Overview of Nigeria's Solid mineral Potentials, Challenges and Prospects

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Abstract

Nigeria is rich in abundant solid mineral resources, including gold, iron, lead, zinc, coal, and gemstones, which hold great potential for the country's development. Despite this mineral endowment, the mineral sector has not lived up to its potential, contributing less than 3% to the nation's GDP. This paradox of being resource-rich yet poor can be attributed to overreliance on oil, political instability, frail legal and regulatory frameworks, and a lack of up-to-date geosciences data for investment decisions. To address this issue, recent governments have initiated policies to attract foreign investors interested in tapping into Nigeria's vast but largely untapped mineral resources. The geological setting of the mineral deposits spans different eras, presenting opportunities for exploration and extraction. A strategic roadmap has been devised to provide up-to-date geosciences data, strengthen legal frameworks, and create a favorable investment environment. If diligently pursued and sustained, this roadmap aims to revamp the mineral sector, significantly increasing its contribution to the nation's GDP, possibly reaching 10%. By harnessing these resources effectively, Nigeria has the potential to drive economic growth, generate employment opportunities, and achieve better overall development.

Keywords: Nigeria solid minerals, Gold, Lead-zinc, Gemstones, Nigeria mining law.

INTRODUCTION

The exploitation of solid minerals has significant economic benefits. It generates substantial government revenue through taxes, royalties, and revenue-sharing arrangements. Additionally, it fosters economic diversification, reducing reliance on a single sector and improving stability. The mining and processing of solid minerals create direct employment and support industries, contributing to job creation. Exporting these minerals brings in valuable foreign exchange, strengthening the country's financial position. They also serve as crucial raw materials for industries, promoting industrial growth and infrastructure development. Furthermore, the sector encourages technology transfer and skills development through foreign investments. Exploiting solid minerals leads to regional development, balanced growth, and improved quality of life through reinvestment in various sectors. The development of downstream industries adds value to raw materials, creating more economic opportunities. Lastly, the abundance of solid minerals reduces dependence on imports, enhancing national security.

Nigeria, which lies in West Africa (Fig. 1a, b) is comprised of three major geological components including the Basement Complex (Precambrian- Pan-African), Mesozoic Younger Granites (200 – 145 million years) and the Cretaceous to Recent Sedimentary Basins (Fig. 2; Obaje, 2009). The basement complex is further divided into: Migmatite-Gneiss Complexes, Schist belts and the Pan-African Older granites.

It is beyond doubt that Nigeria is endowed with enormous mineral resources, with about 34 solid minerals found to occur in 450 locations nationwide. These minerals include gold, iron ore, cassiterite, columbite, wolframite, pyrochlore, monazite, marble, coal, limestone, clays, barites, lead-zinc, etc. and occur in the different metallogenic provinces of Nigeria (Lar, 2018). Within these 34 minerals, 7 were classified by the government as strategic minerals and they include gold, iron ore, lead-zinc, coal, limestone, barites and bitumen. In addition, tin, niobium, columbite, tantalite, gypsum, gemstones, kaolin, dolomite etc. constitute great economic prospects in the Nigerian mining sector. However, not more than 5% of these economic minerals are now being exploited, which includes mainly the strategic minerals. Whereas, the remaining 95% solid minerals, even though in demand are largely unexploited. Currently, Solid minerals contribute as low as 3% to the country's GDP as against oil export which forms more than 95% of Nigeria's foreign exchange earnings (Lar, 2018).

Conversely, mineral resource exploration and development (exploitation) constitute an important part of Nigeria's economy and continues to be essential for future economic evolution. Despite the good economic policy for mining, the growth of the mineral sector has been hindered by several constraints such as the lack of proven mineral reserves, illegal mining, overdependence on oil, political instability, the lack of infrastructure, the lack of mineral production and processing capacity, the smuggling of minerals out of the country etc (Lar, 2018). It is on this note that this paper reviews the occurrences and exploitation of some important solid mineral deposits in Nigeria, with the aim of highlighting their potentials, challenges and prospects. This perhaps can increase awareness and stimulate the growth of the solid mineral sector by renewing the commitment/interest of both administrators and potential investors in the sector.

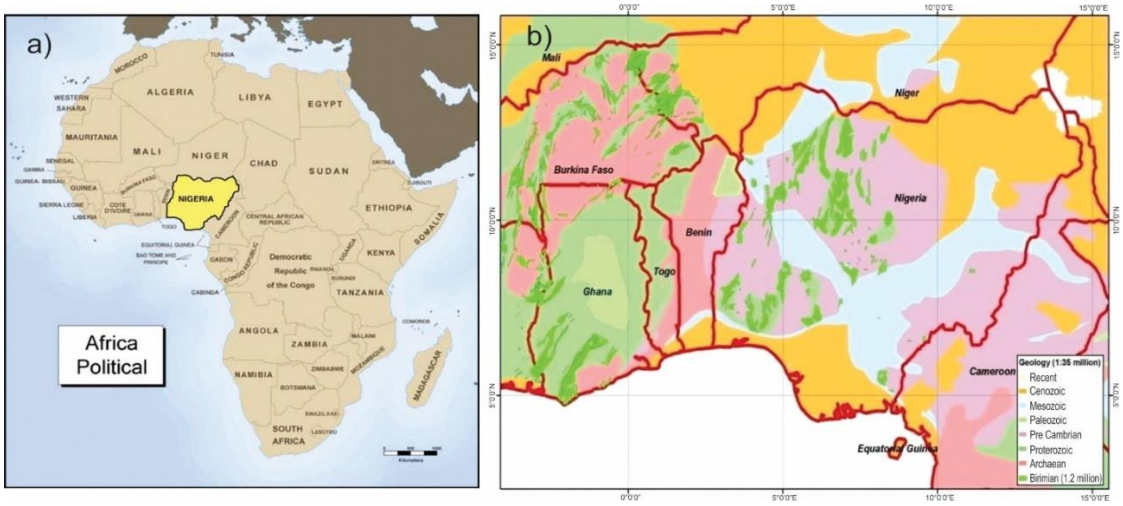

Fig. 1 (a) Africa Political Map Showing the location in Africa (Lar, 2018) (b) Showing the Geological Setting of Nigeria within West Africa (Modified after Garba, 2016).

Geological Setting of Nigeria

The Archean Migmatite-Gneiss Complex

This is a polymorphic unit believed to have formed from a complex association of deformation, shearing and folding, granitization and migmatization, involving crust-forming processes. It

affected the oldest rocks in the Basement Complex dating over 3000Ma. (Mc Curry, 1976; Rahaman, 1976; Dada, 1999 and Ekwueme, 1991). It comprises the various migmatites and gneisses as well as a series of metamorphosed basic and ultrabasic rocks with petrographic evidence of upper amphibolite facies metamorphism. A similar migmatite-gneiss complex in NE Brazil has revealed sedimentary origin (Dada, 2008). These rocks in Nigeria have some petrological and geochemical characteristics of a primary igneous origin (Dada, 1999; 2008).

The Proterozoic (Schist Rocks)

This consist of low-grade sediment dominated schist group comprised of metamorphosed schist, psammitic schist, calcareous rocks, conglomerates, mafic to ultramafic rocks and phyllites with minor talcose rocks, greywacke and acid to intermediate volcanic rocks. The various formations occur in linear N-S trending belts commonly referred to as "Schist belts" and constitute the most remarkable structural features in Nigeria and in Nigeria-Borborema shield (Dada, 2008).

The summary of the available geochronological data on the schist belts given by Rahaman (1988) shows that over 92% of the sample data gave Pan-African ages ranging from 450Ma to 680 Ma, whilst less than 8% gave Kibaran (1000Ma) age. Ajibade (1988) and Ajibade and Fitches (1988), interpreted the Pan-African ages as reflecting a later reheating event during the thermo- tectonic event, believing that Pan-African is too young for the metamorphism of the schist belts. However, Rahaman (1988) is of the opinion that lithologically different schist belts, which Ajibade (1988) suggested were contemporaneous, indicate widely differing ages and therefore, the Kibaran age cannot have any geological significance in the evolution of the schist belts and in the context of the Nigerian Basement geology.

The Pan-African Granitoids

The Pan-African thermo-tectonic events which took place between 750Ma and 450Ma is believed to be the last major orogenic event that affected the Nigerian basement. The activity resulted in structural modification and migmatization of the older basement and emplacement of a suite of rocks referred to as Older Granites. About 45% of the Nigerian basement is made up of Older Granite rocks. Rahaman (1988), predicted an upward review of this figure with more detailed geological and geochronological mapping. The unit covers about 75% of the Basement Complex outcrops in the northeastern part of the country. Older Granite bodies are commonly plutons of batholitic dimensions and stocks. They can be elongated, elliptical or domal in shape, usually concordant to sub concordant with respect to the N-S trending country rocks. The outcrops form the most prominent topographic expressions within the Basement Complex terrain of Nigeria. According to Rahaman (1988), the following rock types constitute the Older Granites: Migmatites or migmatitic granite, granite gneiss or anatectic migmatite, early pegmatite dykes and fine-grained granites, homogeneous medium to coarse grained granites, slightly deformed pegmatites and aplite dykes and veins.

Field and petrographic studies carried out in different parts of the country indicate both intrusive and replacement origin for the Older Granite, particularly the main phase where there are gradational contacts between the coarse porphyritic granite and the country rock. Granitization (metasomatism) is indicated by the development of chemically similar alkali feldspar megacryst in both rocks. In such case, the Older Granite is distinguished by its prominent topographic expression (Kayode, 1976).

Geochemical investigations have thrown some light in favour of magmatic origin for the Older Granite rocks. As stated earlier, the early and the late phases are, on the basis of field relationship and petrography, evidently intrusive. Ike (1988), argued that the abundance of pegmatites in the marginal zones of older granite batholiths and their roofs are pointers to late-stage availability of excess water and volatile. He pointed out under such conditions, crystallization of deuteric feldspar megacryst within a thermally and chemically mobile orogenic system is deemed possible while the regime still remains essentially igneous.

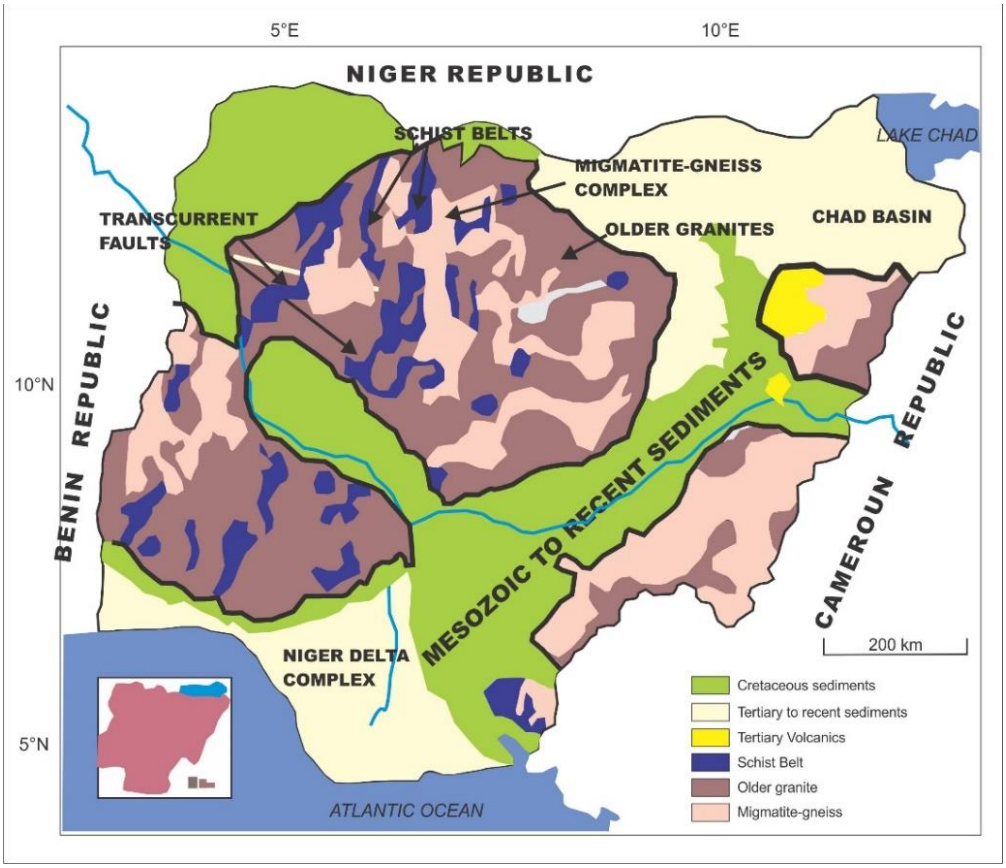

Fig. 2 Geological Map Showing Subdivision of Lithologic Units (Modified after Obaje, 2009)
The Mesozoic younger granites

Mesozoic Younger Granites

The term Younger Granite was originally coined by Falconer (1911) to distinguish Pan- African orogenic calc-alkaline Older Granites from the Mesozoic high level non-orogenic alkaline granites of north central Nigeria. They are epizonal rocks occurring in a broad N-S zone measuring 250 X 100Km (Turner, 1986). The N-S alignment coincides with an apparent continuous line of separation of the African and south American continents during the opening of the Atlantic Ocean in the Mesozoic period. They are believed to be the Cratonic response to this separation and the associated rifting which led to the formation of the Benue Trough (Badejoko, 1985). The Mesozoic Younger Granite ring complexes of Nigeria form part of a wider province of alkaline anorogenic magmatism extending from Northern Niger Republic to South Central Nigeria. More than 50 complexes occur in Nigeria (Magaji et al, 2011; Ahmed et al, 2021).

Sedimentary Basins

The Cretaceous to Recent Basins in Nigeria include: Anambra Basin, Benue Trough, Bida, Bornu, Niger Delta and Sokoto Basins. The sedimentary basins are a host of variety of industrial minerals such as limestone, gypsum, salt, barites clay, and energy raw materials like coal, oil, gas, and bitumen (Bamalli et al, 2011). Furthermore, the sediments hosted non-ferrous base metals such as lead and zinc occurring in veins (Bamalli et al, 2011).

Major Minerals in Nigeria

There are about 34 mineral occurrences in Nigeria (Fig. 3, table 1) that cut across Metallic minerals, precious metals, precious stone, and industrial minerals. In this review, some selected major minerals will be discussed.

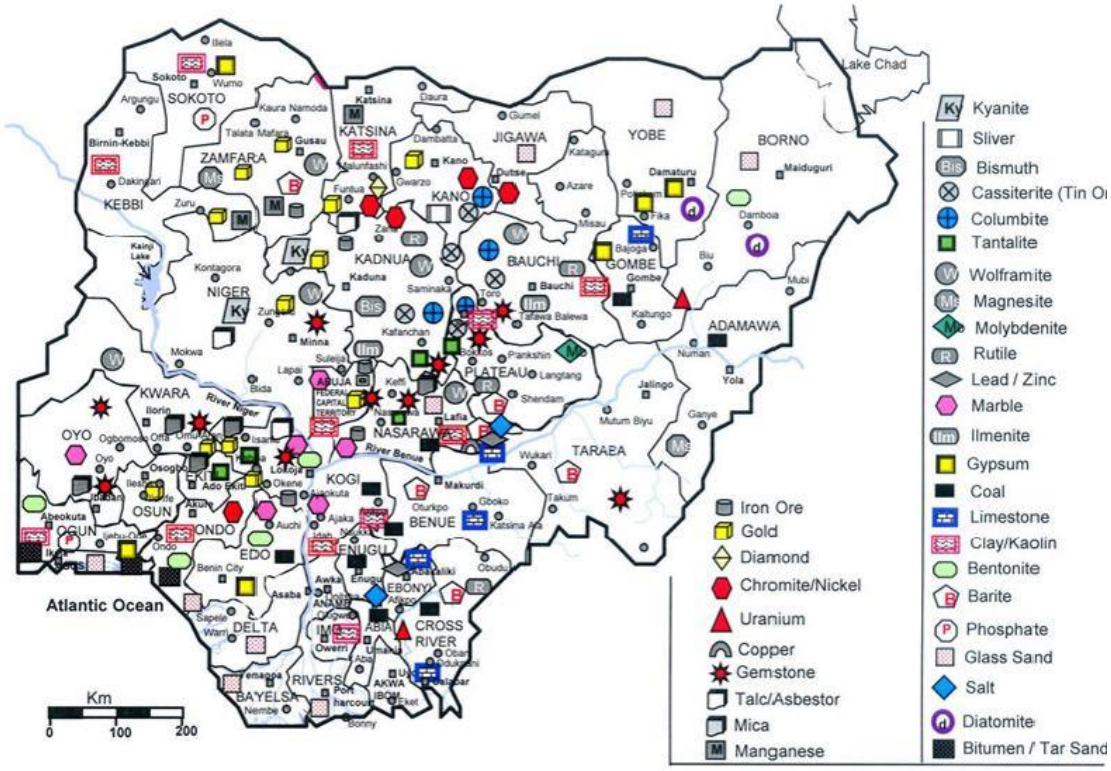

Fig. 3. Map of Nigeria Showing the distribution of Minerals occurrences. Source (RV2020)

Table 1: Minerals, metals and precious stones

S/N	Mineral	Examples
1	Metallic Minerals	These include Tin, Columbite, Tantalite, Lead-Zinc. Manganese, Uranium, Iron ore etc.
2	Precious Metals	Gold
3	Precious Stones	Rubby, Sapphire, Beryl, and other Gemstones
4	Industrial Minerals	Limestone, Baryte Kaolin, Gypsum, lithium etc.

Overview of Past Mineral Production in Nigeria

Gold production started in 1913 and peaked before the Second World War (Fig. 5d). Reports by BusinessDay (Oladipo, 2023), showed that Nigeria is increasingly tapping from a cash-revolving mining sector that has remained largely under-utilized since the crude oil boom, a development that is part of a key step in efforts to turn the economy away from oil.

Before the discovery of oil in Nigeria, the major income and source of foreign exchange for the country was from Tin (Cassiterite) mining activities (Bamalli et al., 2011). Tin production started in 1905 and up to 1972, Nigeria was the World's 6th largest producer. Extensive tin (cassiterite) deposits within the Mesozoic younger granites especially in Plateau, Bauchi, Nasarawa, FCT, Kano, Kaduna, Kwara, Kogi, Ondo and Osun States (Bamalli et al, 2011).

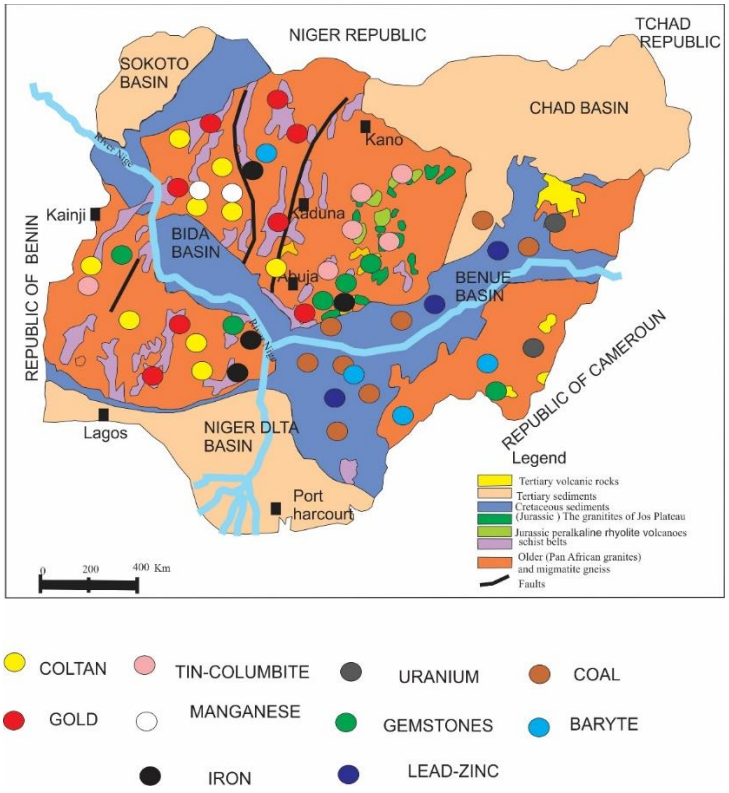

Fig. 4 Geological Map of Nigeria Showing the Distribution of the Major Mineral Deposits

Between 1933-1965, Nigeria was the world's largest exporter of columbite, accounting for about 95% of total world supply (Garba, 2016). Columbite occurs in Plateau state, Jos Nigeria, mainly in the placer deposits of cassiterite. Recently, columbite occurrence is also reported in Mubi, Adamawa state of Nigeria (Okon, 2023). Coal production started in 1915 and was the main energy source until 1960. Substantial Wolfram production also took place between 1939-45. Commercial production of Lead-Zinc started in 1947 (Garba, 2016).

Mineral Deposits Associated with Paleoproterozoic Schist Belt

Gold

Gold in Nigeria is found in alluvial and eluvial placers and primary veins from several parts of supracrustal (schist) belts in the northwest and southwest of Nigeria (Fig. 4) spatially related to major NNE-trending faults and their subsidiary structures constrained in time and space by late Pan-African tectonic features (MSMD, 2010; Garba, 2016).

The most important occurrences are found in the Maru, Anka, Malele, Tsohon Birnin Gwari-Kwaga, Gurmana, Bin Yauri, Okolom- Dogondaji and Iperindo areas, all associated with the schist belts of northwest and southwest Nigeria (MSMD, 2010). There are also a number of smaller occurrences beyond these major areas (MSMD, 2010). Over 20 old gold mines abandoned since 1940s, currently exploited by artisanal miners. Modern and systematic exploration is on-going. More than 1million ounces of gold have been delineated in Ilesha schist belt by Segilola Nig. Ltd (Garba, 2016).

Data compiled by BusinessDay showed Nigeria has significant gold reserves, estimated at 300 million ounces. However, the country has only produced a small amount of gold in recent years. In 2021, Nigeria produced just 2,000 ounces of gold (Oladipo, 2023).

Iron Ore

Widespread occurrence of BIFs in the schist belts (Figs.4 and 6a), with grades seldom exceed 40% Fe. Purer iron ores are interbedded among basement gneisses in the Okene-Lokoja area, which are probably older relics, perhaps correlated with the ores in Liberia and Guinea. About 150 metric tons (approx.) of 30-50% Fe reserve have been proved in Itakpe hills. Larger reserves of iron ore (1.2 billion tons) are found in the oolitic ores of the Agbaja plateau with higher grades (47-51%Fe) but also higher content of deleterious phosphorous of 0.8-1.3% P (Garba, 2016). There are over 3 billion metric tons of iron ore deposits in the country (Bamalli et al., 2011)

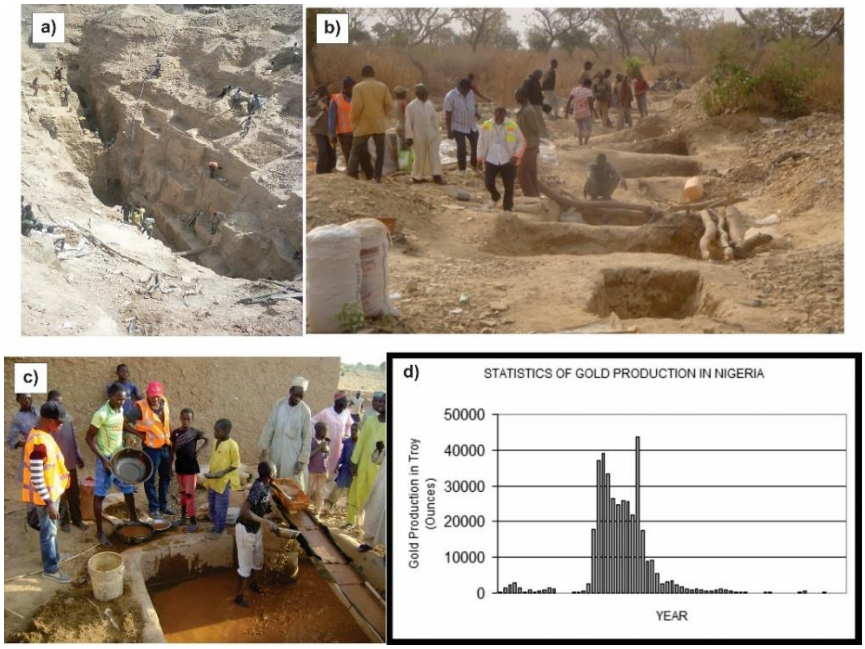

Fig. 5 (a) Artisanal Gold Mine at Gunabi, Kebbi State, (b) Artisanal gold mining within Quartzite Schist in Kebbi State, (c) Local separation /processing of gold in Zamfara State, (d) Statistics of Gold Production in Nigeria (Garba, 2016).

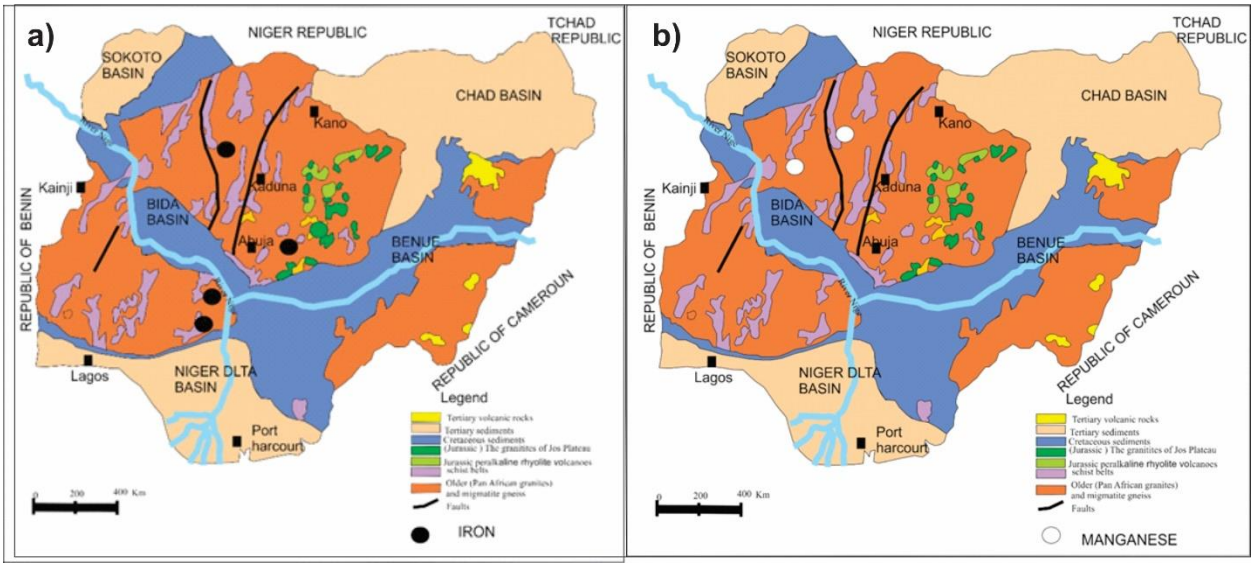

Fig. 6 (a) Geological Map of Nigeria Showing the location of some Iron Ore (b) Geological Map of Nigeria Showing the location Manganese ore occurrences

Manganese Occurrence

The Northern Nigeria basement complex encompasses a huge amount of manganese deposits. To date, ten deposits of manganese have been reported by previous workers (Akintola, 2018). These deposits occur within Precambrian metasediments (schist belt), mafic and ultramafic rocks (Figs. 6b, 7a and b) which are Proterozoic in age and folded into synclinorial belts within the crystalline basement complex (Akintola, 2018). Recent studies by (Kamaunji, et al., 2019) reported the occurrence of manganese in Mubi area of Hawal Massif, North-Eastern Nigeria.

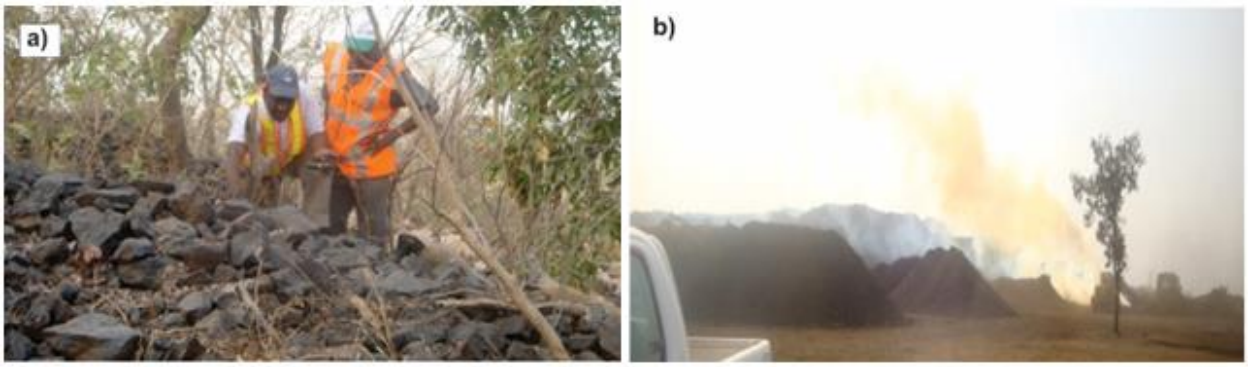

Fig. 7. (a) Manganese Deposits in Kebbi State, Northwestern Nigeria, (b) Manganese open cast Mine in Kebbi State, Northwestern Nigeria.

Mineral Deposits Associated with Neoproterozoic Pegmatites

Columbite-Tantalite (Coltan) ±Tin

Nigeria was the largest producer of Columbite-Tantalite (Coltan) ±Tin in Africa in recent times (1995-2003). Between 40,000 and 70,000 lb/yr was produced by artisanal miners. Widespread

deposits and occurrences are reported in the central and western half of Nigeria (Garba, 2016), and mostly coincident with the goldfields (Fig. 8a).

Gemstones

Gemstones are non-metallic minerals (and rocks) that are treasured for several reasons, and used in the production of jewelry and other personal adornments (Olade, 2021). Gemstones are mostly minerals that occur naturally in rocks as well-formed crystals.

Gemstones are categorized based on several criteria including precious and semi-precious stones. Precious stones are highly valuable and attractive, comprising four minerals: diamond, emerald, ruby, and sapphire. On the other hand, the semi-precious stones comprise all other gemstones; mostly colored gems that are considered less valuable or less appealing. Examples include tourmaline, topaz, zircon, garnets, amethyst and aquamarine (Fig. 9; Olade, 2021). The states with gemstone deposits include Kaduna, Nasarawa, Plateau, Kano, Bauchi, Taraba, Zamfara, Benue, Kwara, Oyo, Ogun, Osun, Ekiti, Cross River, and Borno States (Fig. 8b)

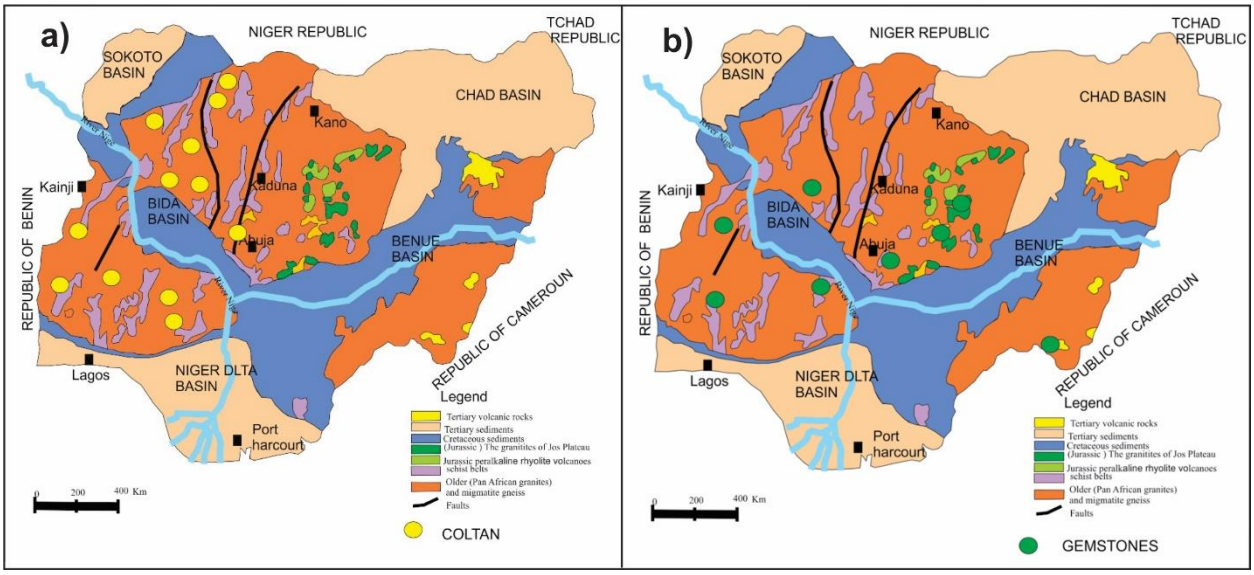

Fig. 8 (a) Geological Map of Nigeria Showing the Distribution of Columbite Tantalite ± Tin, (b) Geological Map of Nigeria Showing the location Gemstone occurrences

Fig. 9 Some of the gemstones mined in Nigeria (a) Ruby, (b) beryl, (c) Tourmaline

Lithium Deposits

Nigeria is a place having economic quantities of Lithium distributed across the states of the country from north to the south. This economic raw material is mined by artisanal miners in Taraba, Nasarawa, Plateau, Kogi, Cross River and Ekiti States of Nigeria.

Lithium mining is currently booming in Nigeria, and the government is committed to develop the industry and has recently started issuing mining permits. Furthermore, Nigeria's lithium is characterized by high-grade up to 13 wt.% (Ewepu, 2022). The director-general of the Nigerian Geological Survey Agency, Dr Abdulrazaq Garba stated that: "the standard worldwide for even exploration and mining starts from 0.4 per cent lithium oxide but when we started exploration and mining, we saw one per cent up to 13 per cent lithium oxide content" (Ewepu, 2022).

Mineral Deposits Associated with Mesozoic Anorogenic Granite

The Jurassic Younger Granites are a series of alkaline igneous complexes that were emplaced mostly as ring dykes into the uplifted basement of the Jos Plateau and surrounding areas of central Nigeria (Fig. 10a). These rocks consist predominantly of biotite granites and peralkaline granites. The biotite granites are mineralized with tin (cassiterite), columbite, niobium, tungsten and gemstones within the albitized zones where the economic minerals occur as disseminations, and greisen veins and quartz stringers in the roof zones of the intrusive rocks (Olade, 2021; Bowden and Kinnard, 1984). Niobium and Tantalum ores usually occur together. The most significant minerals are the admixture of iron-manganese niobotantalate-niobite and tantalite with the chemical formula (FeMn) (Nb Ta)$5O_6$. Niobite may contain up to 34% Ta_2O_5 and tantalite up to 27% of Nb_2O_6 (Bamalli et al, 2011).

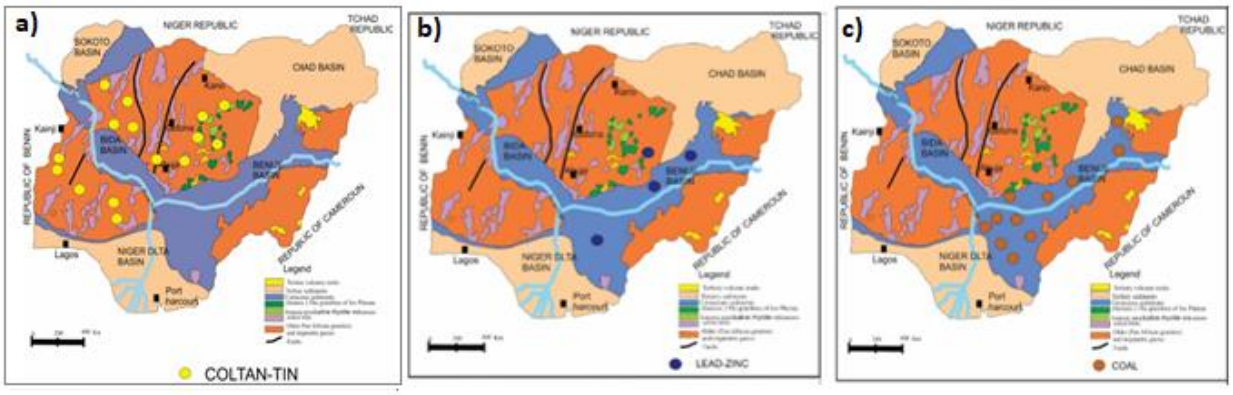

Fig. 10 (a) Geological Map of Nigeria Showing the Distribution of Tin, Columbite and Tantalite, (b) Geological Map of Nigeria Showing the Distribution of Lead-Zinc-Baryte Mineralized Belt, (c) Geological Map of Nigeria Showing the Distribution of Coal Deposits

Tin, columbite and pyrochlore occur in Mesozoic Ring Complexes of the Jos Plateau and surrounding regions (Younger Granite Province, Figs. 4 and 10a). Pyrochlore-bearing granites containing economic niobium, uranium, tantalum and cryolite are also known in this region. Ririwai complex has a measured reserve of 582,668 tonnes at 0.7% Sn and 2.56% Zn; and an Indicated reserves of 2,830,351 tonnes at 0.61% Sn and 2.05% Zn (Garba, 2016). Sn-Nb-Zn mineralization in the Ririwai granite complex resulted from complex magmatic evolutionary

processes involving extensive fractional crystallization coupled with crustal assimilation and late-stage hydrothermal alteration (Girei et al., 2019).

Mineral Deposits Associated with Cretaceous Sedimentary Basin

Lead-Zinc ±Copper, Baryte

Lead and zinc mineralization occur in rocks of Lower Cretaceous sediments. They are generally tele-thermal in origin and formed from low temperature hydrothermal solutions related to Tertiary and Recent volcanism in the region. Lodes and veins of lead and zinc minerals ± small amount of copper minerals is known in many locations in the Benue Trough (Figs. 10b and 11), from Abakaliki in the southeast to Gombe in the northeast. This region has been the attraction of some exploration and mining activities in recent times.

Baryte and fluorite are common associates of the lead-zinc veins and occur in exploitable quantities in a number of locations, including Nasarawa, Plateau, Taraba, Benue, Adamawa, Cross River, Gombe, Ebonyi, and Zamfara. A very vast percentage of baryte resources in Nigeria is still underexploited and further exploration work is needed to boost its exploitation (Labe et al., 2018). The inferred resource and proven reserve of baryte is put at over 21,000,000 and about 11,000,000 metric tons respectively. The economic evaluation of these barytes is viable having low (SG = < 3.5) to high (SG = 5.3) grades (Labe et al., 2018).

Fig. 11. Lead Mining in (a) Bauchi, Northeastern Nigeria, (b) Gombe, Northeastern Nigeria.

Coal

There are at least 11 significant known coal deposits in Nigeria, mostly located in the eastern flank of the Anambra Basin in south central Nigeria (Fig 10c), that appear to contain the largest and most economically viable coal resources (Garba, 2016). Behre Dolbear (2006) has developed a short list of 4 properties that appear to have the highest economic potential for development in conjunction with coal-fired power plants. These are: Ogboyega (Kogi), Okaba (Kogi), Owukpa (Benue) and Ezimo (Enugu). A total of 22 occurrences have been reported across Nigeria (Fig. 10c). Despite the challenges faced in the production of coal since the oil boom, Nigeria still holds large coal reserves, estimated to be at least 2 billion metric tons (Odesola et al., 2013).

Challenges Facing Solid Mineral Development in Nigeria

The oil discovery in Nigeria has caused the neglect in the solid mineral sector of the economy that has the capacity to create large revenue, foreign exchange and employment for the nation. This therefore, resulted into the economic challenges the country is facing such as unpredictability in the revenue from crude oil, high rate of unemployment and poverty. For these reasons, it is important to outline the challenges facing the solid mineral development in Nigeria, with the view to having positive prospects for a better future. Some of the key challenges facing the solid mineral development in Nigeria include:

(a) Dwindling metal prices:
(b) Exhausted alluvial reserves (e.g., tin fields in Jos)
(c) Flourishing oil revenues/ over-reliance on Petroleum Resources
(d) Incompetent State-owned companies/corruption
(e) Dominance of illegal mining
(f) Inadequate and reliable geoscience data that will entice investors
(g) Policy Instability from successive governments
(h) Lack of Credit and Financing
(i) Information (reliable data) on Minerals Mined
(j) Lack of/improper land reclamation after mining and the adverse effects on the environment

Mining Sector Reform Strategy in Nigeria Since 2005

Successive Nigerian governments in the recent past have been making efforts to overcome these problems by attempting to diversify the economy by giving increased attention to the solid mineral sector. To accomplish this, many strategies were put in place to reform the solid mineral sector, including the following.

(a) Changing the direction of government from "property owner", to "overseer-Regulator"
(b) Providing a 100% Private sector ownership of Mining activities
(c) Provision of New Minerals and Mining Act (2007)
(d) Liberal and transparent access to mining rights
(e) Consolidation of Geoscience and data generation

Important Provisions in The New Nigerian Minerals and Mining Act, 2007

The following are some of the Important Provisions in the New Nigerian Minerals and Mining Act, 2007, which when properly enforced will boost the solid mineral sector.

(a) Competition for mining titles/rights on "first-come, first-served" basis.
(b) Removal of discretionary powers of government officials in mining title grant.
(c) (c) Creation of autonomous Mining Cadastre Office.
(d) Security of tenure of mining rights.
(e) Provision of the principle of "use it or lose it" in mining rights administration.
(f) Use of time limits for granting titles.
(g) Mining titles are transferable and amendable.
(h) Introduction of Community Development Agreement.
(i) Introduction of Mineral Resources and Environmental Management Committee in States to facilitate mining development

Summary

The geology of Nigeria Favors the occurrence of numerous economic solid mineral deposits in the country including gold, iron ore, cassiterite, columbite, wolframite, pyrochlore, monazite, marble, coal, limestone, clays, barites, lead-zinc, etc. However, only less than 5% of these economic minerals are now being exploited. Gold deposits in Nigeria is known to occur within the western half of the country and mostly worked out by the artisanal miners at present. They usually target rich veins and associated alluvial deposits. Gold in the past was being mined in a large scale. With the ongoing reforms in the sector, it is expected that the large-scale mining will dominate again considering the enormous potential of the mineral and demand. Apart from gold, many other solid minerals are being mined in small-scale in the country. In general, the solid mineral resources of Nigeria have not been fully evaluated due to lack of sufficient researches and technology. Previous studies identified a number of minerals deposits which have remained largely unevaluated (Bamalli et al, 2011). Sufficient data and proper evaluation of mineral resources is paramount for attracting local and foreign investors in to the sector. Similar mineral occurrences in other African countries received adequate attention from their respective governments and contributing well to their GDP's. In Nigeria, there is no doubt that the distraction by the oil boom and high revenue from oil has hindered the development of the solid mineral sector. However, with the dwindling oil price over the years and yearning for alternative energy sources, it is very essential for the Nigerian government to aggressively refocus on the growth and development of the solid mineral sector. Although a strategic roadmap was outlined to revamp the sector, sustained commitment and implementation by successive governments is necessary in order to get the desired result.

a) Nigeria is richly endowed with significant solid mineral occurrences of high economic potentials. Paradoxically, the country is so much endowed yet so poor!

b) The Paleoproterozoic schist belt is associated with orogenic gold, manganese and Algoma type banded iron formation.

c) The Neoproterozoic Pan-African orogenic cycle culminated with the formation of some mineralized pegmatite fields in Nigeria. This broad pegmatite belt also refers to as "the Older Tin Belt" is rich in Sn, Nb, Ta and world class gemstones including tourmaline, aquamarine, kunzite.

d) The emplacement of silica saturated A-type granites (the Younger Granites) led to the formation of significant Sn-Nb-W mineralization.

e) The new strategic roadmap drawn by the successive governments in recent times, if vigorously pursued, thoroughly implemented and religiously sustained will significantly revamp the mineral sector.

Recommendation

a) Government should facilitate the Generation of additional and reliable geoscience data/information for the Nigeria solid minerals.
b) Promote geoscience research by funding/disbursing grants to relevant research institutions.
c) Provide effective and operational mining sector governance.
d) Impose the terms and provisions of the Nigeria Mining Law and Regulations.
e) Regulate mining labour issues, flexible rules on visas and work permits for expatriates.

f) Compatible tax regime.

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References

Ahmed, H.A., Wang, LX., Ma, CQ. Abdallsamed, M.I.M., Girei, M.B., Zhu, Y.X., Vincent, V.I., Kamaunji, D.V., Cao, L. (2021). Contrasting Neoproterozoic and Mesozoic granitoids in Zaranda complex (Nigeria): insights into the distinct origins, tectonic settings and mineralization potential. Int J Earth Sci (Geol Rundsch) 110, 1389–1413. https://doi.org/10.1007/s00531-021-02021-z

Ajibade, A.C. and Fitches, W.R. (1988). The Nigerian Precambrian and Pan African Orogeny. In P. O. Oluyide, (Editor), Precambrian Geology of Nigeria. Geological Survey of Nigeria Publication. pp 45-53.

Akintola, O.A. (2018). Distribution and Economic Potential of Manganese Deposits in Nigeria: A Review. Asian Journal of Geographical Research 2(1): 1-8, 2019; Article no.AJGR. 46745. DOI: 10.9734/AJGR/2019/v2i130076

Badejoko, T.A. (1985). Petrogenesis of the Younger Granites of Nigeria. Journal of African Sciences. Vol.5(3). pp233-242.

Bamalli, U.S., Moumouni, A., Chaanda, M.S. (2011). A Review of Nigerian Metallic Minerals for Technological Development. Natural Resources, 2011, 2, 87-91. doi: 10.4236/nr.2011.22011 Published Online June 2011 (http://www.scirp.org/journal/nr)

Behre D. (2006). Feasibility of Nigerian Coal Resources Development CMM Global Overview, 2006 Report by the U.S. Environmental Protection Agency Coal bed Methane Outreach Program.

Bowden, P., Kinnaird, J.A., 1984. The petrology and geochemistry of alkaline granites from Nigeria. Phys. Earth Planet. Inter. 35, 199–211. https://doi.org/10.1016/0031-9201(84)90043-8.

Dada SS (1999) Pb–Pb and Sm-Nd isotope study of metaigneous rocks of Kaduna Region: implications for Archean crustal development in Northern Nigeria. Pure Appl Sci 6:7–16

Dada SS (2008) Proterozoic evolution of the Nigeria–Boborema province. Geol Soc Lond Spec Publ 294:121–136. https://doi.org/10.1144/SP294.7

Ekwueme, B.M. (1991). Geology of the Area around Obudu Cattle Ranch, S.E. Nigeria. Journal of Mining and Geology, 27, pp129-134.

Ewepu, G. (2022) "Mining: Agency Discloses Discovery of High-Grade Lithium" - Vanguard News (vanguardngr.com) (7 June 2022).

Falconer J.D. 1911. The Geology and Geography of Northern Nigeria. Macmillan and Company London.

Garba, I. (2016). "*Why Nigeria, Why Now?" – Brief on Potential of the Nigerian Mining Terrain*. [Power point] Unpublished paper presented at iPAD Nigeria mining Forum between 26-27October, 2016 held in Abuja, Nigeria.

Girei MB, Najime T, Ogunleye PO (2020) Geochemical characteristics and origin of the Neoproterozoic high-K calc-alkaline granitoids in the northern part of Mandara hills, northeastern Nigeria. Acta Geochimica Acta Geochim. https://doi.org/10. 1007/s11631-019-00365-7

Girei M.B., Li H., Algeo T.J., Bonin B., Ogunleye P.O., Bute S.I., Ahmed H.A. (2019). Petrogenesis of A-type granites associated with Sn–Nb–Zn mineralization in Ririwai complex, north-Central Nigeria: Constraints from whole-rock Sm-Nd and zircon Lu-Hf isotope systematics, (2019) Lithos, https://doi.org/10.1016/j.lithos.2019.05.003

Ike, E.C. (1988). Late-Stage Geological Phenomena in the Late Zaria Basement Granite.

Precambrian Geology of Nigeria. Geological Survey of Nigeria, pp 83-89.

Kamaunji D. V., Ntekim E.E., Ahmed H.A. (2019). Petrochemistry and manganese mineralization potentials of the calc-alkaline granitoids from Northeastern Hawal Massif, North-Eastern Nigeria. Science Forum (Journal of Pure and Applied Sciences, Faculty of Science, ATBU Bauchi.) 16: 18 – 42.

Kayode, A.A. (1976). On The Genesis of Small and Large Feldspar Porphyritic Granites in Igbo- Ora Complex, SW Nigeria. In C.A Kogbe (Ed), Geology of Nigeria, Elizabethan Publishing Company, Lagos, Nigeria.

Labe, N.A., Ogunleye, P.O., Ibrahim, A.A., Fajulugbe, T., Gbadema, S.T. (2021). Review of the occurrence and structural controls of Baryte resources of Nigeria. Journal of Degraded and Mining Lands Management ISSN: 2339-076X (p); 2502-2458 (e), Volume 5, Number 3: 1207-1216 DOI:10.15243/jdmlm.2018.053.1207.

Lar, U.A. (2018). Geology and Mineral Resources of Nigeria and their Uses. A paper presented at a 3-day capacity building workshop by Telpon Environment Ltd for the Nigerian Commodity Exchange (NCX) Staff, Abuja on "Product development for solid minerals in Nigeria", Tuesday 16th- Thursday 18th January 2018; at Elim Top Suites & Hotels, Rayfield, Jos, Nigeria.

Magaji, S.S., Martin, R.F., Ike, E.C., Ikpokonte, A.E., 2011. The Geshere syenite-peralkaline granite pluton: a key to understanding the anorogenic Nigerian Younger Granites and analogues elsewhere. Period. Mineral. 80, 199. https://doi.org/10.2451/ 2011PM0016.

Mc CURRY, P. (1976). Geology of the Precambrian to Lower Paleozoic Rocks of Northern Nigeria- A Review in Kogbe, C.A (Ed) Geology of Nigeria, Elizabethan Publishing Company,Lagos. pp 15-39.

Obaje, N.G. (2009). Geology and Mineral Resources of Nigeria. Lecture Notes in Earth Sciences Eds: S. Bhattacharji, Brooklyn H. J. Neugebauer, Bonn J. Reitner, Gottingen ¨ K. Stuwe, Graz, Springer Dordrecht Heidelberg London New York. ISSN 0930-0317 ISBN 978-3-540-92684-9 e-ISBN 978-3-540-92685-6 DOI 10.1007/978-3-540-92685-6

Odesola, I.F., Samuel, E., Olugasa, T. (2013). Coal Development in Nigeria: Prospects and Challenges. International Journal of Engineering and Applied Sciences Vol. 4, No. 1 ISSN 2305-8269.

Okon, L.A., (2023). Geology andgeochemistry of tantalite-columbite occurrencein granitic rocks of Mujara area, Mubi South, North-eastern Nigeria. Unpublished M.Sc. thesissubmitted to the department of Geology, Modibbo Adama University, Yola. 81p.

Olade, M. A. (2021). org Gemstones of Nigeria: An Overview of Their Geological Occurrence, Provenance and Origin. Achievers Journal of Scientific Research. Volume 3, Issue 1, pp 1-22.

Oladipo, O. (2023). Gold export hits N78bn, highest on record, published in Business Day report. https://businessday.ng/business-economy/article/gold-export-hits-n78bn-highest-on-record/#:~:text=Data%20compiled%20by%20BusinessDay%20showed,just%202%2C000%20ounces%20of%20gold. Accessed on 16/7/2023.

Rahaman, M.A. (1976). A Review of the Basement Complex of Southeastern Nigeria. In C.A Kogbe (Ed), Geology of Nigeria, Elizabethan Publishing Company, Lagos, Nigeria. pp 41-58.

Rahaman, M.A. (1988). Recent Advance in the Study of the Basement Complex of Nigeria, in: Precambrian Geology of Nigeria. Geological Survey of Nigeria Publication. 1143p.

Report of the Vision 2020 National Technical Group on Minerals and Metals Development Turner, D.C. (1986). Magma Distribution and Crustal Extension in the Nigerian Younger Granite Province: Evidence Fromm the Wase Area. Journal of Africa Earth Sciences, Vol.5, No. 3, pp. 243-247.

MMSD (2010). Gold deposit exploration opportunities in Nigeria. 14p.