COMPUTER APPLICATION TO MINERAL EXPLORATION

BY

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THE PROJECT

SUBMITTED

TO

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APPROVAL SHEET

This project has been duely supervised, examined and found acceptable, in partial fulfillment of the requirement for the award of the Post Graduate Diploma in Computer Science of the Federal University of Technology, Minna.

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DEDICATION

The entire work is dedicated to my loving wife, Mrs. Margaret Mebenwa Okoye, for her encouragement, understanding and support; and to our children, Chijindu , Tochukwu, Onyinye and Oluchi for their burning love and joy.

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ABSTRACT

Some field work was carried out on four half degree sheets in Niger State. These are 1:100,000 sheets 163 (Zungeru), 164 (Minna.) 184 (Bida) and 185 (Paiko). These four sheets comprise the 1:250,000 sheet 42 (Minna) which is of bulletin standard.

The mineral occurrences of these sheets were noted against the background Geology- the host rock. The coordinates of the location of these minerals were noted, making use of an instrument called Global positioning system (GPS).

The minerals discovered within the project area were analyzed for their chemical characteristics and industrial potentials. Appropriate hardware requirements of the new system were put together to produce a computer configuration that suits the envisaged system. The new system was designed to run three database files. The system requires loading dBase IV into computer memory before the execution of the program.

The study made it easy to retrieve information on these minerals at any given time.

Such information revealed the type of mineral, host rock, place of occurrence, physical and chemical characteristics, co-ordinates, industrial potentials and major uses.

The application of computer to mineral exploration was found to be of immense importance and indeed revolutionary to the traditional file keeping method. It reduced repetition of data instead promoted its integration and usage. In the last analysis, it did enhance information flow on existing economic minerals for the consumption of genuine investors in mineral industry.

CHAPTER ONE

1.0 INTRODUCTION

PREAMBLE: Industrialization is dependent on the availability of mineral resources. Minerals provide the necessary input which is transformed into finished products. A strong industrial base in any nation is contingent upon dependable suppliers of critical minerals.

Infact, only few countries can boast of stable economy without mineral or mineral related dependence. Mineral resources form a base for development plans. The search for funds for the rapid transformation of the rural areas leads to search and identification of available resources that would form the pivot of any development plans (Onuoha 1991).

In order, therefore, to assume a stable economy, and adequate standard of living, Governments need up to date information on existing and new sources of mineral resources. A data based computer application to mineral exploration and development in the country would grossly enhance data compilation and storage of our mineral resources.

It is envisaged that when such data are stored in computers, all necessary information about any mineral type and place of occurrence can easily be retrieved by mere pressing buttons. This would put to rest the arduous task of labouring through piles of files and maps stocked away in the shelves, for years.

Such information as area of occurrence, background geology, chemical and physical characteristics, industrial potentials and other uses of these minerals can easily be retrieved from the computer, for immediate utilization.

In order to get enough data of various mineral occurrences, an exploratory project was planned to cover an area of about 12000sq kms in Niger State (Fig. 1) It comprises four composite 1:100,000 sheets - 163 (Zungeru), 164 (Minna), 184 (Bida) and 185 (Paiko). The area lies within latitudes 9^0 to 10^0 N and longitudes 6^0 to 7^0 E. The four composite sheets are referred to as Minna degree; 1:250,000 sheets 42 (Minna).

RESULTS: At the end of the exercise, a total of about 37 mineral occurrences were mapped out. Samples of both mineral and host rocks were analyzed for their physical/chemical properties.

The data were compiled in four distinct tables depicting the four quadrangles covering the project area viz 1:100,000 sheets 163 (Zungeru), 164 (Minna), 184 (Bida) and 185 (Paiko).

These data were made applicable to computer data base management system (DBMS) for programming and storing. The stored data in (DBMS) on the mineral resources of the project area, its Geology/mineral map were packaged for utilization by interested investors.

1.2 GEOMORPHOLOGY: The North West, North East and South East quadrangles of the project area are ruggedly adorned with granitic/gneissic inselbergs and residual hills of Nigerian basement complex rocks. Also sparsely dotted about these areas are few low attitude domes of some ultramafic rocks. The North East quadrangle, especially, features many spot heights, ranging from, Tsaunin Kuta - 1423, Tsaunin Zuba - 1814, and Tsaunin Egba - 1830 above seal level.

The North West quadrangle, though equally underlain by basement rocks, is devoid of major intrusive rocks and as such, low-lying, exposing few metamorphic spot heights as pongu 1387 and Maikunkele - 1535 above sea level; both occurring with the eastern half of

the quadrangle. Other topographic heights within this region range from 1117''- 3000''above sea level. The South West portion of the quadrangle is largely underlain by sedimentary rocks; as such, it is low --lying, undulatory and lacks major spot heights.

The South West quadrangle is mainly underlain by sedimentary rocks. It is, therefore, low-lying with few topographic heights ranging from 300′ - 500′ above sea level. The only remarkable spot height in this region is shown by Sansun hill-1186′ above sea-level.

On the contrary, the south eastern quadrangle, around Paiko exhibits remarkable topographic heights ranging from 1578′ - 2008′ above sea level; such spot heights as Fuka - 2008′ Kudan - 1891′ Kasakba - 1970′ and Shaki - 1916′ above sea level easily recognizable. They are mainly intrusive and granitic. Nevertheless, its western portion which lies within the sedimentary bed rock is generally low-lying and undulatory.

1.3 DRAINAGE: The exploration project area is drained by three major rivers (fig. 2), namely, Kaduna, Chanchaga and Gurara. The river Kaduna is in the north; the river Chanchaga in the Central and South Western parts while the River Gurara is in the South Eastern part.

In the areas underlain by metamorphic rocks, the river valleys are narrow and controlled by the foliation and joints (Ajibade 1997). A good example of lithologic structural control can be seen in the segment of the River Kaduna, Manta and Wushishi, where the river flows E-W across the scnist belts, it cuts deep gorges into the rock by exploiting the cross joints. At the junction between the Birnin Gwari formation and the Zungeru Mylonites, the river changes course and flows NNE-SSW parallel to the foliation in the rocks.

In the areas underlain by granitic rocks, the river generally develop broad valleys. An exception to this is the Shiroro gorge, where the river which flows N-S is diverted by a fault to SE-NW, into the direction of flow of the smaller River Dinya., The gorge is being exploited for the Shiroro hydroelectric dam project (Ajibade 1997).

The structure (faults and fractures) are incised into the bed rock of the area by major earth movement (tectonism) referred to as Pan African Orogeny. The event rocked Africa some 500 - 600 million years ago. The unit of rocks composing the hard bed rock units of Nigeria are called basement complex. It is composed of amphibolite grade gneisses and magnetites, layers and lenses of quartzites, marbles and amphibolites. Others are low - medium grade schists, phyllites, older granites and some metavolcanic rocks.

1.4 GEOLOGY: For effective mineral exploration, there is great need for detailed Geological mapping of the area. The field work lasted about 3 years (1994 - 1997). After putting together both the physical and chemical studies of the rocks encountered, it was discovered that about 70% of the project area lies within the basement complex rocks of Nigeria.

The basement complex itself lies within the Pan-African belt of West Africa (Kennedy, 1964) which was affected by a major tectonic event (earth movement) about 600 million years ago. The basement complex rocks include migmatities, gneisses, volcanic rocks and high grade metasediments, low grade schists which occupy North-South trending belts and granitic rocks belonging to older granite group. They are Precambrian to early Paleozoic in age (2500 - 2000 million years).

The basement complex rocks (hard rocks) are overlain by sedimentary rocks of upper cretaceous and tertiary ages (16 - 110 million years). These cover and underlie the remaining 30% of the project area. These sedimentary rocks occupy what is known as the middle Niger River Basin (Bida Basin). The rocks consist of sands-tones, iron stones, clays and sand.

Migmatites: Two generations of migmatites (mixed rocks) are distinguished; early migmatites and late migmatites. The early migmatities are believed to have been formed during the early history of the basement, prior to the deposition of the rocks of the schist belts. The late migmatites referred to as the Pan-African Migmatites are believed to be related to the older granite emplacement (Ajibade 1997).

Low to medium grade metasedimentary and metavolcanic rocks occur in three belts; the Ushama, the Birnin Gwari and the Kushaka belts in the northern half of the sheet.

From the above named schist formations using field evidence, it was discovered that the region has been subjected to four major deformation.

Consequent upon the detailed field work, many types of ore and industrial minerals were discovered (fig.3). These minerals were never occurring by chance but were formed and emplaced in their host rocks by definite Geological processes.

They were ushered in during the major Geologic events in the region. These major Geologic events are referred to as Orogonic events and they affect extensive regions of the earth. The events fracture, fault and shear the pre-existing rocks. In so doing, room is made for the intrusion of new rocks. Mineralising fluids from the earth's interior enrich the affected regions in mineral resources.

1.5 FIELDWORK: Due to the ruggedness of the terrain of the region, Land Rovers were effectively used for the exercise. The fieldwork was mainly carried out during the dry seasons. This was so, to avoid the problems rain may create in the field, both to the field maps and to the terrain for vehicle movement. The other reason was that during the dry seasons the bushes are normally burnt off, making visibility and accessibility much easier.

On daily basis, looping traverses were made on well planned routes. This was so done as to make sure that the entire project area was effectively covered with little or no repetition of traverse routes.

All the locations, where necessary data were taken on rock outcrops or mineral deposits were given location numbers. At such a location, the Geology was noted, the structures on the existing rock unit and the associated minerals were noted. The attitude of the rock was read; making use of a brunten compass. The attitude of the rock tells the general trend and dip direction of the rock. The rock units in the field are generally referred to as outcrops. In addition, at such locations, the reading of the Global positioning system (GPS) was taken. This instrument, making use of three satellites in space, displays in a matter of few seconds and latitude, longitude, altitude and time of taken the reading. It was very useful in the entire exercise as it locates accurately both the rock units (outcrops) and the mineral deposits.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 PREVIOUS WORK

Previous workers have contributed immensely in elucidating the Geology and mineral potentials of the project area. Foremost among them is A.C. Ajibade. He has worked extensively in these areas. Other workers in the area included Dunstan (1908). The first Geological report covering some part of the project area was by him. During the mineral survey of Northern Nigeria by the colonial masters, he visited Zungeru and observed that the rocks around the ancient town consists of gneisses, quartzites, quartz schists and amphibolites.

Falconer (1911), described rocks outcropping at the banks of R. Kaduna in Zungeru as quartzites, quartz schist and feldspathic schist. While observing the parallel arrangement of these rock units, he equally noted the invasion of steeply folded phyllites between Gidan Mata and Kato; the micaceous and feldspathic gneisses at Maikunkele, Minna and Paiko by large masses of granites.

Also within the period 1927 - 1938 Russ (1957) worked in northern half of the sheet in connection with gold exploration. He described the granitic rocks around Maikunkele as orthogneises, which were later intruded by large granitic masses. Russ also concluded that the quartzitic rocks and amphiolites outcropping at Kaduna River around Zungeru are of sedimentary origin.

Trus well and cope (1963), traced the rocks which were well exposed in Kaduna River at Zungeru into the adjacent Kusheriki

sheet. They classified the rocks into Zungeru Granulite member of Kusheriki Psamnite formation.

They also classified the schist belts which occur in both the Kusheriki and Minna areas into two formations; the Kushaka and the Birnin Gwari schist formations.

Investigations relating to mineral deposits, water supply and Engineering works have been done. These include the investigation of Shiroro Gorge (dupreez 1952), the Kwakuti marble (Tait and Casey 1957) and Galena bearing veins at Babban Tsanmi (10^0 10'N, 6^0 48'E).

A.C. Ajibade worked extensively in the area; elucidating primarily the Geology of the region. In 1968, he worked on 1:100,000 sheet 42 (Minna). While the work was completed in 1970, more mapping exercise, he investigated the structural and age relationship between and within the schist belts and that between deformation and plutonism (intrusion of granites) in the region. Some of these results are contained in Ajibade (1971, 1980).

Other previous work in the include; the mapping of 100,000 sheet 164 (Minna) O.M. Ojo worked in the same sheet 164 (Minna) for gold exploration; the mapping of 1:100,000 sheet 184 (Bida) by Kolawole (1978 - 79); the mapping of NW quadrant of the 1:100,000 sheet 185 (Paiko) by Nnolim (1977).

The mapping of the remaining three quadrants of the above sheet was done by Okoro, Okafo and Archbong (1983-84). Age determination of some of the rock units, especially the schist belts was carried out by Ogezi (1977), Harper (1973) Grant 1978, Turner 1983 and Fitches (1985). Their age determination varied from Kibaran (1000 my) to Pan African (550 + 100 my).

2.2 PRESENT WORK: The present work was done under the close supervision of A.C. Ajibade. Also in the mapping team were other officers of Geological Survey Department of Nigerian. They include Dada, Okudo, Anyanwu, Ikejiaku Shaibu and Afiakurue, I was the leader of the team. The project was closely monitored from the Headquarters, Abuja by the Director of Geological Survey of Nigeria, Dr. O.M. Ojo. He provided the funds for the exercise. The Deputy Director - Regional Mapping - Mr. Abatan S.) closely supervised field operations.

2.3 SCOPE OF THE WORK: Taking cognisance of the main aim of the exercise, interest was concentrated on the mineral occurrences in the project area for this reason, all efforts were geared towards locating identifying, and assessing the economic importance of these minerals. Field work was carried out by the use of Land Rovers, motor cycles and on foot; where any of them is applicable. The work lasted three years 1994 - 1997.

The aim for extensive traversing is to encounter as many different rock/mineral units as possible outcropping in the project area. At each outcrop, the following information was noted.

i. The name of the rock (granite, schist, sand stone etc. adequate fresh sample of the rock was taken for mineral content analysis.
ii. The description of the mineral content of the rock (quartz, feldspar, biotite, muscovite etc)
iii. The description of the structures on the rock (faults fractures, folititions etc)
iv. The attitude of the rock (strike and dip), making use of compass.

v. Other imprint of metamorphism or sedimentary structures (lineation, cross bedding etc)

vi. Minerals of economic interest, their physical characteristics and mode of occurrence.

vii. Location of the outcrop in the base map, making use of an equipment - Global positioning system -GPS. The equipment locates the co-ordinates of the point in question, as well as the altitude. The obtained co-ordinates are finally transferred to the base map as well as the compass reading of the strike and dip of the rocks.

viii. The geologic boundary of the various rock types is attempted right in the field.

ix. The co-ordinates of points of mineral occurrence are equally noted and inserted in the base map.

GEOLOGICAL/MINERAL MAP: At the end of the exercise, the Geological and Mineral map of the area was produced (fig. 3).

2.4 ORGANOGRAM OF THE MINISTRY

The organogram of the ministry of Solid Minerals Development is shown in fig.5. It outlays the structural setting of the ministry. Chief Executive and Accounting Officer of the ministry is the Minister, Then the Director General, Directors, Deputy Director and down to the Chief Executive Officer who is in charge of a section of the department.

The ministry can have a maximum of eight departments. While the Directors take charge of the departments at headquarters, the Deputy Directors take charge at the Zonal headquarters. All field offices are manned by Assistant Directors.

2.5 FUNCTIONS OF FEDERAL MINISTRY OF SOLID MINERALS DEVELOPMENT

The ministry of Solid Minerals Development was established in 1995 by the Federal Military Government of late General Sani Abacha, with the following objectives.

i. The acquisition and dissemination of detailed and reliable data on the Geology of the country and on the quality and quantity of the country's solid mineral resources, to ensure real economic growth, improvement in the standard of living of the people, creation of favourable investment atmosphere, and boosting of employment, and ensuring maximization of revenue (foreign and local) to the government.

ii. Adequate supply of mineral resources from internal sources and when necessary, from external sources to maintain the security, national well being and industrial development of the nation.

iii. Promotion and diversification of the country's primary mineral products.

iv. Conservation of mineral resource through research into different extractive methods and the wider application and use of minerals.

v. Provision of control, infrastructural support and all the where-withal necessary to promote and sustain investment mining and mineral processing.

vi. The establishment and/or promotion of appropriate institutions and strategies that will lead to improvement in man power technology, processing facilities and extension services and

vii. Provision of necessary investment environment that will motivate and attract the private sector to invest in the solid mineral sector, (Annual Report, 1997).

CHAPTER THREE

2.0 SYSTEM ANALYSIS AND DESIGN

3.1 SYSTEM: System analysis and design are concerned with man made systems involving input, processes and outputs. In short, it is a set of interacting elements responding to inputs to produce outputs.

3.2 SUBSYSTEM: System may consist of numerous subsystem, each of which has elements, interactions and objectives. Subsystem perform specialized tasks related to the overall objectives of the total system. Infact, all human endeavour is replete in systems and subsystems; all working in concert towards the achievement of the expected goal.

In business system, for example, various functions such as marketing finance and manufacturing are subsystems. Each subsystem uses its resources to meet specific objectives. Assessment of current performance of a system with a view to making continuing adjustments provides a feedback which ensures that the system achieves its goals. (Badmus 1998).

3.3 CLASSIFICATION: System are classified along various spectra: namely simple or complex, open or close, stable or dynamic, adaptive or non-adaptive, permanent or temporary.

3.4 SYSTEM ANALYSIS: Having given the above definitions about system and subsystem, system analysis can then be defined as the methods of determining how best to use computer with other resources to perform tasks which meet the information needs of the organisation. This was developed (initially) as specialized

branch of organisation and method (O & M), which is general approach to solving procedural problems.

In this project, therefore, the primary responsibility of the author is to identify information needs of Federal Ministry of Solid Minerals Development, Nigeria and obtain a logical design of an information system which would be combination of manual and computer based procedures to process a collection of field data on rocks and minerals. This would be useful to the ministry in taking decisions related to mineral exploration and exploitation.

3.5 NEED FOR NEW SYSTEM ANALYSIS

As had been earlier mentioned, the office of the Ministry of Solid Minerals Development, Minna branch is yet to be computerised, infact it is the same for all the branch offices in the thirty states of Nigeria. Some effort at computerising the activities of the ministry is getting some green light only at the headquarters - Abuja.

HISTORY:

It may be necessary to mention that Geological Survey of Nigeria was established in 1919 at Kaduna. Since then the office has continued to spread out to other areas of the country, with offices mainly at the state capital. This spread was consummated by 1995 when at the establishment of the Federal Ministry of Solid Minerals Development; branch offices of the ministry were opened up at all state capitals, as a matter of Government policy. Historically, the ministry has metamorphosed from Federal Ministry of Mines and Power to Federal Ministry of Petroleum and Mineral Resources before it finally crystallized to Federal Ministry of Solid Minerals Development.

One can, therefore, imagine the arduous problem involved in storing and retrieving field data from piles of files and maps for use by companies and individuals who are interested in mineral based ventures. Now that computer has come to the rescue; there is urgent need to computerise the activities of the ministry. This will in no small measure help in achieving the following.

(i) Storage of volumes of field data with very little effort.

(ii) Retrieving of necessary data for the consumption of companies and individuals interested in mineral industry, also with little effort.

(iii) The ups and downs of crude oil pricing has shown OPEC countries that any country depending solely on crude oil as its main revenue earner is perching on a keg of gunpower. As such the diversification of the economy via harnessing our solid minerals becomes not only imperative but also inevitable.

(iv) There is no doubt that if our field data on our existing minerals are fully computerized, the information needs of the organisation must have been met. In so doing, both local and foreign investors in mineral industry would be readily attracted.

(v) Apart from satisfying the industrial needs of the investors, computerization of the activities of the ministry would raise the working moral of the staff of the ministry, especially Geologists. The field officers can now with ease make reference to previous works and then be on a better ground to know what input to make in the filed.

The Federal Ministry of Solid Minerals Development urgently needs a swift change from the old traditional storing of

data in files and other reports to a modern computerised system.

3.6 METHOD AND OUTLAY OF DATA COLLECTION

An outlay of the mode of data collection employed in the project is shown in Table 1. It comprises broadly, detailed aerial photo studies of the project area; making use of stereoscope. This is meant, by the use of some professional techniques to locate within the project area possible areas of mineralization; rock types and structures. An attempt can even be made, at this initial stage, making use of tonal valves of the rocks to produce a tentative Geological map of the area with the aid of computer. This would help in prioritizing areas of interest during the actual field work.

3.7 FIELD DATA: Raw data on rocks and minerals are collected in the field by observations, measurements, inferences, logical scientific deductions and conclusions. Traverses are thoughtfully planned to avoid unnecessary waste of time, money and energy. These traverses were made to cover all the nooks and corners of the entire project area.

Along each traverse, the following are carefully sought for.

(i) Rock outcrops.

(ii) Mineral deposit/outcrops. In the event of any of the above mentioned occurring, it is given a location number and necessary data taken and noted.

These date include:

(i) Latitude, Longitude and Altitude of the outcrop using global positioning system (GPS).

(ii) Altitude (strike and dip) of the outcrop.

(iii) The mineral constituent of the rock/mineral deposit as can be seen Megascopically and tentative name for the rock/ mineral deposit proffered and noted.

(iv) Name of the area of occurrence of the rock/mineral deposit.

(v) Appropriate aspects of these data are inserted in the base map immediately while details are put down in a note book.

(vi) Structures associated with the rocks (e.g joints, faults, fractures) are noted too. These structures are noted in the base map.

(vii) As the exercise continues, tentative boundaries between the rock types are noted in the base map.

(viii) Fresh samples of both the rocks and minerals encountered are taken for laboratory analysis.

(ix) In the case of mineral deposit, its mode of occurrence is equally noted as it would influence decisions for its exploitation.

(x) In the case of rocks (granites, tonolite) etc, the texture (coarse, even grained, fine grained etc) is noted. This also influences decision on its use as an industrial mineral.

(xi) All the major and minor rock types encountered are noted in the base map and appropriate descriptions made and sample taken. These are necessary tools to the production of a Geological map and guide to mineral exploration.

3.8 DATA FROM LABORATORY ANALYSIS

The rock and mineral samples collected from the field are subjected to the following laboratory analysis.

(A) Thin sectioning of rock and mineral samples, in the process,

certain equipment is used to prepare slides of the rock and mineral samples. The slides are studies using petrographic Microscope. During the microscope study, the following are taken note of:

(i) The mineral constituent of the rock (such as quartz, biotite, feldspar etc.)

(ii) The percentage content of each mineral from which the actual name of the rock would be attempted.

(iii) The sizes of the crystals of each mineral type, from which the texture of the rock would be known, whether coarse, even, medium or fine grained. All these have impact on the industrial usefulness of the particular rock.

(iv) The economic mineral content of the rock and its percentage occurrence within the slide. This would help in calculating the tonnage of the particular mineral within the rock after some other exploratory input.

(v) The grain sizes of such economic mineral is also noted. This would help in selecting the right mesh (sieve) when separating the mineral from the crushed rock.

(vi) In the same manner, the slides of the economic minerals are subjected to detailed studies with a view to knowing their economic potentials.

B. CHEMICAL ANALYSIS OF ROCK AND MINERALS

The mineral finds are chemically analyzed to determine their chemical characteristics i.e. the elements with which they are made up of. These characteristics are of importance in determining their industrial and economic potentials. In the final analysis, all the properties of the rocks and minerals explored in each sheet area are tabulated (Table 2,3,4,5) and got ready for computer application. A total of about 37 mineral occurrences were mapped out during the exercise.

3.9 COST AND BENEFIT ANALYSIS

Cost- Benefit analysis follows immediately after thorough evaluation of the proposed project. In evaluating the project, after looking at broad alternative solutions, a short list of the solutions is kept and then subjected to the following:

(i) Their technical feasibility

(ii) Operational feasibility

(iii) Economic feasibility (Badmus 1998)

In the organisation in question - Federal Ministry of Solid Minerals Development, therefore, a parallel comparativeness can be drawn to see how compatible the above feasibility criteria are within the system.

Under technical feasibility, the technology needed is quite available and is very much in use. This is so because in most countries of the world, especially the western world, all forms of Geological processes and activities are fully computerised; be it mapping, mineral exploration and exploitation. Therefore, Nigeria, a country stupendously endowed with mineral resources has no alternative but to comply and employ computer services so as to effectively harness these resources.

On operational feasibility, it goes without saying that the proposed solution -computerization - would fit into the present traditional ways of mineral exploration. This is because, all that is needed is to make all field and laboratory data collected from explored areas available to computer centres. In these centres highly trained hands would programme them into computers and get the information stored. The information can be retrieved to desiring companies and individuals by mere pressing of buttons instead of sweating over files and reports. Therefore, the right information would be provided at the right time to users.

One economic viability, it is envisaged that the proposed solution would sail through, because the new system is meant to be introduced by "staged change over" method. This involves a series of limited size direct changeovers; the new system being introduced piece by piece.

In applying the above system to Federal Ministry of Solid Minerals Development, it is known that there are thirty six branch offices of the ministry spanning out to all the states of the nation with the capital at Abuja. The change over can take off from four strategically chosen branch offices with Minna branch office as one. The number 4 (four) is chosen because there are four zonal areas covering the entire country. Each chosen zonal centre would then serve as focus of changeover for the particular zone.

It is necessary to mention that in attempting the changeover, there is need to embark on a new but small project whose plan would be made compatible to the new system. This would streamline all the data collecting arrangement both in the field and in the laboratory. Moreover, there is need to keep the Geologists active in the field. Once the changeover has been successfully done with the four pilot running centres, then gradually a parallel running in which all old data are ploughed into the new system for accessibility to mineral based companies and individuals. In the same way as years roll by and with the yearly Federal Government allocation to the ministry, the changeover would spread out to all the branch offices within the federation.

Under cost, it is envisaged that a take off amount which would be required to purchase a few computers for the take off centres, training of necessary staff to man the computers, Providing necessary material to run and repair the machines, can be accommodated by the budgetary annual allocation to the ministry. Even under special request with clear elucidation of the benefits of the system, the Federal Government can make money available; judging from her interest in the development of

the vast resources of solid minerals in the country.

The benefits of computerising mineral exploration and exploitation in the country's solid mineral development can be immense. The country has just been experiencing a new democratic life. From the recent achievements of the people in Government, there is hope that the new democratic setting is heading for something good. It is seen to be tenacious to its promises; some lapses not withstanding.

That Nigeria is really endowed with abundant mineral resources goes without saying. Recent survey by NIMAMOP) (Nigerian Mineral Appraisal & Monitoring Programme) reveals that Nigeria has up to 250 mineral occurrences. The outside industrialized world has the technology and ready to invest in Nigeria Solid Mineral Resources; either solely or in partnership with Nigerian businessman and women. What is needed now is for the right business environment to be created by the new democratic set-up. The type of climate needed is social stability, freedom of individual to go about his/her business. Then on the solid mineral front, for the ministry to be able to supply required data about all the mineral occurrences of the country for easy consumption by these investors. It is only computer that can handle, conserve and retrieve such enormous data regarding our mineral resources. There is no doubt that there is all evidence of such business environment within the country.

The ministry should, therefore, entertain no fear about failure but has to take the bull by the horn and changeover quickly so as to harness the obvious benefits therefrom.

The laboratory technicians and indeed the field officers (Geologists and Geophysicists) would become much more active and result oriented. This is so, because any data, be it right from the field or laboratory would be fed into the computer, processed and the result dished out immediately for implementation and further action.

CHAPTER FOUR

4.0 SOFTWARE DEVELOPMENT

4.1 INTRODUCTION

SOFTWARE: Software is the term used to describe all programmes that are used in a particular computer installation.

TYPES OF SOFTWARE: There are two types of application

(i) System Software: This is a software provided by computer manufacturers. Much of the software is a programme which contribute to the performance and control of the computer system. Examples of this types of software are:

(a) Operating System: It is a set of programmes which take over the operation of the computer to the extent of being able to allow a number of programmes to be run without much human effort (Ayo 1994).

(B) TRANSLATORS: These are programmes that translate programmes written in high level language to the machine language for execution on the computer system.

HIGH LEVEL LANGUAGE: These are languages that allow a programmer to write a program in almost English like statement. They are generally problem oriented and easy to understand.

LOW LEVEL LANGUAGE: It entails writing a program in a symbolic language provided by the computer manufacturers. The symbolic language is then translated by a translator called ASSEMBLER on the machine code for execution.

(c) **ULILITY:** These are system programme which provide a useful service to the computer by providing facility for performing common task; for example Edit or File copying.

(ii) **THE APPLICATION SOFTWARE:** This may be provided by the computer manufacturer or suppliers. In most cases, however, the users usually produce their own application programme called users programme. Example of this are: Payroll, Stock Control programmes etc. **JOB:** The art of executing an individual application programme is called job.

4.2 FIELD DESIGN

The new system is designed to run three database files namely;

MASTER DATABASE FILE, MASTER DBF

ROCK DATABASE FILE, ROCK DBF

MINERAL DATABASE FILE, MINERAL DBF

Each of the above files are described as follows:

MASTER.DBF: This is a master file that contained details of information about all the recorded rock. The structure of the file is as given below;

Field	**Field**	**Name**	**Type**	**Width**	**Dec.**	**Index**
1	LAT	Character		5		N
2.	LOG	"		5		N
3.	RCODE	"		2		N
4.	RNAME	"		12		N
5.	MCODE	"		2		N
6.	MNAME	"		12		N
7.	USES	"		25		N
8.	INDUS	"		25		N
9.	NUMBER	Numeric		1		N

Rock Dnf: This is a reference file that contained details of information about all the recorded rock. The structure of the file is as shown below.

Field	Field	Name	Type	Width	Dec.	Index
1.	RECODE	Character		5		N
2.	RENAME	"		12		N

Mineral Dbf: This is also a reference that contain codes and names of the available minerals. The structure of the file is as shown below:

Field	Field	Name	Type	Width	Dec.	Index
1.	MCODE	Character	2			N
2.	MNAME	"	15			N

HARDWARE REQUIREMENT

The hardware requirement has to do with the computer hardware configuration needed for effective execution of the new system. Company configuration is a collection of hardware which is done to suit the current and future needs of the ministry with respect to the volume and types of data to be processed (Ayo, 1994).

However, with the newly developed system a computer with higher speed and larger storage space is required. This should be so, taking into account the fact that field data associated with mineral exploration are always voluminous. It is equally good to take care of the future need of the ministry. Procurement of standing generators at proposed computer centres would serve as backup for the unreliable NEPA power supply.

All in all, a computer with disks of adequate megabits, having floppy disks and CD-Room drive units are recommended. The drive units will provide for the installation and transfer of new software, other packages and data from diskettes and CD-Room into the hard disks as well as making backups. The computers should have printers for printing out reports and even graphic print out for certain reports.

SOFTWARE REQUIREMENT

Software is the term used to describe all programmes that are used in a particular computer installation.
Therefore, the proposed system requires the availability of some forms of software which would enhance the working of the system and other tasks that would be placed on the modification as the need arises (Lawrence, 1979).

There is need for Microsoft Office which is an integrated package for various purposes. In the Microsoft office, items as Microsoft Word and Microsoft Excel is required. The installation of Microsoft Word is to enable the computer user create, modify and print text of documents such as report, proposals and other forms of official letter.

The use of word processing package for this purpose enhances the output of the reports and allows flexibility of the contents of the documents.

Microsoft Excel is equally an asset. This is because it has a wide range of usefulness. The package is used to carry out calculations, graphic and statistical analysis of data.

SYSTEM TESTING

System testing as the name implies, is the stage of implementation which is aimed at ensuring that the new system works; accurately and efficiently before full life operation of the system kicks off.

At this stage, the logical and physical design should be thoroughly and continually examined on paper to ensure that they would work when implemented, system test implementation, therefore should be confirmed that the system is correct. It is an opportunity to show the user that the system works.

The proposed system was fully tested to confirm its reliability. Definitely a user acceptance testing is performed. The testing done in the presence of the user is primarily carried out to confirm that the system is doing what it is required to do.

The testing was done using a set of carefully selected test data which are entered into the system. The result was exciting and raised the hopes of the users for what the ministry anticipated towards data and information flow about mineral exploration.

Based on the above it was then concluded that the new system was far from exercise in futility but has injected new exploratory plans into the ministry.

4.6 SYSTEM CONVERSION AND CHANGEOVER

This has to do with conversion, file set up and changeover. The conversion requires changing the old (existing) system files to the format and content required by the new system.

File set up is the process of setting up the new files that would be required in the new system (Lawrence, 1986).

Changeover is the full replacement of the old procedure by the new ones.

In the system in question, the file set up and the changeover are required. File conversion is not needed because the old system is a manual procedure. The file set up is required to create the database files needed for the successful operation of the system.

Changeover could be any of these three:

i. Direct changeover

ii. Parallel changeover

iii. Pilot changeover.

In direct change, the old system is completely replaced by the new one in one move.

In parallel, the process combines the new and old to cross-check results. It allows the result of the new system to be compared with the old system before acceptance by the user.

This ultimately promotes users confidence.

In the case of Federal Ministry of Solid Minerals Development for which the system is being worked out, the issue is conversion of age long manual data to computer system.

As soon as the direct conversion of exploration data from few planned projects are made and are fully computerised, the benefits would be there for all to see. Subsequently, all that is left is to set up a plan to convert the manually accumulated data to the new system.

This will run along with direct conversion of newly collected field data. This is necessary to keep the Geologists busy.

4.7 POST IMPLEMENTATION REVIEW

These are properly mapped out steps taken to review the implications of the new system on the ideas and goals of the organisation.

In the ministry, therefore, after all the steps taken to implement the computerization of the minerals exploration, there was a review. The review revealed the need to go ahead with the new system. The benefits and advantages to the organisation are remarkably outstanding.

CHAPTER FIVE

5.0 SYSTEM DOCUMENTATION AND CONCLUSION

System documentation is the process of describing how a new system works. It serves as reference point for the end user in case they run into one problem or the other.

In documenting the new system, the mode of starting the system as well as description of the new menu structure is considered. This is to enable the potential users understand the full modus operandi of the steps of getting the job done.

5.1 DESCRIPTION OF THE NEW SYSTEM

Starting the system requires loading dBASE IV into the computer memory before executing the program. This is done by taking the following steps.

- At C prompt, type CD/DBASE and press ENTER key
- Type DBASE and press ENTER key
- Press ESC key to exit to the dos prompt
- Type SET DEFAULT TO A: and Press ENTER key
- Type DO ROCK and Press ENTER key.

At this point, the main menu appears on the screen. It contains five options as contained in the Appendix. Each of the options are described below.

ROCK INFORMATION UPDATE: This option enables the users to manipulate the content of the master file, MASTER. DBF. The option has 5 suboptions namely New Rock Information for entering new records, Edict Rock Information for changing existing record, View Rock Information for displaying existing record, Delete Rock Information for deleting existing record and Exit for quitting the submenu. The format of each of the suboptions are displayed in the Appendix.

ROCK TYPE UPDATE: This option is used for entering and updating the Rock files in terms of code and name of a rock that has not been previously entered into the appropriate file. The format of this is in the Appendix.

MINERALS TYPE UPDATE: This option is used for entering and updating the minerals file in terms of code and name of a minerals that has not been previously entered into the appropriate file. The format of this is in the Appendix.

GENERAL ROCK REPORT: This is an option used to print a report about the available rock in the system as contained in the Appendix.

EXIT: This option is used to quit the main menu for the system.

5.3 BENEFITS OF THE NEW SYSTEM

The new system was found to be of immense benefit to the Ministry, with DBASE IV loaded into the computer memory, the programme were conveniently executed by manipulating the options available in the main menu.

The main menu itself contain the following five options.

i. Rocks information update
ii. Rocks type update
iii. Minerals type update
iv. General Rock report
v. Exit.

In addition, the system was designed to run three database files viz:

i. Master Database file, Master dbf
ii. Rock Database file, Rock dbf.
iii. Minerals Database file, Mineral dbf

The interplay of the database files and the five options of the main menu made it possible to derive the following benefits from the new system.

(i) It was easy to update database on the new findings in the field, be it rock type, mineral occurrence, place of occurrence latitude and longitude; including uses and industrial potentials of such minerals.

(ii) It was equally easy to view, delete or exit any undesired information about the rocks and minerals of the project area.

(iii) The ministry can comfortably store in the computer, field and laboratory data related to rocks and mineral occurrences, in any project area.

(iv) The stored data can then be retrived for the consumption of entrepreneurs who are interested in mineral base industry.

5.4 CONCLUSION

The result and the benefits of computer application to mineral exploration was quite exciting and rewarding. The project was executed with zeal; as it is going to usher in a new dawn in the ministry's approach to mineral exploration.

It was heart warming that the voluminous data usually associated with such projects could easily be manipulated by the computer. In same manner, all the stored data can easily be retrieved.

The careful and thorough understanding of the problem associated with mineral exploration made it easy to plan out appropriate problems comprising the menu and the files. These were then loaded into the computer memory using Database IV. They were adequately manipulated to produce results.

As a result of the outcome of the exercise, the Federal Ministry of Solid Minerals Development can go ahead to computerise its mineral exploration activities.

About four zonal centres should be taken as take off points. From these centres the computerization should spread till the Ministry's activities are fully covered with adequate computer facilities.

As soon as this is accomplished, the Ministry would join the rest of the world in being computer oriented in all its exploratory activities. It is only the that the much advertised commercialization of the nation's abundant mineral resources would boast of having a reliable organ to handle data and information flow on these minerals.

As quarterly allocation from the Federal Government to the Ministry comes in, expansion of the computer centres should be encouraged. This should continue until each state branch office

of the ministry is fully computerised. Each state office computer staff should be limited to one or two to save cost.

It is then, and only then, can the Federal Ministry of Solid Minerals Development boast of being fully computerised. If this happens it would be the only way of assuring Nigerians that the Ministry is fully prepared to handle whatever challenges there are in providing the much needed data and information flow about the numerous mineral occurrences of the country.

In the last analysis, this would be the only, way to lure both local and foreign investors to invest in our solid mineral resources.

5.5 RECOMMENDATION

Having made a break through in computerization of mineral exploration activities of the Ministry, there is need to proffer recommendations that would enable the Ministry hold and expand gradually on this achievements.

(i) There is need to establish as a matter of urgency four computer zones within the projected zonal headquarters of the Ministry.

(ii) Computers, printers, plotters and other necessary accessories relevant to the Ministry's activities should be purchase and installed

(iii) Adequate number of staff strength should be raised and appropriately trained to handle the equipment.

(iv) Henceforth all mineral exploration activities should be computerised, making use of the facilities provided in each zonal headquarters.

(v) Geologists are field officers and as such must be found digging out new data in the field. Such new date should be given a direct change over treatment. This means that the data collected are given direct computerization for immediate results.

(vi) Along with computerising current data from the field, old data stocked away in files before the introduction of the computer system are to be computerised by parallel change over. In this method the old data are gradually but consistently computerised along side the new data.

(vii) Those members of staff who might become redundant as a result of the introduction of the computer should be trained to handle computer operations.

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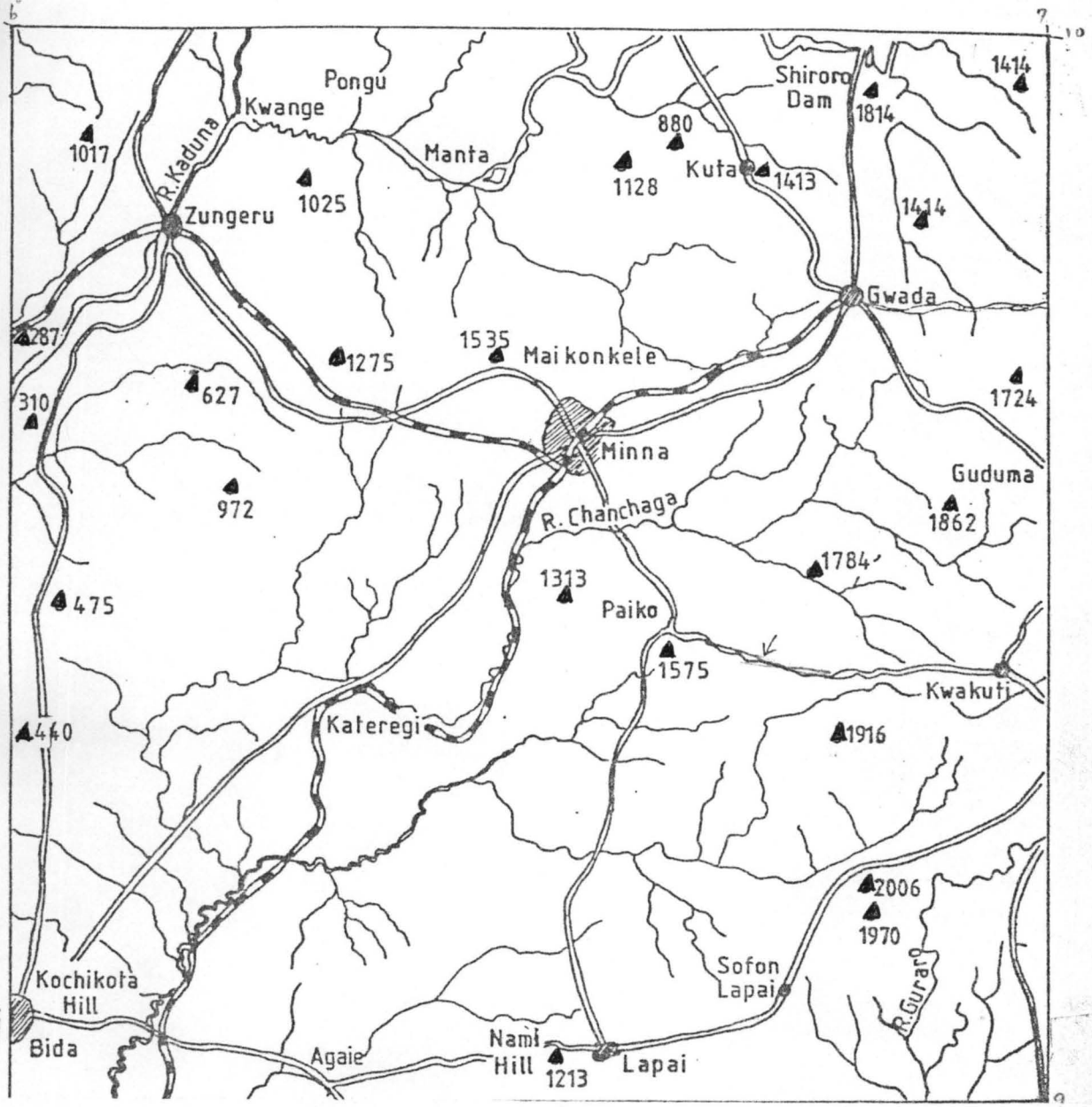

The main Rivers and Spot heights

Key

Railway

Road

Settlement

A
1

FIELD AND LABORATORY DATA - ROCKS AND MINERALS OF 1:100,000 SHEET 163 (ZUNGERU)

Sheet No.	Rock Type	Mineral Occurrence	Mode of Occurrence	Co-ordinate of Occurrence	Place of Occurrence	Level of Development	Physical and Chemical properties
1:100,000 Sheet 163 (Zungeru)	Schist	Gold	Alluvial	9° 51.5' 6 °19'	Rawo	Local exploitation	Melting point 1060° C Colour: Yellow Lustre: Metalic Fracture: Hackly ■ ductile ■ meleable ■ sectile Hardness: 2.5 - 3 Sp. GR: 12-20 Chem: Au
	Mica Schist	Staurolite	Prismatic crystals	9° 47' 6° 9'	Katako Gulangi	Nil	Colour: Reddish Brown Lustre: Sub vitreous Streak: Greyish Fracture: Conchoidel Hardness: 7 - 7.5 SP. GR. 3.7 Chem: Mg, Fe, Al, Si, O, OH.
	Mylonite	Gold	Primary	9° 49' 6° 9'	Zungeru	Local exploitation	As above
	Sandstone	Ironstone	Sedimentary	9° 32'' 6° 12'	Makira	Local for tool making	Colour: Steel Grey, Red Lustre: Metalic etc Chem: Fe, O, H
	Mylonite	Gold	Primary	9° 43.5' 6° 5'	Wushishi	- do -	- do -
	Magmatite Gneiss	Laterite	Laterization product	9° 58' 6° 19'	Zungeru	Nil	Colour: Darkish Brown Chem: Fe, O, H.

A
2

FIELD AND LABORATORY DATA - ROCKS AND MINERALS OF 1:100,000 SHEET 163 (ZUNGERU)

Chemical Symbol	Use Of Rocks And Minerals	Possible Small Scale Industry
Au	■ Coinage ■ Electronics ■ Jeweleries ■ Electroplating	■ Jewellery workshop ■ Smelting workshop ■ Gold mining
$(MgFe^{2+})(AlFe^{3+})^{O6}$ $(SiO_4)_4$ $(O\text{-}OH)_2$	Germstone, high temperature equipment manufacture	Staurolite quarrying and cutting
Au	as above	as above
Fe_2O_3 n H_2O	■ metallurgical building construction industry	- Metallurgical iron and steel rolling mills
Au	- do -	- do -
Fe_2O_3 ..nH_2O	Road construction Acquifer for ground water	Laterite quarrying
-	■ aggregates ■ railroad ballasts ■ fencing stone ■ decorative stone ■ flooring stone	Quarrying

B
1

FIELD AND LABORATORY DATA - ROCKS AND MINERALS OF 1:100,000 SHEET 164 (MINNA)

Sheet No.	Rock Type	Mineral Occurrence	Mode of Occurrence	Co-ordinate of Occurrence	Place of Occurrence	Level of Development
1:100,000 Sheet 164 (Minna)	Schist	Gold	Elluvial Alluvial	9° 36.5' 6 °33'	Minna	Local exploitation
	Migmatite	Kyanite	Metamorphic relict	9° 51.5' 6° 43'	Kuta	Nil
	Schist	Gold	Elluvial Alluvial	9° 56' 6° 47'	Ashara	Local exploitation
	Tonolite	Toumaline	Pegmatite	9° 38'' 6° 46.5'	Gbaha	Local exploitation
	Migmatite	Mica	In pegmatite	9° 31.5' 6° 34'	Minna	Nil
	Migmatite	Laterite	Lateritezation	9° 31' 6° 34.5'	Minna	Local exploitation
	Granites	Granite Minerals		9° 37' 6° 34'	Minna	Quarrying
	Schist Amphibolite	Gold	Veins	9° 48' 6° 44.5'	Gusuru	Exploited by ICALLIT NIG. LTD.

C
1

FIELD AND LABORATORY DATA - ROCKS AND MINERALS OF 1:100,000 SHEET 184 (BIDA)

Sheet No.	Rock Type	Mineral Occurrence	Mode of Occurrence	Co-ordinate of Occurrence	Place of Occurrence	Level of Development
1:100,000 Sheet 184 (Bida)	Sand Stone	Clay	Sedimentary	9° 21.5' 6 °16.5'	Kutigi	Local exploitation
	Sand Stone	Clay	Sedimentary	9° 3.3' 6° 8.3'	Baddegi	do
	Sand Stone	Clay	Sedimentary	9° 20.5' 6° 18'	Kateregi	do
	Sandstone	Silica sand	Sedimentary	9° 20.5' 6° 18'	Kateregi	Nil
	Sand Stone	Silica sand	Sedimentary	9° 5' 6° 1'	Bida	Local exploitation
	Sandstone	Clay	Sedimentary	-	Gbako	Nil
	Sandstone	Clay	Sedimentary	-	Batati	Nil
	Sandstone	Ironstone (Haematite)	Sedimentary	9° 5' 6° 1'	Bida	Local exploitation
	Sandstone	Clay	Sedimentary	9° 1' 6° 19'	Agaie	do
	Sandstone	Clay	Sedimentary	9° 24' 6° 2'	Lemu	do
	Granites	Granitic minerals	Intrusive			Local exploitation

FIELD AND LABORATORY DATA - ROCKS AND MINERALS OF 1:100,000 SHEET 164 (MINNA)

Physical & Chemical Properties	Chemical Symbol	Use Of Rocks And Minerals	Possible Small Scale Industry
Colour: Yellow Melting point Lustre: Metallic - 1060c Fracture: Hackly ■ ductile ■ maleable sectile Hardness: 2.5 - 3 Sp. GR 12 - 20	Au	■ Coinage ■ Electronics ■ Jeweleries	■ Jewellery workshop ■ Smelting workshop ■ Gold mining
Colour: White Streak: White Lustre: Transparent Chem: Al, Si, O	Al_2SiO_5	■ spark plugs for automabiles ■ flux in tile manufacture - flux in sanitary wares	■ spark plug industry ■ kyanite grinding plant ■ kyanite quarrying
As above	Au	as above	as above
Colour: Black Streak: Colourless Lustre: Opaque Chem: Ca, Mg, B, Al, Fe, OH, F	$CaMgB_3(AlFe^{3+})_6(OH,F)_4$	■ Jewelleries for ornamental purposes	■ Jewellery workshop ■ Germstone mining
Colour: Black, Grey Chem: K, Al, Si, O, OH, F	$KAl_2(AlSi_3)O_{10}(OH,F)_2$	■ Insulator ■ Electrical Appliances ■ Electornics ■ Mirror Making	Mica mining
Colour: Darkish Brown Chem: Fe, O, H	$Fe_2O_3 \cdot nH_2O$	■ Road Construction ■ Iron Production	Laterite quarrying
Colour: Darkish Grey		■ Aggregates ■ Rail Road Ballasts ■ Fencing ■ Decorative Stone, Flooring Stone and Mirror Making	Quarrying
As above	Au	as above	as above

FIELD AND LABORATORY DATA - ROCKS AND MINERALS OF 1:100,000 SHEET 184 (BIDA)

Physical & Chemical Properties	Chemical Symbol	Use Of Rocks And Minerals	Possible Small Scale Industry
Colour: White Grey Lustre: dull earthy Hardness: 2. - 2.5 Sp. GR 2.6 Chem. Al, Si, O, OH	$Al_4Si_4O_{10}(OH)_8$	■ Pottery ■ burnt brick ■ floor tiles ■ frefractories ■ insulators	■ pottery industry ■ burnt brick ■ floor tiles making industry ■ insulators manufacture
do	do	do	do
do	do	do	do
Colour: Colourless Hardness: Lustre: Vitreous Sp. GR. 2.65 Chem: Si, O	Si_1O_2	■ foundary facing ■ glass making ■ quartz paints ■ bitumen	■ Glass Industry
do	Si_1O_2	do	do
Colour: White grey Lustre: dull earthy Hardness: vitreous Sp. GR. 2 - 2.5 Chem: Al, Si, O, OH	$Al_4Si_4O_{10}(OH)_8$	■ pottery ■ burnt brick ■ floor tiles ■ refractories ■ insulators	■ pottery industry ■ burnt brick ■ floor tiles industry ■ insulator manufacture
do	do	do	do
Colour: Steel grey, Red Streak: Cherry Red Lustre: Metallic Hardness: 5.5 - 6.5 Sp. GR. 4.9 - 5.3 Chem: Fe, O.	$Fe_2O_3H_2O$	■ metallurgical ■ building and ■ construction industry	■ metallurgical ■ iron and steel ■ rolling mills

FIELD AND LABORATORY DATA - ROCKS AND MINERALS OF 1:100,000 SHEET 184 (BIDA)

as above	$Al_4Si_4O_{10}(OH)_8$	as above	as above
as above	$Al_4Si_4O_{10}(OH)_8$	as above	as above
Colour:Greyish	-	■ aggregates ■ rail road ballasts ■ fencing stone ■ decorative & flooring stone	Quarrying

D
1

FIELD AND LABORATORY DATA - ROCKS AND MINERALS OF 1:100,000 SHEET 185 (PAIKO)

Sheet No.	Rock Type	Mineral Occurrence	Mode of Occurrence	Co-ordinate of Occurrence	Place of Occurrence	Level of Development
1:100,000 Sheet 185 (Paiko)	Migmatite	Marble	Relict in migmatite	9° 23.5' 6 °56'	Kwakuti	Exploited by metallurgical Company Nig. Ltd
	Magmatite	Lead zinc	Lode	9° 2.3' 6° 56'	Webe	Local exploitation
	Granite	Gold	Alluvial Elluvial	9° 27' 6° 42'	Sapai Dere	do
	Granite	Gold	do	9° 27.5' 6° 42'	Kotoma	Nil
	Migmatite	Graphite	Disseminations in marble and countary rock	9° 23.5' 6° 56'	Kwakuti	Nil
	Migmatite	Marble	Relict	9° 2' 6° 37.3'	Takalafia	Nil
	Migmatite	Quartzite Quartz	Small bodies veins	9° 27' 6° 40'	Paiko	Nil
	Pegmatite	Mica (Muscovite)	Pegmatite vein		Paiko	do
	Magmatite	Laterite	Laterite capping	9° 23', 6° 45' 9° 23' 6° 52'	Makutu Perindoki	Local exploitation
	Granites	Granitic minerals	Intrusive	9° 26' 6° 39'	Paiko	Nil

FIELD AND LABORATORY DATA - ROCKS AND MINERALS OF 1:100,000 SHEET 185 (PAIKO)

Physical & Chemical Properties	Chemical Symbol	Use Of Rocks And Minerals	Possible Small Scale Industry
Colour: White creamy Chem. Ca, Mg, $C0_3$	$Ca_4 Ma_4 (CO_3)_2$	■ construction and ornamental stones ■ hydrated lime ■ filler in paint & rubber ■ super phosphate fertilizer	■ Quarrying ■ Marble cutting & polishing ■ Hydrated lime production ■ Precipitated $Ca CO_3$ production ■ Marble grinding plant
Pb, Zn, S.	Pbs - Zns	■ Alloys ■ Storage battery ■ Pipes	■ Lead mining ■ Smelting industry ■ Pipes manufacture
Colour: Yellow Lustre: Metallic Fracture: Hackly - ductiles Maleable - sectile Hardness: 2.5 - 3 Sp. GR. 12 - 20 Melting point - 1060°	Au	■ Coinage ■ Electronics ■ Jewelleries ■ Electroplating	■ Jewellery workshop ■ Smelting workshop ■ Gold mining
do	Au	do	do
Colour: Black Streak: Jet Black	C	■ Paint ■ Crucibles ■ Pencils ■ Lubricant ■ Electroplating	■ Pencil industry ■ Batter industry ■ Crucible production industry ■ Graphite mining

COMPUTERISED ROCK INFORMATION SYSTEM

CODE	TASK
A	ROCK INFORMATION UPDATE
B	ROCK TYPE UPDATE
C	MINERAL TYPE UPDATE
D	GENERAL ROCK REPORT
E	E X I T

SELECT CHOICE:

LIST OF RECORDED ROCKS

S/NO	LATITUDE	LONGITUDE	ROCK NAME
1	300	400	GRANITE
2	250	300	GRANITE
3	112	213	SCHIST
4	543	243	MARBLE

ROCK TYPE UPDATE
==========

Enter ROCK TYPE CODE (or ** to Exit) 04

ROCK NAME: MARBLE

TO SAVE INFORMATION (Y/N)

MINERALS TYPE UPDATE
==========

Enter MINERALS TYPE CODE (or ** to Exit) 06

MINERALS NAME: GRAPHITE

TO SAVE INFORMATION (Y/N)

ROCK INFORMATION UPDATE - DELETE

LATITUDE: 250 LONGITUDE: 300

ROCK TYPE - CODE: 02 NAME: GRANITE

TYPES OF MINERALS - HOW MANY TYPES AVAILABLE IN THE ROCK: 4

CODE	NAME	USES	INDUSTRIES
01	GOLD	COINAGE	MINTING INDUSTRY
02	TALC	MEDICINE	PHARMACEUTICALS
03	IRON STONE	PRODUCTION OF IRON RODS	STEEL INDUSTRY
04	MICA	MANUFACTURE OF MIRROR	ELECTRICAL INSULATORS

TO DELETE THIS RECORD (Y/N)

ROCK INFORMATION UPDATE - VIEW

LATITUDE: 250 LONGITUDE: 300

ROCK TYPE - CODE: 02 NAME: GRANITE

TYPES OF MINERALS - HOW MANY TYPES AVAILABLE IN THE ROCK: 4

CODE	NAME	USES	INDUSTRIES
01	GOLD	COINAGE	MINTING INDUSTRY
02	TALC	MEDICINE	PHARMACEUTICALS
03	IRON STONE	PRODUCTION OF IRON RODS	STEEL INDUSTRY
04	MICA	MANUFACTURE OF MIRROR	ELECTRICAL INSULATORS

PRESS ANY KEY TO CONTINUE

ROCK INFORMATION UPDATE - ADD

LATITUDE: 250 LONGITUDE: 300

ROCK TYPE - CODE: 02 NAME: GRANITE

TYPES OF MINERALS - HOW MANY TYPES AVAILABLE IN THE ROCK: 4

ODE	NAME	USES	INDUSTRIES
01	GOLD	COINAGE	MINTING INDUSTRY
02	TALC	MEDICINE	PHARMACEUTICALS
03	IRON STONE	PRODUCTION OF IRON RODS	STEEL INDUSTRY
04	MICA	MANUFACTURE OF MIRROR	ELECTRICAL INSULATORS

TO SAVE INFORMATION (Y/N)

ROCK INFORMATION UPDATE - EDIT

LATITUDE: 250 LONGITUDE: 300

ROCK TYPE - CODE: 02 NAME: GRANITE

TYPES OF MINERALS - HOW MANY TYPES AVAILABLE IN THE ROCK: 4

CODE	NAME	USES	INDUSTRIES
01	GOLD	COINAGE	MINTING INDUSTRY
02	TALC	MEDICINE	PHARMACEUTICALS
03	IRON STONE	PRODUCTION OF IRON RODS	STEEL INDUSTRY
04	MICA	MANUFACTURE OF MIRROR	ELECTRICAL INSULATORS

TO SAVE CHANGES (Y/N)