AN INVESTIGATION INTO THE DEVELOPMENT OF LOCAL RAW MATERIALS FOR THE CERAMICS INDUSTRY IN NIGERIA

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CERTIFICATION

This Thesis entitled "An Investigation Into the Development of Local Raw Materials for the Ceramics Industry in Nigeria" written by Opoku, Eric Vernon meets the regulations governing the award of the degree of Master of Arts (Industrial Design) of Ahmadu Bello University and it is approved for its contribution to knowledge and literary presentation.

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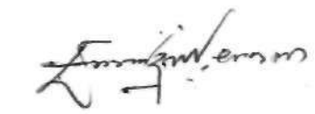
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DECLARATION

I Opoku, Eric Vernon solemnly declare that the content of this thesis is the report of my study on the Investigation into the Development of Local Raw Materials for the Ceramics Industry in Nigeria, I collected the necessary information and adequately acknowledged by means of references.



Opoku, Eric Vernon

DEDICATION

This thesis is dedicated to my family, my late father and mother respectively.

ACKNOWLEDGEMENT

In the collection of materials and writing of this report, I received tremendous help from a number of people. All those concerned should be aware that their efforts have been highly commendable in this study.

This token of appreciation goes to my supervisors, Dr. Abashiya Ahuwan and Mr. Michael Aluwong who not only supervised this work but also showed great interest in the study.

I am forever indebted to the members of my family who stood steadfastly beside me through this effort, I refer in particular to my wife Faustina, and my children, Sarah and Sylvia.

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ABSTRACT

Opoku, Eric Vernon. An Investigation Into The Development Of Local Raw Materials For The Ceramics Industry In Nigeria. Masters of Arts, Industry Design. October 2000, 9 appendices, 6 tables, 6 figures, 96 pages.

The problem of this study is to examine the extent of development of locally available ceramic raw materials. It is pertinent that enquiry is made into the problems confronting the beneficiation raw materials for the ceramics and related industries and to explore what the future holds for this sub-sector of the Nigerian economy.

Being a descriptive or survey research, two types of questionnaire were used for the collection of data about :he selected variables. Category one was intended to collect data on the development of the locally sourced raw materials from the mining and processing companies. Category two was aimed at measuring the perception regarding the locally developed ceramic raw materials from the users of the ceramics raw materials i.e. the pottery and ceramic industries. The responses provided the knowledge and understanding required to express a meaningful opinion about the study.

The following findings are drawn from the investigations carried out in the course of the study:

1. There are prospects for setting up companies to mine arid process local raw materials for the pottery and ceramics industries as well as

other industries that use some of these raw materials for their production.

2. The local demand for the locally processed raw materials is very high.
3. There is the possibility of setting up more pottery and ceramics industries in most part of the federation.
4. Although the demand for the locally processed raw materials is high, there is the need to further develop these raw materials to meet the stringent requirement of modem day ceramics.
5. The source of initial capital for setting up the mining and processing companies in most cases have beer through the personal savings of the owners and other investors.
6. Lack of funds have made it impossible for the local mining and processing companies to acquire the plant and equipment for the proper beneficiation of the local raw materials.
7. Inspite of the vital role Solid Mineral Development to the Nigerian economy: it has not received the desired patronage from the government.

Based on the findings of this study: the following conclusions are drawn.

1. All the principal raw materials for the production of pottery and ceramics glass etc. are abundant in Nigeria and their reserves will last for several years.

2. With proper beneficiation, these raw materials can be utilized for the production of many functional products.
3. There are prospects for the setting up of mineral development companies in Nigeria due to the heavy demand of raw materials produced from the minerals
4. The source of initial capital for the setting up of the mineral development companies has been through the personal savings of the owners and other investors.

The following recommendations have also been made.

1. Priority must but given to the developments connected with solid minerals.
2. The government and policy makers should need to be informed of the broad scope of ceramics to clearly understand the importance of developments connected to the industry.
3. Since the mining and processing companies has proven to be viable there is the need for the banks to rethink their support for the industry.
4. There is the need for join effort between industries and government to collaborate more with the National Research Institutes and the universities to finance research into the development of local ceramic raw materials.

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DEFINITION OF TERMS

Ceramics: Used in the widest Application to include artides of in-organic and non-metallic materials made permanent by heat.

Comminution: The progressive reduction of minerals until the clean particles can be separated by such methods as are available.

Electron-magnetic separation: Separation of minerals utilizing the difference in electrical conductivity between the various minerals in the are fed.

Geology: Sciences of the Earth.

Geo-Chemistry: The Study of the chemical composition and chemical changes in the earths crust.

Geo-physics: The application of physics to the study of the earth and atmosphere.

Minerals: A body produced by processes of in-organic nature having certain characteristics in chemical composition and certain characteristics in molecular structure exhibited in its crystalline form.

Over-burden: Layer of soil and vegetation that covers a rock stratum of ground level.

Out-crops: An exposure of a rock stratum at ground level.

Solid Minerals: Natural in organic substances possessing definate chemical composition and atomic structure.

Subsoil: Layer of materials beneath the soil.

Tailings: Waste products resulting from the Processing of minerals.

CHAPTER ONE

1.1 INTRODUCTION AND BACKGROUND OF THE STUDY

Mankind must have realized the importance of minerals in very early times. We are told that man used cinnabar ochre and red hematite as pigments long before smelting was devised. Gregory (1980) reported that mankind started making ceramic articles using industrial minerals as early as 15,000 BC. The clay product industry was well known in Egypt by 14000 BC. It is also recorded that the Phoenicians made glass very early in history. Knowledge of the process of smelting silica sand to form glass crystals was used by the Phoenicians. Use of mineral, particularly "industrial rocks" continue to contribute substantially to the development of mankind.

The discovery of industrial minerals by man has been valuable in countless ways since the dawn of history. The durability of pottery and ceramic objects made from the industrial minerals like clay, kaolin, feldspar, gypsum etc, and used by man for example has provided, an index to our heritage, a mirrow to our civilization with which the modern man has been able to find out more about himself and his environment at any point in recorded history. Today, it would be hard to imagine the consequences of a world without bricks, tiles, pottery and refractories, necessary to withstand the high temperature in the smelting of glass and metals.

Recent technological advancement have of course enhance the speed of development and placed the potentials of the ceramic industry on a very important level: The use and consumption of ceramics, glass, cement per capita as a yard stick for human development is well understood. This is to say that the

consumption of these items per given population is used as an indicator of development of a particular society. The higher the consumption, the greater the development.

The future of ceramics appears to be even more promising. It is reported that the Japanese have started to make automobile engines using ceramic taking advantage of their ability to withstand very high temperature.

The principal raw materials for ceramics manufacture are available in Nigeria, nevertheless, domestic production is low and imports are large constituting a major drain to the scarce foreign exchange reserves. This has its historical basis on the fact that virtually all Nigerian industries depend on foreign source for both plants equipments as well as raw materials.

Even though attempts have been made as regards the processing of refined materials for the ceramic and pottery industry, the results have not been all that successful. Most of the materials used for ceramics are wanted in a relatively high state of purity. It is therefore apparent that many of these raw materials require some preparation before they are used either to enhance their chemical purity or to better utilize their physical properties. According to Gaudin (1967), the proper processing of minerals yields marketable products by means that do not destroy the physical and chemical identity. In a number of cases as in the marketing of feldspar, flint, kaolin, talc, whiting etc. the product sold have to meet certain stringent requirements or standards. It they do not meet them, they are unusable.

With the current drive towards the attainment of self reliance in the local sourcing of industrial raw materials, a new vista have been opened in the previously unexplored areas of mining and beneficiation of industrial minerals. It is thus

profitable to set up profitable ventures for the supply of raw materials as a feedstock to industries.

Nigeria like most developing countries have come to accept that industrialization must form the core of her development strategy. In January 1984 for example, the 3rd and 4th National Economic Plans were restructured by a new industrial policy blue print backed by a package of incentives to enhance industrial development. Unfortunately, the records of the country's industrialization programs have not been impressive in many aspects compared with other 3rd world countries like South Africa, and Indonesia with sustained industrial development.

Since the creation of the Ministry for Solid Minerals Development, series of events have taken place which has shown the total commitment of the Federal Government to ensuring that the solid mineral sector takes off successfully. In the budget of 1995, for example, a sum of 2 billion naira was allocated to this new ministry. To articulate this policy, government officials addressed seminars, workshops, visited South Africa and other advanced countries to understudy their experiences in mineral developments with the aim of sensitizing the business community and the government on the potentials of Nigeria's solid minerals.

The discovery and development of industrial minerals can only be appreciated by glancing at the role products manufactured from these raw materials plays in today's highly advanced technologies (appendix C). There is the need therefore for a coordinated effort between government and the private sector for the strategic management and development of the industrial minerals that abound in Nigeria.

1.2 STATEMENT OF THE PROBLEM

The problem of this study is to examine the extent of development of locally available ceramic raw materials in Nigeria. It is pertinent that enquiry is made into the problems confronting the development of ceramic raw materials and to explore what the future holds for this subsector of the Nigerian economy.

1.3 PURPOSE OF THE STUDY

The purpose of this study is to determine.

1. Which of the ceramic raw materials are ideally available in Nigeria,
2. Examine the technology employed for their processing and the extent of development of these ceramic raw materials.
3. Determine the extent of patronage of these ceramic raw materials by the local industries.
4. Determine the constraints militating against the production of the finest quality of ceramic raw materials.

1.4 LIMITATION

Although the findings of this study may be used to generalize the development of ceramic raw materials available in Nigeria, the research will only review the technology for processing the ceramic raw materials and recommendations made on the need and thrust of future research.

1.5 DELIMITATION

The study was confined to Kaduna, Niger, Plateau and Kano States, because a survey of the ceramic raw materials found all over the Federation

would not be possible due to time and inaccessibility to some of the raw material sites.

1.6 BASIC ASSUMPTIONS

For the purpose of this study, the following assumptions are made.

1. That there are several ceramic raw materials locally available in Nigeria.
2. There is the desire to develop these raw materials.
3. There is a growing demand for the raw materials locally and externally.

1.7 THE SIGNIFICANCE OF THE STUDY

Generally, the development of local raw materials plays a very important role in the socio-economic life of the people of any nation. The development of this sub-sector of the economy helps to expedite industrial development and self-reliance through the maximum utilization of local raw materials as inputs for industries.

Nigeria is gradually industrializing with various industrial projects proposed for development in the public and private set up. This underscores the critical role of the solid minerals development as per the provision of processed raw material for the ceramics and related industries.

The creation of the Solid Minerals Development Ministry in 1995 is a giant stride towards the dismantling the over dependence of the country on a mono culture economy which has remained oil export and raw materials import since independence.

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According to Hill (1967) the mineral resources of any nation can be one of its greatest assets and more than one war has been fought over these natural riches. The Romans for example pushed the boundaries of their Empire westwards with an eye on British lead and the rich silver mines of Spain.

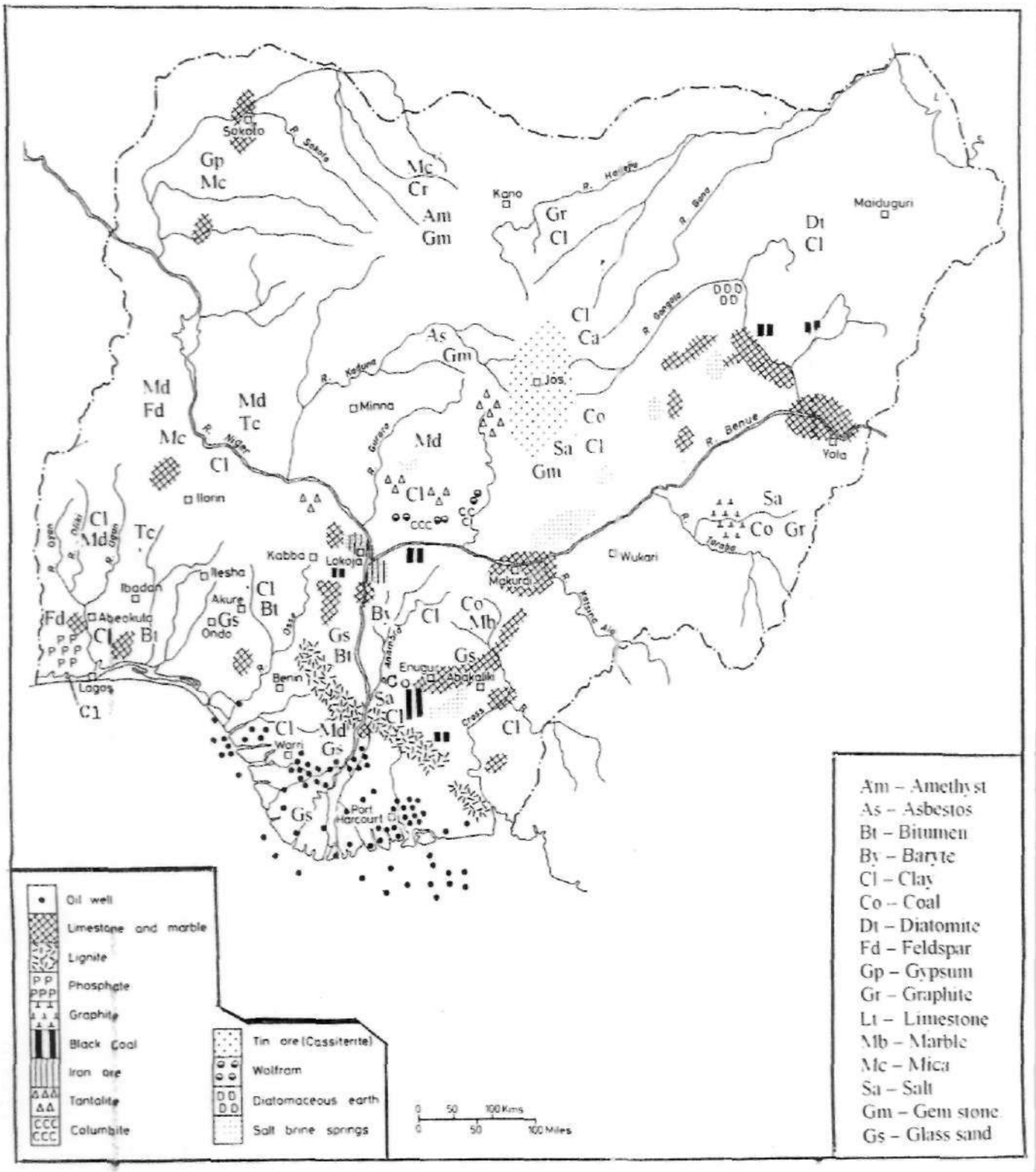
A brief tour of the mineral deposits around the world highlights the fact that not all nations have a fair share in the essential minerals. Nature made them more easily available to some than to others. Even the United States of America consuming 25 percent of the total world output of metals, has to import all the tin and manganese she needs. At the other end of the scale are the developing nations like Ghana with large deposits of manganese and bauxite and Nigeria with tin. In fact taken as a whole, the African continent has most of the minerals that other developed nations lack.

Minerals are an important part of the development plan of any nation particularly those who have not yet had an industrial revolution, because these natural assets are converted to other forms of capital, power stations transport and basic industries. These are essential to the life of any modern nation.

Fortunately, Nigeria is blessed with a lot of minerals both metallic and non-metallic. The geological and mineral map of Nigeria (page 7) reveals a wide range of ceramic raw material spread across the nation. There is the need therefore to encourage the development and commercialization of these raw materials.

South Africa which does not have a wide range of ceramic raw materials has developed the few that it has and today there is a drastic increase in production to meet the demands of the ceramic industry all over the world.

Map Showing Known Occurrences Of Some Minerals In Nigeria



Source: A Geography of Nigerian Development (1983).

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The significance of this study is based on the benefits to be accrued as a result of sustained development and commercialization of raw materials for the ceramic industry in Nigeria. As stated by Emmouns (1964), the development of the subsoil is one of the main elements in an economic plan. The benefits of these raw materials development are based on the following considerations:

a) Mining plays a large part in diversifying economies based mainly on agricultural and forestry resources.

b) Mining assists industrial development by giving rise to subsidiary activities, service industries for the mining operations and its personnel, and the manufacturing industries to which the operations supplies raw materials.

c) Mining earns and saves foreign exchange. If finance is sought locally or from abroad, the inflow of fresh capital may be considerable. Such currency imported without any corresponding export is in fact a loan from abroad to the local economy, which will be paid back only gradually out of the mine production.

d) Mining is a source of private income and public revenue. A large part of the expenses of the enterprise are paid in local currency, thus creating a flow of income to labour and services.

The money continues to circulate creating a nucleus of commercial and economic prosperity which has a "multiplier" effect. The country will obtain new source of revenue not only from taxes paid by mining enterprises itself, but also from the taxes on all induced or derived activities and income taxes paid by labour and services.

e) Mining provides an opportunity to develop professional and technological qualifications of the population and creates interest for the public.

f) The world demand for raw materials is growing rapidly from year to year. It

is therefore essential for the nations economic progress to find and develop new source of raw materials. Countries where these resources are found have promoted related activities in the international interest as well as their own.

Based on these considerations enumerated, the significance of the study cannot be over-emphasized. It is envisaged that the study will be a resource material for professionals, students and other interested bodies working towards the development of ceramic raw materials.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

The review of synthesized literature deals with the various aspects of the development of Ceramic Raw Materials which falls under the Solid Minerals Industry of Nigeria. It also reveals the progress made over the years with regards to the development of solid minerals.

For the purpose of this research the development of the ceramic raw materials may be generally divided into the following successive stages namely:

a) Basic Mapping (topographical and geological).

b) Exploration

c) Evaluation

d) Exploitation which consists of Mining and Beneficiation.

e) Marketing considerations

f) Financial aspects.

Mining and agriculture are two basic industries which have led to the development of modern civilization. Agriculture gives us chiefly our food and other materials from which clothes and some of our buildings are made. Mining supplies us with the fuels, natural gas, coal, petroleum; with abrasive such as garnet and corundum; with substances having various industrial uses such as clays, feldspars, quartz, borax and asbestos, copper, iron and aluminum. From these substances come the materials which are of such vital importance to the growth of our arts, sciences and industry.

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It is very clear that the bulk of the industrial activities of man is involved in the processing of minerals, in fact almost all of man's requirements are derived from the earths crust.

The beginning of mining lies far back in the pre-historic times. According to Lewis (1964) flint implements have been found with the bones of the paleolithic man who lived some centuries ago. Gold was washed from gravels, copper was mined and reduced from its ore and bitumen was used before recorded civilization. The first primitive mining was trenching or open cast work. Later man advanced to underground mining by sinking pits up to 50fts in depth. The tools used were picks, hammers and wedges made of horns of cows as well as hammers and wedges of flint.

The mineral industry of the world are basic to human progress and civilization. One must not forget that the search for the resources of earth particularly minerals of the soil was the chief cause of international wars and conflicts as well as the colonization of many countries in the world. Hence the availability of mineral resources is wealth while the lack of it is poverty. The search for minerals is even on the increase and has not been limited to the planet earth alone, but to bodies within and outside the solar system.

The mineral industry in Nigeria falls under the development of primary production industry; those minerals used in their raw or almost raw state. According to Okenzie (1983) this industry represents one of the oldest industries having its origin as far back as the Nok culture period of Nigeria's pre-history. Simple labour intensive operations, primitive communications and marketing systems however, limited output.

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Like in other developing countries, the Nigerian mineral industry was not oriented to the needs of the local industries except for providing revenue and local employment. This situation could be attributed to the absence of industries that could utilize the raw materials or unawareness of the existence of such materials; or the lack of expertise to locate the raw materials. The situation might even be attributed to a combination of some or all of these factors. The advent of industries, in the country is however, necessitating the development of related minerals or raw materials. Nigeria is richly endowed with mineral resources of many kinds but the problem has been how best can these mineral resources be exploited efficiently and economically.

Figures on the minerals production of Nigeria shows that production is largely under commercial control of private individuals. It is therefore desirable according to Lukman (1983) for the government to aid in securing the open door for the minerals exploitation and development by maintaining close touch with both local and foreign investors since the industry is a capital intensive one. Real advances have been made in mineral exploitation in countries with less mineral potentials. The case of Nigeria thus needs critical appraisal.

2.2 BASIC MAPPING

The first phase in the development of a country's subsoil resources is a study of its possibilities carried out by a general plan. This study according to Flawn (1966) begins with the preparation of two basic documents, the topographical map and the geological maps both on a sufficiently detailed scale if possible 1:200,000. This preparation of the two documents and publication of associated descriptive

report is normally the responsibility of the state's Geological Survey Department.

The departments most valuable contribution in terms of this direct discovery of economic minerals deposits is as a result of its systematic geological mapping programs. Feyide (1983) records that the establishment of the porcelain industry at Umuahia and Ikorodu were partly or wholly due to the discovery of ball and Kaolinite clays based on investigations made by the Geological Survey Department.

According to Flawn (1966) the basic geological study of any area establishes the rock type, sequence and structure present and interpreted in their historical setting with due regards to any possible development application. The geological structure and the nature of rocks themselves give some indication of what is possible and what is not. This permits selection of regions deserving a more detailed examination.

The systematic geological mapping from the ground is very often accompanied by a primary reconnaissance of the mineral possibilities of the region.

2.3 EXPLORATION

The discovery of mineral deposits which outcrop at the surface of the earth is largely on occurrence of the past. New deposits are discovered usually by geological methods supplemented by exploration geophysics and geochemistry.

Notwithstanding the scientific approach brought to exploration in the last decade many of the production projects in Nigeria reveal Fayide (1983) have employed more traditional prospecting methods which have not had the same impact on mineral resource development as in the industrialized countries. The natural conditions are often not favourable here in the tropics where visible

outcrops may be scarce and surface examination is difficult due to dense vegetation cover.

A more scientific method of exploration has recently been developed which recognizes the mineral deposits in smaller targets when considered in terms of the vast region in which they are found. Searching for minerals is infact a formidable task.

Elliot (1974) reveals that modern exploration has become a process of selection starting with the consideration of vast areas and systematically narrowing the search by discarding the less favourable areas. Additional information is also gained through airborne geophysics survey. The airborne magnetic survey are particularly effective in outlining the geological formation and structure as well as locating the mineral deposits.

One of the recent exploration tools widely used since the Second World War according to Elliot (1974) is geochemical prospecting in which drainage sediments, water and rocks of a given region are analysed for significant traces of minerals. The operational techniques are usually simple and therefore particularly suitable for a developing country like Nigeria where skilled labour and technicians are at a premium. Under suitable conditions geochemical drainage and sediment surveys are very useful in delineating mineral resources within which more detailed drainage and soil survey are used to track down mineral deposits.

The application of various modern exploration techniques on the surface and from the air speeds up the examination of large regions narrowing the search to smaller target areas for detailed investigations and eventually concentrating on relatively small areas likely to contain mineral bodies.

Modern methods of exploration have greatly increased man's skill in mineral search, complementing usefully the exploration geologist.

2.4 EVALUATION

Evaluation is the detailed investigation of mineral occurrences or deposits using all appropriate techniques, in order to discover their nature and origin, to establish the quantity, tenor and other characteristics of the minerals contained therein, to determine how best they may be exploited and generally to consider all other factors affecting their economic development, according to Morgan (1970).

Ideally, evaluation immediately follow the work which has shown the existence of a mineral concentration. It is much more costly and often includes the use of heavy equipments such as diamond drills and the opening of exploratory mine workings. It is thus carried out under the provisions of an exclusive license granted by the State. At this stage the physical and chemical characteristics of a mineral deposit are determined by systematic investigation and may require several years of costly work in the field.

The evaluation of alluvial and other type of mineral deposits at or near the surface present few problems Trenches provides a continuous lateral exposure down to several feet below the surface. Deeper examinations however requires drilling operations usually by diamond drill, the most widely used exploration tool today. The core obtained permits the study of the rock and also furnishes samples of minerals.

Govett (1976) states that sampling is a vital part of both exploration and evaluation, since it establishes the quality of the mineral concentration. The results

of chemical analysis for example determine whether or not the materials is of economic interest. Not all mineral concentrations are economically exploitable. The element to be considered in evaluation are varied and depend on the technical, economic and sometimes political factors.

Among the technical factors are the nature of the mineral, its content of useful and recoverable substances and the nature of impurities contained. Example may be cited of mining undertakings at Dawakin Tofa in Kano State which ended up in failure for lack of adequate preliminary studies of the clay to be mined.

The consideration of the economic factors involved includes the price at which the mineral can be sold after adequate treatment, transportation expenses (this depends on the general level of freight rates and infrastructure of the area), the various forms of taxation and other charges which may be critical. Excessive levies for example compromise the exploitation of a deposit which otherwise is economically viable.

Morgan (1970) also reveals that the prime objective of evaluation must be the determination of the mineral reserve. It is observed that mining enterprises are rarely concerned with an estimation of their total reserves. In most developing countries it is assumed reserves last for a period of ten to twenty years. This can be improved by continuous exploration work, the evaluation of new deposits, the extension and improvement in techniques to extend the life of the mine.

Under the changing circumstances of technological progress, the improvements of transportation techniques and the like is always a welcome development in evaluation of minerals. Even the most meticulous assessment can seldom be regarded as final as regard evaluation. This however, in no way affects

the need for evaluating a mineral resource as accurately as possible. The cost of evaluation including exploration and feasibility studies according to Morgan (1970) can amount to many millions of naira.

Although certain economic factors in feasibility studies may be with a fair degree of confidence Lewis (1964) reveals that some eventualities can rarely be predicted with any accuracy. This is particularly true with regards to future demands or prices, fundamental changes in technology, natural disasters and other considerations both economic and political. It is therefore prudent to make allowances for any adverse factors during evaluation while taking a conservative view of all the possible benefits.

2.5 EXPLOITATION

The term exploitation according to Lewis (1964) may be used in a broad sense to cover the various operations of mining processes and beneficiation of minerals. It may also be used sometimes to cover only mining with subsequent operations as a separate stage. Similarly the term development which is commonly used in a broad sense of establishing, promoting or expanding the mineral industry is also used to cover the stages immediately preceding mining. A growing awareness of the importance of mineral resources in the development of basic industries has resulted in the ever increasing tendency to employ the most efficient methods of extraction that modern technology permits. Modern techniques are evolving towards the recovery with minimum wastage in mineral exploitation. Irrespective of whether the deposit is large or small great care is required in planning for the most effective exploitation.

Selection of the most appropriate mining methods follow evaluation during which ideally all the physical and chemical characteristics of the mineral body will have been determined.

2.5.1 **MINING**

Most industrial minerals or rocks are mined using the open cast or quarrying method, and are carried out through the following activities:

(a) Clearing of the overburden to expose the hard rock using bulldozers.

(b) Mining of the minerals using mobile rock drills with a compressor to break up the rocks into pieces.

(c) Transportation of the minerals from the quarry to the plant is done by stumper trucks, loading into the trucks is done using wheel loaders of caterpillar or Komatisu shovels.

2.5.2 **SIZE REDUCTION**

The reduction of size of the minerals is done through two main stages namely:

- Crushing (primary and secondary crushing) whereby the sizes are reduced to a small size of 3/4" and 1/2".
- Grinding where the materials are reduced to very small sizes (into powder); the actual size depending on the requirement.

Crushing: Primary crushers could be jaw crushers consisting of two steel plates facing each other, one is fixed and the other is movable. The coarse material from the screens of the jaw crusher can then go into a secondary crusher such as a

gyratory crusher. This resembles a cone with heavy steel swinging in a circle, crushing the rocks against the enclosing steel walls.

Grinding: Further reduction in size is done by grinding. This can also be done in several ways. The material form the secondary crusher can be ground in a rod mill. It can also be ground in ball mil, and sometimes both rod and ball mill can be included in the circuit. The ball mill is a rotating steel drum, in which the grinding is done by the falling and rolling action of steel balls. In cases where recontamination by iron is not acceptable as in the grinding of raw materials for ceramic wares, e.g feldspar, quartz etc., the balls are made up of quartz or pebbles, flint or other non-ferrous hard artificial materials; The materials from the grinding circuit would have attained the size of about 1.0 to 0.1mm and for all practical purposes, Gaudin (ibid) reveals that this range of sizes would be within the economic limits for grinding.

2.5.3 TREATMENT OF THE MINERALS

There are a few minerals which are used or exported after selective mining and hand picking. Infact almost all minerals are subjected to a treatment more or less complex. The first and probably principal reason for this arises from the fact that most of these minerals are wanted in their refined state especially for application in modern industries with a high degree of specification as in glass and ceramics.

The quality of certain raw materials have to be improved in order to remove any undesirable materials. In some cases particularly in upgrading of some

industrial minerals, this separation can be achieved by a selective mining, hand-picking or by simple crushing, screening and wasting without using any expensive machinery, equipments, and chemicals.

A second reason is the impact of transport cost which makes it essential to transport rich products containing as little waste as is economically feasible. A third desire is the legitimate desire of the producing country to process locally the mined minerals to an advance state so as to stimulate profit from the added value of the processed mineral.

According to Lewis (1964) it is desirable to carry out the treatment of the minerals as near as possible to the place where it is mined so as to reduce transportation cost. Most often it is done right at the mine head and extremely varied processes may be adapted to the mineral concerned and also the requirement of the customers. The process employed may consist of simple crushing and screening or of washing in water for the removal of clay or free silica. In some cases enrichment may be obtained by calcination which eliminates both carbon dioxide of carbonates and combined water.

The treatment of minerals and especially the process for enrichment Lewis (1964) reveals, involves mineral loses. No industrial operation achieves a recovery of 100 per cent. Losses are often extremely high, hence the importance of efficient extraction process for the economy of the producing enterprise.

Mineral substances are wasting asset and as such they should be adequately studied before the manner of treatment is chosen. In some advance countries, the government assist greatly in this process by placing at the disposal of operators not only experienced mineralogist but also pilot plants for mineral

dressing. Furthermore, the performance of the mineral contractors are checked with adequate sampling to ensure efficient functioning.

The most basic guiding principle that must be kept in mind states Gaudin (ibid) is that the art of mineral dressing is adapted because it permits one to make profit of a venture of mineral exploitation where less profit or no profit would accrue without any treatment. The proper dressing methods yields the greatest profit even if it does not yield the highest recovery or the cleanest material. Where several methods may be considered in competition with each other, the correct method is determined by the yardstick of optimum profit.

Gaudin (ibid) also states that it is very important that the chemical and physical properties of the raw materials (minerals) are well established, in detail, through detailed exploration. It is also necessary to establish, the presence of any undesirable impurities, variations in composition etc, in order to decide on their suitability for the particular use. The product to be produced cannot be of the desired quality if the qualities of the raw materials are not within the desired specifications. It is therefore necessary to ensure that the raw materials meet the specification for the particular process. Often, in the case of such industries as high quality ceramic and glass wares, the natural raw material is likely to have some undesirable mineral impurities which must be removed by beneficiation or mineral dressings. In fact the technology for beneficiation non metallic minerals to a particular or desired quality has advanced to such an extent that practically, the limiting factor is mainly cost. Often the utilization of the by product according to Lewis (ibid) goes a long way in reducing the cost of raw material beneficiation and thus makes the process more viable.

It may be appropriate at this stage to define a few of the common methods used in mineral dressing and how these methods are applied in the upgrading certain raw materials in the industrial mineral field.

In general, mineral dressing may be divided into two parts:

- The liberation or freeing of the valuable minerals from the waste.
- The actual separation of the liberated minerals into the various final concentrates and waste products (tailings).

In order to separate the valuable fractions from the worthless fraction, various steps of comminution have to be used. These are breaking, crushing and grinding. The extent of the fineness to which comminution should be carried will depend on the mineralogical nature of the mineral and the nature of the association of the valuable minerals and the worthless minerals.

Sometimes the actual concentration process may give two or more valuable products and a waste product or tailings. During the concentration operation, various unfinished products of intermediate grade may be produced and are known as middling." The percentage of the total quantity of materials which is recovered in the concentrate is called "recovery or extraction".

From an economic point of view, the mineral dressing process should be profitable. The highest economic recovery is the ideal condition. In general mineral dressing makes use of the physical and chemical properties of the minerals. The difference in the properties of the valuable minerals and the waste minerals afford methods for the separation.

The properties of interest in mineral dressing include the following.

(a) Hardness and Toughness

The hardest mineral is diamond and the softest is talc. The hardness of the mineral is very important in determining the machinery for communition. The harder the minerals, the greater the ware and the more energy necessary, therefore, the higher the cost required for breaking up the rocks or minerals.

In general, when dealing with minerals, the hardness and toughness are the two very important properties. Toughness determines the resistance to break. Some minerals are soft but hard to break due to their toughness, example, Talc ($Mg_3 Si_4 0_{10}. (2H)_2$) gypsum ($CaSi0_4 2H_20$). Mica ($H_2KAL_2(Si0_2$ Feldspar ($K_20.Al_20_3$ $6Si0_2$) etc. Toughness combined with hardness are the main determining factors in crushing and grinding.

(b) Specific Gravity

The difference in specific gravity of the minerals presents a means of separating them from one another. According to Gaudin (ibid), minerals that can be separated using this method include:

Mineral	**Specific Gravity**
Albite ($Na\ ALSi_3\ 0_5$)	2.62 - 2.77
Orthoclase feldspar ($K_20.Al_20_3\ 6S_i0_2$)	2.57
Calcite ($CaCO_3$)	2.71
Dolomite ($CaCO_3\ MgCo_3$)	2.8 - 2.9
Ilmenite ($Fe\ T_i0_3$)	4.3 - 5.5
Corundum ($Al_2\ 0_3$)	3.95 - 4.10
Gypsum ($Ca\ Si0_4 2H_20$)	2.3

Kaolinite ($Al_2O_32H_20.2SiO_2$)	2.6 - 2.63
Magnetite ($MgCO_3$)	3.0 - 3.1
Quartz SiO_2)	2.65
Rutile (TiO_2)	4.2 - 4.3
Zircon ($ZrSiO_2$)	4.7
Talc ($Mg_3Si_4O_{10}(OH)_2$)	3.52

Gravity concentration using ferrosilica suspension is often used. Furthermore, the use of jigging machine, jerking tables spirals etc for initial concentrations is a well known practice.

The Froth Flotation method is (Figure 5) one of the most useful beneficiation processes for non metallic minerals today. It is based on selective chemical reagent absorption mechanism on the surface of the various minerals species, giving water repellent coating to some minerals and not others. Frothing material is added to produce bubbles to which the grains of the minerals with water repellent coated surface cling and are removed from the top. This method can be used in the beneficiation of nearly all non-metallic minerals including feldspar, quartz, silica, kaolin, magnetite, phosphate ore, limestone etc.

(c) Magnetic susceptibility

Another property is the magnetic susceptibility of the valuable or waste. Where a mixture of non-magnetic and magnetic are to be separated this method can be used. An example of this is the silica sand for sheet glass project in which the Ilimenite, Zircon have to be separated.

Application of these properties in the beneficiation of non-metallic minerals has been in use for many years. Magnetic minerals are, for example removed from

silica sand for glass manufacture, from kaolin, quartz and feldspar for ceramics and from many other deposits having those magnetic impurities. The most common process of electromagnetic separation today is high intensity magnetic separation (Figure 6). The high intensity magnetic separation method according to Singer and Singer (ibid) has gone a long way in solving the problems which the conventional dressing methods (gravity, centrifugal, floatation, electromagnetic) had not been able to solve, such as removing of iron content in clayey and kaolinic materials.

d. Conductivity

This is based on the different surface conductivity of the minerals when it is electrically charged. In practice the materials to be separated are fed on to a resolving cylinder electrically charged with a high potential. The conducting mineral particles become electrically charged and repelled while the non-conductors fall undeflected. This method of electrostatic separation is often used in the beneficiation of say beach sand deposits containing such minerals as ilmenite, garnet etc.

Very often separation of particular assemblage of minerals will require utilization of more than one of the above mentioned properties. Recently there has been increasing necessity to develop more elaborate processing techniques to meet the manufacturing quality specifications. Kaolin for example depending on the impurities contained in it can be refined using so many techniques depending on the quality requirement of the final product.

It can be ground and airfloated to produce filler good enough for say the rubber industry, or it can be water-washed to produce filler for the paper industry, but it will need more elaborate treatment like high intensity magnetic separation to

produce the finest filler for paper coating and high quality for ceramic products. Where the kaolin contains feldspar, mica, quartz etc, the flotation method can also be used. Feldspar and quartz used for ceramic industry can be beneficiated to remove such impurities as mica, tourmaline, garnet etc., by different stages of flotation, electrostatic and magnetic separation methods. Nepheline seyenite which is used as a source of Al_2O_3 for the ceramic and glass industries can be beneficiated by flotation, high intensity magnetic or other separation methods depending on the impurities to be removed.

In fact, the flotation method is about the most popular method used in the beneficiation of non-metallic minerals.

2.6 TRANSPORTATION OF MINERALS

An economic means of transporting the minerals even after all efforts have been made to eliminate the greater part of the unwanted materials is of vital importance. In general they are relatively heavy products of low to moderate unit value. According to Gaudin (1967) the choice of method of transportation is a fundamental decision in equipping a mine. Transportation constitutes a high proportion of the necessary investment and greatly affect production cost. A better situated deposit therefore enjoys an obvious advantage. The transport system at the mine itself or between the mine and the central plant constitutes in the broad sense a part of the mine equipments.

Factors to be considered according to Gaudin (ibid) in terms of transportation are the transportation of the minerals from the mine to the point of utilization, the annual tonnage to be transported; and the ease of adaptation to different

production schedules, in particular the possibility of expanding in a subsequent phase beyond the capacity initially provided for.

Road transportation constitutes a simple and flexible solution to the transportation of minerals but it is often burdensome because of the high cost of operation and maintenance cost. For small to medium size operations, it is the obvious means of connecting with a railway or other existing large capacity transportation system, large scale working on the other hand requires extensive technical and economic study to ensure that the deposit could be exploited for a long time so as to recover at least the cost of installation.

The railway is an expensive solution for very large deposits of very bulky products. Standard gauge track, although costly to install, is desirable for these very large tonnage because the operating expenses are a great deal less.

2.7 MARKETING CONSIDERATIONS

The necessity of selling the minerals at a remunerative price makes it absolutely important that a market survey be undertaken before large sums of money are spent in bringing a mine into production. From a technical point of view, there are generally accepted standards for most of these minerals which must be met. These are usually dictated by the end use of the raw material.

Usually, there is the problem of marketing particularly in the case of raw materials already in adequate supply. This could be a formidable difficulty for new comers trying to enter the market in competition with long established suppliers. In many cases therefore it is much easier for such established companies to develop new deposits and market their products.

There is also a greater likelihood of a regular outlet if the users of the minerals participate in the development of the deposit, but Gaudin (ibid) advises that certain precautions must however be taken to protect the producing company's legitimate interests. The participation of an external consuming industry are often advantageous to both parties concerned.

2.8 FINANCIAL ASPECTS

This chapter would be incomplete if mention is not made of the financing required for the stages of mineral development, outlined. According to Lukman (1983), three main divisions for this financing may be recognised; the funds required for the general exploration and detailed studies, leading to the location of the deposits, those required for establishing the necessary infrastructure and those needed to meet the cost of actual mining development. The mineral development industry is a capital intensive business which involves huge financial commitment. For a developing country like Nigeria, the most ideal thing is the participation of government. This will however depend on the nature of the economy and the services available in the field of natural resource development. The state is expected in this area to assume some responsibility for the general exploration in the program of geological mapping and for that portion of the infrastructure which contributes to the country's general development.

The development of mining involves not only the cost of opening the mine, but also the establishment of its technical and social facilities. These investments normally amounts to huge financial commitments which may be financed partly by

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the funds of the enterprise itself; by long term loans from bank or the public through shares.

In considering any mining project Govett (1976), states that the following features must be noted:

(a) Large amount of capital is necessary to mount a major mining project in a developing country.

(b) It is necessary for preliminary studies to be made before the decision to go ahead with the project.

(c) Large fraction of the financing should be allocated for transport when the mine to be established is not near an existing transport route.

(d) It is important to develop supporting facilities like accommodation workshops etc in its entirety.

CHAPTER THREE

METHODOLOGY

3.1 INTRODUCTION

In this chapter, the methodology/research design in which details of population, data collection tools commonly employed for descriptive or survey research are discussed. The face to face interview based on a structured questionnaire is the primary data collection tool employed within the framework of this study is also discussed. Finally, the data analysis procedures are presented.

The questionnaire survey lends itself to the survey approach in which public opinion or the behaviour of a large population is sampled within a time frame and is used as a basis for predicting future behaviours or trends. The questionnaire, is usually aimed at collecting standardised information from all subjects in the sample sharing a common condition. The purpose of the questionnaire for this study is to collect data about selected variables. Each questionnaire item is designed to obtain specific responses sometimes using multiple choice questions. According to Borg and Gall (1983) such questionnaire items having been conceived as a measure for a specific variable should in the final analysis contribute some vital informations towards the overall subject, that is being treated.

This research is essentially a descriptive or survey one. According to Adetor (1986), a descriptive or survey research is that which is used to find the meaning and to obtain understanding of present conditions, beliefs, attitudes uses etc. for the purpose of knowning ones future direction. Osuala (1987) also states that descriptive research gives a picture of a situation or population. Any consideration of a phenomena generally begins with a full understanding (description) of the

phenomena. In this direction therefore, the descriptive survey method of research has been used to collect the necessary informations and data for anaylysis in a bid to solve the problem of this study.

Osuala (ibid) states that observation and survey methods are frequently used to collect descriptive or survey data. The survey method deals with both large and small population by selecting and studying samples drawn from the population to discover the relative incidences, distribution and interrelation of the variables. The samples drawn from the population are studied and inferences are then made for the defined population.

For the purpose of this study some existing companies that mine and process ceramics raw materials as well as existing pottery and ceramic enterprises that make use of the processed ceramic raw materials for their production were surveyed and the following were studied:

a) Various production processes

b) Source of raw materials

c) Quality of the processes raw materials

d) Equipments used for the processing of the raw materials

e) Organisation, including number and calibre of personnel employed.

f) Source of finance for the mining and processing industry

g) Problems encountered by the mining and processing companies in the course of their operations

h) Prospects.

3.2 POPULATION AND SAMPLING

The subject for the current study consisted of administrative and technical staff of some selected mining and processing companies as well as the pottery and ceramic enterprises. As it is always the case with surveys of this nature, time and financial constraints did not permit the researcher to draw representative sample from some of the states in Nigeria.

For the purpose of this study, three mining and processing companies were selected from Plateau and Kaduna States. These are the Nigerian Mining Corporation Jos, Abdullahi Mohammed Industries Limited (solid Minerals Division) Kaduna and Crystal Talc Nigeria Limited, Kaduna. The study of these mining and processing companies was conducted to find out the types of ceramic raw materials they process, the source of raw materials, beneficiation processes, problems and prospects.

To ascertain the quality of the ceramics raw materials processed by the mining and processing companies selected for this study, the research was conducted at five pottery and ceramics enterprises. These enterprises are Dawakin Tofa Pottery at Kano in Kano State, Maraba and Jacaranda Potteries Kaduna in Kaduna State, Royal Ceramic and Capital Ceramic at Suleja in Niger State.

These companies were selected because it was felt by experts that they represent a broad technical spectrum for some of reasons. First, they employ varied production processes since they have some differences in the types of materials processed. Due to the diversity of the production techniques employed, it provided an avenue for assessing the technologies employed locally for beneficiation or mineral dressing. It was also possible to ascertain the quality of the

locally processed raw materials because of the diversity in the production processes of the pottery and industrial ceramic companies.

The members from these groups i.e mining and processing companies who are the producers of the ceramic raw materials and the pottery and ceramic enterprises, the consumers of the processed raw materials were not selected at random but instead certain key personnel from the two groups like the Managers, Geologist, Chemical Engineers, Production Managers and quality control officers were selected for the investigation. The fact that the present investigation is aimed at a specific professional group does facilitate the sampling procedure. According to Borg and Gall (ibid) ones it established that a professional group selected actually has access to the information being sought, the entire group can be surveyed or a sample can be selected from the population.

This mode of selecting respondents from the larger population was adapted because of the technical nature of informations required. These two groups were therefore investigated and informations data required to solve the problem of this study.

3.3 INSTRUMENTATION

Survey and descriptive research according to Kerlinger (1973) is classified by the following methods of obtaining information. These are personal interviews questionnaires and controlled observation in each case the aim is to obtain informations by either experiencing a situation directly or by having someone to tell us what happened. For the purpose of this study, the personal interview (face to face) and the non-participatory observation methods were used. In the course of

the observations, the researcher watched the respondents at work for a better understanding of their mode of operations. This had the advantage of getting additional informations that had not been discussed in the course of the face to face interview because the problem must have been ommitted in the structured questionnaire. In the present investigation, the face to face interview schedule based on a structured questionnaire and supplemented by a period of observation of work processes were selected as data gathering instruments primarily because of the size of the samples involved as well as the breath of information being sought.

3.4 THE QUESTIONNAIRE

The questionnaire for the present study (Appendix A) was intended to collect data an demographic and percieved attributes of the subject. On the whole the instrument consisted of 25 items out of which 11 were closed ended questions while the remaining solicited for additional comments. The instruments was arranged into two categories.

Category one was primarily intended to collect data on the development of locally sourced raw materials and category two was aimed at measuring the perceptions regarding the locally developed raw materials. The responses provided the knowledge and understanding required to express a meaningful opinion about the study.

3.5 VALIDITY

As the case may be with all questionnaire instruments, it was particularly important to ensure that the instrument used for this study will measure what it was

purported to measure and also to eliminate any ambiguity, slopply diction lexical complexity and other source of confusion. To address the content validity usually requires the use of competent judges (Kerlinger, (ibid). In this study, a judge who is a specialist in research education was asked to critically review each questionnaire items in terms of its relevance to the specific content domain to be tested. His recommendation was used to finalize the instruments used for this study.

3.6 THE INTERVIEW SCHEDULE

It has been noted in the foregoing section that survey questionnaires are known to be associated with problems of validity and reliability. But since questionnaires have to be used particularly where large sample size are involved, researchers generally use a variety of strategies to maximize validity and reliabity of the instrument used. In the current study besides addressing the validity and reliability of the questionnaire in other ways, it was felt that the normal questionnaire instrument alone was insufficient for validating the survey. Subsequently the decision was taken to conduct the interview by way of structured interview to provide an additional avenue for enhancing the accuracy and objectivity of the information being sought. With this method, the respondents were in a position to answer any critical question that the researcher might have omitted from the instrument, shed light on any relevant or deviant response, clarify important along the way, and also to discuss possible biases that might arise from other positions unknown to the researcher.

On the whole the interview schedule allows the investigator to obtain more information by obtaining immediate feedback on ambigous information.

3.7 OBSERVATION

According to Kerlinger (ibid) there are two basic methods of observation; we can watch people do and say things, actions or activities and we also ask people about their own actions and the behaviour of others. In each case, the aim is to obtain information by either experiencing the situation directly or by having someone tell us what happened. Both instruments were considered for the purpose of this study.

During the field trip, the researcher spent some time after the administration of the interview to watch the respondents at work for a better understanding of their work.

Some statistical and governmental records are also consulted for data's like the Geological Map of Nigeria, estimates of the reserves of some non metallic minerals which is beyond the scope of this study etc. These are attached to the final report as appendixes.

3.8 DATA GATHERING PROCEDURE

The first step in the field research was to approach the Head of Department for an introductory letter which was granted (Appendix B). This was to enable the researcher get the necessary cooperation and assistance from the places identified for the collection of the information because it takes time to access to some of these enterprises.

Having identified the target population, the next step was to draw up samples from the two categories selected i.e. the mining and processing companies and the pottery and ceramic enterprises. The samples were drawn from the target population to form the key respondents. It was decided that respondents like General Managers, Geologist Production Managers, Quality Control Officers, Minners and Production staff would be the target for the face to face interview using the questionnaire as the basis.

The structured interview took place in each key respondents office. Note taking was the method of recording the responses and were documented along each on the interview schedule being used by the interviewer. The categorization provided a quick means of organising and recording the responses.

In addition, while in the field, the researcher took the liberty to interview other personalities external to the population who are well placed persons in mineral development activities. Amongst them is the Technical Director, Task Force for the Techno-Economic Survey of Nigeria under the auspices of the Raw Materials Research and Development Council. Such interviews were not used in the analysis but they did add an additional perspective to the researchers body of information.

3.9 DATA ANALYSIS PROCEDURE

The interview data collected for this study were analyzed qualitatively, Kerlinger (ibid) suggests that once a population is perceived to comprise of professional who posses the information being sought the assumption underlying the use of qualitative analysis is deem to have been met.

To analyze the qualitative data, a list of typical responses were compiled. By comparing each key respondents set of responses against the range of typical responses, it was possible to identify which particular responses were most dominant for each question. The analysis of these responses were then collated to find solutions that attempt to solve the problem of this study as well as the findings.

CHAPTER FOUR

ANALYSIS OF DATA COLLECTED, DISCUSSIONS AND FINDINGS

4.1 INTRODUCTION

In an attempt to solve the problem of this study, which is the extend of development of locally available ceramic raw materials, the researcher employed various methods including interviews, and observations. This chapter is a documentation of the discussion and findings of the study based on the data collected during the field work to find solutions that attempt to solve the problem of this study.

The respondents were categorized into two groups. The first category comprises the mining and processing companies made up of Abdullahi Mohammed Industries Limited (Solid Minerals Division) Crystal Talc Nigeria Limited and the Nigerian Mining Corporation while the second category is made up of the Pottery and Ceramics Enterprises that utilizes the processed raw materials of the first category. The Pottery and Ceramics Enterprises are Maraba Pottery, Jacaranda Pottery, Royal Ceramics and Capital Ceramics.

This chapter opens with the report of responses transcribed from the notes for the present study. A presentation of the qualitative data organised into the pertinent content areas follows. Finally, the finding are presented.

4.2 THE INTERVIEW DATA

After the responses had been transcribed from the notes, they were categorized into two groups i.e. the data from the mining and processing companies

and data from the pottery and ceramics enterprises. A presentation of the report organized into categories follows.

4.2.1 DATA FROM THE MINING AND PROCESSING COMPANIES

The Nigerian Mining Corporation, Jos

The Nigerian Mining Corporation Jos, is owned by the Federal Government of Nigeria and was established in 1968. The corporation presently has a work force of about 850 personnels made up of a Managing Director, Personnel Manager, Accountants, Production Managers, Geologists, Chemical Engineers, Miners and other auxiliary staff.

- The Nigerian Mining Corporation, Jos, mines and processes, baryte quartz and feldspar. It also owns a brick and tile factory. The quartz processed by the company is a by product of the processed baryte ($BaCO_2$) from Azare in Bauchi State. The feldspar, white albite type ($Na_20\ Al_20_3\ 6Si0_2$) is mined at Jos in Plateau State.

  Before the raw materials are mined and processed, samples are brought to the corporations laboratory for testing. Regular testing is however not done as confirmed by a respondent from the corporation.

- Processing of raw materials at the Nigerian Mining Corporation plant is done through primary and intermediate crushing using jaw crushers and edge crushers respectively before being ground with the hammer mill. All the equipment used for the processing of the raw materials wre imported.

- It was observed at the corporations plant that the processed quartz and feldspar are not of the finest quality. The particle size of the milled raw

material are about 1.0 - 0.1mm (a mixture of fine and coarse materials).

Investigations by the researcher reveal that the corporation does not have a ball mill for grinding the materials into powder. A respondent from the corporation reveals that the materials from the milling circuit that would have attained the size of 1.0 - 0.1mm was within the corporations economic limit for grinding.

- Apart from washing, the quartz and feldspar processed by the Nigerian Mining Corporation is Jos are not beneficiated to remove such impurities as mica, ($K_20.3AL_20_3.6Si0_2 H_20$).

The quartz and feldspar processed by the Nigerian Mining Corporation, Jos are sold to customers at the corporations office at Jos and other Nigerian Mining Corporations offices in places like Kaduna and Lagos. The sales of the quartz and feldspar processed by the corporation have not been very encouraging due to the low demand.

- The Nigerian Mining Corporation Jos funded by the government of Nigeria through the Federal Ministry of Mines and Power. The researcher was told by a respondent from the corporation that the funds from the Federal government has been inadequate for the past ten years and as such the corporation has not been able to replace the old equipment to facilitate and improve upon production.
- The processed raw materials of the Nigerian Mining Corporation Jos are mainly for local consumption and there are no plans in the very near future to export some of the processed raw materials.

CRYSTAL TALC NIGERIA LIMITED, KADUNA

Crystal Talc Nigeria Limited Kaduna was established in 1996 with an estimated capital of about N100 million (one hundred million Naira) is privately owned company with a staff of 350 made up of a General Manager, Production Manager, Marketing Managers, Chemist, Chemical Engineers, Miners Millers and other auxilliary staff. The company mines and processes local raw materials like baryte, quartz, feldspar, talc and dolomite not only for the pottery and ceramic enterprises but also for glass, fertilizer, paint and plastic manufacturing industries.

- The raw materials processed by the company are mined at different locations in Nigeria. Feldspar, quartz and talc are mined at Kagara, Phosphate at Sokoto, dolomite and Marble at Lokoja and Kaolin at Bauchi.
- The main processing plant is at Kagara in Niger State, while the distribution of the processed raw materials are through wholesale retail outlets headed by a marketing manager.
- **Mining and Processing**

  The Mining operation begins with the removal of the over burden with bull-dozers and scrappers. Excavator are then used to load the mined raw materials into dumper truck and brought to the processing plant.

  With the exception of talc the majority of the raw materials do not undergo any treatments. Kaolin for example does not undergo any purification. The larger particles of feldspar, quartz or mica are separated by screens. The benefication of talc at the Kagara plant include, jaw crushing, hammer milling, bleaching and washing, ball milling, hydraulic pressing, drying and baggaging.

These observations were recorded during the field studies.

- The patronage of the company's processed raw materials have been very high since is started its operations. Their customers apart from the pottery and ceramic enterprises includes, paint, glass companies. The national demand for talc as revealed by a respondent is about 50,000 tonnes per year and as such about seventeen of such industries are required to be established in the country in order to meet the demand.
- Testing of Raw Materials

  Apart from the initial testing of the raw materials before the mining operations begins, the company does not carry out regular testing of both the raw and the processed materials.
- The initial capital for setting up of the company and its operation is from the personal savings of the Chief Executive and Managing Director of the Company. The company does not enjoy and financial support from the banks or Federal government.
- **Problems:**

a) The mining activities of the company are disrupted during the raining season because the mining sites are flooded with water.

b) Some of the company's customer have not been making prompt payment for the processed saw materials they buy.

- None of the raw materials processed by the company is exported.

ABDULLAHI MOHAMMED INDUSTRIES LIMITED (SOLID MINERALS DIVISION) KADUNA (AMIL).

Abdullahi Mohammed Industries Limited (Solid Minerals Division) was established om 1995 at the wake of the Federal Ministry of Solid Minerals Development. The mandate of the company includes mineral exploration, mining, beneficiation, packaging and marketing of metallic and non metallic minerals available in Nigeria.

The prospecting and mining licenses of the company covers metallic minerals like zinc ore, tantalite, columbite, rhodolite pyrites, lead/gelena and cholcopyrite and non-metallic minerals like kaolin bentonite (AL_2O_3 25i O_2 $2H_2O$) gypsum ($CaSO_4 2H_2O$) Baryte ($BaCo_3$), talc ($Mg2Si_4O_{10}(OH_2)$ dolomite ($CaCO_3$ Mg CO_3) Limestone ($CaCo_3$) Rutile (TiO_2) Magnesite ($MgCO_3$).

Abdullahi Mohammed Industries Limited (Solid Mineral Division) is joint venture company made up of Nigerian and Chinese investors.

AMIL Solid Mineral Division has a staff of 28 excluding the Chief Executive/Chairman of the Abdullahi Mohammed Industries. Other members of staff include the Director of Solid Minerals, Project Director, Ceramist, Chemical Engineer, Accountant, Secretary/Legal Adviser Miners and Millers.

- All the raw materials processed by the company are locally sourced. Gypsum is mined at Yobe in Yobe State, Feldspar at Azare in Bauchi State, tourmoline at Kogi State, Kaolin at Kankara in Katsina State and Bauchi and tantalite at Gidan Wire in Kaduna State.
- The equipment used for the mining and processing of the raw materials were imported. These equipments include - Jaw crushers, hammer and pendulum

roller mills, ball mill and cyclonic shifters. The kiln and accessories for the calcination of the material wre locally fabricated.

- AMIL solid minerals Division does not have a laboratory for the testing of the raw material mined and processed. The preliminary testing of the raw materials is carried out at the laboratory of either the Nigerian Mining Corporation Jos or The National Steel Council, Katsina.
- The lack of laboratory equipment have made it impossible for the routine testing of the materials.
- Mining and Processing of the Raw Materials.

After the removal of the over burden with bulldozers and scrappers, the raw materials are brought to the processing plants in dumper trucks. The bulk of the primary crushing and milling is done at the company's plant Lokoja or at the site of mining using jaw crushers and hammer mills.

For those raw materials that require treatment like calcination before milling, the crushed raw materials are brought to the company's plant at Kaduna. In the case of gypsum for example, it is upgraded after the initial crushing to improve its purity through reduction of the lump size to loosen the clay and then washed to remove the clay. The gypsum is then calcined milled and bagged.

- It was observed at the company that most of the modern beneficiation process like the high intensity magnetic separation and froth floatation method needed for more elaborated treatment of raw materias are not employed, because the company does not have the equipment needed for such operations.

- **Problems**

a) Lack of funds have not made it possible to import equipments for the processing of oxides and colourants from the semi precious stones and metallic minerals, like tourmaline, tantalite, tin and chalcopyrite.

b) The non co-operative attitude of the land-owner at the mining sites have sometimes hampered the smooth operations of the company.

Long after the payment of royalties and taxes to the land owners, are not willing to vacate the land for the mining operations to begin.

c) The researcher was also tolf that the company spends a lot of money on the construction of access roads to the mining sites.

- **Demand for Processed Raw Materials**

The demand for the raw materials processed by the company is very high. The company's processed raw materials are patronized not only by the pottery and ceramics enterprises but also by other industries industries like the glass, chalk, paint and petroleum industries.

4.2.2 DATA FROM THE POTTERY AND CERAMICS ENTERPRISES <u>CAPITAL CERAMICS, SULEJA</u>

Capital ceramics, Suleja a privately owned pottery was established in 1990. At that time, the pottery had only three staff plus three trainee potters. The pottery presently has three directors, four senior staff who are trained in ceramics from various institutions, three skilled workers who were trained in the pottery, three supporting staff and four trainee staff.

- The pottery produces mainly table wares like mugs casseroles, tea/coffee

sets, vases as well as modelled pieces for decorative usage.

- As a matter of policy, all the raw materials and equipments used at the pottery are locally sourced. The raw materials are sourced between Lokoja and Suleja and are found in large quantities. Kaolin for example is mined at Kwakuti along the road between Suleja and Minna.

  The raw materials used at the pottery are feldspar, quartz, ball clay, Talc, Zircon and Dolomite.

- The raw materials are processed at the pottery using locally fabricated equipment like the ball mill. The researcher was told that on a few occasions they consulted the Industrial Development Centre at Zaria to confirm tests already carried out on ceramic raw materials.

- The quality of the locally sourced raw materials are comparatively high because the pottery does not face any serious problems while using them.

  On a few occasions when they encountered such problem like crazing of glazes, the problem was solved by adjusting the glaze composition.

- The deliberate policy of the pottery on the development and utilization of local raw materials have been very successful because a respondent from the pottery told the researcher that the pottery spends less money on procurement of raw materials.

ROYAL CERAMICS, SULEJA

Royal Ceramics, Suleja, is a joint venture company owned by Nigerian and Indian investors. It was established in 1995 and produces mainly industrial wares like tiles and toiletries.

The company has a Board of Directors, General Manager, Production Manager, Marketing Manager, Quality Control Manager as well as other skilled and unskilled staff. There is a total 545 staff on the companys payroll.

- The bulk of the materials apart from the equipments are sourced locally. These material which are already processed include feldspar, quartz kaolin, and zircon. The ball clay used by the company is mined at a site acquired locally. The plaster of paris for mould making is also locally sourced.
- Imported materials used by the company are mainly colouring oxides' body stains and colourants like cobalt oxide, tin oxides and onglaze enamels. Although tin ore is available in Nigeria, the mining and processing companies have not been able to produce tin oxide due to lack of equipment as revealed by the respondent.
- At Royal Ceramics, production of ceramics wares is an everyday business and as such both the local and imported raw materials are used on a daily basis. The local material are used for body and glaze preparation while the imported materials are used for glaze and decoration.
- At the factory the researcher was told that although the physical and chemical quality of the local raw material are high, the materials had to be processed again to remove certain impurities.

Information gathered at the factory revealed that at the inception of production, it was detected that the locally processed raw materials contained such impurities like mica garnet etc. These impurities posed such problems like incorrect porosity, inadequate strength, changing shrinkage, crazing or peeling of the glaze and lack of gloss of the glaze.

In a bid to solve these problems, the electromagnetic separation process was employed to remove the impurities.

- The imported raw materials rarely pose any problems if used in the right proportion.
- Because the imported raw materials did not have local substitutes if it was not easy to assess the differences in cost so as to be in the position to tell which one was expensive or cheap. The researcher was however told that the high foreign exchange component of the imported materials certainly adds to the cost of production.
- Apart from the ball clay, the company does not process any of the other raw materials used for production. There are no plans in the very near future to process the raw materials at the factory because the company does not have the resources to acquire the processing equipments.

DAWAKINTOFA POTTERY, KANO

Dawakin Tofa pottery was established by the Kano State government as a small scale cottage industry established for the development of the local traditional pottery as well as a pottery training centre.

At the inception of the pottery there were only five staff but presently there are fifteen staff made up of a Manager, 3 skilled workers who are trained potters, two supporting staff and nine trainee staff.

- Both locally processed and imported raw material are used for production at the pottery. The locally processed raw materials include feldspar, kaolin, quartz, iron oxide and the secondary clay.

- All the local and imported raw materials are frequently used as imputs for body and glaze preparation. The imported raw materials i.e. the oxides are also used for decorating the pots.

  The plaster of paris (POP) used for the making of mould for slip casting is also locally sourced.

- The pottery produces mainly earthen-ware pieces like casseroles mugs, coffee and tea sets, flower pots and vases.
- Both the imported and locally processed raw materials do not pose any serious problems when used for production.
- The imported oxides as reported by a respondent are quite expensive and not readily available. Cobolt oxide for example costs about N2,500.00 per kilogram while a 50 kilogram of feldspar processed locally costs about N400.00. Comparatively, a respondent from the pottery is of the opinion that the imported raw materials (oxides) are expensive.
- Apart from the secondary clay, the pottery does not process any of the raw material used as imputs for production because the pottery does not have the equipment for the processing the raw materials that could be sourced locally in Nigeria.

JACARANDA POTTERY, KADUNA

Jacaranda pottery is a privately owned pottery located in Kaduna, 20 kilometres off the Kaduna - Kachia Road. It was established in 1982. The pottery presently has a staff of fifteen made up of the Production Manager, trained potters, and other auxiliary staff.

- The pottery produces mainly pottery like plates, tea/coffee sets, flower vases, flower pots and other decorative pieces from both local and imported processed raw materials.
- The locally processed raw materials used by the pottery for its productions includes, secondary clay (Damanchi Clay) feldspar, quartz, dolomite, talc, quartz and red iron oxide prepared from maramara stones.

  The only imported raw material used at the Jacaranda pottery is cobolt oxides.
- These raw materials are used frequently at the pottery for body and glaze composition at pre-determined percentages. The oxides are also used for decorating the wares.
- Except for the feldspar processed by Crystal Talc Nigeria Limited, the respondent from the pottery certified that both the imported and locally processed raw material used for production are of a high quality.

  The complaint about the feldspar according to the respondent was that each time they used the feldspar processed by Crystal Talc Nigeria Limited, the glazed fixed ware had a lot of craze lines or pinholes.

  These glaze problems however ceased when they used the feldspar from Sunglass Limited (a glass manufacturing company) that had been reprocessed. The respondent reveals that although Sunglass Limited uses feldspar from Crystal Talc Nigeria Limited, it had to be reprocessed to meet the quality desired for the production of the glass wares.
- Apart from the secondary clay and the red iron oxide, all the other raw

materials used by the pottery are not processed by the pottery. There are no plans to process these raw materials at the pottery.

MARABA POTTERY, KADUNA

Mararaba Pottery was established in 1985 as a joint venture enterpprise initially made up of five partners. The present number of the partnership is four because a member opted out.

The pottery has 25 staff on its pay roll. They are the manager, the production manager, trained potters and other auxiliary staff.

- The pottery produces mainly mugs casserols, flower pots, flower vases, tea/coffee sets, and other decorative wares.
- Both locally and imported processed raw materials are used by tbe pottery for its productions. The locally processed raw materials used by the pottery are feldspar, secondary clay, kaolin, quartz, wood ash and iron oxide. The only imported raw material used by the pottery is cobalt oxide. The cobalt oxide is either incorporated into glazes or used for decorating wares.
- All the raw material that have been processed locally and imported oxide are frequently used for product and are of a higher quality as certified by a respondent from the pottery. The pottery has not faced any problems while using these raw materials.
- According to a respondent from the pottery, the imported oxide is quite expensive because a kilogram of the cobalt oxide costs N5,000.00. On the other hand, fifty kilograms of locally processed feldspar costs only N350.00. Comparatively therefore the imported raw material (cobalt oxide) is expensive.

- The pottery does not processes any of the raw materials used for its productions except the secondary clay. However, with the acquisition of a ball mill there are plans on the ground by the pottery management to process some of the materials that could be sourced locally.

4.3 DATA ANALYSIS

As indicated earlier, the semi structured interviews addressed the issues in the questionnaire (appendices A & B). The purpose was to obtain qualitative verbal statements.

The interviews were transcribed from the notes and categorized into pertinent content areas. A presentation of the qualitative data organized into pertinent content areas are as follows.

4.3.1 TABLE 1 DEMOGRAPHIC DATA

S/NO	NAME OF INDUSTRY	LOCATION	YEAR OF ESTABLISHMENT	TYPE OF OWNERSHIP	NUMBER OF WORKERS
1	Nigerian Mining Corporation	Jos (Plateau State)	1968	Public-Federal Government	850
2	Crystal Talc Nigeria Ltd.	Kaduna (Kaduna State)	1996	Private	350
3	Abdullahi Mohammed Ltd (Solid Minerals Division)	Kaduna (Kaduna State)	1995	Joint Private	28
4	Mararaba Pottery	Kaduna (Kaduna State)	1985	Joint Private	25
5	Jacaranda Pottery	Kaduna (Kaduna State)	1982	Prive	15
6	Capital Ceramics	Suleja (Niger State)	1990	Private	17
7	Royal Ceramics	Suleja (Niger State)	1995	Joint Private	14
8	Dawakin Tofa Pottery	Kano (Kano State)	1992	Public	15

Table 1 is the demographic data of the population investigated for this study. As shown in the Table, the majority of the companies are privately owned and employ a few workers for their operations. A consensus of these privately owned companies indicates that the number of employees is kept low so as to cut down operational cost.

4.3.2 TABLE 2: SOURCE OF INVESTMENT FUND FOR MINING AND PROCESSING COMPANIES

S/NO	NAME OF INDUSTRY	PRIVATE SOURCE		LOAN FACILITIES	
		OWNERS SAVINGS	SHARES	GOVERNMENT	BANKS
1.	Crystal Talc Nigeria Limited Kaduna	*			
2.	Abdullahi Mohammed Industries Limited (Solid Minerals Division)	*	*		
3.	Nigerian Mining Corporation, Jos			*	*

The main source of investment for all but one of the mining and processing companies as shown in Table 2 is from the personal savings of the owners and other private investors. Only the Nigerian Mining Corporation enjoys financial support from the government and the banks.

Responses from the respondents of the privately owned mining and processing companies indicates that none had benefited from the any bank loan. Only the Nigerian Mining Corporation is supported by the government because it is a government establishment.

This shows that although the government has set up banks like the Nigerian Bank for Commerce and Industry (NBCI) and others like the Industrial Credit Schemes to provide loans for viable industries, none of the ceramic raw materials processing companies have benefited from the loan schemes hence their dependence on personal savings. When asked further during the interviews if they had ever approached the banks for assistance, they complained of the stringent conditions laid down by the bank if the loans were to be granted.

4.3.3 TABLE 3: SOURCE OF RAW MATERIALS, MACHINERIES AND EQUIPMENT FOR THE MINING AND PROCESSING COMPANIES

S/NO	NAME OF INDUSTRY	RAW MATERIALS		MACHINERIES AND EQUIPMENT	
		LOCALLY OBTAINED	IMPORTED	LOCALLY OBTAINED	IMPORTED
1	Crystal Talc Nigeria Limited Kaduna	*			*
2.	Abdullahi Mohammed *Industries Limited* (Solid Minerals Division) Kaduna	*			*
3.	Nigerian Mining Corporation, Jos	*			*

Table 3 shows that all the plant and the laboratory equipment used for the mining and processing of the locally, sourced ceramic raw materials by the three mining and processing companies are imported, while the raw materials for processing are locally obtained. The respondents however, stressed the point that certain parts of the plant equipments that breakdown and require replacement are sometimes fabricated by local founderies.

With regards to the source of raw materials for processing, the response from the respondents of the mining and processing companies confirms the claims by the Raw Materials Research and Development Council report on multidisciplinary Task Force of 1989 that all the Ceramic Raw Materials Development Companies in Nigeria utilises local raw materials as input. This approach therefore ensures continuity of production because these inputs are always available at their own area of operation or some where else in the country.

4.3.4 TABLE 4: DEMAND LEVEL OF LOCALLY PROCESSED CERAMIC RAW MATERIALS

S/NO	NAME OF INDUSTRY	HIGH DEMAND	LOW DEMAND	POOR DEMAND
1	Crystal Talc Nigeria Limited Kaduna	*		
2	Abdullahi Mohammed Industries Limited (Solid Minerals Division) Kaduna	*		
3	Nigerian Mining Corporation, Jos		*	

Except for the raw materials processed by the Nigerian Mining Corporation, the demand for processed raw materials from the other mining and processing companies are high as indicated in Table 4. The low demand for the processed raw materials as stated by a key respondent is due to their low processed quality.

The study also reveals that the locally processed ceramic raw materials are cheaper and readily available.

4.3.5 TABLE 5: SOURCES OF RAW MATERIALS FOR THE CERAMIC AND POTTERY INDUSTRIES

S/NO	NAME OF INDUSTRY	RAW MATERIALS	
		LOCALLY OBTAINED	IMPORTED
1.	MARABA POTTERY, KADUNA	*	*
2.	JACARANDA POTTERY, KADUNA	*	*
3.	DAWAKIN TOFA POTTERY, KANO	*	*
4.	ROYAL CERAMIC, SULEJA	*	*
5.	CAPITAL CERAMICS, SULEJA	*	

The statistics from Table 5, reveals that all but one of the pottery and ceramics Enterprises investigated utilize both local and imported raw materials for production. The percentage of imported raw materials is however small. The imported materials are mainly oxides, colourants and enamels.

4.3.6 TABLE 6: PREFERENCE FOR LOCALLY PROCESSED RAW MATERIALS

S/NO	NAME OF INDUSTRY	HIGH	LOW
1.	MARABA POTTERY, KADUNA	*	
2.	JACARANDA POTTERY, KADUNA	*	
3.	DAWAKIN TOFA POTTERY, KANO	*	
4.	ROYAL CERAMICS, SULEJA	*	
5.	CAPITAL CERAMICS, SULEJA	*	

Although the demand for the locally processed raw materials is high as shown in Table 6, there is the need to further develop these materials to meet the stringent requirement of modern day ceramic. Responses from a respondent at Royal Ceramics, Suleja reveals that the raw materials sourced locally for production have to undergo further treatment like electro-magnetic separation to remove metallic impurities.

4.3.7 GOVERNMENT SUPPORT AND PATRONAGE

This question was asked to find out the extent of support/financial or otherwise) that the raw material development companies have been receiving from the government. The responses from the mining and processing companies indicated that they do not get any government support whatsoever.

When asked to specifically indicate the kind of assistance they would want from the government apart from the loans, they said that the government could help by creating the enabling environment and infrastructure. They were of the opinion that the government could take on the legislative technical, scientific and other related domains to guide and encourage the development of the industry.

4.4 FINDINGS

The following findings are drawn from the investigations carried out in the course of this study.

1. There are prospects for setting up of companies to mine and process local raw materials for the pottery and ceramic industry as well as other industries that use some of these raw materials for their production. The raw materials for processing are locally available and the reserves of these raw materials e.g feldspar, quartz, talc, dolomite, zircon, etc, according to investigations carried out by the Raw Materials Research and Development Council reveals that these raw materials would last for several years (Appendices E, F, G, H).

2. The local demand for the locally processed raw materials is very high. According to a respondent from Crystal Talc Nigeria Limited, the local demand for talc and other ceramic raw materials is about 50000 tons per year and about seventeen of local processing industries are required to be established in the country in order to meet demand. Estimates by the Raw Material Research and Development Council also reveal that the demand for processed raw materials outstrip supply (appendix I)

3. There is the possibility of setting up more pottery and ceramic industries in the federation because of the availability of most of the basic raw materials needed for production. Clay, which is the basic raw material is a widespread mineral in the country. Other raw materials like feldspar quartz dolomite talc gypsum etc are also locally available.

4. The pottery and ceramic industries as well as other industries like the glass, paint and petroleum industries appreciate and use raw materials produced by the local mining and processing companies.

The current drive towards the local sourcing of raw materials for industries and the high cost of imported industrial raw materials due to their foreign exchange value has been pushed most of the local industries to source their raw materials at home thereby increasing the demand for the locally processed raw materials.

5. Although the demand for the locally processed raw materials is high, there is the need to further develope these raw material to meet the

stringent requirement of modern day ceramics like toiletries, china wares, plumbing fixtures, crucibles electronic and electrical equipments.

Responses from a respondent at Royal Ceramics which is on industrial ceramic company reveals that the processed raw materials sourced locally have to undergo further treatment like electro-magnetic separation to remove metalic impurities to enhance their chemical and physical purity before they are used for production.

Immense losses the researcher was told have been incurred from time to time at the industry due to such deviations from standard qualities of processed raw materials. Many of such losses like lack of strength. Lack of glass, crazing and peeling of glaze can be avoided by adequate process control of raw materials.

6. Responses from the mining and processing companys reveal that there have been lack of routine control and laboratory investigations which ought to be carried out at regular intervals.

These raw materials are heterogenous and variable. By the nature of their geological origin, no two raw materials are alike and even single deposits lack uniformity. The consumer however, requires reliable raw materials of fixed chemical and physical properties to enhance production.

7. The source of initial capital for the setting up of the mining and processing campanies in most cases have been through personal

savings of the owner and other investors. The activities of the various funding agencies have not been encouraging. The Nigerian Bank for Commerce and Industries (NBCI) which is suppose to take care of this sector is not easy to reach. It is equally noted that the National Reconstruction Fund (NERFUND) is too far removed from the small scale industries that if is ment to serve since participating banks regard ceramics and related industries as a risk sub-sector.

8. Lack of funds have not made it possible for the local mining and process companies to acquire the plant and laboratory equipments needed for elaborate processing and testing of the locally sourced raw materials. Most of the locally processed raw materials are not of the finest quality that could be used for industrial ceramic production.

A respondent of Abdullahi Mohammed Industries (Solid Minerals Division) reveals that the company has not been able to start the production of oxide and colorants from the local metallic and non-mentallic minerals because they lack the funds to acquire the required equipments.

9. Inspite of the vital role of the solid mineral sector in the economy, of the nation by providing raw materials for the manufacture of ceramics, cement, glass etc, the consumption of which is a yardstick for human development, the sector has not received the desired patronage from the government to guide and encourage the development of the industry.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 SUMMARY:

This study was inspired by the important role the development of local raw materials plays in the socio-economic life of the people of any nation. The development of this sub-sector helps to expedite industrial development and self reliance through the maximum utilization of local raw materials as inputs for industries.

The problem of the study was therefore to investigate, the extent of development of the local ceramic raw materials for traditional and contemporary productions. The technology for mining and processing is reviewed briefly and recommendations made on the need and thrust for future researchers.

In this direction, a wide range of literature was read and some statistical and governmental documents were also consulted. Several field trips were made to some mining and processing companies as well as pottery and ceramics enterprises in Kano, Jos Kaduna and Suleja. Interviews were conducted at these places using two types of questionnaires. One was directed to the mining and processing companies and the other directed to the uses of the processed ceramic raw materials.

The development of local raw materials has become a way of life in many nations today because recent technological development have enhance the speed of development of our socio-economic lives and placed the potentials of the mineral industry on a very important level. The use and

consumption of ceramics, glass, cement etc. produced from these minerals is used today as a yardstick per capital of human consumption. This is to say that the consumption of these items is used as an indicator for the stage of development a particular society has attained. The higher the consumption is, the greater the development.

The study is therefore aimed at drawing the attention to the fact that the actual mining and production these minerals for the use by industries is a vital industrial activity that should attract the attention of would-be entrepreneurs. Most of the industries which utilize these minerals cannot afford to source their raw materials directly. Thus local production and supply of commercial grade mineral raw materials is a gainful venture that ultimately holds the promise for ending import substitutions.

5.2 CONCLUSION

Based on the findings of this study, the following conclusions are drawn.

1. All the principal raw materials for the production of pottery ceramic glass etc are abundant in Nigeria and their reserves will last for several years.
2. With proper beneficiation, these raw materials can be utilized for the production of many functional products. Ceramic technology have undergone rapid expansion during the past years and with reserves of other strategic materials under pressure coupled with the rising prices of raw materials in response to heavier demands, the vast

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untapped resources of ceramics offers a cheaper alternative that will certainly not become exhausted during this century.

3. There are prospects for the setting up of mineral development companies in Nigeria due to the heavy demand of raw materials produced from the minerals as inputs for industries.

4. The source of initial capital for the setting up of the mineral development companies which is capital intensive has been through the personal savings of the owners and other private investors.

5. The industry have not achieved real development due to the lack of appreciation of the sectors potentials by policy makers. Government is willing to spend risk money in searching for oil, gold, diamond etc, but not for locating clay, gypsum, quartz feldspar and other non metallics.

5.3 GENERAL RECOMMENDATIONS

In view of the facts that the development of local raw materials has become a way of life throughout Nigeria and ceramics are vital for industrial development, the researcher wishes to recommend that:-

1. Priority must be given to ceramics manufacture and developments connected with the ceramic industry. The principal raw materials and fuels for ceramic manufacture are available in Nigeria but local production of elaborately processed raw materials is low. The situation therefore requires urgent and determined action by government, policy makers, and private entrepreneurs.

2. To make any meaningful progress as regards the development of raw materials and ceramic manufacture, the government, policy makers and private entrepreneurs need to informed of the broad scope of ceramics so as to clearly understand the importance ceramics and the investment opportunities in the industry.

3. Since the mining and processing industry has proven to be viable and dependable, there is the need for banks to rethink their support for the industry. Individuals willing to establish such industries should be given loans on liberal terms to enable them acquire all the equipment needed for the proper beneficiation of the raw materials.

4. As a further step towards the development and utilization of the local ceramic raw materials, a full fledge Ceramic Institute should be planned to take off in the very future to train the high level manpower needed for the industry. The chemical Engineering Department, Ahmadu Bello University, Zaria, should also be given all the support to develop the ceramic engineering section.

5. There is the need for joint effort between industries and government to collaborate more with the National Research Institutes and the Universities to finance research into the local ceramic raw materials for the related industries. To do this this successfully a coordinating body is required to monitor the finance between government and the recipients i.e. the research institutions and the industries.

6. A Nigerian Ceramic Society should be formed with membership open to all people engaged in the industry. This society is needed to

promote the growth of the industry, ceramic education and research and other developments related to the industry. The society will also help in the much needed dissemination of information.

5.4 RECOMMENDATION FOR FURTHER STUDIES

The following related areas of study are recommended for future researchers.

1. An indepth study of the technological and financial requirements of the ceramic raw material development industry through a properly executed technical-economic feasibility survey should be carried out to assist would be investors.
2. There is the need to replicate this study with emphasis on the development of oxides and colourants from the local metallic and non-metallic minerals.
3. It is also recommended that investigations aimed at the development and fabrication of equipments for the processing of the local ceramic raw materials should be carried out.

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APPENDICES

APPENDIX A

DEPARTMENT OF INDUSTRIAL DESIGN
Ahmadu Bello University, Zaria

QUESTIONNAIRE FOR THE COLLECTION OF DATA ON THE DEVELOPMENT OF LOCALLY PROCESSED CERAMIC RAW MATERIALS

1. Demographic Data.
   (a) Name of Company
   (b) Date it started its operations
   (c) General Managers or Managing Directors since inception
   (d) Number of workers at the beginning of operations
   (e) Present number of workers.

2. Which type of ceramic raw materials does your company process?

3. From where does your company get these raw materials for processing?

4. Which type of equipments does your company use for the processing of the raw materials?
   (a) Are they locally made?
   (b) Imported?
   (c) Both?

5. Where does the company process the raw materials ? Is the processing done at the site of mining or at different locations?

6. (a) How may skilled workers are employed?
   (b) How many unskilled workers are employed?

7. What are the various processes employed by your company for the processing of the raw materials? Let us discuss individually the various processes your employ.

8. What method does your company use for the distribution of the processed raw materials?

9. What problems are encountered by your company with regards to the processing of the raw materials i.e
   (a) Raw materials
   (b) Labour/personnel
   (c) Sales

10. What is the source of capital for the setting up of your company?
(a) Bank loan? (b) Government loans? (c) Relations/friends?
(d) Personal savings?

11. How much by your estimate did it cost to set up such a raw material company and its operations?

12. Are there any prospects for setting up such a mining and processing company for ceramic raw materials by individuals or government?

13. Does your company export any of the ceramic raw materials it processes?

14. Is the demand for the processed ceramic raw materials from your company.
(a) High? (b) Low? (c) Moderate

15. If low, why do you still operate?

DEPARTMENT OF INDUSTRIAL DESIGN
Ahmadu Bello University, Zaria

QUESTIONNAIRE FOR THE PATRONAGE OF LOCALLY PROCESSED CERAMIC RAW MATERIALS

1. Demographic Data.
   (a) Name of Company
   (b) Date it started its operations
   (c) General Managers or Managing Directors since inception
   (d) Number of workers at the beginning of operations
   (e) Present number of workers.

2. What is the source of raw materials used by your company for its products?
   (a) Locally processed (b) Imported (c) Both

3. Name the locally processed raw materials used by your company.

4. Names imported raw materials used by your company.

5. Which of the processed raw materials does your company use most?

6. How often does your company use the locally processed raw materials for its production?
   (a) Very frequent (b) Frequent (c) Less frequent
   (d) if less frequent, what are the alternative source of raw materials?

7. How often does your company use imported processed raw materials for its production?
   (a) Very frequent (b) Frequent (c) Less frequent
   (d) if less frequent, do we assume that you use the locally professed raw materials?

   Yes or No. If No explain.

8. How do you compare the quality of the imported raw materials to the imported raw materials to the locally processed raw materials assuming that you have used both?

9. What are the problems encountered in the cause of production while using the locally or imported raw materials?

10. How much does it cost your company to use either the locally or imported processed raw materials?

11. Have you considered processing the raw materials you need yourself?

APPENDIX B1

DEPARTMENT OF INDUSTRIAL DESIGN
Ahmadu Bello University, Zaria

ID/110/97 Date: 26th Oct. 1997

THE MANAGER
Dawakin Tofa Pottery
Kano,
KANO STATE

Dear Sir/Madam,

Re: Mr/~~Miss~~/Mrs. ERIC VERNON OPOKU is a bonifide Post Graduate Student in this Department. He/She is pursuing his/~~her~~ Masters Degree in Industrial Design CERAMICS He/~~She~~ is now embarking on his/~~her~~ field work in the collection of data for his/~~her~~ Thesis. I would be grateful for any assistance you can give to him/~~her~~ along this line.

Yours faithfully,

B.A. Sanusi
Head of Department.

DEPARTMENT OF INDUSTRIAL DESIGN
Ahmadu Bello University, Zaria

ID/110/97 Date: 28th Oct. 1997

THE MANAGER

Capital Ceramics

Suleja

NIGER STATE.

Dear Sir/~~Madam~~,

Re: Mr/~~Miss~~/~~Mrs.~~ ERIC VERNON OPOKU is a bonifide Post Graduate Student in this Department. He/~~She~~ is pursuing his/~~her~~ Masters Degree in Industrial Design CERAMICS He/~~She~~ is now embarking on his/~~her~~ field work in the collection of data for his/~~her~~ Thesis. I would be grateful for any assistance you can give to him/~~her~~ along this line.

Yours faithfully,

B.A. Sanusi
Head of Department.

APPENDIX B3

DEPARTMENT OF INDUSTRIAL DESIGN
Ahmadu Bello University, Zaria

ID/110/97 Date: 26th Oct. 1997

THE MANAGER
Royal Ceramics
Sule..., NEW STATE.

Dear Sir/Madam,

Re: Mr/Miss/Mrs. ERIC VERNON OPOKU is a bonifide Post Graduate Student in this Department. He/She is pursuing his/her Masters Degree in Industrial Design CERAMICS He/She is now embarking on his/her field work in the collection of data for his/her Thesis. I would be grateful for any assistance you can give to him/her along this line.

Yours faithfully,

B.A. Sanusi
Head of Department.

KASHIM IBRAHIM LIBRARY

APPENDIX B4

DEPARTMENT OF INDUSTRIAL DESIGN
Ahmadu Bello University, Zaria

ID/110/97 Date: 14th Oct. 1997

THE MANAGER
Nigerian Mining Corporation,
Jos, PLATEAU STATE.

Dear Sir/~~Madam~~,

Re: Mr/Miss/~~Mrs~~. IDIC UTIPNON OPOKU is a bonifide Post Graduate Student in this Department. He/~~She~~ is pursuing his/her Masters Degree in Industrial Design CERAMICS He/~~She~~ is now embarking on his/~~her~~ field work in the collection of data for his/~~her~~ Thesis. I would be grateful for any assistance you can give to him/~~her~~ along this line.

Yours faithfully,

B.A. Sanusi
Head of Department.

APPENDIX B5

DEPARTMENT OF INDUSTRIAL DESIGN
Ahmadu Bello University, Zaria

ID/110/97 Date: 26th Oct. 1997

THE MANAGER
Crystal Talc Nigeria Limited
KADUNA.

Dear Sir/~~Madam~~,

Re: Mr/Miss/~~Mrs.~~ ERIC VERNON CPOKO is a bonifide Post Graduate Student in this Department. He/~~She~~ is pursuing his/~~her~~ Masters Degree in Industrial Design CERAMICS He/~~She~~ is now embarking on his/~~her~~ field work in the collection of data for his/~~her~~ Thesis. I would be grateful for any assistance you can give to him/~~her~~ along this line.

Yours faithfully,

B.A. Samusi
Head of Department.

APPENDIX B6

DEPARTMENT OF INDUSTRIAL DESIGN
Ahmadu Bello University, Zaria

ID/110/97 Date: 26th Oct. 1997

The Manager
Abdullahi Mohammed Industry Limited
P.O.Box 5022
KADUNA.

Dear Sir/~~Madam~~,

Re: Mr/~~Miss~~/~~Mrs.~~ ERIC VERNON OPOKU is a bonifide Post Graduate Student in this Department. He/~~She~~ is pursuing his/~~her~~ Masters Degree in Industrial Design CERAMICS He/~~She~~ is now embarking on his/~~her~~ field work in the collection of data for his/~~her~~ Thesis. I would be grateful for any assistance you can give to him/~~her~~ along this line.

Yours faithfully,

B.A. Sanusi
Head of Department.

APPENDIX C

RAW MATERIALS USED IN THE PRINCIPAL CERAMIC INDUSTRIES

Industry	Type of product	Raw materials used
Structural	Building bricks of all types	Clay (sand,chalk)
	Hollow blocks: Terra cotta	
	Roofing tiles and floor tiles	
	Flower pots. Chimney pots anf flutes	Clay
	unglazed (land) drain-pipes	Clay and glaze (often salt)
	glazed pipes and accessories	Limestone, clay.
	concrete.	
Refrectories	Fireclay bricks and raw fireclay	Fireclay (gong or pre-calcined clay)
	Silica-and siliceous-bricks and raw stone	Quartzite rocks, ganisters, etc.
	Magnesite bricks	Magnesium containing ores, principally carbonates, hydroxide or from sea water.
	Chrome bricks	Chrome ores
	chrome magnesites	Chrome and magnesium-ores
	Dolomite bricks	Dolomite serpentine, talc
	Carbon bricks	Graphite (clay)
	silicon carbide bricks and shapes	Coke, sand (salt, sawdust)
	Insulating refractories	comustible, e.g saw-dust.
		Diatomaceous earth, vermiculite, asbestos.
	Sillimanite bricks	Sillimanite, Kynite or Andalusite
	High (over 50 percent)	Fireclay and Bauxite
	Retorts, Crucibles, etc.	Bauxitic clays
	for metallugical. gas plant	Clays, silica rock, graphite (other
	scienctific and other	refractory material).
	applications.	
Pottery	Glazed wall and the earth tiles	Clays and Glazed. Pyrophylite.
	Domestic and Sanitary Earthen Ware	Talc clays, Feldspar. Flint, glaze
	Bone china (chinaware)	Cornish stone Clays, Bone ash Cornish stone.
	Porcelein (domestic, laboratory. industrial).	Clay, Feldspar, Flint
	Stone ware	Clays, Fint, feldspar, other
	Glazes and Engobes.	fluxing reagent (colouring compounds)

Miscellaneous Ceramic Materials	Fused silica Special refractories	High purity quarzt crystal or and pure oxides e.g BeO, $A1_2O_3$ MgO ZrO_2 ThO_2 zircon, spinels, carbides. nitrides, phosphides, etc.
	Electrical ware	Clays, flint Feldspar Rutile TiO_2 *Steatite, Talc Magnesium and* Barium, Zircon
	Magnetic materials Garnets Glasses	Ferrites Metals and Ceramic Oxides Sand, Soda ash, Limestone (feldsapr.
	Glazes Enamels	Sodium sulphate and nitrate, borax and boric acid, lead oxide, potassium compopnds, miscellaneous colouring and opacifying agents).
	Abrasives	Silicon carbide, alumina

Source: Raw Materials Research and Development council (1989).

APPENDIX D

RANGE OF NON-METALLIC MINERALS RAW MATERIALS FOUND IN NIGERIA

MINERAL	LOCATION	INDUSTRIES MINERAL CAN SUPPORT
Clay (Kaolin China Clay)	Katsina, Kaduna Ogun, Anambra, Bauchi, Kano and Kwara, Plateau Enugu and Abia States.	Ceramic wares; Production of Sanitary wares, tiles, pottery and bricks
Diatomite	Borno and Yobe States.	For preparing Insect Control powders and Filters in food Industry.
Glass Sand	Anambra, Edo, Delta, Kano, Lagos, Niger Imo and Ondo States	Manufacturing of glass wares, and glass fibres and sand paper.
Gypsum	Sokoto and Borno States mainly.	For manufacturing of Cement, refactories and Plaster of Paris.
Limestone	Enugu,Oyo,Ogun Niger, Edo Delta, Sokoto, Rivers, Benue, Kwara and Taraba States.	Cement manufacturing and fluxing agent for Iron and non ferrous Metals smelting.
Marble	Edo, Delta, Kwara, Oyo Niger, and Plateau States.	Metallurgical processes Chemical industreis, quicklime Hydrated and quicklime Cement production, road and building construction.
Phosphate	Ogun and Sokoto States.	For phosphate fertilizers. and phosphoric acid production.
Salt	Anambra, Cross-Rivers, Bauchi, Kwara and Lagos States.	Used in food and chemical industries, Salt. Products are also used in Textile and explosives Industries.
Shale	Anambra, Imo Ogun Borno and Benue States	Used to make bricks and heavy clay products.
Talc	Kwara, Oyo, Osun and Niger States.	Used in paints, cement Toiletries and furnaces.

Zircon (Zircon Sands)	Plateau State Plateau State	Used in nuclear reactors. Ceramics and chemical Industries.

Source: Raw Materials Research and Development Council. (1993)

APPENDIX E

CLAY DEPOSIT IN NIGERIA (FROM NEHIKHAE 1986)

No	deposit/Location	state	Type	Reserves Million tonnes
1	ozubulu	Anambra	Kaolonitic	4.2
2	Enugu	Anambra	Brickclay	19.0
3	Enugu	Anambra	fireclay	50.0
4	Ukpor	Anambra	Kaolin	6.0
5	Tede	Oyo	Brickclay	1.524
6	Mararaba-Rido	Kaduna	Brickclay	5.524
7	Kankara	Kastina	Kaolinitic	3.40
8	Illo	Sokoto	Kaolinitic	Very large
9	Kaoje	sokoto	Kaolinitic	Very lare
10	Bamajo	Ogun	Kaolinitic	Large
11	Onibode	Ogun	Kaolinitic	Large
12	Lisabi	Ogun	Kaolinitic	Large
13	Rop	Plateau	Kaolinitic	N/A
14	Jos	Plateau	Brickclay	Large
15	Maiduguri	Borno	Brickclay	Large
16	Dawakin Tofa	Kano	Kaolinitic	N/a
17	Garkida	Gongola	Kaolinitic	N/A
18	Biu	Borno	Kaolinitic	N/A
19	Giru	sokoto	Location	Large
20	Okpekpe	Bendel	kaolin	6.0

APPENDIX F

SOME REFRACTORY CERAMIC MATERIALS FOUND IN NIGERIA

LOCATION	STATE	MATERIAL	QUANTITY (Million tonnes)
OSARA	Kwara	Dolomite	Large
ELEBU	Kwara	Dolomite	5
BURUM	Kwara	Dolomite	2.6
JAKURA	Kwara	Marble	46
JOS	Plateau	Zircon	-
UDEGI	Plateau	Zircon	-
BIRNI GWARI	Kaduna	Kyanite	Large
DUTSEN FARI	Kaduna	Kyanite	-
UKPILLA	Bendel	Marble	10
DUTSEN MA	Katsina	Graphite	-
IBADAN	Oyo	sillimante	-
MASKA	Katsina	Magnesite	Reported
OBAN HILLS	Cross River	Magnesite	Reported

OTHER MATERIALS FOR THE GLASS AND CERAMIC INDUSTRY

Ago Oleno Abeokuta	Ogun	Feldspar	Small Development
Oshogbo	Oyo	Feldspar	Small Development
Okene	Kogi	Feldspar	Small Development
Jos	Plateau	Feldspar	Small Development
Damboa	Borno	Gypsum	Not development
sokoto	Sokoto	Gypsum	Developed.

APPENDIX G

RESERVE OF KNOWN EDEPOSITS OF LIMESTONE (FROM NEIKHARE 1986)

No.	Location	state	Industry using deposit	Total CaCO3	Si02 Content	Reserves in Million tonnes
1	Nkalagu	Anambra	Nkalagu	84.2	9.4	110
2	Odomoke	Anambra	Nkalagu	-	-	64
3	ugep	C/River	-	-	-	Not estimated
4	Mfamosing	C/River	Calabar	96.6	Negligible	Large
5	Igumale	Benue	-	77.0	13.75	110
6	Ogbolokuta	Benue	-	-	-	0.5
7	Yandev	Benue	B/Cement	94.8	2.25	67
8	Ewekoro	Ogun	Ewekoro & Sagamu	82.7	19.90	135
9	Kalabaina	Sokoto	Sokoto	81.2	11.33	101
10	Ashaka	Bauchi	Ashaka	-	-	Large
11	Kanawa	Bauchi	-	89	-	Fairly large
12	Ukpilla	Bendel	Ukpilla	91.6	3.47	10

Source: Raw Materials Development Council (1989)

APPENDIX H

GLASS SAND OCCURRENCE IN NIGERIA

S/N	LOCATION	STATE	QUALITY	QUANTITY
1	Nsude/Enugu	Anambra	50% Ideal fraction	Large
2	Afowa-Auchi	Bendel	56% Ideal fraction	Fair
3	Ukpowwi	Bendel	60% Ideal fraction	Fair
4	Ughelli	Bendel	50% Ideal fraction	Very Large
5	Badagry Area, Lagos	Lagos	Visibly Okay for coloured glass	Large
6	Ajiran Village, Lagos	Lagos	Suitable for Large Flint Glass	Large
7	Bida Mokwa Lafiaji	Niger	42-58% Ideal fraction	Large
8	Ifo Area	Ogun	Iron Oxide 0.02%	Large
9	Ijebu Ode	Ogun	99.95% Silica 75%	Large
10	Igbakoda	Ondo	Ideal fraction	Very Large
11	Ilaro Area	Ogun	Iron Oxide Ideal Size	Very Large
12	Okitipupa Area	Ondo	Iron Oxide	Very Large
13	Afam	River	Suitable for Flint Glass	Very Large
14	Some 4-9Km Enroute Zaria Sokoto Road	Sokoto	High iron oxide	Large

Source: Raw Materials Development Council (1989)

APPENDIX I

RAW MATERIAL REQUIREMENT OF NON-METALLIC MINERAL SECTOR

Raw Material	Demand (Tonnes)	Supply (Local) (Tonnes)	Supply Demand Gap	Reasons for the gap/Comment
Asbestos				
Asbestos fibre	134.400	-	(134.440	No local production
Cement	13.6 million	4.08million	(9.52)	Low local production
Limestone	1million	300,000	(700,000)	Low local level of exploration
Cellulose	666.670	200,000	(466,670)	Low local production
Pulp	10,000	3,000	(7,000)	Low local production
Cement				
Gypsum	620,000	279,000	(341,000)	Low level of exploration
Limestone	12.8million	5.8million	(7 million)	"
Shales	393,300	177,000	(216,300)	"
Iron Ore	4.440	2,000	(2,440)	"
Laterite	222,300	100,000	(122,300)	"
Clay	411,200	185,000	(226,200)	"
Bed Aluminuim	28,800	-	(28,800)	Low local production
Ceramics				
Kaolin	356,000	89,000	(267,000)	Low level of exploration
Quartz	220,000	55,000	(165,000)	"
Feldspar	192,000	48,000	(144,000)	"
Ball Clay	140,000	35,000	(105,000)	"
Calcium Carbonate	12,800	3,200	(9,600)	"
Glaze	600	-	(600)	No local production

Glass				
Silica	183,000	61,000	(122,000)	Low level of exploration
Soda Ash	67,800	-	(67,800)	"
Marble	12,000	4,000	(8,000)	"
Feldspar	7,400	2,800	(4,600)	"
Dolomite	15,000	5,000	(10,000)	"
Carbon	N/A	N/A	-	-
Alumina	N/A	N/A	-	-
Limestone	34,000	8,450	-	Low level of exploration
Paints				
Kaolin	5,240	1,310	(3,930)	Low level of exploration
Limestone	25,800	6,450	(19,350)	"
Tin Oxide	256,580	-	(256,580)	"

Source: Raw Material Research and Development Council (1993)

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FIGURES

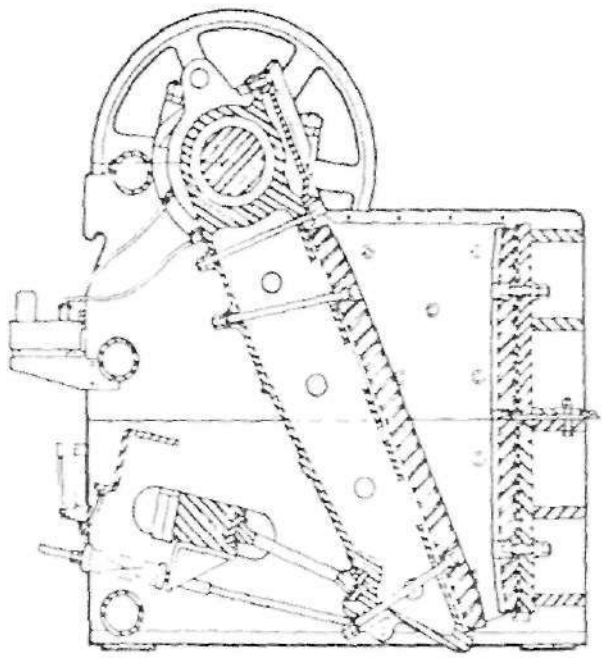


Figure 1: Cross-section of single-toggle jaw crusher
Source: Wills (1992)

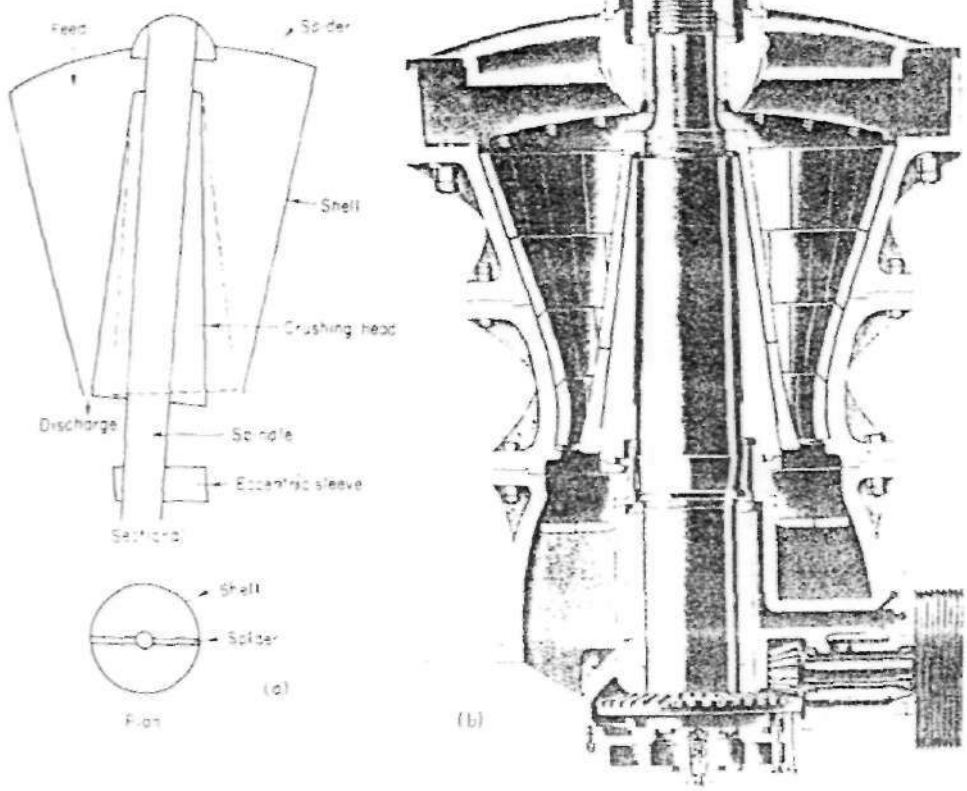


Figure 2: Gyratory Crusher: (a) functional diagram (b) Cross-section
Source: Wills (1992)

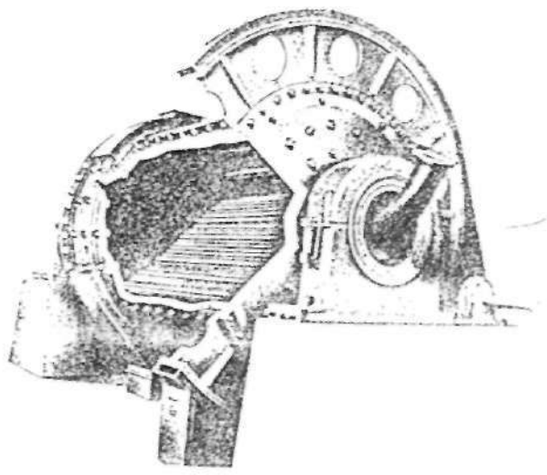


Figure 3: Section of Rod Mill.
Source: Wills (1992)

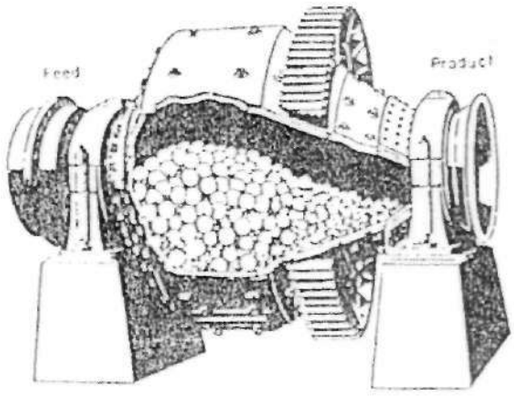


Figure 4: Section of Hardinge ball mill
Source: Wills (1992)

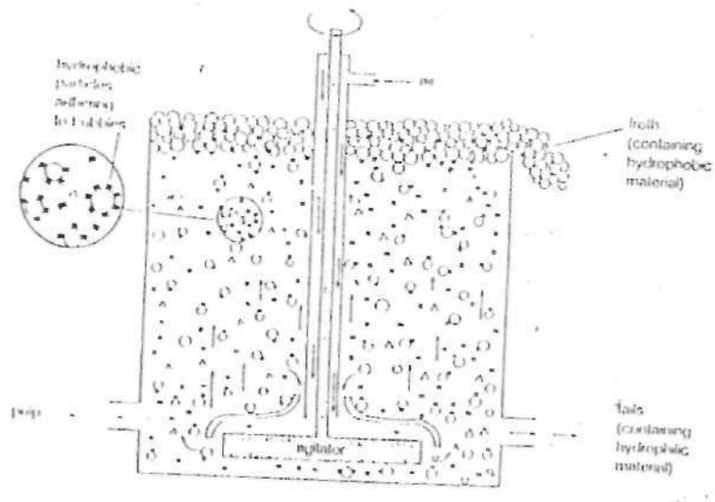


Figure 5: Principle of froth flotation
Source: Wills (1992)

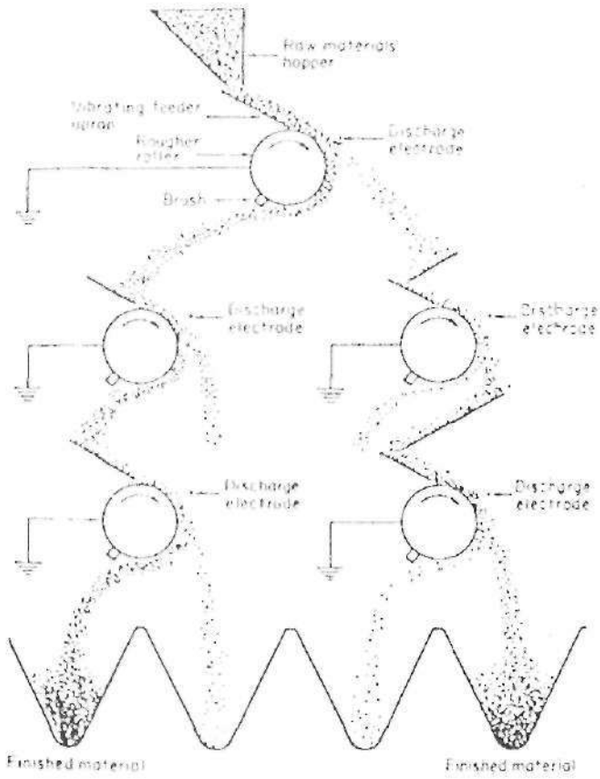


Figure 6: Arrangement of electromagnetic separation in practice
Source: Wills (1992)