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ABUJA

NON – METALLIC MINERAL ENDOWMENTS IN NIGERIA

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PREFACE

Non-metallic mineral raw materials are essential for economic growth and development of any nation. Infrastructural improvement and growth of the manufacturing sector requires sustainable supply of non-metallic minerals in the right quantity and quality.

Although, Nigeria has a significant amount of non-metallic mineral raw materials, low sourcing and utilization have been the main impediment, hence the country continue to import these resources, mostly without value addition, to the detriment of the local industries.

In order to improve on the identified problems, this book attempts to provide the much needed information on sourcing, utilization and development in the sector, thus the book shall serve as an invaluable companion to all the stakeholders in the non-minerals sector. It is hoped that the information provided will assist potential investors and increase the awareness of entrepreneurs in establishing small- scale industries.

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CHAPTER ONE

INTRODUCTION

The Non-metallic Minerals account for the major part of the value of global non-fuel mineral production. They are produced and consumed in virtually all countries and are utilized in the production of all manufactured goods, as well as in construction, agriculture and environmental protection. Mining of Non-metallic minerals is one of the oldest professions of the world and grew with the evolution of man and the civilization. Against this background, it may seem paradoxical that the production and utilization of Non-metallic Minerals are rarely accorded a commensurate level of priority in national development plans. One reason is that the production of Non-metallic Minerals, given their generally low prices and relatively high transport costs, usually does not provide profit margins of the same magnitude as the production of Metallic Mineral or, even more significantly, mineral fuels. Thus, colonial powers and transnational corporations historically took less interest in developing production of Non-metallic Minerals. Even later they were not regarded as a major, potential source of export income for developing countries.

A strong case can nevertheless be made for promoting the production of Non-metallic Minerals in developing Countries. The range of uses of individual non-

metallic mineral commodity is very large and is growing rapidly. For example, clays are used in papers, plastics, rubber, paints, fertilizers, insecticides, foodstuffs, structural products, pharmaceuticals, cosmetics, bone implants, drilling fluids and many other commodities. These minerals offer significant opportunities for import substitution based on comparative advantages. Since transport cost are high relative to the value of the products, domestic production has an initial competitive advantage vis-à-vis imports, which may often outweigh other disadvantages such as limited access to technology.

Furthermore, Non-metallic Minerals production can often be initiated on a small scale, using relatively simple technology, thus limiting the need for large initial investments in fixed capital and import of equipment. Since production rates are usually flexible, they can be increased gradually, and the output can be adjusted according to demand. This also means that the operation can function as a training ground for technical and managerial staff, allowing them to upgrade their skills as output expand and as the product range comes to include more specialized, higher value-added products. Another advantage is that production of Non-metallic Minerals can usually be initiated quickly. There is thus no need for the long lead times between discovery of a deposit and entry into production associated with metallic ore mines. The production of Non-metallic Minerals often offers the possibility of establishing linkages, both backward and forward, to the rest of the economy, given the relatively less advance.

Nigeria is blessed with abundant mineral resources, which are from time immemorial formed the backbone of the nation's economic and industrial development aspirations. Prior to independence, the nation's mineral raw material resources contributed immensely to the export earnings of the nation.

For over three decades, the Country has continued to depend entirely on oil for her revenue and the volatile nature of the oil market has made it imperative for us to diversify the mono-product economy through exploitation and processing of our abundant solid mineral resources. The clamour for resource control being advocated by states with petroleum resources in their domain makes it imperative for us to develop, exploit, process and utilize our solid minerals – particularly Non-metallic Minerals as every part of this country is blessed with one or more solid mineral that could yield substantial revenue for sustainable development.

Exploitation of the Non-metallic Minerals has not attained the desired level, mainly because of the various constraints associated with their exploitation, development and processing for utilization. Many of the non-metallic minerals, which are vital to the industrial take off of the country have been found in commercial quantities within the country. They include limestone, dolomite, marble, kaolin, barite, diatomite, feldspar, quartz and silica sands, gypsum, talc, silimanite, kyanite, phosphate, salt and bentonite. The locations of each of these non-metallic minerals are presented in this handbook.

CHAPTER TWO

BRIEFS ON THE NON-METALLIC MINERALS

It must be stressed that all the non-metallic minerals deserve priority attention. However, highlights on some of the non-metallic minerals e.g. salt, feldspar, phosphate, quartz, gypsum, mica, trona, barytes, bentonites, etc. will be given. For each mineral, background information will be provided on its importance, geological formation, occurrences and extent of known deposits where available.

2.1. PHOSPHATE

Phosphate rock refers to a mineral assemblage that occurs naturally with an exceptionally high concentration of phosphate minerals. Phosphate usually occurs as the mineral apatite, $Ca_5F(PO_4)_3$ in igneous and metamorphic rocks. It may be derived from a number of sources but the most common is the one that contains high concentration of phosphates in nodular or compact masses.

Uses

Phosphate fertilizer and detergents are the major user industries of phosphate

rock. Metal treatment, water treatment, pulp and paper, glass and ceramics, textiles, plastics, rubber, pharmaceuticals and cosmetics, petroleum production, toothpaste, paints, fuels, cells are other end-user industries of phosphate rock.

Demand

Since phosphates are produced in a few countries and are consumed in most, there is a large international trade in phosphate rock, phosphoric acid and phosphate fertilizer. Growth in fertilizer demand worldwide is expected to average annual 2.7% over the next few years, which will directly increase demand for phosphate rock. The Federal super-phosphate Company, Kaduna and the National Fertlizer Company, Port-Harcourt requires about 300,000 tonnes of phosphate rock per annum. Other areas of phosphate use are in Flame retarder/fire extinguisher production, food and beverage industries, dentistry etc. All these would also increase future demand.

Locations of Phosphate Deposits in Nigeria

The Nigerian phosphate rock deposits are sedimentary in origin. They occur mostly in granular, nodular and vesicular forms with an average weight percent of P_20_5 varying from 34.5 to 36.25%, which compares favourably with the phosphate at Hahotos, Togo (36.6%).

Occurrences of phosphate rock are known in Sokoto, Abia, Cross Rivers, Kogi, Ondo and Ogun States. The deposits of phosphate beds in the Sokoto embayment represent southward extension of the deposits in Niger Republic. The deposits are found in areas within the geological feature termed the Illummeden Basin.

SOKOTO STATE:

The occurrence of phosphate in Sokoto State was first reported in 1948 by B. Jones of the Geological Surveys. It occurs in the Sokoto group of sediments which consist of the Dange, Kalambaina Formations. The Dange formation consists of slightly indurated bluish grey shale with a thickness of about 22m. The shales include bands of fibrous gypsum with a large number of irregular shaped phosphatic nodules. The nodules are characteristically marked with irregular striations. The nodules have a dirty white colour externally but are bluish grey internally. The Kalambaina formation consists of clayey limestone and shale, invariably with no phosphate. The specific areas of concentration of phosphate nodules in Sokoto basin include: Dange, Gidan Bauchi, Illela, Gada, Wurno, Gwadabawa etc. Pitting and experimental mining in Sokoto basin carried out by Nigerian Minning corporation (NMC) in Zorow, Shagari and Gwadabawa over an area of $4km^2$ yields average weight % P_2O_5 of 34.50 – 36.25%.

OGUN STATE:

The occurrence of phosphate beds around Ilaro in South-West Nigeria was first reported in 1921 and since then further exploratory activities are been conducted by the Geological Survey of Nigeria Agency (GSNA). Three types of phosphate - granular, nodular and vesicular are reported to occur with an average weight % P_20_5 of up to 34.00%. The bulk of the phosphate beds occur as nodules, which are inter-bedded within shales.

Very little work has been done on the deposits reported to occur in nodules/pellets form in Ifon, Ondo State. Other deposits that need further investigations are reported around Akpet central and Ugep (North-West of Calabar) and in Lokoja. There is need for further investigation to get the actual total reserve of phosphate rocks in the country. A table of phosphate occurrence in Nigeria is given below:

Table 2.1. Locations of Phosphate Deposits in Nigeria

S/N	STATE	LOCATIONS	ESTIMATED RESERVE	REMARKS
1.	Abia	Bende, Umuahia, Ikwuamo	Not yet ascertain	Need further investigation.
2.	Cross River	Akpet, Ugep	Not available	Further investigation
3.	Ogun	Ifo, Ilaro	Not yet estimated	Further investigations required. The RMRDC and Ogun State Government are jointly establishing a processing Plant at Ilaro,
4.	Sokoto	Bodinga, Illo, Dange, Shuni, Gada, Kaura, Yabo, Gwadabawa, Goronyo, Shagari, Raba, Wurno, etc.		The RMRDC in collaboration with the Sokoto State Government and other private investors have Phosphate beneficiation plants.
5.	Ondo	Ifon		Further Investigation required.
6.	Kogi	Lokoja		Further investigation required.

Table 2.2. Chemical Analysis of Phosphate Rocks in Nigeria and some West African Countries.

Wt %	SOKOTO-1	SOKOTO-2	OGUN-2	OGUN-2	TOGO	SENEGAL	NIGER
P_2O_5	36.25	34.20	31.38	31.99	36.60	34.00	27.40
CaO	52.30	47.90	31.68	38.43	52.30	46.10	47.70
FI	3.84	3.40	NA	NA	3.61	6.44	6.23
SiO_2	3.44	4.20	6.68	4.40	3.25	6.19	4.02
Al_2O_3	1.50	1.50	1.70	11.50	2.10	2.39	1.50
Fe_2O_3	1.50	1.50	3.00	4.58	1.20	2.70	1.50
B_2O	NA	NA	0.24	NA	NA	NA	NA
N_gO	NA	NA	0.10	NA	NA	NA	NA
K_2O	NA	NA	0.08	NA	NA	NA	NA
H_2O	0.75	0.76	0.77	NA	0.84	0.68	0.75

Table 2.3. Average P_2O_5 Content of Some Nigerian Phosphate Deposits

LOCATION OF DEPOSIT	P_2O_5 CONTENT (WT.%) GRANULAR PHOSPHATE	NODULAR PHOSPHATE	SOURCE OF DATA
Ogun State	31.99	31.38	Imperial institute, London
Imo/Abia States	31.40	31.50	Geological Surveys of Nigeria
Sokoto	31.50	32.00	Geological Surveys of Nigeria
	-	35.00	Geological Surveys of Nigeria
	-	35.42	Integrated Fertilizer Development Centre
	-	36.25	Chemical Society of Nigeria Bulletin Vol. 7
	-35.10		Geology Department University of Manchester, England.

2.2. BARYTE

Barite is the principal ore of barium, which is essential in the formulation of drilling mud. Drilling mud is a mixture of different types of chemicals in water or oil, which is used in water, solid minerals or petroleum drilling. Baryte is an important weighing ingredient and its usefulness as an addition in drilling mud is that when ground or crushed and added to the fluid, it increases the density of the fluid to counteract formation pressure as well as provide density to the drilling bit for drilling mud in the petroleum industry, The higher the specific gravity of barite, the more useful it is in drilling mud formulation.

Uses

The principal application of Barites is as a weighting agent in drilling fluids for the petroleum and natural gas industries. Use of Barites as filler materials in paper, paints, rubber, plastics etc. industries is another potential area. Barites is also used in the production of barium compounds e.g. Barium carbonate which is an important ingredient in the glass industry.

Demand

Technological developments in petroleum exploration, introduction of 3D seismic surveying techniques and new drilling techniques had resulted in reduction in barites demand in well drilling. However with increase in number of active rigs and drill rig count in Africa, Europe, Asia, Canada, Russia, India etc. the demand for barites would increase. With growth in other industries in future, the overall demand for barites would increase.

Barytes Deposits in Nigeria

The quality of the Nigerian Barytes is moderate to high. It is often associated

with fluorite, calcite, dolomite, quartz, etc. The major impurities are quartz, iron oxide (goethite), and carbonates of iron, calcium and magnesium. These impurities tend to reduce the specific gravity of the unprocessed barytes which range from 3.0 – 4.0. and increase the cost of the processing and wears out mills rapidly. The goethite and silica impurities can be removed by magnetic and gravity separation. Once processed the specific gravity of the Nigerian baryte increases and meets the 4.20 specified value. Barytes bearing veins are found mostly in the area geologically referred to as Middle Benue Trough. The locations are shown below:

Table 2.4. Locations of Barite Deposits in Nigeria

S/N	STATES	LOCATIONS	PURITY	ESTIMATED RESERVE
1.	Benue	Gboko, Guma, Gwer, Ushongo, Makurdi, Konshisha, etc	4.0 – 4.35 f specific gravity	
2.	Plateau	Shendam, Langtang/South		
3.	Nasarawa	Azara, Akiri	4.10 SG	750,000M/T
4.	Gombe	Shongom	4.20 SG	
5.	Bauchi	Bauchi, T/Balewa		
6.	Taraba	Karim-Lamido, Ibi, Dungel, Aloshi		
7.	Cross River	Ugep, Agoibani Yala (Alifokpa), Gbanda		

Table 2.5. Physical Properties of Some Baryte Deposits

S/N.	STATE	LOCATION	PROPERTIES
1.	Benue	New Site Makurdi	Specific gravity 4.12 Colour White Streak White Cleavage Clear
2.	Plateau	Azara	Specific gravity 4.00
3.	Benue	Tongu	Specific gravity 4.48
4.	Benue	Kaseyo	Specific gravity 4.00
5.	Benue	University site, Makurdi	Specific Gravity 4.19 Colour White Streak White
6.	Benue	Ghamijiba	Specific gravity 4.19 Colour White Streak White Cleavage Clear
7.	Benue	Pila-Yandev	Specific gravity 4.40
8.	Benue	Lessel	Specific gravity 3.98 Colour White

2.3 BENTONITE

Bentonite belongs to the group of clays whose technical properties are controlled by the proportion of montmorillonite, a sub-group within the smectitic clays. It is clay derived from deposits of weathered volcanic ash.

Bentonites are hydrated aluminosilicates, which composed predominantly of the clay mineral montmorillonite. They are composed of a 3-tier structure with alumina sheets' sandwiched between tetrahedral silica units. A simplified

formula for montmorillonite is $A1_2O_3.4SiO_2.H_2O$. The other minerals that could be found in bentonite in small content are chrystobalite, biotite, chalcedony, calcite, pyrite, dolomite and plagioclase.

There are three principal types of bentonite namely:

(i) Natural sodium bentonite or sodium montmorillonite;

(ii) Natural calcium bentonite or calcium montmorillonite; and

(iii) Sodium activated bentonites or sodium activated montmorillonites

Natural sodium bentonite as the name suggests, occurs with sodium as the predominant exchange cation. They are characterized by high swelling, high liquid limit and high thermal durability. It is usually used for oil and gas drilling mud.

The vast majority of the montmorillonites occurring in abundance worldwide is of the calcium type and is referred to as calcium bentonite. Much lower swelling and liquid limit values compared to natural sodium bentonite, characterize them. Calcium bentonite is used as a bleaching agent in cooking oil industries, bleaching agent in lubricant oil recycling, as a catalyst, absorber, filler, etc.

Uses

Benitonite has a wide range of industrial uses. The physical and chemical properties of bentonite make it an important industrial mineral, which has widespread application in various industrial sectors, listed as follows:

- It is used as foundry sand bond in iron and steel foundries and in iron ore pelletizing in metallurgy; this is probably the largest use for bentonite;
- As insulators in civil engineering;
- As an efficient materials for drilling mud (because the gel-like

suspension it forms in water)
- As bleaching clay in oil refining; clarifying and decolourising;
- Filtering agent for clarifying wine, beer and treating waste water;
- Ingredient in cosmetics, animal feeds and pharmaceutical;
- Colloidal fillers for paints, and decolourising agent in food industries;
- As soil conditioner, carrier for insecticides/pesticides, coating for seeds and mineral additive in agriculture.
- Additive to ceramic raw materials to increase plasticity and enhance the strength;
- Fire retarding materials;
- As coating on some types of Computer papers, and non-carbon required multiple copy papers;
- As cracking catalysts, bleaching agents, fillers and as dissociating agents in petroleum refining, and chemical industries;
- As water impedance, where it prevents seepage loss from reservoir, irrigation ditches and waste disposal ponds.

Demand

The availability of bentonite in Nigeria and the wide range of industrial application enhance the attractiveness of the bentonite processing ventures. The present level of consumption is about 200,000 MT (for oil well drilling only); much of this is sourced from the foreign market.

Bentonite Deposits in Nigeria

Marine shale units that are highly enriched in montmorillonite are found in Nigerian sedimentary basins. Notable among these are the Awgu shale in Eastern Nigerian, the Imo shale that forms a belt across Southern Nigeria, the Fika shale in the North-eastern parts, and the Dukamaje and Kalambaina

formations in the North West. Many of sections of these formations are said to possess mineralogical compositions of more than 80% montmorillonite. Most of the shale are enriched in Calcium and mixed Montmorillonite, but sections abound that are enriched in sodium. Most of the occurrences are Cretaceous or Recent in age.

Bentonite clays also exist in the North-east quadrant of Nigeria (Borno, Yobe, Taraba and Adamawa) where a probable reserve of more than 700 million tones has been indicated. Similarly, over 90 million tones have been reportedly found in Afuze, Ekpoma-Igunebon road, Ovibiokhuan and Okpebho areas of Edo State. Some occurrences have also been reported in Abia, Ebonyi and Anambra States.

Clay mineral studies of the Tertiary to Recent subsurface in Niger Delta have revealed occurrences of bentonite as well as other non-swelling kaolinitic clays. Since the Niger Delta opens to the sea, there is likelihood that the subsurface Niger Delta bentonite may be enriched in sodium from the saline seawater.

Exploration efforts aimed at commercial exploitation are going on in several localities now, while some companies have actually started test mining. The table below shows the location of bentonite deposits in Nigeria.

Table 2.6. Locations of Bentonite Deposits

S/N	STATE	LOCATION	ESTIMATED RESERVE	REMARKS
1.	Cross River	Ogurude		Need further investigation.
2.	Akwa-Ibom	Itu		"
3.	Ebonyi	Ohaozara		Products of Asu River Group Shale.
4.	Abia	Arochukwu, Umuahia, Bende, Isiukwuato Ikwuano	Proven/inferred reserves is 5.8 – 7.5 mil. tones	Most deposits require further investigation.
5.	Imo	Orlu, Isu, Oru, Okigwe	Inferred reserve estimates are 5.8 - 7.5 million tones	Mining activities are on in some of the locations.
6.	Anambra	Awka	Not yet quantified	Need for more investigation.
7.	Gombe	Akko, Gombe, Yamaltu-Deba		
8.	Adamawa/ Taraba	Gujba (Mutai)	Not yet quantified	Deposits in River Channel
9.	Yobe	Ngala, Marte, Mongunu, Damboa		Black cotton
10.	Borno	Gamboru, Marte, Ngala, Dikwa, Monguno	700 million	Product of Clay of quaternary and tertiary
11.	Edo	Akoko-Edo, Afuze Okpebhio, Esan, Owan, Etsako,		
12.	Kebbi	Jega	Not quantified yet	Found in Benin formation

2.4. Glass Sand/Quartz

Silica Sand/Quartz constitutes one of the most readily available geological materials used in industries and factories such as glass manufacturing companies. Silica Sand/Quartz are said to consist of high optimal percentage of silicon dioxide (SiO_2) which is a very good chemically stable element and it remains almost the same no matter the series of cycles it may have gone through, either in transportation or re-deposition. Quartz is silica occurring alone in pure state. Silica/glass sand on the other hand are products of weathering, erosion and transportation by rivers or/and the sea. Naturally occurring silica sands may contain some undesirable impurities like accessory haematite, rutile and dolomite etc.

Uses

The Glass Sand is used in the production of various glass products: which include sheet glasses for windows, bottles, mirrors, optical instruments, chemical apparatus, electrical insulation and condensers, pipe, doors, crucibles, automobile and aircraft bodies, filters and building blocks. They are also used for making abbrassives and for gravel packing in the petroleum industries.

Locations of Glass Sand/Quartz deposits

Commercially exploitable quartz rock crystal occur in pegmatites and quartzites hosted by rock of the basement complex around Egbe, Udiarehu, Okene and Lokoja in Kogi State, Ijero in Ekiti State. The quartzites occur in the medium to high grade metamorphic terrains of the basement complex. The vein quartz and quartz bearing pegmatite solidified from the hydrothermal fluids associated with the older granites as well as those of the Younger Granites and from the materials of the rocks of the basement complex at different periods.

Nigeria has extensive deposits of good quartz silica sands. Many of which are associated with the coastal plain of sedimentary areas in the southern part of the country, although deposits also occur in some inland areas. The major silica sand deposits in the country are located at Ughecll--Delta State, Igbokoda, Ondo State, Baure, Katsina State, Badagry, Lagos State, and along the sandy shore line of the Atlantic, some inland deposit are also reported at Shebu, Plateau State and Ilaro, Ogun State. Table 2.7 shows locations of some quartz deposits while 2.8 is that of silica sand.

Table 2.7. Locations of Quartz Deposits

S/NO	STATE	LOCATIONS	ESTIMATED RESERVE	REMARKS
1	Ebonyi	Ohaozara, Abakaliki	Not available	More investigation work required
2	Ekiti	Idao, Iroko, Aiyegunle, Efon-Alaaye, Okemesi	23.817 million metric tones	More investigation work required
3	Plateau	Mangu, Pankshin, Kanassm, Langtang		
4	Niger	Duku-Rijau,Gurara		
5	Kogi	Okehi, Okene, Egbe		
6	Katsina	Faskari, Bakori, Kurfi, Funtua	Not available	Not being exploited
7	Kebbi	Danko, Wasagu	Not available	

Table 2.8. Glass sand Deposits

S/NO	STATE	LOCATIONS	REMARKS
1	Cross River	Ikom, Ibine Oban, Mfamosing, Okorotong, etc.	Yet to be investigated
2	Akwa-Ibom	Iwuo Ukem, Ibeno beach, Mbo, Oron	"
3	Benue	Buruku, Gboko, Guma, Katsina-Ala, Makurdi, Vandeikya, Agati, Logo	Quarrying activities are in some locations
4	Abia	Ukwa, Aba, Isiala –Ngwa, Isiala .	Quarrying at Ukwa
5	Imo	Ihiagwa, Obinze, Isu, Njeba, Obowo.	More investigations
6	Enugu	Enugu-Ekulu, Igbo Eze , Isi-Uzo, Nkanut, Udi, etc.	Investigation by PRODA
7	Lagos	Apapa, Badagry, Epe, Ibeju- Lekki, Lagos Island	Being exploited
8	Ondo	Igbokoda, Akata-Agbala, Abotoe, Ese-Odo Ilaje	Partially investigated.
9	Niger	Gbako, Gurara, Lavun, Mokwa, Muya, Bida etc.	Preliminary investigation
10	Nasarawa	Lafia, Done, Nasarawa.	Partial investigation
11	Kaduna	Kaduna	Partial investigation
12	Gombe	Yamaltu-Deba, Akko, Dukku.	

13	Yobe	Ngeji (Fika), Damaturu, Jakusko, Karasuwa, Nguru, Tarmuwa, Geidam	
14	Borno	Dikwa, Gwoza, Jere, Monguno, Kaga, Mafa, etc.	
15	Delta	Ughelli, Aniocha, Bomadi, Burutu, Ethiope, etc.	
16	Rivers	Etche, Obio -Akpor, Okrika, Oyigbo	
17	Bayelsa	Sagbama, Southern Ijaw Yenagoa	
18	Katsina	Zango, Baure	Not being exploited
19	Kano	Danbatta, Makoda	
20	Zamfara	Jarmuna, Gummi	
21	Taraba	Jalingo, Bali, Takum	
22	Sokoto	Sabon Birni, Silame, Wamako	
23	Ogun	Ado-Odo, Ogun-water side, Obafemi-Owode	
24	Jigawa	Jahun, Kangama, Kasaure	

Table 2.9. Chemical Analysis of Igbokoda Silica sand/quartz

Composition	**(I)**	**(II)**	**(III)**	**(IV)**
SiO_2%	99.91	99.83	99.71	99.91
Al_2O_3 (PPM)	20	190	33	9.0
Fe_2O_3	393	754	1358	277
MnO	13	97	45	14
Mgo	74	135	222	136
C_aO	22	51	14	40
Na_2O	278	241	169	199
K_2O	213	307	48	102
Cr	0.8	0.7	6.9	1.9
CO	8.7	12	16	78
Depth of Sampling (M)	Surface	Surface	Surface	2.3

Table 2.10. Qualitative Classification of Quartz/silica sand

S/No	Iron-oxide content Fe_2O_3	Beneficiation	Type of product
1.	0.035-	Simple washing and sorting	
2.	0.080	Require the use of costly decolouring agent	Used for coloured glass production if they do not contain impurities
3.	0.100-0.200	Simple dressing of washing and sorting	Production of all types of white glass.
4.	0.020-0.035	Dressing is complex and involves flotation, rubbing electromagnetic separation processes.	Used mainly for the production of crystal glass and some optical glass.
5.	0.053-0.200	Remover of heavy minerals, flotation gravity separation sorting, rubbing of impurities	Used mainly for the production of crystal glass and some optical glass.
6.	0.001-0.010	Beneficiation involves chemically leaching in an acidic environment and electromagnetic dressing.	Mainly used for the production of optical glass.

2.5. SALT

Brine springs and lake spreads are possible sources of crude salt in Nigeria. The concentration of salt in these springs has been estimated at 15 to 30 parts per thousand. The saline springs occur within the narrow belt which extends in a North-North East – South- South West direction from Gombe to Afikpo, along

the plains of the Benue and Cross River drainage systems. The brines issue from clays, shale, silty and arkosic sandstone, and conglomerates of upper cretaceous age. Geographically, the brine occurrences in Nigeria have been divided into two broad groups.

i) North of river Benue: the Lafia Sale areas, which include:
   a) The Azara-Akiri-Ribi Salt springs and the Awe-keana-Kenge salt speings;
   b) The Mutum Daya, Gyakan, Todi and ayaba salt springs in Adamawa/Taraba States; and

ii) South of River Benue – the Abakaliki – Okposi salt areas, which include:
   a) Enyigba, Ameri, Ameka, Ikwo-abakaliki in Enugu State;
   b) Okpoma, Gabu, Ijegu, Onyi near Ogoja, Cross River State;
   c) Akwana, Arufu and around Takum in Taraba State; and
   d) Uburu Ugwaneke, Afikpo in Ebonyi State

Most of the brines contained high proportion of sodium chloride, with subsidiary amounts of sulphate, nitrates and bicarbonates. A total reserve of about 1.5 billion tones has been estimated.

The Benue trough is also an attractive area for exploration for sedimentary salt deposit. Based on geophysical survey by Nigerian Mining Corporation, a saline lenticular structure of about 600m thick under over burden of 1,500m in the north west of Makurdi (called Oku-Lake) has been explored.

There are also the prospects of producing salt along Nigeria's coast. Locations of Salt/Brine deposits are shown in the table below.

Table 2.11. Locations of Salt/brine Deposits

S/N	STATE	LOCATIONS	REMARKS
1.	Cross River	Okpoma, Gabu, Ijegu, Oba, Olochor, Woda, Egbokoriko, Ogono, Oriyi, Akparabong and Abia Ibene-Ababene Road	Salt is exploited locally in these areas by the natives
2.	Imo	Okigwe	Need for more investigation
3.	Abia	Bende	
4.	Ebonyi	Ikwo, afikpo North, Ohaozara, Onicha, abakaliki	Local refining at Abakaliki and Ohaozara.
5.	Benue	Ado, gboko, Guma, Gwer, Kastina-Ala, Ukum, Ushongo	Investigation not carried out
6.	Nasarawa	Ribi, Keana	Partial investigation
7.	Gombe	Akko, Gombe	
8.	Taraba	Akwana (Wukari) (karim Lamido) Bomanda	
9.	Bayelsa	Brass L.G.A.	

2.6. GYPSUM

Gypsum is a hydrated sulphate of calcium, found usually in clays and limestone, sometimes associated with sulphur. It is the principal commercial form of hydrated calcium sulphate ($CaSO_4 2H_2O$). It is usually formed by either the evaporation of salt in shallow inland seas or by the decomposition of pyrite (FeS) in the presence of calcium carbonate.

Uses

More than 90% of gypsum are used in the building and construction industry while the remaining are used in the agriculture and health sexctors. Gypsum deposit also play important role as a pathfinder in the petroleum industry by virtue of the fact that the organic material commonly associated with its formation is considered as source of hydrocarbon generation and its deposits act as seal for petroleum reservoirs. Gypsum is an important raw material in the production of Portland Cement, Plaster of Paris, School chalk, Wall board etc. Gypsum is also used extensively as a soil conditioner.

Gypsum Deposits in Nigeria

The gypsum grades from the various deposits in the country satisfy the specifications required by the cement industry. Most of the gypsum deposits have not been quantified. There is need for detailed mapping, extensive drilling, reserve evaluation, sample collection and laboratory analysis for all the gypsum deposits in the country. It has become imperative that the large deposits of gypsum in the country should be beneficiated and processed to meet the requirements in the production of crayon, chalk, Plaster of Paris, etc. The existence of gypsum in Nigeria has been reported since 1921. Gypsum deposits are found in the sedimentary basins of the country. Identified deposits are found in Adamawa, Taraba, Yobe, Borno, Bauchi, Benue, Ogun, Sokoto, Edo, Kogi, Abia, etc. as shown in the table below.

Table 2.12. Location of Gypsum Deposits

STATE	LOCATIONS	PURITY % of $CaSO_4$	REMARKS
Borno/Yobe	South-West of Borno-Fika, Fune, Potiskum, Gubio, Turmi, Nanjero Gajiganna, Gadaka, Damboa etc.	85.90%	Investigations by GSN, Ashaka, & Benue Cement Cos.
Bauchi/Gombe	Gombe, Futuk, Kwaru, Turni, Nafada, Bawo, Marwa, Malori, Billiri, Bajoga Basaka, Piliya, Akko, Pindiga, Mada.	85 – 90%	
Taraba	Karim Lamido, Ibbi and Buissa LGA Lamja		
Adamawa	Guyuk, Numan, Ledime Ngurore Gwallum, Jiu, Shelleng, etc.	Not yet quantified	
Edo/Delta	Agbede, auchi, Aviele, Eoli, Oke-ora, Sambogida Ora		Investigations by GSN
Benue	Adoka, Ekobi, Entekpa, Apa, Lobbo, Makurdi, Otukpo, Gure Umogidi, Ushongo etc.		Investigations by NMC, GSN and Federal Univ. of Agric. Makurdi.
Imo/Abia	Abakaliki, Udi Ameki, Afikpo, Amaogugu, Ameki, Ugwa, Ibeku Oka, Okigwe, Okposi Umucheieze, Lokpanta, Bando, etc.	80%	Investigations by GSN, Niger Cement, Fed. Univ. of Tech. Owerri, and Metals and Rocks Cons.
Anambra/ Enugu	Awlaw Adani, Ebitiolo, Izza, Ezeagu, Inyi, Ugwuoba, Oji River etc.	70-80%	

Ogun	Oja Odan, N.W. of Abule Orire, Ifo, Ewekoro, Ibeshe, Shagamu etc.	88%	Investigations by WAPCO, GSN; Metals and Rocks Consultants
Sokoto/ Kebbi	Acida,Dandogi, Yari, Dange, Dukamaje, Kiri Gada, Bako, Fako, Gwada Bawa, Saloma, Kwasare, Kawrawa etc.	79.85%	Investigations by O.A. U. GSN and Metals and Rocks Consultants. Exploitation by CCNN
Ebonyi	Onicha, Ishielu, Ohaozara, Abakaliki		Further investigation required

Table 2.13. Chemical Analysis of Gypsum Samples from Fika, Fume and Dange

	Fika Satinspar	Fika 2 Selenite	Fume 1	Fume 2	Dange	Postkum	Bularafa 1	Bularafa 2
Na_2O	0.008	0.002	0.02	0.05		0.002-0.008		
K_2O	0.005	0.018	0.06	0.02		0.005-0.010		
CaO	22.85	23.24	30.84	30.69	24.48	22.84-23.24	31.04	31.12
MnO	1.58	0.00	1.61	0.56	0.43	0-1.58		
SO_4	54.78	55.77	52.83	52.5	56.90	54.78-55.77	53.21	51.89
Fe_2O_3	-	-	0.26	0.02			0.24	0.23
Al_2O_3		-	0.57	0.02	1.74		-	-
SiO_2	-	-	1.40	1.40	5.85		1.78	2.10
LOI	20.80	20.80	20.73		19.54	20.80	20.80	18.65
Purity	77.62	79.01	83.67	83.19	81.38	78.80		

2.7. FELDSPAR

Feldspar is a group of closely related, rock forming alumino-silicate minerals, which contain varying proportions of potassium, sodium and calcium. The word "feldspar" is derived from the Swedish word "fald" meaning field and German word "Spat" which is said to refer to any transparent or translucent material which is readily clearable. Feldspar is the most abundant of all minerals, comprising over 50% of the earth's crust. It forms the major constituent of most igneous and metamorphic rocks, as well as arkosic sediments. Commercial feldspar occurs in feldspar rich pegmatite of older granites. Feldspars are valued as raw materials that form a vital input in ceramic, glass, paper, chemical, agricultural, pharmaceutical, paints, plastics and rubber industries.

Uses

The alkalis and alumina contents are the two properties of feldspar that make it beneficial for industrial use.

It is estimated that about 85.90% of feldspar produced is consumed by the glass and ceramic industries, although the proportion varies from country to country. Feldspar provides an inexpensive source of the alkali metals (sodium and potassium), and alumina. In the ceramic industry especially in the manufacture of white ware, feldspar is the second most important ingredient after clay. For glass, manufacture, feldspar is still one of the important raw materials.

Outside the use of feldspar as fluxes in the ceramic and glass industries, they are used as fillers and extenders in the paint, chemical, plastic, and rubber industries. They are also useful in the building/construction industries, where they can be used as decorative stones and chippings respectively. At times due

to their luster and colour, they may be used as semi precious stones,; and in the production of mild abrasives.

The Nigerian feldspars are very suitable for use in the ceramics, paints, cosmetics, and glass industries. However, for colourless clear glass sheets, the feldspar may require processing to remove biotite. This may be done by manual hand picking of the chips before grinding. Froth floatation beneficiation technique provides more practical means of separating feldspar from associated mica and quartz minerals.

Feldspar Deposits in Nigeria

There are wide occurrences of feldspar in the granite and pegmatite rocks of Nigeria but concentration of economic size is view. Feldspar occurs in the feldspar rich pegmatite of the older granites around Egbe, Udiarehyu, Okene and Lokoja in Kogi State; Osogbo in Osun State; Ijero-Ekiti in Ondo State; Abeokuta in Ogu state; Gwoza in Borno State and parts of Taraba/Adamawa State. Locations and chemical compositions of some samples of feldspars are shown in the tables below:

Table 2.14. Locations of Feldspar Deposits

S/N	STATE	LOCATIONS	ESTIMATED RESERVE	REMAKRS
1.	Ogun	Abeokuta, Gbegbinlawo, Aiyedeti, Jagunna, Fani, etc.	Reserve not estimated	More investigation
2.	Ekiti	Ijero-Ekiti	3.76 million tons	
3.	Osun	Oshogbo, Ilesha, Ede, Ipole, Iwo, Atakumasa, Irokin, etc.	Not yet estimated	Need further investigation

4.	Plateau	Bassa, Mangu, Pankshin, Lantang, Jos etc.		
5.	Niger	Shiroro, Kontagora, Borgu		
6.	Kogi	Osara, Okene, Egbe, Lokoja etc.	Being exploited	
7.	Nassarawa	Akwanga, Kokone Nasarawa		
8.	Borno	Gwoza, Shani, Kwajaffa Bakin Kasuwa		
9.	Adamawa	Maiha, Guyuk	Large	
10.	Edo	Etsako, East & Central	Not available	.
11.	Kebbi	Zuru, Yauri, Kaoje	Large	
12	Katsina	Faskari, Batsari, Kurfi		
13.	Taraba	Jalingo, Yorro, Zing, Wakuyau, Baissam Ussa		

Table 2. 15. Chemical Composition of some Feldspar Deposits

Location	State	Chemical Composition %						
		SiO_2	Al_2O_3	M_nO	CaO	Fe_2O_3	K_2O	Na_2O
Okene-I	Kogi	65.70	13.81	0.025	-	0.28	10.00	3.05
Okene-2	Kogi	65.50	19.10	0.03		0.25	10.50	2.20
Jos – 1	Plateau	67.00	19.00	0.02		0.03	13.00	13.00
Jos – 2	Plateau	68.00	18.30	ND		0.21	2.50	11.00
Gwoza-1		65.66	18.51	-		0.31	11.08	4.04
Gwoza-2		66.24	17.63	-		0.05	11.45	3.90
Gwoza-3		77.18	11.75	-		0.08	7.71	2.56
Gwoza-4		74.62	13.68	-		0,07	8.31	2/69
Gwoza-5		63.65	14.81	-		2.86	12.49	3.22

N.B. The analyses for Gwoza samples is from Journal of Mining & Geology and Bohler Pneumatic

Rational Analysis (calculated)

K_2O Feldspar %	47.81
Na_2O + CaO Feldspar %	43.25
Quartz %	9.10
Clay substance %	2.05
Specific gravity	2.56
Hardness (mohr's)	6
Porosity	Nil
Bulk density (g/ml)	Nil

Potentials

The estimated demand for feldspar annually by industries in Nigeria is about 200,000 tonnes, while supply locally is far less. Feldspar is a mineral whose important role as fluxing agent in the manufacture of ceramic and glass products cannot be over looked. Feldspar are also being used as extruder and fillers in the paint and rubber industries. The fact that the current production level is not enough to meet the national demand shows that there is opportunity for investors and mineral processors in feldspar milling and beneficiation.

2.8. LIMESTONE/MARBLE

High quality marble/limestone suitable for the production of cement, fluxing material, powder filler for paper, rubber, paint, glass, ceramics, pharmaceutical, quicklime, hydrated lime, calcium carbonate etc. exist in greater abundance in the sedimentary basins and crystalline basement belt.

Potentials

Supply of processed or granulated marble/limestone to end-users has not met demand. There are few producers of ultra-fine grade limestone/marble. Supply

of this quality has largely not been met by small-scale millers whose pooled production output is inadequate. Therefore, what is urgently required in the marble/limestone industry now, is the establishment of grinding/processing industries, for value added primary products.

Limestone/Marble deposits provide the raw materials for the cement factories at Calabar, Cross River state; Sokoto, Sokoto state; Nkalagu, Enugu state; Okpella, Edo state); Ashaka, Gombe state; Gboko, Benue state; Ewekoro and Shagamu Ogun state; and Obajana in Kogi state. The production trend has been influenced by activities in the construction industry especially cement production.

Limestone/Marble Deposits in Nigeria

Limestone is widespread in the sedimentary basins of Nigeria. It is used extensively in cement production, as flux and refractory material, metallurgical applications etc. Prominent reserve has been proved to exist all over the country. The marble and dolomite deposits in Nigeria are often associated with the meta-sediments such as schist, amphibolites complex and metal-conglomerates. They are also used as flux in steel making. The tables 2.16, and 2.17, show the locations of the limestone and marble/dolomite deposits in Nigeria respectifully. The chemical composition of some of the well known high quality marble/limestone deposits are shown in table 2.18, while Table 2.19 presents specifications in some industries.

Table 2.16. Limestone Deposits in Nigeria

S/N	STATE	LOCATIONS	ESTIMATED RESERVE (million tonnes)	REMARKS
1.	Cross River	Mfamosing, Odukpani, Uwet, Akpa, Okranibang, Ugep etc.		Commercially quantities
2.	Akwa Ibom	Obotime		Need further investigation
3.	Imo	Okigwe, Umu-obon	10	Need further investigation
4.	Abia	Aba, amachi, Arochukwu, Ohafia, Bende		Need further investigation
5.	Anambra	Njikoka	Not available	
6.	Ebonyi	Afikpo, abakaliki, Ikwo, Ishielu	About 15.5	Quarrying is being carried out
7.	Enugu	Nkalagu, Nkanu, Awgu, Aninri, Odomoke		Commercial exploitation
8.	Benue	Gboko, Gwer, Yendev, Konshisha, Oju, Makurdi, Apa, Ushongo, Igumale, Ogbolokuta, Guma,	Possible over 400 million tones	Exploitation by Benue Cement
9.	Ogun	Ewekoro, Sagamu	185 million tones	Exploitation by WAPCO
10.	Sokoto	Kalambaina	101.6	Exploitation by CCNN
11.	Nasarawa	Awe		
12.	Gombe	Ashaka, Pindiga, Gombe, Deba, funa-Kaye, Nafada etc.		
13.	Yobe	Garin Ari, Turm (Fika) deda, Kwayaya (Fune)		
14.	Adamawa	Guyuk, Shelleng, Ngurore, Numan		
15.	Borno	Yadi-Gilan (Danboa)		
16.	Edo	Akoko-edo, Owan Ersako	10	
17.	Kebbi	Jega	N.A	N.A.

Table 2.17. Marble/Dolomite deposits in Nigeria

S/N	STATE	LOCATION	ESTIMATED RESERVE (million tones)	REMARKS
1.	Ebonyi	Afikpo North, Abakaliki, Ohaozara, Ezza	20	Quarrying mainly at Ezza North and South
2.	Abia	Ohafia		Need for more investigation
3.	Imo	Okigwe		Further investigation required
4.	Nasarawa	Toto-Muro Hills	10.6	Further investigation
5.	Kogi	Ekinrin-Ade, Elebu Osara Jakura Ubo, ajakuta	Not available 17 68.00 20.00	Further investigation Dolomite/Marble- Commercial exploitation
6.	Benue	Itobe	10.00	Further investigation
7.	Niger	Kwakuti Takalafia	2.5 4.0	Dolomite – commercial exploitation
8.	FCT	Burum Takusara	16.6 12.0	Dolomite – Commercial exploitation
9.	Oyo	Igbetti	Large	Commercial exploitation in progress
10.	Edo	Ukpella, Ubo, Igara Ekpershi, Siluko etc.		Commercial exploitation Marble
11.	Katsina	Kankara, Malumfashi	Not available	Further investigation

Table 2.18. Chemical Composition of Selected Limestone and Marble Deposits

Deposit	Ca0	Mg0	S_i0_2	Al_20_3	Fe_20_3	R_20_3	Na_2O/K_2O	P_20_3	S_i0_3	LOI	Equiv. $CaC0_3$	Equiv $MgCo_3$	Source
Odukpani	54.18	0.57					0.31			42.58	96.60	1.20	GSN 1192
Mfamosing	50.40	1.53	1.05										GEC-002P77
Jakura I	54.05	0.63	1.84	0.34	0.21	0.02	0.09	0.03	0.14	46.89	96.50	1.30	Akingbehin GSN
Jakura II	54.92	0.42	0.50	0.07	0.04		0.05	0.00		43.37			
Ashaka	48.03	1.35				3.99		0.47		42.66			R.O. Roberts GSN
Yandev	53.10	0.61	2.25	0.94	0.49			0.06	0.11	43.07	98.80	1.30	GSN 1192
Edo	53.50	0.80	2.00	1.50	1.20				0.10	42.41	96.00	3.43	Okpella Cement Co.
Okpella	51.29	2.23	3.47	1.00	0.21			0.03	0.03	51.50	91.60	4.60	GSN Report 1192
Nkalagu	49.90	0.70	5.90			3.00				40.57	89.10	1.40	GSN Report 1354
Kumberi	49.19	1.07	5.26	1.43	1.42	0.88				40.07			GSN 771 1354

Table 2.19. Specifications for marble/limestone is as follows:

%	Fertilizer	Cement	Steel
Size	-		20-50mm
$CaCO_3$	90% max		
SiO_2	5 max	2.49	5 max
Al_2O_3	-	1.25	0.002
Fe_2O_3	2 max	1.06	0.002
MgO	6 max	0.72	3
CaO	-	51.94	54.28
P_2O_s	-		1
SO_3	-		
L.O.I	-	42.22	
Others	-	0.32	

2.9. GRANITE

Granite is a coarse-grained intrusive igneous rock composed primarily of light-coloured minerals.

Crushed granites are small chips of granite, used as a base layer for paving. They are rock-aggregate used in building and general construction.

Open pit mining or quarrying is used when the material to be mined and crushed. The processes involved here are drilling and blasting.

Potential

Rock aggregate is a very important raw material in building and construction industries. Recent market survey showed that procurement of quartz/gravel,

which is also used in the construction industry, is given way for the crushed granite rock aggregate. There is a few meaningful granite crushing operations in the country. The main by-product of granite crushing is the stone dust, which is extensively used in place of sand in production of building blocks and concrete works. It is sold cheaply as additional sources of revenue. The market is quite substantial, but one may wonder why it has taken so long for entrepreneurs to direct their attention to granite crushing.

Granite Deposits in Nigeria

Nigeria is blessed with lots of granite, which are widely distributed within the country.

Table 2.20. Some Locations of Granite Deposits

S/N	STATE	LOCATIONS	REMARKS
1.	Cross River	Iyamoyong, Bebi, Ugbakkoko	Abandoned quarry
2.	Imo	Etite	Small scale exploitation
3.	Anambra	Oyi, Onitsha, Idemili, Aniocha, Anambra	
4.	Ebonyi	Abakaliki, Ishielu, Ohaozara, Afikpo, Oricha	Quarries exist in most of the location
5.	Abia	Nnoch	As above
6.	Osun	Iragbiji, Awo, Ile-Ife, Ila, Wasimi.	As above
7.	Ekiti	All over the state	As above
8.	Oyo	Found all over the state	
9.	Ondo	(Charnockite) Idanre	
10.	Niger	Rafi, Kontagora,	

11.	Gombe	Biliri, Balanga, Kaltungo, Shongon	
12.	Bauch	Bauchi, Ganjuwa, Toro, T/Balewa, Shira	
13.	Yobe	Buni – Yadi (gujba)	
14.	Adamawa	Yola, Numan	
15.	Taraba	Maisamari, Mambilla Plateau	Export for cutting and polishing
16.	Borno	Gwoza area	Partial
17.	Edo	Akoko Edo, Etsako, Owan	Exploitation
18.	Katsina	All over the state	Exploitation
19.	Kano	Rogo, Garko	Exploitation

2.10. BALL CLAY

This is noted for its plastic nature – a property which is a direct result of the clay's fine grain sizes. It has appreciable amounts of organic matter and expendable smeltic/mixed layer clays.

Uses

It is used in the manufacture of foundry crucible in furnace lining where ball clay provides the plasticity required for easy shaping and also serves as a bonding agent.

Ball Clay Deposits

Various grades of ball clay occur in Nigeria. Occurrences are in Niger Delta and coastlines, Akabuka, Komo-Boue, Kwawa etc. in Rivers State. Iguioriaki, Aboh and Uzere in Edo State and, Eket and Etinam in Akwa Ibom State. Table 2.21 presents the locations of some of the clay deposits, Table 2.22, presents

chemical composition, while table 2.23, presents Ball Clay specifications for some products. The ball clays are suitable for the production of bricks, fillers and ceramic wares although the highly plastic varieties require the addition of cohesive sand.

Table 2.21. Locations of Ball clays in Nigeria

S/N	STATE	LOCATIONS	REMARKS
1.	Cross River	Appiapume, Ofumbonghaone Ogurude, Ovonum	Detailed investigation required.
2.	Akwa-Ibom	Nkari, Nlung, Ukim, Ikot-Etim, Eket-Uyo, Ekpere-Obom Ikot-Okoro, Ikwa	Detailed investigation required
3.	Benue	Katsina Ala, Otukpo, Buruku, Gwer, Makurdi	
4.	Ebonyi	Ohaukwu, Ezza North, Abakaliki, Ezzi, Afikpo south, Ohaozara	Quarried locally for pottery
5.	Abia	Isikwuato, Ikwuano, Umuahia, Bende, Arochukwu	More investigation required.
6.	Enugu	Enugu, Isi-Uzo, Uzo-Uwani, Oji River, Udi	Used for pottery
7.	Ekiti	Ara-Ijero Igbara, Ado Ekiti	Detailed investigation required.
8.	Ondo	Erusu Akoko, Ikale, Ode-Aye, Ute Arimogija Ifon	More investigation required
9.	Ogun	Bamajo Onibode	Still under investigation
10.	Ekiti	Orin Ekiti	Bauxitic in content
11.	Plateau	Bassa, Barinkin-Ladi, Mangu, Kanam, Langtang North	

12.	Niger	Lavu Gbako Suleja, Minna Agaje, Paikoro	Being exploited
13.	Kaduna	Kachia, Maraba-Rido, Farin-Kassa	
14.	Kogi	All over	
15.	Rivers	(L.G.A.'s) Etche Ikwere	
16.	Kano	All over	
17.	Delta	Ethiope Isoko, Ndokwa Okpe, Ugheli, warri	
18.	Niger	Bida, Lavuw, Mashegu, Agaie Murya	

Table 2.22. Chemical Composition of Some Nigerian Clays

Deposit	SiO_2	Al_2O_3	Fe_2O	TiO_2	CaO	MgO	K_2O	Na_2O	L.O.I
Agbor	46.80	31.21	1.40	1.52	2.96	0.31	0.20	0.35	12.63
Awo-Omamma	53.20	27.84	1.4	1.1	2.01	-	0.40	0.30	12.98
Uyo	45.75	28.34	1.79	1.32	-	-	0.30	0.51	16.72
Ubulu-Uku	46.32	36.83	1.45	1.22	0.22	0.17	0.43	0.26	13.10
Giro	43.63	37.50	1.19	3.41	0.02	0.09	0.22	13.68	-
Kankara	44.09	38.67	1.13	2.21	1.20	0.15	0.52	0.36	14.43
Major Porter	46.57	35.21	2.70	0.07	0.06	0.06	0.97	0.06	13.40
Nahuta	46.80	31.83	1.98	0.75	1.39	0.80	0.86	0.55	12.95
Darazo	51.92	32.92	2.93	0.39	0.29	0.07	0.89	0.13	13.93

Table 2.23. Specifications for Ball clay

	Table wares	Sanitary wares	Tiles
SiO_2	46.0	54.0	70.0
$A1_2O_3$	31.0	30.0	19.0
Fe_2O_3	1.1	1.4	1.6
TiO_2	0.9	1.2	1.6
MgO	0.4	0.4	0.4
CaO	0.4	0.3	0.2
K_2O	2.2	3.1	2.0
Na_2O	0.4	0.5	0.5
LOI	17.5	8.8	5.4
Fired Brightness (1120^oc)	75.0	63.0	63.0
PCE	35.0	32.0	28.0

2.11. KAOLIN

Kaolin is an important and widely used industrial mineral which is refined from Kaolinite. It is a naturally – occurring mineral of the clay family and may contain a number of impurities such as quartz, feldspar, tourmaline, ilmenite, zircon, etc, which were derived from the parent rock. It is a weathering product of silicate rocks which is whitish, earthy to dull with plastic touch. The characteristics and chemical composition of a kaolin deposit usually determines its industrial utilization.

Uses

Kaolin is one of the most valuable of the industrial clays which is used in most manufactured products. Prominent uses include paper filling and coating; paint,

plastic, adhesive and ink pigment; rubber reinforcing agent; ceramic raw materials for porcelain, dinnerware, tiles and enamels; catalyst for petroleum cracking and auto exhaust emission catalytic control devices; cosmetics base; and digestive coating remedy.

Kaolin has numerous industrial applications and new ones are still being discovered. It is a unique industrial mineral because it is chemically inert over a relative wide pH range. It is suitable for moulding mixture in cast iron and steel foundry, and insulator refractories where the most important properties are plasticity, strength and fired colour.

Kaolin Deposits in Nigeria

The bulk of the Kaolinitic clay deposits in the country are either sedimentary or residual in origin and are usually associated with granitic rocks. Occurrences of kaolin have been recorded in different parts of the country and specific abundant deposits have been identified in parts of Enugu, Anambra, Kaduna, Katsina, Plateau, Ondo, Ogun, Oyo, Bauchi, Sokoto, and Borno States. Of these reserves, about 800 million tones of probable/proven deposits have been quantified.

A large proportion of the kaolin deposits in Nigeria is won manually with unsophisticated implements such as shovel and diggers. Further field studies are required for reserve evaluation and documentation, quarry characteristics and mine design. The major problems in the quarrying of kaolin include caving in of holes, influx of ground water particularly in the rainy season and presence of impurities such as quartz, feldspar, tourmaline, muscovite, etc. which are

derived from the parent rock. The locations of some kaolinitic clay deposits are presented in the table below:

Table 2.24. Locations of Kaolin Deposits

S/N	STATE	LOCATIONS	ESTIMATED RESERVE	REMARKS
1.	Cross River	Alege, Betikwe, Mba, Bebuabong		More investigation required
2.	Akwa-Ibom	Ibiaku, Ntok Okpo, Mbiafum, Ikot, Ekwere, etc.		
3.	Abia	Umuahia, Ikwuano, Isiukwato, Nnochi		Small scale exploitation.
4.	Enugu	Uzo Uwani, Nsukka south, Udi, River Oji, Enugu		Small scale mining activities at Nsukka .
5.	Imo	Ehime, Mbano, Ahiazu Mbaise, Orlu, Ngor-Okpalla, Okigwe, Oru		Small scale mining in some of the sites.
6.	Benue	Apa, Ogbadibo, Okpokwu, Vandikya		
7.	Anambra	Ozubulu, Ukpor, Ekwusigo, Nnewi, Ihiala, Njikoka, Aguata, Aambra etc.		Partial exploitation is being carried out

8.	Ondo	Abusoro, Ifora, Ewi, Ode-aye, Okitipupa, Omifun-fun		Partial exploitation is being carried out
9.	Ekiti	Usan-ekiti, Omi-Alafia, Ikere Ekiti		
10.	Nasarawa	Awe, Keffi	45,000 metric tones	
11.	Ogun	Ibeshe, Bamojo, Onibode, Abeokuta	Not yet quantified	Exploitation at small scale level
12.	Kogi	Agbaja		
13.	Niger	Lavun, gbako, Bida, Patigi, Kpaki		
14.	Kaduna	Kachia, Manaraba-Rido	5.5 million tonnes	Partial exploration
15.	Plateau	Major Porter Nahute, Barikin-ladi, Mangu, Kanam	20 million tones	Commercial exploitation
16.	Bauchi	Alkaleri, Ganjuwa, Darzo, Misau, Kirfi, Dambam	20 million tonnes	Commercial exploitation
17.	Yobe	Fika (Turmi)		
18.	Borno	Maiduguri (Gongulon), Bui, Damboa		
19.	Edo	All part of the state	Large	Yet to be exploited
20.	Delta	Aniocha, Ndokwu	Large	Yet to be exploited
21.	Osun	Irewole, Ile-Ife, Ede, Odo Otin, Ilesa, Iwo		Partial exploitation
22.	Katsina	Kankara, Dustsen-ma, Safana, Batsari, Ingawa, Musawa, Kankara	20 million tones	Exploitation by

		Malumfashi		RMRDC /KTSG model factory; Katsina Kaolin and Ceramics Ltd. etc.
23.	Kano	Rabo, Bichi, Tsanyawa, Dawakin Tofa, Gwarzo	Not available	Not available
24.	Kebbi	Danko, Zuru, Giru, Dakin Gari, Illo, Kaoje	Not yet quantified	
25.	Oyo	Tede, Ado-Awaye	Not yet quantified	Exploitation by local porter
26.	FCT	Kwali, Dongara		

Table 2.25. Chemical Composition of some samples of Kaolin deposits

Oxide	Yobe 1	Yobe 2	Ozubulu	Major porter	Nahuta	Darazo	Abeokuta	Ifon	Akure	Kankara
SiO_2	45.70	47.01	60.0	45.57	46.80	51.82	43.12	48.03	48.60	45.90
Al_2O_3	35.02	36.17	26	35.21	31.82	32.92	36.12	33.2	36.50	39.60
Fe_2O_3	2.00	2.31	5	2.70	1.98	2.93	3.1	0.06	1.69	0.37
K_2O	0.01	0.20		0.97	0.86	0.89			0.50	0.43
Na_2O	0.03	0.12		0.06	0.80	0.07			0.03	0.05
TiO_2			5				1.9	1.73	0.83	0.06
CaO				0.07	0.75	0.39			0.23	0.09
MgO				0.06	1.80	0.29			0.08	0.08
L.O.I.	12.58	13.04					12.65		12.00	

2.12. TALC

Talc is an industrial mineral with great commercial value in its pure form. It is a mineral of low and medium grade metamorphic rocks and usually rich in magnesium. It occurs as a secondary mineral resulting from hydration of magnesium bearing rocks generally related to the mafic-ultramafic rocks that are predominantly found within the schist belts of the Precambrian basement complex such as peridotites, dolomites, steatite, gabbro, etc.

Uses

Talc has various industrial applications. The paint, cosmetics, fertilizer, pharmaceutical and ceramic industries are the most dominant users of talc. It is also used as lubricants in leather-making, laboratory table-tops, switch boards, toilet powder and for removing grease from cloth.

Talc Deposits in Nigeria

Occurrences of talc deposits have been reported in various parts of Nigeria where they are associated with the schist belts. Most of the Nigeria talc deposits are often deep coloured and occur in lenses and bands of a few square kilometers. Since strong colours are objectionable in most industrial applications, most of the talc deposits require bleaching before usage.

Table 2.26. Locations of Talc Deposits

S/N	STATE	LOCATIONS	ESTIMATED RESERVE	REMARKS
1.	Cross River	Obudu	Not yet determined	
2.	Osun	Ile-Ife, Ila, Ilesa	Not yet determined	Partial investigation
3.	Ekiti	Ijero-ekiti		"
4.	Plateau	Pankshin		
5.	Niger	Rafi, Shiroro, Kumunu, Tegna, Maru		Being exploited
6.	Kaduna	Zonkwa		Partial investigation
7.	Kogi	Yagba/Isanlu		Partial investigated
8.	Oyo	Iseyin		
9.	Ogun	Shagamu	Not yet quantified	
10.	Ondo	Ijero, Ekiti	Not yet quantified	

Table. 2.27. Chemical Analysis of Some Talc Bodies in Nigeria

Sample	A	B	C	D	E	F
SiO_2	53.81	57.68	55.37	55.72	54.76	59.44
TiO_2	0.17	0.17	0.16	0.21	0.17	0.03
Al_2O_3	1.65	0.60	2.28	2.80	3.54	1.39
Fe_2O_3	5.65	2.75	4.26	4.57	6.50	5.00
MnO	0.12	0.05	0.04	0.04	0.16	0.07
MgO	31.07	33.58	31.73	30.73	27.20	29.36
CaO	4.44	0.69	0.38	0.41	4.43	0.36
Na_2O	0.01	0.01	0.01	0.01	0.22	0.02
K_2O	0.01	0.02	0.02	0.02	0.03	0.01
P_2O_5	0.11	0.10	0.06	0.06	0.02	
L.O.I	3.11	4.33	5.42	4.64	2.99	4.90

Table 2.28. Industrial Specifications for Talc.

	Ceramics	Cosmetics	Foundry castings
$Si0_2$	48.00	48.00	63
Mg0	31.70	5.00	31.7
H_20	4.80	0.10	4.8
Fe_20_3		4.80	

Note: Talc should be ground to very fine particles.

Demand

Talc being the vital material in the ceramics, cosmetics, paint, paper, soap, rubber, fertilizer, pharmaceutical and tyre industries enjoys a ready made market for the huge shortfall in supply. In spite of the high national demand which is over 50,000 tonnes per annum, there is only one talc processing industry in the country which produces about 3,000 tonnes per annum. Thus,

over 90% of the talc used in Nigerian industries is imported. However, if the Nigeria talc is exploited and processed properly, it would not only satisfy the local demand, but would also be ready for export because of the abundant reserves in the country.

Table 2.29. Major Consumers of Talc in Nigeria

S/N	COMPANY	SOURCES
1.	International Equitable Association Limited (Cosmetics and Soap Div.)	Local
2.	Berger Paint Limited, Lagos	Imported/ Local
3.	Modern Ceramics Industries Ltd.	Imported
4.	Fenina Hygienically Product. Port Harcourt	Local and Imported
5.	Starling Nig. Ltd. (Pharmaceutical)	Imported/Local
6.	E & E Chemicals and Cosmetics, Aba	Imported
7.	Boots International industries Ltd. Aba	Imported
8.	Toonal Ind. Ltd. Aba	Imported
9.	Haco Nigeria Ltd, Ikeja	Imported
10.	Avon Cosmetics Limited, Lagos	Imported
11.	A. J. Seward Bullingway, Lagos	Imported
12.	Lever Brothers Nig. Plc. Apapa, Lagos	Imported
13.	Michelin Nig. Plc. Trans-Amadi, Port-Harcourt	Imported
14.	PZ Industries, Ilupeju, Laogs	Imported
15.	Royal Ceramics, Abuja – Kaduna Road, Niger State	Imported/Local
16.	Daily Needs Industries, Matori, Lagos	Imported
17.	Bayer Pharmaceutical, Amuwo Odofin, Lagos	Local/Imported
18.	Cybele Cosmetics, Mushin, Lagos	Imported
19.	General Cosmetics Aba-Owerri, abia State	Imported
20.	Richware Ceramics co. Iluprju, Lagos	Imported
21.	Ceramic Manufacturers of Nigeria, Challawa, Kano	Imported
22	Gateway Ceramics Abeokuta	Local

2.13. MICA

Mica is a generic term which refers to a series of hydrous alumino-silicates, with the common ores being muscovite, biotite and phlogopite. The three main sub-groups of mica are differentiated by the proportion of iron, magnesium and aluminum contained within the crystal structures. The aluminum rich muscovite and magnesium rich phlogopite (amber mica) are the most commonly used industrial varieties. Muscovite and biotite are the most common in terms of occurrence. Mica maintains a privileged position as a unique industrial mineral for which there is yet to emerge a strong substitute.

Geology and Occurrence of Mica

Mica is a type of phyllosilicate exhibiting a two dimensional sheet or layer structure. Mica is common in all the three major rock varieties, which are igneous, sedimentary and metamorphic. It occurs in igneous rocks such as granites and pegmatite; in metamorphic rocks like gneisses and schist; and in sedimentary rocks like sandstones, clays, etc.

Location of Mica deposits in Nigeria

Mica is widely distributed all over Nigeria. Substantial quatities are found in the siliceous gneisses and pegmatite of Moriki district in Zamfara State, also in Kogi, Rivers, Nassarawa, Ogun, Ekiti and some other states. The locations of the mica deposits in Nigeria are shown in Table 2.30.

Table 2.30. Mica Deposits in Nigeria

S/N	STATE	LOCATION
1.	Cross River	Obudu, Akampka, Edondon, Obamilen, etc.
2.	Niger	Shiroro, Alawa, Tambayi, Suleja, etc.
3.	Plateau	Barikin – Ladi, Riyom
4.	Kogi	Isanlu, Ogbom, Yagba, Okolom, Egbe, Osara, Mopa, etc.
5.	Gombe	Gombe, Kwami
6.	Bauchi	Alkaleri, Bauchi, Warji ganjuwa, Ningi, toro, Tafawa Balewa, Barjo, etc
7.	Borno	Shani, Kwaja-Kusar, Niu, Barjo, Askira-Uba
8.	Katsina	Faskari, Batsari, Safana, Ingawa, Funtua, Matazu, etc.
9.	Kebbi	Zuru
10.	Osun	Oshogbo, Orolu, Olorunda, Odo-Otin, Ayedade, Isokan, Irewole, Ila, etc.
11.	Ogun	Abeokuta, Ijebu-Ode, Owode, Ogun water side
12.	Ekiti	Ekiti, Ido-Osi, Ijero, Ikere, Oye, Irepodun, Ifelodun
13.	Benue	Makurdi
14	Kwara	Offa
15	Adamawa	Mayobelwa, Jada,, Mubi, etc.
16	Kaduna	Zaria

Uses of Mica

By virtue of its chemical and physical properties, mica has historically found a niche in a range of industries. In the last two or three centuries the range of uses has been widened.

The introduction of wet and dry ground, micronised, built-up, reconstituted and paper forms of mica have expanded the markets demand for mica, which

previously was only served by sheet mica. The principal markets are construction, coatings, plastics, electronics, paper and drilling mud.

Construction

About 4 – 205 mica added into cement, plaster composite fillers, acoustic board fillers, asphalt felts, shingles and insulating material brings a number of advantages.

Coatings

Mica in the form of fine to superfine powder (100 – 325 mesh) is an important addition to a number of specialty paints and coatings. It is used as a pigment extender, mainly to reduce checking and cracking. Paints products and metal primers rely on mica to control chalking, reduce penetration and assist adhesion. The proportion of mica used in the coating ranges from about 20% in industrial coatings to as much as 40% in textured paints. Either wet or dry mica issued.

Plastics

As relatively low cost filler in plastic, mica improves sizes stability, heat stability, heat insulation, compression, bend modulus, water proof and gas proof characteristics. Mica filled compounds generally use 20 – 50% super fine powder (325 mesh) as a filler.

Electrical and Electronics

The electrical and electronics markets use mica almost entirely in sheet form. Sheet mica is of high uniform quality and has high electric strength, high Q factor and a low temperature coefficient. These characteristic combined with the general characteristic have long made mica an important electrical insulator.

Electrical insulators must be able to withstand electrical, thermal and mechanical forces under both normal and abnormal operating conditions, and to cope with repeated exposure to corrosive elements if they are to do their job.

Commercially, mica is marketed as flat books of finely delaminated mica, graded into 10 qualities by virtue of size and impurities present. The sheet can be easily machined into the strong but complete shapes required by the electrical and electronics industries.

Drilling Muds

Coarse flakes (5 mesh, 3 mm) are added to drilling mud in water – based oil well drilling operations. The mica has several functions e.g. prevention of loss of circulation and seepage in loose formations and to seal up porous section of the drilling hole.

2.14. DIATOMITE

Diatomite is siliceous sediment, which is made up of more or less entirely skeletal remains of microscopic plants (diatoms). It is a lithified low-density sediment which is made up of almost entirely opaline-silica (amorphous) remains of ditoms. It is exceptionally fine grained, incoherent and highly absorbent.

Locations of Diatomite Deposits

The Geological Survey of Nigeria at the North Eastern part of the country first discovered diatomite in 1924. Abundant deposits have been recorded at Bularafa, Abakire, Gujba and Maluri in Yobe State; Shani, and Mirinja in Borno State; Kwani in Gombe State and Udubo area of Bauchi State. Some of the

deposits are found to be good as refractory material, filling medium, earner of active ingredient and pesticide. The diatomite deposits in Nigeria are not being exploited in any appreciable quantity. The little being exploited is by local artisan miners.

Table 2.31. Physical Properties of the Bularafa and Abakire Diatomite Deposits

	Bularafa	**Abakire**
Specific gravity	2.17	2.32
Bulk density	0.45	0.85
Porosity %	85	60
Water Absorption	157 39 % w/w	70.18
Dry Density	-	1.26
pH	8.6	5.3
Colour		Yellowish

Table 2.32. The Chemical Composition of the Bularafa and Abakire Diatomite Deposits

Oxide	Bularaba	Abakire
SiO	73.12%	66.68
AL_2O_3	7.4%	16.19
TiO_2	0.33%	1.15
CaO	12.23%	13.30
MgO	1.01%	1.15
Fe_2O_3	3.06%	3.12%
Na_2O	6.26%	6.28
K_2O	0.68%	1.83
P_2O_5	Trace	1.08
L.O.I.	12.44%	7.60

L.O.I - Loss on Ignition. *Source: NMC*

2.15. GRAPHITE

Natural graphite flake is unique with extra ordinary property of high electrical conductivity, flexibility and caisotropics thermal expansion. This is why the graphite have exceptional resistance to turn-in thermal shock, low co-efficient of expansion distortion. However, graphite moulds are highly susceptible to damage and breakage, and must be handled with care.

Large deposits of low grade graphite are found at Mayo Bytale, Hossere Nuwa, Gayam, and Jauro Jalo in Taraba/Adamawa State. Traces of it have also been recorded in South-Eastern and south-western Nigeria.

Table 2.33. Locations of Graphite

S/N	STATE	LOCATIONS	ESTIMATED RESERVE	REMARKS
1.	Niger	Rafi, Minna	1.1 million M/T 3.3 million M/T	Exploratory work carried out
2.	Gombe	Akko, Gombe		
3.	Taraba	Gayam, Jauro-Jalo (Gashaka)		
4.	Katsina	Dutsin-ma, Kankara	N.A	Not investigated

2.16. TRONA

Trona (kanwa) also known as potash is one of the complex salts which is used for the production of Soda-ash.

Uses

Soda-ash is an important raw material in the manufacturing of glass. Soda ash is presently wholly imported to meet current annual national requirement of about 30,000 tonnes.

Occurrences of Trona

Trona ore contains over 60% of sodium carbonate and are found in large quantities in Lake Chad Basin, Borno, Yobe, Taraba, Adamawa and Bauchi State. The chemical analysis of the trona ore from Borno State revealed that it contains 20-26% pure ash which means that the trona deposit in the country can be economically refined. Table 2.34 shows the locations of the deposits, table2.35 shows the chemical composition of Kanwa from Manga, while table 2.36 presents the specifications for industry.

Table 2.34. Locations of Trona Deposits

S/N	STATE	LOCATIONS
1.	Yobe	Gashua, Machina Nguru, Tuda, Kanamma, Yumusari
2.	Adamawa	Song, Mayo-Balwa
3.	Bauchi	Alkaleri, Gamawa, Kirfi
4.	Borno	Boga, Kakana, Manga
5.	Taraba	Zuno

Table 2.35. Chemical Composition of "Kanwa" from Manga, Borno State.

COMPONENT	**(%)**
NaCl	3.47
Na_2CO_3	20.00
Na_2SO_4	26.53
$CaCO_3$	30.08
$CaSO_4$	2.00
Insolubles	14.00
Water	3.20
	100.00

Source; Mineral and Industry in Nigeria 1978, P.40.

Table 2.36. Specifications for Soda-Ash in Industries:

For Detergent	%	For Glass	%
Na_2CO_3	97.5 min	Na_2CO_3	98min
Moisture	2.0 max	$NaCl_3$	0.3
$NaHCO_3$	2.0 max	Fe_20_3	0.003
Fe ppm	20 max		
Ni + Cr ppm	10 max	$NaHCO_3$	0.10
Cu ppm	1		
Ar	10		
Water insoluble	0.5		
Dense bulk density	1005		
Light bulk density	500		

Appearance: white crystalline powder

2.17. BAUXITE

Aluminum is the most abundant metal in nature representing about 8.2% of the earth's crust. Bauxite is currently the main source of the ore for the production of alumina from which aluminum is smelted. There are known occurrences of bauxitic clays in the following areas of the country.

i)	Mambila Plateau	-	Taraba State
ii)	Giro and Shilto	-	Kebbi State
iii)	Tungan Magaji	-	Sokoto State
iv)	Biu	-	Yobe State
v)	Longuda	-	Bauchi State
vi)	Orin Ekiti	-	Ektiti State
vii)	Barakin Ladi	-	Plateau State
viii)	Oju, Workum Hills	-	Benue State
ix)	Oban Hills	-	Cross River State

However, large commercial exploitable reserves of bauxite that could justify the setting up of alumina plant in the country are yet to be found.

2.18. ZIRCON

Zircon occurs as a wide spread accessory of alluvial tin concentrate especially around Jos, Odegi, Bauchi, Kaduna and Ondo States. Contains $ZrSiO_4$ than 90% and impurities $SiO_2 + Al_2O_3 + TiO_2 < 2\%$. It is got by processing natural zircon sands and has refractoriness of between 2100^0C and 2200^0C.

Table 2.37. Locations of Zircon

S/N	STATE	LOCATIONS
1.	Nasarawa	Keffi, Wamba
2.	Plateau	Jos, Mangu, Bassa, Riyom, Barkin-ladi
3.	Bauchi	Dass, Toro
4.	Kaduna	Birnin Gwari, Jaba, Kaura
5.	Taraba	Gshaka, Karin-Lamido, Sardauna Takum, Ussa

2.19. AMETHYST

Amethyst is an essential constituent of acid igneous plutonic rocks such as granites, granodiorites and pegmatite. It may also be present in some diorites and gabbros where it always occurs as shapeless interstitial grains in extrusive and hypabasal rocks such as rhyolites, dacites, pitchstones and various porphyries. Quartz often occurs as phenocrysts, often with corroded edges.

This is a transparent, purple, semi-precious variety, with impurities of ferric iron giving the colour. The colour fades on exposure but may be partly restored by moistening the crystal.

Heated alone before the blowpipe, amethyst is unaltered. It is soluble in borax and carbonate beads; but insoluble in the microcosimic salt heat test.

Location in Nigeria

Amethyst is been mined in Bauchi, Kaduna, Kano and Oyo States.

2.20. SAPHIRE

Saphire occurs in silica poor rocks such as Nepheline syenites, and other under-saturated alkali igneous rocks. It occurs as veins and segregations associated with peridotite. It may also occur in contact aureous in thermally altered alumina rich shale or impure limestone and, in aluminous zenoliths found within basic igneous rocks, where it is found in association with spinell, cordierite and orthopyroxene.

Saphire is not acted on by acids. Its hardness and physical properties are usually distinctive. Finely powdered sapphire heated with cobalt nitrate on charcoal assumes a fine blue colour.

Saphire Deposits in Nigeria

Saphire has been mined in Antah and Gidan Waya in Kaduna State, Gunda in Yobe State, Mambilla Plateau in Taraba State; Bogoro in Bauchi State and Bokkos in Plateau State.

The quality ranges from rich indigo blue to pale green and colourless varieties. The Antah/Gidan Waya deposits produce tabular, rich to dark blue crystals while the Gundon and Mambilla Plateau Saphires are in fine pencil shape – crystals with blue rich colour. The colour intensity of the dark blue variety which constitute a sizable portion of the mine output, may be eliminated by application of appropriate heating technology for colour enhancement.

2.21 ASBESTOS

Asbestos is a group of silicate minerals that occur as fiber forms with high tensile strength. Asbestos occur naturally in certain geological settings in association with ultramafic rocks and along associated faults.

Asbestos Deposits in Nigeria

Deposits of asbestos are found in River Kawo, Kontagora in Niger state; and Faskari in Katsina state.

2.22. KYANITE

Kyanite is a polymorph with two other minerals:- andalusite and sillimanite. Kyanite has a unique characteristic in that it has a wide variation in hardness, in the same crystal. It is used in the manufacture of spark plugs, refractory etc.

Deposits of Kyanite in Nigeria

Deposits of kyanite are found in Rafi and Shiroro in Niger state; and, Tugan Bargwana in Kaduna state.

2.23. TOURMALINE

Tourmaline is a group name for several different, but closely related minerals. Members of tourmaline group are favorites of mineral collectors because of their rich and varied colours. Tourmalines are cut as precious gems, carved into figurines, cut as cabochons, etc.Tourmalines are piezoelectric and pleochroic. The four most common and well known tourmalines-(Elbait, Schorl, Dravite and Uvite)- are distinguished by their colour and transparencies.

Table 2.38. Tourmaline Deposits

S/N	STATE	LOCATIONS	REMARKS
1.	Cross River	Uwet	Pegmatite source rock
2.	Nasarawa	Nasarawa Eggon	
3.	Ekiti	Ijero-Ekiti	

4.	Katsina	Faskari, Kurfi, funtua, Bakari	Further investigation necessary
5.	Niger	Rafi	Not being exploited
6.	Oyo	Oluyole	
7.	Taraba	Bali, Gashaka,, Sardauna	

AQUAMARINE

Aquamarine is one of the most popular gemstones, and distinguishes itself by many good qualities. It is a fascinating beautiful gemstone and belongs to the beryl family. The colour of aquamarine is even and often free of inclusions Aquamarine is found in Olode and Oluyole, Oyo state; and, Jama'a in Kaduna state.

2.24 SILLIMANITE

Sillimanite is an alumino-silicate mineral with the chemical formula Al_2SiO_5. It is one of the three alumino-silicates polymorphs, the other two being andalusite and kyanite. A common variety of sillimanite is fibrolite because the mineral appears like a bunch of fibres twisted together when viewed under thin section or even by the naked eye. Sillimanite is an index mineral indicating a high degree of metamorphism.

Sillimanite deposit is found in Okekalu, Oyo state.

2.26. FLOUSPAR

Flourspar is used in the manufacture of steel, hydrofluoric acid and ceramic products. Fluorite and barite occur together or separately in hydrothermal veins or other cavity-filled deposits and in replacements, generally formed at low temperature. Although both fluorite and barite may be produced from the same

deposits, generally the deposits of fluorspar occur in different areas from the deposits of barite.

Table 2.39 Flourspar Deposits

S/N	STATE	LOCATIONS	ESTIMATED RESRVE	REMARKS
1.	Ebonyi	Onicha, Ohaozara	No available	Need for further investigation
2.	Benue	Katsina-ala	Estimated to be more than 500,000 tonnes	Mining activities are on in some locations
3.	Taraba	Wukari		

CHAPTER THREE

OVERVIEW OF MINING AND PROCESSING OF SOME NON-METALLIC MINERALS

3.1 FELDSPAR

Scope of Beneficiation:

Exploration for feldspar deposit is fairly simple in that it involves mainly basic mapping for pegmatite, aplites and granite deposits that are highly enriched in feldspar. Most pegmatite or aplite ores of feldspar are mined by conventional open-pit methods through the removal of overburden, drilling and blasting.

Reserve estimation of known available deposits has to be evaluated to enable interested industrialists and investors sourcing for them locally to be sure it can

meet their requirement and need for production and supply. Not much work has been carried out on the deposits\ evaluation in terms of the chemical and physical properties, which are equally important to industries. The widespread occurrence of feldspar and its relatively inexpensive cost of supply create the needs for more local exploratory and quarrying work to be carried out as well as establishment of more processing outfits.

Feldspars to be effectively used in the ceramics industry required to be processed into fine grain particles and those for other uses have a specific grade requirement thereby pointing to the importance of processing. There is a few commercial miners and millers of feldspar deposits in the country, however the production and beneficiation is limited.

There is need for the establishment of more feldspar grinding and processing plants.

Processing:

The traditional method of feldspar production by hand selection of large feldspar crystals from pegmatite deposits, is being increasingly replaced by bulk extraction and application of beneficiation techniques such as, froth flotation and magnetic separation, to enable the removal of accessory minerals and iron bearing impurities present in the feldspar.

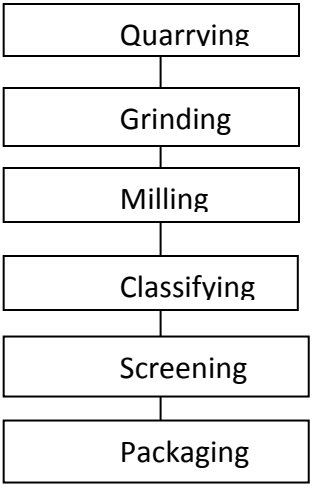
The degree of grinding depends upon the final use of the materials. With grade, feldspar is coarse followed by ceramic grade, and finally finely ground grade for fillers and extenders.

The froth flotation techniques provide more practical means of separating feldspar from associated mica and quartz minerals. This technique involves the crude ore being crushed, ground and screened to yield a suitable liberated mesh size, which is then deslimed. The micaceous minerals are removed through amine collectors in an acidic environment. Following the dewatering of the feed in a classifier or cyclone to remove the reagents, pH is lowered by sulphuric acid, and petroleum sulphonate is then used as the collector for iron bearing minerals removal. Following further dewatering, the feldspar is floated from quartz in a hydrochloric acid environment, again using amine as the collector. The resulting feldspar flat concentration is dewatered in a drain bin or over a vacuum filter for centrifuges and is dried, screened and bagged.

There are also wet processing mills with simper separation techniques. Here, the wetted ore is put through a large hammer mill, then a rod mill and screens, reducing it to 20 mesh. It is them passed via scrubbers and classifier circuits before spiraling to remove biotite, ilmenite and rutile. The remaining material is then dewatered on drain bins and dried in a rotary dryer. After this, it is passed over high intensity magnetic separators and stored in silos for packaging.

In cases where the ore is relatively pure, feldspar can be processed much cheaper by simple milling in harmer mills, rod mills, or ball mills. Depending on the amount of iron bearing impurities in the ore, and the use to which the feldspar is to be put into, the simple milling process may or may not be followed by magnetic separation.

Fig. 1 SIMPLE FLOW DIAGRAM FOR FELDSPAR PROCESSING



3.2. KAOLIN

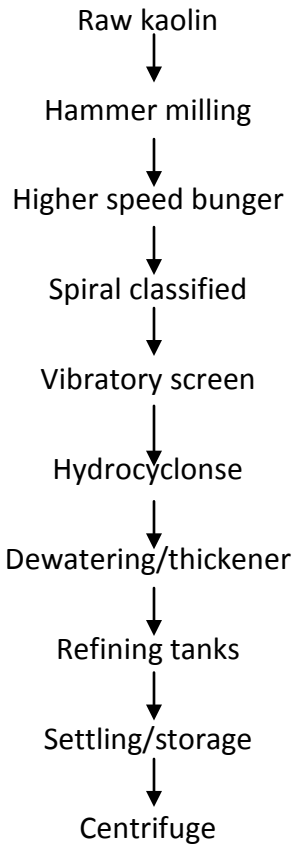
Kaolin is an important industrial mineral raw material which occurs in abundant quantities in many parts of Nigeria and can be processed to various grades required by different industries. It is a versatile industrial material of wide application in cosmetic, pulp and papers, chalk, plastic, soap, agro-allied and pharmaceutical industries, etc.

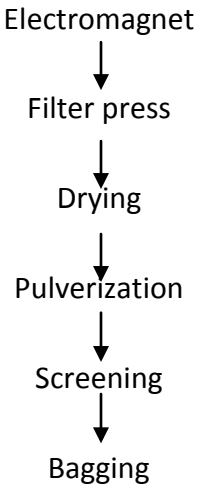
Processing Technology:

Mined kaolin is crushed and mixed with water into a slurry. The slurry is pumped into degritting equipment and then stored in tanks for further processing. The slurry can be decolorized by a chemical leaching process, and by magnetically separating iron contaminants. The Kaolin particles are removed from suspension using press filters, rotary filters or continuous centrifuges. The filtered cake can

be dried in apron dryers or sprayed-dried. It may be processed further to improve properties. The flow sheet diagram for the beneficiation of Kaolin is shown in fig. 1. The equipment require include blungers, hydrocyclones, serves, tanks, filter press, dryers, hammer mills, calciners, pumps conditioners, floatation machines and weighing/bagging machine

Fig. 2: FLOWSHEET DIAGRAM FOR THE BENEFICIATION OF KAOLIN





3.3 TALC

Mining

Techniques of mining mica in Nigeria are primitive in some cases. Typically, ore is dug especially where the depth at which it is found is not deep. Heavy equipment is currently employed to exploit the material using the dredge and the excavator. Mica can be dressed by hand sorting and washing. Raw mica from the mine in lumps is washed and separation takes place by removing other impurities such as quartz, if wet, it is then dried.

Beneficiation:

Nigerian talc deposits are coloured and hence require bleaching treatment before usage. Some of the Nigeria talc are being exploited and sold as raw material to some pharmaceutical and cosmetic industries. In spite of the high demand for the product, it is important to note that the level of talc processing is very low in the country.

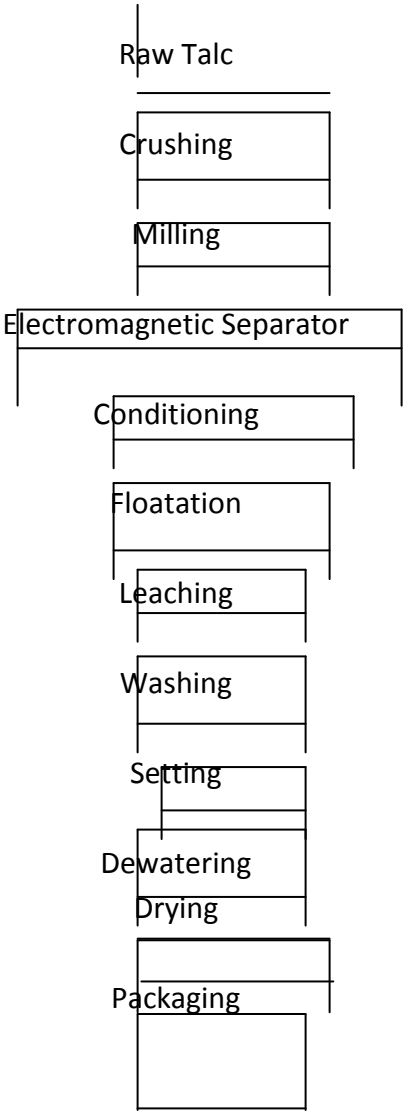
However, since most of the talc deposits are yet to be quantified, there is need for detailed mapping, extensive drilling, sample collection and laboratory analysis of talc deposits in the country. Two processing companies have been established in Niger State – Kagara Talc Company and Crystal Talc Company.

Processing:

Raw talc is crushed in a jaw crusher, screened in a rotary screen and milled in a hammer mill fitted with a cyclone and finally in a pebble mill. If the talc product from the pebble mill is white enough and satisfactory, it is then packed.

However, for the contaminated talc, the product from the pebble mills is fed into floatation cells and into a hydrocyclone assembly for thickening. The product from the floatation cells is bleached with acid before going through the cyclone. The product from the cyclone assembly is dewatered. The cake is granulated in a disintegrator, and dried in flash dryer. The dried talc is pebble-milled to the required particle size before packaging.

Fig. 3 **FLOW DIAGRAM FOR TALC PROCESSING**



3.4 TRONA

Production of Soda Ash from Trona:

Soda Ash, also know as Sodium carbonate (Na_2CO_3) is one of the most important inorganic chemicals. It is one of the two principal commercial alkalis, its principal competitor being Sodium Hydroxide (caustic soda)

Processing Method:

During the eighteenth century, soda Ash producers resorted to burning seaweed which was hence leached with hot water and evaporated to give a form of soda ash. Soda Ash can be produced by the following processes.

a. **Leblanc Process:**

This was the oldest method used between 1823 and 1885. This method use salt, sulphuric acid, coal and limestone;

b. **Solvay Process:**

This method superseded the Leblanc process and is the most popular method of soda Ash production especially in USA, Europe etc, the solvay process is used in the production of synthesis Soda Ash.

c. **Trona Purification Method:**

The Trona purification process is considered to be the simplest and cheapest method. Trona is the raw material for the production of soda Ash.

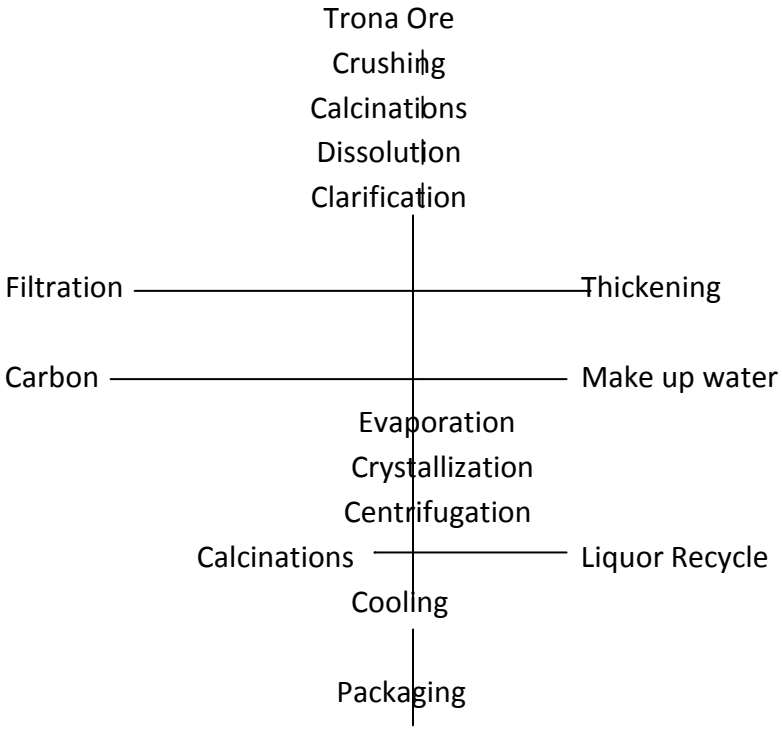
i. The mono-hydrate process in which the trona ore is calcined to impure soda ash which is then purified.

ii. The carbonate process which produces soda ash from Trona by calcinations of the carbonate obtained from Trona.

In the monohydrate process, the trona ore is crushed and calcined in a rotary kiln 160 – 200^{o}c. This treatment results in the decomposition of the sodium carbonate with liberation of water and carbon dioxide. The impure soda ash so

produced is dissolved in water where insoluble materials like shale, clay and other complex salts are separated from the near saturated soda ash solution. The filtered liquor is treated with activated carbon to remove soluble organic compounds and to reduce foaming during evaporation to produce crystals of sodium carbonate monohydrate. The monohydrate crystals are dehydrated at about 150^{o}C to produce the pure Na_2CO_3 – Soda Ash.

Fig. 4. <u>FLOW DIAGRAM FOR THE PRODUCTION OF SODA ASH FROM TRONA ORE</u>



Machinery and Equipment:

The machinery and equipment for processing Trona Ore into Soda Ash include crusher, pulverzer, rotary dryer, mixer, sedimentation tanks, filter press, thickener, evaporator, steam boiler, weighing and bagging machine.

Uses of Trona/Soda Ash:

Trona, the major raw material needed for the production of soda ash is also used in cooking and production of animal feeds in combination with cereal, tobacco, etc.

Soda ash, one of the important inorganic chemicals, is one of the two principal commercial alkalis, its principal competitor being sodium hydroxide (caustic soda), is commercially used for the following:

- In the manufacture of glass, soda ash is used a flux;
- Manufacture of various chemicals which include:
    - Sodium silicates
    - Phosphates, etc.

It is also used in production of:

- Paper
- Detergents and soaps, and
- In the petrochemical industries

3.5 DIATOMITE

Mining and Processing:

Diatomite deposits are worked by quarrying or open pit method. Commercial deep sites are mined by surface, underground and under-water method. In quarrying, after removal of the overburden, the crude ore is ripped by bulldozers and taken away by scraper, front end loaders and trucks. Quarries are usually mined in benches with the crude ore being stockpiled according to properties such as colour, wet and dry density, filtration properties and purity. At smaller operations, dry seasons can be used to their full advantage to allow sun drying of the ore. The moisture content of the diatomite, which may be as high as 60% can be reduced to less than 20%. Smaller operations also use hand selection in narrow beds to separate chert lenses and carbonate inclusions.

In industrial practice, it is found that a diatomite deposit suitable for a particular application may be virtually unsatisfactory for another. The method of assessing or determining the quality of a deposit and its suitability for a specific use is based mainly on the physical and chemical composition of the deposit which can be determined when necessary analyses are carried out.

To process diatomite, the bulk material is crushed and separated from impurities by suspension in hot air blowers. About 90% of the milled product is calcined at $1{,}000^{0}$C to fuse the finer particles and remove volatiles, as this increases its absorptive properties and reduce the production of the fines in handling.

Owing to the high moisture content of the crude ore, the mill is almost always located as near as possible to the mine. Great care must be taken during the milling and processing stage to preserve the particular shape and structure of

the diatom skeleton. Since this is the physical structure of the diatom property that set diatomite apart from other forms of silica. The crude diatomite is crushed in spiker rolls, and hammer mills to less than 13mm. this is the preferred comminution process since others tends to destroy the diatom structure and hence its usefulness in the final product.

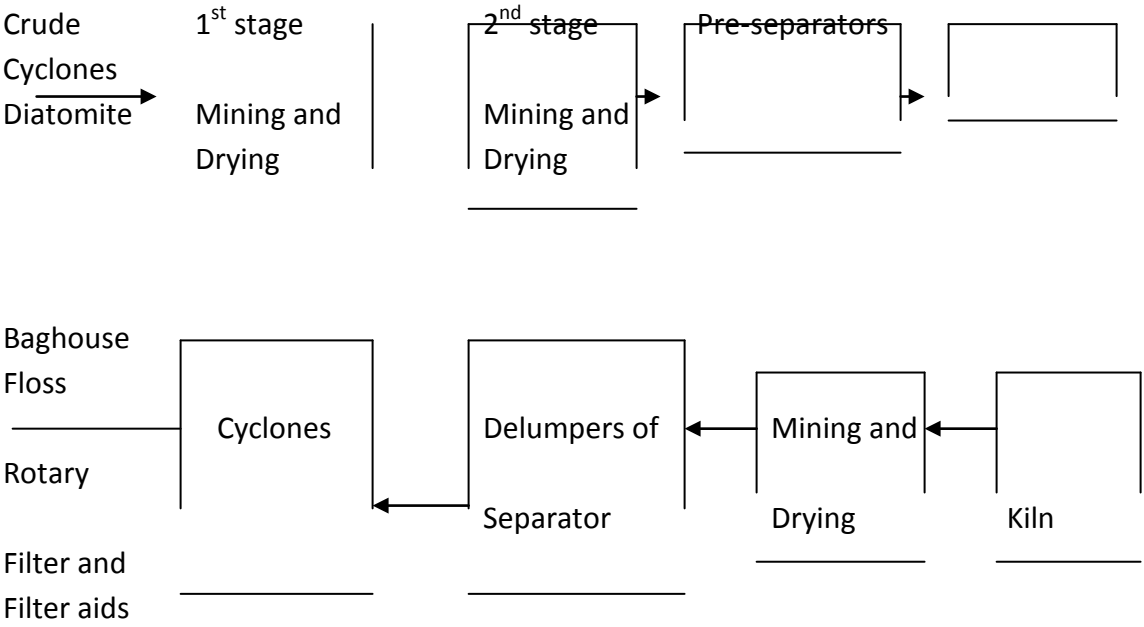
Primary crushing to aggregate size is followed by simultaneous milling and drying during which the crushed diatomite is conveyed in heated air through milling fans in stages until the appropriate moisture reduction is achieved. The dried diatomite is collected in air cylones and separated into various size with coarse, denser accessory minerals being removed. Diatomite processed in this way is then bagged or handled in bulk and sold as a natural milled products.

If additional particle size distribution adjustment is required e.g, for filter aids, diatomite powder is sintered or as it was traditionally termed calcined in rotary kilns before under going further milling and classifying. When processed through a rotary kiln at typical temperature of 870^{o} – 1090^{o}C the organic residues are burned away, the diatom structure shrinks and hardens, and some diatom and fragments are sintered into agglomerates.

The soft agglomerate discharge is reworked through milling fans, air separators, and vibratory screens to give various product grades. Owing to the oxidation of included iron, the resultant products are pink in colour and posses dry densities of about 128kg/m_3 and have greater filetration rates than their natural counterparts usually, of medium flow rate grade. Should grades processing faster flow rate be desired, while sintered diatomite products can be produced through the addition of a flux e.g. soda ash or sodium chloride, before the

sintering state. The action of the flux causes the iron oxides to enter a glassy phase and additionally produces a greater agglomeration of diatom fragments. By controlling the kiln temperature, the amount of composition of flux, and retention time in the kiln, the particle size of the diatomite can be controlled to produce with differing filteration rates to meet specific market requirement.

Fig 5. **Typical Diatomite Processing Flow Sheet**



3.6 MICA

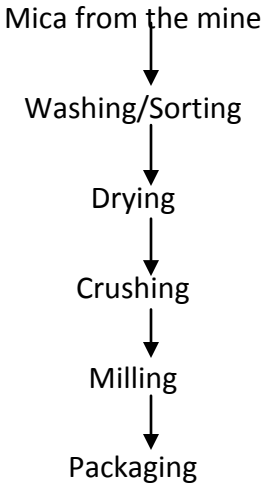
Processing:

Drying grinding is essentially a straight forward and simple process. Mica is fed into the crushing plant. The pre-crushed plant is fed into a mill and the oversized material returns back to the mill. The ground mica is graded on vibrating screens with mesh range 16 – 100, and bagged for marketing. Depending on the requirement, a micronising mill is fed with the end product of the initial milling operation and classified.

Built up mica or micanite, is made by overlapping small flakes of mica in uniform layers and alternating these with a cementing application agent. The whole is then bonded by the application of heat and pressure. In a similar manner, glass bonded mica is made by pressing together, ground mica and powered boro-silicate glass.

Reconstituted mica is produced by the partial exfoliation of high quality scrape mica which is then processed through a modified paper making machine as pulp to produce mica paper.

Fig. 6. **MICA PROCESSING FLOW CHAT**



3.7 GYPSUM

Processing Technology:

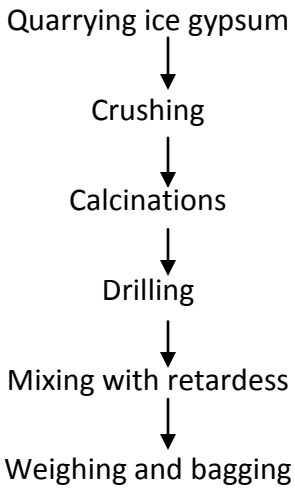
Generally, the process involves quarrying, blasting, crushing and milling. This project is expected to concentrate in grinding operations.

Gypsum ore, from quarries and underground mines, is crushed and stockpiled near the plant. A needed, the stockpiled ore is further crushed and screen to about 5.0 millimeters (2 inches) in diameter. If the moisture content of the minded ore is grater than 0.5 weight percent the ore must be dried in a rotating dryer or heated in heated roller mill. Ore dried in a rotary dryer is conveyed to a roller mill, where it is ground to the extent that as percent of it is less than 149 micrometer (MM) or (100mesh). The ground powders are now bagged for sale.

As Plaster of Paris:

When gypsum is heated to a temperature of between 130OC and 180oC, it losses a proportion of its water or crystallization and form a quick-setting cement known as Plaster of Pairs. The calcinations of gypsum can be carried out ether in a kettle or rotary kiln. After the calcinations, the product is ground to about 75 – 120mm. The flow diagram is in fig. ... Equipment required is washer, dryer rusher (hammer mill), calciner, miller, sieve and bagger

Fig. 7: FLOW OF DIAGRAM FOR GYPSUM PROCESSING



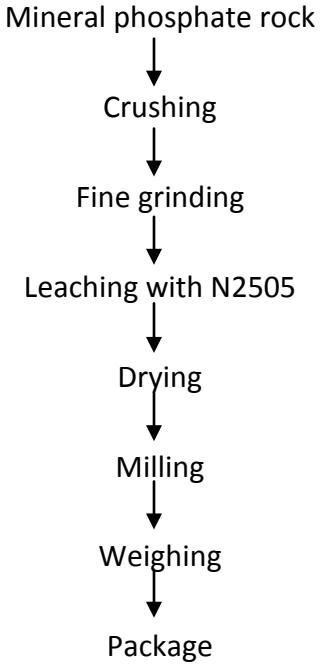
3.8 PHOSPHATE:

Phosphate rock is found in Sokoto, Ogun, Anambra, Bendal and Imo States.

Processing:

Raw phosphate rock is fed into rotary washeRs where water is added to wash the rocks it is then crushed milled and classified. The classified material is leaded with suplphuric acid. The leaded material is then dried, milled and screened. Finally the materials weighed and bagged. The equipment needed are:- rotary washers, trammel, rusher, screen, classification floatation machines, tanks and silo hammer mill, weighing bagger equipment.

Fig 8. FLOW DIAGRAM FOR PHOSPHATE PROCESSING



3.9 BARYTE:

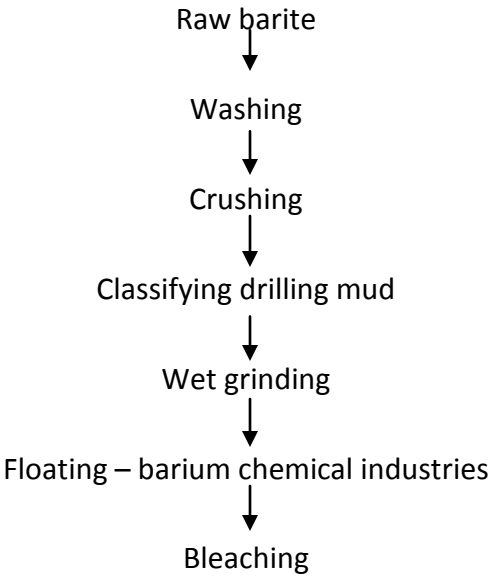
Barytes, BaS04, is the most common barium mineral which occurs principally as a ganzue mineral in the hydrothermal metallic ferrous. It is widely distributed in van, lenses, clarify fillings or replacement deposit in limestone. Baryte is used as drilling mud in petroleum industry, fillers in plastics industry, production of barium chemicals, additive in glass manufacturing, binder in ceramics industry and primers and anti-corrosive agents in pain industry.

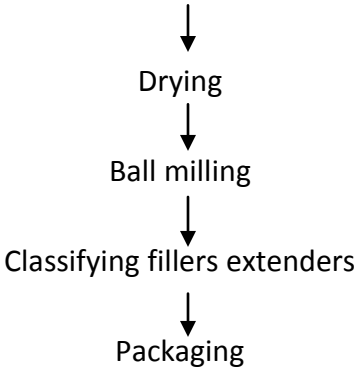
Processing:

Raw barite is washed to remove adherent argillaceous impurities. The washed barite are crushed at 90 - 100 mesh and fortes impurities removed by leading. The leached solution is pumped into a precipitation tank where it is reached with sodium sulphate to precipitation barium sulphate. The white precipitate of barium sulphate is filtered, washed, dried, pulverized and packaged.

The required equipment include; jaw crusher, trammel, screen, mills, electric hoist, blenders, furnace, leaching tanks, filters, dryer reactors conveyors, weighing and bagging devices. The flow diagram is in fig. 9

Fig. 9 FLOW DIAGRAM FOR BARYTE PROCESSING





3.10 BENTONITE

PROCESSING

Most bentonite is mined by open pit or stripping method; but underground method is used in a few places. Because of variable physical properties, most bentonite deposits are selectively mined.

Processing consists of three main steps:

- Separation of undesirable impurities that decrease the relative contents of montmorilonite in the natural state and reduce its quality;
- Physio-mechanical beneficiation;
- Chemical-mechanical activation.

Generally, when bentonite is to be applied in its natural form, it is homogenized, dried and milled to the required grain size.

The clay is processed dry or in some cases, wet. In most plants, the raw bentonite is passed through some sort of clay slicer to break up the large chunks

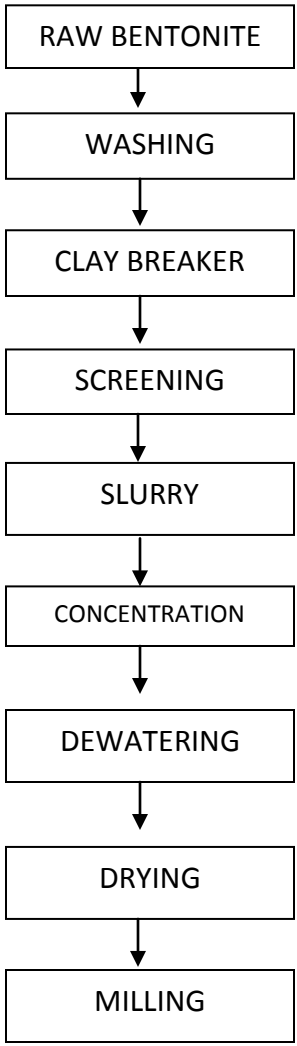
before drying. Gas or oil-fired rotary dryer as large as 10 metres in diameter and 100 metres long does the drying in most plants. The temperature in dryers varies with the intended use of the clay. The desirable properties of both bentonite and colloidal grades of fuller's earth are reduced greatly if the clay is heated too much. The temperature in the dryer is to be approximately 800^0C at the inlet, 100 to 200^0C at the outlet, and 400 to 500 ^{0}C in the main drying zone. The bentonite itself is kept at temperature less than 150^0C. Grinding may include rods in the rotary dryers while others utilize roll and hammer mills.

Where more exacting products must be produced, as in the case of bentonite for certain pharmaceutical uses wet processing is used. The general processing steps are particle size fractionation (that is separation into coarse and fine particles); leaching out iron impurities; dewatering by filtration; and, drying and pulverization. Fractionation is done by centrifuges, filter presses or rotary vacuum drum filters, and drying by rotary, apron, drum or spray dryers. Where Sodium activation of the bentonite is necessary, any of the following three processes can be adopted:

- Dry technology where dried bentonite is milled jointly with sodium carbonate;
- Wet (or paste) technology where raw bentonite is moistened with water solution of sodium carbonate to form plastic paste, activation occurs during kneading;
- Activation in slurry where sodium carbonate is added to the suspension of bentonite.

The dried clay is ground to the required particle size.

Fig. 10. FLOW SHEET FOR BENTONITE PROCESSING



Scope of Beneficiation

Bentonite can be applied in its natural form in many industrial applications e.g. metallurgy, textiles, ceramics, papers, agriculture etc. However, for more specialized uses, beneficiation and activation is required as follows:

(i) Sodium-activated, using sodium carbonate as activating agent;
(ii) Acid-activated, using mineral acids as agent;
(iii) Organic-activated, using hydrochlorides of long chain organic amines.

The greater part of the current national demand of bentonite is being source through import in spite of the following:

(i) There is indication of enough bentonite reserve in the country;
(ii) It is on record that between 1960 and 1964, bentonite clays from Edo State were employed by the Shell Dark Company for drilling operations and those from Afuze area were used in 1973 during drilling operations for coal by the defunct National Steel Development Authority;
(iii) Research findings have shown that the calcium bentonite in the country can easily be upgraded to sodium bentonite.

A major setback in the processing of Montmorillonitic clays into commercially acceptable grade is their appearance. Because they are derived from mostly marine shale, they are usually enriched in organic matter, which colours them black or grey. As such most of the prospective miners of bentonite in the country today are eyeing the drilling mud market where colour is not a very critical factor. However, the production of bentonite needs to be encouraged through:

- Detail geological mapping, core drilling and sampling, etc;
- Laboratory testing of physical, chemical and mineralogical properties and;
- Processing of local bentonite.

As at now, only a few companies are known to produce bentonite in the country, and most of them process wholly imported sodium bentonite for use in the industry. They are:

(a) Baroid Nig. Ltd. 474, Trans-Amadi Industrial Layout, Port-Harcourt.
(b) Magcobar Manufacturing Nig. Ltd. P.M.B. 5123, Port-Harcourt
(c) Kragha and Associate, Apapa road, Ijora, Lagos.
(d) Suritilo Co. Ltd. P.O. Box 17, Maiduguri.
(e) M-L Nigerian Limited, Port-Harcourt.
(f) Dowel-Schlumberger, Port-Harcourt.
(g) Star/AP Nigerian Limited, Port-Harcourt.
(h) Mill-PARK Nigerian Limited, Port-Harcourt

On her effort towards local sourcing and development of bentonite, the Raw Materials Research and Development Council with some private investors established the Integrated Solid Mineral Processing Plant in Owerri, Imo State, for the processing of bentonite and other industrial non-metallic minerals.

CHAPTER FOUR

BRIEF ON ACTIVITIES OF RMRDC ON THE SOLID MINERALS DEVELOPMENT AS INDUSTRIAL INPUT

The Raw Materials Research and Development Council was established through the Federal Government Act No. 39 of 1987. The Council was charged with the primary responsibility of promoting, supporting and expediting industrial development and self-reliance through optimal utilization of local raw materials (both agro and minerals) as input to the nation's industries. The activities of the Council in this sector focused mainly on the value-addition to raw materials and the development of alternatives for imported raw materials. The Council also provides information to prospective investors on processing of the mineral raw materials, and quality/grade assessment through chemical and physical laboratory analysis.

The Council has been promoting the development of resource-based industries in Nigeria, as part of its primary mandate. The challenge of appropriate delivery of industry-related services to the private sector becomes critical to the realization for the overall mandate of the council. Indeed, the promotion of resource-based industries is seen as a strategy towards the implementation of

the National Economic Empowerment and Development Strategy (NEEDS) and State Economic Empowerment and Development Strategy (SEEDS).

DEVELOPMENT OF INDUSTRIAL MINERALS

In 1991, before the advent of the Solid Minerals Development Ministry, the Council in collaboration with UNIDO organized an international forum to sensitize and promote industrial mineral processing in Nigeria. As at 1991, only few industries were involved in industrial mineral processing, for example, it was only Kavitex Nig. Ltd. that was involved in the production of technical grade kaolin. The local production was less than 2,000MT/A with the national demand far above 10,000 MT/A, the gap was met through importation.

After the forum and subsequently through segmented promotional activities, a lot of investors embarked on the development of industrial minerals. From 1991 to date there are over 33 industries that are involved in the production of the following solid mineral products:

(i) Technical grade kaolin;
(ii) Calcium carbonate;
(iii) Feldspar;
(iv) Talc;
(v) Hydrate lime.

For example, as at 2003, the annual local production of technical grade kaolin amounted to over, 150,000 MT which was above the annual national demand of about 100,000 MT. This trend has continued and presently, the annual local production of the industrial minerals exceeds the annual national demand.

Based on the successes achieved in the sector, the Council through the Tariff Board advised the Federal Government to ban the importation of some industrial minerals such as:

(i) Technical grade kaolin
(ii) Hydrated lime
(iii) Calcium carbonate
(iv) Talc
(v) Feldspar, and
(vi) Gypsum

The Council also embarked on the development of other specialized grades of industrial minerals such as:

(a) Pharmaceutical grade kaolin
(b) Production of calcined kaolin
(c) Pharmaceutical grade talc.

The pharmaceutical grade kaolin project is jointly established by the Council and Katsina State Government. The project is sited at Kankara and it is almost completed. The expected installed capacity is about 2,000 MT/a. When completed the ban on importation of industrial minerals will also be extended to pharmaceutical grade kaolin.

Calcined kaolin is being developed as a substitute for imported titanium dioxide in the paint industries. The project is still at the laboratory (R&D) stage, but the result of the preliminary stage has been found to be able to replace 5% of titanium dioxide in paint production. A 5% reduction in the importation of this substance will amount to a saving of over N200m per annum.

The production of pharmaceutical grade talc from the available talc mineral deposits has been done at the laboratory (R&D) stage. The expected talcum power when commercialized will replace the imported powder.

Relatedly, the Council commenced interactions with the Nigerian content committee of NNPC and Chevron with a view to generating the synergy on sourcing and processing of some vital minerals in the Petroleum sector, notably barite and bentonite. It is worthy of note that the Council has been collaborating with some oil companies such as Chevron and NNPC on local sourcing of bentonite and baryte.

An Integrated solid Mineral processing was established to process non-metallic minerals resources especially diatomite, bentonite, kaolin, barite, limestone, etc. The target markets are the petroleum prospecting industry and other industries utilizing non-metallic minerals as fillers such as paint, soap and detergent, and the paper products industries. It had both backward and forward linkages to mining and mineral processing respectively. The multiplier effects are numerous in terms of raw materials supply to industries and job creation.

Whilst RMRDC facilitated the establishment of this plant, ISOMP is a good example of a private sector-driven partnership. RMRDC has, through this project, built local capacity in the maintenance and supply of spare parts of the Bradley-type roller mill.

Kaolin processing: the effort of the Council was to promote processing of raw kaolin into both technical and pharmaceutical grades respectively. Currently, the plants process milled technical grade kaolin to the paint, foam and paper making

industries. The Katsina plant is integrated to produce pharmaceutical grade kaolin, for pharmaceutical industry for drug formulation and production. There is equally high demand for this grade by the cosmetic and toiletry industries.

Talc processing, was to stimulate the emergence of small and medium scale enterprises (SMEs) in this sector.

The Country has been importing talc estimated at well over six million US dollars ($6.0million) per annum. The project has the potential to reduce the importation of talc and therefore save foreign exchange. Other similar plants e.g. Crystal Talc Nigeria Limited, have been established in Niger State following this initiative. To enhance production and increase market, a pulverizer is to be incorporated.

Phosphate processing, the phosphate plant was set up to beneficiate phosphate available in the state as feedstock to the fertilizer industries in the country. In 2004, the Country imported ten million US dollars ($10.0million) (CB?N 2004 report) worth of phosphate. The high demand of milled phosphate by fertilizer blending companies makes this project very critical to both the agricultural and manufacturing sub-sectors of the economy.

The pioneering efforts of RMRDC on phosphate led to the establishment of at least 5 phosphate processing plants:

- Kamiyya Phosphate Mill Ltd.
- Chiso Phosphate Mill Ltd.
- Bayaks Phosphate Mill Ltd.
- Mainaco Phosphate Mill Ltd.

- Sokoto Phosphate Mills Ltd.

The plant supply 100% of the phosphate needs of the Nigerian Supper Phosphate Plant, Ltd. Kaduna representing 40% of the total import. Over three hundred Nigerians are gainfully employed by these companies. In addition, local engineering capabilities in the design, fabrication and installation of phosphate processing plants were promoted by the Council.

Limestone processing: the project initially established to produce granulated limestone targeted the NAFCON, Onne, Rivers State as a key user industry. Due to the closure of NAFCON, the plant diversified into the production of high quality barite, to services the Nigerian Oil Industry. The current production level at the factory is 100MT/day with the capacity to ultimately produce 90,000MT/A. However, the production of granulated limestone will resume with the expected activities at the NOTORE Chemicals, the new owners of NAFCON.

In essence, the activities of the Council is to attract investments by demonstrating viability of some projects, and also through improvement in technical expertise of local equipment fabricators, RMRDC has adopted the concept of catalytic or model factories, which is based on the following:

- The need to penetrate areas where the country has competitive advantages in terms of markets, simplicity of technology and availability of indigenous engineering capabilities;
- The need to develop local raw materials in order to fill existing gaps;
- The occurrence of abundant primary raw materials;
- Expected foreign exchange savings;

Based on the above criteria, a number of model or catalytic factories, were attempted in the following areas: Talc, Phosphate, Soda-Ash, Kaolin, Baryte, Hydrated Lime etc.

Information Generation on Mineral Exploitation and Development

In order to ensure an effective stock taking of available raw materials and technology requirements of industries, the Council in 1989 embarked on the first techno-economic surveys and industrial potentials which focused on the 10 industrial sectors. Five of these sectors which are to large extent mineral raw materials based are as follows:-

i) Non-Metallic Minerals;
ii) Base-metals, Iron and Steel and Engineering Services;
iii) Chemical and Pharmaceuticals;
iv) Motor Vehicles and Miscellaneous; and,
v) Electrical and Electronics.

The reports of the earlier surveys conducted have been successfully and periodically updated at intervals of 3 years. The various reports have provided vital data in the following areas:

- Mineral raw materials requirements of the existing mineral based - industries;
- Mineral raw materials that are available locally;
- Imported mineral raw materials;
- Mineral raw materials that are available locally and can be developed to substitute those being imported;
- Technologies/machineries requirement for the conversion of resources into industrial input;

- Potential R&D projects for exploiting and developing the country's national mineral resources etc.

The reports are published in the various publications of the Council and, used in updating the Raw Materials Information System (RMIS) on our website- www.rmrdc.gov.org.

Further to this, is the study on the audit of indigenous and emerging technologies and machinery for processing raw materials. The current effort by the government to encourage local processing of raw materials revealed a number of problems. Among these is the fact that industrial scale processing of various mineral raw materials depends on imported technologies and machinery. Apart from the enormous attendance cost, the issue of non-availability of critical spares and replacement parts for sophisticated equipment, and in a few cases, experienced technical personnel to man the equipment, have given rise to the need to examine other possible means of processing these materials.

At intervals, the RMRDC set up two teams to audit available technologies and machinery for processing mineral and agro-based raw materials. A number of machinery for processing solid mineral raw materials were identified as being fabricated locally e.g. hammer mills, mixers, blungers, blenders, tanks etc. The Council has consistently taken steps to encourage and promote local capability in the design and fabrication of components, equipment, plant and machinery through its biennial Techno Exposition. The last Techno-Expo was held in October 2006.

Information Dissemination on Mineral Exploitation and Development

The aims of the Council's mineral exploitation and development programme are two-fold: Firstly, to stimulate and generate awareness on various solid mineral materials; and secondly, to facilitate an increase in the local production of diverse mineral raw materials which can serve as input for industries in Nigeria. The programme is being vigorously pursued through:

(i) ***The preparation of Technical Briefs***

This involves the collection, collation and synthesis of available information on minerals into technical briefs or handbooks for use by investors and interested organizations. The publications provide information on chemical nature/characteristic, occurrence, industrial uses, investment potentials and status of exploitation of various mineral raw materials in the Country. The Council has so far published technical briefs on the following: Kaolin, Bentonite, Phosphate, Gypsum, Baryte, Trona, Talc, Feldspar, Mica, Diatomite, Silica Sand/Quartz, Gold, Ilmenite, etc.

(ii) ***Promotion of small scale mining***

Small scale mine operators are the basic units that are employed worldwide in the development of solid minerals. They are usually found in areas where large-scale exploitation is considered uneconomical. The Council's headquarters as well as its 29 State Liaison offices are engaged in mobilizing the establishment of State Miners Associations.

(iii) ***Collaboration with Mineral Based Agencies and Industrial Groups***

In pursuance of its primary mandate, the Council interacts with various industrial mineral development and utilization agencies, industrial groups and professional

societies including Mineral Sectoral Groups of the Manufacturers' Association of Nigeria, Geological Survey of Nigeria Agency, National Steel Raw Materials Exploration Agency, amongst others, on sourcing and development of mineral raw materials. The Council also collaborates with relevant Higher Institutions to organise workshops on development of solid mineral sector. For example the Council in collaboration with Benson Idahosa University jointly organized a three-day workshop on "Small-Scale Mining and Investment Opportunities in Solid Minerals Sector" between July 11-13, 2006. The main objectives of the initiative are:

i) To sensitize the investing public on opportunities opened up by reforms introduced by the Federal Ministry of Solid minerals Development;
ii) To examine the problems confronting the solid minerals sub-sector of the economy;
iii) To chart a new direction for safe environmentally friendly and economically profitable exploration, exploitation, processing, extraction and utilization of solid mineral resources.

Preparation of Feasibility Reports and Investment Profiles

The Council as part of its services supply to the public prepares feasibility study reports and investment profiles on resource-based mineral projects. The feasibility study is prepared on cost-shared basis with the entrepreneurs in order to mitigate on cost of entering into a business enterprise. Many feasibility reports and investment profiles have been prepared on various mineral based projects; hence given investors an insight into the viability of mineral resources based investment opportunities.

Advisory Services

The Council renders advisory services to many clients in the areas of raw materials sourcing, machinery and equipment fabrication, provision of information on investment opportunities in mineral resources, pre-investment studies/counseling, linkages between industrialists and mineral raw materials producers, etc.

In order to enhance the capacity of cottage scale mineral processing companies to supply required quantity and quality of raw materials to industry, the Council rose to the challenge of replacing the crude manual implements used by some mineral processing co-operative societies with modern and motorized equipment. For example, in other to ensure increase productivity of the small scale granite crushers scattered in and around Nyanyan area of the Federal Capital Territory, the Council stimulated the formation of a cooperative association known as the United Peoples' Quarry Venture, Nyanyan. In addition, the Council procured a 10 tonnes per day granite crusher to enhance operation. Similarly the Council sponsored the fabrication and installation of a unit of gypsum processing plant for the Bauchi Kaolin and Gypsum Multipurpose Cooperative Society.

The RMRDC being a member of the Tariff Technical Committee of the Federal Mineral of finance and several Presidential Task Forces on the manufacturing sector has found the recommendations from these seminars useful in contributing to discussions on policy issues as they relate to manufacturing in Nigeria.

Technology Exposition

Since inception, the Council has organised eight Technology Expositions wherein the locally manufactured equipment were demonstrate to potential investors. It is pertinent to point out that the Technology Expositions have impacted positively on the nation's industrial sector by creating linkages among stakeholders in the industrial sector as well as generating investment opportunities in resource – based cottage, small and medium scale industrial projects.

Raw Materials Display Centres

The concept of the Raw Materials Display Centre was developed by the Council in order to present available raw materials in the physical forms for ease of identification. In addition, existing processed forms of local raw materials are displayed to show their potential use as alternative imported ones. This is with a view to further elicit interest of has established the Raw Materials Display Centres in each of the 36 state capitals including a unit in the FCT and is currently working at transforming them into resource centres to be known as Raw Materials Information Centres.

Raw materials Information System (RMIS)

The Raw Materials Information System (RMIS) is a computerized databank developed by the Council to generate and provide information to stakeholders on all areas of local raw materials development and manufacturing in the Country. With the RMIS information is easily provided to enquires through simples prompts/clicks on the computer system from any location.

International Collaboration

The Council has some international co-operation on solid mineral development:

(i) Development and Utilization of Non-metallic Mineral Raw Materials (G.- 15 Project)

The Council serves as both the Regional co-ordinator and National Focal Point for Nigeria's project with the Group of fifteen Countries (G-15) under the acronym "Collaboration on the Development and Utilization of Non-metallic Mineral Raw Materials". The objective of this project is to bring about collaborations in order to generate and share technical information; facilitate easy access to new prospecting strategies and processing technologies, and share experiences in the development and utilization of non-metallic minerals among the G-15 Countries.

(ii) Action Committee on Raw Materials (ACRM)

The Action Committee on Raw Materials was established by the Inter-governmental follow-up co-ordination committee (IFCC) of the Group of 77 in 1987. The Secretariat is located at the Raw Materials Research and Development Council. The objective of the ACRM is to strengthen co-operation among developing countries in the areas of raw materials (including solid minerals) development and their exportation in primary and processed forms. It is also designed to formulate appropriate programmes of action and strategies that would enable developing countries to accelerate the processing of their agricultural and non-metallic minerals raw materials into useable and tradable products

(iii) Technical cooperation among Developing Countries

In the last six years, over Twenty-Five (25) staff of the Council have benefited from training opportunities under the TCDC programme from countries like China, India, Malaysia, Thailand, Cyprus and Israel, amongst others.

Resources Based Investments

The Investors' forum is designed as a means of providing a platform for the exposition of the nation's resources, investment opportunities and machinery/equipment with a bid of drawing attention of local and foreign investors to the array of opportunities in the country. Each forum offers its unique opportunity as it showcases the resources and the processing technologies available within the state where the forum is held. A recent one, organised by the Council in collaboration with ACE chemical Resources Ltd. (ACRL), was held in Lagos and Kano in October 2006 on the establishment of a N500m project on production of Chlor-Alkali in Ogun State. The basic raw material for this industry is salt. The product expected include Caustic, Soda, Chlorine, Hydrochloric acid, etc. used in the textile, leather, soap and paper industries, including water treatment plants.

Interaction with Manufacturers' Association of Nigeria (MAN)

The Council interacts and collaborate with all the sectoral groups of the Manufacturers' Association of Nigeria on sourcing and development of industrial raw materials. The Council in collaboration with the Association as since inception organised series of seminars annually to address the raw material problems in the manufacturing sector. In 2006, seminars organized in the series covered Chemicals and Pharmaceuticals, Non-metallic Minerals Products, etc.

CHAPTER FIVE
CONCLUSION AND RECOMMENDATIONS

Nigeria is rich in various Non-metallic minerals. The minerals required further processing to different grades to be used in industries. Technology is vital factor in upgrading these mineral raw materials to enable the country gained the desired increase revenue and further enhance the potentials for development.

A Non-metallic Mineral Technology Co-operation Centre may be established to link primary research with industrial applications, so that innovations can be developed into commercially applicable patented entities. This idea can succeed only with full commitment and positive contributions from relevant government agencies and the private sector.

The quickest way of bringing technology to the Country for the private and public sector is through joint ventures and bilateral projects. Another avenue for upgrading expertise is development of human resources through formal courses and attachment to appropriate institutions overseas. We can also improve our expertise through usual help by shoeing expertise of relevant organization.

To stem the problem of standards and testing of on-metallic Minerals raw materials required by industries, a Non-metallic Mineral laboratory, Research and Development Centre should be established. The Centre should undertake the following function:-

- Non-metallic Mineral Raw Materials testing and evaluation;
- Process and Plant Design;
- Products Technology and Evaluation;
- Indigenous Technology Development;
- Exogenous Technology Acquisition and Adaptation;
- Technological trouble shooting, including the provision of technological extension services to small enterprises;
- Dissemination of scientific and technological information.

The diversity of uses, technologies, quantities, nature and types of raw materials make it virtually impossible for any single developing country to build up a complete spectrum of knowledge and know-how mineral processing. A possible solution is the establishment of a Non-metallic Industrial and Technological Information Bank which would collect and disseminate information from and among the G.15 participating countries.

The technology of mineral processing poses a great challenge with increasing demand for processed minerals by an ever-growing number of end-users, resulting from an increasingly industrialized economy.

Government should establish some incentive for entrepreneur willing to acquire some machine tools that are vital to the production of mineral processing plants. The incentives should include:

- Loan;
- Equipment leasing;
- Low tariff;
- Foundry development;
- Production of flat sheets;
- Copy technology and reverse engineering of plant and machinery should be encouraged;
- Establishment of Catalytic Model Factory Projects involving the development of local plant and machinery to process mineral raw materials should be encourage;
- Local R & D project to develop the appropriate processing technologies, plant and machinery etc. should be sponsored and well-funded.

The processing, development and utilization of the non-metallic minerals has to be undertaken in a well co-ordinated and organized manner in order to reap the best benefit from the non-metallic mineral endowment. There should be input and full co-operation from all relevant government agencies as well as the private sector. Considering the availability of non-metallic minerals for energy; relative ease of sourcing plants, machinery and technology; importing infrastructural facilities as well as favourable investment environment under democratic rule, there are high potential and bright prospects in non-metallic mineral processing and development as may be applicable to each of the member countries

Concluding, the NEEDS document specifically placed the responsibility for providing techno-economic information on both agro and mineral raw materials

on RMRDC. Information is to be provided for investors, industrialist, researchers, policy – makers and other stakeholders, in the following areas:-

- Raw materials availability by sector;
- Location and estimates of reserves;
- National demand for raw materials;
- Industrial uses;
- Processing equipment fabricators in Nigeria;
- Science and technology experts in Nigeria, and
- Quantities and prices of important commodities, etc.

Raw materials resources endowment constitutes an area of strength, which should feature prominently in Nigerian industrial development considerations. It is imperative that a systematic approach is adopted in the sustainable development of raw materials and that is what RMREC is all about and its major responsibility