COMPUTATIONAL ANALYSIS AND EVALUATION OF GROUNDWATER DEPTH USING ELECTRICAL METHOD IN SOME PARTS OF EDO STATE.

PRESENTED BY

OGUNMWOYI DANIEL

(PGD/MCS/538/97/98)

DEPARTMENT OF MATHEMATICS/COMPUTER SCIENCE

POST GRADUATE SCHOOL

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

IN

PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF THE POST GRADUATE DIPLOMA (PGD) IN COMPUTER SCIENCE OF THE FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

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CERTIFICATION

This is to certify that this project work was undertaken by OGUNMWOYI DANIEL (PGD/MCS/538/97/98) of the Department of Mathematics/ Computer science.

That the work is adequate in scope and quality for the partial fulfillment for the award of the post Graduate Diploma (PGD) in computer science.

______________________ ______________________

MR L. N. EZEAKO Date

PROJECT SUPERVISOR

______________________ ______________________

Dr. S.A REJU Date

Head of Department

Mathematics/Computer Science

______________________ ______________________

EXTERNAL EXAMINER Date

DEDICATION

This project is dedicated to the Almighty God who ensured for the peaceful and successful completion of this post Graduate programme up to this time.

ACKNOWLEDGEMENT

I am immensely filled with gratitude at heart to the Almighty God who gave me the strength and good health throughout my academic pursuit . A big thanks goes to my project supervisor MR. L.N. EZEAKO for his advice, patience and positive criticism during the write up and who never got bored. I also thank the Head of Department Dr. S.A. REJU and the entire lecturers for their encouragement and advice which were quite sources of hope and aspiration to me when I was writing this project.

Also, I am highly grateful to my parents Mr. and Mrs. A.O. OGUNMWOYI who saw my academic pursuit up to this level. I am also indebted to my brothers and sisters whose various and varied contributions to my academic pursuit cannot be over -emphasized. May Almighty God bless them.

I will also remember special friends who were of great company during the course of the programme. They are Dele Omotosho, Timothy Akpovwovowo, Richard Adamu and Lola Olukini. Special thanks to Joyce Eni for typesetting this work.

Finally, I ever remain grateful to all those who contributed financially, morally and spiritually towards the success of this project work. I pray for God's guidance and protection in their lives.

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TABLE OF CONTENTS

ABSTRACT

This project work dealt with the different methods used in groundwater exploration with great emphasis on the Electrical method in some parts of Edo State and the involved Apparent Resisitivity.

Electrical Resisitivity method involves the passage of current into the ground through two electrodes called Current Electrodes and the measurement of the potential drop through two other electrodes called the potential Electrodes.

The schlumberger arrangement system was used and vertical Electrical sounding (VES) was carried out throughout the survey.

CHAPTER ONE

1.1 GENERAL INTRODUCTION:

By definition, Geophysics involves the study of those parts of the earth hidden from direct view by measuring their physical properties with appropriate instruments usually on the surface.

Summarily, geophysics provides the tools for studying the structure and composition of the earth's interior. The existence and properties of the earth's crust, mantle and core have been determined primarily, by observation upon seismic waves from earthquakes as well as by measurements of the earth's gravitational, magnetic, natural under-groundwater and thermal properties. Since the great majority of mineral deposits and groundwater are beneath the earth surfaces, their detection depends upon those characteristics which differentiate from the surrounding media. The elastic properties of the rock based on variation have been developed for determining the structure concerning oil and groundwater such as faults, anticlines and synclines and so on. Based on the variation in electrical conductivity and the natural currents in the earth, the rate of decay of artificial potential difference introduced into the ground, local changes in gravity, magnetism and radio activity provide information to the geophysicist about the nature of the structure below the surface, thereby allowing the geophysicist to determine the most favourable places for locating the mineral deposit he wants.

The various methods involved in discovering a certain mineral and undergroundwater level depends on the nature of the minerals and the surrounding rocks. There are several methods that can be sued to detect a discontinuity. Discontinuity is where one region differs sufficiently from another in some property.

1.2 OBJECTIVES:

The major objective is to know the level of water table beneath the earth surface so as to know the degree of exploration work to be carried out. The quantity of water in underground is being affected by the nature and presence of aquifers (formation which contain and transmit water) and the main sources of groundwater are precipitation, which may penetrate the soil directly to the groundwater. it should be noted that the groundwater has the lowest priority on the limits the rates at which groundwater may be utilized. Interception, depression storage and soil moisture must be satisfied before any large amount of water can percolate to the ground water. Except where sandy soils occur, only prolonged periods of heavy precipitation can supply large quantities of water for ground water recharge. Groundwater recharge is an intermittent process.

Geologic conditions determine the path by which water from precipitation reaches the zone of saturation . If the water table is near the surface there may be considerable percolation through the soil. Relatively, impermeable layers above the water table may prevent such direct percolation.

Other sources of groundwater include water from deep in the earth which is carried upward intrusive rocks and water which is trapped in sedimentary rocks during their formation. The quantity of such water are often so highly mineralized as to be unsuited for use. These deep groundwater may however contaminate other useful waters. For example, considerable boron is added to groundwater rising through faults in the fransciscan rocks of the Coast Ranges.

1.3 METHODOLOGY :

ELECTRICAL METHOD

The geophysical methods variously used for exploration are Gravitational, Magnetic, Electromagnetic, Radioactivity, well-logging, seismic and Electrical. However, out of these methods, Electrical method will be employed for the purpose of this project where resisitivity measurements are used for finding the depths to bedrock and water bearing formations.

The electrical method of prospecting involves the passage of currents into the ground through two electrodes called Electrodes and the measurement of the potential Electrodes. Measurement of potentials, currents and electromagentism occurs either naturally or are introduced artificially into the earth. Considering the type of energy source utilized, Electrical method is classified into two which include Natural and Artificial methods. These methods are employed to an increasing extent in engineering geology and hydrogeophysical studies.

1.4 COMPUTER SYSTEMS:

A computer is an electronic machine which is capable of processing data in a wide variety of ways with an extremely high degree of speed and accuracy.

When trying to figure out the various events, discovers and inventions which had taken place up to success in the development of a modern day ultra fast computer requires an intensive analysis of computational mathematics and other relevant field of studies. The development of tools to aid in calculation began with early civilization. people first used sticks, stones, toes, thick notches on a stick, marks in the sand or knots in a rope to aid in counting etc. However, all these processes were hard and extremely difficult to keep accurate record.

One of the earliest calculating devices created by man was the ABACUS. This was attributed to Chinese around 1642. This ancient calculating instrument has been used for the past 2000 years.

However, from the 19th century onward, significant advances, invention and discoveries were made. John Attanasoff, a mathematics professor of Lowa State College along with his assistant Clifford- berry completed a proto-typed electronic computer in 1939.

John Vincent Attanasoff was the first man to design and develop the first electronic computer.

This was the beginning of wide public awareness of computers. The refinements of the computing concept focused on speed, size and cost gave the page to the computer generation.

1.4.1. GENERATIONS OF COMPUTER

The computer generation was gradually intended to suggest different development of the hardware components but nowadays it is being applied to both hardware and software systems of computers. it is also the gradual integration and refinement of computer concept that gave way to the five existing generations.

In the **FIRST** generation, the computer uses vaccum tubes which control the internal operation of the computer. Computers were mostly huge and require cooling system. Magnetic drum was used by computers as a means of storage . Use of punched cards become so common.

In the **SECOND** generation, solid state transistor replaced the vaccum tubes, the size of computer was greatly reduced. Computers were faster, had increased storage capacity and do not require cooling system. The magnetic tapes, disks are supplementary memories invention of the low level language for computers.

In the **THIRD** generation, the development of integrated circuit (IC) software industries emerged. Miniscripts came into being. Operating system, greater compatibility of components allowing easier expansion of computer system. Microcomputers and minicomputers came into being and development of higher level language e.g Pascal, Basic, Fortran came into being.

In the **FOURTH** generation, there was an introduction of very large scale integrated circuits Technology, user-friendly. Development of data recording equipments that capture data e.g optical character recognition, densely packed chips were developed.

In the **FIFTH** generation, there is an advent of Artificial Intelligence (AI) and Expert system.

Artificial intelligence is the ability of the computer to exhibit behaviours like an intelligent person. The aim is to speck to the computer and obtain solutions through voice output.

Expert system on the other hand is an application program that has the capability of making judgment and decisions like an experts in a particular field of application.

1.4.2 CLASSIFICATION OF COMPUTERS IN TERMS OF SIZE:

Computers came in a wide variety of sizes ranging from tiny handhead devices to some that are several feet in height and diameter . The four categories are :-

SUPERCOMPUTERS:-

These are the most powerful machines available in the mid-1980s. They are the fastest and most expensive computers. They are also called maxicomputers or monster computers. Supercomputers have the capability to process seismic data gathered during crude oil-seeking explorations.

MAINFRAMES:

A mainframe is a large computer commonly used in business and industry. mainframe are used to solve highly sophisticated problems. They are large in memory capability and are the most powerful. They operate at very high speeds and create a fair amount of heat requiring cooling systems. Mainframe computers often serve more than one user at a time, because they are able to support large networks of individual terminals and remote job-entry locations.

MICROCOMPUTERS:

The microcomputers is the lowest and least expensive computers currently available. This is the type of computer often found in small business, homes and classrooms. The primary storage units of a microcomputer is usually smaller than that of the other types of computers. It is generally less complex and execute programs at slower speeds.

MINI COMPUTERS:

A mini computer is a computer with many of the capabilities of a mainframe but generally lower priced and with a smaller primary storage unit. Minicomputers in general are lower price, have smaller memories and process data more slowly than mainframes. They can support a network of user terminals but not as many as mainframe can.

1.4.3 **CLASSIFICATION OF COMPUTER IN TERMS OF LOGIC:**

In terms of logic, a computer can be classified into three categories. These are:-

ANALOGUE:-

This kind of computer performs its operation by measuring and comparing physical phenomena changes and variables in the form of mathematical equations in some notable quantities.

An analogue computer processes data that vary continuously such as variation in temperature, speed, the chemical composition of petroleum products or the amount of current flowing through electric conductor. Analogue computers are used for a wide variety of industrial and scientific applications that require the processing of data that are measured continuously. It does not contain memory since it measures or compares data / value.

DIGITAL:

A digital computer is one which performs arithmetic operations and access logical decisions according to instructions coded to it in advance. In the digital computers, numbers and letters are represented as digits.

HYBRID:

This is simply a combination of Analogue and Digital computers. This combines the capabilities of analogue and digital computer systems in one. Hybrid computers are powerful computing devices and as such they are mostly used to solve rather sophiscated problems such as those from the studies of process control and optimization and physical process described by a set of physical simultaneous ordinary or positive differentiation.

1.4.4 CLASSIFICATION OF COMPUTER IN TERMS OF PURPOSE:

In terms of purpose, computers can be classified into two classes. These are :-

SPECIAL PURPOSE:

A special purpose computer is designed for only one purpose . It is designed to carry out specific tasks. The computers used for guiding NASA space shuttles are examples of special purpose computers which cannot be used for other purposes.

GENERAL PURPOSE:

A general purpose computer can be used for many purposes. They are designed not specifically jobs. For example, it may be used for playing games, for handling payroll computations for graphics, to design buildings or to solve complex mathematical problems.

1.5 **SCOPE AMD LIMITATION**

The electrical resistivity survey method employed will not be able to determine the quality of the water at any depth as there is no provision for that. In dry conditions, the soil about the electrodes has to be moistened to ensure good electrical contact to reduce errors due to contact resistance.

However, there could still be some errors and these can be attributed to the problem of continuously changing electrical properties of the earth due to weathering and lack of complete knowledge of the path transversed by the signal.

CHAPTER TWO

2.1 GENERAL REVIEW OF ELECTRICAL RESISITIVITY SURVEY

This is a highly employed method in the search for water bearing formations especially in stratigraphic correlations in oil fields and in prospecting for conductive ore-bodies.

However, for the purpose of this project work, this method will be used in analyzing and evaluating groundwater potential in some parts of Edo state. This electrical method of prospecting is more diversified than any other geophysical methods. Some of them include spontaneous potential (SP) and telluric current depends on naturally occuring field as in magnetic and gravity prospecting. The electrical resistivity of earth materials varies over a wide range and is affected by some properties which include porosity, the crystalline nature of the minerals as well as the nature of the fluids which fill space.

However, the electrical method of prospecting shows a picture of the composition and nature of earth's subsurface. The survey could be depth sounding and is a very powerful tool in any exploration work and is used commonly for groundwater investigation.

2.2 EQUIPMENT FOR RESISITIVITY SURVEY

The major components of equipment for resistivity survey are electrodes, cables, generator, transmitter and receivers.

The current electrodes should be made up of ordinary steel while the potential electrodes should be made up of stainless steel because it polarizes less than most other metals.

In resistivity survey, single core, multistrand copper wires insulated with PVC are commonly used. The mechanical strength required usually tells the thickness of the cable since ground resistance is usually very much higher than the resistance of the cable.

Dry or rechargeable battery is usually connected to a transmitter or an instrument called a Terameter which measures the current and the potential while the distance between each current electrode and the Terameter is measured directly on both sides of the instrument.

The usual practice in resistivity surveying technique is to pass current into the ground by means of two electrodes called current Electrodes and to measure potential drop through a second pair of the electrodes called potential Electrodes.

The principle of operation depends on the fact any subsurface variation in conductivity alters the current flow within the earth and this in turn affect the distribution of electric potential. However, it is possible to have information about the subsurface formation from potential measurements made at the surface.

However, the resistivity measured is called true resistivity if the earth is homogeneous. The inhomogneity of the earth lead to apparent resistivity and this is a weighted average of the various formations.

Conduction of electricity in the ground occurs through the interstitial water which is usually present in the rock and invariably contains some dissolved salts. As such low resistivity usually indicates presence of water in the formation. if the resistivity is small it is not necessary to have powerful source of current. Conversely, resistivity, is inversely proportional to the effective porosity and the degree of saturation.

2.3 CONCEPT OF APPARENT RESISTIVITY

This means that what is measured is really a weighted average of the resistivity of several layers. It is however necessary to consider what is actually measured by array of current and potential electrodes before treating the various electrode spreads

Thus, we have the equation below:-

$$P = 2\Pi\Delta V/I \quad 1/(1/r_1 - 1/r_2) - (1/r_3 - 1/r_4) = (2\Pi\Delta V/I)\, P'$$

Where the parameters

P'= electrode geometry

V=Potential

I= Current

r= resistance

P= resistivity

This resistivity will be constant for any current and electrode arrangement. This means that if the current is maintained constant and the electrodes are moved around the potential ΔV will adjust at each configuration to keep the ratio $\Delta V/I$ constant.

If the ground is inhomogeneous and the electrode spacing is varied or the spacing remain fixed while the whole array is moved, then this results in a different value of P for each measurement.

This measured quantity known as the apparent resistivity (Pa) is equivalent to the actual resistivity (P). Another term which is called frequently found is the so called surface resistivity. This is the value of Pa obtained with small electrode spacing.

2.4 **RESISTIVITY OF ROCKS.**

The electrical resistivity of rocks has variable properties which depend on a number of factors such as rock types, porosity, degree of saturation of porous materials and the chemistry of the saturating fluids.

The resistivity seen in crystalline rock formations such as gneisis, , granite, diorite e.t.c. is largely dependent upon the water in the fissures and fractures.

Similarly, the porosity; the degree of saturation and the chemistry of saturating fluids governs the resistivity of sedimentary rocks.

Generally, hard rocks are bad conductors of electricity. Crushed rock zones and completely fractured rocks may have low resistivities. Some clay as well as water logged soils and sedimentary rocks like marls, chalk e.t.c. may possess low resistivites. Resisitivity of different rock types are shown below.

ROCK TYPES	RESISTIVITY
SEDIMENTARY	
Alluvium & Silt	25-1500
Clay- Shales	0.0004-900
Clay	50-1500
Limestone	60-500,000
Loams	10-450
Marl	5-70
Sand	95-700
Sandstone	30-500,000
Shales	80-20,000
Consolidated sedimentary rock	10-500
unconsolidated and recent sedimentary formation	0.5-100
(IGNEOUS AND METAMORPHIC)	
Granite	300-20,000
Basalt	200-20,000
Gabbro	100-15,000
Gneisis	2000-34,000
Schist	50-10,000
Quartzite	10-200,000
Syenite	100-100,000
Marble	100-100,000

2.5 **EFFECT OF TOPOGRAPHY**

Resistivity measurements are strongly influenced by local variation in surface conductivity caused by weathering and moisture content.

However, rugged topography will have a similar effect since the current flow tends to follow the surface particularly if the shallow layer are some what conductive.

The equipotential are distorted as a result, producing false anomalies due to the topography alone. This may distort a real anomaly.

Also, in the case of anisotropic ground there is no method of isolating the topography effect. In simple cases such as sharp depression and knolls, the potential distortion might be connected by graphic method.

2.6 **ELECTRICAL PROFILING**

This is a type of resistivity surveying technique Electrical profiling is the use of an electrical prospecting arrangement with fixed spacing of electrodes by moving the system progressively along profile lines. it is used for detecting changes in the resistivity of the earth as one moves along the profiles. it measures lateral variation of apparent resistivity.

However, the method is suitable for detecting a fault or fracture. This method is also called Transverese electrical -survey.

2.7 VERTICAL ELECTRICAL SOUNDING

This is also another type of resistivity surveying techniques or depth probing (dp) .Vertical electrical sounding(VES) is the use of electrical methods with depth control in which electrode spacing is increased to obtain information from greater depth at a given surface location.

However, it enables us to detect changes in the resistivity of the earth with depth beneath the given location. The principles of VES are based on the fact that the wider the current electrode separation, the deeper the current penetration. The apparent resistivity values observed at large separation are governed by the resistivity of deeper layers.

CHAPTER THREE

3.1 CONCEPT OF SYSTEMS ANALYSIS

Systems analysis as applied to Geophysics is defined as the method of determining how best to use computers with other resources to perform geophysical tasks which meet the information needs if the geophysical exploration. The systems analysis also tend to identify the information needs of the geophysical explorers. it tends to obtain a logical design of an information system that will be a combination of manual and computer based procedures to process a collection of geophysical data which are useful to the geophysicists in taking decisions . These decisions enable the fieldworks to guide against ugly occurrences in the course of prospecting and discovering certain mineral and underground water level as there are bound to be periods of discontinuities.

3.2 WEAKNESSES OF THE MANUAL METHOD.

The previous manual method of analyzing and evaluating the geophysical data was labourious tedious, time-consuming and cumbersome because of the following problems--

(a) Access to information contained in the field files is usually slow because of large volume of manual filings.

(b) There is poor security and privacy of the field files.

(c) Files are misplaced after accessing them for particular information. This results in several days of delay in accessing the files at another time. Hence these delays may cause suspension of fieldwork.

(d) Better quality management information and a wide range of reports, graph, statistics e.t.c. are always tedious to be achieved. This is due to the large volume of exploration records involved.

3.3 PURPOSES OF SYSTEMS ANALYSIS AND DESIGN

In order to overcome completely the problem encountered during the manual method of processing, the use of computer was introduced. This has really helped in the following ways :-

(a) To provide an opportunity for water exploration information procedures in preparation of field report, laboratory analysis result and determining the appropriate uses of the aquifers (formations that contain and transmit water)

(b) To provide an effective means of generating summaries of the exploration activities covered within a period for better management information.

(c) To allow for interactive and batch method of processing in preparation to exploration activities and reports which can be monthly , quarterly or yearly.

(d) To provide appropriate security to the nature of geophysical information collected through the use of password.

(e) Geophysical information from several files is coordinated, access and operated upon as though it is in a single file. Logically the information is centralized. Physically the data may be located on different field locations.

(f) it enables data redundancy to be eliminated in the sense that the same result cannot appear in more than one file. The duplication of data leads to wastage of storage space and duplication of efforts during data entry.

3.4 EVALUATING PROPOSED PROJECT

The purpose of this evaluation is to enable me embrace the feasibility studies as to investigate the project yin sufficient depth to be able to provide information that justifies the development of the new system. During these studies, information was also collected about the difficulties associated with the manual method. These include:----

(a) TECHNICAL FEASIBILITY

This tries to see whether the technology needed to operate the new system is available and if the available whether it can be utilized .

(b) ECONOMIC FEASIBILITY

This enables one to know whether finances are available for implementing the proposed system and whether the money spent is recovered from the geophysical exploration carried out.

(c) OPERATIONAL FEASIBILITY

In this study, we asked whether the proposed system can fit in with the existing geophysical operations and whether the right information is provided to the explorers at the right time.

3.5 INPUT AND OUTPUT SPECIFICATIONS.

It is important to specify the type of input and output required of the new system. This is necessary because of the kind of geophysical data that need to be processed and this is seen below:-

(a) INPUT

Considering of input will be influenced greatly by the needs of output e.g the necessity for quick response from system would determine the need for an on-line type of input. However, consideration would be given to the method of data collection, type of input media available, volumes of geophysical data that need to be inputted and design of input layouts.

(b) OUTPUT

It is necessary to consider what is required from the system before deciding how to set about producing it. These requirements will be clearer as the exploration progresses. The geophysicist needs to consider the form, type, volume and frequency of reports.

3.6 COST- BENEFIT ANALYSIS

A cost-benefit analysis is necessary to determine economic feasibility. The primary objective of cost-benefit analysis is to find out whether it is economically wise to invest in the project. it is necessary to find out whether the introduction of computer will be profitable compared to be effort, time and money spent on the geophysical exploration.

However, some of the elements of cost which must be considered by the explorers include :-

(a) Equipment costs:- These include capital costs, leasing costs of computer and the peripheral devices.

(b) Installation Costs:- These include new building for the computer.

(c) Developing Costs:- These include software consultancy and changeover costs.

(d) personnel Costs:- These involve the training of staff, recruitment of staff, relocation of staff, recruitment of staff, salaries of staff, allowances, pensions, e.t.c.

(e) Operating Costs:- These include consumable materials (tape, cards, disks, stationery), maintenance cost, accommodation costs, insurance cost, power cost e.t.c.

3.7 CONCEPT AND METHODS OF CHANGEOVER

This is the conversion of the manual method of geophysical exploration into the form required and acceptable by the new system. This process of changeover may take place when:-

(a) The system has been proved to the satisfaction of the geophysicists and other implementation activities have been completed.

(b) Explorers and users of the system are satisfy with the results of the system tests and staff training.

(c) The changeover date is due.

METHODS OF CHANGEOVER.

The concept of changeover discussed above may be achieved in many ways.

These include :-

(a) DIRECT CHANGEOVER

This means processing the current geophysical data by the new system. it is however a bold move which should be undertaken only when everyone concerned has confidence in the new system. When a direct changeover is planned, system tests and training should be comprehensive and the changeover itself should be planned, in detail. This method is potentially the least expensive but the most risky.

However, for security reasons the previous manual methods should be held in abeyance including people and equipment. In the event of a major failure of the new system, the field workers would revert to the manual methods.

(b) PARALLEL CHANGEOVER

This means processing current geophysical data by both the manual method and the new system to cross- check the results.

The main point is that the manual methods are kept alive and operational until the new system has been proved for at least one system cycle, using full live data in the real operational environment of place, people, equipment and time. it allows the results of the new system to be compared with the results of the manual method before acceptance by the users, thereby promoting user's confidence.

However, the main disadvantage associated with this method of changeover is the extra cost involved in carrying out the different clerical operations for the manual method and the new system.

(c) PILOT CHANGEOVER

This is similar to parallel changeover. Data from one or more previous periods for the whole or part of the system is run on the new system after results of the manual method. it is not as disruptive as parallel operation since timing is less critical. This method is more like an extended system test and it may be considered a more practical form of changeover.

(d) STAGED CHANGEOVER

This involves a series of limited size direct changeovers, the new system being introduced piece by piece. A complete part or logical section is committed to the new system while the remaining parts or sections are processed by the manual method. Only when the selected part is operating satisfactorily is the reminder transferred.

This method of changeover reduces the risks inherent in a direct changeover of the whole system and enables the users to learn from mistakes made as the changeover progresses.

The major disadvantages associated with this method are - it creates problems of controlling the selected parts of the manual method and the new system and it tends to prolong the implementation period.

3.8 **RECOMMENDATION**

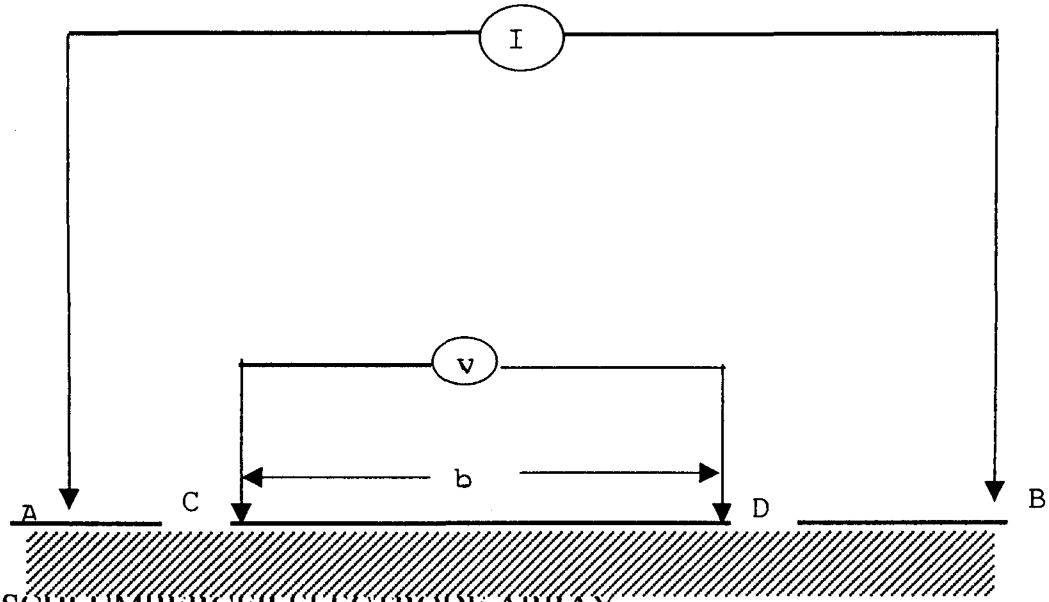
Considering the various methods of changeover discussed above with their strong points and weak point, the PILOT CHANGEOVER was applied during the geophysical exploration because it is not disruptive as any error in data processing would causes further suspension in field work. Timing is less critical because numerous data are being collected on every exploration activity. it is however an extended system test and a more practical form of changeover.

3.9 SCHLUMBERGER ARRAY METHOD OF PROSPECTING

Different types of electrodes configuration are used over the years. The wenner, Dipole-Dipole arrays, pole-dipole, square array lee partition, Trielectrode arrangement and a host of others. These are all very complicated. However, a recent and more acceptable method of prospecting is the schlumberger array method.

In Europe the schlumberger was first used and is still very popular for aquifer investigations.

This schlumberger array will be used for electrical prospecting arrangement with fixed spacing of electrodes by moving the system progressively along profile lines and suitable in depth control in which electrode spacing is increased to obtain information from greater depth at a given surface location. In this arrangement, the electrodes are co-linear and the current electrodes are relatively widely spaced apart while the potential electrodes which are in between them are closely spaced as illustrated below.:



SCHLUMBERGER ELECTRODE ARRAY
A AND B ARE CURRENT ELECTRODE
C AND D ARE POTENTIAL ELECTRODES.

In the schlumberger arrangement, it is required that separation of potential electrode (CD) must never exceed two- fifth (2/5) of AB/5. In practice, this demands for the expansion of the current electrodes while the potential electrodes remain constant. The shallow depths penetrated are majority for small spacing.

The field procedure consists of expanding the current electrodes such that the current penetrates continuously deeper with the increasing separation of the current electrodes using separation of the electrodes, the process yields a progressively decreasing potential difference across the potential electrodes. Ultimately, this potential different sensitively would exceed the measuring capabilities of the instrument.

A new distance of separation for the potential electrodes must be sought at this point. it is mainly two to four times the proceeding value. The change is affected and the survey continuous.

The potential electrodes are started initially only a few centimeters apart and buried to a depth of a few centimeters, during the survey.

However, certain associated problems such as local compaction, discontinuity and inhomogeneity may be created around the probe when deriving the probe and the general inhomogneity of a layered earth.

The survey may be affected by two problems mentioned above in such a way that if the probe are too close. These inhomogeneities will have a high influence on the apparent resistivity and even if current electrodes separation is increased, the effect of this inhomogeneities will still be significant.

However, if the first layer has a thickness which is the same order of magnitude as the potential electrode separation, the potential field gradient in the region of the electrode separation will give incorrect results. Also, different results may be gotten due to the ground being inhomogeneous.

ADVANTAGES OF SCHLUMBERGER ARRANGEMENT

In spite of the various problems that are encountered during the geophysical exploration as regards the discontinuities, local compaction and inhomogeneities of the earth, the schlumberger array method of prospecting still has the following advantages-:

(a) Considering the cost-benefit analysis, it is highly more separation, current penetrates deeper.

(b) During fieldwork, it is possible for one person to handle the potential electrode and take readings.

(c) Out of all the array methods of prospecting, the schlumberger array is less sensitive to lateral inhomogeneities as well as strong currents.

(d) The geophysical cover are generally smoother and free from steep gradient.

(e) It is very suitable for both profiling and depth sounding survey.

CHAPTER FOUR

4.1 PROGRAMMING THE APPARENT RESISITIVITY

Software is the general term used to denote all forms of program that control the activities of a computer. It refers to the set of computer programs, procedures and associated documentation related to the effective operation of a data processing system. Software therefore enables us to exploit the capabilities of a computer. It can be classified into two, namely: system software and Application Software.

SYSTEM SOFTWARE:

These are programs usually supplied by the computer manufacturers which are designed to control the operation of a computer system. They are written to assist human or users in the use of the computer system by performing task such as controlling all the operations required to move data into and out of a computer and enhance performance of the computer system especially in the implementation of the application programs. Examples of system software are operating system, Translators Editors e.t.c.

APPLICATION SOFTWARE:

These are general programs written with a view to solving a problem. This may appear in standard application packages or in the form of programs written by the users or programmers for specific application or local use (Home -made packages).

APPLICATION PACKAGE:

An application package is a collection fully documented programs designed to perform a particular data processing task in more than one organization. it is made up of pre-written and tested programs that are designed by experts to perform one or more specific purposes. Examples of such packages include word-processing packages, spreadsheet, packages, Database management packages, Statistical analysis package e.t.c.

HOME -MADE PACKAGE:

These are programs written to solve local problems in the geophysical exploration. Such programs are designed to suit what is obtainable within the fieldwork.

4.2 STAGES AND QUALITIES OF THE PROGRAM

Programs can be solved through the use of computers. Using computers to solve problems require writing programs for that purpose. programs do not spring into being they require a number of stages or applied. The various stages are :-

(a) PROGRAM PLANNING:-

This is the preliminary stage of program development. It is virtually impossible to write a computer program without first identifying and clearly understanding the problem. The planning stage is concerned with the formulation of the geophysical requirements that the task places on the computer. It also involves identifying the input data, the required output and the formula needed.

(b) PROGRAM DESIGN:

The design stage is an important stage as it outlines and defines the set of rules required for the solution to the geophysical problems. it involves the listing and ordering of successive steps and the tools mostly used in this stage are for algorithmic representation.

(c) CODING:

Once the steps of the solution have been ordered and outlined, the next stage is the transformation of these steps to the form understandable by the computer. The coding stage covers the transformation of the design made earlier into a chosen computer language as well as entering the programs into the computer.

(d) DEBUGGING:

This is the process of detecting and removing program errors . There are two kinds of errors. These are syntax errors and logic errors.

Syntax errors involve incorrect punctuation, incorrect word sequence, undeclared identifiers or misuse of terms.

Logic errors can be associated to the problem of the program logic.

(e) TESTING

This is the process of running the computers program and evaluating the program results in order to determine if any errors exist. The testing is done by running values so as to be sure that the expected result is gotten.

(f) IMPLEMENTATION.

Once a program has been tested and found working as required, the next stage is the implementation of the program. This stage is concerned with making the program fully operational.

(g) DOCUMENTATION.

This is the description of the program in the proper form for users and to enhance maintainability. it describes the workings of a program and how expected problems could be solved.

QUALITIES.

A program is termed qualified when it possesses some inherent qualities. Some of these qualities include:-

(a) CORRECTNESS.

Once the objectives of a program has been determined, the next thing is to see that the program actually does the geophysical data computation correctly. it is necessary to ensure that the program works for all cases, making sure it works with the full range of numbers that the field workers require.

(b) UNDERSTANDABILITY

These are programs written using a clear logic and pattern that allow for easy flow of control. They also involve the use of variable names that are similar to real life situation.

(c) MAINTAINABILITY

Most of the time, programs already developed are subjected to one modification or the other. Maintainable programs are programs that allow for easy modification as the need arises. One of the ways of designing a maintainable program is the used of modularity which is a programming technique that permits program to be written bite by bite.

(d) EFFICIENCY

The operation of a program requires the use of some resources which are the programmers time, Random Access Memory (RAM) and the disk storage space. A good quality program is expected to minimize the use of these resources.

(e) PORTABILITY

This is a program that is designed to work on different models of a computer system. To ensure portability, one should avoid features that are unique to a particular complier or computer.

(f) COST-BENEFIT ANALYSIS

This involves the comparison of the cost of computation and the benefit aspect from it. The cost of computation is measured in terms of initial and the running cost. While the benefit can take the form of speedily operation, reduction or elimination in fraudulent practices, easy control, speedily retrieval of data e.t.c.

(g) USERS -FRIENDLINESS:

This means that, the program has to be informative such that it tells the users the operation expected at any point in time. It should display errors messages which will serve as a guide whenever an error is committed.

(h) RELIABILITY

Reliable programs require given the right answers if the right kind of geophysical data is entered and whenever any unusual or erroneous data is entered, the program should fail either by producting incorrect output or by generating a run time error.

4.3 APPLICATION OF BASIC LANGUAGE TO APPARENT RESISTIVITY

BASIC is the acronym for Beginners All-Purpose Symbolic Instruction Code.

BASIC is a high level language designed for people who have no prior programming experience and is one of the easiest of all programming languages to learn. it is widely used in programming scientific, mathematical and many business problems. One important features about BASIC is that it encourages running the computer in an interactive mode.

4.4 **DEFINITION OF TERMS IN BASIC**

These are terms which are used in the BASIC programming environment. They include:-

(a) CONSTANT

A constant is the geophysical data written into a program whose value does not change during the execution of the program. There are two types of constants. These are String and Numeric constants.

STRING CONSTANT

This consist of a sequence of characters that may or may not be separated by spaces include enclosed in apostrophe or double quotation marks. They are not used for computation.

NUMERIC CONSTANT

This is made up of numbers. This include whole numbers and decimal numbers. They are used for computation.

(b) VARIABLES

These are geophysical data whose values can change during the execution of a program. The two types of variables are Numeric and String variables.

NUMERIC VARIABLES

These are variables that are used in computation within the program . They are made up of numbers or digits which will be used in calculations.

STRING VARIABLES

These are variables that can not be used for computation.

(c) RESERVE WORDS

These are set of words that are meaningful to the computer or compiler. They have predefined meaning within a computer language.

(d) EXECUTABLE AND NON EXECUTABLE STATEMENT

An executable statement is a statement that tells BASIC what operation to perform e.g PRINT Y which require BASIC to write the value contained in Y . A non-executable statement does not require any action on the part of the program e.g

REM (meaning remark)

4.5 PROGRAM AND NESTED LOOPS IN ELECTRICAL SOUNDING

A loop is the set of geophysical instructions that may be executed repeatedly while a certain condition prevails. In some implementations, no test is made to discover whether a condition prevail until the loop has been executed once.

In BASIC, the way of executing loop is achieved by the used of FOR ------- NEXT Statements. This is refer to as unconditional loop and it is used if the problem requires a specified number of repetitions. The FOR statement begins the loop while the NEXT statement ends it. The general format of these is given below:

```
FOR K= N1 TO N2 STEP N3
---------
----------
NEXT K
```

Where K is the countered variable that controls the loop.

N1 is the initial value which K takes at first.

N2 is the upper limit which K should not exceed.

N3 is the incremental rate.

Another form of loop is the conditional loop. The execution of this loop depends on the result of the condition tested such that if the condition is true, the loop is skipped. This requires the use of WHILE and WEND. The WHILE along with a condition begins the loop while the WEND ends the loop.

NESTED LOOPS

These is the process of having a loop written another loop. The general format of a nested loop is given below:-

```
FOR I= 1 TO 10

FOR J= 1 TO 12

- - - - - ———
- - - - - - ———
NEXT J

NEXT I
```

The NEXT statement for the inner loop comes before that of the outer loop which implies that for each execution of the outer, the inner loop is repeatedly executed until the condition becomes false before the outer loop is executed again.

4.6 ARRAY AND DIMENSION IN RESISTIVITY SURVEY

The process of organizing geophysical data is to be so referenced by one variable is called an ARRAY. This concept of array requires the understanding of subscripted variables. A subscripted variable is a subscript can be an integer number or a character which stored an integer or an arithmetic expression which has an integer result enclosed in parenthesis.

The use of an array is a powerful programming technique which enable explorers to store numerous geophysical data with the same variable name and access can be made to any of the data.

DIMENSION

The ability to make use of subscripted variable is limited by what BASIC can accept without the use of a DIMENSION statement. In the absence of DIMENSION statement usually abbreviated as DIM, BASIC provides not more than ten cells when subscripted variables are used. However, to be able to reference more cells, the DIMENSION statement has to be used and it has to appear at the earlier part of the program.

4.7 PROGRAM IMPLEMENTATION AND GRAPHICAL REPRESENTATION OF APPARENT RESISTIVITY AGAINST CURRENT ELETRODE SPACING

In the two locations surveyed geophysically for the state of Nigeria, the same spacing for the current and potential electrodes was made but there were variations in their resistance due to the differences in their geophysical stratification and composition.

The implementation of their respective apparent resistivities as programmed in the computer and the required output obtained are seen below: -

PROGRAM 1 FOR EKPOMA LOCATION:

The program below is expected to compute the various apparent resistivities (Pa) using the formula Pa=ΠRCD{(L/CD)2 -0.25} while the corresponding current electrode spacing (L), potential electrode spacing (CD) and the resistance (R) that was displayed on the screen of the Terameter used was entered while the program was running and the output will be presented in the format below:-

L	CD	R	PA
1.00	0.15	38.50	?
1.47	0.15	22.86	?
2.15	0.15	13.70	?
3.16	0.15	9.42	?
4.64	0.15	6.85	?
6.81	0.15	4.37	?
10.00	0.15	2.55	?
14.70	1.50	4.20	?
21.50	1.50	2.68	?
31.60	1.50	1.57	?
46.40	1.50	0.44	?
68.10	1.50	0.22	?
100.00	1.50	0.15	?
200.00	5.00	0.19	?
400.00	5.00	0.13	?
600.00	5.00	0.11	?

PROGRAM 2 FOR IRRUA LOCATION:

The program below is expected to computer the various apparent resistivities (Pa) using the formula Pa = ΠRCD {(L/CD) ^{2} -0.25} while the corresponding current electrode spacing (L) potential electrode spacing (CD) and the resistance (R) that was displayed on the screen of the Terameter used was entered while the program was running and the output will be presented in the format below:

L	CD	R	PA
1.00	0.15	56.40	?
1.47	0.15	40.20	?
2.15	0.15	25.45	?
3.16	0.15	19.00	?
4.64	0.15	12.50	?
6.81	0.15	7.00	?
10.00	0.15	5.88	?
14.70	1.50	6.55	?
21.50	1.50	3.72	?
31.60	1.50	2.96	?
46.40	1.50	1.44	?
68.10	1.50	0.38	?
100.00	1.50	0.34	?
200.00	5.00	0.30	?
400.00	5.00	0.23	?
600.00	5.00	0.14	?

CHAPTER FIVE

5.1 SUMMARY

The aim and objective of any geophysical survey is to provide some data that can be analyzed and evaluated computationally to give some information on the surface and subsurface geology of an area.

In this instance, data have been acquired as shown in chapter four. The geoelectric stratification of the surveyed area and an interpretation are presented to allow an insight into the subsurface geology initially and ultimately the hydrogeology of the said area.

However, it must be noted that any attempt to an interpretation of geophysical data without some reliable stratigraphic or geologic constraints will produce ambiguous and meaningless results.

Bearing this in mind, an extensive review of the existing literature on geology, stratigraphy and borehole logs of the area surveyed was made and it afforded a reasonably reliable interpretation of the vertical electrical sounding (VES) curves.

5.2 PRECAUTIONS

To ensure a maximum accuracy in the readings, certain vital limitations and precautions have to be taken.

The effect of small earth's galvanic voltage can be reduced by the use of alternating current across the electrodes. It is highly minimized in this ABEM TERRAMETER 300B by simultaneously switching the battery across the electrodes in alternate potential.

For the greatest accuracy in deferming the ratio V/I, it is desirable that the current I be maximized and hence the following conditions are to be fully satisfied.

(1) In a dry condition, the soil about the electrodes are moistened to ensure good electrical contact to reduce errors due to contact resistance.

(2) The electrode connections were securely made.

(3) The electrodes were cleaned before operation.

(4) The readings were taken at closer interval and electrode spacing to achieve greater resolution.

(5) After each reading, the resistance button is switched off immediately to avoid unnecessary running down of the battery.

From the above analysis, it could be inferred that inspite of these limitations and precautions there were still some errors and these can be attributed to the problem of continuously changing electrical properties of the earth due to weathering and lack of complete knowledge of the path transversed by the signal.

5.3 CONCLUSION

Practical and computer-based investigations from the two locations which include Ekpoma and Irrua of Edo State show that the depth of the aquifer is about 400m.

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APPENDIX

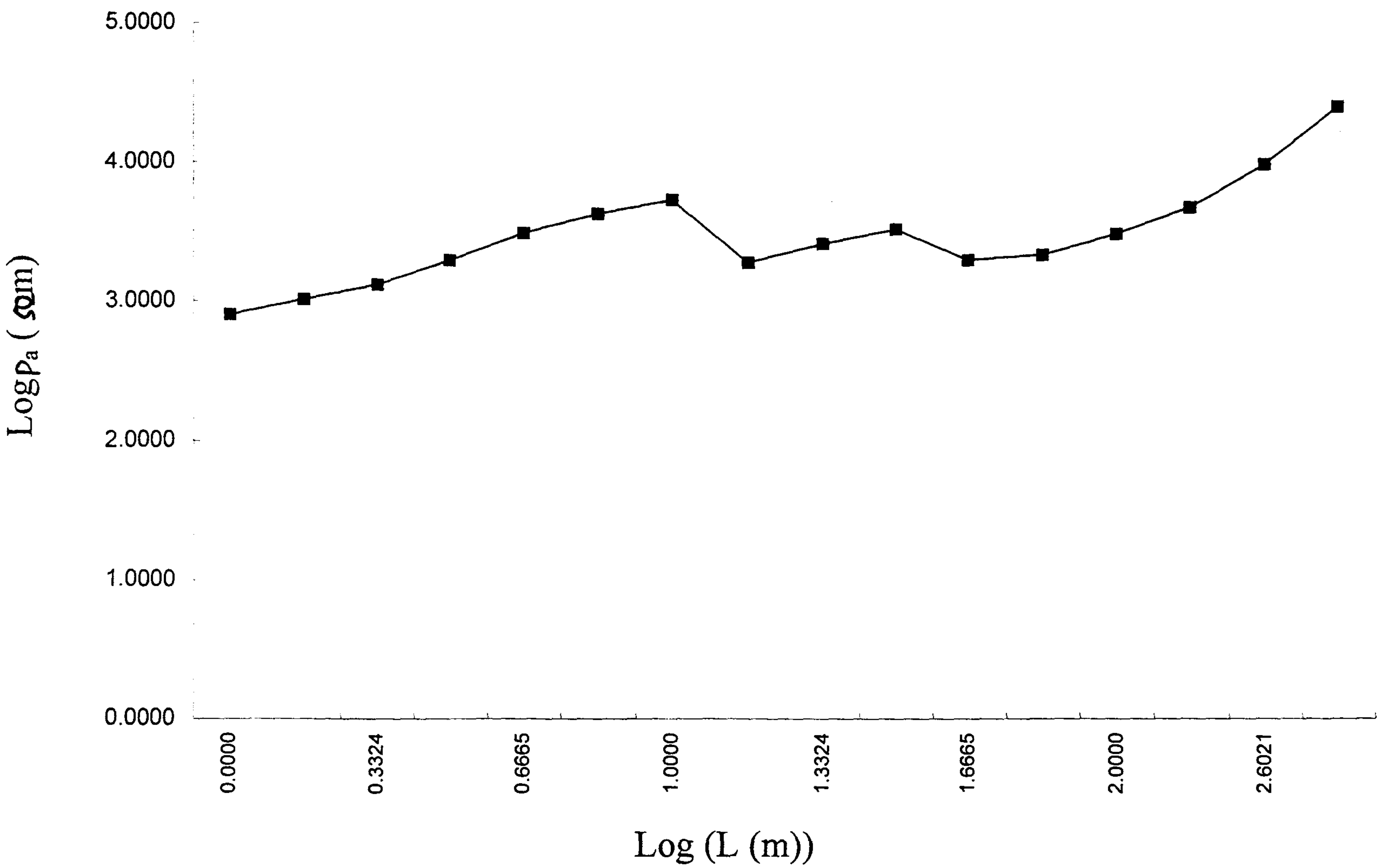
PROGRAM IMPLEMENTATION

```
CLS

REM PROJECT PROGRAM ON GEOPHYSICAL

REM EXPLORATION DATA COLLECTED AT EKPOMA

REM IN EDO STATE

DIM L (16), CD (16), R(16), PA(16)

FOR K = 1 TO 16

INPUT "enter value of L", L (K)

INPUT "enter value of CD", CD(K)

INPUT "enter value of R", R(K)

PI=3.142

PA(K) = PI * R (K) * CD(K) * ((L(K)/CD(K)}^2-0.25)

NEXT K

PRINT TAB (20); "L"; TAB (32); "CD"; TAB (42); "R";

        TAB (54); "PA";

PRINT TAB (5); STRING $ (64,"*")

FOR T= 1 TO 16

PRINT TAB (20); L(T); TAB (30); CD (T); TAB (40); R(T);

        TAB (50); PA (T);

NEXT T

END
```

GRAPHICAL REPRESENTATION OF APPARENT RESISTIVITY AGAINST CURRENT ELECTRODE SPACING.

L	CD	R	PA
1	.15	38.5	801.9103
1.47	.15	22.86	1032.034
2.15	.15	13.7	1324.902
3.16	.15	9.42	1969.225
4.64	.15	6.85	3088.36
6.81	.15	4.37	4244.611
10	.15	2.55	5341.099
14.7	1.5	4.2	1896.125
21.5	1.5	2.68	2591.778
31.6	1.5	1.57	3282.041
46.4	1.5	.44	1983.764
68.1	1.5	.22	2136.875
100	1.5	.15	3141.823
200	5	.19	4775.094
400	5	.13	13070.21
600	5	.11	24884.21

s any key to continue



Geophysical exploration carried out in Ekpoma

PROGRAM IMPLEMENTATION

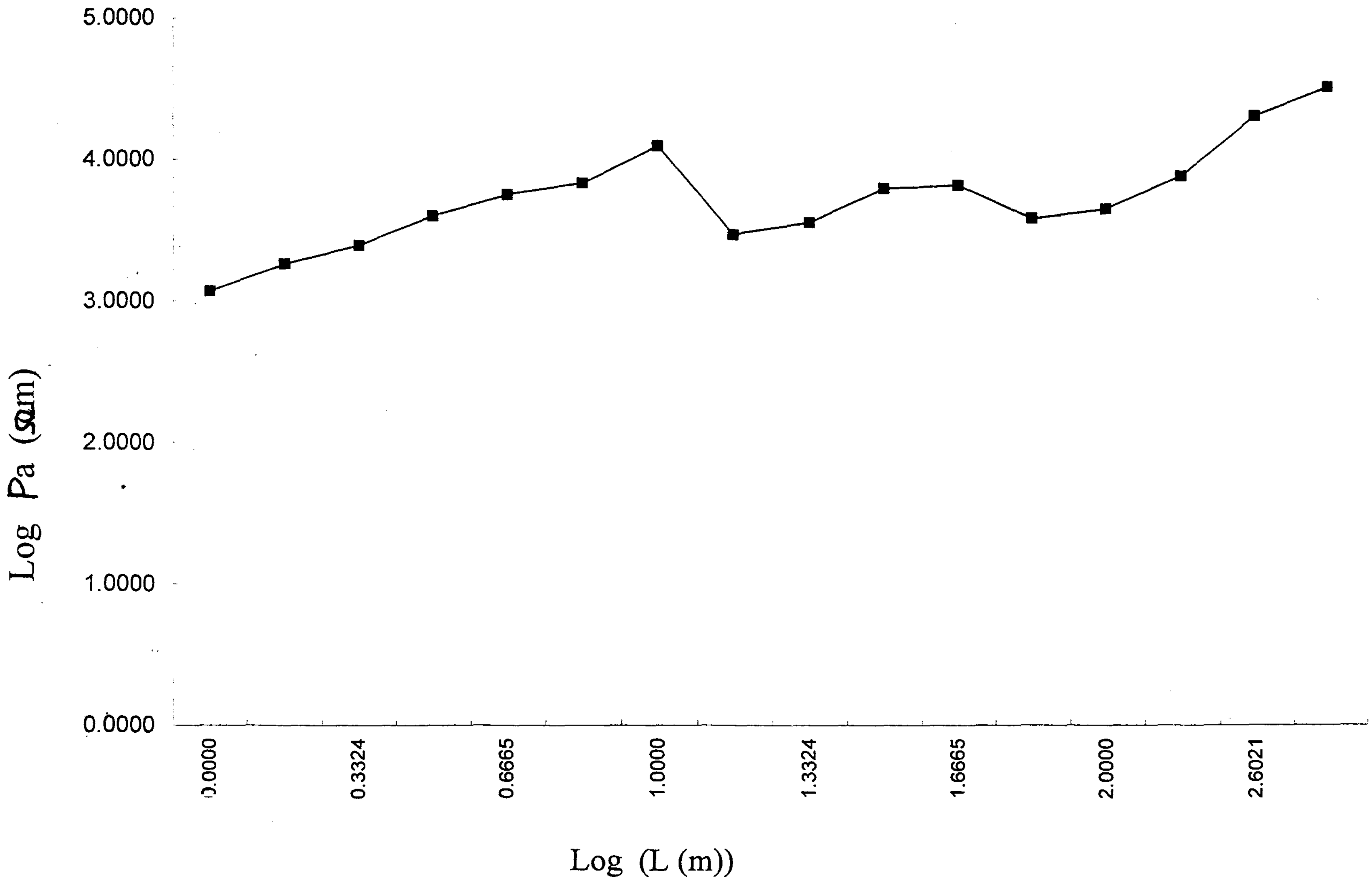
```
CLS
REM PROJECT ON GEOPHYSICAL
REM EXPLORATION DATA COLLECTED AT
REM IRRUA IN EDO STATE
DIM L (16), CD(16), R(16), PA(16)
FOR K=1 TO 16
INPUT "enter value of L", L(K)
INPUT "enter value of CD", CD(K)
INPUT "enter value of R", R(K)
PI = 3.142
PA (K) = PI* R(K) * CD (K) * {(L(K)/CD (K)}^ 2-0.25)
NEXT K
PRINT TAB (20); "L"; TAB(32); "CD"; TAB(42); "R"; TAB (54);
        " PA";
PRINT TAB (5); STRING $ (64,"*")
FOR T=1 TO 16
PRINT TAB (20); L(J); TAB (30); CD(T); TAB (40); R(T);          TAB(50);
PA(T);
NEXT T
END
```

GRAPHICAL REPRESENTATION OF APPARENT RESISTIVITY AGAINST CURRENT ELECTRODE SPACING.

IRRUA LOCATION

L	CD	R	PA
1	.15	56.4	1174.747
1.47	.15	40.2	1814.862
2.15	.15	25.45	2461.222
3.16	.15	19	3971.897
4.64	.15	12.5	5635.693
6.81	.15	7	6799.148
10	.15	5.88	12315.95
14.7	1.5	6.55	2957.052
21.5	1.5	3.72	3597.543
31.6	1.5	2.96	6187.797
46.4	1.5	1.44	6492.32
68.1	1.5	.38	3690.966
100	1.5	.34	7121.466
200	5	.3	7539.622
400	5	.23	23124.22
600	5	.14	31670.81

s any key to continue



Geophysical exploration carried out in Irrua