COMPUTER ASSISTED GEOPHYSICAL DATA ANALYSIS

Case study of :

Rock conductivity and Hydrogeological condition of FCDA Abuja

BY

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CERTIFICATION

This project entitled '**COMPUTER ASSISTED GEOPHYSICAL DATA ANALYSIS:** Case study of Rock conductivity and Hyrogeological condition of FCDA Abuja' by Abel T. Audu meets the regulations governing the award of Post Graduate Diploma in Computer Science of Federal University of Technology, Minna and is approved for its contribution to scientific knowledge and literary presentations.

....

Audu Isah Date

(Project Supervisor)

....

Dr. S. A. Reju Date

(H. O. D.)

....

External Examiner Date

DEDICATED

TO

My Brother

CHRIS AUDU

AND

My Dear Mother

NAOMI AUDU

QUOTATION

As the entire world gradually turns into a global village by the surging influence of computer technology, the computer, which is not meant to replace human intelligence and intellectual capability but to assist the human brain in task performance remains the most powerful tool for harnessing information.

.... Abel T. Audu

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ABSTRACT

The area used as a case study within the context of this project is FCDA Abuja in connection with groundwater exploration. The knowledge of the geological framework of an area is of paramount importance before the mineral and other earth's material can be maximally exploited.

The major part of the aspects addressed in this project include the design of a set of program modules which can be used to compute the apparent resistivities using resistance values as field data. DBase V was used in designing the programs owing to its versatility in handling structured programming. Three subprograms which are linked to the main program were designed for generating geophysical results for the three portions of the area under study. The unprofessional practice of random drilling for groundwater mostly results to uneconomical and unreliable boreholes which dry up during dry spells. The results to be generated using the program modules in this project can serve as a guide to the drilling engineers so as to avoid drilling at unfavourable locations.

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CHAPTER ONE

INTRODUCTION

1.1 OVERVIEW

Geophysical exploration involves the method of measuring one or more of the physical properties of the rocks within an area so that relevant computations, analysis and interpretation can be achieved all in an attempt to unravel the presence of one or more of the natural resources such as solid minerals, petroleum oil and ground water which are stored within the bowels of the earth. However, the analysis and interpretation of geophysical data often prove to be sophisticated and tedious using manual methods. Human errors in the course of the computation, analysis and interpretation of the results grossly complicate the method stated above. This therefore calls for an effective, efficient and versatile method of analysis using computers. The computer has proved to be a powerful and versatile tool for processing data due to its enormous capabilities.The introduction of the computers in geological studies particularly in the developed countries has remarkably promoted the growth of the discipline. Most geophysical computations, analysis and interpretation of data require the use of a computer either because the number of computations become tiresome or due to the fact that the problem involves large sets of data points. The computer handles simple as well as complex and repetitive calculations and provides timely, accurate and reliable results.

1.2 PROBLEM DEFINITION

Most aspects of geophysical work are still done manually especially in the developing countries. The manual methods of geophysical work have proved to be tedious and ineffective and are in addition prone to human errors. The problem to be addressed in this project is that of designing a method of computing geophysical information that will lead to proper analysis and interpretation so that all the drawbacks associated with the manual method are eliminated or at least drastically reduced. A computerized method of generating geophysical results is to be designed and recommended for implementation in the form functional, structured and effective program modules.

1.3 BACKGROUND

The project writer, who is a geologist has an inclination towards measurement and analysis of data. This is based on the fact that measurement and analysis of data often lead to accurate and reliable results which in turn allows quick decision making, strategic planning and operational efficiency. Petroleum' and hydrogeological companies are the largest employers of geologists It is therefore not unexpected that a tremendous interest in geomathematical techniques has developed in these organisations especially in the developed countries. This interest has spread back into the academic world and has resulted in an increasing emphasis on computer languages and mathematical skills in the training of geologists.

1.4 OBJECTIVES OF THE STUDY

Within the scope of any study or research, there are always a number of objectives to be achieved. The cardinal objective of this study is that of designing a functional and effective system for handling the generation of geophysical results which will serve as a useful guide for groundwater drilling. In addition to broadening the writer's experience in computer programming and data processing, it gears towards motivating the geologist to develop more interest in computer-based geological work; thus serving as a motivating report to the earth's scientist. Furthermore, the project has the aim of assessing the rock conductivity and hydrogeological condition of the area under study with a view to providing vital information which will be of assistance to groundwater drilling engineers.

Other objectives of .the study are as follows:-

* To demonstrate the computer's capability in solving problems
* To device a system with universal applicability if certain modifications are effected
* To emphasize the need for eliminating data loss and human errors in data processing.

1.5 SIGNIFICANCE OF THE STUDY

Mathematical methods have been employed by some geologists since the earliest days of the profession. Mining geologists and engineers for example have calculated tonnages and estimated ore tenor from samples for centuries. Lyell's subdivision of the tertiary (on the geological time scale) on the basis of the relative abundance of modern marine organisms was a statistical procedure. Sedimentary petrologists have regarded grain size and shape measurement as important sources of sedimentological information since the beginning of the century. The hybrid earth sciences of geostatistics, geochemistry, geophysics and hydrology require a firm background in mathematics. The methods used presently in the developing countries are mostly through manual means. The construction of Russ diagrams, Strike and dips of structures have been done using crude methods. Frequently, simpler and apparent clumsy operations especially involving repetitive computations can be substituted with the more elegant operations using computers.

This study is of tremendous relevance due to the following reasons:-

a) It is envisaged that when completed, this study will lead to the provision of timely,

b) Accurate and more reliable geophysical results.

c) The project will serve as a highly motivating report to the earth's scientist towards more involvement in computer-based geological work.

d) The study will reveal how a set of structured program modules can be of great assistance in problem solving techniques.

e) A revelation of how a versatile database management system software such as dBase V can be used to develop well structured and functional program modules.

1.6 SCOPE OF THE STUDY

Geophysical data can be analysed for various purposes. This can be for the investigation of local geological structures of an area, solid minerals, petroleum oil deposits evaluation or for hydrogeological studies as intended for in this project. However, this study is primarily centered on the use of computer's in the computation and analysis of geophysical information using rock resistivity (the opposite of conductivity) as one of the physical properties of the earth. An adoption of the system designed in this project to other study areas must call for its modification.

As a result of the varied requirements of different groundwater resources environments around the world, the scientific breadth of hydrogeological studies has widened tremendously. The subject has benefited greatly from allied disciplines such as engineering geology and petroleum engineering but much purely hydrological technique has been developed as well. The most important scientific realization to appear over the past two decades however, has been the gradual emergence of hydrogeology as a multi-disciplinary subject. Surprisingly, this development has perhaps been mostly appreciated in more specialized facets of the subject such as, for example, pollution control or hydrothermal energy. Unfortunately, in groundwater resources assessment, although there is a growing adoption of multi-disciplinary programmes, there is still a real reluctance or lack of awareness of the need to incorporate a multi-disciplinary approach into many plans of operation. Too frequently, a hydrogeological study proves to be too "geologically" based.

Much of the difficulty in the development of multi-disciplinary hydrogeological approaches is the inbred result of specialised education which is probably unavoidable, and indeed probably essential in purely scientific terms. Undoubtedly, specialisation within hydrogeology is also necessary for the advancement of the subject, but cross discipline education which is equally important and encouraging is beginning to emerge.

Areas considered in this study include:-

a) Specification of the drawbacks of the manual method of carrying out geophysical work

b) Design of a set of program modules for generating timely, accurate and reliable geophysical information

c) Demonstration of the use of dBase V as a versatile programming language

d) Examination of the apparent resistivity values of the locations within the area under study for relevant conclusions and recommendations to be made.

e) Books, journals and programs consultations for relevant facts and information.

1.7 STUDY METHODOLOGY

Using a professional approach, the efforts to be applied on a large scale in groundwater resources evaluation is through the use of geophysical exploration techniques. The focus of attention on groundwater resources and the attendant scientific progress that has ensured have arisen in a number of ways:-

In industrialised countries, there has been an increasing realization of the need to conserve and protect water resources and to ensure economic supplies. As a result, planning programmes have been widely instituted with the frequent requirement for the optimization of groundwater utilization and its co-ordination with other water resources. Optimization cases have been that groundwater resources can be preferable to surface water resources on the basis of easier protection from pollution and better dependability during drought periods. In the less industrialized nations, much of the increased emphasis on groundwater resources and the improvement in investigation techniques are related to the growth in population needs in the form of portable water supplies and irrigation water for agriculture, although the contribution of specialized hydrogeological studies to provide water for industrial and mineral resources development should not be neglected. In tropical areas such as the one in connection with this study, surface water resources are subject to marked seasonal variation, groundwater is becoming increasingly important as a dry season supplementary supply to support stable economic conditions. The greatest emphasis on groundwater resources assessment, however, has been , and will continue to be, in those areas where semi-arid and arid climatic conditions exitst.

Two disciplines - **Computing** and **Geology** are involved in this project. Of particular importance to man are the natural resources stored within the bowels of the earth. Geology is the main discipline that unravels how these useful materials can be tapped for environmental and industrial growth. But the techniques involved in geological work are often complex and wide in scope. These therefore call for equally challenging capabilities such as those posed by computers, hence the interest developed by the writer who is a geologist.

The method employed in securing data for this project was that of record searching at SAFCO Ltd., Samaru, Zaria. It was kept in mind that a versatile tool such as the computer is the most powerful device for harnessing information. A practical approach in program development and compilation of the project is considered as the most versatile method in the study.

CHAPTER TWO

COMPUTERS AND ASPECTS OF GEOPHYSICAL EXPLORATION

2.1 THE ELECTRONIC BRAIN

Computerization compliance is a requirement which has to be met by all and sundry to match the current and future global challenges. There is no doubt that computers are bringing about fundamental changes in the way many things are done and are consequently employed in all facets of human endeavours. It is no longer questionable whether computer technology has come not only to wade into every imaginable discipline today but in addition to make a starting point for those who wish to forge ahead in any sphere of knowledge

There is no doubt that computers are bringing about fundamental changes in the way many things are done. They represent an extension to intellectual activity and enable us to hand over to machines tasks which we are accustomed to performing at home , industry and in the office. In addition, they enable us to tackle problems which were hitherto of insurmountable complexity.

Computers are employed in almost all facets of human endeavours and development ranging from micro-wave ovens, internet service operations as well as industrial, domestic, professional applications, space exploration and nuclear research to mention a few. In industrial and engineering applications, the use of robots has greatly increased productivity and efficiency. Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM) have promoted engineering and architectural design techniques. Business operations and transactions have been greatly enhanced using computers. Other professions such as Law, Medicine, Education, Sports, Telecommunication, Military operations, Transport as well as Science to which this study belongs have embraced the use of the computer's potentials.

2.2.1 COMPUTERS AND THE EARTH SCIENCES

All scientists today have a growing need for, as well as a pre-occupation with, basic skills in data analysis. The need for rapid methods of analyzing data increasing with every working day. Thus spurred, technical progress in electronic computers has outpaced the ability of many scientists and engineers to use the new instruments and techniques effectively. The situation cries out for data processing methods which will somehow make it possible for the relatively uninitiated worker in the computational and programming field to employ all the advances in the solution to problems in his own scientific specialty. At least an amount of skill is is required of the earth scientists who, in the past 25 to 30 years have become increasingly interested in the processing of data. Probably among these scientists, the geophysicists have had the most intimate contact with the relatively new computational techniques. And although the geophysicists have been spurred in their use of data processing by the economic applicability of the results obtained, many new and important scientific facts are being developed. Geophysical observations and measurements made at the surface can be employed in suitable circumstances to assist in the evaluation of local geological structures likely to favour the accumulation of water as employed in this study.

2.2.2 GEOPHYSICAL EXPLORATION

All geophysical exploration activities aim at determining one or more of the physical properties of the rocks within an area so that observed variation of these properties can be interpreted in terms relevant to the particular investigation taken into consideration.

Thus, the application of geophysical methods to groundwater investigations necessitates the determination of those physical properties which can be interpreted in terms of aquifer distribution and saturation. Data gathering techniques are now giving geophysical data a resolution at lower cost. In addition to geological interpretation, attention is also paid to the hydraulic properties of aquifers. Qauntitative surface resistivity investigations can be used to assess variations in transmissivity in primary permeability sandstones: Worthington and Griffiths et al(1975).

2.3 METHODS OF MEASURING GEOPHYSICAL DATA

Various methods are employed in measuring geophysical data. The type of approach used depends to a large extent on the geophysical exploration being considered. These methods are discussed below.

2.3.1 ELECTRICAL METHOD

The method that was used in the measurement of the data used in this project was the electrical profiling technique by SAFCO Ltd, Samaru, Zaria, using the constant separation traverse principle. This involves placing a device or pieces of equipment at regular intervals in the field in the course of taking measurements. The array type employed was the Wenner electrode configuration. The instruments used were an AC terrameter and electrodes. The separation gap was 50m. Measurements were taken by applying an electrical current to the ground surface through two appropriately arranged electrodes and measuring the potential drop between two other suitably placed electrodes.

2.3.2 SEISMIC METHOD

This method is based on the measurement of the speed of propagation of shock waves through a rock or formation. The shock waves emanate from a localised source of energy, commonly an explosive charge or mechanical blow. The velocities and travel time of the reflected or refracted waves set up are measured at the ground surface by appropriately sited geophones (seismometers). The velocity vary from 610m/s for unconsolidated deposits up to

6,096 m/s in igneous and metamorphic rocks. The value is determined by the elasticity of the strata which is related closely to the porosity. Other factors such as grain size, cementation, saturation and stress conditions are also determinants of the velocity of the shock waves.

2.3.3 MAGNETIC METHOD

This method employs a magnetometer to measure the magnetic properties of rocks and minerals. The magnetic properties of rocks are induced by the earth's magnetic field, which is modified by the pressure of magnetic minerals such as magnetite, limonite, glouconite within a rock mineral or formation. A magnetic survey permits the identification of local variations in the distribution of the earth's magnetic field.

2.3.4 DENSITY METHOD

The density method involves the use of sensitive gravimeters to measure the density variations of strata in the earth's total gravitational field arising from changes in the density of strata or rocks. The distribution of such variations in an area can be plotted after corrections have been applied to observed values for latitude, elevation and local terrain effects. The use of gravity method has met with some success in hydrogeological work.

2.3.5 SUB-SURFACE METHOD

In oil exploration activities, borehole logging is the term commonly applied to the process by which measurements are made in an borehole, of the physical properties of rocks or strata into which it is sunk or the column of water it contains. Inspection of the engineering condition of the borehole by underwater television camera, or photographic methods can also be regarded as a sub-surface method of investigation . Such sub-surface activities have become more widespread in recent years, but are aids to borehole development rather than exploratory methods. Appropriately designed probes are lowered into the borehole and the particular parameter under investigation is either measured at selected depth intervals or its variations recorded continuously. Other borehole logging methods whch are used in oil field practice, and which could be employed to advantages in groundwater work include: formation density log, sonic log, self-potential log, caliper log and neutron log. Numerous application of the borehole television camera have now been made for engineering purposes in groundwater problems.

2.3.6 PHYSICAL PROPERTIES FOR GROUNDWATER EXPLORATION

The four physical properties of rocks and strata normally used for water exploration include: electrical resistivity, seismic velocity, magnetism and density. Of these four, the electrical properties are commonly used. This is due to fact that of all the physical properties of rocks, minerals or formation, electrical resistivity (the opposite of conductivity) shows the greatest variation. Furthermore, electrical resistance is the property of a rock or formation which is most easily measured and most directly affected by water. The measurement, computation analysis and interpretation of the physical properties allow the geological condition and hydrogeological environment to be inferred.

2.4.0 ELECTRICAL CONDUCTIVITIES

Electrical current may be propagated in rocks and minerals in three ways: Electronic (Ohmic), Electrolytic and Dielectric conduction. The first is the normal type of current flow in minerals containing free electrons, such as the metals. In an electrolyte the current is carried by ions at a comparatively slow rate. Dielectric conduction takes place in poor conductors or insulators, which have very few free carriers or none at all. Under the influence of an external varying electric field, the atomic electrons are displaced slightly with respect to their nuclei; this slight relative separation of negative and positive charges is known as dielectric polarization of the material. Tonic and molecular polarization may occur in materials with ionic and molecular bonds. In all these cases, dielectric conduction is the result of changing electronic, ionic or molecular polarization caused by alternation electric field.

2.4.1 ELECTRICAL CONDUCTION

The electrical resistivity of a cylindrical solid of length **L** and cross-sectional area **A**, having a resistance **R** between the end faces is given by: $\rho = \mathbf{RA/L}$. If **A** is in metre^2, **L** in metres and **R** in Ohms, the resistivity unit is the ohm-metre(Ωm). For dimensions in centimetres, the unit becomes ohm-centimetre. 1Ωm = 100Ωcm

cm. The resistance **R** is given in terms of the voltage V applied across the ends of the cylinder and the resultant current **I** flowing through it. By Ohm's Law, **R=V/I**, where **R** is in ohms and the units of **V** and **I** are Volts and Amperes respectively. The resiprocal of resistivity is conductivity. i.e. $\sigma = 1/\rho$

2.4.2 ELECTROLYTIC CONDUCTION

Since most rocks are poor conductors, their resistivities would be extremely large were it not for the fact that some are porous and the pores filled with fluids especially water. As a result, the rocks are electrolytic conductors, whose effective resistivity may be defined as mentioned earlier. But it must be kept in mind that the conduction is electrolytic rather than ohmic. That is, the propagation of current is by ionic conduction - by molecules having an excess or deficiency of electrons.

2.4.3 DIELECTRIC CONDUCTION

The significant parameter in dielectric conduction is the dielectric constant **K**, sometimes called the specific inductive capacity of the medium. The dielctric constant is similar to the conductivity in porous formations as it varies with the amount water present. The mechanism of dielectric conduction or the displacement current flows only in non-conductors when the external electric field changes with time.

2.5 ROCK CONDUCTIVITY AND HYDROGEOLOGICAL CONDITION

Rock conductivity is an electrical property of a rock which is a measure of the degree to which it allows electrical current to pass through it. It is the opposite of rock resistivity. The higher the conductivity of a rock, the lower is its resistivity. Hence measurement of the resistivity of a rock or formation as applicable to this study indicates the level of conductivity of the rock. These two properties of rocks are highly related to the hydrogeological condition of an area.

The hydrogeologcal condition of an area refers to the overall groundgwater potential of the area. A high level of rock resistivity indicates a poor hydrogeological condition which makes groundwater exploration expensive to undertake. On the other hand, low rock resistivity shows high conductivity which favours groundwater exploration. Since water is a universal solvent, it allows the dissolution of most eart materials such as minerals including those that conduct electricity examples of which include: magnetite, limonite, muscovite, biotite, graphite, cassiterite among others. High rock conductivity which invariably indicates low resistivity is a finger point to a favourable groundwater conditions. Therefore, a careful measurement, computation analysis as well as result interpretation can lead to proper planning in groundwater exploration.

2.6 MODEL STUDIES

The understanding of groundwater modeling is now well established and many excellent techniques often assist in achieving successful results. Unfortunately, there is a tendency towards the principle that aquifer models are the solution to all problems.

Once a model has been constructed, a sense of well-being prevails and a mass of response permutations are forth coming. Where reliable groundwater data have being used, that approach is not disputed, but mathematical solutions have advanced far beyond the ability to assess ground conditions and there is a temptation to oversimplify the real situation and to turn all too quickly to sophisticated model techniques. As a result, predictions frequently do not stand the test of time. There exists in hydrogeology, therefore, a need for more research into measuring techniques that will provide good aquifer data, so that understanding of the ground can catch up with the understanding of mathematical simulation.

Groundwater modeling can may be viewed in two stages:- Investigation and feasibility. The value of coarse-grid steady state model in the early stage of investigation is considerable. It provides an appreciable input and flow volumes as well as a broad-based idea of their distribution. Such a model can equally indicate areas where a particular investigation is required. In aquifers where existing abstraction is significant, a preliminary model is probably more helpful than in undeveloped ones. Although modeling is a continuing process in a project, once the investigative model has been studied, emphasis should change to obtaining reliable ground data.

2.7 ASPECTS OF DRILLING

The acquisition of data for hydrogeological map compilation is predominantly provided by surface geological mapping and drilling. In carrying out a programme of drilling for groundwater, geological control is of prime consideration. Although in some instances much is made of remote sensing and such techniques as surface thermometry(Cartwright, 1974) in groundwater studies, they have only very limited application and normally can only provide quite preliminary indications of groundwater presence. Whatever the situation, however, some form of positive assessment is required in which drilling is usually an integral factor. In groundwater exploration programmes, drilling usually proves to be one of the most expensive operations. In the oil industry, the responsibility of drilling operations are carried out by specially trained drilling and petroleum reservoir engineers. In hydrogeology however, the salary structure and budget allocations rarely attract such personnel and as a result, the supervision of the drilling operation falls to the hydrogeologist. He is responsible for drawing up and supervising drilling contracts or for determining the specifications for rig purchases and it is vital that he should be familiar with the the various techniques, rig components and capacities that are best suited for different

CHAPTER THREE

SYSTEM ANALYSIS AND DESIGN

3.1 OVERVIEW

System analysis is the method of determining how best to use computers with other resources to produce results which meet the information needs of an organisation. The task of developing a system for a particular organisation is usually headed by a system analyst. The system analyst has to work in cooperation with the users of the system as well as the hardware and software manufacturers. He has to mediate properly to ensure that the hardware and software manufacturers satisfy the needs of the user. System analysis requires a careful examination of an existing system so as to identify its strengths and weaknesses before a functional and efficient system can be developed. It is imperative that the problem to be solved by the new system are thoroughly addressed, otherwise, the end result of the system development will turn out to be total failure. On the whole, the system analyst must be a vanguard and ensure that the new system is developed within the budgetary constraints of the organisation concerned.

3.2 ANALYSIS OF THE CURRENT SYSTEM

It has been stated in the introductory part of the first chapter of this project that most aspects of geological work especially in the developing countries are still done manually. Computation of geological parameters such as porosity, permeability, grain size, saturation apparent dip, hydraulic pressure and apparent resistivity among others are done using the hand calculator and tables of logarithm. Other aspects of geological work such as contour plotting, construction of Russ diagrams, graphics, cross correlation, trend analysis and filtering as well as structural parameters determination and analysis are still done using crude methods.

3.3 DRAWBACKS OF THE CURRENT SYSTEM

The crude methods of carrying out geological work and study renders them tedious and unattractive. In most cases especially in situations involving large number of data points, the process turns out to be cumbersome, time-wasting and erroneous. Furthermore, this type of approach to scientific work undoubtedly prove to be inefficient. All computations and the aspects of geological work highlighted earlier can be handled with the aid of a computer thereby ensuring timely, accurate and reliable geophysical information.

3.4 DATABASE SYSTEM

A database is a collection of organised and meaningful information. It can equally be defined as a collection of stored operational data used by the application system of an enterprise. All enterprise. All enterprises store and maintain their operational data. The data used in this study are resistivity values for computing the apparent resistivities whose analysis and interpretation are of paramount importance in groundwater exploration.

A database is a file organizer which allows data and information to be maintained properly. This information can be anything that is deemed to be of relevance to the organisation which the system is serving to anything that may be necessary to help in the decision making process of the management of the organisation. The types of operations which can be performed on the data in a database include: insertion, retrieval, sorting, querying, deletion, computation and updating of records.

Between the database and the user of the system is a software called database Management System (DBMS). The various advantages of using a database are as follows:-

* Data and information integration is possible between files in a centralised system and between users in a network environment
* Data redundancy can be eliminated as redundancy can result in storage space wastage

* A database management system allows data and files independence
* Data integrity can be ensured and this leads to information consistence
* Operations on data and information are centrally controlled and this can results to better management of data and information.

3.5 FILES STRUCTURE AND DESIGN

Three database files designed for use in this study which store the data (resistivity values). These file are accessed by the program modules described in 3.6 below. The database files include:-

a) NE.dbf

This database file contains the resistance values belonging to the northeast portion and will be accessed by the file NEAST.prg for the computation of the apparent resistivities of the locations therein as well as the mean and standard deviation of the values.

b) NW.dbf

This database file contains the resistance values belonging to the northwestern part and will be accessed by the file NWEST.prg for the computation of the apparent resistivities of the locations therein as well as the mean and standard deviation of the values.

c) SOUTH.dbf

This database file contains the resistance values belonging to the southern portion and will be accessed by the file SOUTH.prg for the computation of the apparent resistivities of the locations therein as well as the mean and standard deviation of the values.

These three files have the same structure as the data have been grouped into three sets for proper organisation and easy analysis as well as interpretation and the structure is described as follows:-

S/No	Fieldname	Type	Width	Dec	Index
1	Location	Character	2	-	-
2	Resistivity	Numeric	5	-	-
3	A-Resistivity	Numeric	10	-	-
4	Remarks	Character	12	-	-

3.6 ANALYSIS OF THE NEW SYSTEM

The new system designed in this study is in the form of program modules. The main menu program specifies which and how any of the sub-modules linked to it can be executed. The execution of the main menu program results in the presentation of a menu screen which specifies options available and a description of what should be done once an option is selected. The program modules and their descriptions each are as follows:-

* MAIN.prg
* NEAST.prg
* NWEST.prg
* SOUTH.prg

- MAIN.prg

This is the main menu program whose execution displays the main menu screen with options for processing other program modules

NEAST.prg

This program module processes the apparent resistivities of the locations belonging to the north-east part of the area under study. It accesses the database file (NE.dbf) for data and displays a tabulated result as well as the mean apparent resistivity of the portion and the standard deviation of the values.

NWEST.prg

This program module handles the computation of the results for the northwest part and accesses the database file (NW.dbf) for data and displays a tabulated result as well as the mean apparent resistivity of the portion and the standard deviation of the values.

SOUTH.prg

The subprogam which is linked to the database file (SOUTH.dbf) for computing the required result for the southern part, the tabulated result of which is displayed as well as the mean apparent resistivity of the portion and the standard deviation of the values.

The formula used in computing the apparent resistivity values is as follows:-

A = KR

Where K = 2IIa

R = resistance (in ohms)

II = 22/7

a = 50m

The various remarks to be assigned for each of the locations is based on the following conditions:-

i) For apparent resistivity value less than or equal to 300 ohm metre, then the remark should be "Highly favourable Location"

ii) For apparent resistivity value greater than 300 ohm metre but less than or equal to 500 ohm metre, then the remark should be "Favourable Location"

iii) For apparent resistivity value greater than 500 ohm metre, the remark for that location should be "Unfavourable Location"

CHAPTER FOUR

SYSTEM IMPLEMENTATION

4.1 OVERVIEW

System implementation refers to the process of making it operational where it meant to be used. The introduction of a new system of operation is not to be taken as a trivial matter. A great deal of caution should therefore be exercised and careful decisions made in the course of implementing a new system; otherwise, there are bound to be serious problems arising and the result of the system developed can turn out to be total failure.

4.2 INPUT AND OUTPUT SPECIFICATIONS

The input elements considered in this study are the location numbers and their respective resistance values. These input parameters are stored in the three database files described in chapter three. The program modules equally described access their respective database files for the input elements for the computation of the apparent resistivity values of the various locations specified in the database files. After the computations, the outputs are displayed as specified in the respective programs.

4.3 USER DOCUMENTATION

The program modules designed in this project can be run in both dBase IV and V. The user documentation for a particular system is a stepwise description of how the user can run or make use of it. The program modules are processed as follows:-

For dBase V (i.e. dBase for Windows), select the **START** option followed by the dBase group icon and the program icon. Thereafter, type **DO MAIN** in the INPUT windows to run the main menu program. Select any of the options displayed to execute any of the program modles. However, for dBaseIV proceed as follows:-

i) Change directory to that of dBaseIV using the change directory command. i.e. at the DOS prompt, type **CD\dbaseIV** and press the **return** key (Enter)

NB: Check the name of the directory into which the dbaseIV program is installed before typing the command stated above as the directory name may be dbase4, dbase, etc as specified by the person who installed it in the computer. The command begins with **CD** followed by the directory name.

ii) Type **dbase** and press the **return** key. The computer displays the copyright protection and welcome screen before displaying either the control center or the dot prompt. If the controlled center is displayed, press the **escape** key and press **Y** to switch over to the dot prompt.

iii) At the dot prompt, type **DO MENU** and press the return key.

iv) On the menu display screen, choose to press any of the numbers **1, 2,** or **3** to run any of the program modules. Option **1** is for running the module responsible for generating the output for the north east portion. Option **2** is for the north west portion and **3** is for the southern part. The last option **4** is for exiting or terminating the processing of the program and takes the user to the dot prompt.

4.4 SYSTEM IMPLEMENTATION

There are various methods of implementing a new system. The conversion process can be any of the following alternatives:-

a) Crash (Direct) conversion

b) Pilot changeover

c) Phased conversion

d) Parallel changeover

The crash approach of conversion is a drastic measure in which the old system is completely replaced by the new one at once.

The phased method of changeover requires a gradual retirement of the old system as the new system is put in place in a piecemeal process.

The pilot approach involves only the conversion of some units or departments of an organisation into the new system.

The parallel method involves running the new system concurrently with the old one so that the performance of the two can be assessed.

From the nature of the problems addressed in this study, the most appropriate method of conversion is the crash approach.

4.5 PROGRAM DOCUMENTATION

Program documentation refers to a written description of the program. The programming language employed in writing the program modules of this study is dbaseV. The variable names used in the programs are as follows:-

AR = Apparent resistivity

Rem = Remark

PI = π

The program modules can both be executed in the windows environment as well as from the DOS environment (in the case of dBaseIV) . However, for them to be processed from the windows environment, dbaseIV has be set up to be invoked from windows.

- The modify command (MODI COMM) is used in the INPUT window (in the case of dBaseV) and at the dot prompt (in the case of dBaseIV) to retrieve any of the program modules .
- The DO command is used to run a program.
- The RETURN command transfers control from a module to the main menu screen.
- The EXIT command of the main program transfers control to the dot prompt.
- The USE command activates a specified database file.
- SKIP moves the record pointer to the next record in a database file.
- ENDIF terminates the IF programming structure.
- ENDDO terminates the DO WHILE programming structure.
- CASE introduces optional statements for selection by the user.
- ENCASE terminates the CASE programming structure.
- WAIT temporarily halts the execution of the program.

CHAPTER FIVE

SUMMARY CONCLUSION AND RECOMMENDATIONS

5.1 SUMMARY

The provision of timely, reliable and accurate information is vital for qualitative and meaningful decision making in any organization. Throughout the course of this study, it was kept in mind that an effective and powerful tool such as the computer is the best in handling repetitive operations involving many data points. Ease of computation was therefore a motivating factor. The set of program modules designed, tested and presented in this project constitute the new system to be applied in hydrogeological studies. DBase V was chosen owing to its data handling capability and ease of information organisation. Groundwater studies is a challenging aspect of geological work and is attracting more attention due to the varied application of water in the society.

In the process of determining geological parameters such as the ones taken into consideration in this study, the computer comes in as a useful aid to simplify the task of computation and generation of the required information which will serve as a guide to the groundwater drilling engineers. There are instances where a violation of the proper ethics in geophysical exploration for groundwater or oil leads to uneconomical and wasteful drillings at locations underneath which thick and extensive hard rocks are encountered and the drilling operation terminated for other locations. This unprofessional practice leads to operational inefficiency in hydrogeological organizations.

5.1.2 LIMITATIONS OF THE STUDY

The limitations encountered in this study are as follows:

a) Finance

Funds to carry out all the activities in connection with this study from the conceptualisaton stage to its completion was problematic. As an applicant, the writer has to struggle hard to accomplish the study.

b) Dearth of study materials

Programming textbook authors merely present description of keywords, definitions and few program segments in their textbooks. The task of writing and debugging a program for any application is left to the project writer or researcher concerned. The set of program modules in this project is a product of hard work and perseverance.

5.1.3 SYSTEM REVIEW AND MAINTENANCE

System review and maintenance are of prime importance for the system to remain functional. Once the system has become operational, it will need to be examined to see if it meets the set objectives. The system will also need to be reviewed when the need arises for the following reasons:-

a) To deal with unforeseen problems in its operation. E.g. programs may need to be modified and backup copies made to tackle unforeseen circumstances.
b) To confirm that the planned objectives are being met and to take appropriate actions if they are not.
c) To ensure that the system is able to cope with changing requirements of business operations.

Servicing the equipments and additional training of the users can keep the system up to date to reflect changing needs. Current softwares will give good and efficient output from the system than outdated ones and the users of the system will be kept confident in carrying out their duties. It is a good practice to make backup copies of all softwares and documents to safeguard against accidental corruption of the originals. Virus preventive measures are equally essential to protect data, softwares and information against virus attack.

5.2 CONCLUSION

Exploration techniques in groundwater assessment depend to a large extent on the geology of an area. Without a proper understanding of the geological framework of an area, it is impossible to quantify its natural resources. As a guide, a dry unconsolidated porous rock composed of the common rock forming minerals has a high resistivity (low conductivity) due to the fact that most of the rock forming minerals are insulators. If the pore spaces or fissures in the rock are partially or wholly saturated with water, the resistvity of the rock will be lowered and vice versa.

The results of the program modules indicate that the southern part of the area under study has more lower apparent resistivity values than the north-eastern as well as the north-western parts. Therefore southern part has more favourable groundwater potentials than the other parts. This shows a better hydrogeologcal condition than those of the other portions. Hence, groundwater drilling operations will be less expensive and economical in this area.

On the whole, the results will enable proper planning for groundwater drilling operations to be carried out. The reports can be used by any hydrogeological organization.

It should be noted that although the computations stated in the study employs a simple formula, the program modules can handle lots of data points requiring much iterations and the tabulated results are essential as they can assist in timely decision making in connection with groundwater exploration.

5.3 RECOMMENDATIONS

In the light of the findings and scope of work addressed in this study, the following recommendations are proffered:-

i) The writer is of the opinion that more computer techniques should be involved in geological work to assist in the provision of timely, accurate and reliable geological information as the unraveling of geological parameters often requires the use of a large set of data points. This should apply to the training of geologists in various tertiary institutions the world over. The earth scientist should therefore explore more ways of using the capabilities and potentials of the computer to greater depths.

ii) Other areas of geophysical work such as contour plotting, cross-correlation and map analysis not covered in this study can provide additional information which can be useful in drawing inferences on the hydrogeological conditions of an area.

The required software for carrying out these additional tasks and their operational know how have not been at the writer's disposal. Although the main issue involved in analyzing and interpreting the results has been addressed, others mentioned above can further enhance the task of analysis and interpretation and are therefore recommended for study to any interested earth scientist.

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```
#    1

grammer's Name:   Abel T. Audu
ject Title : COMPUTER ASSISTED GEOPHYSICAL DATA ANALYSIS
e Study : Rock conductivity and hydrogeological condition of FCDA Abuja
TALK OFF
=0
HILE .NOT. CODE>1
AR
6 TO 20,75 DOUBLE COLO W+/R
, 9 SAY "TASK CODE               TASK"
0,12 SAY "1.         COMPUTE A_RESISTIVITIES FOR THE NORTH EAST PORTION"
2,12 SAY "2.         APPARENT RESISTIVITIES FOR THE NORTH WEST PORTION"
4,12 SAY "3.         APPARENT RESISTIVITIES FOR THE SOUTHERN PART"
6,12 SAY "4.         QUIT MENU PROGRAM"
9,28 SAY "CHOOSE A TASK CODE:"
19,47 GET CODE PICTURE "9"
AD
 CASE
 CASE CODE=1
   DO NEAST
 CASE CODE=2
   DO NWEST
 CASE CODE=3
   DO SOUTH
 CASE CODE=4
   EXIT
DCASE
DDO
TURN
```

```
* PROJECT PROGRAM
* Programmer's Name: Abel T. Audu
SET TALK OFF
CLEAR
USE NE
@ 2, 4 SAY "COMPUTATION OF THE APPARENT RESISTIVITY VALUES"
@ 3,4 SAY "FOR THE NORTH EAST PORTION IN PROGRESS....."
WAIT "PLEASE STRIKE N TO PROCEED" TO N
CLEAR
@ 1, 5 SAY "LOCATION    RESISTANCE   AP_RESITIVITY            REMARKS"
@ 2, 5 SAY "========    ==========   =============            ======="
@ 3,19 SAY "[Ohm]         [Ohm-Metre]"
KOUNT=0
SUMM=0
R=3
DO WHILE .NOT. EOF()
R=R+1
KOUNT=KOUNT+1
* TRANSFER FIELD CONTENTS TO MEMORY VARIABLES
MLOC=LOCATION
MRESIST=RESISTANCE
PI=22/7
A=50
K=2*PI*A
AP_RESIST=K*MRESIST
IF AP_RESIST<=300
REMARK="HIGHLY FAVOURABLE LOC."
ENDIF
IF AP_RESIST> 300 .AND. AP_RESIST<=500
REMARK="FAVOURABLE LOC."
ENDIF
IF AP_RESIST>500
REMARK="UNFAVOURABLE LOC."
ENDIF
*DISPLAY RESULT
@ R,8 SAY MLOC
@ R,11 SAY MRESIST
@ R,27 SAY AP_RESIST
@ R,47 SAY REMARK
*TEST FOR THE FIRST 20 RECORDS
IF KOUNT=20
WAIT
@ 2,0 CLEAR TO 24,70
R=2
ENDIF
SUMM=SUMM+AP_RESIST
SKIP
ENDDO
MEAN=SUMM/KOUNT
SUMSD=0
KOUNT=0
*GO TOP
*DO WHILE .NOT. EOF()
KOUNT=KOUNT+1
DEVIATION=AP_RESIST-MEAN
SQDEV=DEVIATION^2
SUMSD=SUMSD+SQDEV
*SKIP
*ENDDO
STANDEV=SQRT(SUMSD/KOUNT)
```

```
WAIT
CLEAR
@ 1,3 TO 5,75 DOUBLE COLOR W+/G
@ 3,5  SAY "THE MEAN APPARENT RESITIVITY FOR THE NORTH EAST ZONE="
@ 3,59 SAY MEAN
@ 4,35 SAY "THE STANDARD DEVIATION=";
COLOR W+/G
@ 4,59 SAY STANDEV
WAIT
CLOSE DATA
DO MAIN
SET TALK OFF
```

```
* PROJECT PROGRAM
* Programmer's Name: Abel T. Audu
SET TALK OFF
CLEAR
@ 2, 4 SAY "CALCULATION OF THE APPARENT RESISTIVITY VALUES"
@ 3,4 SAY "FOR THE NORTH WEST PORTION IN PROGRESS....."
WAIT "PLEASE STRIKE ANY KEY TO PROCEED" TO NW
CLEAR
@ 1, 5 SAY "LOCATION    RESISTANCE   AP_RESITIVITY            REMARKS"
@ 2, 5 SAY "========    ==========   =============            ======="
@ 3,19 SAY "[Ohm]          [Ohm-Metre]"
USE NW
KOUNT=0
SUMM=0
R=3
DO WHILE .NOT. EOF()
R=R+1
KOUNT=KOUNT+1
* TRANSFER FIELD CONTENTS TO MEMORY VARIABLES
MLOC=LOCATION
MRESIST=RESISTANCE
PI=22/7
A=50
K=2*PI*A
AP_RESIST=K*MRESIST
IF AP_RESIST<=300
REMARK="HIGHLY FAVOURABLE LOC."
ENDIF
IF AP_RESIST> 300 .AND. AP_RESIST<=500
REMARK="FAVOURABLE LOC."
ENDIF
IF AP_RESIST>500
REMARK="UNFAVOURABLE LOC."
ENDIF
*DISPLAY RESULT
@ R,8 SAY MLOC
@ R,11 SAY MRESIST
@ R,27 SAY AP_RESIST
@ R,47 SAY REMARK
* TEST FOR THE FIRST 20 RECORDS
IF KOUNT=20
WAIT
@ 2,0 CLEAR TO 24,70
R=2
ENDIF
SUMM=SUMM+AP_RESIST
SKIP
ENDDO
MEAN=SUMM/KOUNT
SUMSD=0
KOUNT=0
GO TOP
```

```
DO WHILE .NOT. EOF()
KOUNT=KOUNT+1
DEVIATION=AP_RESIST-MEAN
SQDEV=DEVIATION^2
SUMSD=SUMSD+SQDEV
SKIP
ENDDO
STANDEV=SQRT(SUMSD/KOUNT)
WAIT
CLEAR
@ 2,3 TO 6,75 DOUBLE COLOR W+/B
@ 3,5  SAY "THE MEAN APPARENT RESITIVITY FOR THE NORTH WEST ZONE="
@ 3,59 SAY MEAN
@ 5,35 SAY "THE STANDARD DEVIATION=";
COLOR W+/G
@ 5,59 SAY STANDEV
WAIT
CLOSE DATA
DO MAIN
SET TALK OFF
```

```
* PROJECT PROGRAM
* Programmer's Name: Abel T. Audu
SET TALK OFF
CLEAR
@ 2, 4 SAY "CALCULATION OF THE APPARENT RESISTIVITY VALUES"
@ 3,4 SAY "FOR THE SOUTHERN PORTION IN PROGRESS....."
WAIT "PLEASE STRIKE ANY KEY TO PROCEED" TO SOUTH
CLEAR
@ 1, 5 SAY "LOCATION    RESISTANCE   AP_RESITIVITY          REMARKS"
@ 2, 5 SAY "========    ==========   =============          ======="
@ 3,19 SAY "[Ohm]       [Ohm-Metre]"
R=3
USE SOUTH
KOUNT=0
SUMM=0
DO WHILE .NOT. EOF()
R=R+1
KOUNT=KOUNT+1
* TRANSFER FIELD CONTENTS TO MEMORY VARIABLES
MLOC=LOCATION
MRESIST=RESISTANCE
PI=22/7
A=50
K=2*PI*A
AP_RESIST=K*MRESIST
IF AP_RESIST<=300
REMARK="HIGHLY FAVOURABLE LOC."
ENDIF
IF AP_RESIST> 300 .AND. AP_RESIST<=500
REMARK="FAVOURABLE LOC."
ENDIF
IF AP_RESIST>500
REMARK="UNFAVOURABLE LOC."
ENDIF
*DISPLAY RESULT
@ R,8 SAY MLOC
@ R,11 SAY MRESIST
@ R,27 SAY AP_RESIST
@ R,47 SAY REMARK
* TEST FOR THE FIRST 20 RECORDS
IF KOUNT=20
WAIT
@ 2,0 CLEAR TO 24,70
R=2
ENDIF
SUMM=SUMM+AP_RESIST
SKIP
ENDDO
MEAN=SUMM/KOUNT
SUMSD=0
KOUNT=0
GO TOP
DO WHILE .NOT. EOF()
KOUNT=KOUNT+1
DEVIATION=AP_RESIST-MEAN
SQDEV=DEVIATION^2
SUMSD=SUMSD+SQDEV
```

```
SKIP
ENDDO
STANDEV=SQRT(SUMSD/KOUNT)
WAIT
CLEAR
@ 2,3 TO 6,75 DOUBLE COLOR N/W+
@ 3,5  SAY "THE MEAN APPARENT RESITIVITY FOR THE SOUTHERN PORTION ="
@ 3,60 SAY MEAN
@ 5,35 SAY "THE STANDARD DEVIATION =";
COLOR W+/RB
@ 5,60 SAY STANDEV
WAIT
CLOSE DATA
DO MAIN
SET TALK OFF
```

MAIN MENU SCREEN

TASK CODE	TASK
1.	COMPUTE A_RESISTIVITIES FOR THE NORTH EAST PORTION
2.	APPARENT RESISTIVITIES FOR THE NORTH WEST PORTION
3.	APPARENT RESISTIVITIES FOR THE SOUTHERN PART
4.	QUIT MENU PROGRAM.

CHOOSE A TASK CODE:0

LOCATION	RESISTANCE	AP_RESITIVITY	REMARKS
========	==========	=============	=======
	[Ohm]	[Ohm-Metre]	
L2	0.89	279.71	HIGHLY FAVOURABLE LOC.
L3	2.40	754.29	UNFAVOURABLE LOC.
L4	3.50	1100	UNFAVOURABLE LOC.
L5	1.50	471.43	FAVOURABLE LOC.
L5	2.40	754.29	UNFAVOURABLE LOC.
L7	0.98	308	FAVOURABLE LOC.
L8	4.30	1351.43	UNFAVOURABLE LOC.
L9	1.50	471.43	FAVOURABLE LOC.
L10	0.92	289.14	HIGHLY FAVOURABLE LOC.

THE MEAN APPARENT RESITIVITY FOR THE NORTH WEST ZONE= 642.19

THE STANDARD DEVIATION= 353.05

ess any key to continue...

LOCATION	RESISTANCE	AP_RESITIVITY	REMARKS
========	==========	=============	=======
	[Ohm]	[Ohm-Metre]	
L1	0.75	235.71	HIGHLY FAVOURABLE LOC.
L2	2.20	691.43	UNFAVOURABLE LOC.
L3	1.35	424.29	FAVOURABLE LOC.
L4	2.70	848.57	UNFAVOURABLE LOC.
L5	1.20	377.14	FAVOURABLE LOC.
L6	0.45	141.43	HIGHLY FAVOURABLE LOC.
L7	0.78	245.14	HIGHLY FAVOURABLE LOC.
L8	0.09	28.29	HIGHLY FAVOURABLE LOC.
L9	1.20	377.14	FAVOURABLE LOC.
L10	0.98	308	FAVOURABLE LOC.

THE MEAN APPARENT RESITIVITY FOR THE SOUTHERN PORTION = 367.71

THE STANDARD DEVIATION = 59.71

ess any key to continue...

@@q@@ssa@q@@s@q@a≈a@a@

LOCATION	RESISTANCE [Ohm]	AP_RESITIVITY [Ohm-Metre]	REMARKS
L1	0.05	15.71	HIGHLY FAVOURABLE LOC.
L2	1.50	471.43	FAVOURABLE LOC.
L3	2.50	785.71	UNFAVOURABLE LOC.
L4	3.50	1100	UNFAVOURABLE LOC.
L5	0.60	188.57	HIGHLY FAVOURABLE LOC.
L6	0.54	169.71	HIGHLY FAVOURABLE LOC.
L7	1.45	455.71	FAVOURABLE LOC.
L8	1.57	493.43	FAVOURABLE LOC.
L9	1.25	392.86	FAVOURABLE LOC.
L10	0.98	308	FAVOURABLE LOC.

THE MEAN APPARENT RESITIVITY FOR THE NORTH EAST ZONE= 438.11

THE STANDARD DEVIATION= 130.11

ess any key to continue...