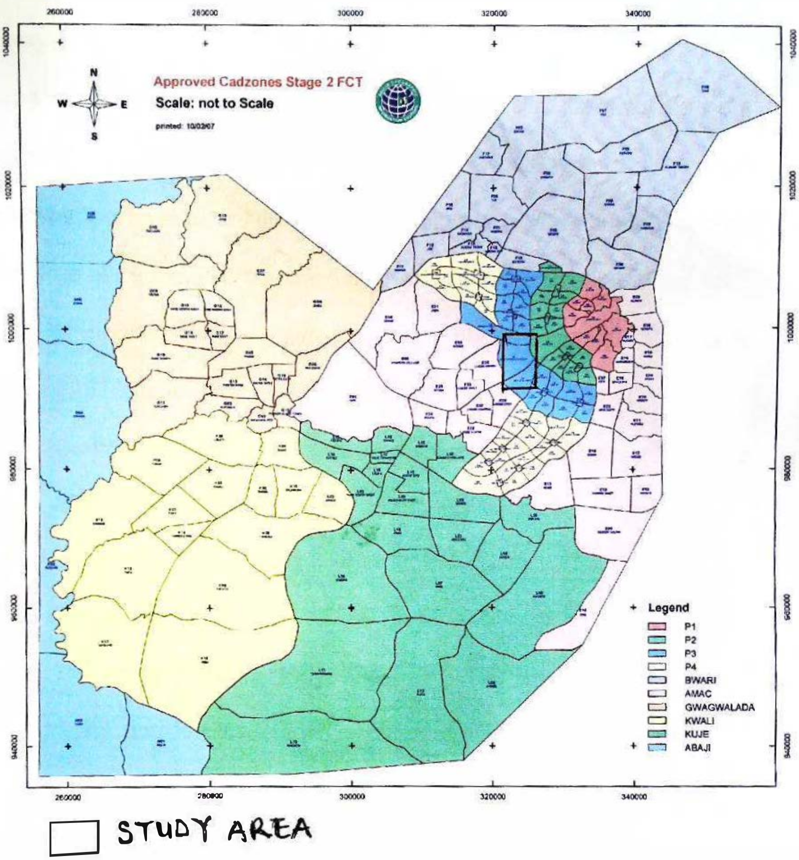


Fig 2: Map of Abuja showing project area (from AGIS, Abuja)

The site for the Abuja Technology Village is located about 11Km away from the Abuja-Airport road (Fig 1& 2). It covers a total land area of about 660 hectares. The site shares boundary to the north with the African Institute of Science and Technology and to the south east by the Pyakassa Village. A well recognized settlement around the area is Lugbe. It is bounded by the following coordinates:

- Northern perimeter extremes lay between longitude 324432 to 325783 and latitude 994303 to 993540.
- Southern perimeters extremes lay between longitude 322999 to 324706 and latitude 993492 to 992387.

1.4 Topography

The Abuja Technology Village (ATV) has an undulating topography and is dissected by seasonal streams/rivulets that start from the eastern part of the area. The streams originate mainly from the eastern hilly terrains and flow in the east-west, southeast-northwest directions. The elevations vary from 410 m within the valley, to 463 m at the edge of the profiles.

The Federal Capital Territory, can generally, be visualized into three broad landforms; the hilly clusters of the northernmost section, the gently rolling plains of the central lowlands and the craggy terrains of the south and southwest areas.

The northern highlands consist of rugged and shapeless hills characterized mainly by broken rock boulders. South, these granite rocks become more compact, giving rise to massive elongated hills and inselbergs in the vicinity due east of Abuja town. The rocks are elongated mainly in a NNW-SSE direction and they are formed by coarse porphyritic granites. (FMWR, Abuja).

The central region of Abuja is made up of gently rolling peneplains characterized by low-lying inconspicuous ridges and punctuated by isolated surface-level elongated hills.

The southern part of the territory has a sedimentary terrain. The sandstone formation does not outcrop but rather is masked by a thick ferruginous laterite capping which because of its incongruous weathering pattern gives rise to a craggy landform caused by frequent interchanging of stream gullies and laterite ridges. Lateralized ironstones also occur occasionally with the formation. On the whole, the relief of this sedimentary terrain ranges from 91m (300ft) in the south to over 960m (2,500ft) towards the north, where it has contact with the Basement Complex (FMWR, Abuja).

1.5. Vegetation

The ATV is within the Federal Capital Territory and falls within the Guinea Savannah Vegetation zone of Nigeria. The vegetation of the territory has orchard bush of varying density with dominant elephant grasses. The plant species found in the area consists mainly of palm trees, *Parki* Spp, *Anona Sengalensis, Daciella Oliverri, Pillois Sigma spp and Prosopic spp.*

1.6 Settlement, Soil and Land Use

There are three main local settlements within the study area. They are Shika, Pyakassa and Aleita. Shika and Aleita mark the northeastern and northwestern boundaries of the ATV, while Pyakassa marks the southeastern boundary.

The predominant inhabitants of the area are the the Gbagyi people. However, there are other settlers, including the Hausas and Koros.

The top soil in the study area is generally lateritic. The valleys/streams flood plains consist mainly of alluvial soils thinly overlying the bedrock.

1.7 HYDROLOGY AND DRAINAGE

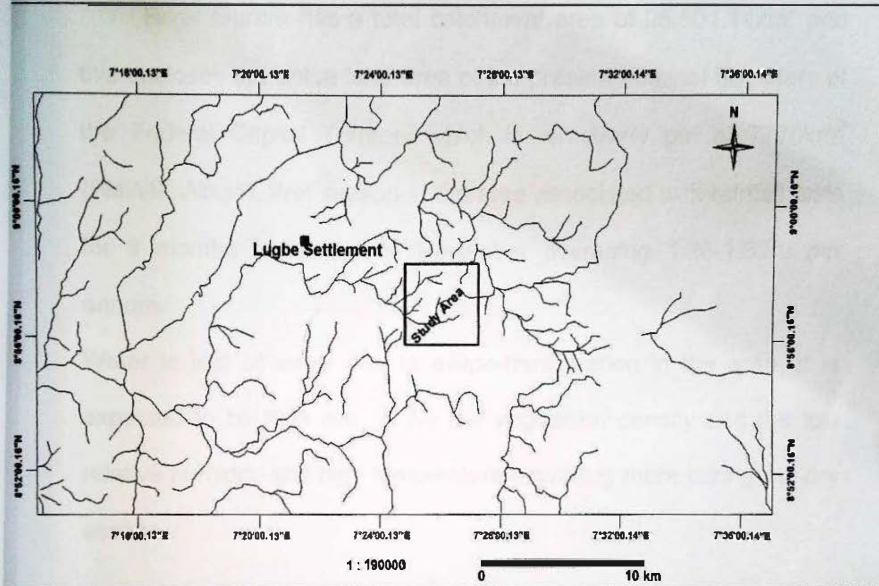


Fig 3: Drainage map of the study area from the satellite image

The territory is well drained by the river Gurara and its major tributaries. The main body of the river flows roughly north-south for about 150km across the western part. It has a generally low gradient of about 1 in 296 and a broad and deep channel which measures 82m wide at the bridge crossing over it near the town of Izom. Its bedload is thin, consisting mainly of fine sand and silt. (FMWR, Abuja). Toward its mouth, where it flows into the River Niger, the river meanders indicating some structural control.

River Gurara has a total catchment area of 25,501.14km^2 and this encloses the entire land area of the present nominal boundary of the Federal Capital Territory which is tentatively put at 7770km^2 (FMWR, Abuja). Wet season in the area associated with rainfall lasts for 8 months from April to November averaging 1.26-1.52m per annum.

Water is lost of water due to evapo-transpiration in the area. It is expected to be high due to the low vegetation density and the low relative humidity and high temperature prevailing there during the dry season.

CHAPTER TWO: Literature Review

2.0 INTRODUCTION

Abuja lies within latitudes $8^0 26'$ and $9^0 26'$N and longitudes $6^0 45'$ and $7^0 45'$E. It covers approximately 7770 Km^2 Abuja is underlain by crystalline basement rocks at the northern part and by the Cretaceous sandstones at the southern part. In between these two groups, are metasediments and meta-igneous rocks, which form a buffer zone.

2.1 GEOLOGY OF ABUJA

The basement rocks include different textures of granites, coarse to fine, consisting essentially of biotite, feldspars and quartz. In most cases the rocks have weathered into reddish micaceous sandy clay to clay materials capped by laterites. (Offodile 1992).

The sandstone formation is a member of the Cretaceous Nupe sandstone formation of the Middle Niger Basin. This consists mainly of weakly cemented fine-coarse grained sandstones and siltstones with thin beds of carbonaceous shales that are locally interbedded; lenses of conglomerates and pebbly sandstones also occur particularly near the contact with the underlying basement rocks. (Barber 1965).

The metasediment trend NNE-SSW and consist mostly of metagneisses and haematite quartz-schists while the metamorphosed rocks are derived mainly from diorites and granodiortites. (Ajakaiye, 1989). Igneous and high grade metamorphic rock exposures are widespread to the north and east of the area respectively.

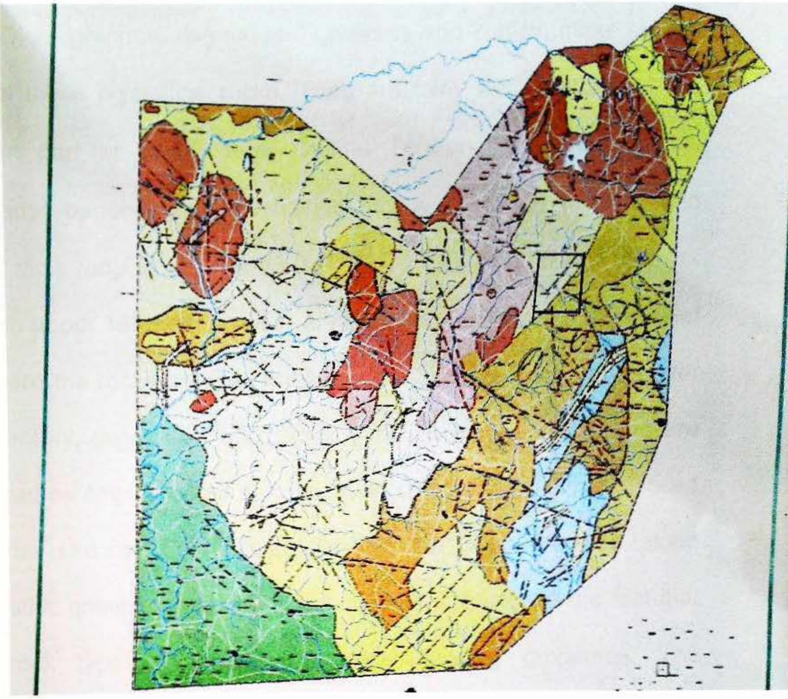


Fig 4: Geologic map of Abuja. [MODIFIED FROM NIGERIAN GEOLOGICAL SURVEY AGENCY (NGSA)]

KEY

MIGMATITE

MIGMATITE - GNEISS

Older granites, migmatites, gneisses and schists make up the bulk of these crystalline rocks.These are fairly well exposed at the eastern part of the Federal Capital Territory. They are mainly migmatitic banded gneisses having mostly contorted foliation and steep dips ranging between 60-90^{0}E. At Gurfataq village and its environ about 16Km south-west of Abuja, migmatites form high relief and here the rocks are well fractured, but in other locations all over the territory, migmatites occur mostly in non massive form and are exposed as small isolated surface level outcrops. Also it was noticed that the streams of the area tend to cut their channels along migmatitic gneiss outcrops and this may be a pointer to the fact that this rock type has favourable water bearing properties. The paloesomes of the migmatites are of dark mineral composition probably diorite or amphibolite while their metasomes are made up of light quartzo-feldsparthic and granitic veinlets (FMWR, Abuja).

Gneisses are not very distinctive in the area as a result of their outcrop situation which is often small and disjointed. However a mapable unit of granite gneisses occurs in the locality just south east of Izom town. Here the rock is essentially granitic but with streaks of green and white mineral banding caused probably by a planar concentration of its chloritic and micaceous mineral contents. The rock is invariably very fine grained and often assumes an overly pinkish coloration owing to a disproportionately large content of pink-coloured potash feldspar or to albertisation.

Diorite intrusives are found exposed at the southwest area of the territory. In some locations the rocks contain enough quartz in its mineral composition to pass as granodiorites. The rock is compact, fine-grained with bluish to greenish colour contrast. The diorite exposures are adjacent to the sedimentary formation to the south; the metasediments to the east, and the granites to the north and as such they are strongly metamorphosed. The process of metamorphism is both contact and hydrothermal as evident by porphyritic, ophitic and granitoid textures of the igneous members of the rock. The metamorphism of the rock is further accentuated by its macrotextural form which often includes both augen gneiss, micaceous (semi basic materials) and quartz feldspar megacrysts (FMWR, Abuja). As such, although the host rock is diorite, and this occurs in unadulterated form in some locations – a typical hand specimen of the rock may show alternatively on the three facial planes, schistose, gneissic and granulitic structures; the granulite being the deformation of the recrystallized quartz-porphyroblasts. These relicts structures are distinctive of igneous rocks affected by contact or hydrothermal metamorphism.

Also found in the area are pelitic to semi pelitic micaceous schists which probably derived from the siltstone horizon of the original sedimentary sequence but generally the ground surface is made up of clusters of rounded lowly hills littered with iron-stained quartzite cobbles and pebbles of hard-grit latrites.

Sandstone rocks form the underlying formation of the southernmost part of the Capital Territory. The rocks themselves are probably not exposed anywhere in this area as they are masked on the surface by a top layer of ferruginous laterites and ironstones.

The migmatites to the east generally form low lying ridges of no prominent feature while the metasediments which form the transition zone between the Basement Complex rocks of the north and the sedimentary formation in the south are characterized by semi-pelitic schists, indurated migmatitic gneisses and ubiquitous iron stained quartzite pebbles (FMWR Abuja).

One noticeable occurrence in the area is the paucity of laterite cover in the areas underlain by crystalline rocks. Isolated outcrops of gritty laterite do occur, but they are small and far apart. Also, it is most likely that the topography and the soil cover reflect the geology of the underlying rocks.

Generally only small amount of water can be obtained in the freshly unweathered bedrock below the weathered layers. Groundwater is found mainly in the variable weathered/transition zone and in fractures, joints and cracks of the crystalline basement. Fissure systems in Nigeria rarely extend beyond 50m, as evidenced by the available drilling data (Clark 1985). The local water table depth is controlled by textural and compositional changes within the regolith vertical profile and the bedrock topography (David & Ofrey 1989).

CHAPTER THREE: Methodology

3.0 INTRODUCTION

The work is basically a geophysical investigation using resistivity method. The instrument used is an ABEM Terrameter SAS 4000 (fig 5) Schlumberger electrode arrangement was used for the measurements. The maximum current electrodes distance was 120m. Small segments of field curves will be matched with theoretical curves to determine both the thicknesses and apparent resistivity of layers. The disadvantage of this type of project is that experienced personnels are needed to handle the instruments, particularly where the layering exceeds two different types of layers. A computer program was used to establish the layers beneath the ground surface using least square techniques to match the theoretical apparent resistivity curves as close as possible to the field curves. Initial input to the computer program was obtained by sampling the field curve at specific intervals.

3.2 FIELD PROCEDURE

The arrangement of the instrument is illustrated in figure 8, where two current electrodes C1 and C2 are placed at equidistance from the point of interest (VES point) and are progressively expanded to get deeper penetrations.

Figure 5 SAS 4000 Panel with four communication connectors

To carry out the present investigation, only one channel (out of the four channels) of the Abem Terrameter SAS 4000 (fig 5) was used. It is often easier to use the four "banana" connectors labeled 'C1', 'C2', 'P1, and 'P2". These connectors are displayed on the instrument's screen (Fig 5). Where more channels are needed, multi connectors are used. The 'banana' C1', 'C2', 'P1, and 'P2" are connected parallel to the corresponding pins on the instrument. To connect more than one set of potential electrodes, multi channel adapter, supplied with the system are needed. The Abem Terrameter SAS 4000 works with other apparatus to facilitate the measurement of ground resistivity of rock formations.

To carry out geophysical survey in the field, the following equipments are required:

1. Terrameter attached with a power source (battery).
2. 4 or more sets of electrodes (preferable steel electrodes).
3. A well calibrated set of ropes for determining the depth of various subsurface formations.
4. A set of geological/field hammers.
5. A bottle of saline solution.
6. A set of communication gadgets (Walkie Talkie).
7. A field data sheet.
8. A Global Positioning System (GPS)

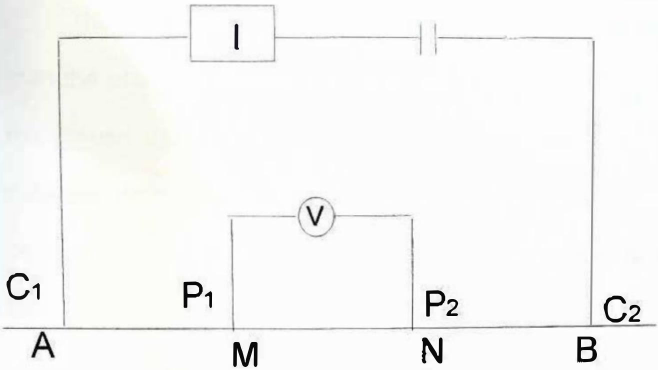


Figure 6: Schlumberger array for vertical electrical sounding

Figure 7: 'Travelling' with electrode during data acquisition.

The distance (AB) of the current electrode spread is greater than the potential electrode spread (MN) (fig 6). Current is sent into the ground using the two current electrodes (fig 8) resulting in a potential drop which is measured by the instrument through the potential electrodes. The principle of this operation is based on Ohm's law:

$$V = IR$$

Where V = Voltage/potential drop

I = Current transmitted into the ground

R = Resistance of the encountered layers/boundaries

From the formula above, it is clear that:

$$R = \frac{V}{I}$$

According to Schlumberger's formula, the k factor for a schlumberger array is:

$$k = \frac{(AB/2)^2 - (MN/2)2}{MN} \quad \frac{\Delta V}{I}$$

Where AB = Current Electrode Spread

MN = Potential Electrode Spread

ΔV = Potential Difference

I = Current

The k factor is computed for each distance attained. This factor multiplied by the resistivity obtained from the readings on the instrument gives the apparent resistivity. The apparent resistivity is used in getting the different lithology encountered using computer software known as ZHODY.

Figure 8: Driving electrodes into the ground during data acquisition

3.2 DIGITAL ANALYSIS

The computer program (ZHODY) is based on DOS operational system. It is designed to facilitate the interpretation of schlumberger and Wenner sounding curves. This program is designed to automatically interprete the soundings obtained from the terrameter.

3.2.1 Zhody Program

The Zhody program has a drive menu command that is very important because it allows easy saving of work done. The work could be saved in either drive A, B, or C depending on the disk drive selected.

a) Main Menu

The menu has four options, which are:

1. Enter: sounding from keyboard
2. RETURN to disk drive menu.
3. QUIT.

⇒ **Enter Sounding from Keyboard**

If option one is selected, it means that new field data will be entered.

(a) The name of the survey area is the first data required.

(b) If no name, press enter (It is important to name all fields).

(c) Typed a name and press enter (computer will ask if it is a new or old name).

(e) Electrode spacing in feet or meters? (F/M)

(Press M if your measurements are in meters)

(f) Enter sounding number (e.g. Pd), then press enter. It is important to give a number (VES station number) to distinguish all files.

⇒ **Return to Disk Drive Menu**

When the "return to disk drive menu is selected, a disk drive option will appear (A, B or C) for saving of data.

⇒ **Quit**

To exit the application and returns to DOS prompt, option Quit is selected.

b) **Data Entry**

To enter data, the following options are provided:

1. Enter AB/2 and Field Apparent Resistivity
2. Type smallest AB/2 and Digitized Apparent Resistivity.
3. Return to Main Menu.

Enter AB/2 and Field Apparent Resistivities if option 1 is selected, the next screen that appears is the AB/2. When all data is entered, type 0 and press Enter. Apparent resistivity data is the next data required, after which 0 will be typed followed by Enter. To edit data, escape the Main Menu.

CHAPTER FOUR: Data Analysis

4.0 INTRODUCTION

This chapter attempts to interprete the data that has been collected in the course of this work. The processed data are mainly as figures and tables. Some data are also presented in form of structural maps.

4.1 QUALITATIVE INTERPRETATION

This section deals with the various curve types encountered in the study area. The data are presented in form of resistivity contour maps at different depths in the subsurface (topsoil, 5m, 10m, 20m, and 30m). The contour maps (plotted with surfer 8 software) show areas of high resistivities (poor aquiferous zones) and how resistivities (good aquiferous zones). Geo-electric soundings (Appendix A) from the work have been reflected in sections to show the thicknesses of the different layers encountered in the study area.

a. **Resistivity Contour Map of the topsoil.**

Concentration of VES points plotted as contour lines, with resistivity values ranging between 800 ohm-m to 100 ohm-m show VES points number P2, P12, P15, P20 and P35 as the high resistivity values (Appendix B) while the low resistivity values are observed on the contour lines joining VES points P11, P16, P21, P23, P28, P29, P33, P34, & P37 (Appendix B). This can be confirmed in the Appendix A.

b. **The resistivity contour map at the depth of 5meters**

The resistivity contour map at 5m depth shows low resistivity values (<500 ohm-m) clustering together to show the aquiferous zones (Appendix B).

c. **Resistivity contour map at 10m**

Resistivity contour map at 10m shows a density of VES points on contour lines with resistivity ranging from 300 ohm-m to 100 ohm-m. A few VES points are scattered on contour lines with resistivity greater than 300 ohm-m. The low values encountered identify the points as possibly aquiferous

d. Resistivity contour map at 20m

Resistivity contour map at depth of 20m also shows a concentration of VES points on contour lines with resistivity values ranging from 500 ohm-m to below 100ohm-m (Appendix B).

e. The resistivity contour map at depth of 30 m

The resistivity contour map at depth of 30 meters shows a density of VES points (Appendix B) on contour lines with resistivity value ranging from 2000 ohm-m to 1000 ohm-m. Because of the high resistivity values, the high density is not pointing to aquiferous zones.

f. The geo-electric sounding location map

The geo-electric sounding location map displays the profile along which different VES points were taken. The distance between one profile and the other is 200 meters and that from one VES point to another along the same profile is 400 meters. Each profile contains 5 VES points, bringing the total number of profiles to 8making a total of 40 VES points. Superimposing the Elevation Contour Map on the geo-electric map (Appendix B) show uplifted profiles. The VES points with high elevations and occurring at the edges of the profiles are P1,

P5, P6, P10, P11, P15, P16, P19, P20, P21, P25, P26, P30, P31, P32, and P36. The VES points with depressed elevations are: P3, P8, P13, P18, P23, P28, P33, P39 and P40 (Appendix B). The remaining points lay between the two extremes. Based on this observation, it is most likely that a graben-like structure could have been formed (fig 9).

g Elevation Contour Map

This plot that was developed using surfer 8 software shows the different elevations with height and the depressions encountered in the course of the research work. A summary of the plots can be found in Appendix B.

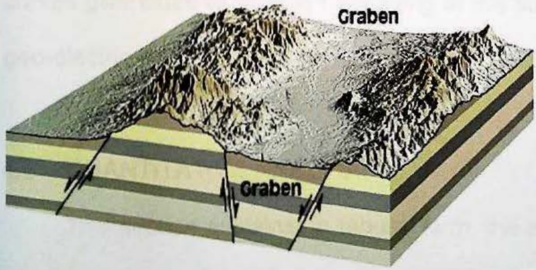


Fig 9: A Graben (Extracted from Geode II, Frederic, K. Lutgens)

A Graben is a Basin that is bounded by two normal faults. (Fig 9). Thus it would be noted that the middle block will be downthrown causing a depression to occur; in which case useful mineralization can be found or water storage achieved (aquifer) because of the lack of pressure on the fault plains.

Curve Types

Basically, all the curves encountered in the course of this research work are the K, H, A and Q types. These are explained below. Curves H, K, Q or a combination of any two of the three curves can yield significant amount of water. Thus, when such curves are encountered, the remarks in the geo-electric table (Appendix) shows that water can be recovered at the depth indicated. These curves give clues to what is happening at the subsurface. The three geo-electric or geologic layers in this work are described as a, b, c.

4.2 QUANTITATIVE ANALYSIS

This section explains, in tabular form, the aquiferous potentials of the various geologic layers encountered. This may be in the form of depth, inferred lithostrata and remarks. From the various tables, the thicknesses of aquifers can be inferred. A geo-electric section is presented at the end of each profile (Appendix A).

A summary of the fractures encountered VES points is given in table below.

Table 1: Summary of fractures

Profile	VES point	Fracturing depth (m)	Aquiferous potential
1	2	3-11	Low
2	9	11-37	Medium
3	11	4-15	Fair
4	16	5-25	Medium
5	21	5-17	Fair
6	26	17	Fair
7	31	4-19	Fair

Structural Interpretation

Several sets of fractures with N-S NNE-SSW, NE-SW, NNW-SSE and NW-SE trends are characteristics of the Basement Complex. These lineaments have been extracted from the Satellite Image shown in figure below.

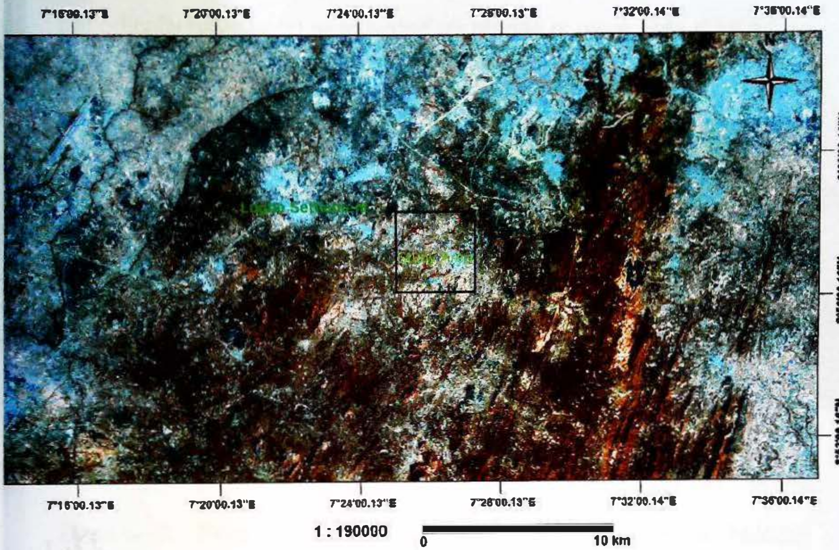


Fig 10: Satellite image of Abuja and its environments obtained from

`LandSat 7 ETM'

Extraction of Lineaments

A lineament is a simple or composite linear feature of a surface, whose parts are aligned in a rectilinear or slightly curvilinear relationship which differs distinctly from the patterns of adjacent features and presumably reflects a subsurface phenomenon (Oleary et al., 1976). Lineaments are believed to be the expressions of ancient, deep-crustal or trans-lithospheric structures, which periodically have been reactivated as planes of weakness during subsequent tectonic events. These planes of weakness, and in particular their intersections, may provide high-permeability channels for storage of water (Richards, 2000). Structures (lineaments) are therefore considered as conduits and trap zones for water.

From the Satellite Image (fig 10 & 11) obtained from LandSat 7 ETM, a pattern of lineaments was delineated. It would be noted that the dominant lineaments trend in a NE-SW, and N – S, direction. This is the general trend of Pan African structures in the North Central Basement. Few structures are however trending in a NW-SE direction. The trend of the structures and the profiling in the VES show some degree of agreement. Thus with liberality, it can be inferred that appearance of structures at the surface as demonstrated in the satellite image is truly a representation of the subsurface structures.

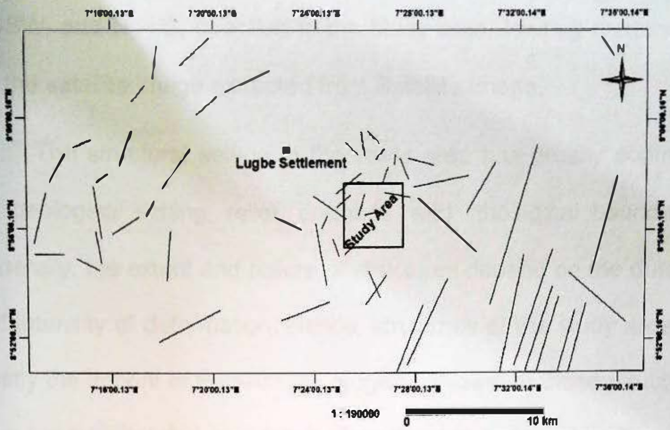


Fig 11: Lineaments of Abuja and its environemt extracted from Satellite Image

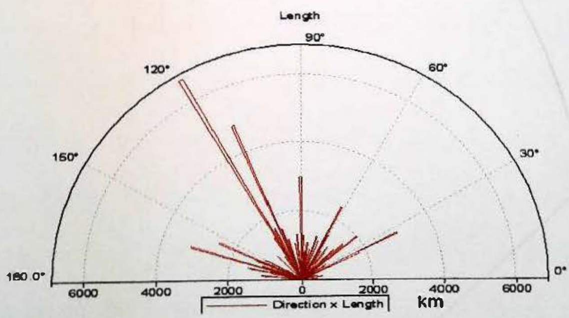


Fig 12: Rose Diagram of Lineaments Extracted from LandSat Imagery of Parts Abuja and Environs

The above rose diagram shows that lineaments trend in a NW, NE-SW, and N – S, direction in the study area, lending credence to the the satellite image extracted from Satellite Image.

The structural setting in the study area has greatly controlled the geological setting, relief, drainage, and lithological boundaries. Generally, the extent and nature of structures depend on the duration and intensity of deformation. Hence, structures of the study area are mostly the imprint of Pan-African orogeny. However these structures have been obliterated as a result of weathering and erosion. They are observed as relics in some parts. While in a few exposures they are still well preserved.

CHAPTER FIVE: Summary, Conclusion and Recommendation

5.0 Summary

A total of 40 geophysical soundings were carried out in the study area. From the interpretation of the VES (Vertical Electrical Sounding), the area is characterized mainly by H, HA, QH, QHA, A, AK and HK type curves with 2 to 4 geo-electric layers/geologic units (Appendix A). Depth of 0m to 8.92m is the average thickness and depth of the top soil. It is hard, dry and lateritic. It is characterized by varying resistivity values ranging from 32 ohm-m to 2915 ohm-m. The second layer which is from 8.92m to 19.2m and has resistivity values ranging from 23 Ohm-m to 1127 ohm-m. This layer is considered to be the weathered layer. The third layer starts from the depth of 19.2m. It is slightly weathered and grades into fresh basement with increasing depth. Several fractures of varying thicknesses were encountered in the course of the study. Boreholes can thus be drilled on VES points with weathering and/or fracturing (VES 9, VES 11, VES 16, VES 21, and VES 31). However, drilling on fractured points should be on exploratory basis. This is because not all fractures are aquiferous and they can only be aquiferous if they are well linked with other fractures.

The Global Positioning System (GPS) readings in the Elevation Contour Map reveal that the area has been affected by tectonic events that transformed it to a graben.

5.1 Conclusion

- This information is going to be relevant to the development of an effective water scheme in the study area.
- From the Vertical Electrical Sounding (VES) interpretations, the study area can be described as fair to good for groundwater exploration. Boreholes can therefore be drilled on the VES points shown in table 42 (Appendix A).
- The rose diagram calculated from the lineaments generated from the satellite image of the study area, show that NE-SW, and N – S fractures are more abundant in the study area with few trending in a NW-SE (fig 12). These structures agree with the trends of Pan – African structures (fractures and faults) `found in the Basement Complex of Nigeria (Oluyide, 1981).
- Subsurface (VES) interpretation show the lineaments that were run on the profiles in a N-E and S-W direction ,to be concurrent with the trend of the structures in the regional lineament map

thus showing that the surface is a representation of the subsurface.

5.2 Recommendation

- Comprehensive pre-drilling, hydrogeological studies should be carried out for the entire area and all boreholes should be properly designed, developed and pump tested. The knowledge of this will reduce borehole failures and low yield currently experienced in some parts of the project area.
- Geophysical survey results should be compared with drilling data for better resistivity interpretations in order for productive and effective borehole construction to be achieved.
- The Federal Government should provide more incentives to enable researchers carry out more detailed research work successfully.

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APPENDIX A

Geophysical Electrode Sounding Interpretation Tables

Geophysical Sounding No. P1
Table 2
Curve type: A - type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-6.50	109-441	Weathered basement	
2	6.50-30.17	1054-15865	Basement, fresh	

Geophysical Sounding No. P2
Table 3
Curve type: K - type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-1.18	1510-2915	Topsoil, hard	
2	1.18-3.72	5185-7623	Basement	
3	3.72-11.78	1207-2990	Basement with minor fractures	
4	11.78-37.3	1638-6584	Fresh basement	

Geophysical Sounding No. P3
Table 4
Curve type: HA - type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-0.89	605	Topsoil, dry	
2	0.89-13.1	107-397	Sand/sandy clay	Possibly Aquiferous
3	13.1-19.21	445	Slightly weathered basement	Possibly Aquiferous
4	19.21-41.39	1251-3312	Fresh basement	

Geophysical Sounding No. P4
Table 5
Curve type: H - type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-2.82	354-666	Topsoil, dry	
2	2.82-13.09	152-246	Weathered basement (sand/sandy clay)	Possibly Aquiferous
3	13.09-41.39	479-3914	Slightly weathered basement and freshening with increasing depth	

Geophysical Sounding No. P5
Table 6
Curve type: HA - type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-0.81	535	Topsoil	
2	0.81-3.74	106-274	Weathered basement	
3	3.74-25.48	699-6782	Slightly weathered basement grading to fresh basement with increasing depth	

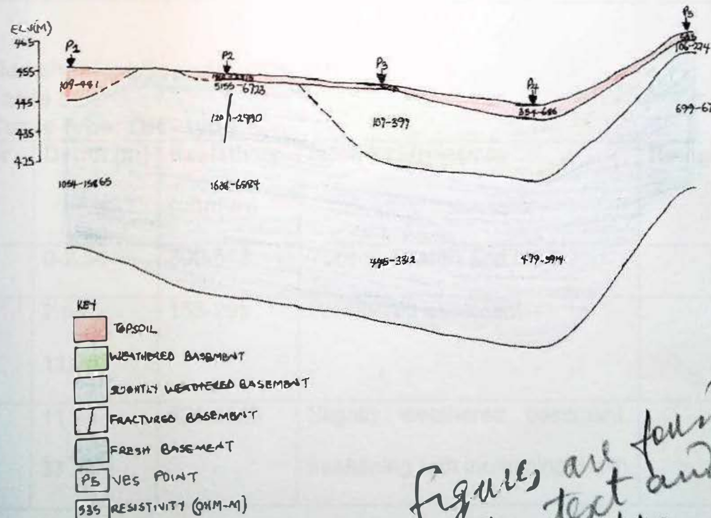


Fig 17: Geo-electric Section 1/profile 1

figures are found written text and not as appendice

Geophysical Sounding No. P6
Table 7
Curve type: H - type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-1.92	217-305	Topsoil	
2	1.92-8.92	37-83	Weathered basement (sand/sandy clays)	Possibly Aquiferous
3	8.92-41.39	164-2981	Slightly weathered basement freshening with depth	

Geophysical Sounding No. P7
Table 8
Curve type: QH - type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-2.54	300-513	Topsoil, lateritic and hard	
2	2.54-11.78	153-295	Weathered basement	
3	11.78-37.25	621-4143	Slightly weathered basement, freshening with increasing depth	

Geophysical Sounding No. P8
Table 9
Curve type: H- type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-4.60	328-570	Topsoil, hard	
2	4.60-21.35	80-231	Weathered basement (sand/sandy clay)	Possibly Aquiferous
3	21.35-4599	789-2654	Basement, fresh	

Geophysical Sounding No. P9
Table 10
Curve type: AK - type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-2.54	464-571	Topsoil (weathered basement)	
2	2.54-11.78	836-3473	Basement	
3	11.78-37.25	1593-2890	Basement, fractured	Possibly Aquiferous

Geophysical Sounding No. P10
Table 11
Curve type: H - type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-4.14	219-550	Topsoil, lateritic	
2	4.14-13.09	88-224	Weathered basement (sands/sandy clay)	Possibly Aquiferous
3	13.09-41.39	631-4629	Slightly weathered basement freshening with increasing depth	

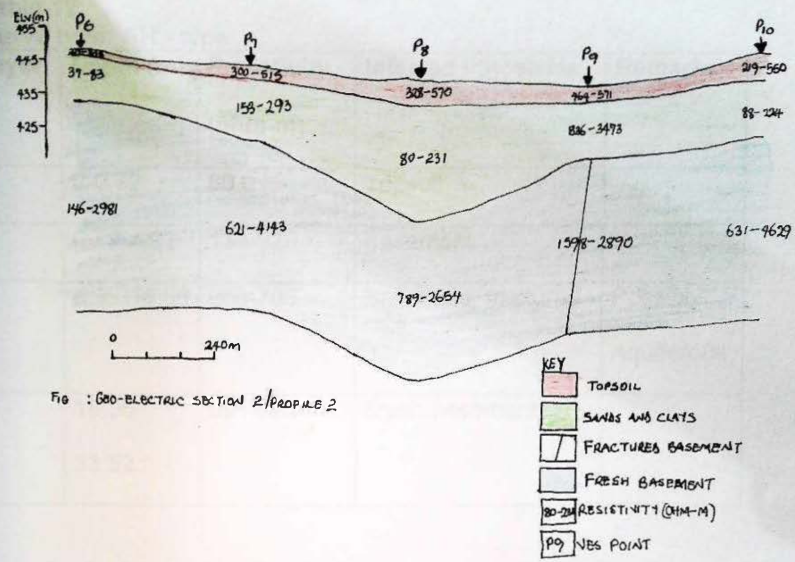


Fig 18: Geo-electric section 2/profile 2

Geophysical Sounding No. P11
Table 12
Curve type: AH - type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-0.72	80.0	Topsoil	
2	0.72-4.92	134-929	Basement	
3	4.92-15.56	256-786	Basement, fractured	Possibly Aquiferous
4	15.56-33.52	301-720	Fresh basement	

Geophysical Sounding No. P12
Table 13
Curve type: QH - type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-8.92	1097-2398	Hard, lateritic topsoil	
2	8.92-19.2	180-301	Sands/sandy clay	Possibly Aquiferous
3	19.2-41.39	392-962	Slightly weathered basement freshening with increasing depth	

Geophysical Sounding No. P13
Table 14
Curve type: QH - type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-0.89	327	Topsoil, hard	
2	0.89-6.1	178-768	Laterite	
3	6.1-13.1	95-97	Sand/sandy clay	Possibly Aquiferous
4	13.1-28.2	189-439	Weathered basement	
5	28.2-41.4	1154	Fresh basement	

Geophysical Sounding No. P14
Table 15
Curve type: QH - type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-2.82	461-765	Topsoil, laterite	
2	2.82-13.09	88-265	Weathered basement (sands/sandy clay)	Possibly Aquiferous
3	13.09-41.39	309-2360	Basement, freshening with increasing depth	

Geophysical Sounding No. P15
Table 16
Curve type: QH - type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-2.82	724-1267	Topsoil, lateritic, hard	
2	2.82-19.21	341-590	Weathered basement	
3	19.21-41.39	791-1416	Slightly weathered basement, freshening with depth	

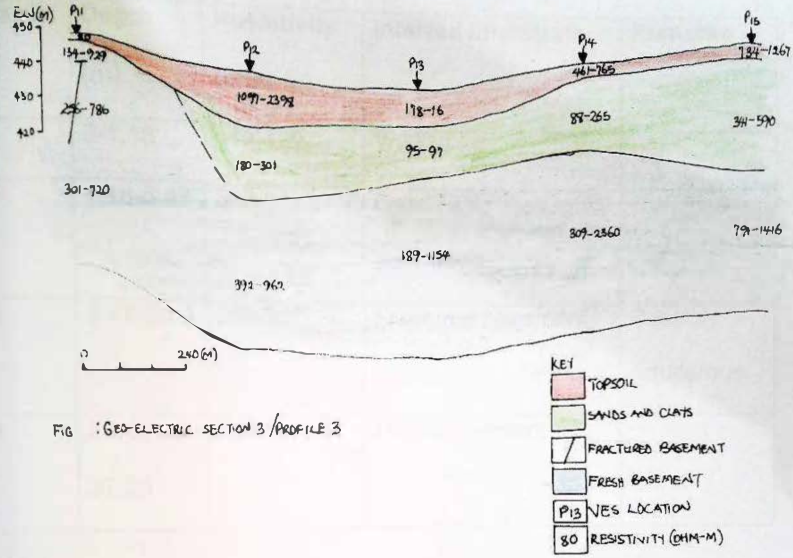


Fig 19: Geo-electric section 3/profile 3

Geophysical Sounding No. P16
Table 17
Curve type: AK - type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-1.18	112-182	Topsoil	
2	1.18-5.47	323-1172	Basement, slightly weathered	
3	5.47-25.4	269-967	Fractured basement	Possibly Aquiferous
4	25.4-37.25	748	Fresh basement	

Geophysical Sounding No. P17
Table 18
Curve type: A- type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-4.92	71-206	Weathered basement (sands and clays)	
2	4.92-33.52	347-2686	Basement, freshening with increasing depth	

Geophysical Sounding No. P18
Table 19
Curve type: H - type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-0.80	217	Topsoil	
2	0.80-8.03	23-78	Weathered basement (sands/sandy clay)	Possibly Aquiferous
3	8.03-37.25	133-12.58	Slightly weathered basement freshening with depth	

Geophysical Sounding no. P19
Table 20
Curve type: A- type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-4.92	294-522	Slightly weathered basement	
2	4.92-33.52	635-21299	Slightly weathered basement grading into fresh with increasing depth	

Geophysical Sounding No. P20
Table 21
Curve type: H- type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-6.75	654-918	Topsoil, lateritic, hard	
2	6.75-31.33	128-434	Weathered basement (sand/sandy clay)	Possibly Aquiferous
3	31.33-45.99	779	Fresh basement	

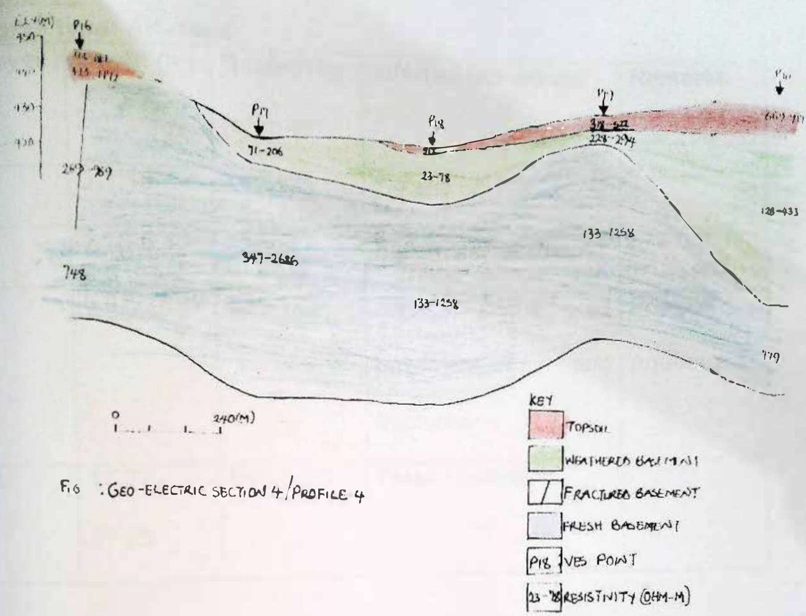


Fig 20: Geo-electric section 4/profile 4

Geophysical Sounding No. P21
Table 22
Curve type: AK- type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-1.18	151-173	Topsoil	
2	1.18-5.47	277-527	Basement, weathered	
3	5.47-17.29	291-372	Slightly weathered basement and fractured	Possibly Aquiferous
4	17.27-37.25	849-1980	Fresh basement	

Geophysical Sounding No. P22
Table 23
Curve type: HA- type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-1.92	108-407	Topsoil	
2	1.92-13.09	49-70	Weathered basement (sands and clays)	Possibly Aquiferous
3	13.09-	173-429	Slightly weathered to	

	28.2		fresh basement	
4	28.2-41.4	1120	Fresh basement	

Geophysical Sounding No. P23
Table 24
Curve type: H- type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-1.06	81-85	Topsoil	
2	1.06-7.22	53-92	Sands and clays	Possibly Aquiferous
3	7.22-22.84	112-421	Weathered basement	Possibly Aquiferous
4	22.84-33.52	1176	Fresh basement`	

Geophysical Sounding No. P24
Table 25
Curve type: H- type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-2.83	165-213	Topsoil	
2	2.83-8.95	60-98	Weathered basement (sands and clays)	Possibly Aquiferous
3	8.95-28.31	198-876	Slightly weathered basement, freshening with increasing depth	

Geophysical Sounding No. P25
Table 26
Curve type: H- type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-4.14	352-726	Topsoil, lateritic	
2	4.14-19.21	113-297	Weathered basement	

3	19.21-41.4	789-2174	Slightly weathered basement grading to fresh with increasing depth	

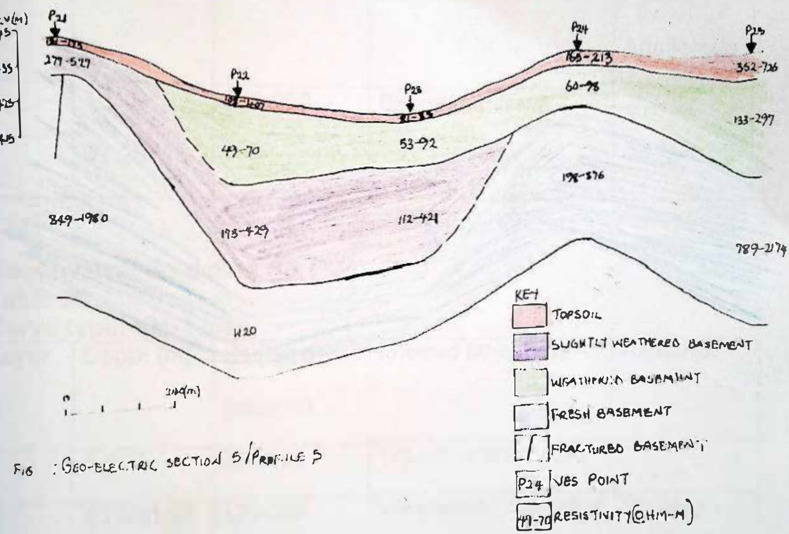


Fig 21: Geo-electric section 5/profile 5

Geophysical Sounding No. P26
Table 27
Curve type: AK-type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-1.18	119-138	Topsoil	
2	1.18-5.47	214-864	Basement	
3	5.47-17.29	181-616	Basement, fractured	Possibly Aquiferous
4	17.29-37.25	298-980	Basement, fresh	

Geophysical Sounding No. P27
Table 28
Curve type: KH- type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-6.75	277-409	Topsoil, lateritic, hard	
2	6.75-31.33	120-392	Weathered basement (sand/sandy clay)	Possibly Aquiferous
3	31.33-45.99	559	Fresh basement	

Geophysical Sounding No. P28
Table 29
Curve type: A- type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-15.56	108-340	Weathered basement	Possibly Aquiferous
2	15.56-33.52	653-1455	Slightly weathered basement, freshening with increasing depth	

Geophysical Sounding No. P29
Table 30
Curve type: H- type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-4.14	722-1754	Topsoil	
2	4.14-19.21	41-168	Weathered basedment	Possibly Aquiferous
3	19.21-41.39	365-894	Basement, freshening with depth	

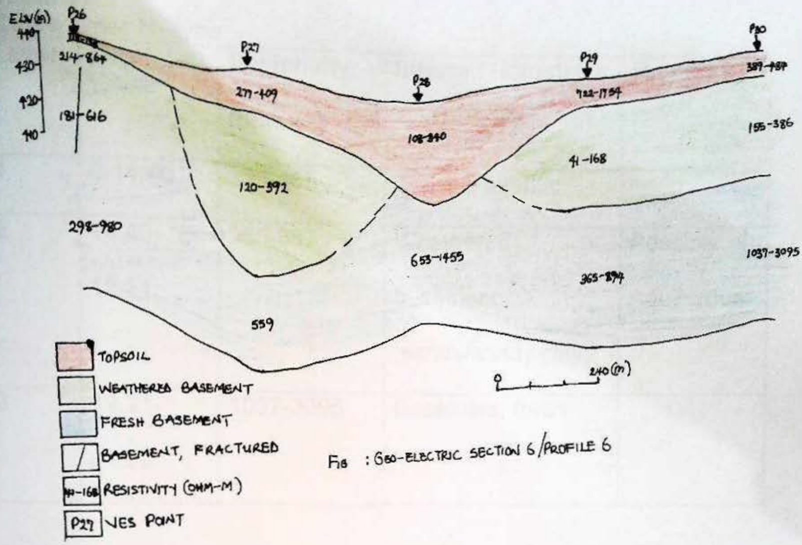


Fig 22: Geo-electric section 6/profile 6

Geophysical Sounding No. P30
Table 31
Curve type: H- type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-14.40	339-485	Topsoil, lateritic	
2	14.40-19.21	155-387	Weathered basement (sands/sandy clay)	Possibly Aquiferous
3	19.21-41.39	1037-3095	Basement, fresh	

Geophysical Sounding No. P31
Table 32
Curve type: AK- type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-1.31	187-193	Topsoil	
2	1.31-4.14	285-619	Basement, slightly weathered	
3	4.14-13.09	159-449	Fractured basement	Possibly Aquiferous
4	13.09-41.39	279-1310	Slightly weathered basement and freshening with increasing depth	

Geophysical Sounding No. P32
Table 33
Curve type: H- type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-1.18	133-275	Topsoil	
2	1.18-5.74	42-77	Weathered basement (sands and clays)	Possibly Aquiferous
3	5.47-37.30	103-176	Slightly weathered basement freshening with increasing depth	Possibly Aquiferous

Geophysical Sounding No. P33
Table 34
Curve type: QH- type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-2.82	127-224	Topsoil	
2	2.82-13.09	18-66	Sandy clays	Possibly Aquiferous
3	13.09-41.39	179-1185	Slightly weathered basement, freshening with increasing depth	

Geophysical Sounding No. P34
Table 35
Curve type: H- type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-1.18	130-159	Topsoil	
2	1.18-8.03	56-79	Sands and clays	Possibly Aquiferous
3	8.03-17.29	122-697	Slightly weathered basement, freshening with increasing depth	

Geophysical Sounding No. P35
Table 36
Curve type: HA- type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-6.08	1325-1634	Topsoil, lateritic, hard	
2	6.08-28.20	67-157	Weathered basement (sands/sandy clays)	Possibly Aquiferous
3	28.20-41.39	273	Slightly weathered basement	

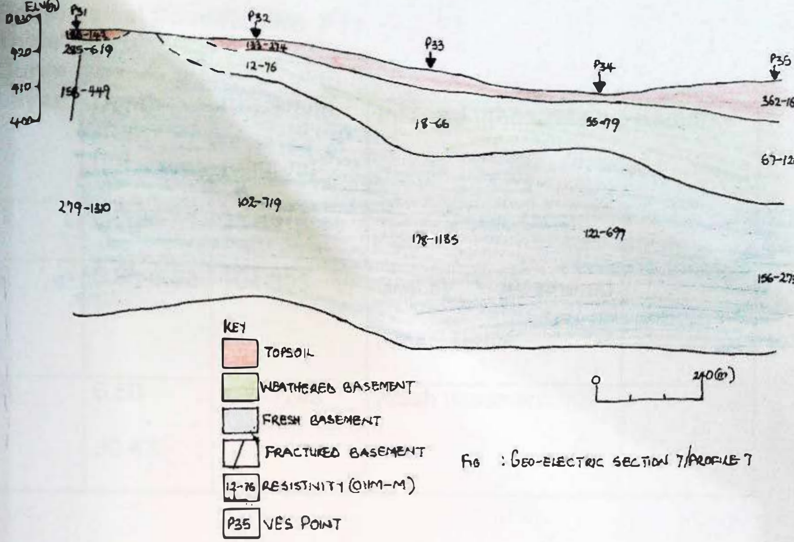


Fig 23: Geo-electric section 7/profile 7

Geophysical Sounding No. P36
Table 37
Curve type: QH- type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-4.14	400-959	Topsoil, lateritic	
2	4.14-28.20	198-363	Weathered basement (sands/sandy clay)	Possibly Aquiferous
3	28.20-41.39	1160	Fresh basement	

Geophysical Sounding No. P37
Table 38
Curve type: A- type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-0.95	33-49	Topsoil	
2	0.95-6.50	104-393	Slightly weathered basement	
3	6.50-30.47	405-1246	Fresh basement	

Geophysical Sounding No. P38
Table 39
Curve type: QH- type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-6.08	399-753	Topsoil, lateritic, hard	
2	6.08-28.20	163-449	Weathered basement (sands/sandy clays)	Possibly Aquiferous
3	28.20-41.39	249	Slightly weathered basement	

Geophysical Sounding No. P39
Table 40
Curve type: QHA- type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-1.18	69-100	Topsoil	
2	1.18-5.47	136-229	Laterite	
3	5.47-17.29	76-193	Sands/sandy clay	Possibly Aquiferous
4	17.29-37.25	535-1553	Slightly weathered basement, freshening with increasing depth	

Geophysical Sounding No. P40
Table 41
Curve type: H - type

Layer	Depth (m)	Resistivity (ohm-m)	Inferred lithostrata	Remarks
1	0-3.50	198-594	Topsoil	
2	3.50-23.81	15-108	Sands/sandy clay	Possibly Aquiferous
3	23.81-34.95	326	Slightly weathered basement	

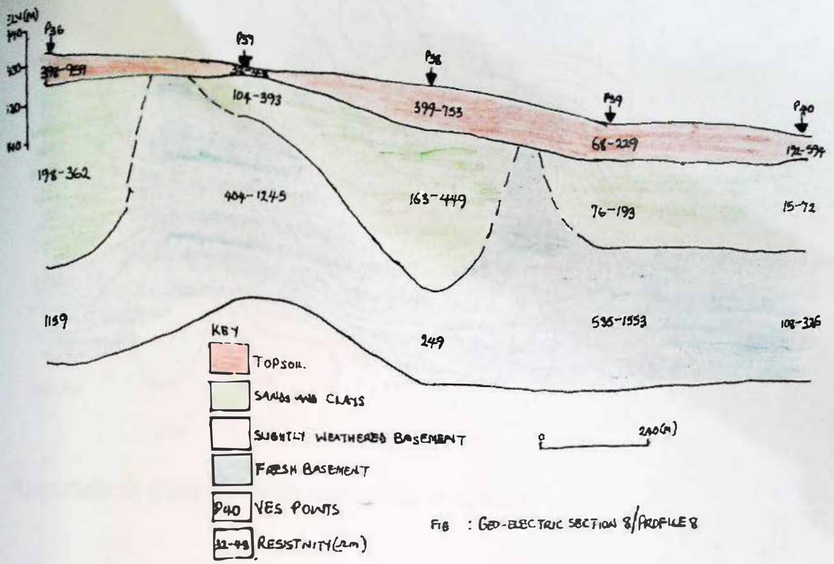
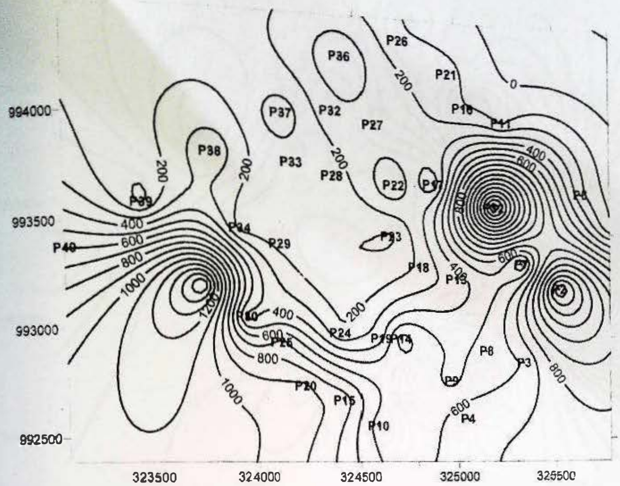
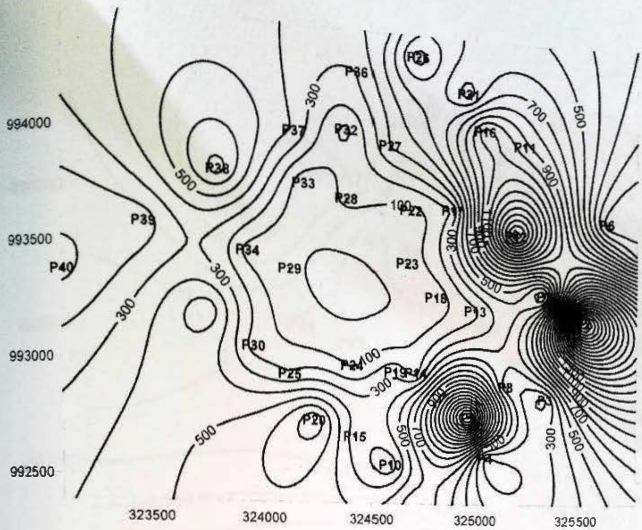


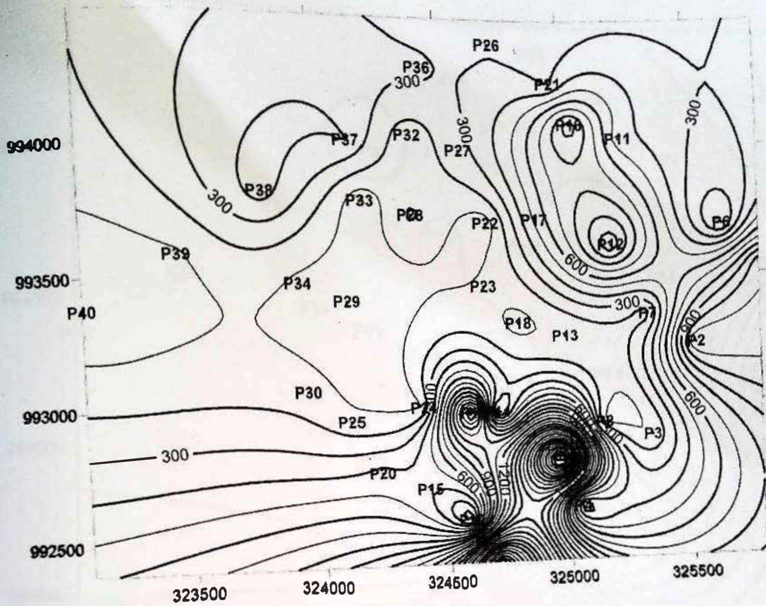
Fig24: Geo-electric section 8/profile8



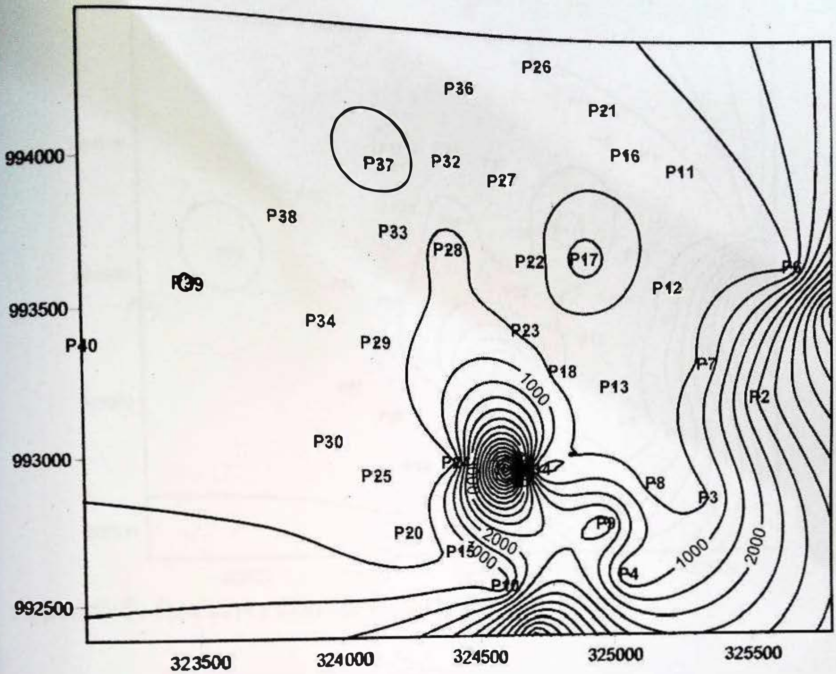
Appendix B (Resistivity Contour Map of topsoil)



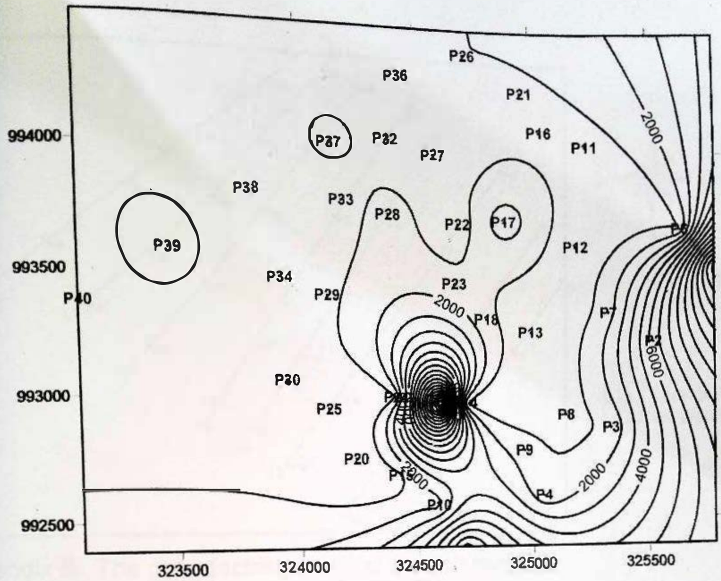
Appendix B: Resistivity Contour Map at 5m



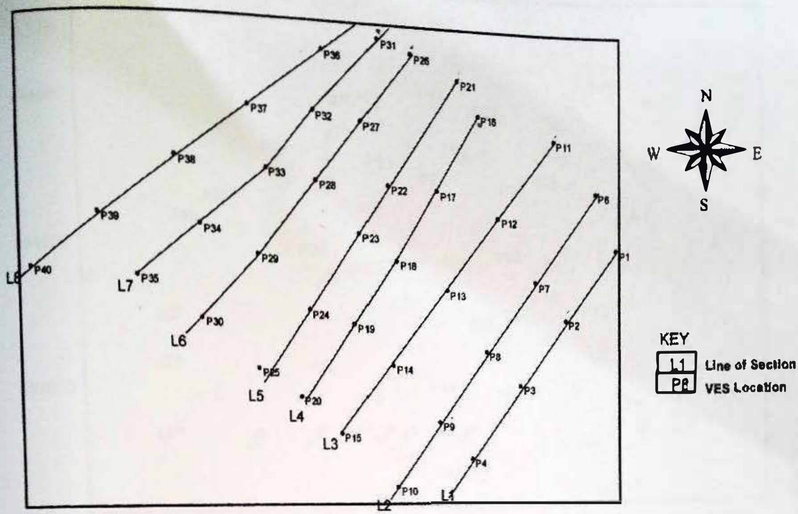
Appendix B: Resistivity Contour Map at 10m



Appendix B : Resistivity Contour Map at 20m

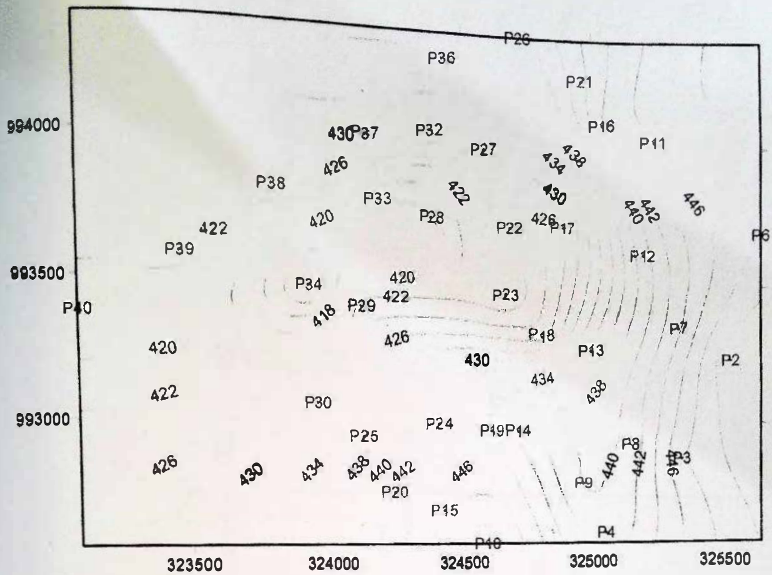


Appendix B: Resistivity Contour Map at 30m



Appendix B: The geo-electric sounding location map

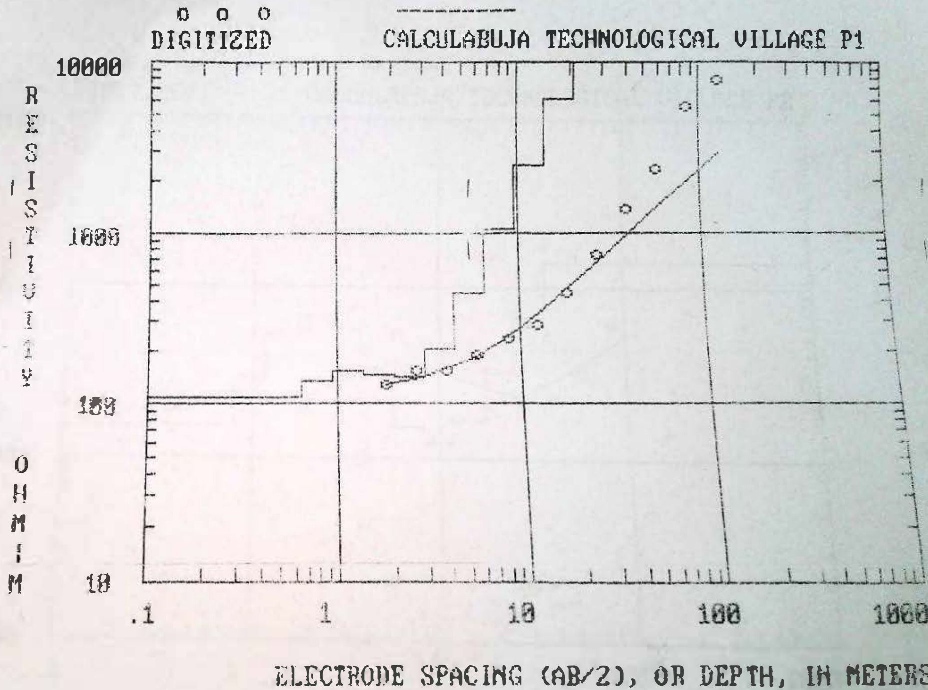
should be in the text.



Appendix B: Elevation Contour Map

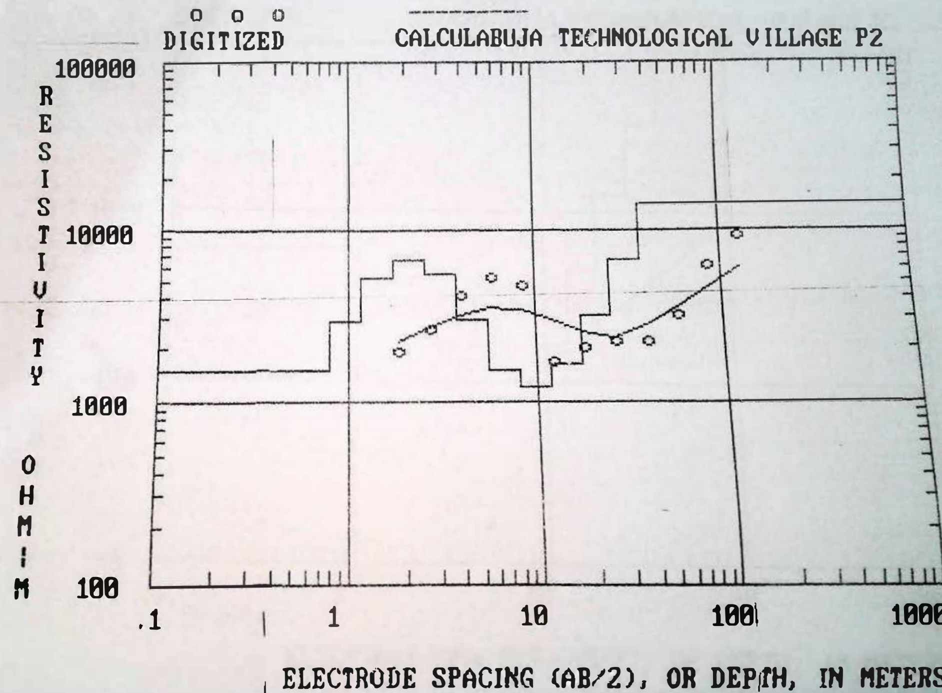
...BUJA TECHNOLOGICAL VILLAGE P1 (INTERPRETATION)

DEPTH	RESIS.	DEPTH	RESIS.
0.65	109.34	6.50	441.31
0.95	135.88	9.54	1054.22
1.40	153.34	14.00	2540.55
2.06	144.32	20.56	6152.41
3.02	142.96	30.17	15864.63
4.43	210.34	99999.00	46737.69



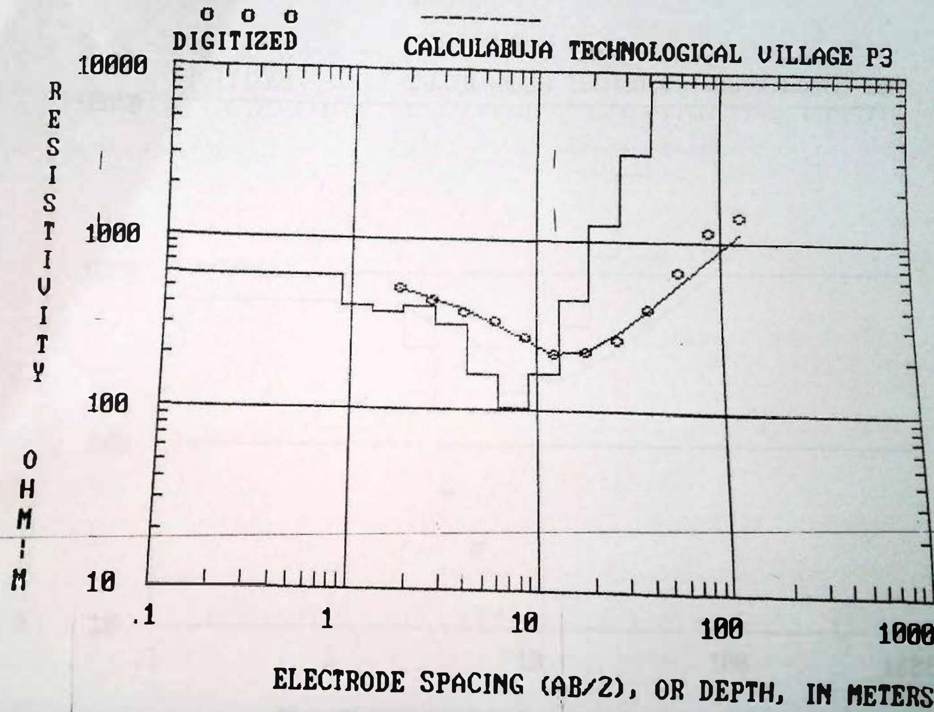
LOGICAL VILLAGE P2 (INTERPRETATION)

DEPTH RESIS. DEPTH RESIS.



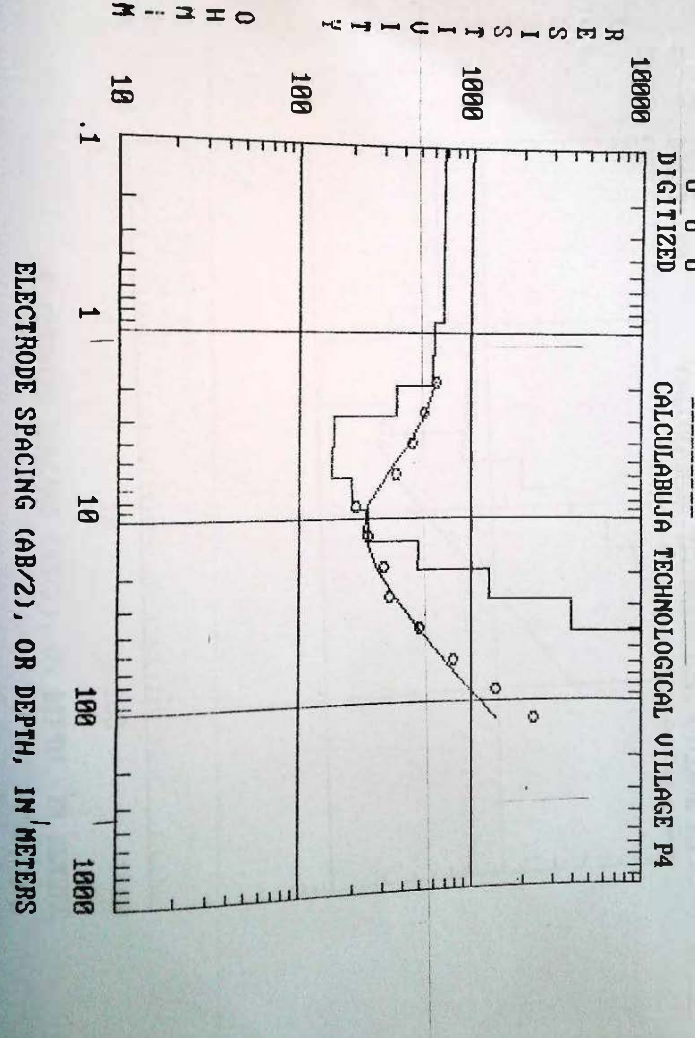
ECHNOLOGICAL VILLAGE P3 (INTERPRETATION)

DEPTH	RESIS.	DEPTH	RESIS.
0.89	605.28	8.97	101.63
1.31	397.03	13.09	163.08
1.92	362.71	19.21	445.47
2.82	395.77	28.20	1251.38
4.14	311.59	41.39	3311.64
6.08	157.69	99999.00	8917.98



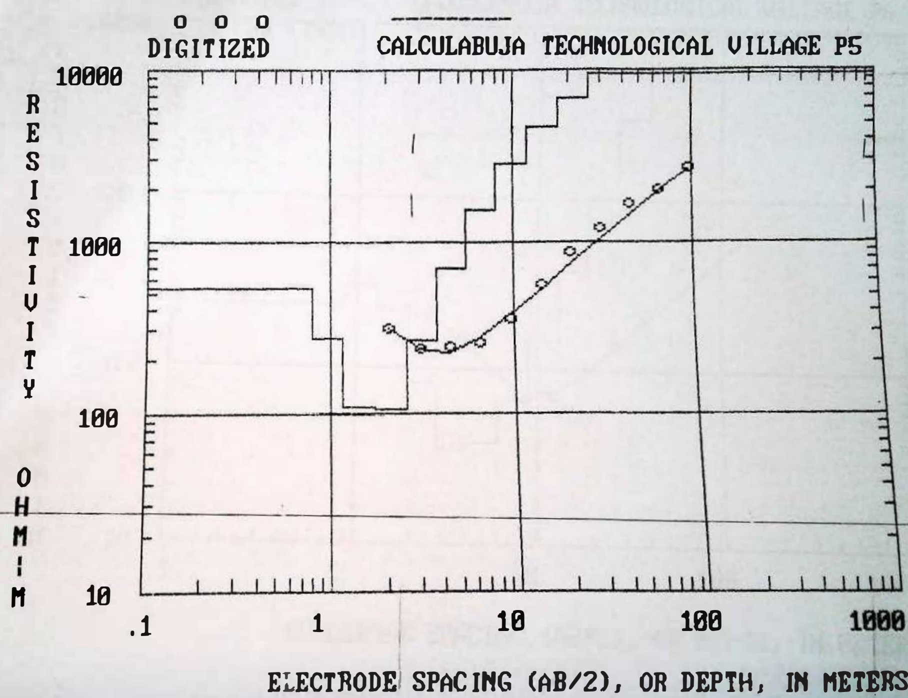
ABUJA TECHNOLOGICAL VILLAGE P4 (INTERPRETATION)

DEPTH	RESIS.	DEPTH	RESIS.
0.89	685.67	8.92	194.99
1.31	597.75	13.09	246.35
1.93	577.50	19.21	479.61
2.83	353.58	28.20	1284.83
4.14	154.66	41.39	3913.95
6.08	152.13	99999.00	13548.28



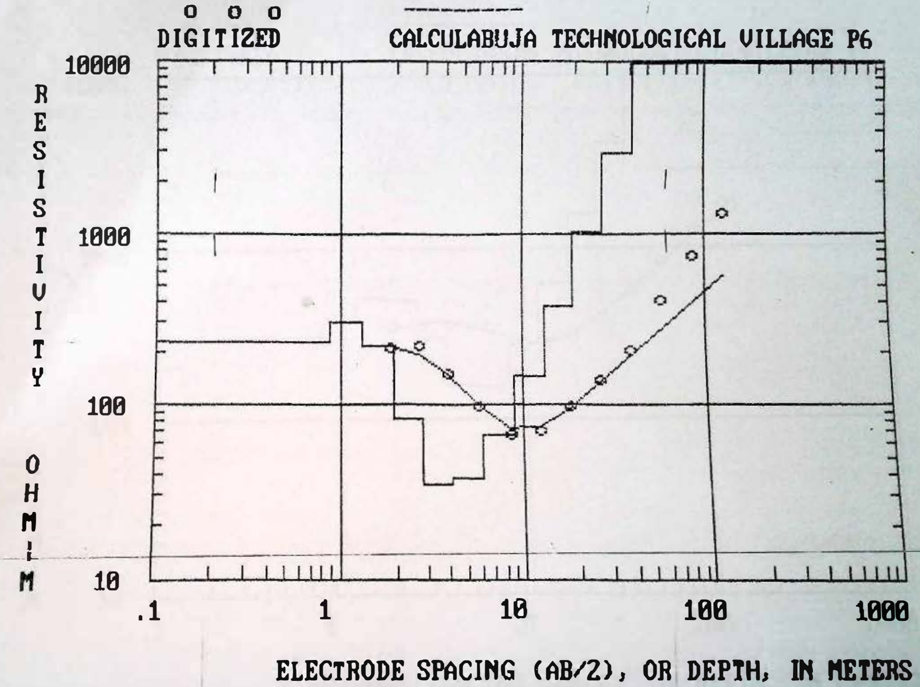
ABUJA TECHNOLOGICAL VILLAGE P5 (INTERPRETATION)

DEPTH	RESIS.	DEPTH	RESIS.
0.81	535.41	5.49	699.04
1.18	274.05	8.06	1555.38
1.74	109.87	11.83	2886.43
2.55	106.38	17.36	4630.91
3.74	262.49	25.48	6781.98
		99999.00	9471.50



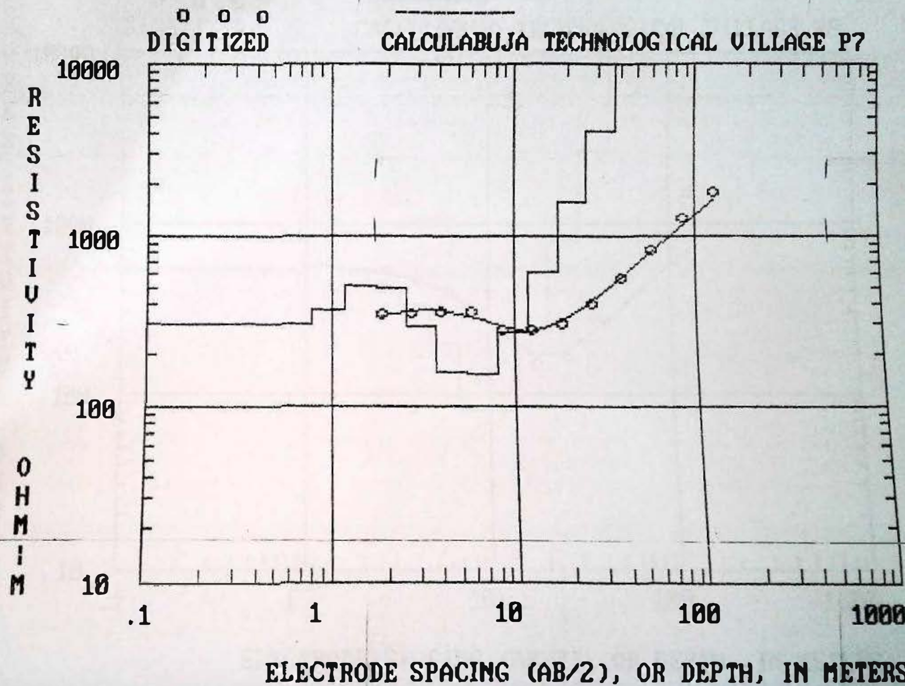
ABUJA TECHNOLOGICAL VILLAGE P6 (INTERPRETATION)

DEPTH	RESIS.	DEPTH	RESIS.
0.89	231.37	8.92	67.40
1.31	305.08	13.09	146.11
1.92	217.38	19.21	376.12
2.82	83.31	28.20	1035.40
4.14	34.94	41.39	2981.37
6.08	37.99	99999.00	9635.29



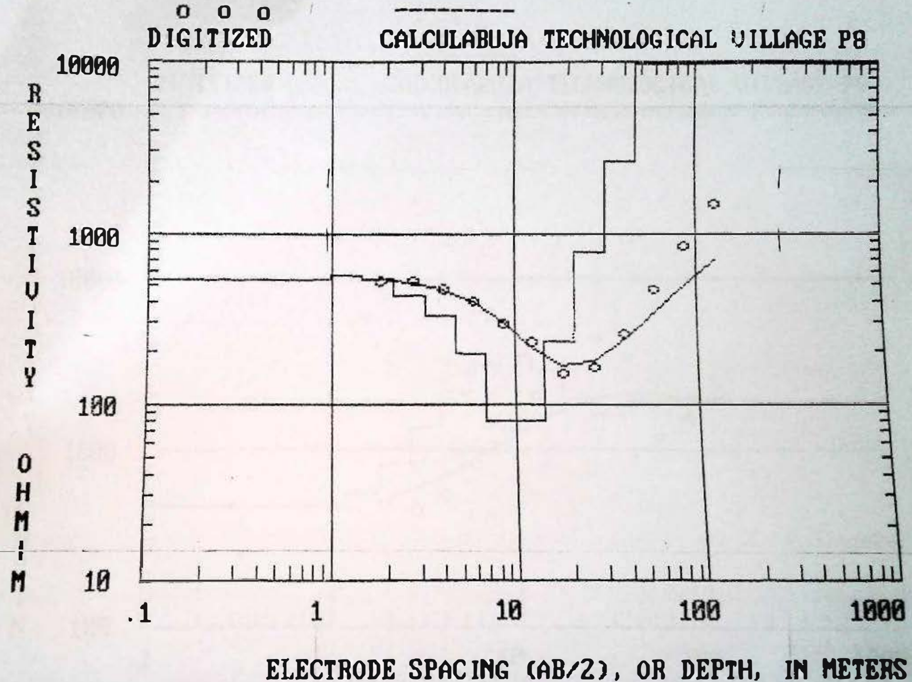
ABUJA TECHNOLOGICAL VILLAGE P7 (INTERPRETATION)

DEPTH	RESIS.	DEPTH	RESIS.
0.80	299.83	8.03	153.25
1.18	370.41	11.78	269.30
1.73	513.16	17.29	620.77
2.54	501.16	25.38	1563.90
3.72	295.48	37.25	4142.68
5.47	160.45	99999.00	11965.58



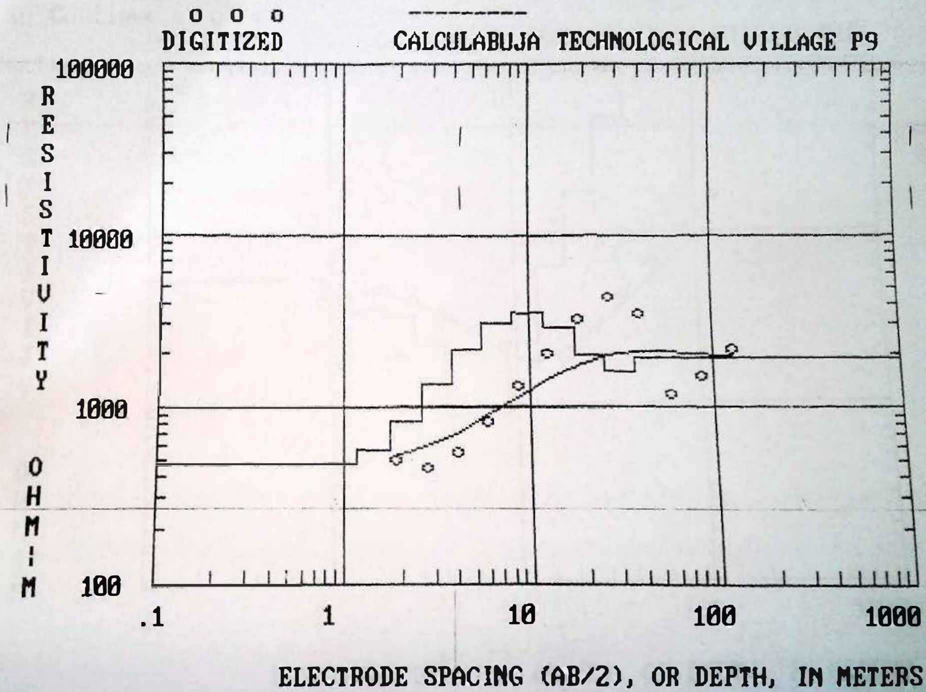
ABUJA TECHNOLOGICAL VILLAGE P8 (INTERPRETATION)

DEPTH	RESIS.	DEPTH	RESIS.
0.99	537.79	9.91	80.92
1.45	570.37	14.54	79.81
2.13	535.37	21.35	230.79
3.13	435.91	31.33	788.66
4.60	327.57	45.99	2653.54
6.75	194.99	99999.00	9784.48



ABUJA TECHNOLOGICAL VILLAGE P9 (INTERPRETATION)

DEPTH	RESIS.	DEPTH	RESIS.
0.80	474.61	8.03	3061.17
1.18	464.15	11.78	3473.27
1.73	570.80	17.29	2890.09
2.54	836.11	25.38	1982.96
3.72	1333.03	37.25	1592.53
5.47	2130.23	99999.00	1916.82



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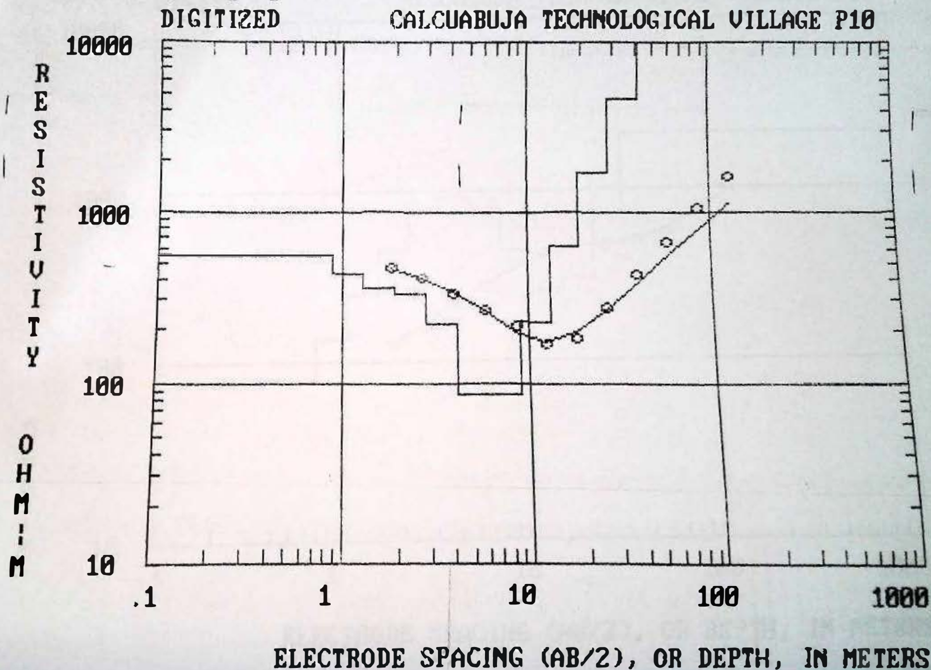

DEPTH	RESIS.	DEPTH	RESIS.
0.89	[illegible]	8.92	87.91
1.31	[illegible]	13.09	223.52
1.92	[illegible]	19.21	[illegible]
2.82	[illegible]	28.20	[illegible]
4.14	[illegible]	41.39	4628.54
6.08	88.07	99999.00	13776.60

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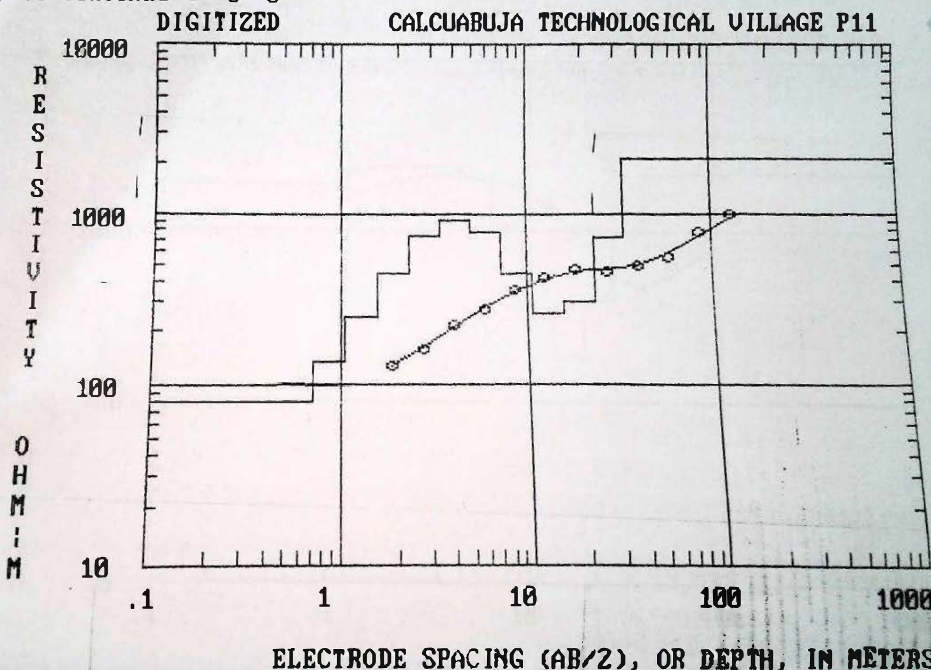
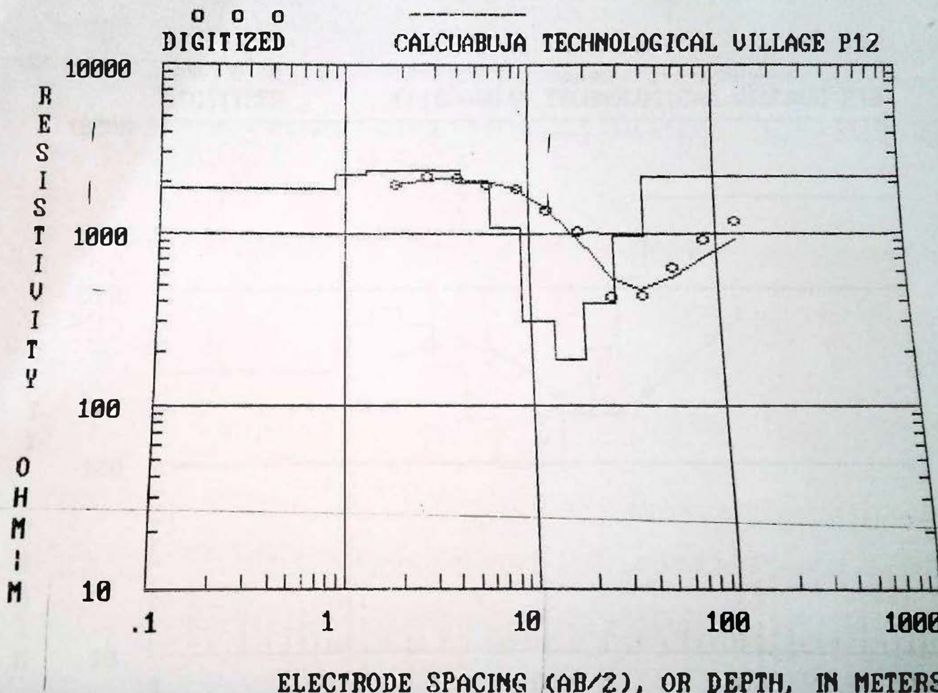
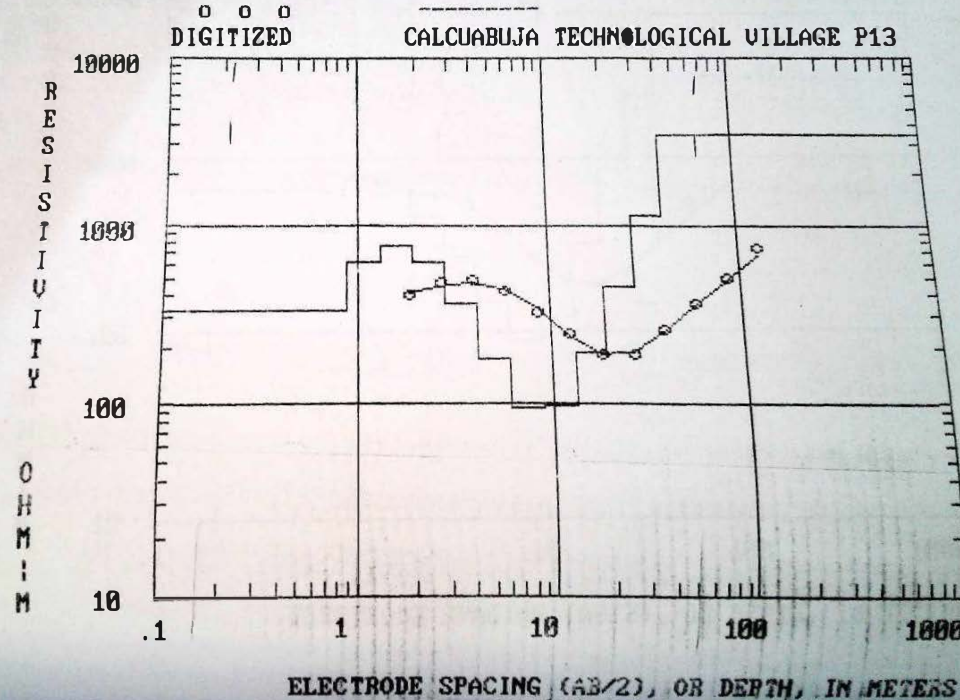


...ICAL VILLAGE P12 (INTERPRETATION)

DEPTH	RESIS.	DEPTH	RESIS.
0.89	1840.39	8.92	1096.63
1.31	2232.47	13.09	301.73
1.92	2398.41	19.21	180.14
2.82	2401.04	28.20	392.67
4.14	2353.50	41.39	962.42
6.08	2041.21	99999.00	2206.32

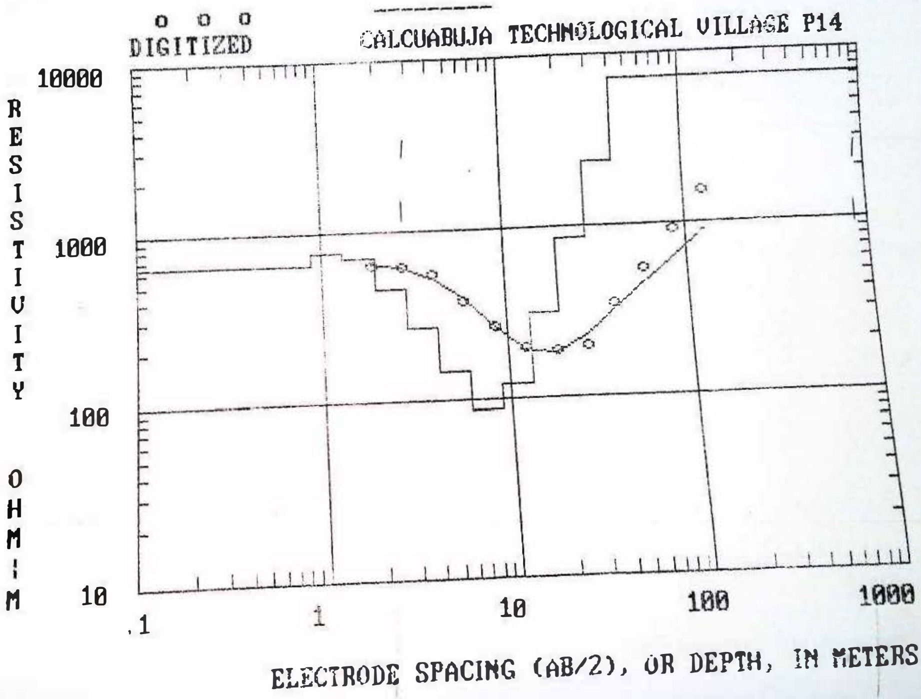




DIGITIZED
CALCUABUJA TECHNOLOGICAL VILLAGE P13
RESISTIVITY OHM-M
10000
1000
100
10
.1
1
10
100
1000
ELECTRODE SPACING (AB/2), OR DEPTH, IN METERS

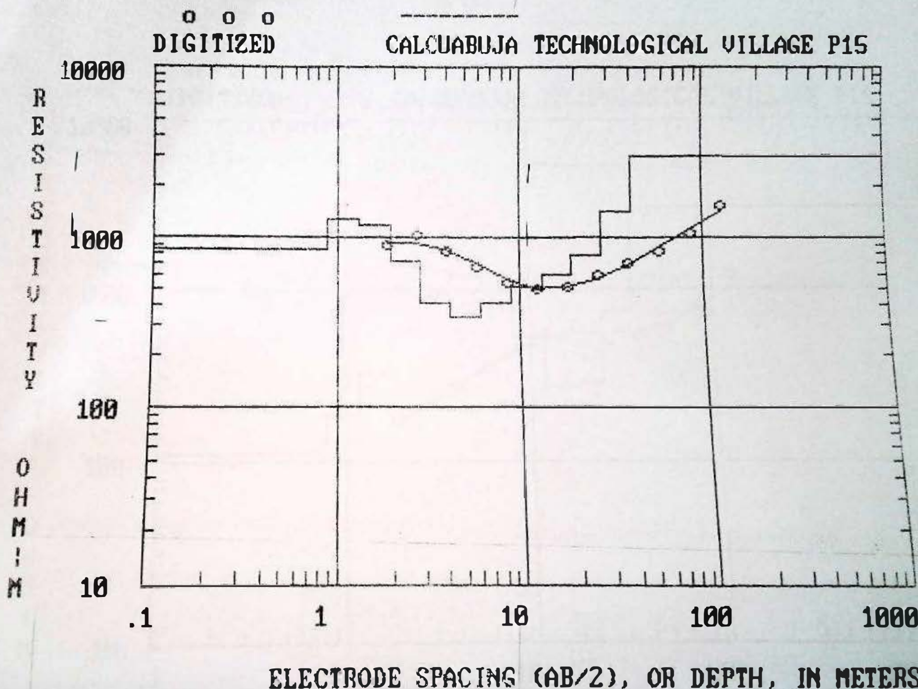
ABUJA TECHNOLOGICAL VILLAGE P14 (INTERPRETATION)

DEPTH	RESIS.	DEPTH	RESIS.
0.89	652.25	8.92	87.92
1.31	769.80	13.09	122.06
1.92	609.56	19.21	309.11
2.82	460.69	28.20	844.43
4.14	265.28	41.39	2359.76
6.08	147.55	9999.00	7197.01



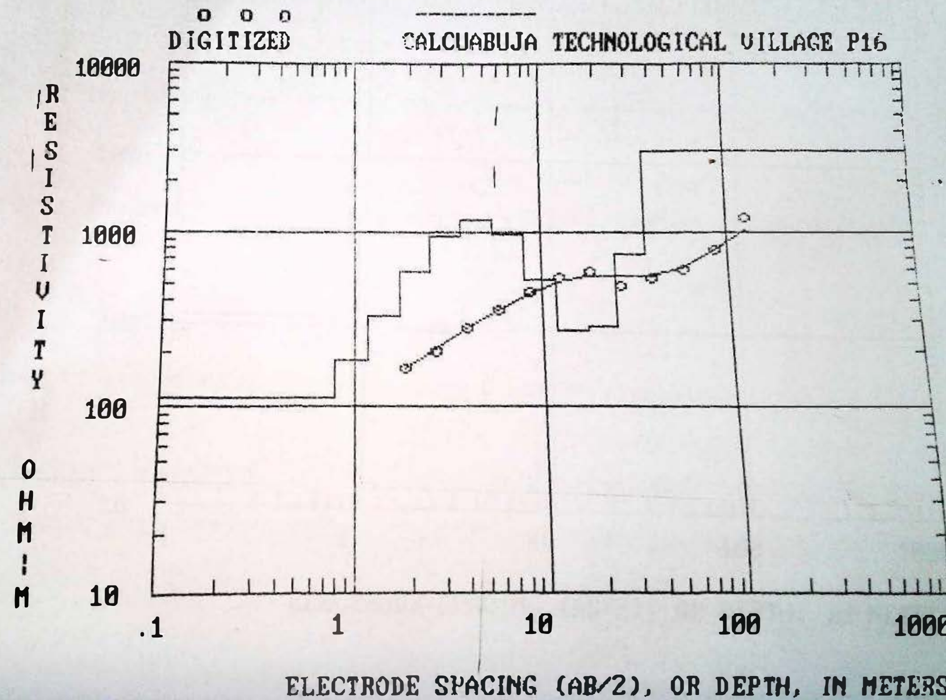
...LOGICAL VILLAGE P15 (INTERPRETATION)

DEPTH	RESIS.	DEPTH	RESIS.
0.89	858.18	8.92	414.09
1.31	1266.99	13.09	511.26
1.92	1178.04	19.21	589.77
2.82	723.93	28.20	791.41
4.14	410.73	41.39	1415.51
6.08	340.69	99999.00	3065.66



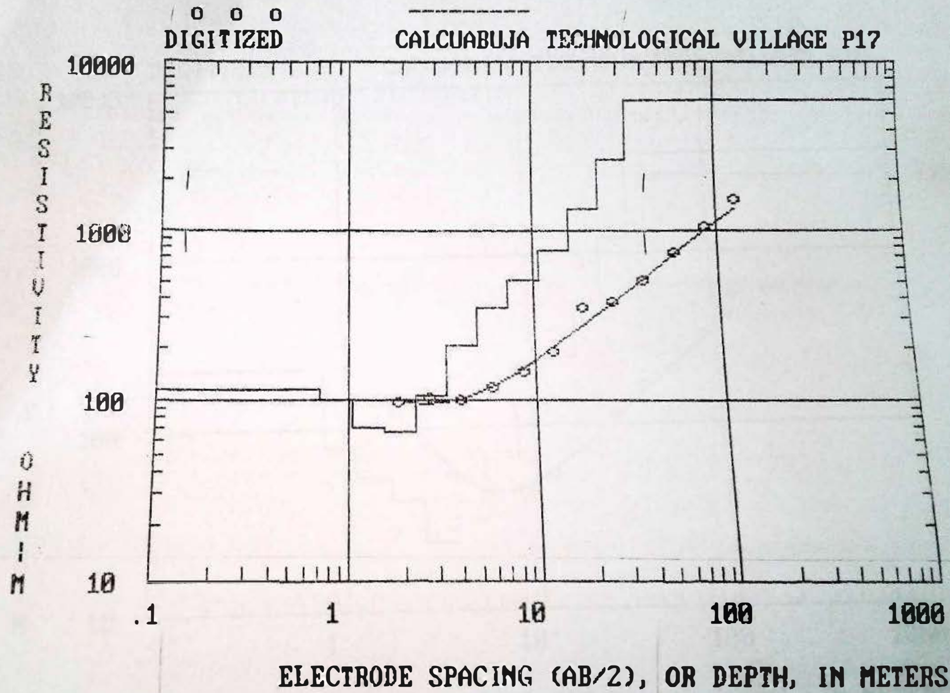
VILLAGE P16 (INTERPRETATION)

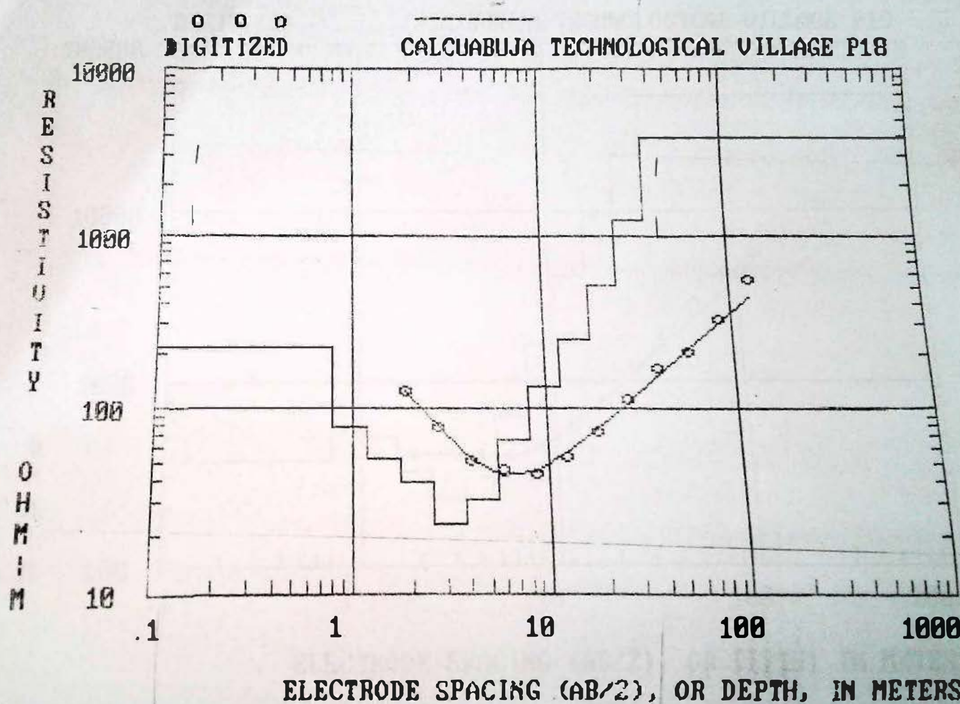
DEPTH	RESIS.
8.03	968.57
11.78	522.05
17.29	268.62
25.38	282.59
37.25	748.48
99999.00	3027.92



...NOLOGICAL VILLAGE P17 (INTERPRETATION)

DEPTH	RESIS.	DEPTH	RESIS.
0.72	113.93	7.22	347.34
1.06	99.37	10.60	510.07
1.56	70.56	15.56	769.68
2.28	65.90	22.84	1337.04
3.35	105.14	33.52	2686.[illegible]5
4.92	205.75	99999.00	6008.08

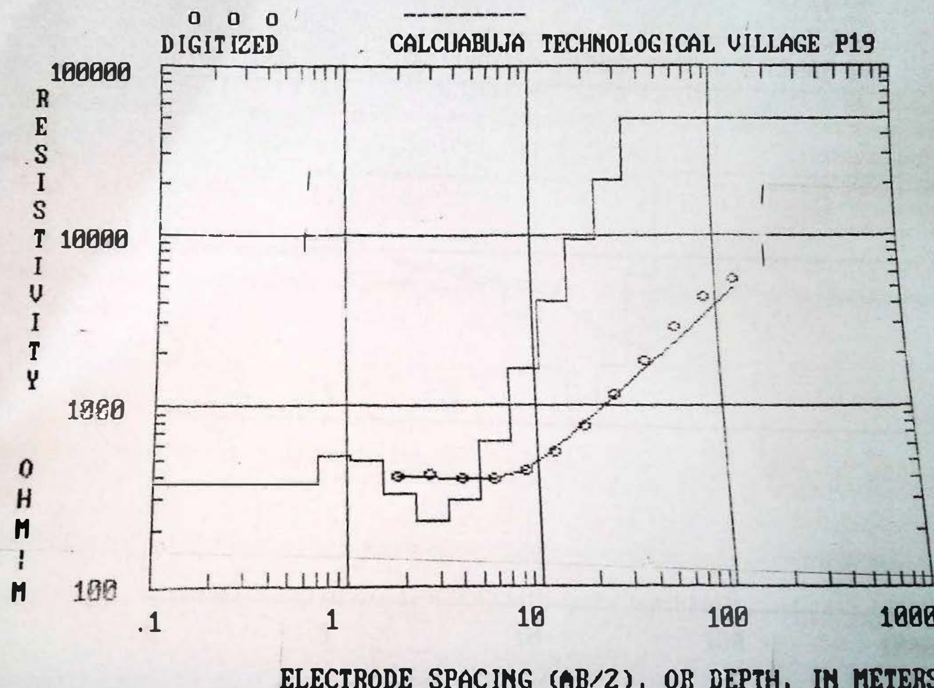




DIGITIZED
CALCUABUJA TECHNOLOGICAL VILLAGE P18
RESISTIVITY OHM-M
10000
1000
100
10
.1
1
10
100
1000
ELECTRODE SPACING (AB/2), OR DEPTH, IN METERS

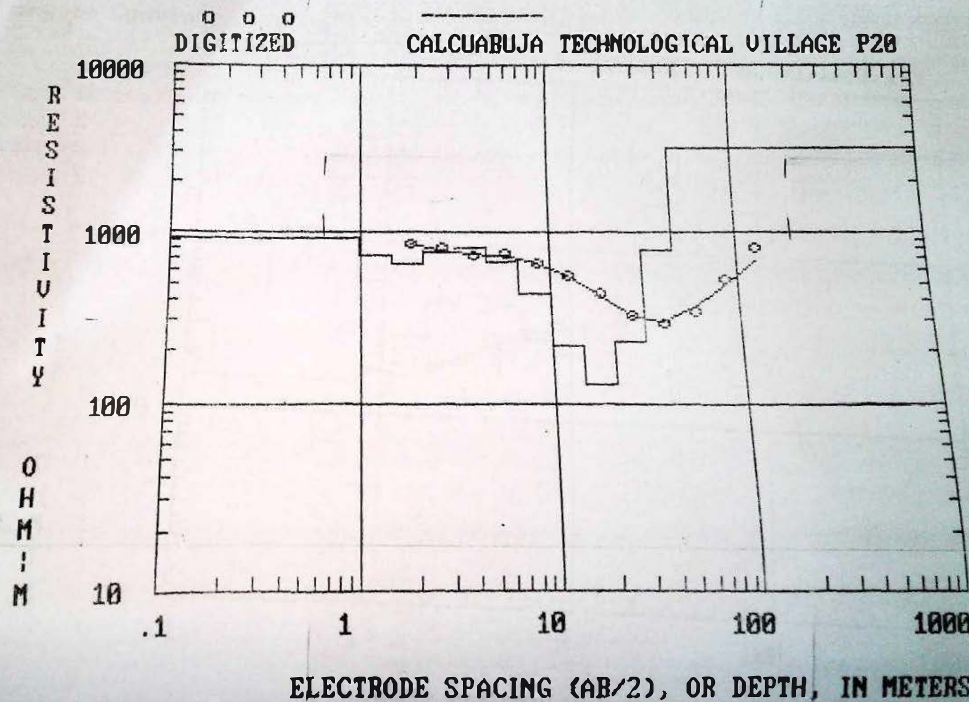
...LOGICAL VILLAGE P19 (INTERPRETATION)

DEPTH	RESIS.	DEPTH	RESIS.
0.72	366.16	7.22	633.31
1.06	522.18	10.60	1644.99
1.56	493.71	15.56	4097.68
2.28	318.60	22.84	9450.74
3.35	228.39	33.52	21299.98
4.92	294.11	99999.00	49966.69



	RESIS.	DEPTH	RESIS.	
0.99	917.52	9.91	433.77	
1.45	713.76	14.54	210.98	
2.13	654.16	21.35	128.45	
3.13	754.50	31.33	226.62	
4.60	804.63	45.99	779.48	
6.75	669.81	99999.00	3184.16	

P20 (INTERPRETATION)



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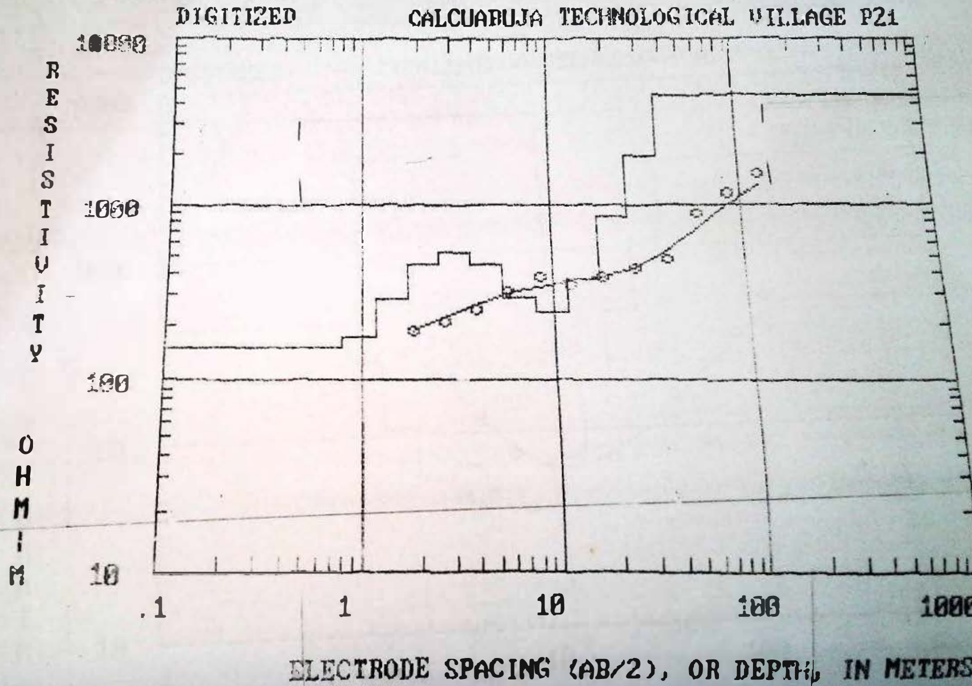

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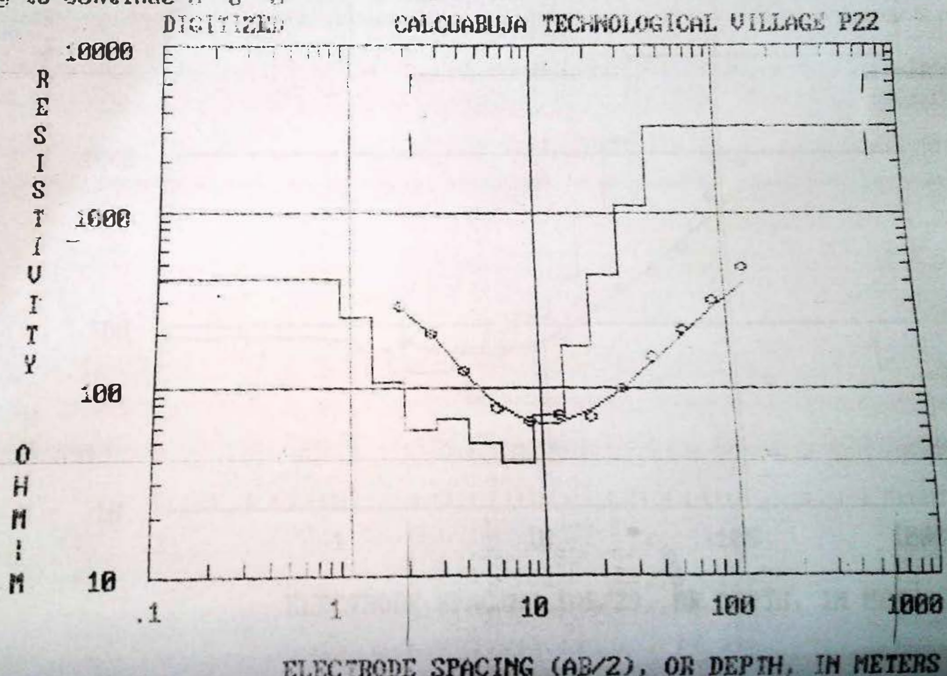
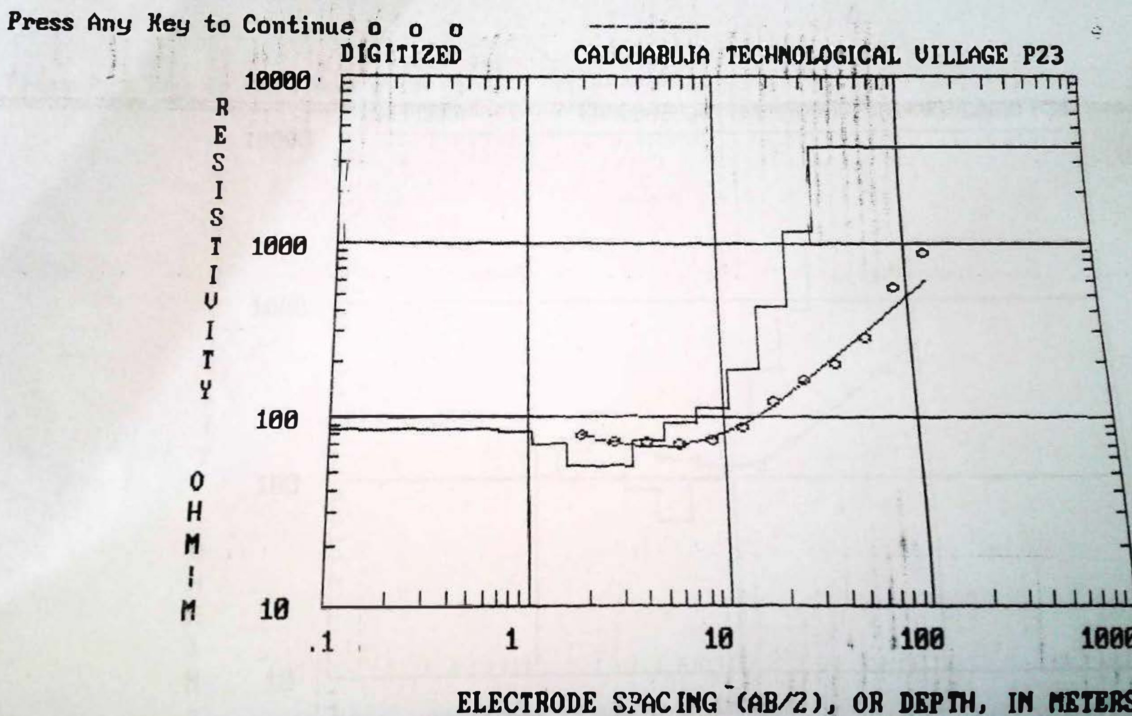
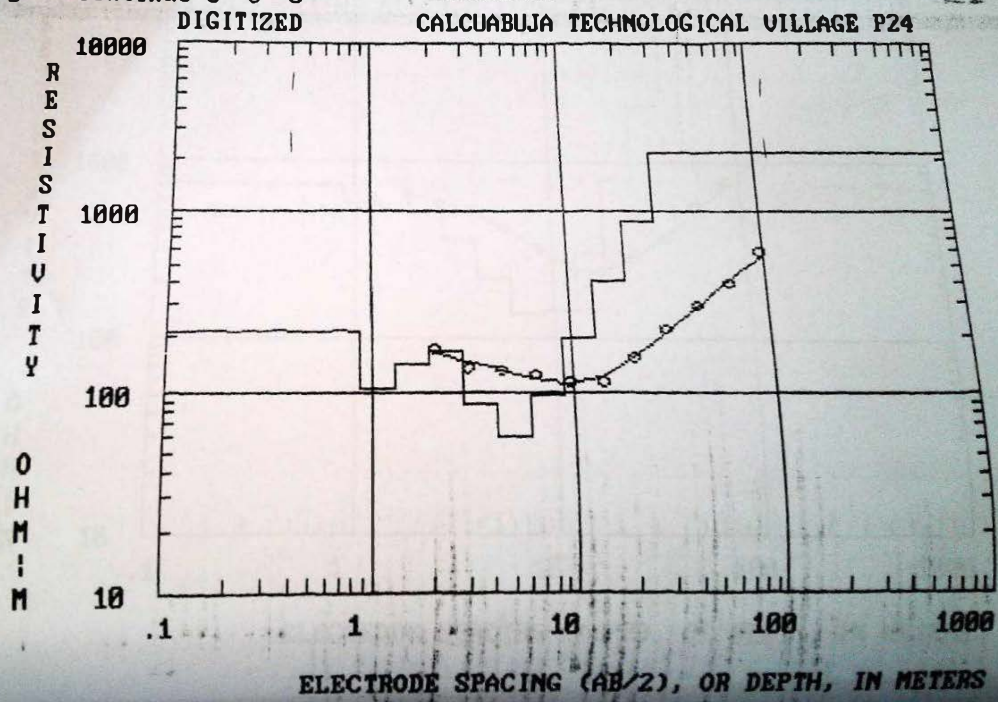




Press Any Key to Continue
DIGITIZED
CALCUABUJA TECHNOLOGICAL VILLAGE P23
RESISTIVITY OHM-M
10000
1000
100
10
.1
1
10
100
1000
ELECTRODE SPACING (AB/2), OR DEPTH, IN METERS

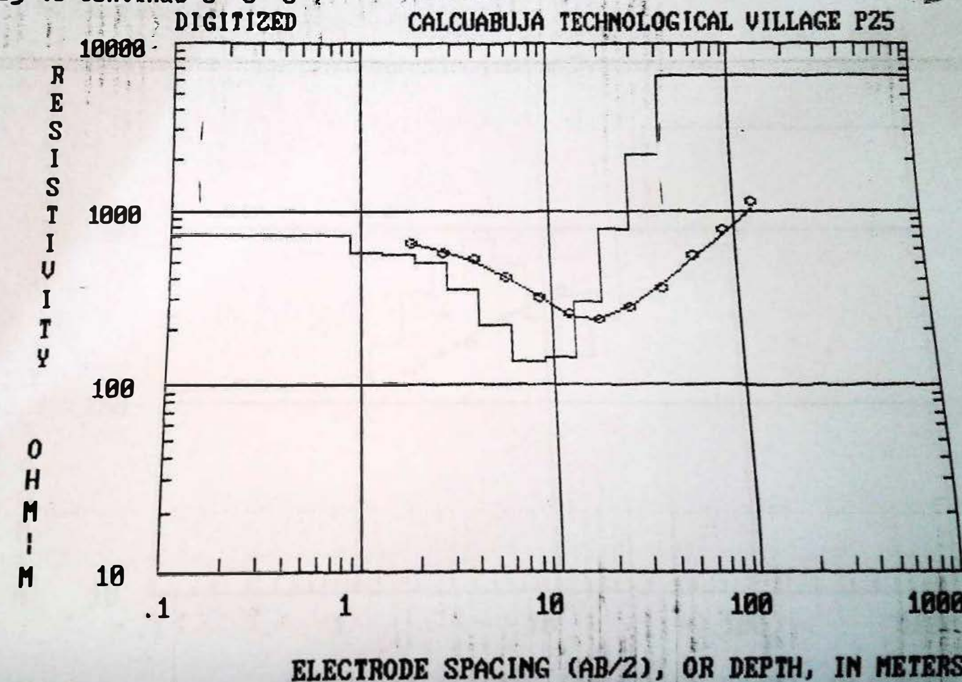
Press Any Key to Continue o o o



P25 (INTERPRETATION)

DEPTH	RESIS.
8.92	133.06
13.09	142.17
19.21	296.61
28.09	789.04
41.30	2174.72
9999.00	6417.26

Press Any Key to Continue



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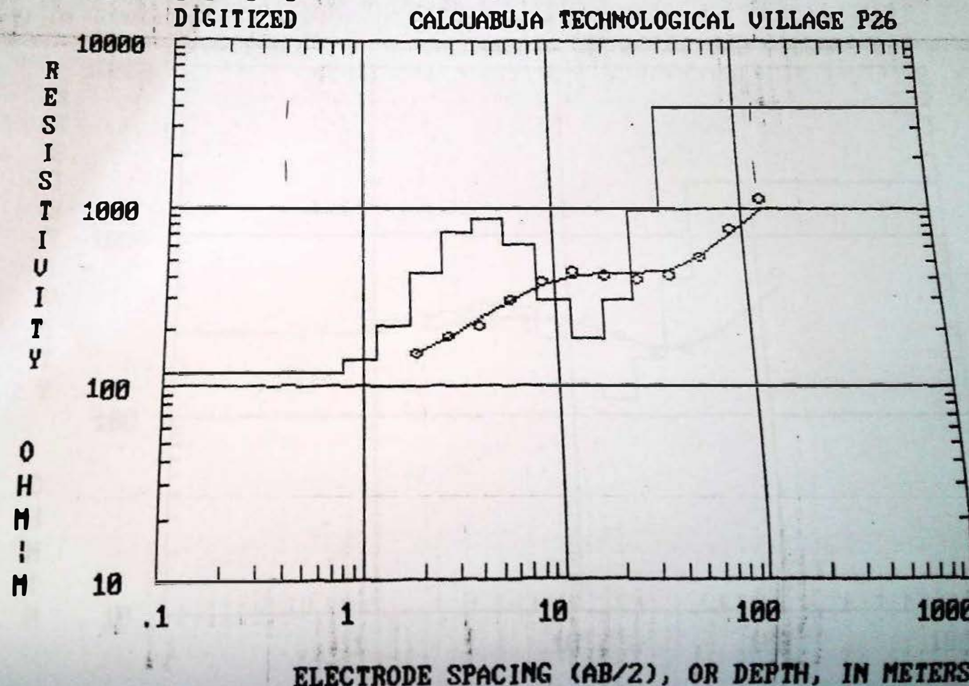

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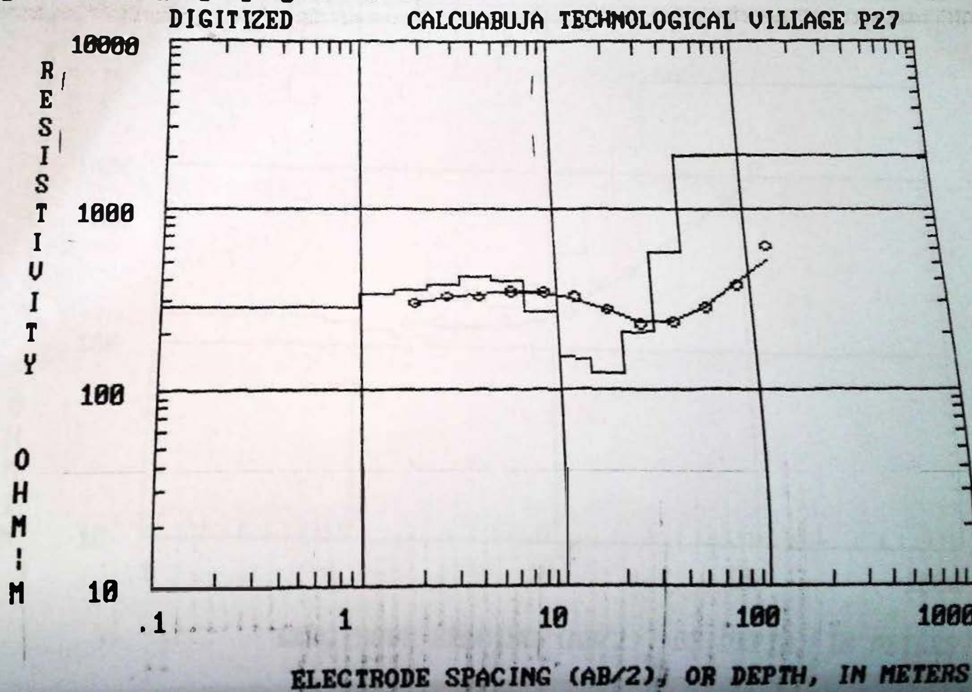

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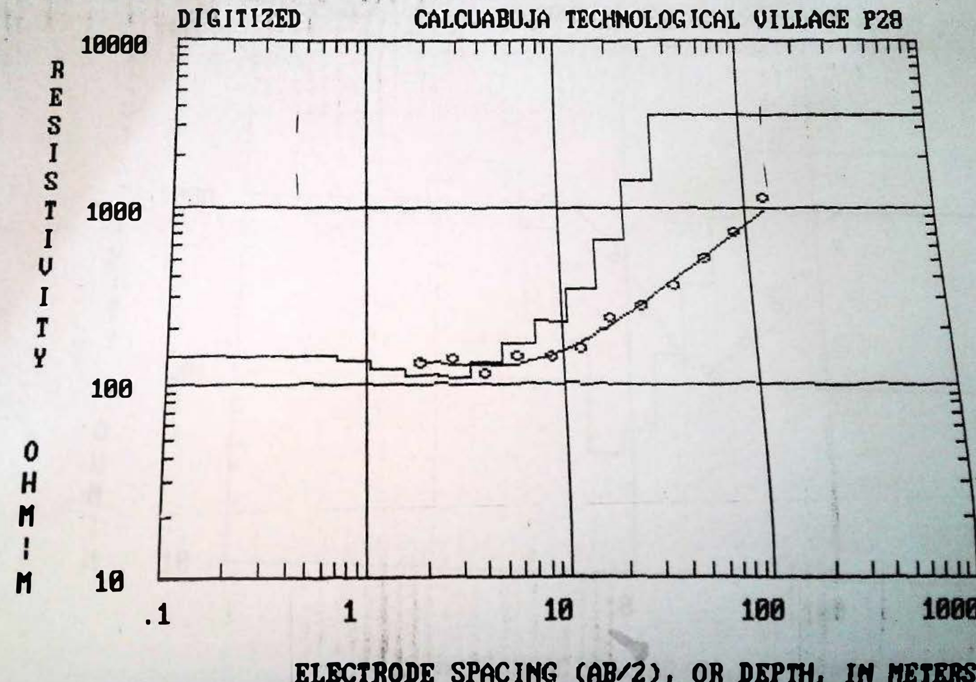
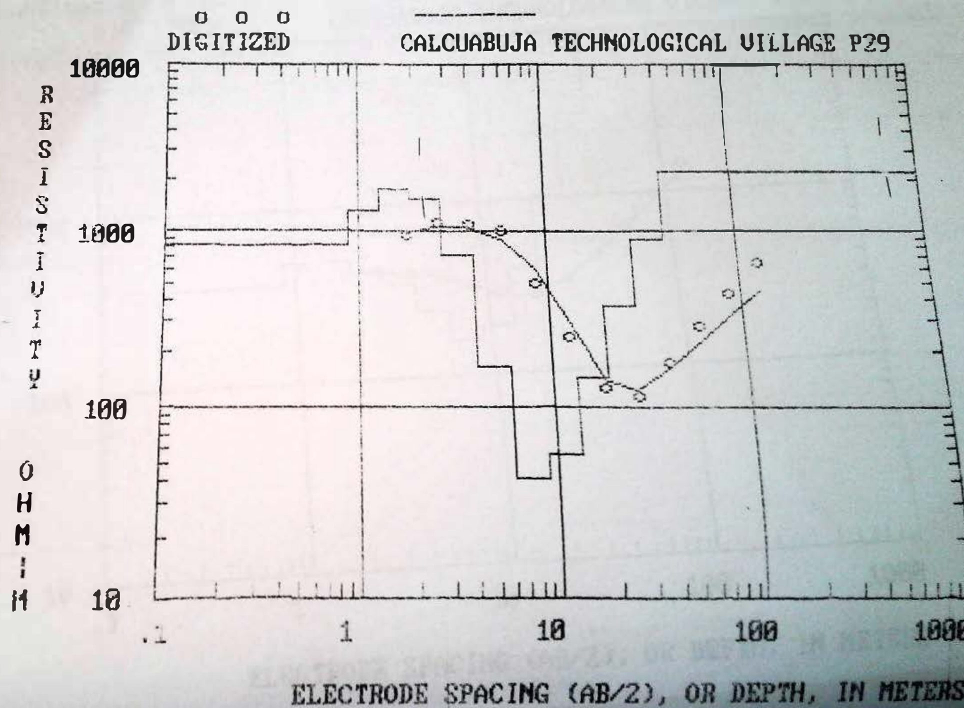


(INTERPRETATION)

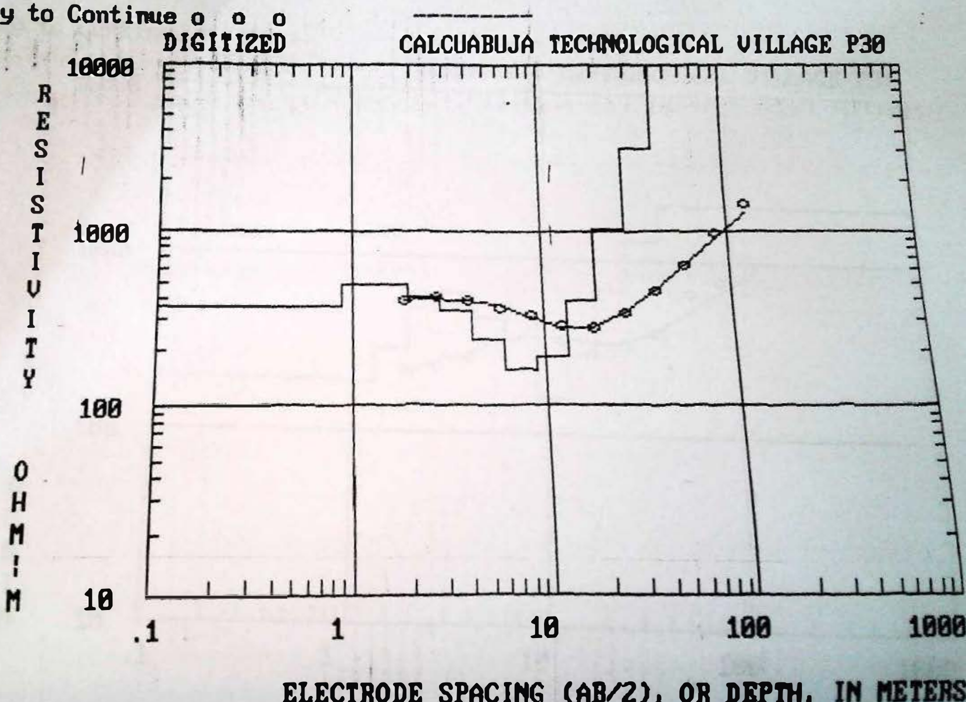
	RESIS.	DEPTH	RESIS.
0.89	817.71	8.92	41.39
1.31	1326.98	13.09	55.63
1.92	1754.96	19.21	146.15
2.82	1538.57	28.20	365.48
4.14	722.83	41.39	374.28
6.08	168.68	99999.00	2243.37



P30 (INTERPRETATION)

RESIS. DEPTH RESIS.

Press Any Key to Continue



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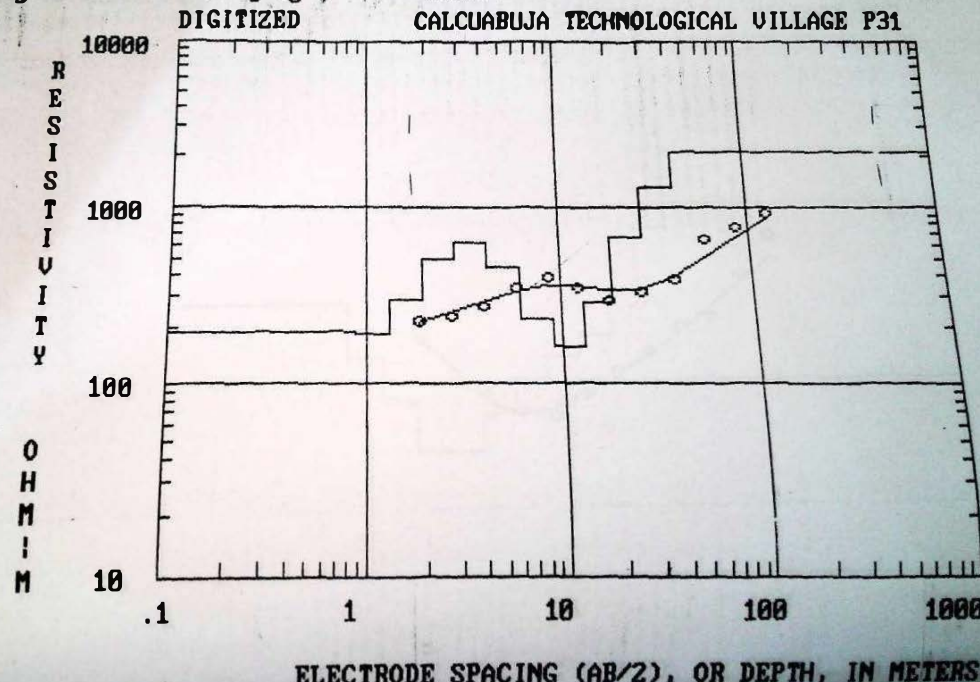

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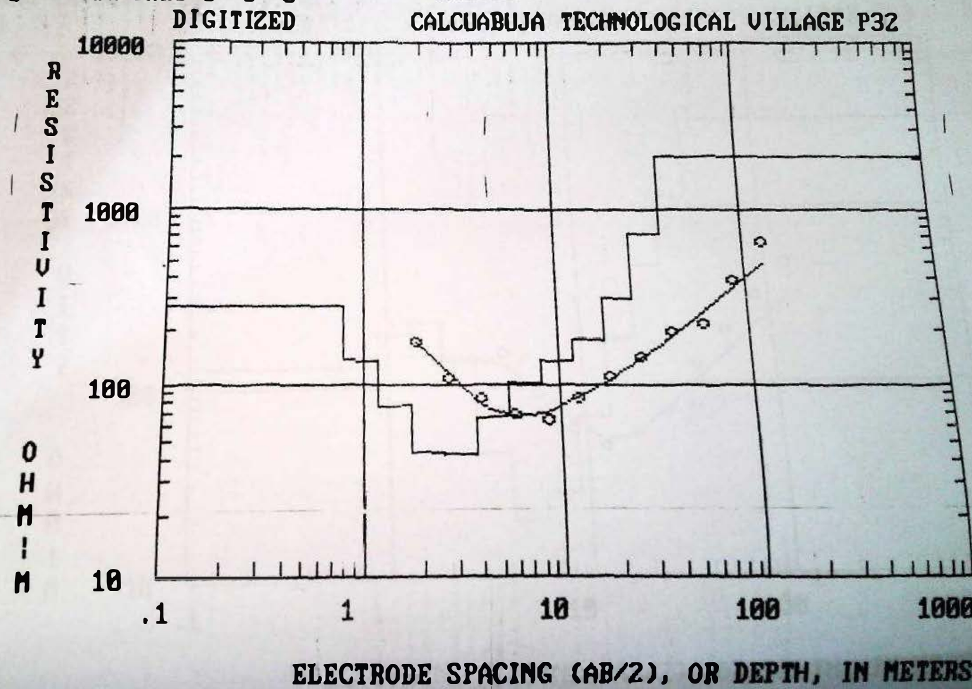

P32 (INTERPRETATION)

DEPTH	RESIS.
[illegible]	102.74
[illegible]	134.70
[illegible]	175.08
[illegible]	302.78
[illegible]	719.80
99999.00	2104.47

TECHNOLOGICAL VILLAGE P33 (INTERPRETATION)

DEPTH	RESIS.	DEPTH	RESIS.
0.89	126.63	8.92	26.54
1.31	191.84	13.09	66.30
1.92	225.48	19.21	178.59
2.82	135.60	28.20	459.51
4.14	43.59	41.39	1185.25
6.08	18.96	99999.00	3296.27

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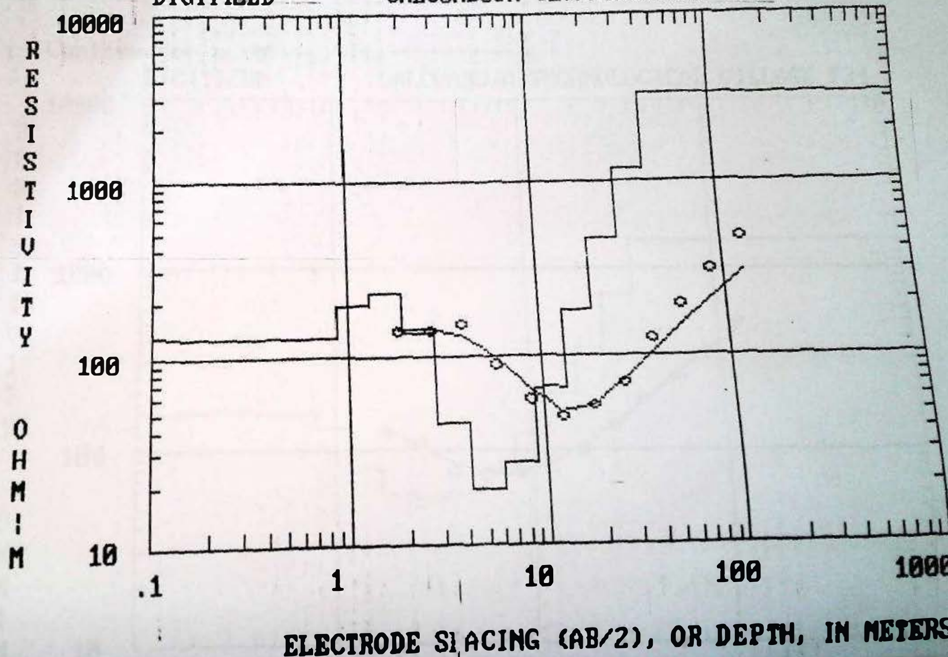
DIGITIZED

CALCUABUJA TECHNOLOGICAL VILLAGE P33



P34 (INTERPRETATION)

DEPTH RESIS.

78.26

[illegible]

999999.00 1444.39

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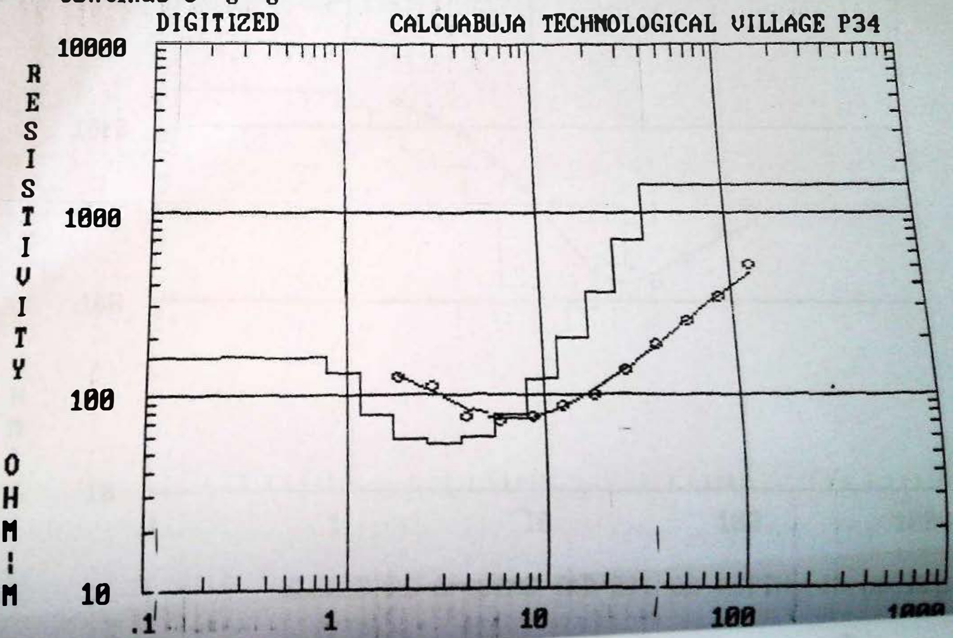

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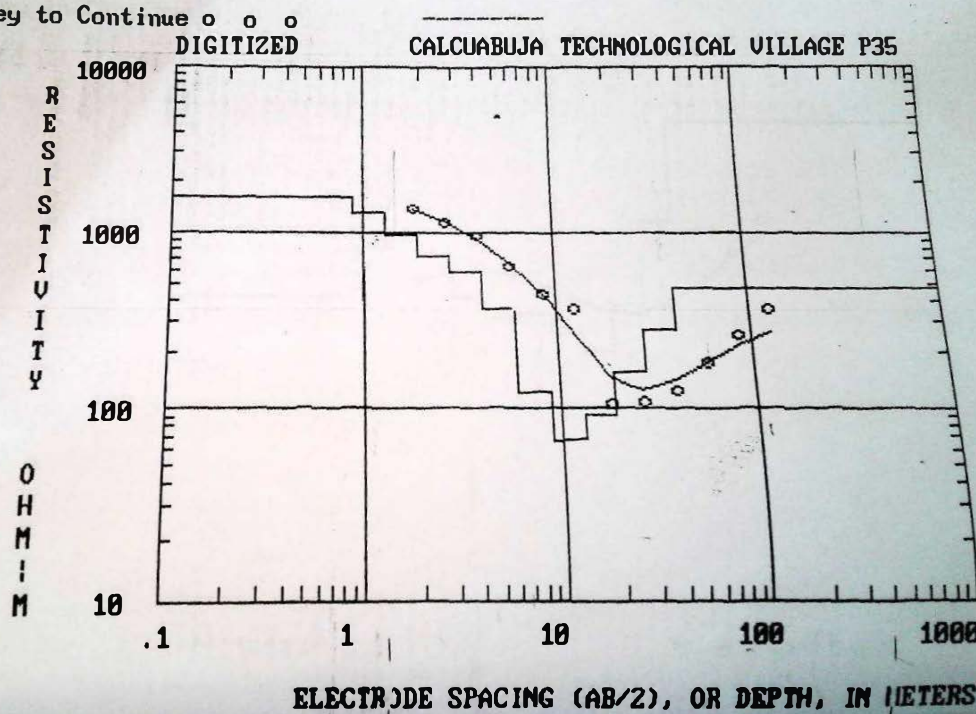

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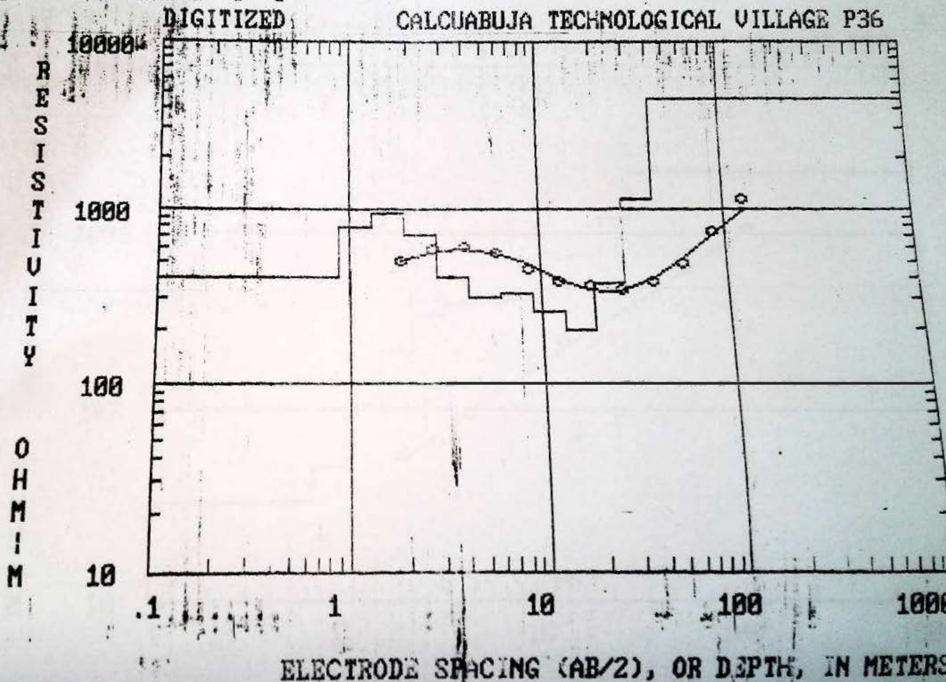

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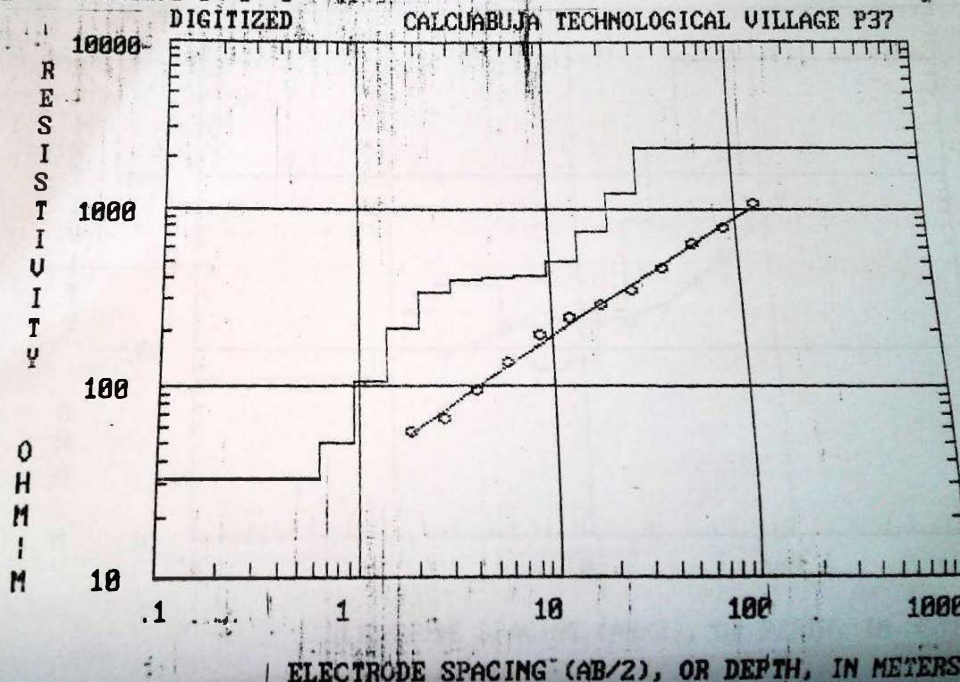
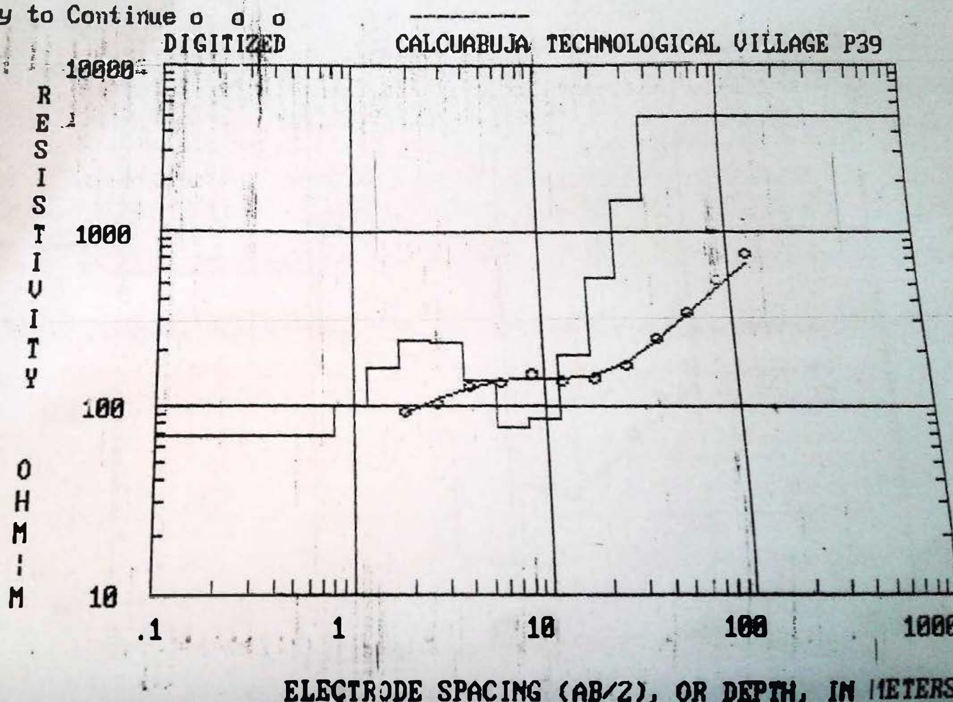


ABUJA TECHNOLOGICAL VILLAGE P39 (INTERPRETATION)

DEPTH	RESIS.	DEPTH	RESIS.
0.80	68.77	8.03	76.57
[illegible]	[illegible]	[illegible]	[illegible]
5.47	1336.73	99999.00	4951.02

Press Any Key to Continue



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