

Review

A Review of Agrogeological resources of Nigeria

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The distribution and utilization of agrogeological resources in Nigeria are discussed. These are rocks and minerals applied in agriculture. They occur in a wide variety of environments that range in age from Pre-Cambrian to Recent. The resources may be utilized to solve problems of pH, texture and structure of rocks. Limestone, dolomite and any base-rich materials like carbonatites, as well as basic and ultra basic silicate rocks could be used to correct acidity in soils. The adverse effects of soil alkalinity may be tackled by the application of sulphides, for example pyrite and marcasite. Texture can be modified by adding geological materials to the soil that have contrasting grain size. Solid structure may be improved upon by providing a good nutrient base and by encouraging a buildup of organic matter. The resources could also provide essential plant nutrients which include nitrogen, phosphorus, potassium, calcium, magnesium, copper, manganese, iron, molybdenum, sulphur and boron.

Key words: Agriculture, geology, agrominerals, nutrients

INTRODUCTION

Agrogeology, broadly defined as 'geology in the service of agriculture', is a relatively new inter-disciplinary science involving geologists, soil scientists, agronomists and farmers. The two main aspects of agrogeology are: 1) The influence of parent material on soil development and soil properties, and 2) beneficial application of rocks and minerals to enhance productivity of soils for increased social, economic and environmental benefits (Van Straaten, 2002; Van Straaten and Fernandes, 1995). Agriculture is of prime importance in the economics of Nigeria, for example, cash crops provide foreign exchange while food crops are necessary for the survival of the inhabitants.

Agricultural nutrient inputs include manures, fertilizers, and geological resources (agrominerals) with the potential to enhance soil productivity. Agrominerals are naturally occurring geological materials in both unprocessed and processed forms that can be used in crop production systems to enhance soil productivity (Van Straaten, 2002). They are geological materials that contain one or more recognized plant nutrients and so-called 'rock fertilizers' (Benetti, 1983; Appleton, 1990), sometimes called 'petrofertilizers' (Mathers, 1994) which are ground rocks of different compositions.

The physical basis of the agro ecosystem consists of climate, land, water, energy, fertilizer and pesticide. As

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many of these factors as possible should be manipulated to produce food in a manner that does not destroy the ability of the agro ecosystem to continue functioning for a reasonable period of time. The agro ecosystem is an ecosystem deliberately modified by human beings in order to obtain goods and services with different purposes and therefore it is the place where dynamic relationships between the culture and its physical-biological environment are presented (León-Sicard et al., 2018). Many fertilizer raw materials and soil conditioners are of geological provenance and therefore agrogeology or agricultural geology should be an important aspect of the agricultural industry.

This study identifies the problems of food production in Nigeria which may be solved by proper utilization of agrogeological resources. It discusses the distribution of these resources in time and space and emphasizes the importance of the classification of soils and relevant agronomic studies prior to cultivation of plants.

DISTRIBUTION OF AGROGEOLOGICAL RESOURCES IN NIGERIA

Agrogeological resources are distributed in the three major geological units. The geological history of Nigeria dates from Pre-Cambrian to Recent. The three broad units considered are:

- (i) The Pre-Cambrian Basement.
- (ii) The Younger Granites.
- (iii) The Sedimentary Basins.

Figure 1 shows the general geology of Nigeria.

The Pre-Cambrian Basement

The Pre-Cambrian of Nigeria has been discussed by many authors (Oyawoye 1964; Rahaman, 1988; Nwabufo Ene and Mbonu, 1988, among others). Three main rock groups are usually distinguished: the Migmatite-Gneiss complex, the Younger Metasediments and Metavolcanics which form narrow Schist belts and the older Granites which intrude both the Migmatite-Gneiss complex and the Schist-belt. The Migmatite-Gneiss complex is believed to be the basement *sensu-stricto* and accounts for about 50% of the Nigerian Pre-Cambrian. The complex is composed of Migmatite-Gneiss of varying textures and origins and metasedimentary and metavolcanic rocks now represented by quartzites, marble, calc-silicate rocks and amphibolites which occur as relicts within the gneisses and migmatite or interlayered with them. The schist belts are composed of low grade metasedimentary and metavolcanic rocks and they appear to be restricted to the western half of the country. The Older Granites which vary from true granites through grano-diorites to

tonalities and gabbros intrude the rocks of the migmatite gneiss complex and the schist-belts. They have consistently yielded broad Pan-African ages but the precise time and sequence of emplacement are still not clear.

The Younger Granites

The numerous ring complexes collectively termed the Younger Granites are now found along a nearly 500 km long belt in areas of Pan-African Basement uplift surrounded by sedimentary basins that achieved their main development in the cretaceous. Over 95% of the rocks can be classified as rhyolites, quartz-syenites or granites with basic rocks forming the remaining 5%. Many of the rocks have strongly alkaline to peralkaline compositions. Others are aluminous to per aluminous. Initial stages in development of the complexes involved extrusion of vast amounts of acid lavas, tuffs and ignimbrites, now only preserved as a result of subsidence along ring faults. Almost everywhere, these rhyolitic rocks directly overlie the metamorphic basement which means that the Younger Granites were emplaced in uplifted areas that were undergoing erosion (Jacobson and Macleod, 1977).

Granitic ring dykes are the major component of most complexes, ranging from 5 km or less to over 30 km in diameter and varying in plan from polygonal to circular or concentric and through more irregular shapes to simple stocks and bosses. The volcanic rocks were down-faulted in great collapse structures that formed calderas at the surface. The volcanics are fairly well stratified and are tilted to varying degrees. Although the volcanics probably once extended well beyond the present limits of the complexes, they are now only preserved in these down-faulted regions. Virtually all traces of their former extent outside the caldera walls have long been eroded away.

The Sedimentary Basins

The sedimentary basins developed mainly during the Mesozoic and are of two types (Figure 2):

- i) Intercontinental Basins
- ii) Coastal Basins.

The Illumedden and Chad Basins, as well as the Bida Basin, are broad and shallow synclinal depressions, similar to the older basins. Their present extent is less than it once was, for numerous outliers can be found beyond the main sediment outcrops. The sediments in these basins are virtually horizontal. The Benue Trough is also an intercontinental basin, but the sediments in it have been strongly folded and faulted, and it was probably a rifted depression.

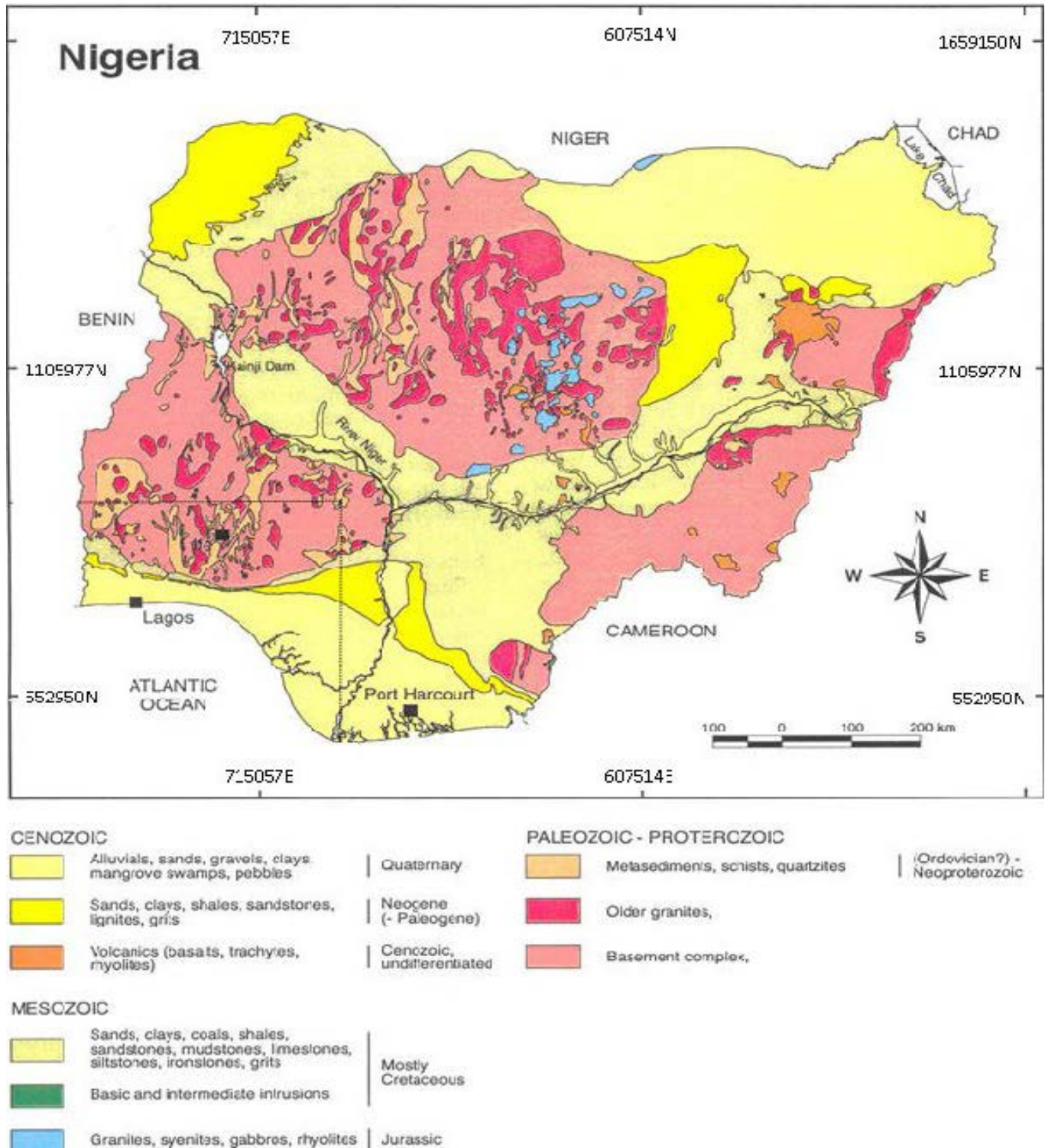


Figure 1. Simplified geological map of Nigeria. Source: NGSA (2000).

The coastal basins differ from the intercontinental basins in two important ways. Instead of being broad and shallow, they tend to be long and deep, with up to 10 km

of sediments in them, sometimes more. They are developed partly on oceanic crust and partly on continental crust. These basins developed mostly as a result of

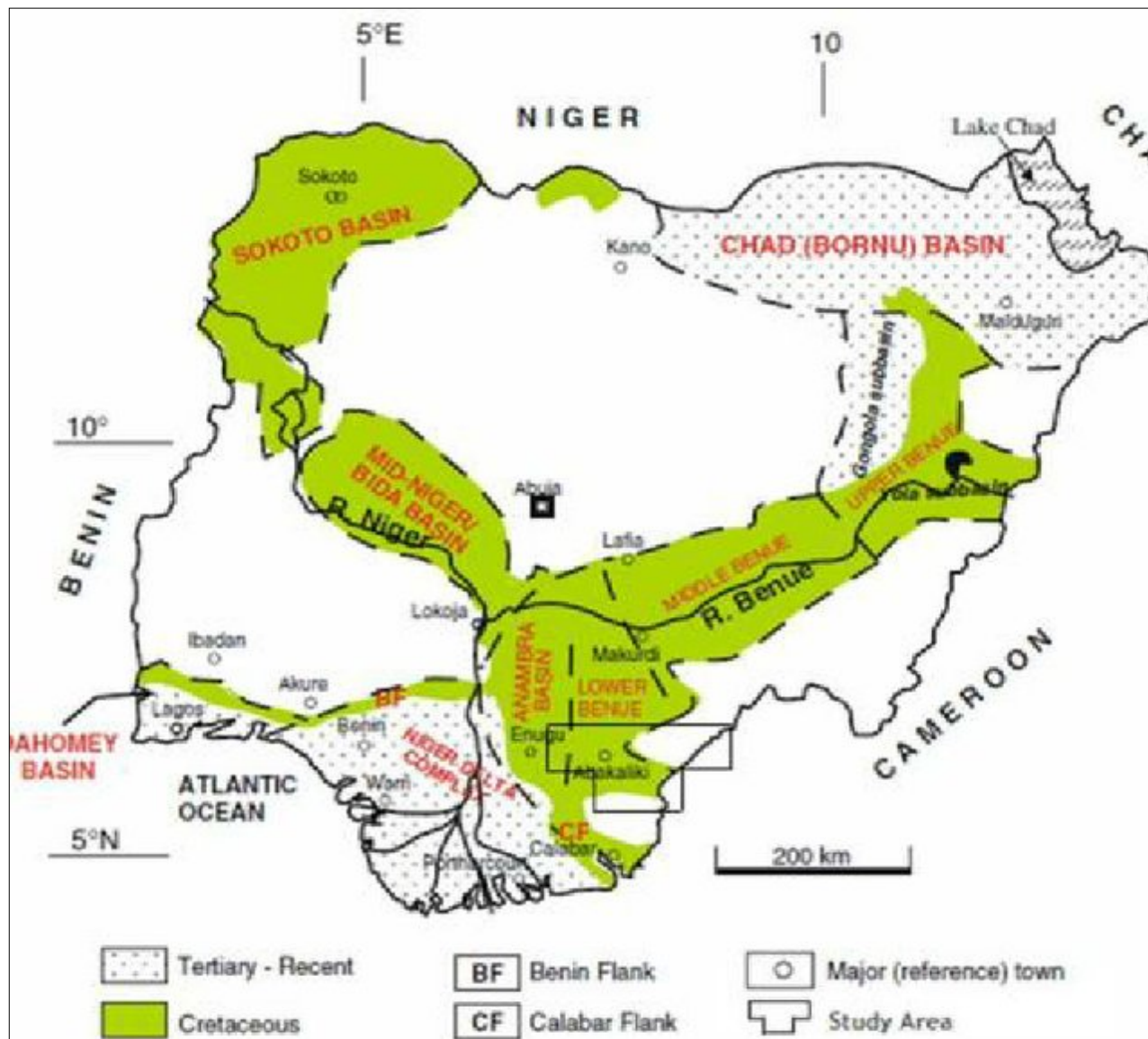


Figure 2. Map of sedimentary basins of Nigeria. Source: Obaje (2009).

crustal stretching, faulting and subsidence as Africa and South America separated in the mid-Cretaceous, and their mode of origin is thus distinctly different from that of the intercontinental basin.

MINERAL RESOURCES OF NIGERIA

The solid mineral occurrences in Nigeria are summarized in Figure 3 and Table 1. The minerals are associated with the main rock types found in various geological ages from Pre-Cambrian to Recent and in diverse geological environments. The level of exploitation of these minerals is very low in relation to the extent of the deposits.

UTILIZATION OF AGROGEOLOGICAL RESOURCES

Agrogeological resources may be utilized to deal with three important features in agriculture which includes:

- (i) pH problems
- (ii) Fertility problems
- (iii) Improving the conditions of the soil (texture and structure).

Some physical and chemical manipulations may be necessary before agrominerals and rocks are effectively used in plant cultivation. For example, beneficiation of phosphates involves the processes of preparation and

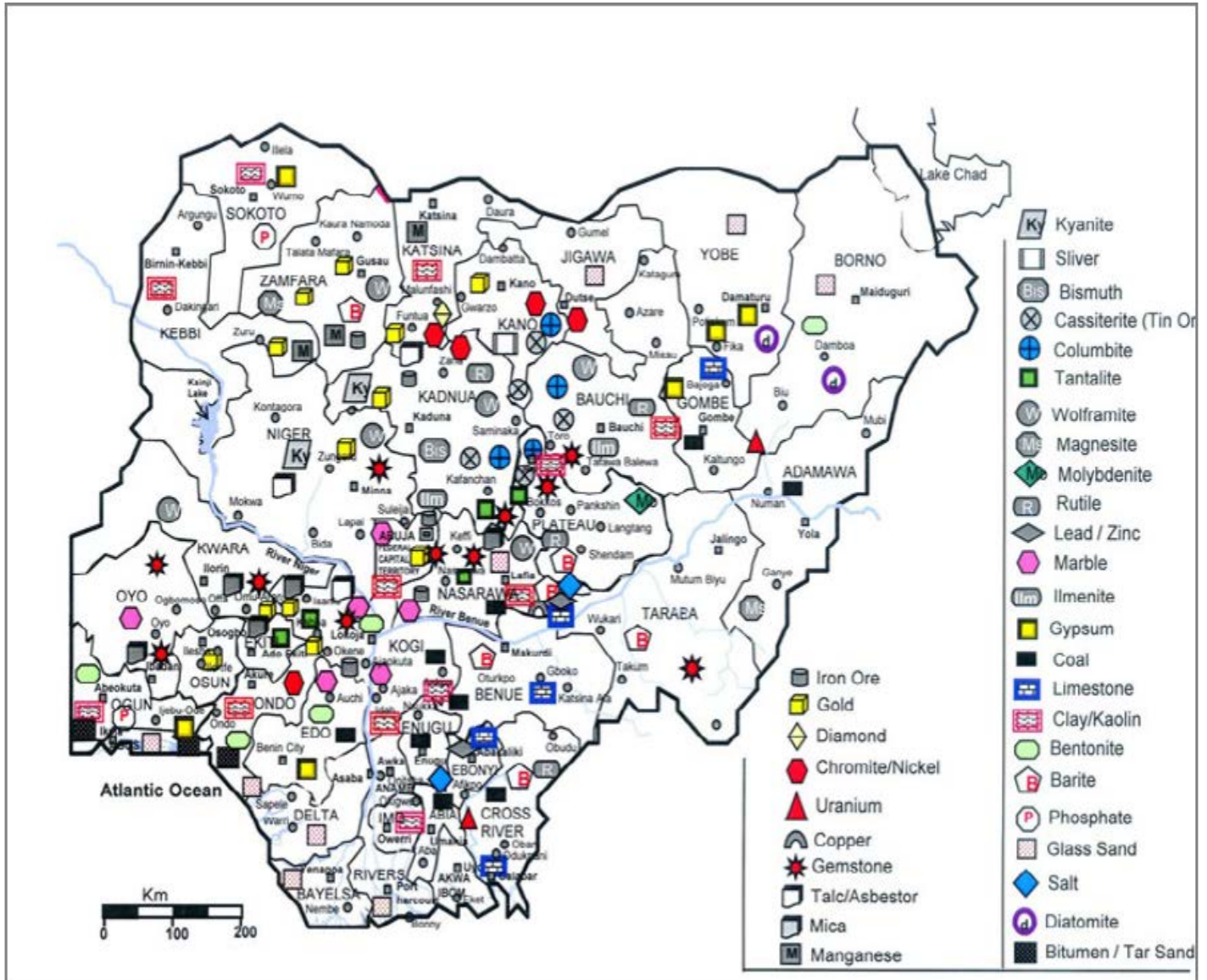


Figure 3. An overview of the solid mineral resources distribution map of Nigeria.
Source: Nigeria Vision (2020).

separation. Some agrominerals and rocks may be added directly to soils with little physical processing. Limestone and dolomite may be applied directly to soils after crushing and screening. Regarding plant nutrients, some of the agogeological resources may be used without the expensive reprocessing that normally goes with the production of commercial fertilizers. Fast weathering is essential for the release of nutrients and the humid tropical climate in Nigeria is ideal for this purpose.

Agrogeological resources for solving pH problems

Soils are produced by the physical and chemical

weathering that take place on the earth's surface which is a complex zone of interaction. The main chemical processes for soil formation are hydrolysis and dissolution which involve a titration whereby bases that are contained in the solid phases of the land neutralize acids in a co-existing aqueous phase. With this, the soil inevitably becomes a sink for protons which displace cations and enter solutions where they are readily available to plant growth or loss to the system by leaching. This protonisation of the land surface results in the decrease in and may, as well increase the availability of Aluminum and Manganese in the system which now gives rise to toxicities (Chesworth, 1986; Sumner, 1994). At the other end of the pH scale, alkalinity problems are

Table 1. Solid mineral occurrences in the federating States of Nigeria.

S/N	Minerals	Occurrences
1	Tantalite	Cross River, Ekiti, Kogi, Kwara, Nasarawa
2	Kaolin	Akwa Ibom, Anambra, Bauchi, Bayelsa, Ekiti, Imo, Katsina, Kebbi, Kogi, Ogun, Ondo, Plateau, Rivers
3	Mica	Ekiti, Kogi, Kwara, Nasarawa, Oyo
4	Baryte	Benue, Cross River, Taraba Zamfara
5	Coal and Lignite	Abia, Adamawa, Anambra, Bauchi, Benue, Cross-River, Delta, Ebonyi, Edo Gombe, Imo, Kogi, Nasarawa, Plateau
6	Rutile	Bauchi, Cross-River, Kaduna, Plateau
7	Talc	Ekiti, Kaduna, Kogi, Niger
8	Bimuth	Kaduna
9	Gypsum	Adamawa, Edo, Gombe, Ogun, Sokoto, Yobe
10	Marble	Edo, FCT, Kogi, Kwara, Nasarawa, Oyo
11	Gemstones	Bauchi, Kaduna, Kogi, Kwara, Nasarawa, Niger, Ogun, Oyo, Plateau, Taraba
12	Feldspar	Bauchi, Borno, FCT, Kaduna, Kogi
13	Gold	FCT, Kaduna, Kano, Katsina, Kebbi, Kogi, Kwara, Niger, Osun, Zamfara
14	Clay	In all the States of the Federation
15	Silver	Ebonyi, Kano
16	Ilmenite	Benue, Cross River, Kaduna, Plateau
17	Limestone	Benue, Cross River, Ebonyi, Edo, Gombe, Kogi, Ogun, Sokoto
18	Columbite	Bauchi, Cross River, Kaduna, Kano, Kwara, Nasarawa, Plateau
19	Cassiterite	Bauchi, Cross-River, Kaduna, Kano, Kwara, Nasarawa, Plateau
20	Dolomite	Borno, Yobe
21	Phosphate	Ogun, Sokoto
22	Manganese	Katsina, Kebbi, Zamfara
23	Silica Sand	Delta, Jigawa, Kano, Lagos, Ondo, Rivers
24	Flourite	Bauchi, Ebonyi, Plateau, Taraba
25	Bitumen	Edo, Lagos, Ondo, Ogun
26	Lead	Cross-River, Ebonyi, FCT, Plateau, Zamfara
27	Zinc	Cross River, Ebonyi, FCT, Plateau, Zamfara
28	Bentonite	Borno, Edo, Kogi, Ogun, Ondo
29	Kyanite	Kaduna, Niger
30	Iron-Ore	Enugu, FCT, Kaduna, Kogi, Nasarawa, Zamfara
31	Lithium	Kaduna, Nasarawa, Niger, Zamfara
32	Wolframite	Bauchi, Kaduna, Kano, Kwara, Nasarawa, Niger, Zamfara
33	Molybdenite	Plateau
34	Dolomite	Kogi, Oyo, Edo, Kwara and the Federal Capital Territory, Abuja

Source: Nigeria Vision (2020).

common especially in the arid and semi-arid regions where irrigation is practiced.

Limestone, dolomite, base-rich materials (carbonatites) as well as basic and ultrabasic silicate rocks may be applied directly to soils after little physical processing. Unfortunately, some of these may introduce toxicities (transition elements, rare earths and actinides) and pH should not be raised more than 1 or 2 units otherwise deficiency in some essential elements may be introduced. Alkalinity problems are common in Nigerian

soils especially in the semi-arid parts, hence acidifying agents like sulphides may be used. Unfortunately, pyrites which is a useful material require expensive processing.

Agrogeological resources for solving fertility problems

Nutrients are lost by leaching and cropping, resulting in a relatively infertile soil. Farmers may solve this problem by

adding fertilizers which provide plant nutrients. The major nutrients are nitrogen, phosphorus, and potassium. Others which may be regarded as trace or minor nutrients are sulphur, calcium, magnesium, manganese, copper, zinc, manganese, iron, boron, and molybdenum.

Agrogeological resources for solving physical problems

These are generally associated with texture and structure of soil and with factors external to the soil itself such as the shape of the landscape. The two most important problem areas relate to water and erosion. Agrogeological resources and geological expertise may be used in tackling these problems. The sandy soils may be improved upon by adding clays especially calcareous clays. The principle is to modify the texture by adding material of contrasting grain size. Coarse materials like medium to coarse grained sand may be used to lighten heavy soils. The main aim is of course water management. Also, a build-up of organic matter will improve soils structure while the use of rock mulches will minimize evaporitic loss.

MAJOR NUTRIENT SOURCES IN NIGERIA

Nitrogen raw materials

The major sources of hydrogen for producing nitrogenous fertilizer are: natural gas, fuel oil and coal. Natural gas and fuel oil occur in a number of basins in Nigeria, the most notable being the Niger Delta Basin. Good potential for these hydrocarbons have been noted in the Anambra Basin and the Benue Trough. Available data show that coals are mainly sub-bituminous steam coals except for the Lafia-Obi bituminous cooking coal. Occurrences in Nigeria have been indicated in more than 27 coal fields spread in over 13 states of the federation. Presently, the Coal Industry has four existing mines which are Okpara and Onyeama underground mines in Enugu State, Okaba Surface Mine in Kogi State and Owukpa Underground Mine in Benue State. In addition, there are 13 undeveloped coal fields. The undeveloped coal fields in Nigeria are in two categories, viz: the virgin coal fields where further detailed exploration work and or access roadways are required and the developing coal fields where reserves have been proven and mine access roadways developed.

Phosphorous

Phosphates are the major sources for phosphorus. The phosphates occur as nodules and primary phosphatic shales and siltstones in Sokoto, parts of south west

Nigeria and Bende area of Abia State. Phosphates also occur in metamorphic and igneous rocks in parts of the country, but these have not been studied in any significant detail.

Potassium

The possible sources of potassium include Feldspar, Orthoclase $KAlSi_3O_8$, Microcline $KAlSi_3O_8$, Mica, Biotite and Muscovite. Orthoclase and microcline are abundant in the granites, pegmatites and gneisses. Nepheline syenite deposit is located at Opiriki – Oyoba area of Cross River State. Biotite and muscovite are abundant in the granites and pegmatites.

Sulphur

No native sulphur source is known. Sulphur may however be obtained from sulphides in parts of Benue Trough especially at Abakaliki, Ishiagu, Zurak and Arufu. Pyrite may be obtained from parts of Benue Trough associated with metallic sulphide ores. Marcasite may be obtained from parts of Benue Trough associated with metallic sulphide, while Inyi coal seams contain abundant marcasite.

Manganese

Pyrolusite has been recorded in the Basement Complex in Cross River State. Manganese nodules may be obtained from the ocean floor at depths of 4000 – 6000 m. A summary of the distribution of nutrient sources in Nigeria is shown in Table 2.

DISCUSSION

Nigeria has large resources of agro-minerals and rocks in a wide variety of environments. The position compares favourably with many African countries, for example, Mozambique, Rwanda, Tanzania, Zambia, Burundi and Kenya. Unfortunately, Nigeria trails these countries with respect to the evaluation of the resources, processing and application of the same in agriculture. It is suggested that the main reason for this is unawareness of the immense potential of the agro geological resources and their utility in agriculture. Truly successful agriculture can only be achieved by the manipulation of the factors that constitute the physical basis of the agroecosystem (climate, land, water, energy, fertilizers and pesticides) to provide food in such a manner that does not destroy the ability of the agroecosystem to continue to function into the foreseeable future. Before the introduction of industrialized agriculture in Nigeria, farmers cultivated

Table 2. Nutrient sources in Nigeria.

Nutrient	Usual source	Source in Nigeria	Processing
Nitrogen	Natural gas coal, fuel oil nitrogen from their air	Niger Delta	$7\text{CH}_4 + 10\text{H}_2\text{O} + 8\text{N}_2 + \text{CO}_2$ (Methane) (Air) $= 6\text{NH}_3 + 7\text{CO}_2$
Phosphorus	Phosphates	Sokoto, Bende,	Partial and full acidulation with sulphuric and phosphoric acid, heat treatment.
Potassium	Feldspar: Orthoclase, Microcline	Benue Trough, Sokoto, Borno, Cross River State	Needs modification to be effective
Sulphur	Pyrite Marcasite	Parts of Benue Trough, Marcasite, Occurs Inyi	Production of H_2SO_4 for phosphate acidulation
Manganese	Pyrolusite	Oban Massiff	
Molybdenum	Molybdenite	Younger Granites	
Zinc	Sphalerite	Parts of Benue Trough	Needs processing to obtain elemental Zinc ₂ .
Magnesium	Magnesite MgCO_3 Talc	Borno State, Kogi, Chaje, Zonkwa, Isanlu, Makata and Iregun, in parts of Benue Trough, etc.	
Calcium	Limestone, Dolomitic marble	Nkalagu, Awgu, Yandev Ahsake, Kalambina, Jakura, etc.	Physical processing, crushing and sorting, solubility is fairly good.
Iron	Siderite	In parts of Benue Trough	Expensive processing necessary to improve solubility
Copper	Chalcopyrite	In parts of Benue Trough (CuFeS_2)	ditto

crops cheaply using traditional methods. Most of the industrialized agricultural projects not only failed to produce adequate food but destroyed the physical well-being of the soils. It appears that if hunger is to be averted in Nigeria, there should be a review of farming methods; also, beneficiation and processing plants should be set up. Certain economic considerations are vital in the production of food and cash crops as many grand industrialized agricultural programmes set up by western countries in Nigeria have failed. The high cost of imported commercial fertilizers and soil conditioners make them uneconomical in agricultural production. The new frontier must emphasize the reduction of the cost of production of food and cash crops by the proper utilization of agrogeological resources available in Nigeria.

CONCLUSION

The exploitation, processing and application of the various agrominerals and rocks found in Nigeria will benefit agriculture immensely; hence, direct application of some of the materials will lower the cost of production of crops. It is therefore logical that meaningful agricultural practice in Nigeria must rely heavily on locally available agrogeological resources and expertise.

The subject of agrogeology or agricultural geology is of prime importance and will continue to be an important part of applied science on which successful agriculture must be based in Nigeria. Agronomic and other relevant studies should be carried out to determine the nature of the soils and the needs of plants to be cultivated so as to use the agrogeological resources appropriately. Exploitation and processing of these resources must be

carried out effectively and at reasonable cost so as to keep the prices of the raw materials at levels affordable by farmers especially at the grassroots level. Limiting the use of expensive commercial fertilizers and the development of the techniques for direct application of fertilizers and soil conditioners will be useful in this regard. Further, application of fertilizers and soil conditioners needlessly will be a waste of resources, hence geologists must define in time and space the rocks and minerals relevant to agriculture.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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