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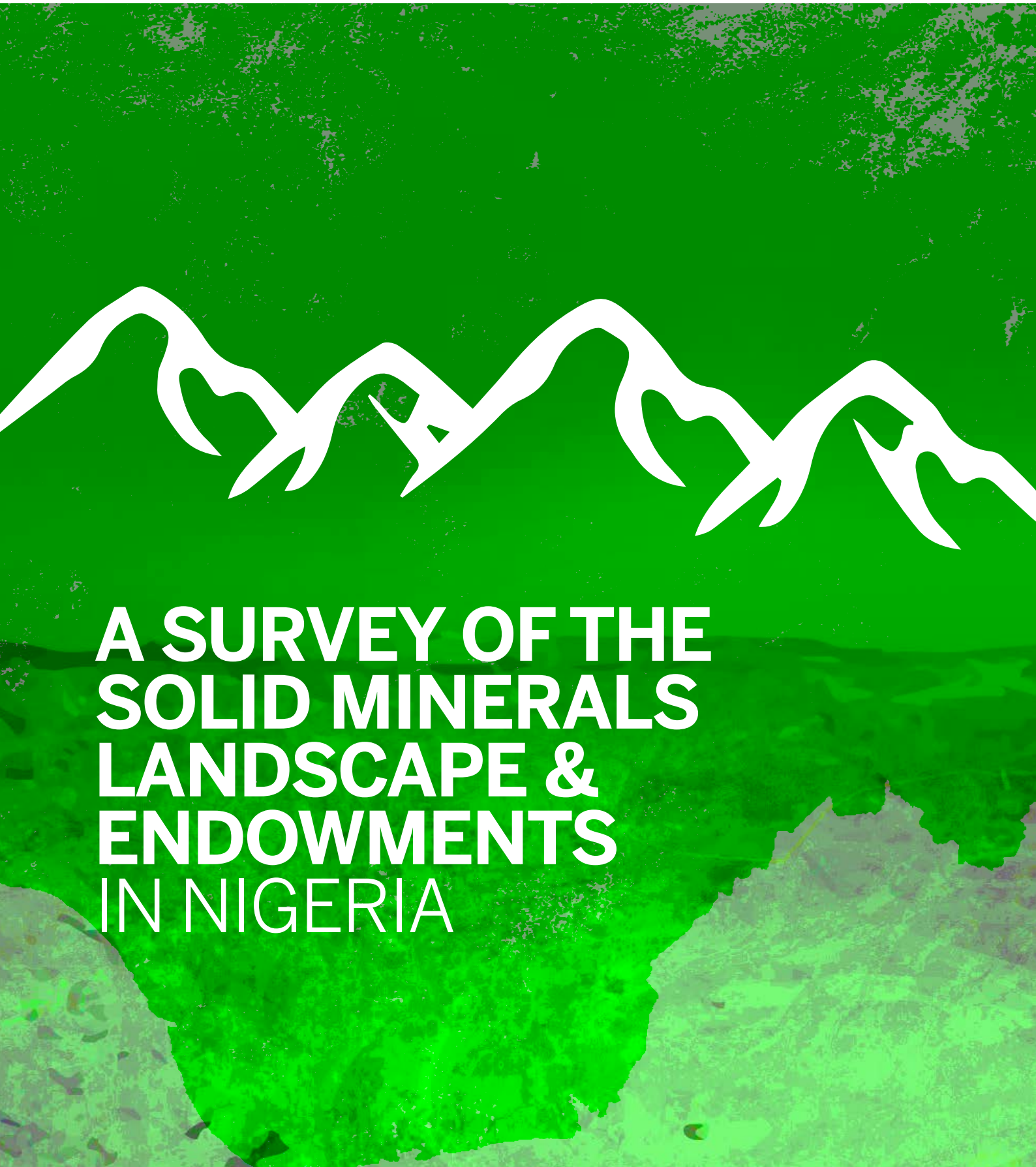

A SURVEY OF THE SOLID MINERALS LANDSCAPE & ENDOWMENTS IN NIGERIA

NEITI Nigeria Extractive Industries Transparency Initiative

THE PRESIDENCY

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A SURVEY OF THE SOLID MINERALS LANDSCAPE & ENDOWMENTS IN NIGERIA

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1.0 Introduction

Industry Overview, Historical Context and Governance Issues

Mining formally began as an organised activity in Nigeria in 1903. Following this development, the Mineral Survey of the Northern Protectorates was founded. This was subsequently followed by the formation of the Mineral Survey of Southern Protectorates in 1904. The mining industry at the time was dominated by European companies involved in the mining of tin, gold and base metals. The adoption of mechanised mining brought about high productivity, which also came with negative environmental impact, due to the absence of a law regulating mining activity at the tim

MINING IN NIGERIA

1914

The year mining formally began as an organised activity

The earliest recorded mineral mined was tin ore by the Royal Niger Company in 1905. Gold mining was next, and it began in 1914 in areas located within the present day Niger and Kogi states.

By the 1940s, Nigeria had become a major producer of tin, columbite and coal. For instance, tin production reached 15,842 tonnes in 1943, from a mere 1.36 tonnes in 1904. Tin and columbite mining occurred mainly in Jos, in current Plateau State, but also extended to Jarawa Hills, equally in today's Plateau State, Wamba in Nasarawa State, Kafanchan in Kaduna State, Ningi in Bauchi State, and Ririwe in the present Kano State.

With the mining of tin on industrial scale came the establishment of smelting industries, such as the Makeri Smelting Company established in 1961.

[1] See Stephen J. Malo (2012). The Nigerian Mining Sector: An Overview, Continental Journal of Applied Sciences, 7(1):34-45.

Apart from tin and columbite, lead mining also took place in Zurak and Ameri in Plateau State, while zinc was mined in Enugu and Ogoja in present Enugu and Cross River states respectively. The mining of coal took place mostly in Enugu, with the discovery of coal in the city in 1909, followed by the establishment of the Agbete Mine in 1916. By 1960, coal production had exceeded 500,000 tonnes from about 180,000 tones in 1920.

Mining of other minerals began at various times in Nigeria, including bitumen (1905), iron ore, and uranium.

Mining was a significant driver of industrialisation and development in Nigeria. Coal mining gave birth to the railway industry, with the earliest rail infrastructure built to transport mined coal from Enugu to the seaport in Port Harcourt, and to a power plant on the Oji River. Evolving with tin ore mining and processing came the establishment of the largest smelter in Africa (the Makeri Smelter, in 1961), as well as a power plant in Jos. And finally, with iron ore came the founding of industrial complexes and behemoths (at the time) of manufacturing –

TIN PRODUCTION

1943		1904
15,842 tonnes	vs	1.36 tonnes

COAL PRODUCTION

1960		1920
500,000 tonnes	vs	180,000 tonnes

Ajaokuta, with 5.7 million tonnes of liquid steel; Delta steel plant, with a capacity of 2 million tonnes of steel products; and three inland mills in Osogbo, Jos and Katsina.

In 1971, things began to change as the government reviewed its policy on minerals and metals. It decided to act as a catalyst in the mining sector through the establishment of mining corporations that would use public funds for its operations. To achieve this, government decided to participate directly in the mining industry, and it established the Nigerian Mining Corporation (NMC) in 1972, to engage in direct investment in the exploitation of known economically viable minerals other than coal and marble. Through subsidiaries, the NMC engaged in the exploitation of kaolin, barites, cassiterite, columbite, limestone and clay. The Nigerian Coal Corporation (NCC) was separately responsible for mining coal and a little later, the Nigerian Uranium Mining Company (NUMCO) was incorporated to mine and develop uranium.

LATE 1970s

Decline in the production of solid minerals in Nigeria

The government also exercised control and direct involvement in the sector through a number of institutions such as the Nigerian Iron Ore Mining Company (NIOMCO), for iron ore mining at Itakpe; the National Steel Raw Materials Exploration Agency (NSRMEA), to concentrate on exploration of iron ore and coking coals; and the National Metallurgical Development Centre (NMDC), whose focus was to be on research in mineral processing and downstream utilisation studies on minerals.

In 1972, the government also enacted an indigenisation decree that resulted in the acquisition of majority shares in the main expatriate tin mining companies in the country, causing large-scale withdrawal of foreign investment in the industry and a downturn in production. With the exit of multinational companies and their expatriate professionals, the bulk of mining operations by the private sector fell into the hands of small-scale indigenous miners. These factors were largely responsible for the decline in the production of solid minerals in Nigeria, particularly metallic minerals, starting in the late 1970s.

Nigeria's mineral extractive processes had operated for long, independent of any clearly identified and formulated plan for the mining industry, and this was in spite of the many benefits

of markets and expert proficiencies that existed across the African continent. However, following the African Union Assembly's 2009 adoption of the Africa Mining Vision (AMV) as a key continental framework, the need to promote mineral resources-based development and structural transformation on the continent has become clearer.

In the short term, the AMV not only presents Nigeria with the opportunities available in the pan-African market, but also makes the leveraging of African products and expertise against the more established regions of the world possible. In the long-term, it will allow for the creation of a knowledge-driven African mining sector that spurs the existence of multi-sectorial development, including the beneficiation of excavated resources downstream, or the more familiar upstream uses of produced goods (as seen in the case of limestone and cement production) or even the ancillary benefits derived from employing realised minerals, such as coal, for the production of power in the power sector and so on. At this point the AMV is no longer just a good idea, but has become the basis of an imperative that needs to drive national mining activity and governmental planning.

2016

"A Road Map for the Growth and Development of the Nigerian Mining Industry". This has given impetus to the focused development of the sector in the past three years.

Also, at the West African regional level, the Economic Community of West African States (ECOWAS) has keyed into the AMV and produced the ECOWAS Mineral Development Policy (EMDD) accordingly, in line with the AMV, which ECOWAS member Heads of States adopted in 2012. Nigeria as a member of both the African Union (AU) and ECOWAS is yet to domesticate these regional mining statutes and protocols.

In 2016, as part of efforts to clearly develop and formulate short- and long-term plans for the mining industry in Nigeria, the government launched "A Road Map for the Growth and Development of the Nigerian Mining Industry". This has given impetus to the focused development of the sector in the past three years.

Critical stakeholders in the mining landscape

States

Under the Nigerian Minerals and Mining Act (2007), all mineral deposits belong to the Federal Government, who then allocates revenues back to the states, in a formula similar to that used to share out oil and gas revenues, with a special allocation (representing 13 percent of derived revenue) going to states that yield the mineral revenues. The resource-bearing states, however, continue to push for more control over ownership and extraction of minerals found within their territories and the ability to allocate licenses for exploration and exploitation of these minerals.

All mineral deposits belong to the Federal Government, who then allocates revenues back to the states, in a formula similar to that used to share out oil and gas revenues

Although illegal under the current mining law, reports from the field indicate that some states of the federation are currently exceeding their legal authority and exercising powers reserved for the Federal Government. This is a challenge to the development of the sector because the practice discourages investors from participating in the sector, as they are uncertain of their property rights and are worried about intimidation and conflict of interest in competing against the states. There is, on the other hand, more clamour for institutionalisation through appropriate legislation for the participation of states in this extractive activity and their co-ownership of the sector.

Communities

Mining is a very environmentally intensive and intrusive activity, with its biggest impact felt by the immediate communities in which it is carried out. Yet in many cases, communities fail to benefit from ongoing activities, but instead suffer in a number of ways, including: bearing the brunt of damaging environmental practices that affect their livelihoods and destroy community assets (e.g. polluted rivers, gutted land that is no longer suitable for farming, etc.); and experiencing limited to no social investments by participating companies. Also, being sidetracked through non-consultation and limited participation in the mining decision-making process, especially in terms of decisions that could adversely affect the entire community (e.g. waste treatment and disposal, and the types of social amenities provided).

Donors and International Agencies

Donors and international agencies are great sources of development funds for early stage investments in mining, as they are often willing to contribute both directly (through grants, aid and low-cost loans) and through expertise (advisory services, research, capability building and human capital development). However, Nigeria tends to be overlooked or has difficulty attracting these funds and investments given the historical dormancy and neglect of the mining sector, as well as the legacy of lack of transparency in the utilisation of these funds.

Some of the training programmes available are outdated, as in a number of industry segments, while technology has advanced significantly beyond the levels they were when mining in Nigeria was significant.

Professional Associations and Civil Society

Professional associations, especially those that qualify the various professions engaged in the sector (mining engineering, geoscience, geology, etc.), remain the gatekeepers of talent and human capital in the industry. They ensure that those admitted into their cadre retain the highest levels of professionalism and ethics, preserving the integrity of the industry. They are also meant to serve as advocates for the industry – educating the public and championing reform in the sector through policy dialogues with government and other stakeholders.

However, with the decline of the industry, the effectiveness and relevance of these associations have suffered, with fewer people admitted due to limited avenues for the relevant education (only two universities in Nigeria currently offer any formal mining engineering training), decimating the ranks of these professions and weakening their powers of advocacy. Hence, expertise is less specialised and practical, given the lack of hands-on training opportunities available when mines and factories were in active operation. Some of the training programmes available are outdated, as in a number of industry segments, while technology has advanced significantly beyond the levels they were when mining in Nigeria was significant.

Industry Participants

Upstream Large-scale Miners

There are no large-scale miners in operation in Nigeria today. This is due largely to poor investment climate and policy uncertainty. Large-scale mining takes a long period to come to fruition. It is not uncommon, especially in large-scale mines, for preparation and construction to go on for three to five years before actual production commences. It takes even longer for more complicated operations. Investments like these can only take place in an environment where investors are certain of their returns at the end of the day.

Large-scale mining requires heavy equipment (e.g. draglines) and supporting infrastructure (power, transportation), much of which are provided and readily available in the more prominent mining destinations in Africa, but are absent in Nigeria

The absence of a clear, believable, long-term policy for the mining sector in Nigeria will continue to push these investors to neighbouring countries. This is compounded by the lack of supporting infrastructure (e.g. drilling rigs). Large-scale mining requires heavy equipment (e.g. draglines) and supporting infrastructure (power, transportation), much of which are provided and readily available in the more prominent mining destinations in Africa, but are absent in Nigeria, requiring significant additional investment by these companies. This raises the relative cost of doing business in Nigeria.

Junior Operators and Explorers

Junior operators and explorers experience some of the challenges of the large-scale miners, but have a few additional ones of their own, including: access to funding and capital markets due to risks. Mining exploration is very expensive and at the same time quite risky, and it is not unusual to conduct 10 or more exploratory projects for each mining project undertaken. Unlike the large-scale miners, junior miners often lack the capital and funding for these projects as their scale and risk profiles usually lock them out of cheaper sources of funds open to their larger counterparts.

Also, while large-scale miners typically have access to talents globally and can generally deploy them at will to segments of their business where they are most needed, junior miners and

explorers are limited by their geography and scale. Most have to make do with the available local content and technology in Nigeria, much of which is limited.

Artisanal Miners

Small-scale mining in Nigeria suffers from the following major challenges:

The practice (Artisanal) generally tends to be destructive and harmful to the environment: stripping thousands of square miles of topsoil from arable land

Risk and safety: As it currently exists, artisanal mining in Nigeria is often an illegal and high-risk activity. Because it is practiced on a small scale by people who are often poor, uneducated, and lack other employment opportunities, it is a highly unregulated sector and subject to harsh working and living conditions. And because small-scale miners are not trained, they often do not realise that the methods they use to mine minerals are damaging their environment and health. In addition, many resort to destructive behaviour (abuse of drugs and violence) to enable them survive the harsh conditions under which they operate.

Environmental degradation: Artisanal and small-scale mining is largely unregulated, and in the cases where regulations exist, they are not well enforced. The practice generally tends to be destructive and harmful to the environment: stripping thousands of square miles of topsoil from arable land across Nigeria and damaging/destroying the vegetation, animal habitats, and natural water courses in affected communities.

Low productivity and poverty: Most ASMs lack formal training in mining methods and hence mostly make use of ad-hoc techniques in mining, many of which result in low output and productivity. This keeps many stuck in a cycle of poverty, as much of what they produce can only sustain them in a subsistence manner, limiting their opportunities for economic advancement.

Logistics/Midstream Transportation: As highlighted, the biggest challenge of midstream participants in the Nigerian mining sector is the lack of infrastructure for moving bulk loads of ore and minerals from ore/mine-sites to refining or processing factories. For local production and beneficiation, this need can be obviated by locating the processing sites close to the mines, but for export production, particularly for ore/mineral exports, this

becomes a big bottleneck as many mines are located far away from ports and waterways.

Minerals Handling: Besides transportation, midstream companies also engage in materials handling, a delicate issue since a number of minerals (e.g. uranium ore, gold) need special handling, given their values or safety risks. At present, Nigeria has few ports with limited capacity to handle tonnes of ore and mineral products for export, which will constitute a bottleneck as production begins to increase.

Downstream Refining/Processing

The lack of market pricing and a solid minerals commodity exchange has caused minerals/metals pricing to be inelastic.

Downstream companies in Nigeria face two main challenges:

Availability of raw materials: This is very important and generally necessary to make the economics of downstream processing work, thus requiring supplies of large amounts of ore. Given the limited productivity and dispersed nature of mining activities in the country (limiting the centralisation of processing), this is a challenge that is yet to be overcome.

Lack of formalised exchanges for traders, certifiability, uniform reference standards, and inelastic markets: The lack of market pricing and a solid minerals commodity exchange has caused minerals/metals pricing to be inelastic. This dynamic often frustrates buyers, who then resort to withholding patronage in order to force local selling prices down. This generally arises because local miners and suppliers are not aware of international pricing dynamics and they hold rates at the last offer price.

The last offer price is often set by Chinese spot buyers trying to secure market size and supply on the short term to meet supply orders to smelters or refineries (for short term deals/hedging and also direct supplies to smelters, they can afford this price).

After they leave, local suppliers hold on to the last price, while willing buyers at this price exist, and they only drop the price when there are no buyers any longer. Pricing is often set regionally among local associations, but after a few weeks, it homogenises across the country. We believe that a commodity exchange and proper price discovery will solve this problem, as proven with the local gold market.

Geosciences information and limited resource mapping and quantification: The lack of adequate and reliable data for investment purposes will discourage investor interest. Much of the available geological information is dated, having been produced in the 1950s, largely by the Geological Survey of Nigeria. Nigeria recently completed a High Resolution Airborne Geophysical Survey involving magnetic, radiometric and limited electromagnetic surveys aimed at assisting and promoting mineral exploitation. The objective is to provide access to airborne geophysical survey data of Nigeria to investors, with the intention of accelerating mining sector investments.

The lack of adequate and reliable data for investment purposes will discourage investor interest.

However, considerable additional work is necessary to fully explore solid mineral resources and develop sufficient confidence in the mineral resource and "proven project reserves", in order to engender and support investment interests that are fundamental to initiating and building investor confidence in the mining industry.
Three underlying factors responsible for the limited availability of this data:

1. The lack of infrastructure for data gathering and processing, e.g. drilling rigs for subsurface specimen collection, airplanes and access to geo-stationary satellites for aerial surveys, specialised spectrometers for mineral analysis, computing software and tools for 3D (three-dimensional) and four-dimensional (4D) simulations and visualisations of reserve formations, etc.

2. The dearth of technical (field) expertise for reviewing and analysing data, as a lot of the equipment used in field exploration and evaluation need people with specialised trainings and backgrounds, to be able to correctly translate the obtained data into useful information.

3. The lack of adequate funding for the sector through years of neglect, as the government focused on driving income and revenue through other sectors

Data dissemination, archiving and reporting: After data is gathered, for it to be ultimately useful, it needs to be properly captured, archived and disseminated.

Dissemination: As highlighted previously section, the Nigerian Geological Survey Agency has commenced the collection and evaluation of sizeable amounts of information on the locations and quantities of the minerals available in the country. However, much of this remains unknown to the sector, as much of the information collected have not been made readily available through the many channels that most interested parties are likely to engage with, such as web portals or journals with wide readership. Limited accessibility to information on the sector continues to limit investment, as the less that is known about the potential value of a resource, the less an investor will be prepared to pay in concession rent, due to the additional costs perceived as required to establish the specifics of the reserve.

03

Only institutions in the country offering mining programmes, and even that being done at a general level.

Archiving: A lot of geological data previously collected in the earlier years of the sector, especially under the British government, have been stolen, destroyed or simply lost due to poor archiving. As a result, there are limited returns on investment in data gathering, since the same data always has to be collected repeatedly, thereby increasing costs and limiting participation.

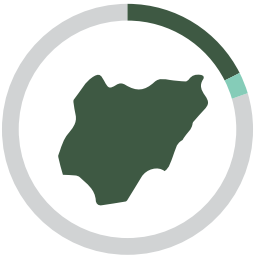
Enabling Environment/Human Capacity Building

Since mining in Nigeria has been dysfunctional for nearly four decades, there is a dearth of human capital and skills in key areas of the sector. The loss of a recognisable mining industry means that there is a low skills base upon which to build, leading to the necessity of huge investments in training, as well as importation of qualified labour. University curricula also need overhauling, with only three institutions in the country offering mining programmes, and even that being done at a general level. Professional associations have equally become shells of their former selves and have limited capacity to offer continuous learning and professional development workshops to their members.

Gender Equality and Children's Rights

Historically, women have been subject to gender inequalities and economic marginalisation in the mining sector. They experience the risks of the mining sector disproportionality, while men tend to accrue more of the benefits therein. This problem is worse in the artisanal mining sector which has largely dominated the mining

sector in Nigeria due to the absence of mining majors in the country. Women are more prone to physical and sexual abuse and, in the informal sector, tend to have less secure property and ownership rights than men. At the decision-making level, their involvement is also much lower than it could be, which limits the opportunities for choosing and enacting policies that are in favour of women, thereby further worsening the current cycle. It is therefore crucial to identify the underlying gender bias in the sector, to understand how the issue affects the mining sector and how mining activities can benefit men and women more equally. The mining sector strategy provides the umbrella for a number of specific initiatives to address the underlying gender issues in the sector.

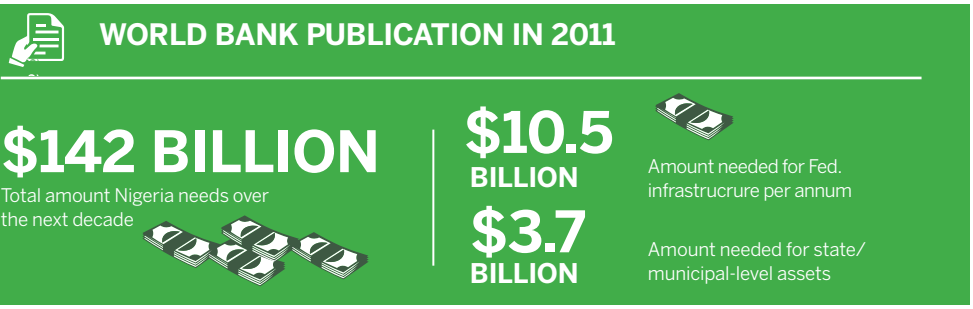


30-40%

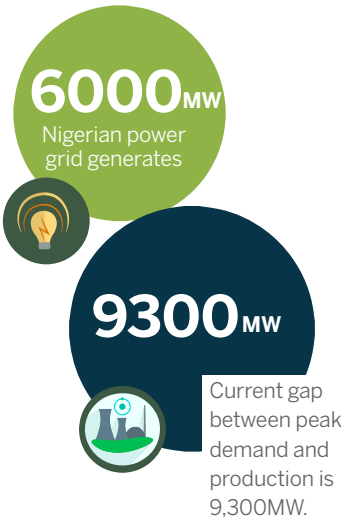
Nigeria's core infrastructure stock is estimated at only 35-40 percent of GDP.

Supporting Infrastructure

Nigeria's infrastructure has long been a bottleneck for economic growth, and it is underdeveloped in comparison to those of other fast-growing emerging economies. Of recent, however, a lot of efforts are going on with the present government in terms of the upgrade of the country's infrastructure. According to international benchmarks, more developed countries typically have a "core infrastructure" stock (roads, rail, ports, airports, power, water, ICT) equal in value to about 70 percent of the gross domestic product (GDP), with power and transportation infrastructure usually accounting for at least half of the total volume. Nigeria's core infrastructure stock is estimated at only 35-40 percent of GDP. This low value has been driven by historically low public and private spending on infrastructure. A 2011 World Bank publication asserted that Nigeria needs to increase its spending to US$14.2 billion per annum over the next decade, reaching a total of US$142 billion, with US$10.5 billion per annum needed for federal infrastructure and US$3.7 billion for state/municipal-level assets.



Power



Power shortages are endemic in Nigeria and the current gap between peak demand and production is 9,300MW, much of which has had to be filled by private corporations and households. Mining is an energy intensive business. Smelters typically have huge energy requirements, which is why they are either located near power stations or have their own power sources. The Nigerian power grid generates about 6000 megawatts (MW) of electricity, which is about an eighth of the power generation capacity of South Africa (with a total generation capacity of ~50GW). As a result, any company interested in establishing a mine in Nigeria will have to build its own power generation infrastructure to support its production, thereby increasing the cost and size of the investment required for successful operation.

Financing and Business Climate

Access to capital (credit) is probably the most widespread constraint experienced by West African businesses. Due to the long period of inactivity and slow progress in implementing the government's reform agenda in the mining sector, multinational companies have been reluctant to fund projects in the country. Due, also to the absence of reliable geosciences data, Nigerian mining companies find it extremely difficult to access finance from the formal money markets in Nigeria to engage in meaningful commercial mining, thus they engage in artisanal mining with its low production volumes, sterilisation of mining sites, land degradation, uncoordinated and inefficient mining methods, with its inherent threats to the safety of workers.

A key challenge is inadequate access to loan facilities to procure site equipment on the basis of long-term loans. Banks favour short-term loans, as opposed to the long term financing required in the mining sector. Other financial challenges include poor financial management by miners, unwillingness of banks to fund the sector, and the high cost of capital.

The World Economic Forum's Global Competitiveness Report for 2014-2015 placed Nigeria in the 127th place out of 144 economies. This has improved recently, with Nigeria jumping over 20 places to the 106th position by virtue of a gradually revamping macroeconomic environment. The Global Competitiveness Report

is a comprehensive assessment of the operating environment of institutions in each country, i.e. infrastructure, health, education, finance, goods and labour markets, technological state, as well as business sophistication and innovation.

WORLD ECONOMIC FORUM'S GLOBAL COMPETITIVENESS REPORT FOR 2014-2015

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CURRENT POSITION

Nigeria jumping over 20 places to the 106th position by virtue of revamping macroeconomic environment

Nigeria is seen to benefit from its large market size (the 33rd), which has the potential for significant economies of scale and is an important factor for attracting investment into the domestic and regional markets. Nigeria also benefits from a relatively efficient and flexible labour market. However, the country's institutions are considered to be weak, with insufficiently protected property rights. The security situation in the country is worrying, and this places Nigeria in the bottom 5 percent of country rankings at the 139th position. Infrastructure upgrades continue to be required, coupled with improvements in health and primary education. The critical factors governing improvement are considered in terms of maintaining the country's reform momentum in diversifying the economy and increasing its long-term competitiveness.

As earlier mentioned, in 2016, with the advent of the current Buhari administration, a major effort at providing a sustainable and focused plan was achieved with the launch of the road map for the development of the solid minerals sector.

The 2016 Roadmap

The Honourable Minister and Honourable Minister of State of the Ministry of Solid Minerals Development set up a 17-man committee to develop a roadmap for the sustainable development of the mining and metals sector in Nigeria. The committee was made up of representatives spanning the value chain of the sector and it also consulted with external stakeholders.

While the roadmap centres around the path to sustainable development in the sector for the next couple of years, it places special emphasis on the critical issues and challenges which must be addressed for value creation in the immediate, short, mid-term and long-term periods.
The roadmap focuses on all areas that must be addressed in order to rekindle and sustain the required momentum for reforms in the sector. It prioritises activities for implementation,

includes scenarios and case studies as models for successful implementation, and monitors and envelopes these in a coherent, consensus strategy for the buy-in of all stakeholders.

The plan also leverages prior roadmaps and development initiatives instituted by the Federal Government, and aims to improve deficiencies encumbering the growth of the sector.

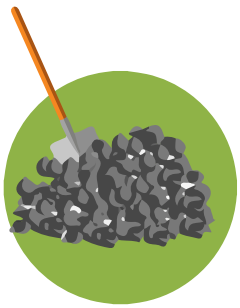
This roadmap represents a coherent strategy to rejuvenate the mining sector, which can be briefly summarised as follows:

• Nigeria's ambition should be to create a globally competitive sector capable of contributing to wealth creation, providing jobs and advancing our social and human security;

• Nigeria can achieve this by focusing on using its mining assets to drive domestic industrialisation initially, and then migrating to win in global markets;

• Nigeria should pursue this strategy through a value chain based growth plan.

The successful execution of a mining plan will unlock significant value for Nigeria.



Nigeria's ambition should be to create a globally competitive sector capable of contributing to wealth creation, providing jobs and advancing our social and human security

Timeline of key action items for executing the roadmap

Immediate	Short-term	Medium term	Long-term	Ongoing
0-6 months	6 months – 2 years	2 – 5 years	5 – 10years	To refresh regularly
■ Launch roadmap and begin communication campaign to generate indus try buy-in ■ Set up Mining Implementation and Strategy Team (MIST) to drive execution of the roadmap ■ Design/establish process for strategic planning for long-term development ■ Begin active communication and promotion of roadmap with stakeholders ■ Finalize review of key industrial assets and prepare them for strategic turn arounds ■ Identity gaps in existing training programs and suggest changes	■ Develop strategy to utilize priority minerals domestically and substitute exports ■ Restructure and reorganize the MSMD for more efficient operations ■ Improve regulatory clarity on powers and duties of MDAs in mining and establish clear fiscal framework for state participation ■ Incentivize financial participation of communities in mining ■ Actively drive the formalization of ASMs ■ Expand coverage, resolution of, and access to geosciences data in Nigeria ■ Strengthen the financial and business climate	■ Work with National & State legislatures and govts to address gaps and conflicts in governing legislation ■ Deepen engagement of communities in mining ■ Develop and harmonize (financial) incentives for attracting mining majors and juniors to Nigeria ■ Encourage forward integration of mining and exploration companies into downstream operations ■ Build local technical/ managerial skills and capabilities required in the industry ■ Promote gender equity and female participation in the sector ■ Catalyse investments in infrastructure	■ Drive the development and expansion of supporting infrastructure for mining (e.g. power generation, transportation) ■ Invest in education for citizens of mining communities ■ Drive the growth of export of value-added mining products ■ Encourage the formation of private minerals and metals exchanges to increase trading liquidity ■ Entrench gender equity and eliminate the exploitation of child labour ■ Deepen financial services expertise and access to funds to drive sector growth	■ Invest in tools and trainings required for effective service delivery by the MSMD and its agencies ■ Enforce established laws and regulations governing the mining sector ■ Work with other MDAs involved in the sector to coordinate policies, regulations and their implementation ■ Work with state governments to build and maintain an enabling environment for the mining sector ■ Provide trainings and extension services for ASMs to improve their productivity ■ Reinforce geoscience technical and research capabilities to drive investments

Re-engineering the Mineral Sector to Contribute to the Growth of the GDP

The successful execution of a mining plan will unlock significant value for Nigeria.

Nigeria has a robust mining regulatory framework but needs to improve its policy perception scores

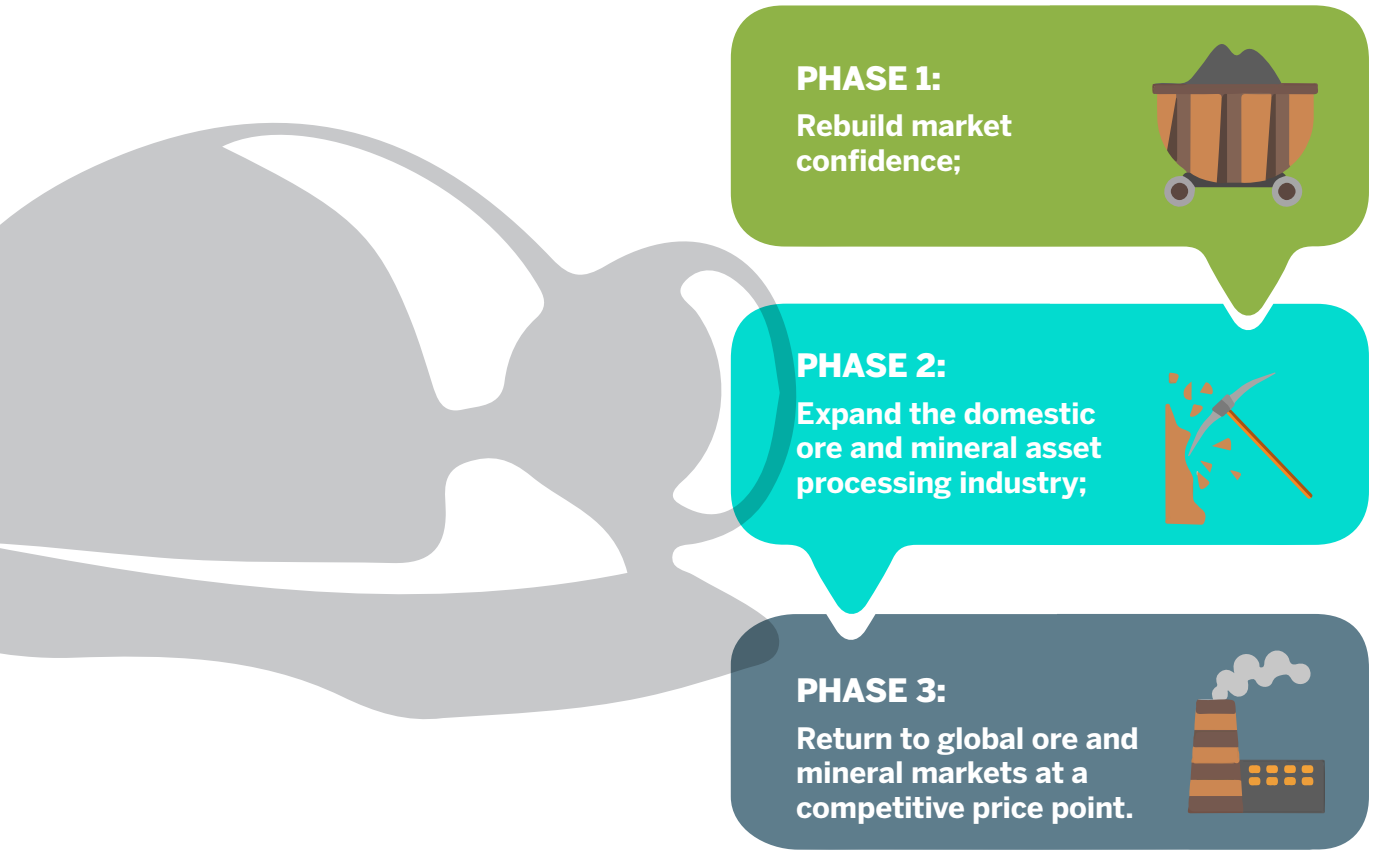
		Australia	Chile	South Africa	USA	Nigeria
Corporate Income Tax		30%	20%	28%	40%	20-30%
Royalty	Coal	2.75-15%	0-14%	0.5-7%	8-12.5%	3-5%
	Gold	2.5-5%	0-14%	0.5-7%	4-10%	3-5%
	Copper	2.5-5%	0-20%	0.5-7%	4-10%	3-5%
	Iron ore	5.35-7.5%	0-14%	0.5-7%	4-10%	3-5%
Financial Incentives		• EDI encourages shareholder investment in small exploration companies by offering tax credits	• Companies under stability tax agreements charged flat tax rate (4-5%), lower than progressive tax rate paid by others	• CAPEX by mining companies can be fully deducted against tax - E.g. spending on prospecting; mining equipment etc.	• Tax structure permits depletion deduction which can lower federal income tax rate by ~3%	• Tax holiday for an initial period of 3 years from commencement of operations
Custom duty		• 5% import duty for importing mining equipment • Additional import processing charge	• 6% import duty for importing mining equipment	• 0% import duty rate for importing mining equipment	• 0% import duty rate for importing mining equipment	• Exemption from custom and import duties on mining equipment*
Lease duration		21 years	Indefinite	30 years	20 years	25 years
Ownership requirement		• Acquisition of 15% or more interest in any Australian mining co • Acquisition of interest in an operational mine	• Non-discrimination between domestic and foreign-owned entities	• 26% stake by a local directly or via holding Co.	• N/A	• Foreign company to incorporate local subsidiary (with exceptions)
Mining production index (2014)		131.2	111	98	133.9	84.1
Policy perception index (2013/14)		76.61/70.47**	70.86/72.23	39.78/44.47	71.8/69.08**	30.54/10.63

Notes: EDI = Exploration Development Incentive, EPBS = Enhanced Project By-law Scheme; higher mining production index indicates better performance. Policy perception index is the outcome of surveys of investors working in the market. Nigeria's scores reflect the absence of global mining majors and juniors
Source: Fraser institute annual- Survey of Mining Companies, 2014; Literature Search

Strategic Framework

Goals: Build a world-class minerals and mining ecosystem designed to serve a targeted domestic and export market for minerals and ores.

Where to play: Rebuild Nigeria's minerals, mining and related processing industries in three phases:

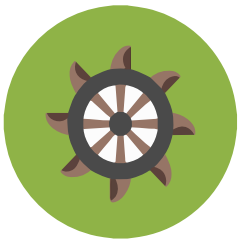


How to win: Build a minerals and mining sector, initially focusing on using Nigeria's industrial mineral endowment to support its industrialisation. This involves private sector friendly policies and the increased ease of doing business. Over time, with an expansion in domestic processing, Nigeria should seek to build a cost-led sector, as well as production expertise in select non-industrial minerals.

Key enablers: Invest in a range of enablers including bulk handling terminals, railroad and rolling stock capacity, technical

and engineering capacity, regulatory reform, reorganisation of the Ministry of Solid Minerals itself, and expansion of access to financing to drive sector transformation.

A key element of the regulatory reorganisation will involve the creation of a new super regulatory agency that will merge and streamline the current functions of the Mining Cadastre, Mines Inspectorate and Mines Environmental Compliance divisions.



Key element of the regulatory reorganisation will involve the creation of a new super regulatory agency that will merge and streamline the current functions of the Mining Cadastre

The Mining Implementation Strategy Team (MIST) was inaugurated to ensure that the process outlined by the Roadmap is followed strictly to achieve maximum success.

The MIST is tasked with the following:

a. Forming the secretariat and implementation office for the execution of the action items and priorities in the Roadmap;

b. Identifying key low cost/low hurdle actions to be implemented by the Ministry, industry and other stakeholders that can start to build a mining revival, and create a positive narrative to drive increased investment;

c. Providing investment advice to the Minister and the Ministry regarding the revival and expansion of the mining and mineral sector;

d. Developing a resource (financial and non-financial) mobilisation strategy for the mining and minerals sector;

e. Providing investment advice to the Minister and the Ministry regarding the revival and expansion of the mining and mineral sector;

f. Developing a resource (financial and non-financial) mobilisation strategy for the mining and minerals sector;

g. Developing a framework for monitoring and evaluating the implementation process and progress. Identifying baselines, implementation inputs, outputs, outcomes, measurement tools, and their linkages towards the country development objectives of economic diversification, job creation, poverty alleviation and sustainable development from mining;

h. Developing an accountability framework (internal control systems) for management and delivery of the Action Plan;

i. Facilitating, in partnership with the Ministry, the development and monitor of institutional and annual work plans that leverage the full capability of the Ministry's technical teams to support the delivery of the Roadmap; and as appropriate, developing capacity building programmes to ensure effective delivery of outcomes contained in the strategic framework;

j. Developing a communication strategy for articulating the implementation process and progress to different audiences, including investors, the President, Federal and State Governments, the public, NASS, etc. on a regular basis;

Strategy framework for the mining sector roadmap

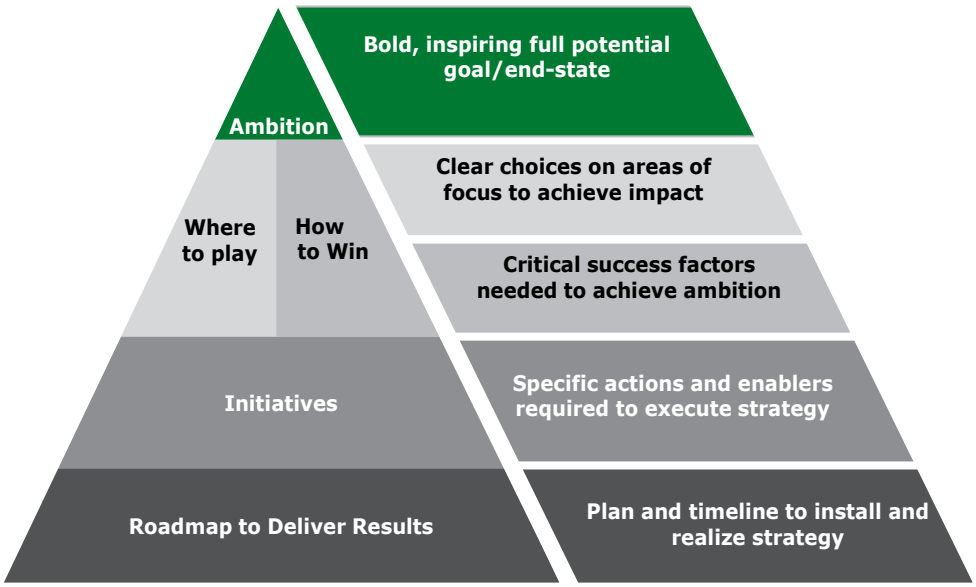


Figure 3: Strategy framework for the mining sector roadmap

Timeline of key action items for executing the roadmap

Priority Minerals

– Nigeria's priority minerals will be those for which data exists around their continued commericial viability (i.e. proven reserves

Operators and participants

– Nigeria will aim to build a competitive enabling environment amd sector for all attempt to select winners and losers

Figure 4: Focus area for the mining roadmap strategy

Served markets

– Nigeria will initially focus on the domestic market

– As global markets recover, Nigeria will seek to serve both domestic and export markets

Target customers

– Nigeria's initial customer focus will be to serve companies and end users that already purchase minerals and process material from offshore sources

Note : The particulars of the focus areas provided are preliminary ; they are expected to evolve as a more detailed strategy is built from a more comprehensive industry factbase

Key element of the regulatory reorganisation will involve the creation of a new super regulatory agency that will merge and streamline the current functions of the Mining Cadastre

Undertaking a stakeholder mapping and engagement exercise to determine the roles and responsibilities of government, civil society organisations, communities, community based organisations, mining associations, the academia, trade unions, religious groups, women groups, media parliament, media, and professional associations, etc.

Building on this introductory journey into the historical perspective, current overview and recent plans for the development of the sector, this scoping study thus aims at presenting an overview of the potentials of the solid minerals sector. In doing this, Nigeria's resource endowments are presented, alongside their geological backgrounds, on a regional and state basis, which is a prerequisite to endowment emplacement, while the industrial potential of each of the commodities present in the

CHAPTER TWO

The Geology of Nigeria

Nigeria has the unique advantage of being endowed with a wide variety of geologic environments

Nigeria is geographically located within the West African subregion and lies between longitudes 3O and 14OE and latitudes 4O and 14ON. It has a landmass of 923,768 square kilometres and is bounded towards the north by Niger Republic and Chad, towards the west by Benin Republic, the east by the Republic of Cameroon and south by the Atlantic Ocean shoreline.

Nigeria has the unique advantage of being endowed with a wide variety of geologic environments. (Figure 5 shows the Geologic Map of Nigeria). There are three major geological components in Nigeria, and these are:

TABLE 2: MAJOR GEOLOGICAL DIVISIONS OF NIGERIA

1	Basement Complex	Pan African and older (Precambrian) >600 million years
2	Basement Complex	Jurassic 200-145 million years
3	Sedimentary Basins	Cretaceous to Recent < 145 million years

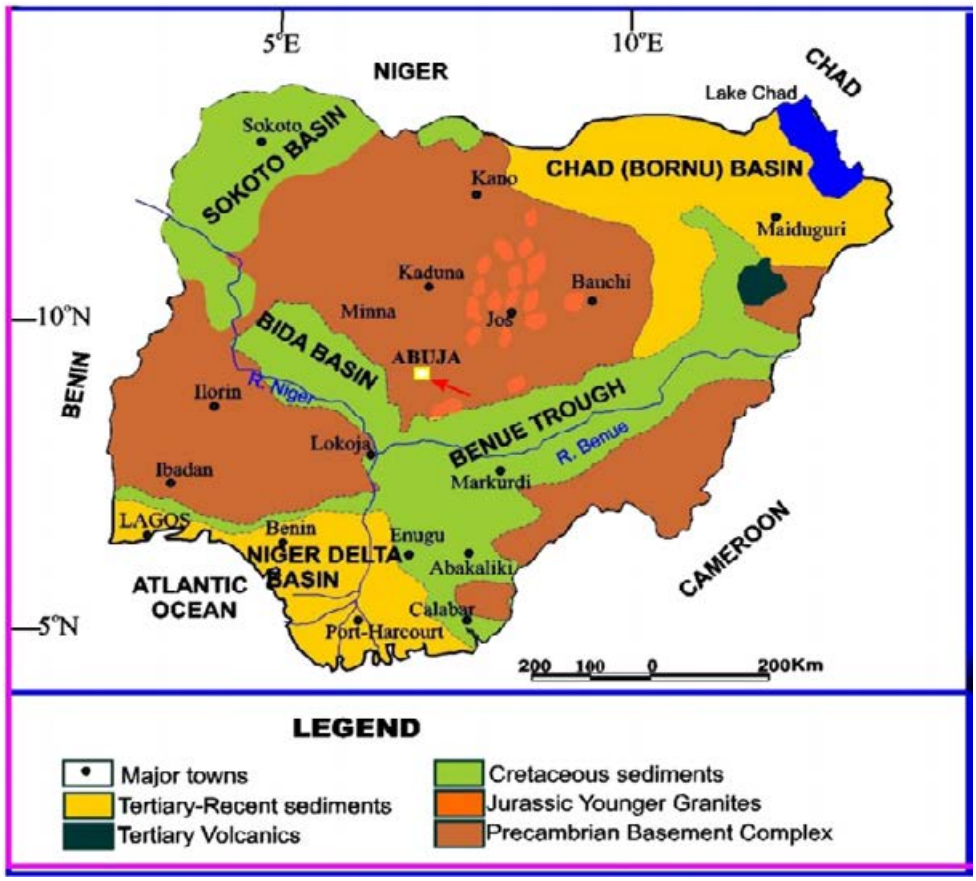


Figure 5: Map of Nigeria Showing the Major Geologic Units

BASEMENT COMPLEX

The whole basement complex has been through at least two tecto-metamorphic cycles and consequent metamorphism

This is one of the three major, and also the oldest (Precambrian), components that make up the geology of Nigeria. It forms part of the pan-African mobile belt and lies between West Africa and Congo.

Cratons and south of the Tuareg Shield: This underlies the entire area and includes all rocks older than the late Proterozoic meta-sediments. It includes meta-sediments of high metamorphic grade, such as paragneiss, basic and calcareous schist, marble and quartzite, as well as orthogneiss, and possibly early Eburnean granite

The whole basement complex has been through at least two tecto-metamorphic cycles and consequent metamorphism, migmatisation and granitisation have extensively modified the original rocks so that they generally occur as relict rafts and xenoliths in migmatites and granites.

It is intruded by the unique Mesozoic calc-alkaline ring complexes referred to as the younger granites that are predominately found around the Jos Plateau, and which extend northwardly towards Kano, up to Aïr Mountains in Niger Republic. More extensive areas of gneiss and ancient meta-sediments occur in North-West Nigeria. The meta-sediments recognised within the basement complex are believed to be relicts of an old supracrustal cover, probably of the Birrimian age, and which are termed older meta-sediments in order to distinguish them from late Proterozoic supracrustal sediments, known as the younger meta-sediments. The Nigerian basement complex consists of five major rock groups:

THE NIGERIAN BASEMENT COMPLEX CONSISTS OF FIVE MAJOR ROCK GROUPS:

1.	Liberian (2,700 Ma)
2.	Eburnean (2,000 Ma)
3.	Kibaran (1,100 Ma)
4.	Pan-African cycles (600 Ma)
5.	Volcanics and hypabyssal rocks[1]

The first three cycles were characterised by intense deformation and isoclinal folding, accompanied by regional metamorphism, which was further followed by extensive migmatisation. The Pan-African deformation was accompanied by a regional metamorphism, migmatisation and extensive granitization and gneissification, which produced syntectonic granites and homogeneous gneisses. Late tectonic emplacement of granites and granodiorites and associated contact metamorphism accompanied the end stages of this last deformation. The end of the orogeny was marked by faulting and fracturing within the basement complex of Nigeria, and four major petro-lithological units are distinguishable.

COMPONENTS OF THE BASEMENT COMPLEX

1.	The Migmatite-Gneiss Complex (MGC)
2.	The Schist Belt (metasedimentary and metavolcanic rocks)
3.	The Older Granites (Pan African granitoids)
4.	Undeformed Acid and Basic Dykes
5.	Volcanics and hypabyssal rocks[1]

The Migmatite–Gneiss Complex (MGC)

This is generally considered as the basement complex sensu stricto and it is the most widespread of the component units in the Nigerian basement. It has a heterogeneous assemblage comprising migmatite, orthogneises, paragneisses, and a series of basic and ultrabasic metamorphosed rocks.

Petrographic evidence indicates that the Pan-African reworking led to recrystallisation of many of the constituent minerals of the Migmatite–Gneiss Complex by partial melting, with majority of the rock types displaying medium to upper amphibolite facies metamorphism. The Migmatite–Gneiss Complex has ages ranging from the Pan-African to the Eburnean.

The Migmatitie-Gneiss Complex, also termed by some workers as the "Migmatite-Gneiss-Quartzite Complex", makes up about 60 percent of the surface area of the Nigerian basement. These rocks record three major geological events, with the earliest, at 2,500 Ma, involving initiation of crust forming processes: There is the banded Ibadan grey gneiss of mantle origin and of crustal growth by sedimentation and orogeny, after which came the Eburnean, at 2,000 ± 200 Ma, marked by the Ibadan type granite gneisses, and this was followed by ages in the range of 900 to 450 Ma. Many areas in northern, western and eastern Nigeria are covered by rocks of the Migmatite–Gneiss Complex

TABLE 3: MAJOR GEOLOGICAL UNITS OF NIGERIA

	Geological Unit	Rock Type
1.	Migmatite-Gneiss Complex	Migmatites, gneisses, granite
2.	Schist Belts (Meta-Sedimentary and meta-volcanic rocks).	Phylites, schists, pelites, quartzites, marbles, amphibolites
3.	Older granite (Pan-African Granitoids)	Granites, granodiorites, syenites, monozonites, gabbro, charnockites.
4.	Undeformed Acid and Basic Dykes	Dykes (muscovite-, tourmaline- and beryl-bearing pegmatites, applites and syenite dykes; basaltic, doleritic and lampropyric dykes).

(Figure 5), and these areas include but are not limited to: Abuja, Keffi, Akwanga, Bauchi, Kaduna, Kano, Funtua, Okenne, Egbe, Ajaokuta (in northern Nigeria); Ibadan, Ile-Ife, Akure, Ikerre, (in western Nigeria) and Obudu and the Oban Massif areas in eastern Nigeria.

The Schist Belt (Meta-sedimentary and Meta-volcanic Rocks)

The schist belts are best developed in the western part of Nigeria, west of 8◦E longitude, though smaller occurrences are found to the east, but only sporadically. The belts are confined to a NNE-trending zone about 300 kilometres wide. The area to the west of this zone is made up of gneisses and migmatites that constitute the Dahomeyan of Burke and Dewey (1972). Similarly to the east, no schist belts are known for a distance of 700 kilometres until in Cameroon, where a number of schist belts, considered to be Upper Proterozoic, occur in the Pan-African granite-migmatite terrain north of the Congo Craton.

No schist belts are known for a distance of 700 kilometres until in Cameroon,

The schist belts have been mapped and studied in detail in the following localities: Maru, Anka, Zuru, Kazaure, Kusheriki, Zungeru, Kushaka, Isheyin Oyan, Iwo, and Ilesha, where they are known to be generally associated with gold mineralisation.

The Older Granites (Pan African Granitoids)

The term “older granite” was introduced by Falconer (1911) to distinguish the deep-seated, often concordant or semi-concordant, granites of the basement complex from the high-level, highly discordant tin-bearing granites of northern Nigeria. The older granites are believed to be pre-, syn- and post-tectonic rocks, which cut both the migmatite-gneiss-quartzite complex and the schist belts. They range widely in age (750–450 Ma) and composition. They represent a varied and long lasting (750–450 Ma) magmatic cycle associated with the Pan-African orogeny. The rocks of this suite range in composition from tonalites and diorites through granodiorites to true granites and syenites.

Charnockites form an important rock group that were emplaced during this period. They are generally high level intrusions and

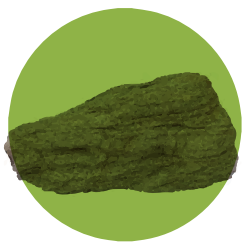
TABLE 4: MAJOR DIVISIONS OF THE OLDER GRANITE SUITE OF NIGERIA (AFTER OKUNLOLA, 2017)

1.	Migmatitic Granite
2.	Granite gneiss
3.	Early pegmatites and fine-grained granite
4.	Homogeneous to coarse porphyritic granite
5.	Slightly deformed pegmatite aplites and vein quarz
6.	Undeformed pegmatites, two-mica granites and vein quartz

anatexis has played an important role in their formation.

The older granites suite is notable for its general lack of associated mineralisation, although the thermal effects may play a role in the remobilisation of mineralising fluids. The older granites are the most obvious manifestation of the Pan-African orogeny and represent significant additions of materials (up to 70 percent in some places) to the crust. The older granite suites were classified as follows, based mainly on the textural characteristics.

Younger Granites



The younger granites are Jurassic-Triassic (135+25Ma) in age

These are found in North Central Nigeria where they intrude from the basement complex. They extend from the Benue valley in the southern Plateau through Kaduna, Bauchi, Kano, and further northwards across the border into the southern part of Niger Republic. They occur in a broad N-S trend, about 1500 by 100 to 1000km in extent, centred on the Jos plateau where the greatest concentrations of the ring complexes are found. The younger granites are Jurassic-Triassic (135+25Ma) in age. The age decreases southwards from Zinder (south of Niger Republic) to Benue valley, suggesting that the intrusion took place earlier in the Aïr Mountains in Niger, than it did in Nigeria.

Most of the younger granite massifs are ring complexes that consist of a series of distinct intrusions often having a concentric arrangement, with each intrusion having a characteristic petrographic feature.

Volcanic rocks commonly represent the earliest igneous activity and are intruded by porphyries, granites and less commonly syenites. These are confined to a roughly circular area bounded by a ring dyke or ring fault. The ring dyke is the main structural feature of the complexes and it controls the distribution of products of spasmodic vent eruption and the late cauldron subsidence. The initial stage of the development of the complexes was marked by the extrusion of vast quantities of acid lava and welded tuffs, which are partially preserved as a result of subsidence along the ring faults. The early rhyolites show a bedded sequence, wedded tuffs, bedded air fall tuffs, agglomerates and occasional basalts and trachytes. These are typical of rocks formed from sporadic eruptions from groups of simple central vent volcanoes or from a group of elongated vents along ring fractures. The most conspicuous structural features of the bedded volcanic rocks are tectonic in origin, and imposed by cauldron subsidence and igneous intrusive rocks.

The most conspicuous structural features of the bedded volcanic rocks are tectonic in origin, and imposed by cauldron subsidence and igneous intrusive rocks

The late rhyolites are crystal rich and represent magma that was already half-crystallised than in the early rhyolites, thus they were confined within caldera where they were able to be accumulated at a very thick cooling point. The central parts of these complexes are occupied by granite intrusions, some of which are ring dykes, but show different characteristics from the outer ring dykes.

Sedimentary Basins

These are made up of sediments deposited on the basement complex rocks. The overlying sediments have undergone several cycles of deformation and metamorphism, and these sediments are in part marine or terrestrial (fluviatile and lacustrine) in origin, having imprints of repeated cycles of transgressions and regression of the sea over areas of very low relief.

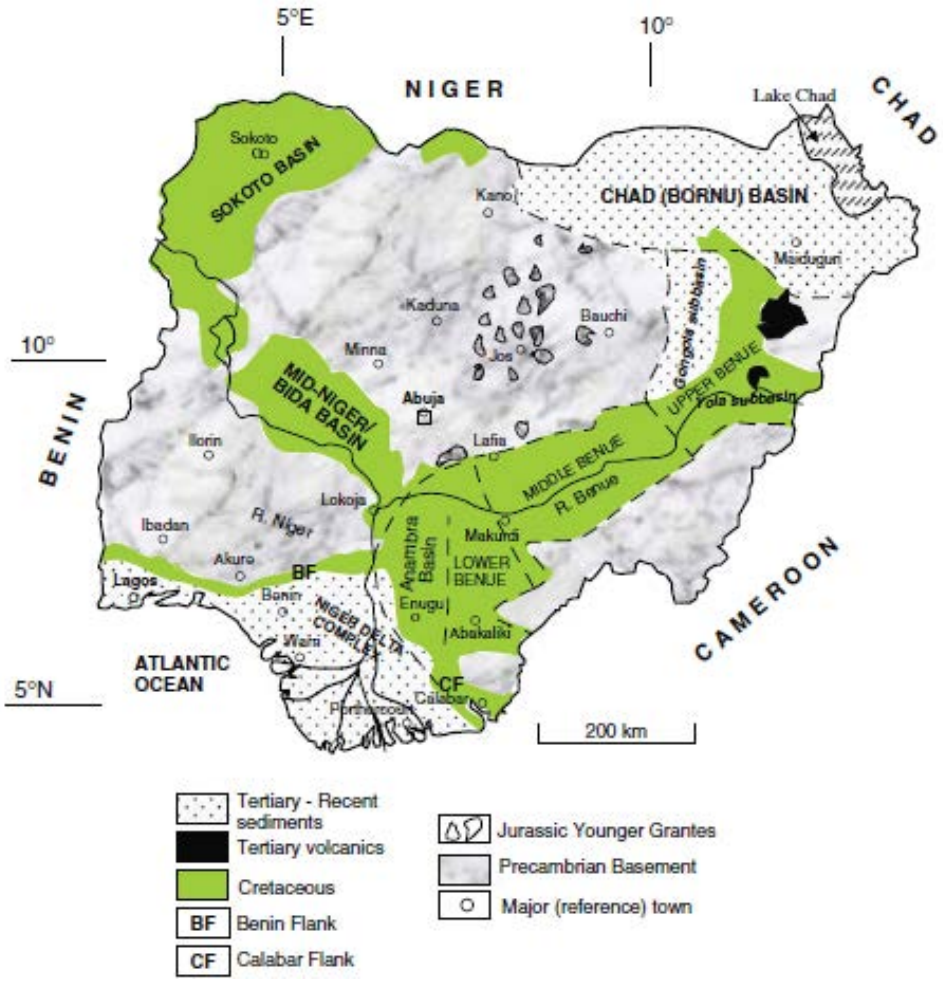
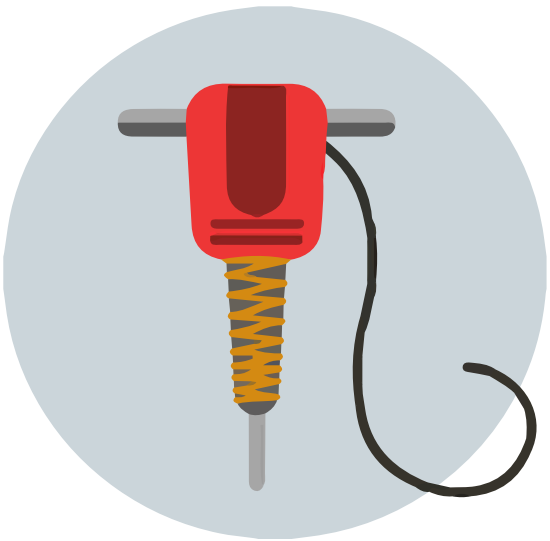


Figure 6: Distribution of sedimentary basins in Nigeria (After Obaje, 2009)

Nigeria has several sedimentary basins cutting across the country from the coastal areas to the inland. They range in age from the Mesozoic to the Cretaceous. The sedimentary basins of Nigeria include:

TABLE 5: MAJOR DIVISIONS OF THE SEDIMENTARY BASINS OF NIGERIA (AFTER NWAJIDE 2013)

1.	The Benue Trough i. The Lower Benue Trough a. The Anambra Basin ii. The Middle Benue Trough iii. The Upper Benue Trough a. The Gongola Basin b. The Yola Basin
2.	The Chad Basin
3.	The Mid-Niger/Bida-Basin
4.	The Sokoto/Iullemedden Basin
5.	The Dahomey Basin
6.	The Niger Delta Basin



Nigeria has several sedimentary basins cutting across the country from the coastal areas to the inland

Mineral Resources and Wealth Creation

The word 'resource' is an economic term that is defined as a thing that actually or potentially creates wealth. Mineral resource can therefore be described as that portion of the mineral endowment of a region from which wealth can be created. The measure of a country's development and civilisation is largely dependent on the use of minerals in different fields and applications.

Three classes of mineral deposits have been identified globally. These include metalliferous deposits, the non-metallic ones, and energy fuels, which in some cases are grouped together with the non-metals. The values of non-metals are now considered to be more than those of metalliferous deposits.

0.5%

is made up of such elements as platinum, gold, silver, nickel, cobalt, lead, zinc, tin, tantalite-columbite

The bulk of the lithosphere (99.5 percent) is made up of only a few minerals, namely: quartz, feldspar, pyroxene, amphibole, olivine, mica, magnetite and ilmenite. Besides, clay (kaolinite), dolomite, chlorite, calcite and limonite are the other important minerals constituting various sedimentary rocks.

The other 0.5 percent is made up of such elements as platinum, gold, silver, nickel, cobalt, lead, zinc, tin, tantalite-columbite, which are quite valuable and useful. The local accumulation of these, in varying sizes and shapes, such as in various pockets or impregnation in rocks, gives rise to different ore and mineral deposits.

Out of the over 2000 mineral species known, only about 200 are of economic value. Nigeria can boast of about 44 of these, which have different commercial potentials. We would only be considering the economic crystalline minerals or the solid minerals here. It is pertinent to note here that there are eight main geological processes that yield mineral deposits, as shown in table below.

TABLE 6: MAIN GEOLOGICAL PROCESSES THAT YIELD MINERAL DEPOSITS

1.	The magmatic concentration process, which gives rise to early and late magmatic deposits.
2.	Sedimentation: These are formed during processes of sedimentary rock formation, which involve weathering, solution and deposition.
3.	Metamorphism: This give rise to many new mineral deposits through recrystallization and reconstruction of pre-existing rocks forming such mineral deposits.
4.	Contact metasomatism: This includes a process of formation of new minerals by the recreation between contact rocks and escaping high temperature gaseous emanations, with other important materials from the magma chamber.
5.	Metasomatic replacement: A process of simultaneous solution and deposition by which ab earlier-formed mineral is replaced by a new one.
6.	Oxidation and supergene enrichment: Both processes occur together. Oxidation is operative in the upper part of the ore deposits above the groundwater table called the zone of oxidation. The secondary or supergene sulphide enrichment takes place when the down trickling solution reaches below the water table and its metallic contents are precipitated as secondary sulphides. Below this zone is the primary or hypogene zone, which remains unaffected together.
7.	Sublimation is a process of mineral deposits associated with volcanism, thermal springs and fumaroles, where fusion, volatilized matter is redeposited at a lower temperature and pressure.
8.	The last, but apparently the most common process is the hydrothermal one, relating to hot water with possible temperatures of ~5000C. The fluid resulting as an end product of magmatic differentiation constitutes a hydrothermal solution that carries metals originally present in the magma to the site of deposition. The process is responsible for the formation of epigenetic mineral deposits, which are those formed later than the rock that hosts them.

The hydrothermal process accounts for about 80 percent of the metallic ore deposits of Nigeria and about 6 percent of the industrial minerals. Many of the industrial minerals of Nigeria evolved as a result of the process of metamorphism (such as marble, graphite, kyanite, sillimanite), while minerals such as limestone, sands and secondary clays, bitumen, coal and lignite arose through the sedimentation process. Virtually all the metallic ores and gemstones are as a result of the hydrothermal process.

2000

1 **Out of the over 2000 mineral species known**

200

2 **only about 200 are of economic value**

44

3 **Nigeria can boast of about 44 of these, which have different commercial potentials**

It is pertinent to note here that there are eight main geological processes that yield mineral deposits

CHAPTER THREE

Nigeria's Mineral Resources

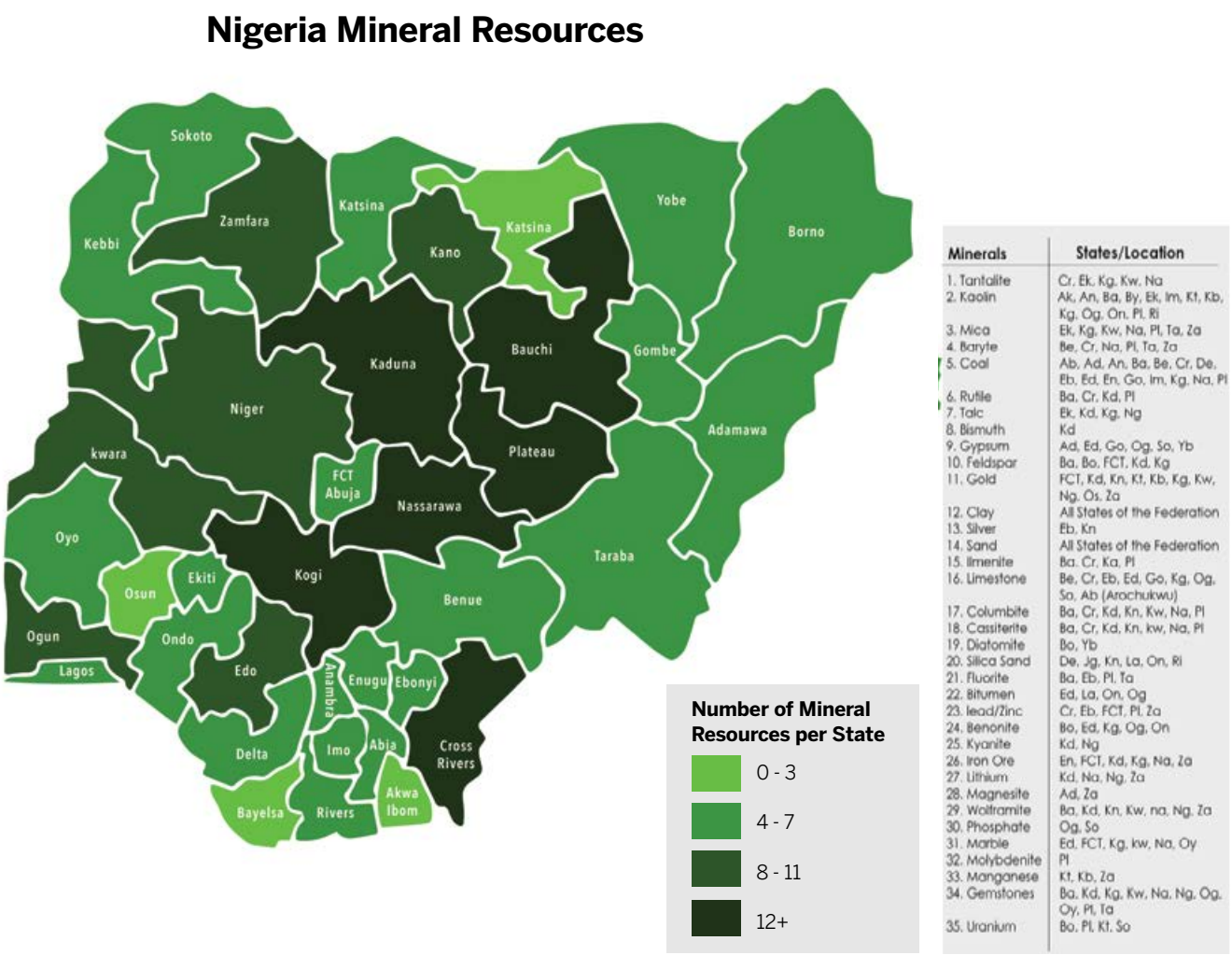


Figure 7: An overview of the distribution of Nigeria's mineral resources, modified from Okunlola (2017)

TABLE 7: CLASSIFICATION OF NIGERIA'S MINERAL ENDOWMENT (MODIFIED FROM OKUNLOLA, 2017)

METALLIC	INDUSTRIAL	ENERGY FUELS	GEMSTONES
Gold	Clays/Shales (Kaolinitic, Smectite)	Coal	Tourmaline
Tantalite	Limestone, Marble (Carbonates)	Uranium	Beryl
Columbite	Gypsum	Bitumen	Sapphire
Cassiterite (Tin)	Barite	Lignite	Amethyst
Iron Ore	Feldspar		Gem quartz (Rose quartz)
Galena	Quartz		Emerald, Kurzite
Sphalerite	Granite dimension/ construction		
Bismuth	Lepidolite		
Tungsten	Diatomite		
Platinum	Talc		
Chromite	Glass sand		
Silver			
Pyrite			
Chalcopyrite			
Manganese			

TABLE 8: NIGERIA'S METALLIC ORES AND THEIR USES (MODIFIED BY OKUNLOLA, 2017)

MINERALS	USAGES
Tantalite and Columbite	Acid resisting chemical wares, synthetic rubber, electric filaments, and special steel employed in dental and surgical instruments.
Cassiterite (Tin)	Tin plate, bronze, brass solder
Iron Ore	Machinery, farm tools, rails, automobiles
Galena	Pipes, cable cover, alloys, bronze
Sphalerite	Coating iron, dry battery, alloys
Bismuth	Alloys, electric fuses, safety plugs, fire protection
Tungsten	Steel and heat resistant alloy, gun barrels, internal combustion engine valves
Chromite	Metallurgical refractory, chemical purpose, alloys, automobiles, aeroplanes, trains
Pyrite	Gemstone, source of sulphur
Chalcopyrite	Ore for copper
Manganese	Iron and steel metallurgy, dry call battery, carbon monoxide gas masks
Pyrite	Gemstone, source of sulphur
Chalcopyrite	Ore for copper
Manganese	Iron and steel metallurgy, dry call battery, carbon monoxide gas masks

TABLE 9: NIGERIA'S ENERGY MINERAL RESOURCES AND THEIR USES (MODIFIED FROM OKUNLOLA, 2017)

MINERALS	USES
Coal	Fuels for railways, domestic fuel, thermal power plants
Uranium	Atomic energy
Bitumen	Paving roads
Lignite	Fuel

TABLE 10: NIGERIA'S INDUSTRIAL MINERAL RESOURCES AND THEIR USES (MODIFIED FROM OKUNLOLA, 2017)

MINERALS	USAGES
Clays/Shales (Kaolinite, Smectite)	Bricks, cement
Limestone, marble (Carbonates)	Cement, fertilizer, glass making, dimension stones
Gypsum	Retardant in cement manufacture, ammonium sulphate fertilizer, Plaster of Paris (POP), pharmaceuticals, textiles
Baryte	Oil and gas drilling, paint, chemical asbestos, glass, rubber, ceramics
Quartz	Sandpaper metallurgical
Granite	Construction, decoration
Diatomite	Abrasive, dental powder and paste
Talc	Polisher for soft metals, leather and rice grains
Feldspar	Scouring powder, soap for cleaning glass and enameled surfaces
Glass sand	Glass
Lepidolite	Lithium element source

TABLE 11: NIGERIA'S PRECIOUS METALS/GEMSTONES, ORNAMENTALS, MINERAL RESOURCES AND THEIR USES (MODIFIED BY OKUNLOLA, 2017)

MINERALS	USAGES
Gold	Jewelry, ornamental stones, optical instruments, watch jewels
Platinum	
Silver	
Tourmaline	
Beryl	
Sapphire	
Amethyst	
Gem quartz (Rose Quartz)	
Emerald	
Kunzite	
Feldspar (Moon Stone)	

TABLE 12: NIGERIA'S ENERGY MINERAL RESOURCES AND THEIR LOCATION (MODIFIED BY OKUNLOLA, 2017)

MINERAL	CLASS	LOCATION	LOCAL GOVERNMENT AREA	STATE
Coal	Mineral fuel	Ogboyoga	Ogbadibo	Benue
	Mineral fuel	Owukpa	Ogbadibo	Benue
	Fossil fuel	Ai-Odu	Ogbadibo	Benue
	Fossil fuel	Ibagba	Ogbadibo	Benue
	Mineral fuel	Ameri	Ezza south	Ebonyi
	Mineral fuel	Ameri	Ezza south	Ebonyi
	Mineral fuel	Enugu	Enugu South	Enugu
	Mineral fuel	Ogugu	Awgu	Enugu
	Mineral fuel	Inyi	Oji River	Enugu
	Mineral fuel	Amansiodo	Ezeagu	Enugu
	Mineral fuel	Ezimo	Udenu	Enugu
	Mineral fuel	Enugu	Enugu North	Enugu
	Mineral fuel	Okpara Mine	Enugu South	Enugu
	Mineral fuel	Ezimo	Udenu	Enugu
	Mineral fuel	Enugu	Enugu North	Enugu
	Energy Minerals	Kolori	Kwami	Gombe
	Energy Minerals	Maiganga	Akko	Gombe
	Energy Minerals	Doho	Kwami	Gombe
	Mineral fuel	Garin Maidugu	Akko	Gombe
	Mineral fuel	Ogboyoga	Dekina	Kogi
	Mineral fuel	Okaba	Okaba	Kogi
	Mineral fuel	Odokpano	Ankpa	Kogi
	Mineral fuel	Okpakiri	Dekina	Kogi
	Mineral fuel	Adagbo (Okaba)	Ankpa	Kogi
	Mineral fuel	Ogboyoaga	Dekina	Kogi
	Mineral fuel	Ahoko-Koto	Kogi	Kogi
	Mineral fuel	Dekina	Dekina	Kogi
	Mineral fuel	Shitire	Obi	Nasarawa

MINERAL	CLASS	LOCATION	LOCAL GOVERNMENT AREA	STATE
Lignite	Mineral fuel	Iberenta	Ikwuano	Abia
	Mineral fuel	Enugu	Enugu North	Enugu
	Mineral fuel	Elemaga Ibere	Ikwuano	Abia
	Mineral fuel	Ezimo	Udenu	Enugu
	Mineral fuel	Usuaka	Ikwuano	Abia
	Energy Minerals	Kolori	Kwami	Gombe
	Mineral fuel	Ogbuebule	Ikwuano	Abia
	Energy Minerals	Doho	Kwami	Gombe
	Mineral fuel	Ekebedi	Ikwuano	Abia
	Mineral fuel	Ogboyoga	Dekina	Kogi
	Mineral fuel	Oba	Idemmili	Anambra
	Mineral fuel	Odokpano	Ankpa	Kogi
	Mineral fuel	Nnewi	Nnewi South	Anambra
	Mineral fuel	Adagbo (Okaba)	Ankpa	Kogi
	Mineral fuel	Ogwashi Uku	Aniocha South	Anambra
	Mineral fuel	Ahoko-Koto	Kogi	Kogi
	Mineral fuel	Gamawa	Akko	Gombe
	Mineral fuel	Shitire	Obi	Nasarawa
	Mineral fuel	Awo- Idemili	Orlu	Imo
Uranium	Energy Mineral	Adim Idom Guburunde Horst	Yakurr	Cross River

CHAPTER FOUR

The Economic And Industrial Potentials of Nigeria's Mineral Endowments

Some minerals could be harnessed toward rapid industrialisation by the government and business communities.

The Federal Government has identified the need to diversify the economy, due to the continued decline in the price of crude oil in the international markets, which has led the country into an economic recession in more recent times. Hence, the solid minerals sector was identified as one of the areas that could be further developed to boost the economy and generate the much-needed jobs.

As such, the mining sector Road Map was drawn up, through which the Federal Government has encouraged state governments in the country to establish special purpose vehicles (SPVs) to access mineral titles and engage in the active exploitation and mining of these minerals, whilst coordinating mineral buying centres, and processing these minerals, either directly or through joint venture (JV) operations with partners in the private sector.

Some states have already taken steps in this direction, even if these have not yet resulted in successful commercial ventures.

Some minerals could be harnessed toward rapid industrialisation by the government and business communities. This can be categorised on the basis of usage/sector:

1. Precious stones, which include emerald, sapphire, topaz and tourmaline;

2. Metallic ore minerals, comprising gold, columbite, iron ore,

copper and cassiterite, etc.;

3. Energy minerals, such as bitumen, coal and uranium;

4. Industrial minerals, including limestone, gypsum, barite and kaoline;

5. Construction minerals like laterite, granite and gravel.

4.1 The Building/Construction Industry

4.1.1 Limestone

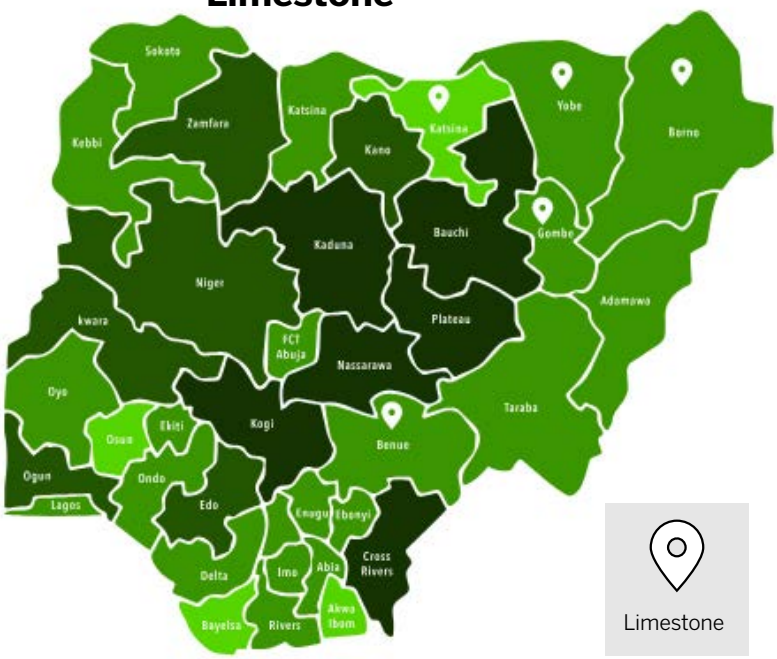
This is an important ingredient in the production of cement, contributing about 80 percentw of the raw materials required. It is also used for the purification of iron in the blast furnace, and in the manufacture of glass.

There are huge deposits of limestone in 14 states of the federation, while there are cement plants in Sokoto, Gombe, Benue, Kogi, Ogun, Cross River, and Edo States.

Limestone

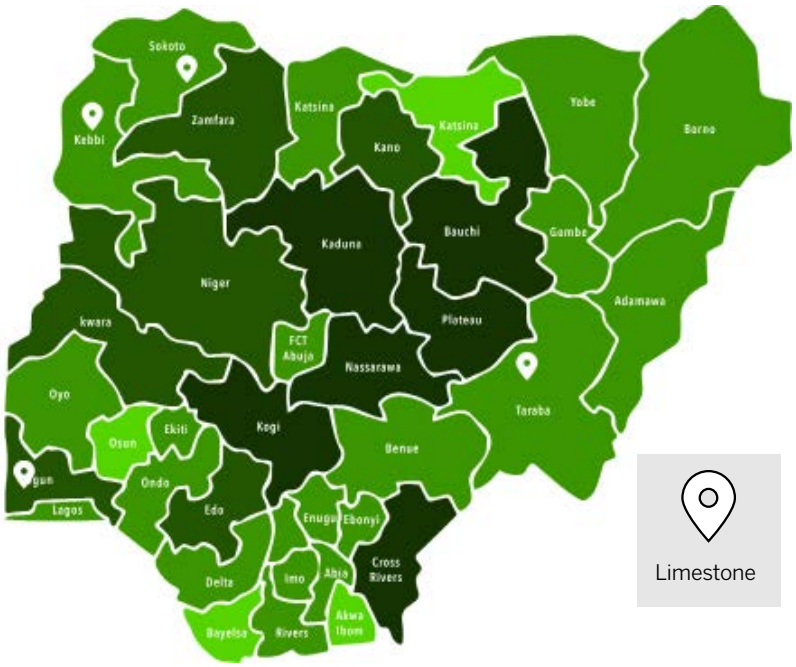
STATE	TOWN	LGA
Cross River	Agoi Ibami Ikot Ana Abini Odukpni Mfamsosing	Yakurr Biase Biase Odukpani Akamkpa
Enugu	Eha-Mufu Idodo Amagunze Nenweh Ogugu Ogbaku	Isi-Uzo Enugu East Nkanu East Aninri Awgu Awgu
Ebonyi	Odomoke Augasui-Ohaffia Agba Amofia-Mgbo Ameka Ohafia Agba Inyimagu 1 Effium Nkalagu	Odomoke Ishielu Ohaukwu Ishielu Ohaukwu Nkalagu
Abia	Arochukwu Ozuabam Oboro	Arochukwu Ozuabam Ohafia

Limestone

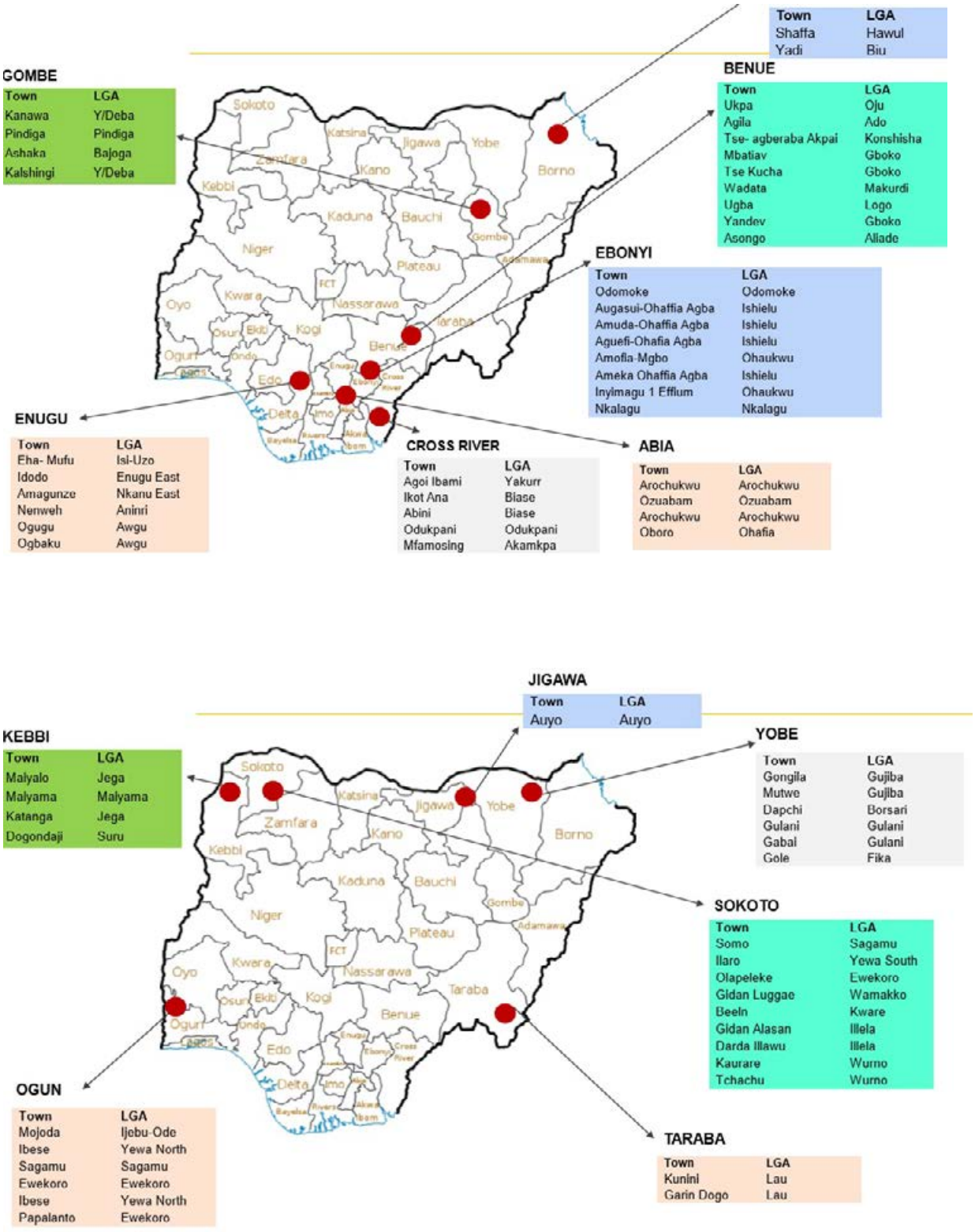


STATE	TOWN	LGA
Yobe	Gongila Mutwe Dapchi Gulani Gole	Gujiba Gujiba Borsari Gulani Fika
Benue	Ukpa Agila Tse-agberaba Akpai Mbatiav Tse Kucha Wadata Ugba Yandev Asongo	Oju Ado Konshisha Gboko Gboko Makurdi Logo Gboko Aliade
Borno	Shaffa Yadi	Hawul Biu
Gombe	Kanawa Pindiga Ashaka Kalshingi	Y/Deba Pindiga Bajoga Y/Deba
Jigawa	Auyo	Auyo

Limestone



STATE	TOWN	LGA
Sokoto	Somo Ilaro Olapeleke GidanLuggae Beein GidanAlasan Dardalllawu Kaurare Tchachu	Sagamu Yawa South Ewekoro Wamakko Kware Llela Llela Wumo Wumo
Taraba	Kunini GarinDogo	Lau Lau
Kebbi	Maiyalo MaiyamaK	Hawul Biu
Ogun	Mojoda Ibese Sagamu Ewekoro Papalanto	Ijebu-Ode Yewa North Sagamu Ewekoro Ewekoro



Figures 2.1, 2.2, 2.3, 2.4 and 2.5: Limestone occurrences and distribution in Nigeria

4.1.2 Calcite

Calcite is a principal constituent of limestone and marble. It is used in the manufacture of cement and paint (whitewash). Deposits of calcite are found in Jigawa, Kano, Gombe, and Taraba States.

4.1.3 Marble

Marble, which is used in architecture (dimension stones) and sculpture as result of its beauty, is also utilised in pharmaceuticals and agriculture due to its chemical composition. For its optical properties, it is used in the making of cosmetics, paint, and paper. Deposits of marble are found in the Federal Capital Territory (FCT), Kogi, Edo, Kwara, Oyo, Ekiti and Nasarawa States.

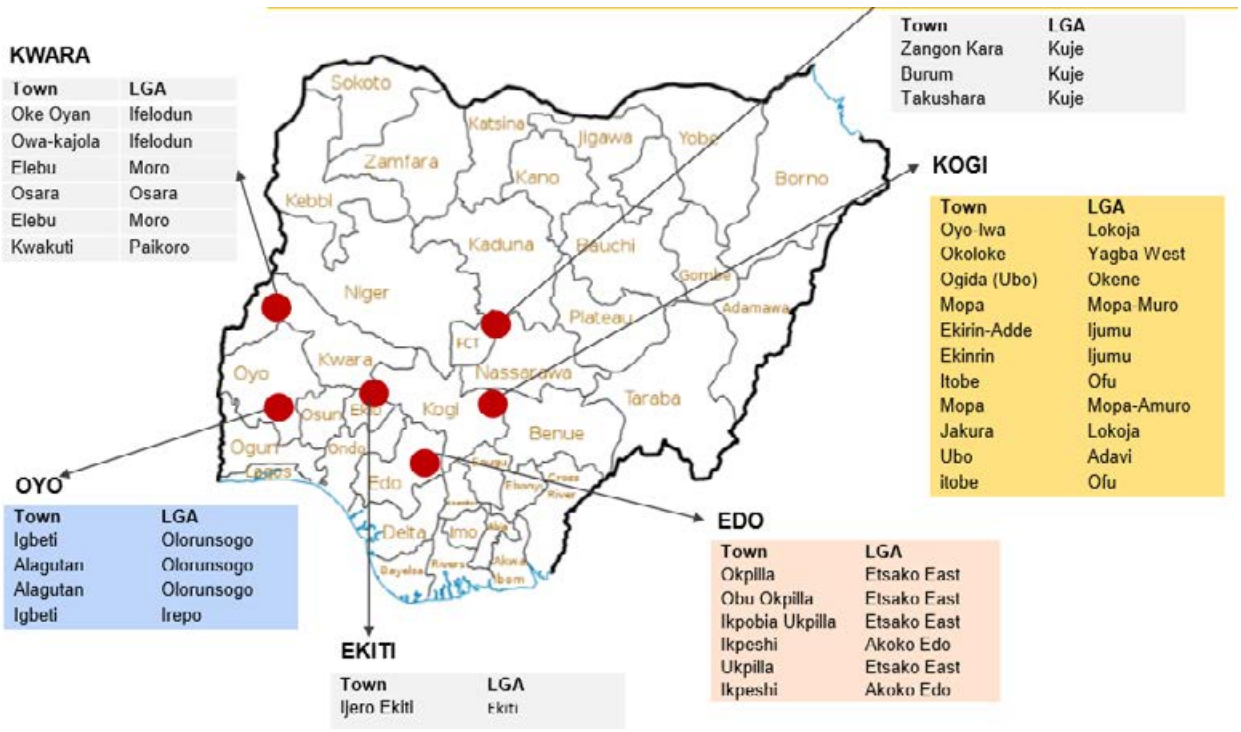
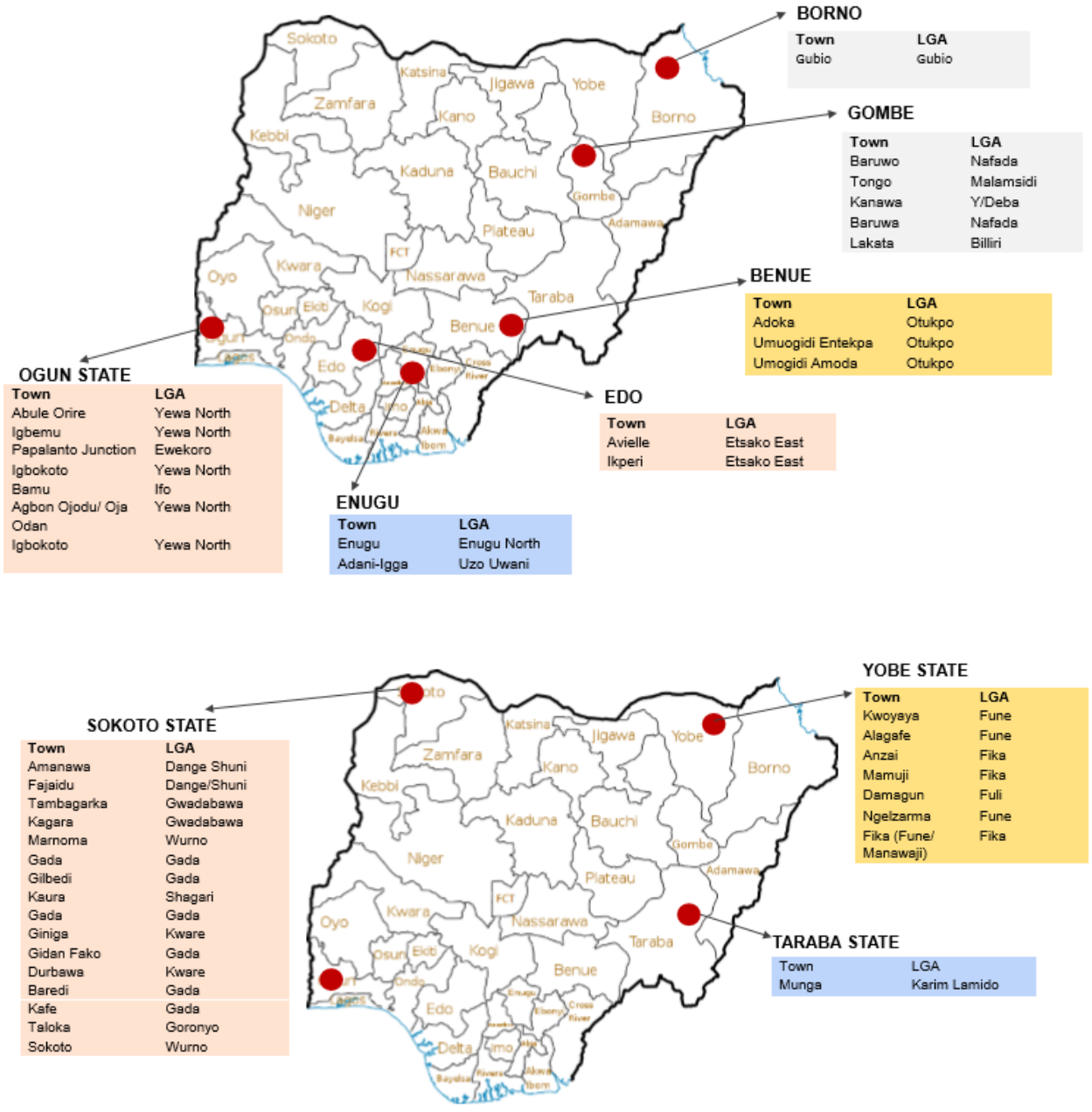


Figure 4: Marble deposit locations of Nigeria

4.1.4 Gypsum

Commonly found in layered sedimentary rocks, gypsum is used in the manufacture of cement as a hardening retarder, and also in the making of Plaster of Paris (POP). Deposits of gypsum can be found in Borno, Yobe, Edo, Gombe, Benue, Edo, Enugu, Ogun, Sokoto and Taraba States.



Figures 5.1 and 5.2: The occurrence and distribution of gypsum in Nigeria.

4.1.5 Silica Sand

This mineral, occurring naturally as quartz, is used in the food and pharmaceutical industries, in glass-making, and as a proppant, by companies involved in oil and natural gas recovery. In its finest form, silica sand is used as a functional filler in paints, plastics and rubber. It is also used in water filtration and agriculture. Deposits of silica sand are found in Kano, Jigawa, Lagos, Rivers and Ondo States.

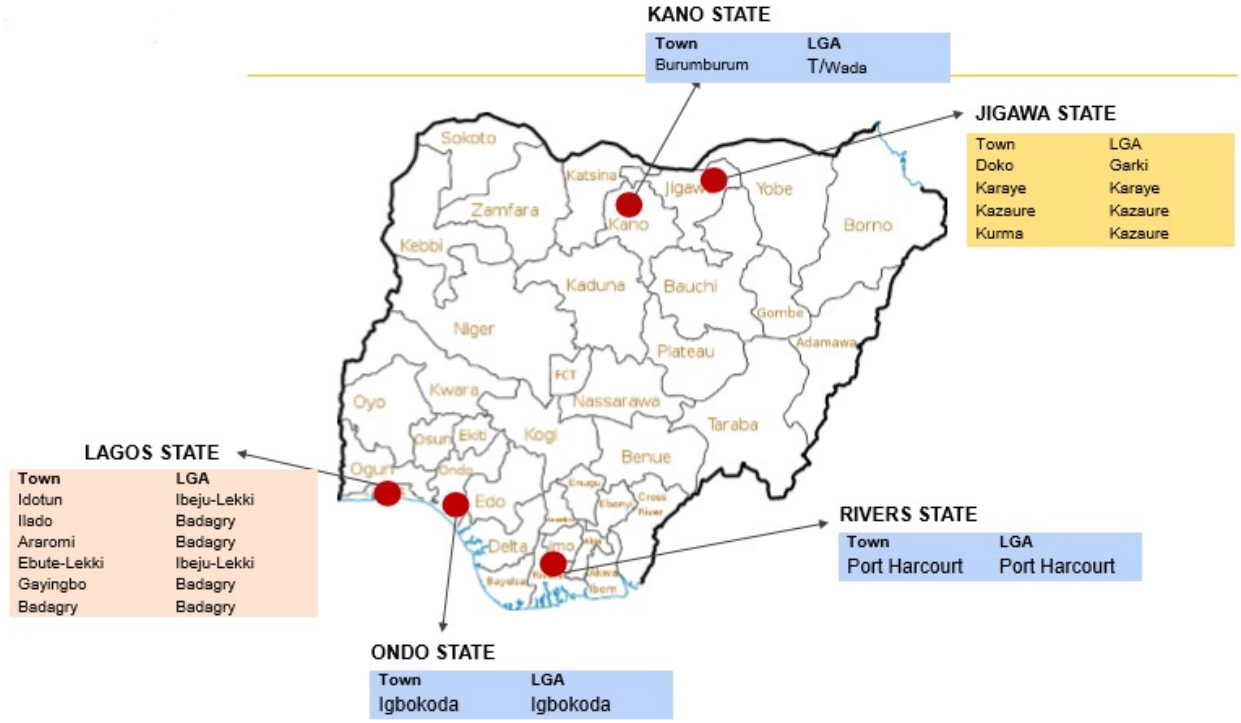


Figure. 6: Occurrences of silica sand in Nigeria.

4.1.6 Dimension Stones

These are natural rock materials quarried for the purpose of obtaining blocks or slabs used for ornamental purposes. Virtually all the states in Nigeria have rock outcrops that can be used for dimension stones.

200

There are over 200 known locations for sourcing raw materials for ceramics in 26 states of Nigeria

4.2 The Ceramics Industry

This industry is concerned with the manufacturing of objects such as clay bricks, floor wall tiles, sanitary wares, plumbing fixtures, china and earth wares, tableware, insulating materials, electrical and electronic equipment. There are over 200 known locations for sourcing raw materials for ceramics in 26 states of Nigeria, with a cumulative resource base of clay/shale estimated at 125 billion tons.

4.2.1 Clay

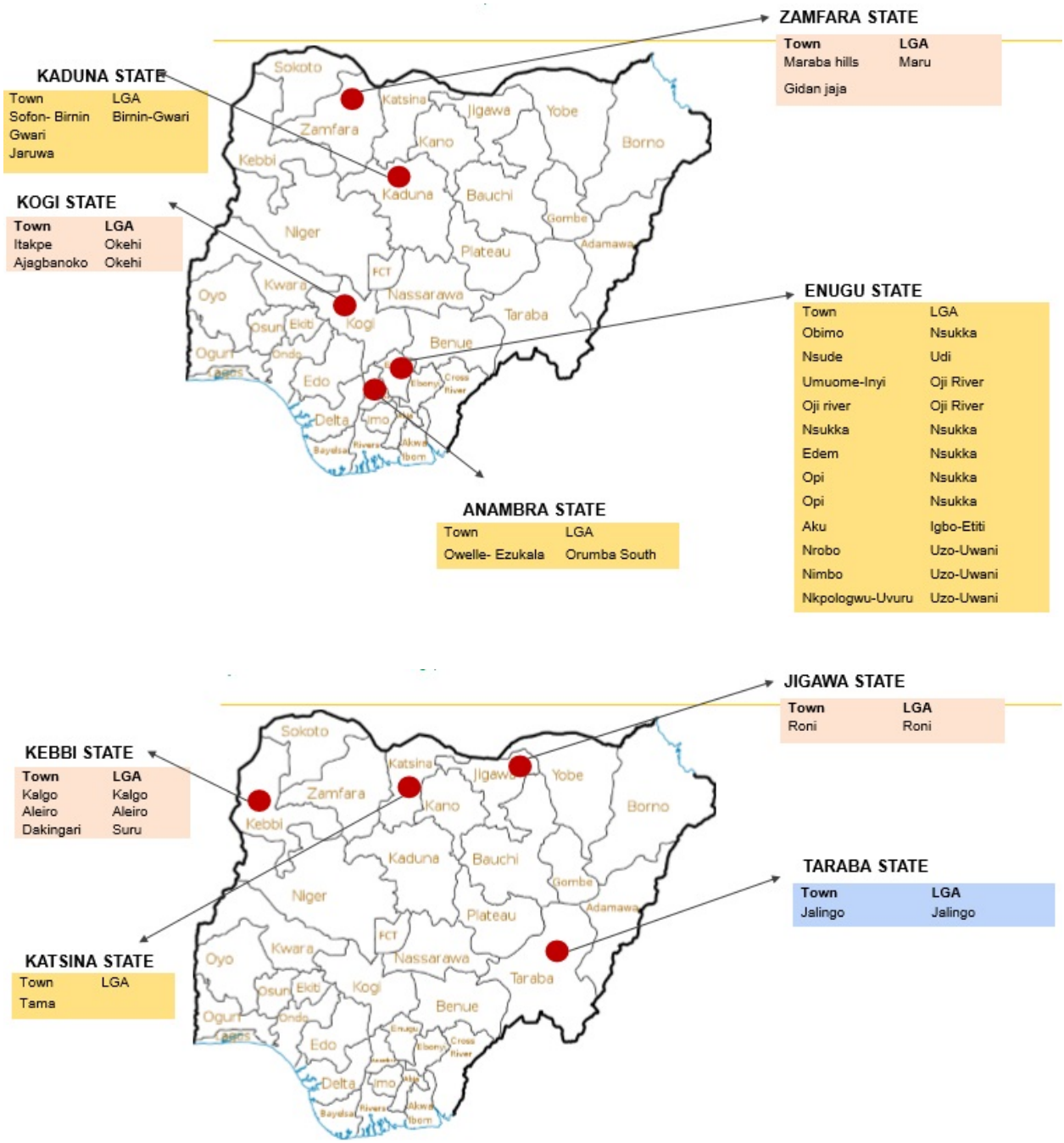
Clay has been used since the beginnings of civilisation in making cooking pots, bricks, porcelain, and also drainage pipes. Both brick clays and other forms of clay are used for purposes, such as the manufacture of clay pipes, and for floor and wall tiles. The major use of clay, besides the making of bricks, is in the manufacture of cement. Less absorbent clays are mainly used in the oil industry, e.g., as filtering and deodorising agents in the refining of petroleum. Some states in Nigeria have already established burnt brick factories on the basis of their clay deposits. Besides the Federal Capital Territory (Abuja), States with abundant clay deposits include Adamawa, Borno, Taraba, Katsina, Kano, Kogi, Ekiti, Yobe, Kebbi, Kwara, Ogun, Zamfara, Plateau, Niger, Oyo, Lagos and Rivers.

1.3 The Steel/Energy Industry

The steel sector is a major driver of industrialisation in any country, and Nigeria has recognised this as being cardinal to its objective of attaining industrialisation. The steel manufacturing projects in Ajaokuta and Delta State, alongside the rolling mills in Katsina and Jos are indicative of this desire. The raw materials used in the steel industry that are available in Nigeria include iron ore (the main mineral), dolomite, refractives and coal.

4.3.1 Iron Ore

While the primary use of iron ore is in the production of iron, yet another of its major use is in the production of steel. Iron ore deposits can be found in the FCT, Zamfara, Kaduna, Kogi, Enugu, Anambra, Kebbi, Jigawa, Taraba, Katsina, and Bauchi States.



Figures 8.1 and 8.2: Iron ore locations in Nigeria

4.3.2 Manganese

Among other uses, manganese is an essential alloy that helps in converting iron to steel. It is also used as an alloy with metals such as aluminum and copper. Important non-metallurgical uses of manganese include its serving as a primary material in battery cathodes, as soft ferrites used in electronics, and as micronutrients in fertilisers and animal feed. Also, it is utilised in water treatment chemicals, colorants for automobile undercoating, bricks, and tiles. Deposits of manganese can be found in Cross River State.

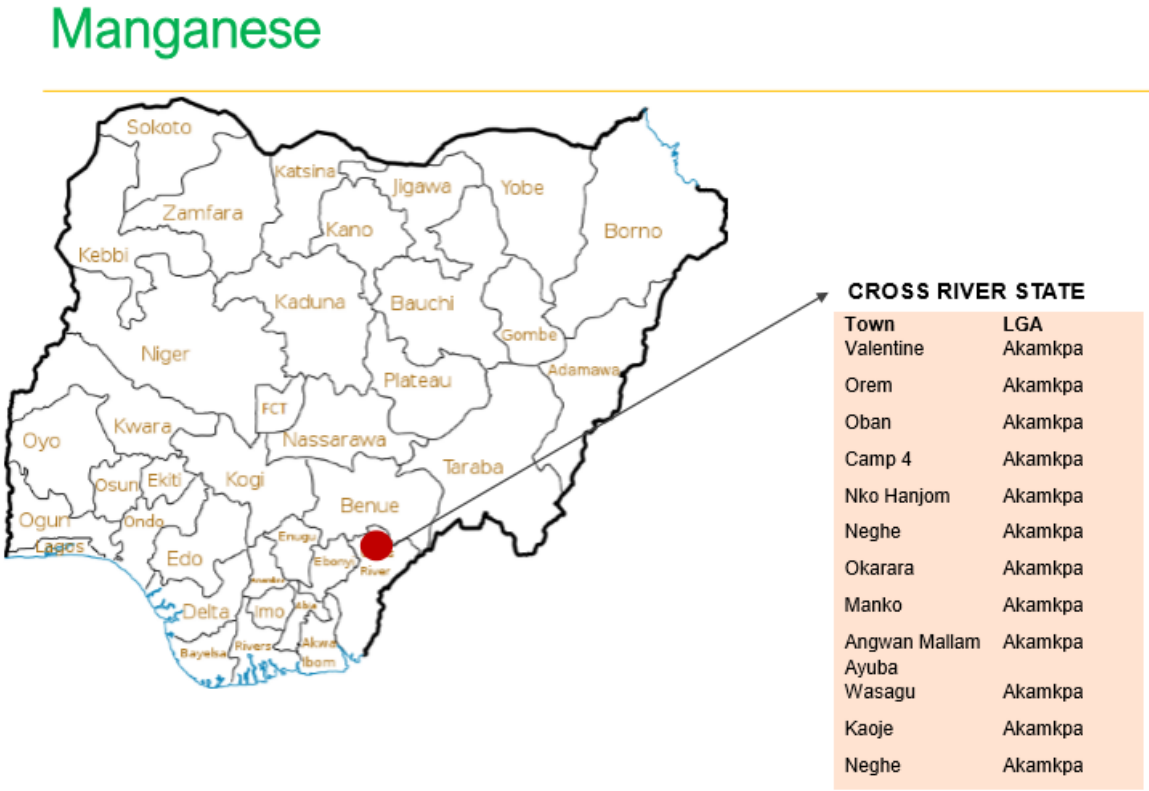


Figure 9: Manganese occurrences in Nigeria

4.4 The Energy Sector

Nigeria's shortfall in electricity supply is over 20,000MW, despite the availability of huge oil and gas reserves in the country. As such, there is need for government to harness alternative sources of energy for the country. The solid minerals sector can play a vital role in achieving this goal.

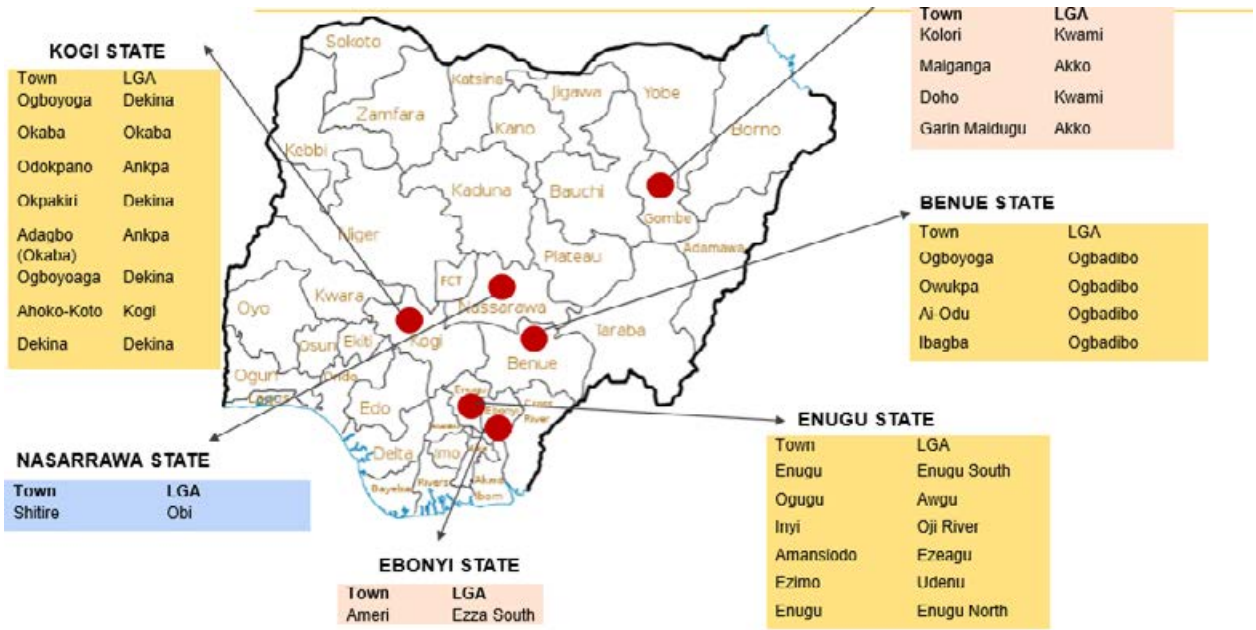
4.4.1 Coal

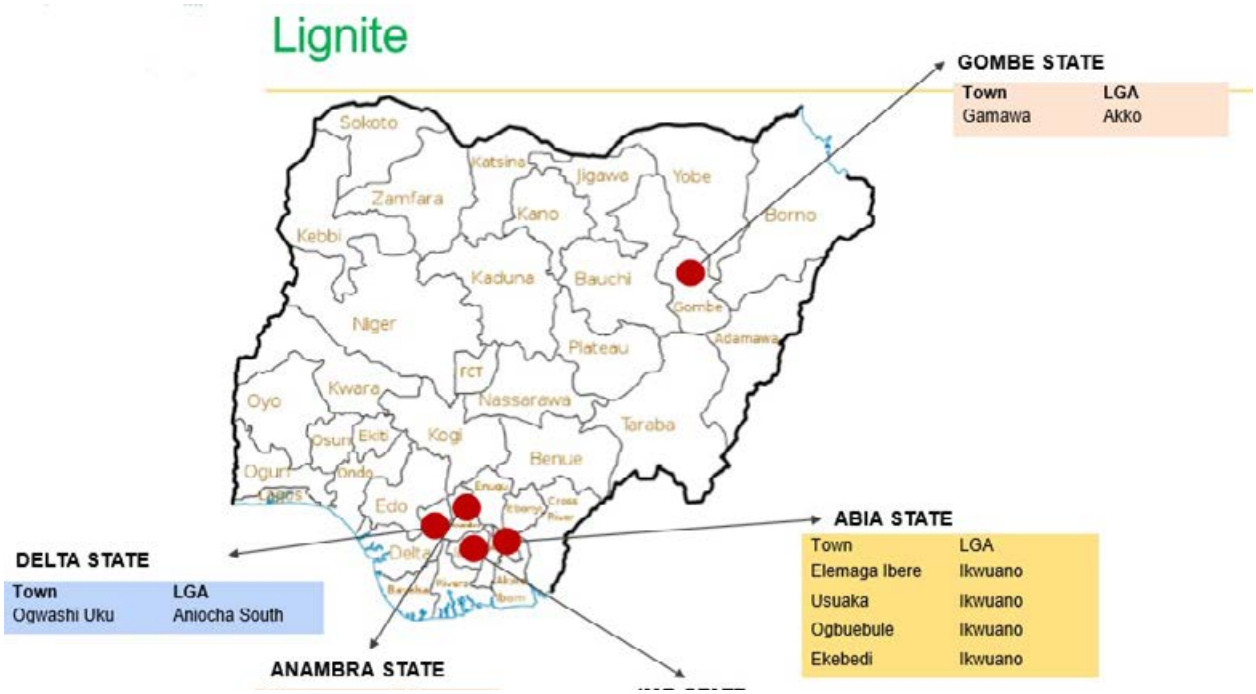
1.5bn

Coal...
The exploration of this mineral resource shows that over 1.5 billion tons of coal is available for mining in Nigeria

Coal is primarily used as an energy source, either for generating heat or producing electricity. Bituminous coal is also used to produce coke for making steel and other forms of heating for industrial processes. Coal gasification and coal liquefaction (coal-to-liquids) are also possible uses of coal for producing synthetic fuel. Coal and lignite, which can equally be used in the production of energy occurs in 46 locations in 13 states, including the Anambra basin, Kogi, Enugu, Benue, Edo, Abia, Imo and Ebonyi. The exploration of this mineral resource shows that over 1.5 billion tons of coal is available for mining in Nigeria.

Coal





Figures 10.1 and 10.2: Coal occurrences in Nigeria

1.4.2 Uranium

This mineral is a source of fuel for generating electricity in nuclear power stations. It is used in creating the steam required to turn turbines and generate electrical power. Deposits of uranium are found in Jigawa and Cross River States.

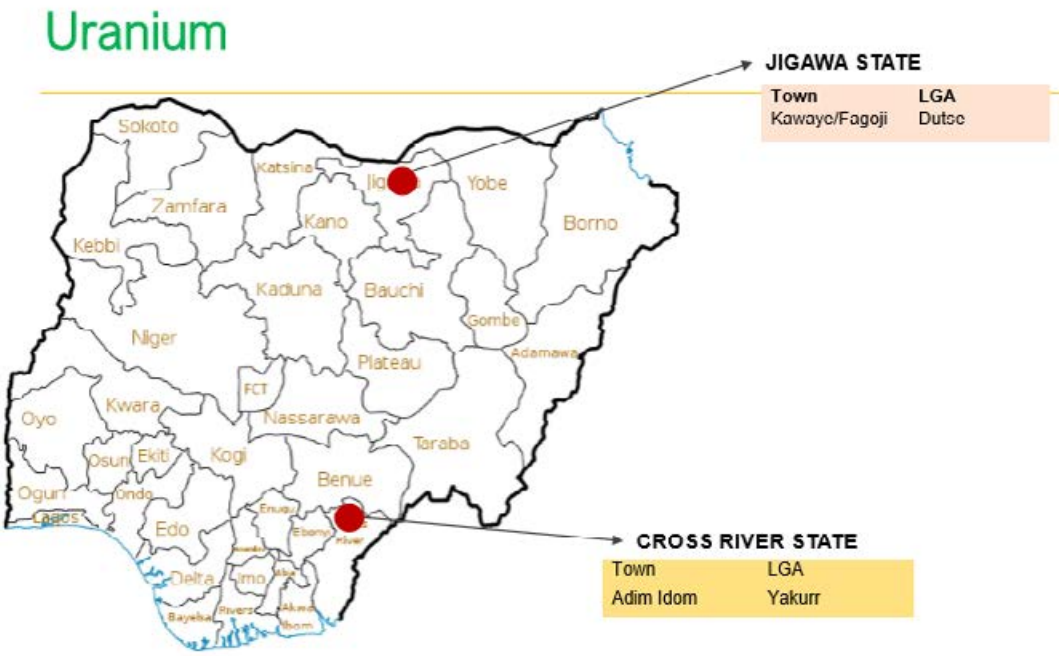


Figure 11: Locations of uranium deposits in Nigeria

4.5 Glass, Paints and Fillers

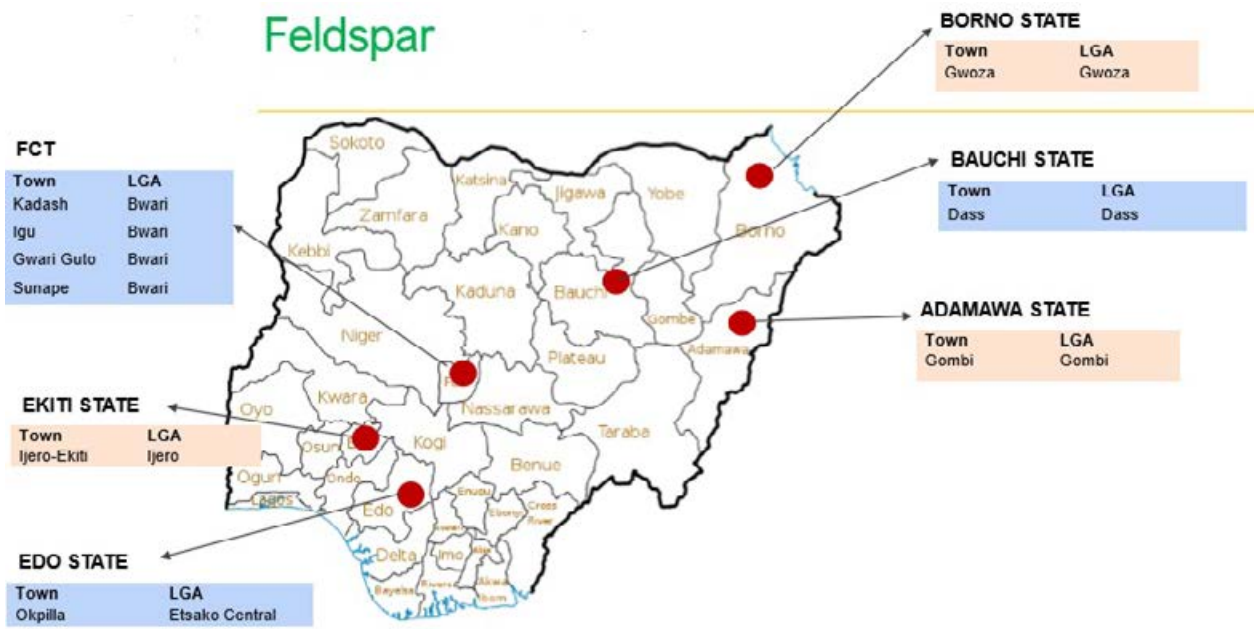
600/100

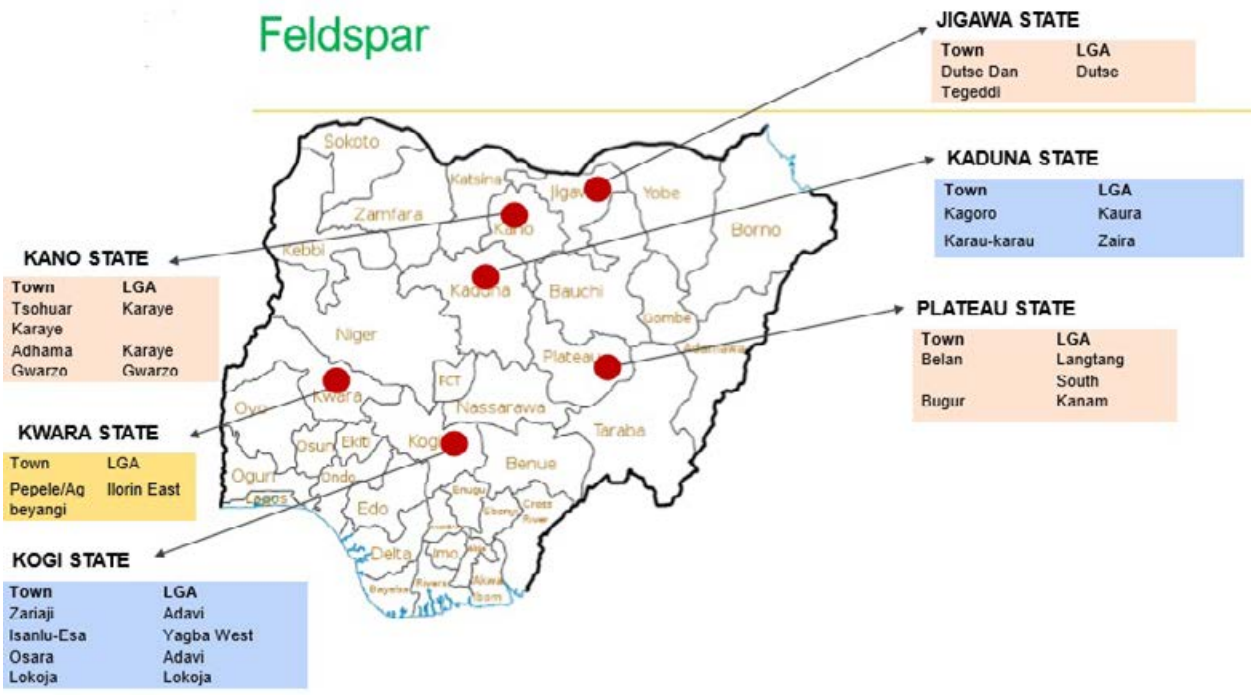
Feldspar is the second most important ingredient after clay, and it is likewise used as fillers and extenders in applications such as paints, plastics and rubber. Feldspar occurs within an estimated 600 kilometre by 100 kilometre belt

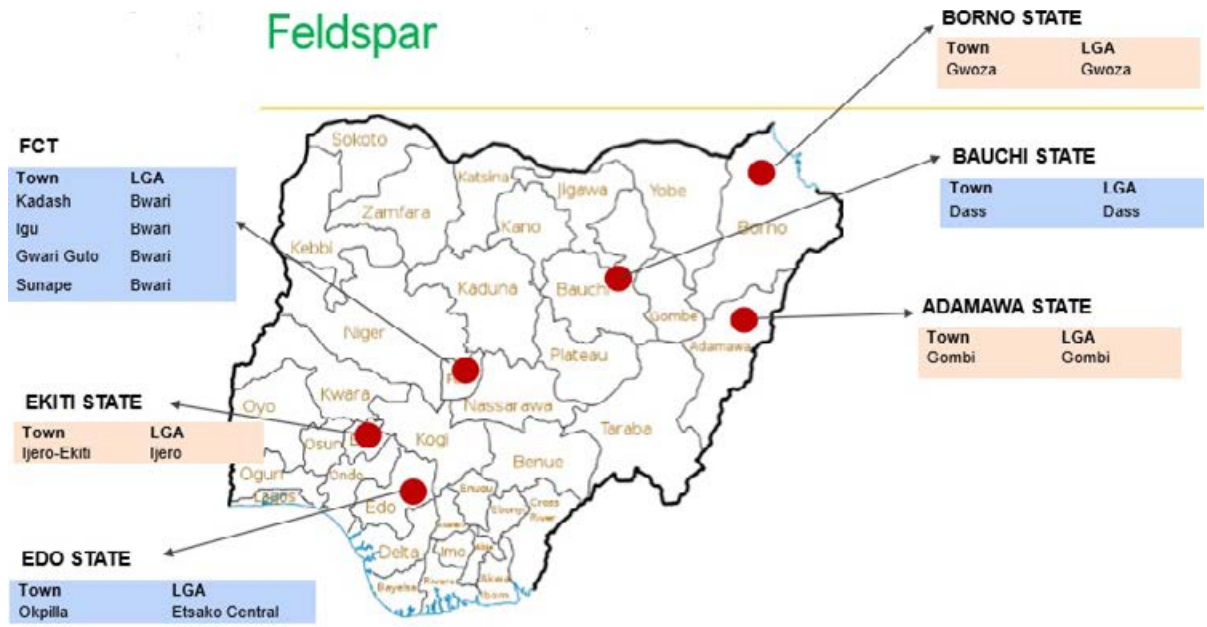
Glass containers, pressed from flat or sheet glass, are produced using glass sand and feldspar, which are found in Nigeria.

4.5.1 Feldspars

The term 'feldspar' encompasses a wide range of materials. Most of the products we use on a daily basis are made from feldspar, which is also an important ingredient in the manufacture of glass. In the production of ceramics, feldspar is the second most important ingredient after clay, and it is likewise used as fillers and extenders in applications such as paints, plastics and rubber. Feldspar occurs within an estimated 600 kilometre by 100 kilometre belt, mostly in the western half of Nigeria. Feldspar deposits are found in the FCT in addition to Borno, Bauchi, Adamawa, Ekiti, Edo, Jigawa and Kaduna States. They are also present in Plateau, Kano, Kwara, Kogi, Katsina, Yobe and Zamfara States.







Figures 12.1, 12.2, 12.3: Occurrences of feldspar in Nigeria

4.5.2 Quartz

Quartz is the most abundant mineral found on the earth's surface, and its unique properties make it one of the most useful natural substances. Quartz sand is used in the production of all types of glass and abrasives. In the petroleum industry, sand slurries are forced down oil and gas wells under very high pressures in a process known as hydraulic fracturing. Deposits of quartz are found in Kano, Katsina, Gombe, Plateau, Kogi, Kebbi States and the FCT.

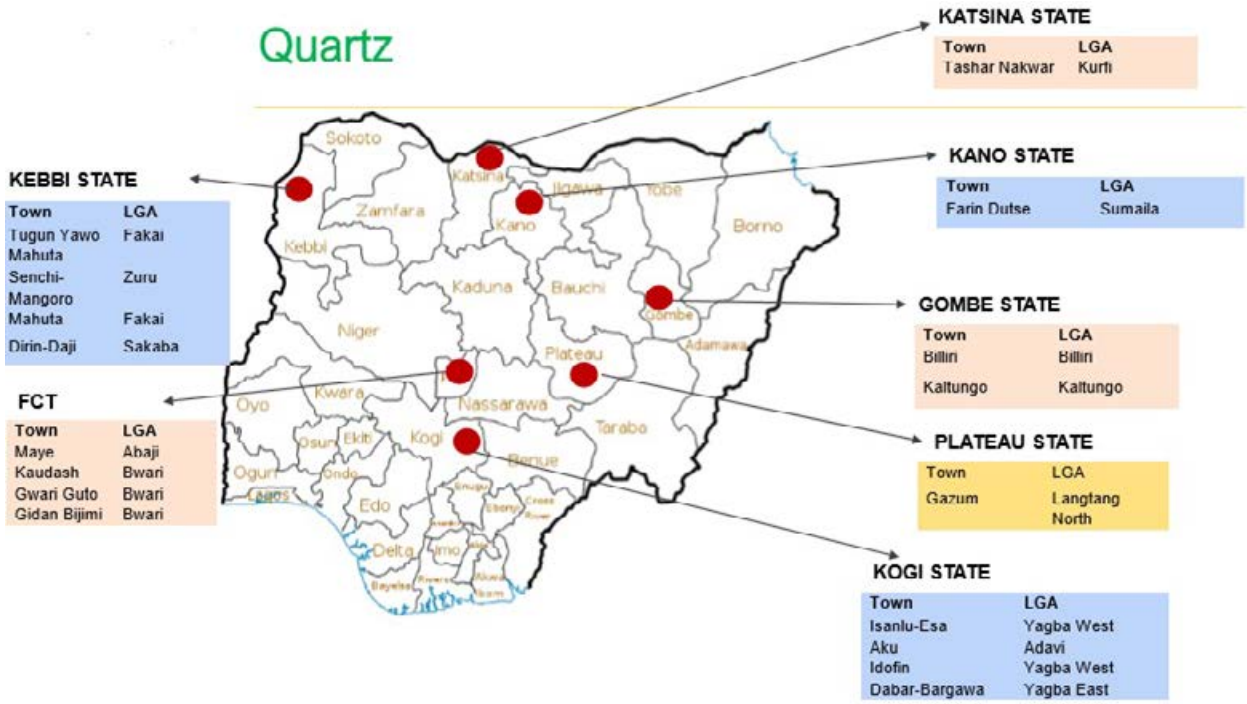


Figure 13: Occurrences of quartz in Nigeria.

4.5.3 Glass Sand

This mineral resource is used in the manufacture of glass and also in the food and pharmaceutical industries. It is a major component of glass and silicon used in sand-casting and in products like Portland cement. Glass sand is used as a proppant by companies involved in oil and natural gas recovery. In its finest form, it is used as a functional filler in paints, plastics and rubber. Deposits of glass sand are found in Jigawa, Kano, Enugu, Edo, Rivers, Imo, and Ogun States. The Igbokoda glass sand (measuring 8.3 kilometres by 3.7 kilometres, and up to 38.5 kilometres) has a reserve of 2.1 billion tons, which is enough for 350 years of glass production.

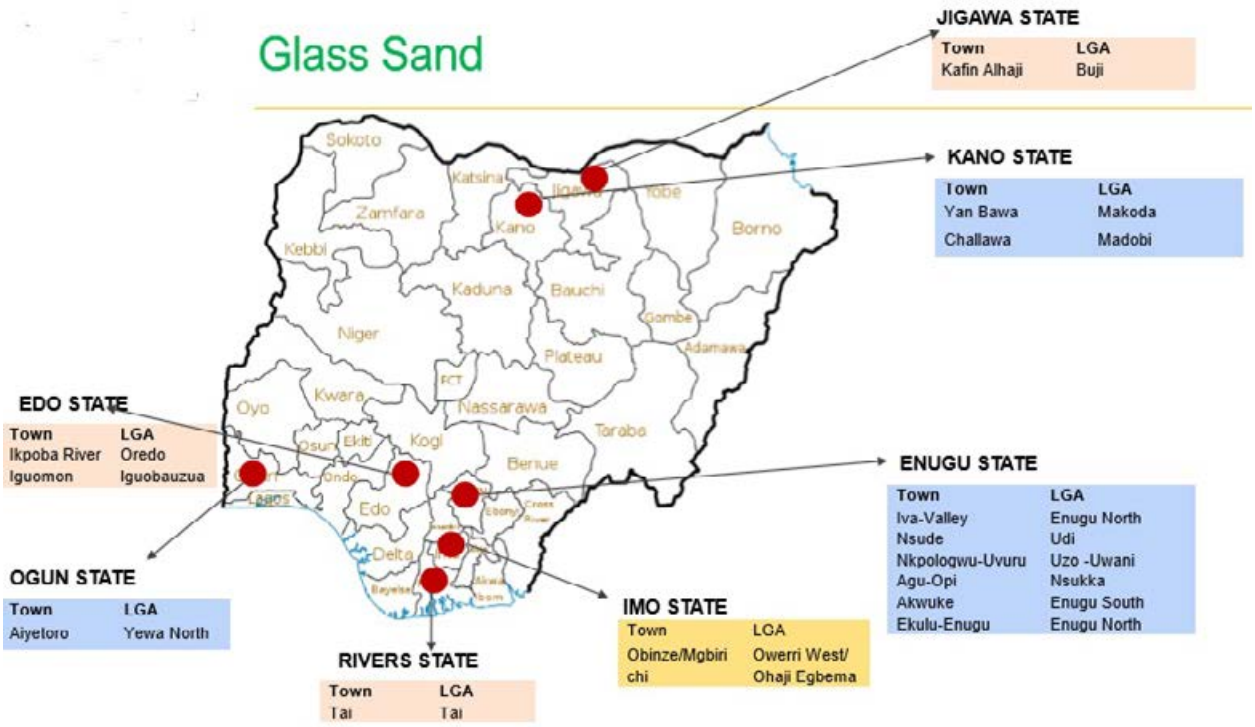


Figure 14: Occurrences of glass sand in Nigeria.

4.5.4 Talc

Talc refers to a wide variety of soft, similarly-named rocks containing hydrated magnesium silicate that are mined and utilised for a variety of applications. It is used in the manufacture of sinks, stoves, soaps and crayons; as a lubricant in applications where high temperatures are involved; as a carrier for insecticides and fungicides (talc powder); in the production of cosmetics such as talcum powder, baby powder and astringent powder. Deposits of talc are available across the country in States such as Kaduna, Niger, Kogi, Osun, Oyo, Kwara and Kebbi.

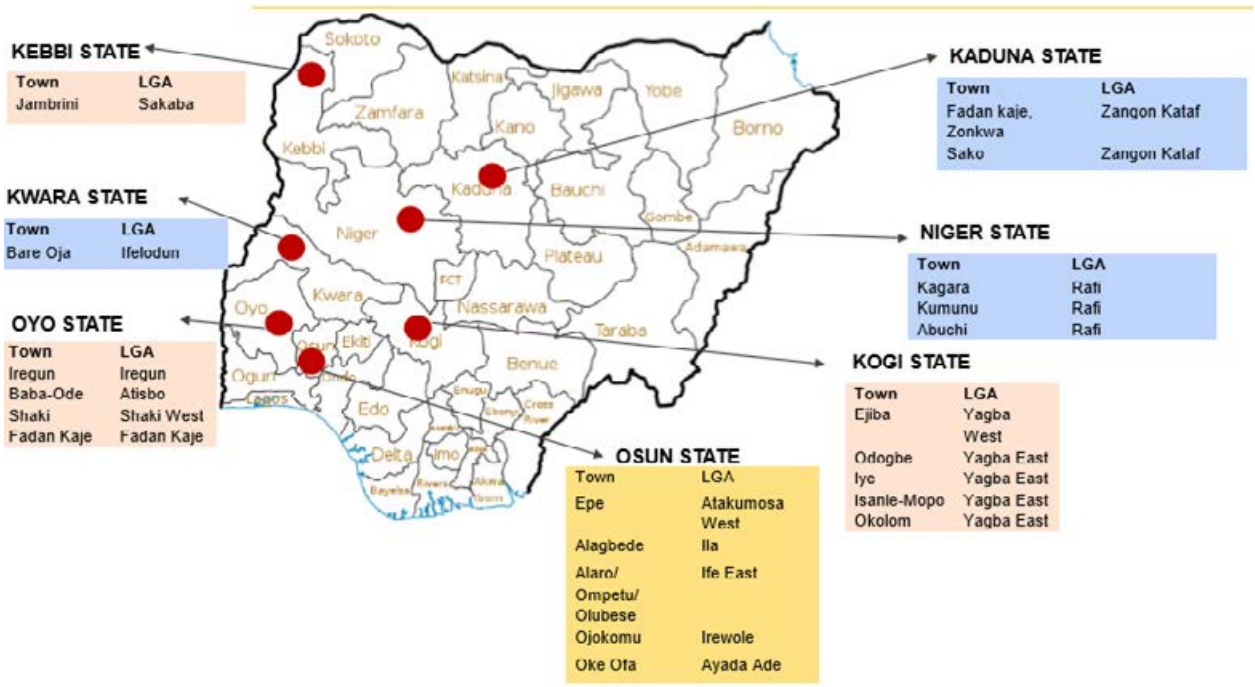


Figure 15: Occurrences of talc in Nigeria.

4.5.5 Diatomite

Diatomaceous earth is safe for human and animal consumption and is also beneficial to the skin, hence its use both inside and outside the body. Diatomite can be used in the making of nutritional products for pets, products used for killing fleas on dogs and cats, and sprays and products used for insect control. Equally, it is used in skin care products, toothpastes, foods and beverages (beer and wine). Deposits of diatomite are found in Gombe, Niger, Borno and Yobe States.

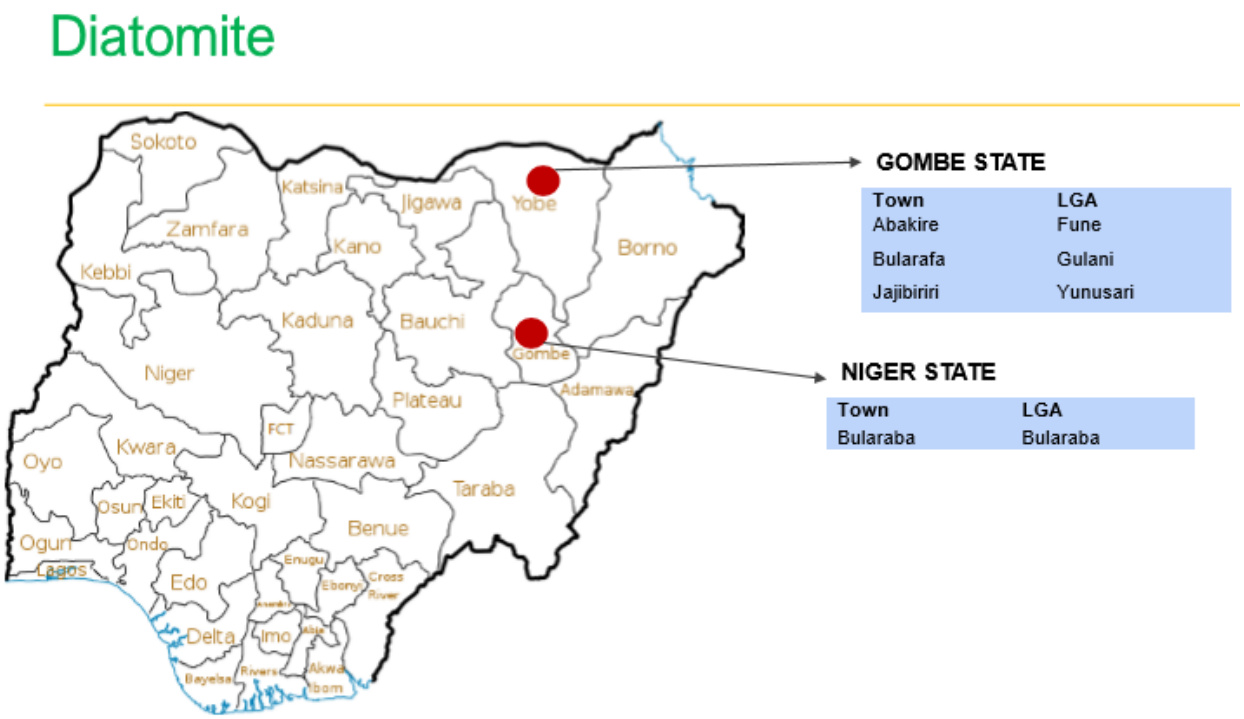


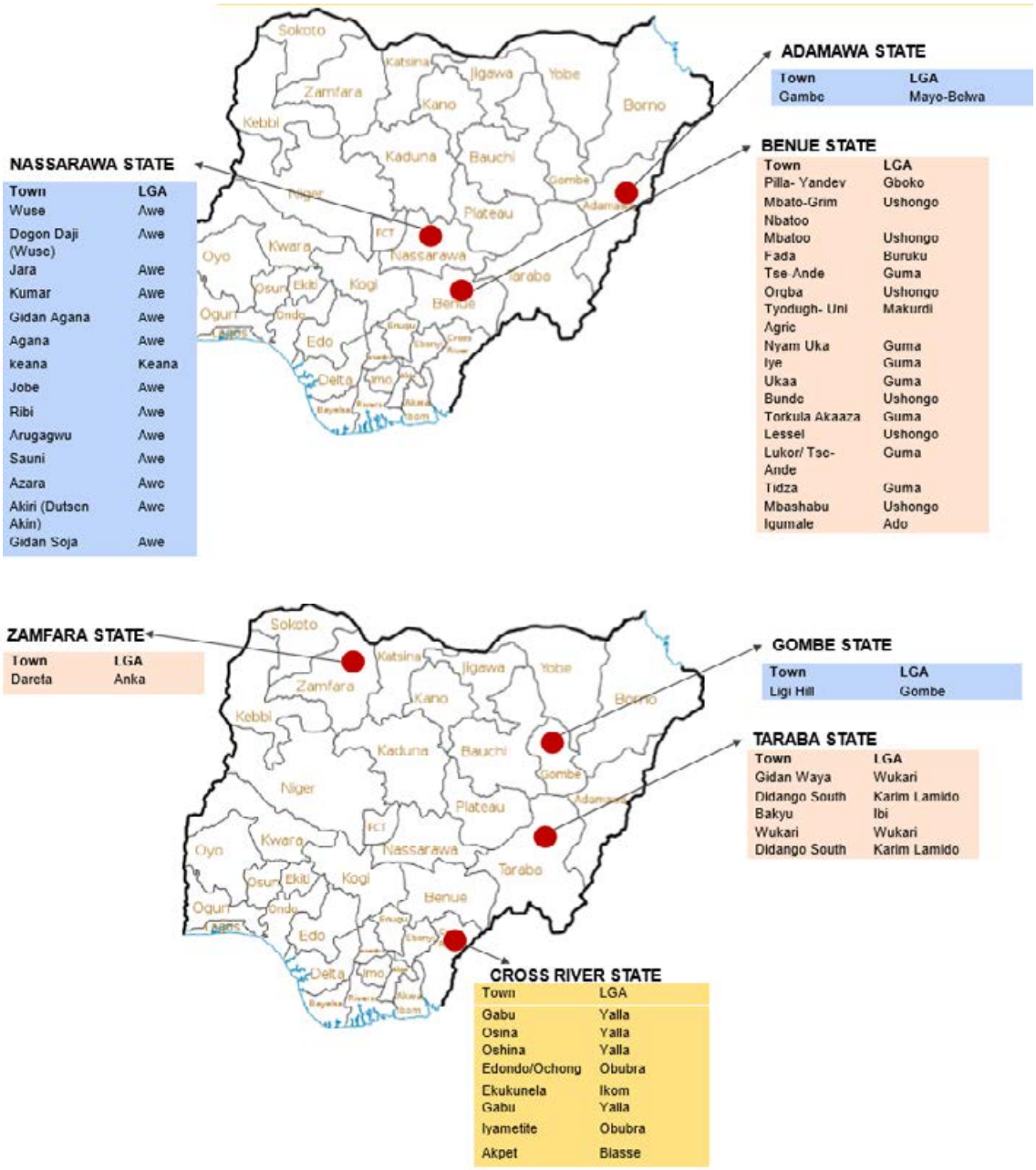
Figure.16: Occurrences of diatomite in Nigeria.

1.6 The Oil and Gas Industry

This industry uses minerals such as drilling muds (a mixture of different types of chemicals in water or oil), which act as transportation media for various cuttings from the bottom of holes to their surfaces, and as lubricant and coolant, among other uses.

4.6.1 Baryte

Used as a weighting agent in drilling muds, baryte is also utilised as a pigment in paints and as weighted filler for paper, cloth and rubber. It is equally used in the production of a wide variety of compounds, some of which are utilised for x-ray shielding. Baryte compounds are also used in diagnostic medical tests. Deposits of baryte are found in Nasarawa, Plateau, Benue, Adamawa, Gombe, Taraba and Cross River States.



Figures 17.1 and 17.2: Occurrences of baryte in Nigeria.

4.6.2 Bentonite

This is a type of absorbent clay used as a bonding material in the preparation of moulding sand for the production of iron, steel and non-ferrous casting. Bentonite is employed as a binding agent in the production of iron ore pellets, and its absorption properties are useful in wastewater purification. It is also used as a mud constituent for oil and water well drilling. Deposits are found in Borno, Gombe, Benue, Cross River and Akwa Ibom States.

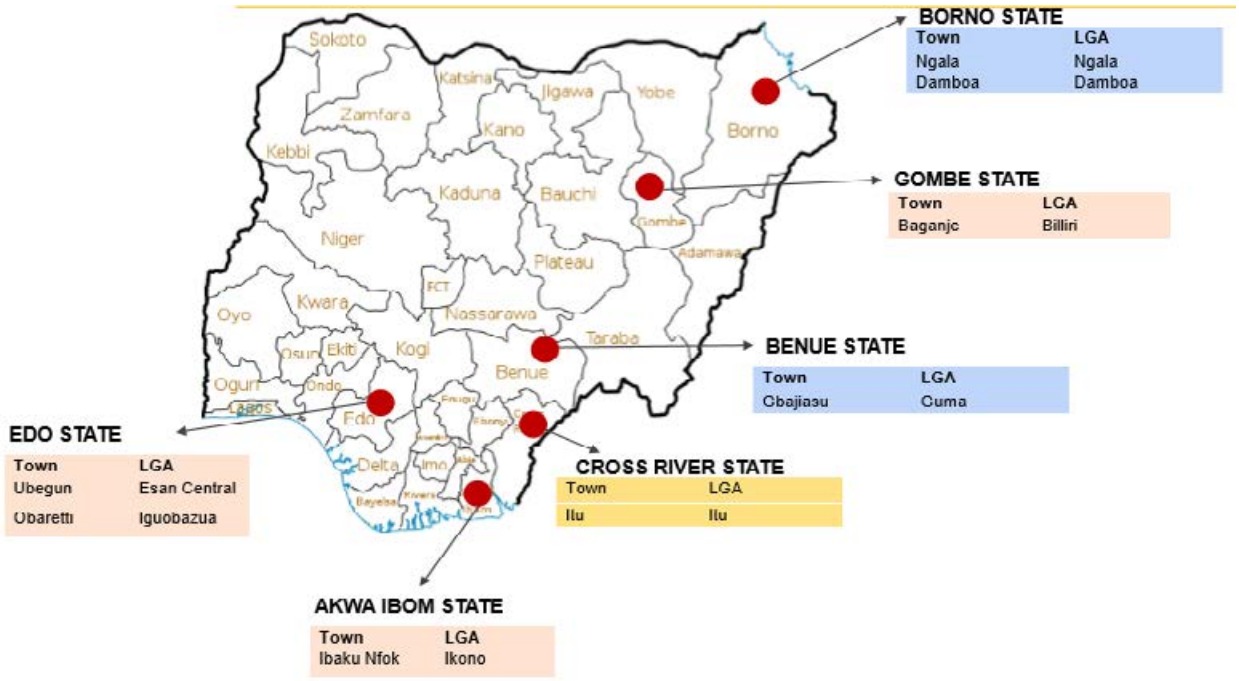


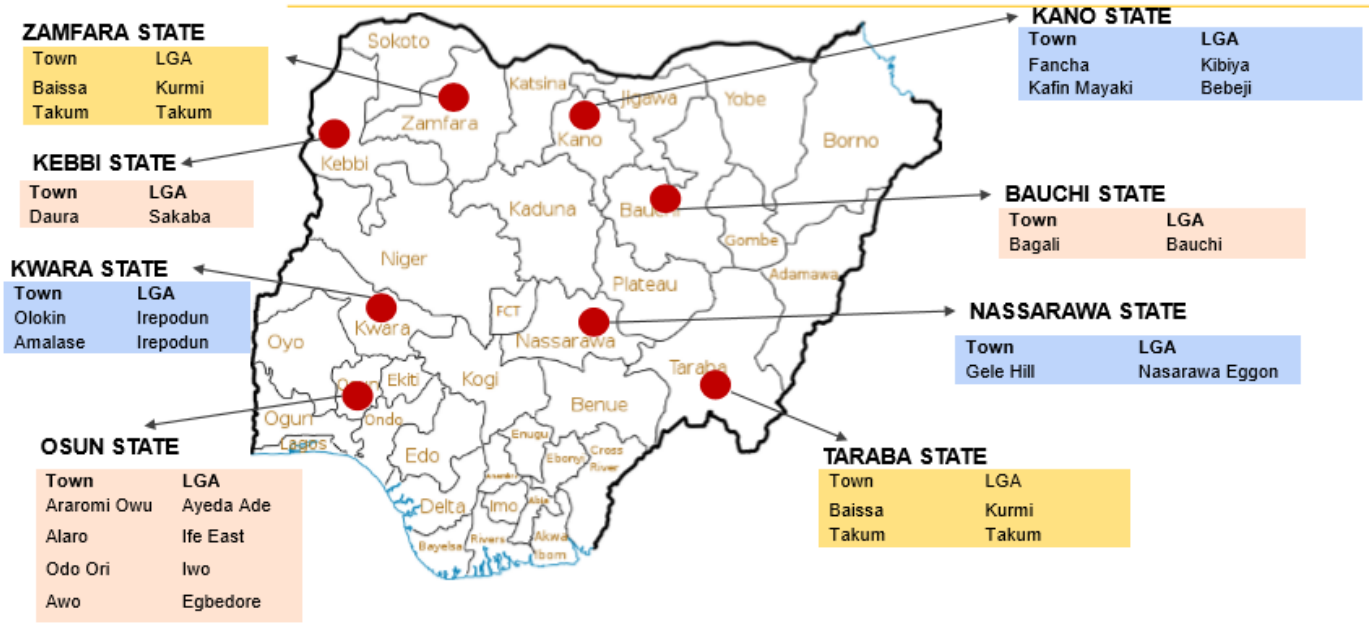
Figure 18: Occurrences of bentonite in Nigeria.

4.7 Lapidary Gem stones

About 15 varieties of lapidary gemstones exist in the country in at least 200 locations across 22 states and possibly in several other places that are still being explored for possible occurrence of the mineral.

4.7.1 Beryl

Beryl is a most alluring and popular mineral, occurring in a diversity of colours, and having several important gemstone varieties. Beryl forms some of the best known and prized gemstones. It is a very important and valuable collector's mineral. Beryl is also an important industrial mineral as a very tough metal that is sometime used in alloys to strengthen other metals. Deposits of beryl are available in Zamfara, Kebbi, Osun, Kwara, Taraba, Nasarawa, Bauchi, Kano and Kaduna States.



Figures 19: Occurrences of beryl In Nigeria.

4.7.2 Tourmaline

Tourmaline is a unique, beautiful semi-precious mineral made out of a variety of elements. It is used in making rings, bracelets, pendants and necklaces. Tourmaline is also used in manufacturing hair straighteners and blow dryers. Many people use tourmaline tongs for polarising purposes. Deposits of this mineral are available in numerous states of Nigeria, including Zamfara, Kebbi, Osun, Kwara, Taraba, Nasarawa, Bauchi, Kano, Oyo, Cross River and Kaduna.

4.7.3 Aquamarine

This is a blue or cyan variety of beryl. It is used as a gemstone, and its deposits are in Zamfara, Kebbi, Osun, Kwara, Taraba, Nasarawa, Bauchi, Kano and Kaduna States.

4.7.4 Sapphire

Sapphire is the most precious and valuable blue gemstone, and is extensively used as jewelry. It is highly desirable due to its excellent colour, hardness, durability, and lustre. Deposits of this gemstone are found in Borno, Oyo and Kaduna States.

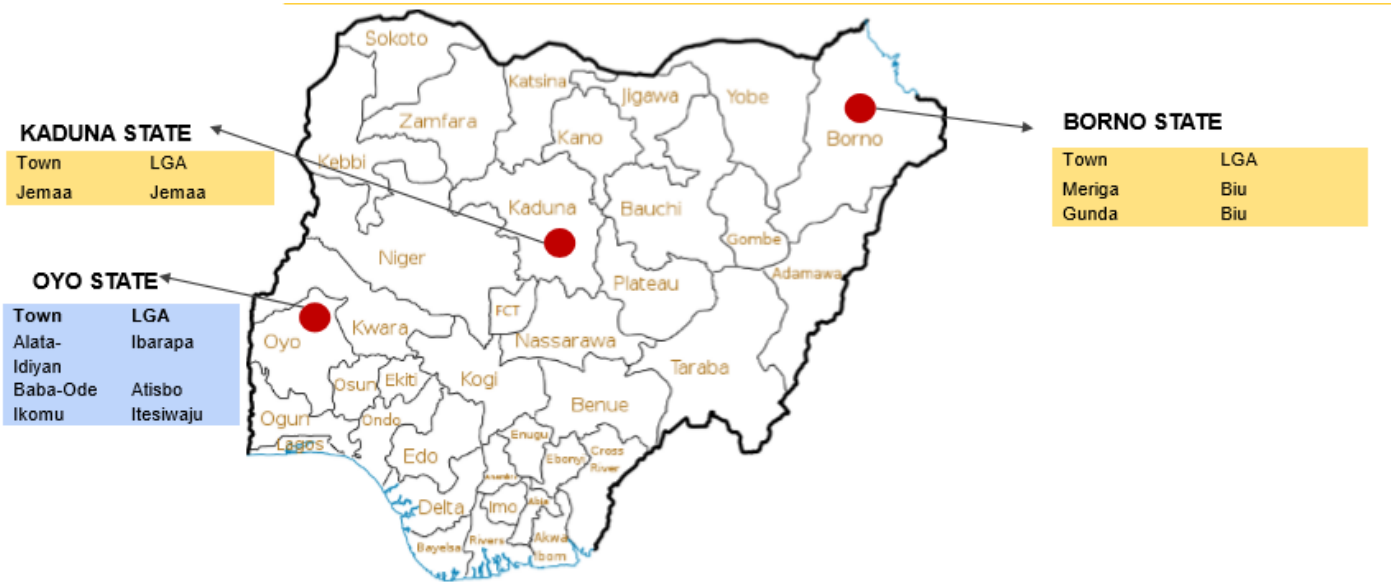


Figure 22: Notable locations of sapphire deposits in Nigeria.

4.7.5 Amethyst

This is a popular gemstone of first preference for many people. Amethyst is also well known for its ability to help the body detoxify from harmful elements such as drugs and alcohol. Amethyst assists in the delivery of infrared light waves, and also delivers balancing negative ion therapy, which is valuable in alleviating a wide variety of health problems. Its deposits are located across a number of States such as Kebbi, Oyo, Taraba, Nasarawa, Bauchi, Kano and Kaduna.

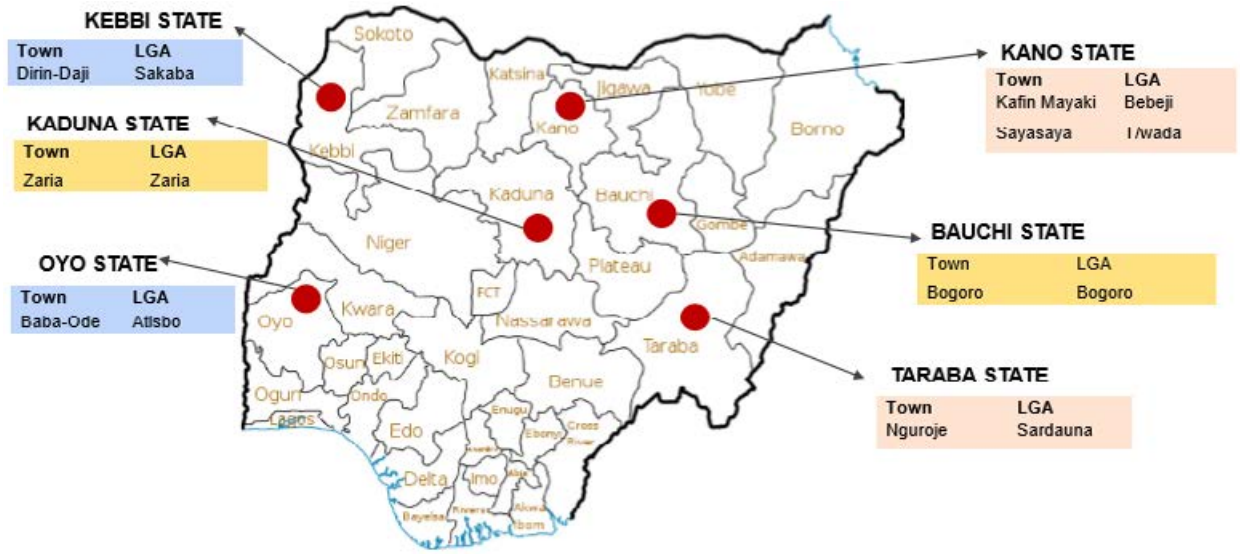


Figure 23: Notable locations of amethyst in Nigeria.

4.7.6 Garnet

This describes a large group of rock-forming minerals found throughout the world. While generally utilised as an abrasive, the largest industrial use of garnet is in waterjet cutting. Garnet granules are used as filter media, whereas smaller particles are used in filling containers through which liquid flows. Deposits of garnet are found in Borno, Bauchi, Plateau, Kogi, Oyo and Zamfara States.

4.7.7 Emeralds

These are green-coloured gemstones found in a small number of locations worldwide. Emerald is one of the most valuable gemstones, and the most famous green gemstone used in all forms of jewelry. Deposits of emerald are found in Nasarawa State.

4.7.8 Topaz

This is a rare and popular gemstone most commonly used as jewelry. Deposits of the mineral are found in Bauchi, Plateau, Kebbi and Oyo States.

Figure 26: Locations of topaz deposits in Nigeria.

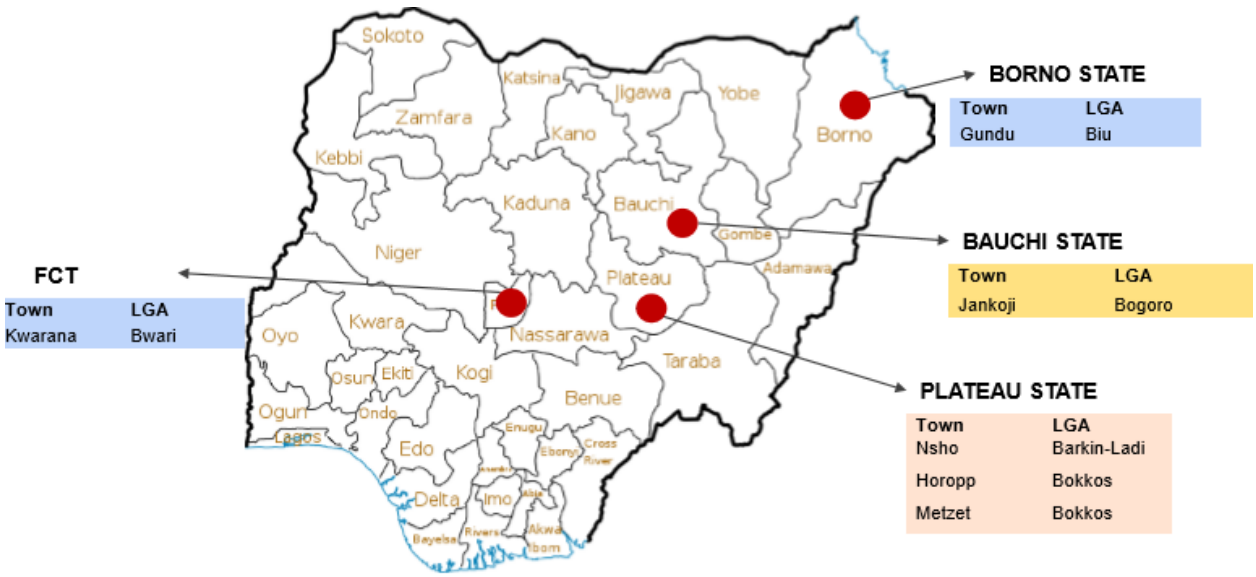


Figure 27: Occurrences of zircon in Nigeria.

4.8 The Agricultural Industry

The importance of fertiliser to Nigeria's agricultural development cannot be overemphasised, particularly with the government's policy of diversifying the economy at this crucial period in the national experience. Nigeria is blessed with abundant minerals required for producing NPK fertilisers, phosphate, etc.

12

Phosphate occurs in mineable quantities in Ogun, Sokoto, Abia, and Enugu States in 12 known locations of various grade

4.8.1 Phosphate

The term phosphate rock (or phosphorite) is used to denote any rock with high phosphorus content. The largest and least expensive source of phosphorus is obtained by mining and concentrating phosphate rock from the numerous phosphate deposits of the world. Phosphate occurs in mineable quantities in Ogun, Sokoto, Abia, and Enugu States in 12 known locations of various grades.

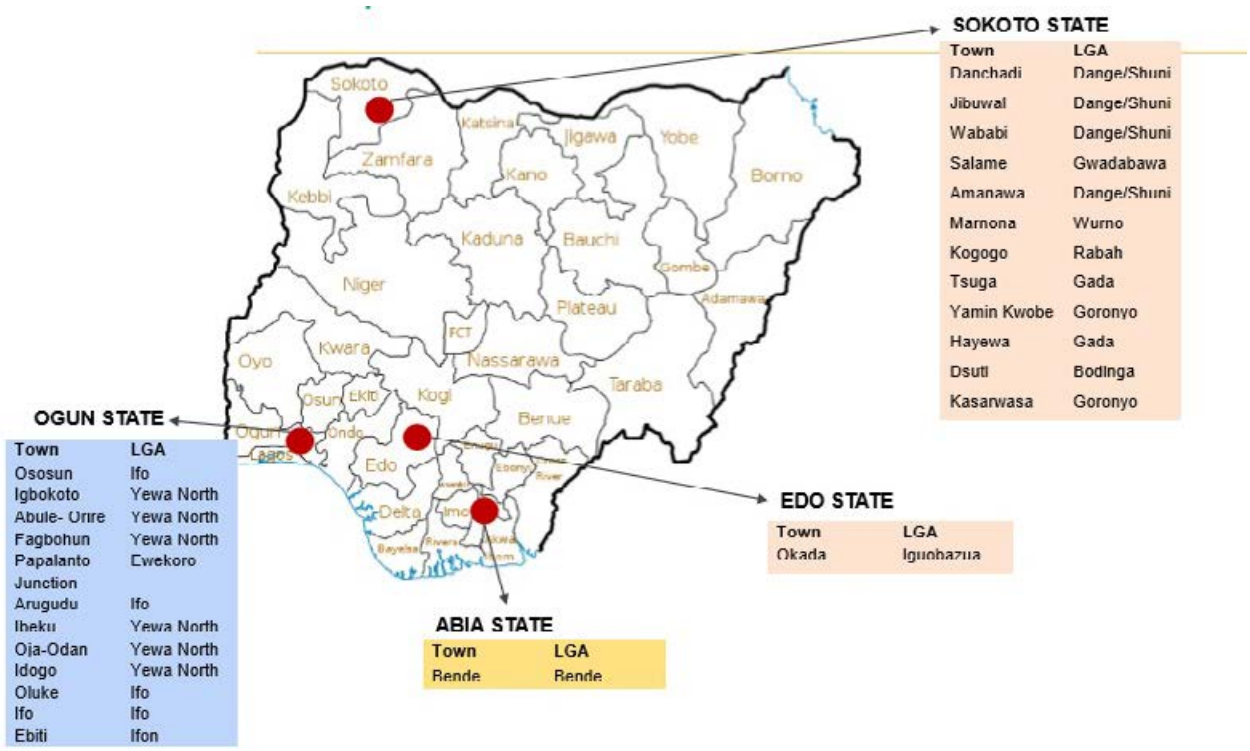


Figure. 28: Phosphatic mineral locations in Nigeria.

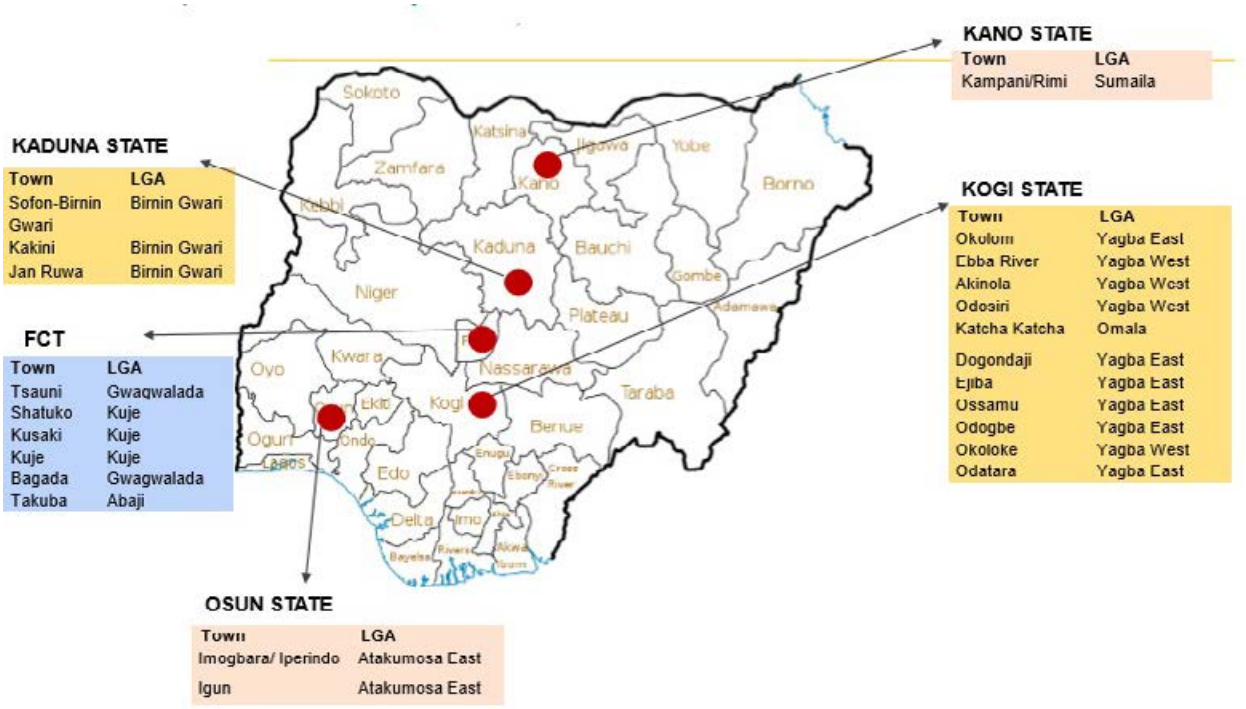
4.9 Precious Metals

A precious metal is a rare, naturally occurring metallic chemical element of high economic value. Several precious metals are found in various locations across Nigeria. Examples include gold, rare metals (tantalite, niobium, cassiterite) and lithium (lepidolite, spoudeme, elbaite).

Percentage of the gold utilised each year is made into jewelry. Because gold is so rare and highly valued, this precious metal serves as a natural currency.

4.9.1 Gold

Of all the minerals mined from the earth, none is more useful than gold. Its usefulness is derived from a diversity of special properties. About 78 percent of the gold utilised each year is made into jewelry. Because gold is so rare and highly valued, this precious metal serves as a natural currency. There is extensive gold mineralisation in Nigeria, with significant deposits in the FCT, Kano, Kogi, Bauchi, Kaduna, Kebbi, Niger, Zamfara, Kwara, Edo, Ogun and Osun States.



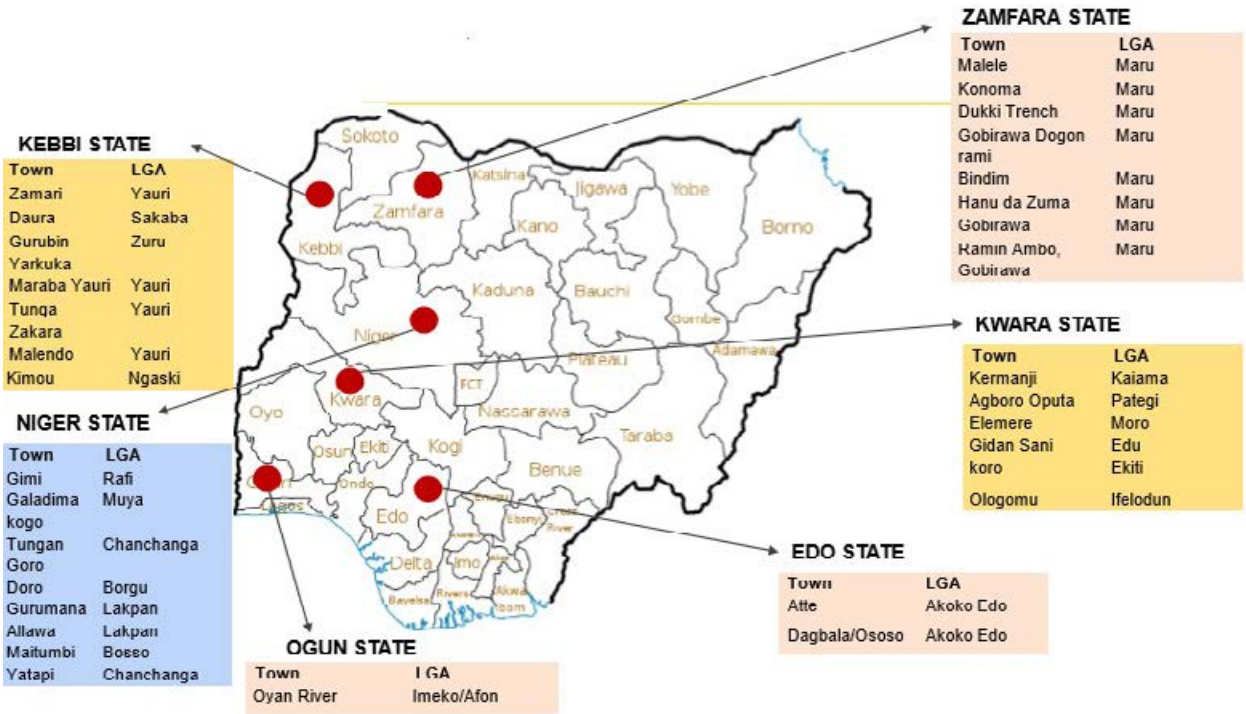


Figure 29 and 30: Locations of gold deposits in Nigeria.

4.9.2 Columbite

Columbite occurs as an important ore of the industrially useful metal, niobium, used in alloys for improved strength. Columbite is widely used in the electronics and telecommunications industry. Deposits of columbite are found in Plateau, Jigawa, Bauchi, Taraba, Zamfara, Nasarawa, Kaduna, Kano, Kogi and Osun States.

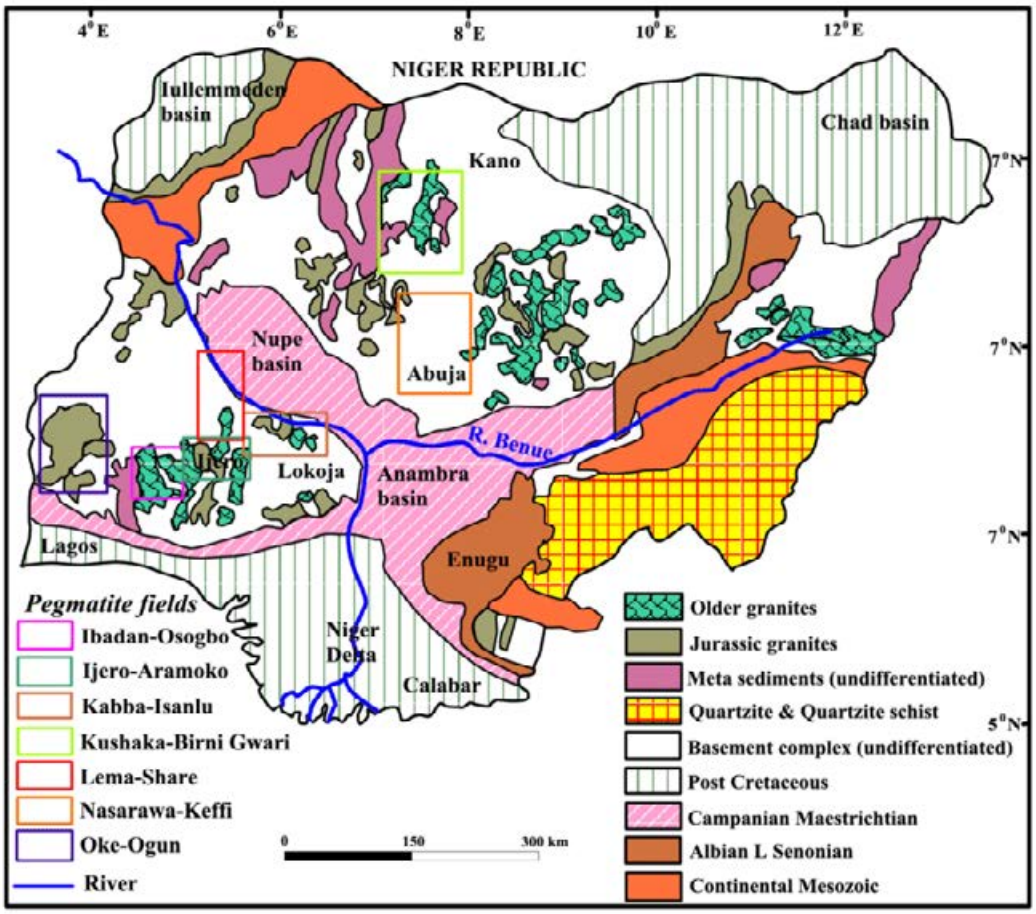
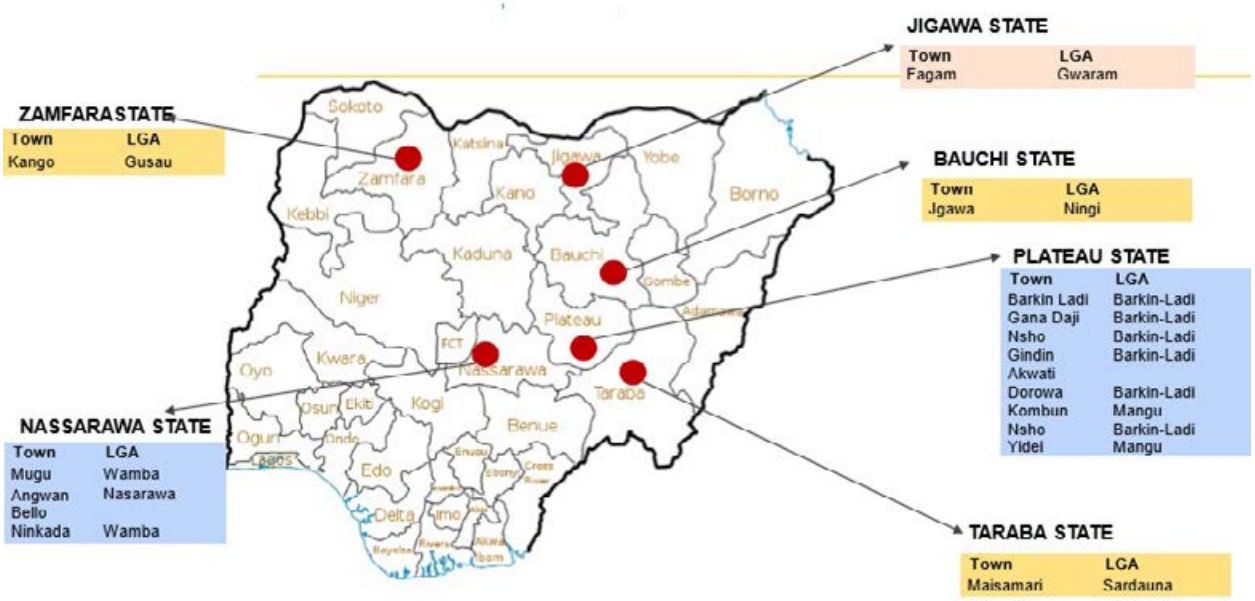
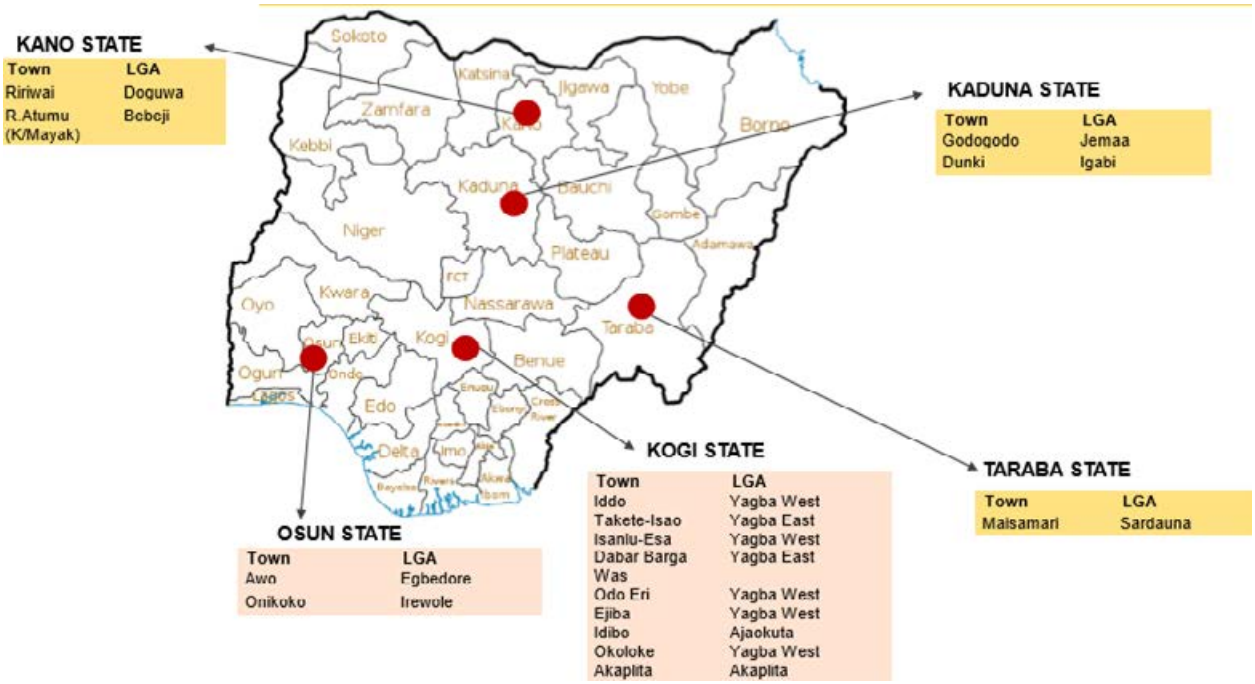


Figure 31: Rare metal pegmatite fields of Nigeria (Okunlola, 2005).





Figures 32 and 33: Rare metal locations in Nigeria.

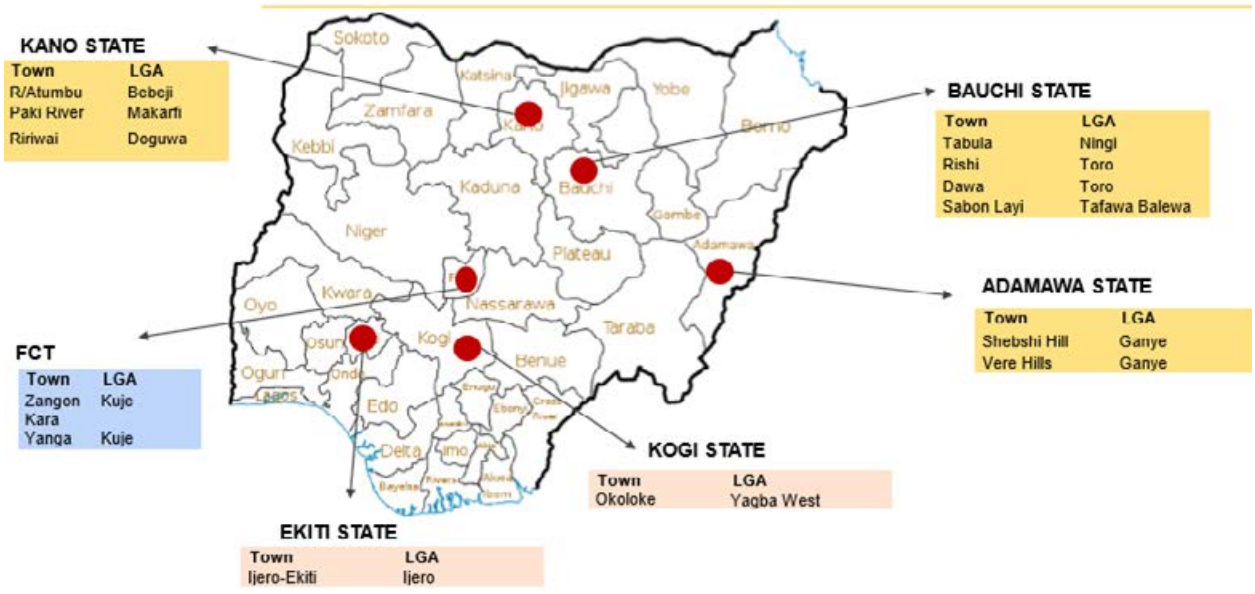
4.9.3 Bismuth

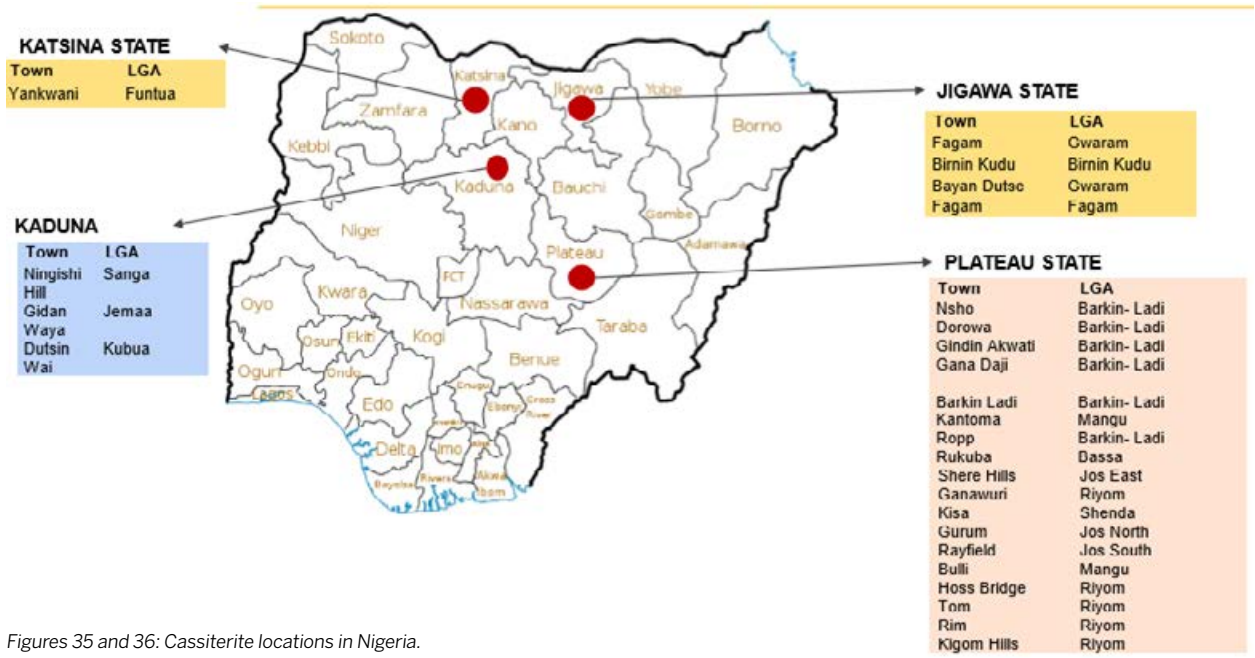
Bismuth occurs freely in nature and in such minerals as "bismuthinite". Bismuth has increasingly been used as a substitute for lead in everything from water pipes to fishing weights, solders and bullets. Alloys of bismuth are also used for thermal electricity generation, as coolants for compact discs and semiconductors, and in high-temperature superconductors. Deposits of bismuth are found in Bauchi State.

Alloys of bismuth are also used for thermal electricity generation, as coolants for compact discs and semiconductors, and in high-temperature superconductors

4.9.4 Cassiterite

A tin oxide mineral, cassiterite is the world's most important source of tin. Also when cut properly, cassiterite can become a beautiful gemstone. It is known to occur in brown, yellow, orange, red and green colours. Deposits of the mineral can be found in the FCT, Plateau, Bauchi, Kano, Nasarawa, Kogi, Ekiti, Jigawa, Kaduna and Katsina States.





Figures 35 and 36: Cassiterite locations in Nigeria.

4.9.5 Galena

Galena is the world's primary ore of lead, which is mined from a large number of deposits in many countries. The foremost use of lead today is in the manufacture of lead-acid batteries used in powering automobiles and for energy storage. Deposits of galena are located in the FCT, Nasarawa, Ebonyi, Bauchi, Benue, Taraba, Plateau, and Gombe States.

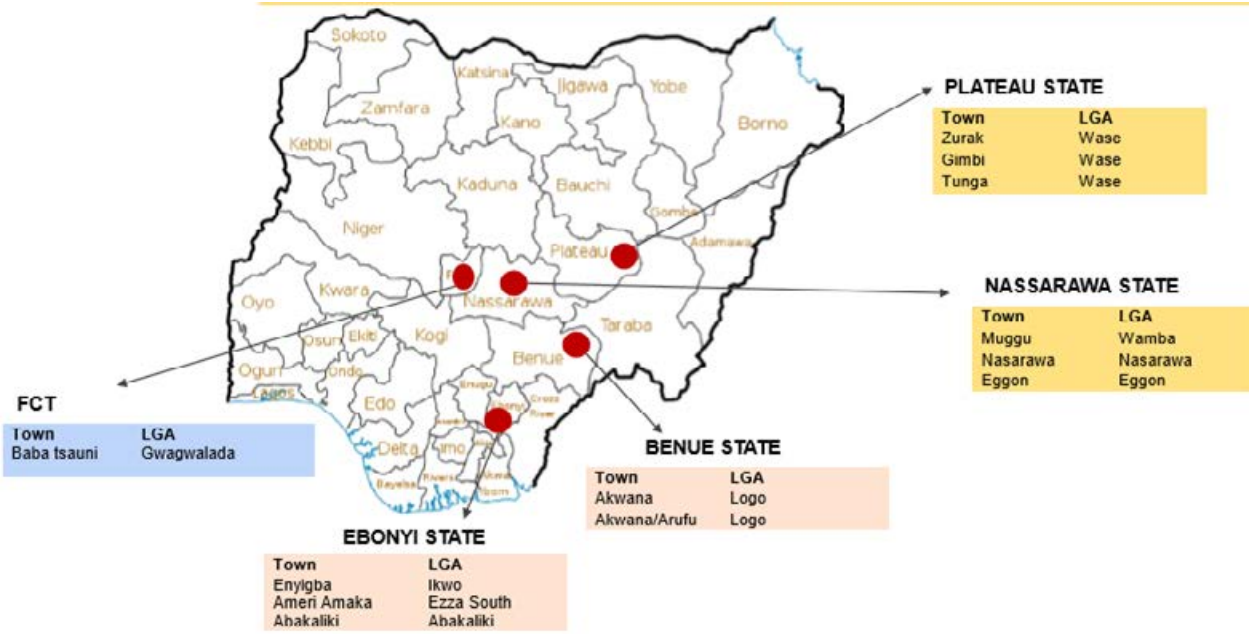


Figure 37: Locations of galena deposits in Nigeria.

4.9.6 Sphalerite

Sphalerite is the most commonly encountered zinc mineral and the world's most important ore of zinc. Zinc is primarily used to galvanise metals such as iron and prevent corrosion. It is also utilised for roof cladding and manufacturing dry batteries. Some zinc metals are also used in making lightweight coins. The utility of zinc sulfide includes the production of luminous dials, TV screens, non-toxic paints, X-ray screens and fluorescent lights. Deposits of the mineral are found in States such as Nasarawa, Ebonyi, Bauchi, Benue, Taraba, Plateau, Gombe and the FCT.

Zinc is primarily used to galvanise metals such as iron and prevent corrosion

4.9.7 Malachite

This is one of the first ores used to produce copper metal. Malachite has a green colour that does not fade over time or when exposed to light. It has been used as a pigment for thousands of years and is one of the oldest known green pigments used in paintings. There is a significant deposit of malachite in Bauchi State.

4.9.8 Cuprite

Cuprite derives its name from the Latin word 'cuprum' for 'copper', due to its copper content. Cuprite is often associated with native copper in copper deposits, and frequently forms as an encrusting reddish coating over the copper. Deposits of cuprite are found in Sokoto State.

CHAPTER FIVE

Mineral Endownments by States

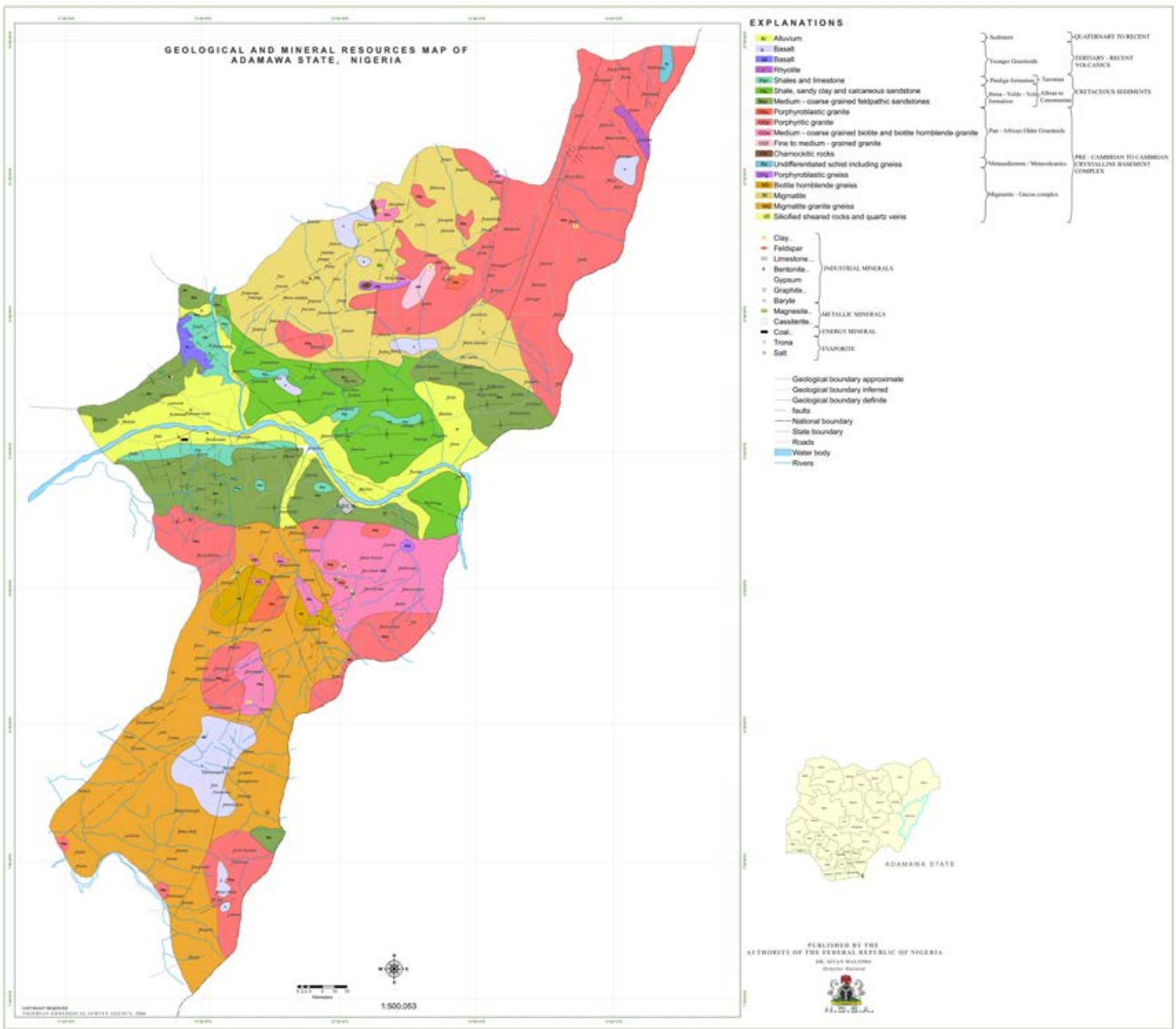
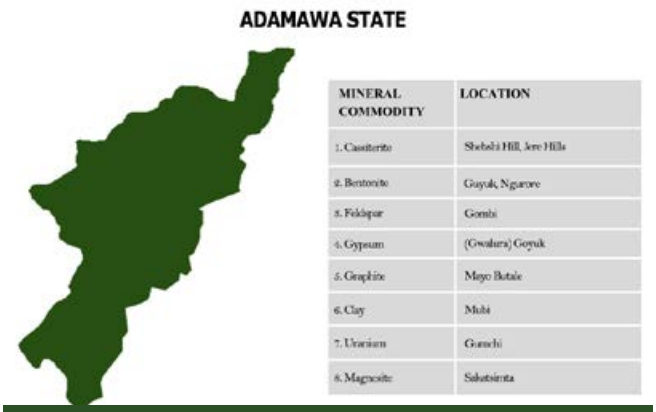


Figure 37: Locations of galena deposits in Nigeria.

ADAMAWA STATE

Brief History

Adamawa State is located in the North-East of Nigeria, with its administrative capital in Yola. It was created out of the former Gongola State on August 27, 1991, by the then Federal Military Government under General Ibrahim Babangida. The State is essentially mountainous land traversed by the river valleys of Benue, Gongola and Yedsarem. The valleys of Cameroon, Mandara and Adamawa mountains form part of its undulating landscape. Adamawa State has some of the longest mountain ranges and breath-taking landscape sceneries in the country, with areas as low as about 129 metres and as high as 2042 metres above the sea level.



Nigeria Mineral Resources

Geology

Adamawa State has three major geological zones, which are defined by three structural types and their corresponding rock types, namely:

1. The basement complex rocks, the oldest known rock-types, constituting areas of uplift that consist of igneous and metamorphic rocks, other than volcanic rocks;

2. Sedimentary rocks, corresponding to areas of sedimentation, i.e. the Benue trough lying wholly within the basement complex rocks; and

3. Volcanic rocks, which are isolated volcanic areas along the Benue trough and the Cameroon volcanic line to the east and north-eastern parts of the State. Quaternary to recent deposits form the youngest lithostratigraphical units in the State, which are confined to river valleys and flood plains. The State has vast mineral deposits cutting across its entire landmass. These minerals are classified into metallic and industrial minerals, energy minerals, and precious and semi-precious stones.

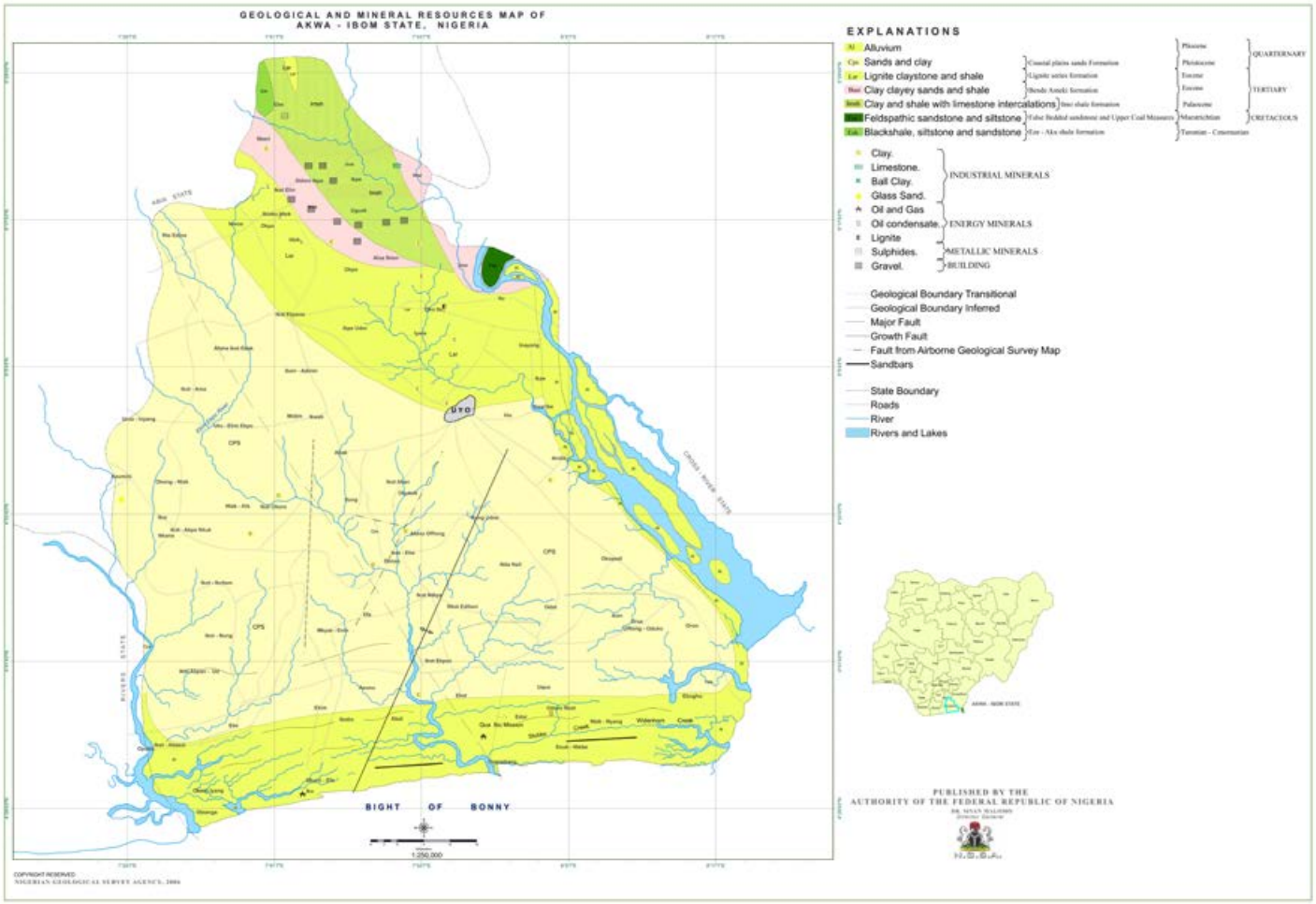
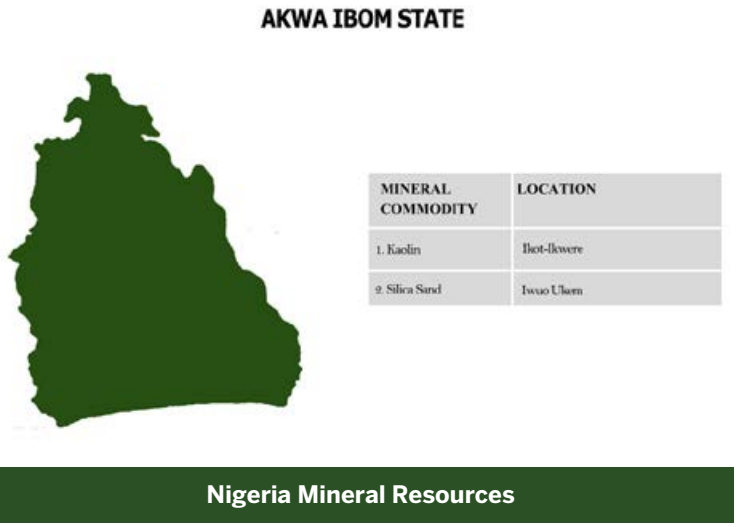


Figure 9: Geological Map of Akwa Ibom State

AKWA IBOM STATE

Brief History

Akwa Ibom is a top oil-producing state located in the south-south geographic region of Nigeria. It was formerly part of Cross River State, but was created as a separate state in 1987. The state has a litoral boundary, meeting the Atlantic Ocean at its southern boundary. It shares land borders with three other states namely Rivers, Abia and Cross River States.



Nigeria Mineral Resources

Geology

In terms of physical structure and characteristics, Akwa Ibom lies on the coastal plain of South-Eastern Nigeria, with the area entirely made up of mostly low relief. Beside Obotme, Nkari, and arears around Itu, Itam, Ibiono, where the land is intensely dissected into a broken "valley and ridge" terrain. Similarly, the Akwa Ibom landscape is largely made up of "low-lying plain and riverine areas". From Eket in the South to Obotme in the North, the land rises progressively above the sea level up to 150 metres.

[5] Akpokodge (1989) "Preliminary Studies on the Geotechnical Characteristics of the Niger Delta Subsoils" in Beka J. E. & Udom G. J (2014), "Quality Status of Ground Water in Akwa Ibom State, Nigeria", *International Journal of Science Inventions Today*, 2014, Vol. 3, Issue 5, pp. 436-449.

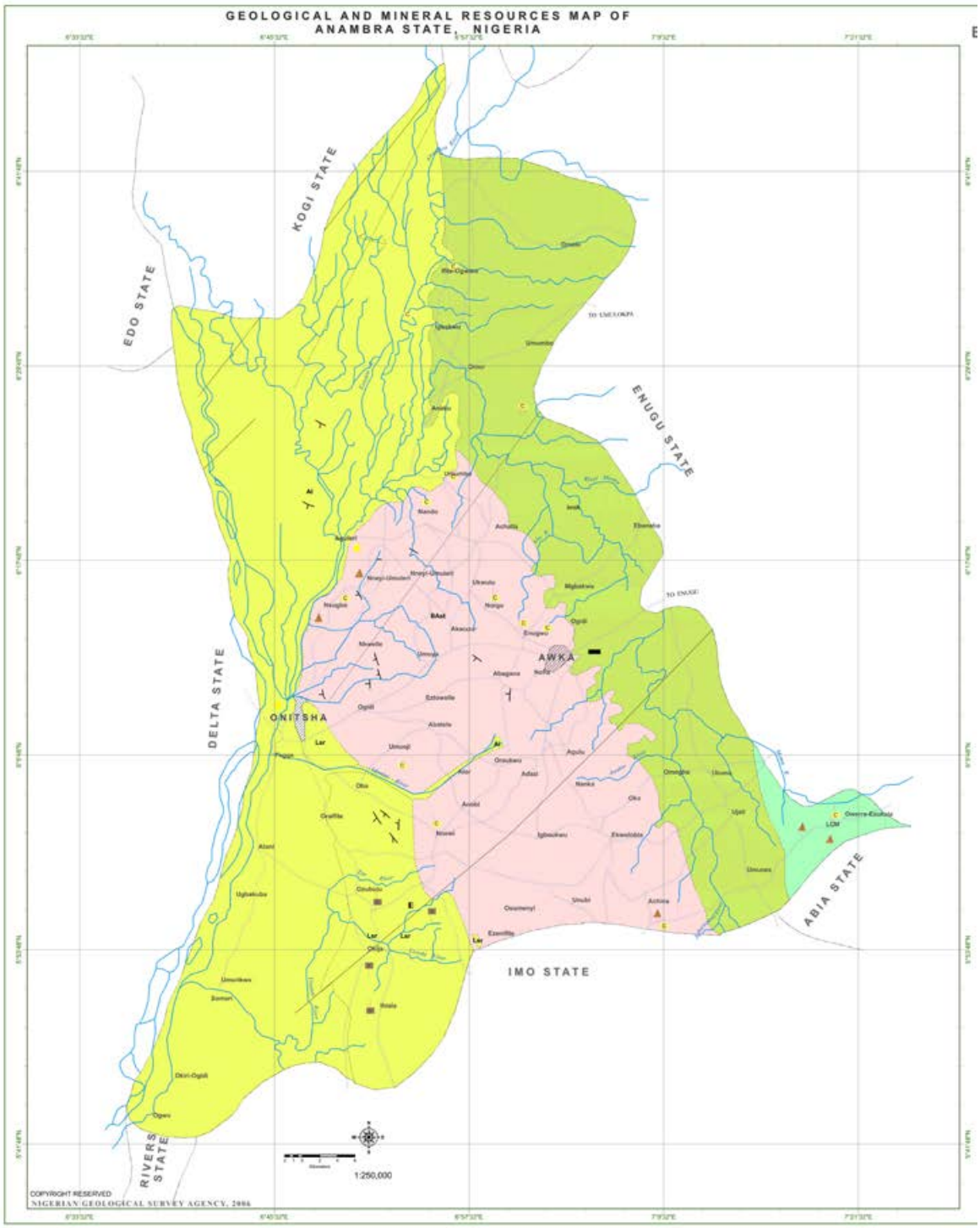


Figure 10: Geological Map of Anambra State

[6] Babatunde, O. L. (2010). The main oil source formations of the Anambra Basin, Southeastern Nigeria. In AAPG International Convention & Exhibition, September (pp. 12-15).

Nigeria Mineral Resources

ANAMBRA STATE

Brief History

Anambra is situated in a partly high- and partly low-plains region in south-east of Nigeria. It is a landlocked, mostly arable area geographically bordered by five other states namely Kogi, Enugu, Imo, Delta and Rivers states. The present Anambra State refers to the land area that existed since 1996, and different from the old Anambra states which existed before 1991 and 1996, when Enugu and Ebonyi States were carved out respectively.

Geology

The geology of Anambra state is defined by that of the Anambra Basin. It is a triangular-shaped area located in the south of Nigeria extending northwards in the lower Benue river. The Anambra basin has the richest deposit of coal and lignite in Nigeria. The Anambra Basin is a cretaceous (formed between 145 million years and 65 million years ago) basin whose sedimentary thickness is about 9km. It has been described as an "ideal geo-reactor" because it possesses the perfect conditions for the kind of chemical reactions that which produce significant hydrocarbon deposits. The Anambra Basin is also believed to have the potential for substantial oil and gas deposits. It is reportedly the first region to experience extensive oil exploration activity within Nigeria. The basin boasts of a rich array of rock types with varied physical characteristics. These rock compositions span both the depth and breadth of the basin form over different geological eras ranging from the Campanian (about 83 million years ago) to Recent geological era.

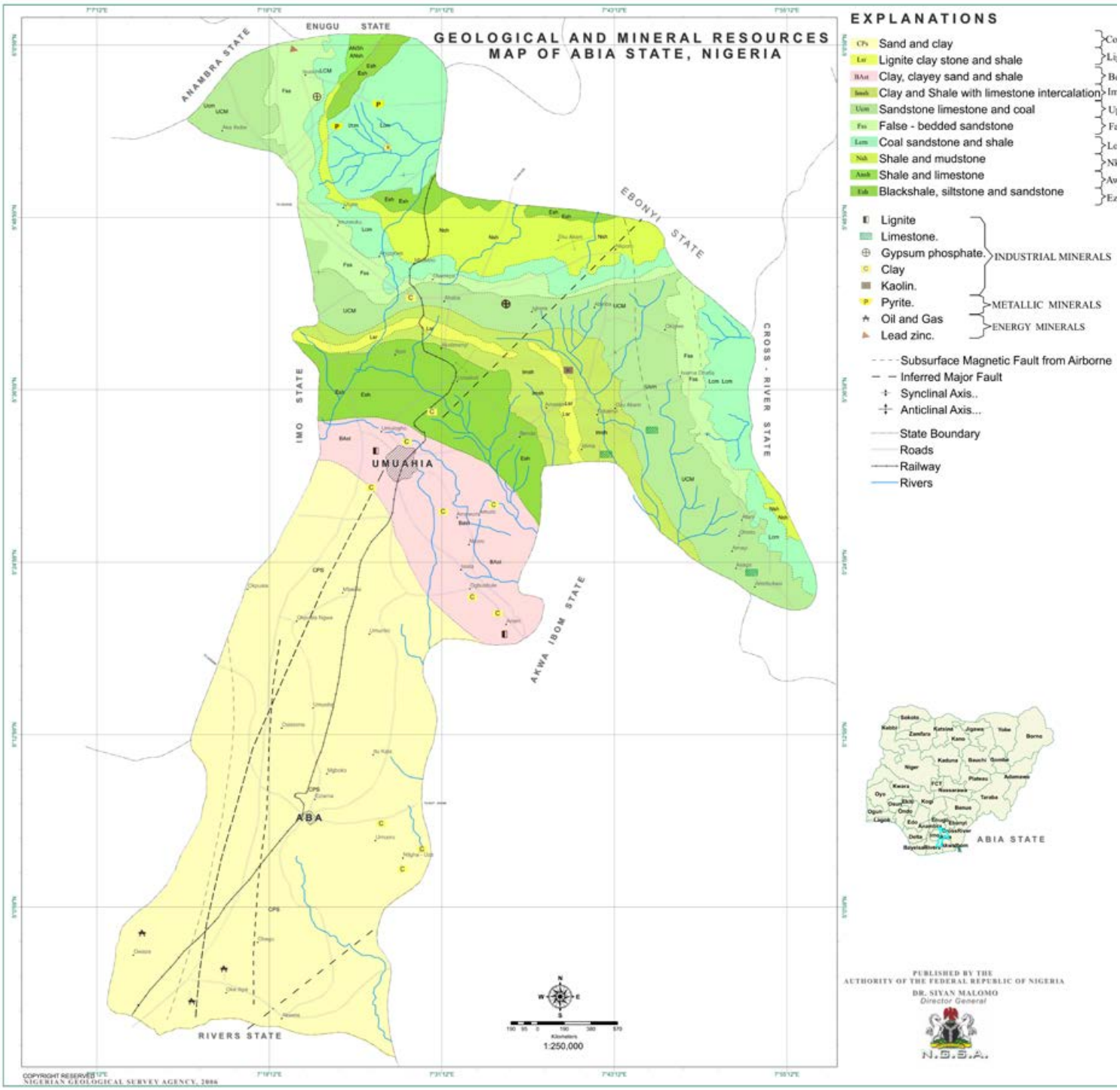


Figure 11: Geological Map of Abia State

[7] 2016 projected population. See Nigeria Bureau of Statistics (2018), Demographic Statistics Bulletin, available at: www/nigerianstat.gov.ng/download/775

[8] See "Abia State Profile: Geography", available at: http://www.abiastate.gov.ng/state-profile/profile/geography/

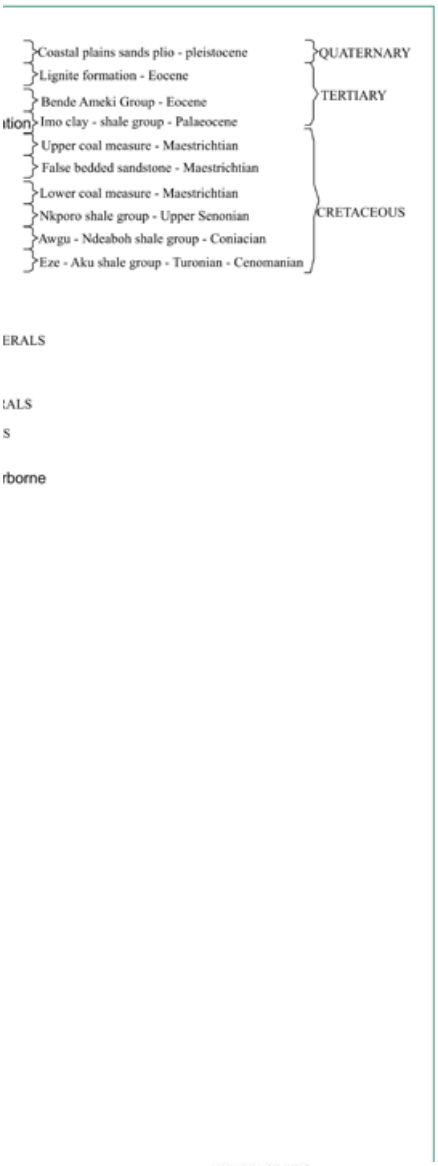
[9] F. A. Abija & H. O. Nwankwoala (2017). *Middle-East Journal of Scientific Research* 25 (12): 2033-2042, 2017

[10] The Tetiary period in geologic calendar is the period between 66 million years ago to 2.6 million years ago.

[11] The Quaternary era in geologic history denotes the period is the period between 2.6 million years ago to the present era.

[12] Igbokwe M. U., Okwueze E. E. and Okereke C. S. (2006), "Delineation of Potential Aquifer Zones from Geoelectric Sounding in Qua Ibo River Watershed, Southeastern Nigeria". *Journal of Enginering and Applied Sciences*, 1(4), 410-421, In F. A. Abija & H. O. Nwankwoala (2017). *Middle-East Journal of Scientific Research* 25 (12): 2033-2042, 2017

[13] F. A. Abija & H. O. Nwankwoala (2017). Middle-East Journal of Scientific Research 25 (12): 2033-2042, 2017



Nigeria Mineral Resources

ABIA STATE

Brief History

Abia, located in the south-east of Nigeria, was created out of the old Imo State in 1991. With an estimated population of 3.7 million,[7] the state measures 5,834 square kilometers comprising partly low-lying (southern part) and the rest moderately high plain. The state is home to Aba, a leading commercial city in Nigeria. Abia is listed as one of the oil-producing states in Nigeria and also classified as a state in the Niger Delta region. It shares physical boundaries with seven states which comprise of all the other southeast states – Anambra, Enugu, Ebonyi and Imo, and three south-south states – Cross River, Akwa Ibom and Rivers. Abia's two major rivers – Imo and Aba – flow into the Atlantic Ocean through the Niger Delta.[8]

Geology

Abia State is situated in transition zone of the Benin and Oguashi-Asaba sedimentary formations.[9] Thus the area is characterized mainly by the Coastal Plain Sands (Benin Formation), the Ogwashi-Asaba and Bende-Ameki (rock) Formations. Underlying these rock types are the Imo shales which were formed between 66 and 56 million years ago. These shales (soft, stratified sedimentary rock) are very visible in the northern part of Abia State. The Benin Formation, which is about 200 meters thick and formed between the Late Tertiary[10] to Early Quaternary[11] geologic period.

The rocks are characterised by deposits of fragments of previously formed sedimentary rocks. It physical characteristics consists of a mixture of sand and pebbles, with localized clays and shales.[12] The Benin Formation is the source of most of the groundwater in the Abia area. On its part, the Ogwashi-Asaba Formation is constituted by sections of sand, clay and grit, each separated by layers of lignite. The Bende-Ameki Formation lies directly under the Benin Formation.[13]

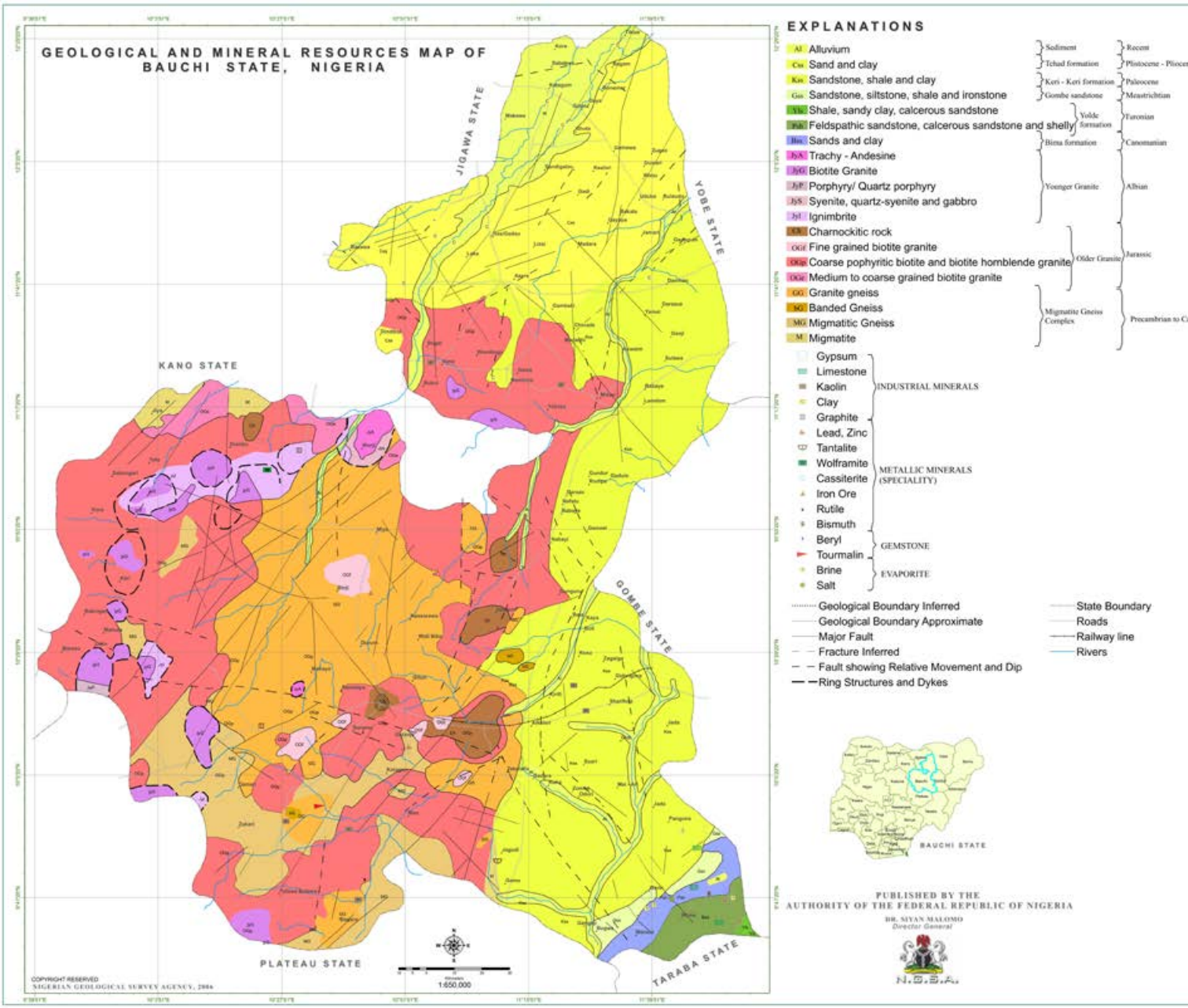


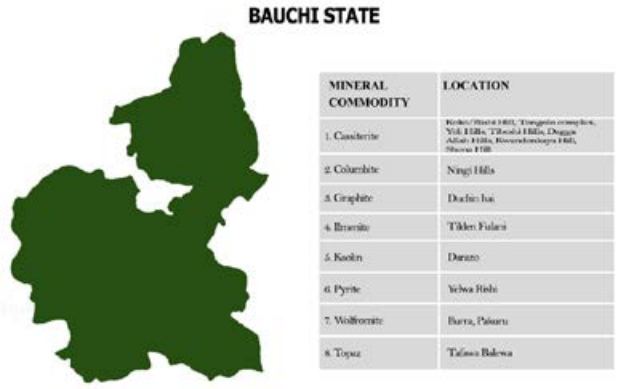
Figure 12: Geological Map of Bauchi State

BAUCHI STATE

Brief History

The present Bauchi State is one of six states in northeastern Nigeria. Although the old Bauchi state (comprising both current Bauchi and Gombe States) was created in 1976, the state began to exist in its current form with current boundaries in October 1996. It is one of Nigeria's largest states in terms of landmass, sharing physical

[7] 2016 projected population. See Nigeria Bureau of Statistics (2018), Demographic Statistics Bulletin, available at: www/nigerianstat.gov.ng/download/775



Nigeria Mineral Resources

boundaries, in a clockwise order, with Kaduna, Kano, Jigawa in the north-west; Yobe, Gombe and Taraba in the north-east; and Plateau States in the north central. Bauchi State sits on an area of 45,837 square kilometres.

Geology

NIGERIA

Bauchi state lies between 10° 20' N and 10° 10' E at an altitude of 670.2 meters above sea level.[14] The state spans two vegetative zones, Sudan Savanah and Sahel Savana.[15] The area is made up largely of plain (flatland) eroded and broken into segments and sloping bedrock surface. The northern part of the state is mostly sandy, while the southern part consists largely of rocky mountains extending from the Jos-Plateau region.[16]

The area comprises of two main relief zones including a hilly western high land. Although Bauchi State is in north-east Nigeria, its geology falls within the general crystalline rock segment that covers the north-central region of the country. The mountains originate from one of the two main rock platforms of Nigeria known as the Basement Complex. The area where these hill ranges are found are "characterized by extensive plateau surfaces and volcanic extrusions".[17] Apart from the hilly western highland, the Bauchi area also consists of a central high plain which is also found in the Basement Complex. The plains comprise of both younger granite and older granite outcrops. The hills ranges of the Western Highlands occur between 600 and 729.3 meters above sea level at their lowest and highest points respectively. The central high plains occur at 798.5 and 816.4 meters above sea level at their lowest and highest points.

[14] Haruna U., Sani M. H., Danwanka H. A. and Adejo E. (2012). Economic Analysis of Fresh Tomato Marketers in Bauchi Metropolis of Bauchi State, Nigeria. *Nigerian Journal of Agriculture, Food and Environment*, 8(3), 1-8) September 2012.

[15] See Bauchi State profile information at: https://www.bauchistate.gov.ng/about-us/

[16] Ibid.

[17] Ajakaiye D. E. (1974). "Gravity Survey over the Nigerian Younger Granite Province" in Dahiru Dahuwa et al (2016), The Analysis of Aeromagnetic Data over Wase and its Adjoining Area, *IOSR Journal of Applied Physics*, Volume 8, Issue 4, Ver. 1, July-August 2016, pp. 57-66.

Figure 13: Geological Map of Bayelsa

[18] J. T. Alfa and C. M. Anaele (2010). Seasonal Variation of Soil Resistivity and Soil Temperature in Bayelsa State. American Journal of Engineering and Applied Sciences, 3(4), 704-709.

[19] Collins C. Chiemeke (2014). Evaluation of Natural Drainage Flow Pattern Necessary for Flood Control, Using Digitised Topographic Information: A Case Study of Bayelsa State, Nigeria. International Journal of Environmental and Ecological Engineering, Volume 8, No. 7, 2014.

[20] Kenneth S. Okiongbo and Edirin Akpofure (2012). Determination of Aquifer Properties and Groundwater Vulnerability Mapping Using Geoelectric Method in Yenagoa City and its Environs in Bayelsa, South-South Nigeria. Journal of Water Resource and Protection, No. 4, pp.354-362. June 2012.

[21] H. O. Nwankwoala and E. Oborie (2014). Geo-Technical Investigation and Characterisation of Sub-Soils in Yenagoa, Bayelsa State, Central Niger Delta, Nigeria. Journal of Civil and Environmental Research, Vol. 6, No. 7, 2014.

[22] Ibid.

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BAYELSA STATE

Brief History

Bayelsa State lies in Southern on Longitude 6° East and 4.5°.[18] The state was created in 1996 from the old Rivers state. Bayelsa State shares land boundaries with Delta and Rivers states, while it meets the Atlantic Ocean at its southern border. The coastal zone, within which Bayelsa is located, is made up of beach ridges and mangrove swamps. The state records very high rainfall for at least eight months of the year. This ensures a network of small streams which flows into the Atlantic Ocean. The general land area is characterised by mostly flatland with average elevation of about 12 meters across the state.[19] The highest elevation is 25 meters, while the lowest is between zero to three meters above sea level. Apart from the riverine mangrove parts of the state, the mainland vegetation consists mainly of oil palm and other large trees.[20]

Geology

The State is situated in the central delta sedimentary basin. Its rock formation span the geologic eras between the Paleocene (66 – 56 million years ago) and the Recent period. These rock formations include the Akata Formation formed in the Paleocene period,[21] the Agbada Formation during the Eocene (56 – 33.9 million years ago) and the Benin Formation in the Miocene (between 23 and 5.3 million years ago) and the Recent period. The major soil types include the dominant coastal soil which has a water table of about 100 centimeters and mostly waterlogged during the wet season; the fresh alluvial plain soil which has a combination of silt, sand and clay characteristic; and the fresh water swamp soil which is mostly sandy clay within 10 meters below the surface, and up to 80 percent clay at a depth of 2 meters.[22]

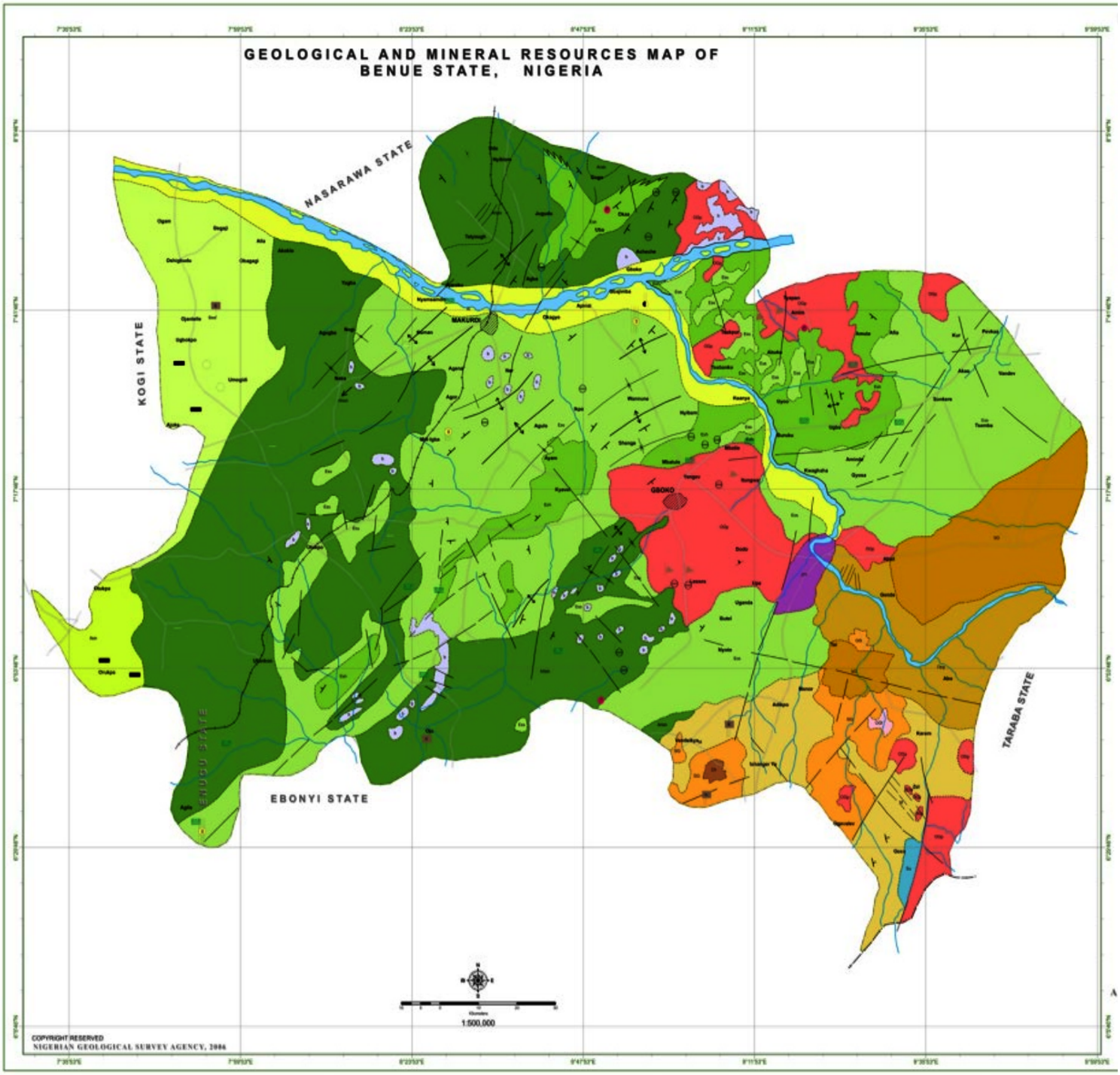

Figure 14: Geological Map of Benue State

BENUE STATE

Brief History

The old Benue State was in 1976, however, its boundaries and land area were adjusted in 1991 when part of the state was carved out to make up Kogi State. The state is located on Longitude 7° 74' and 10° 0' east and Latitude 6° 25' and 8° 8' north.[23] The State's main geographic landmark is the Benue River (from whence the state derives its name), which rises from the Cameroun mountains and runs through north-east of Nigeria into Benue State, ultimately terminating at Lokoja. The area is characterized by moderate rainfall, high temperature and hence high evaporation. The area has predominantly savannah vegetation, with land elevation ranging from 150 – 300 meters above sea level. The state is mostly undulating lowland interspersed with hilly terrain in some parts of Benue South. Here, the terrain is marked by steep slopes, deep valleys and rugged relief.

[23] C. A Akwuobu, R. D. Ailing, K. F. Chah and S.I. Oboegbulem (2014). Studies into the Prevalence of Micoplasma Species in Small Ruminants in Benue State, North Central Nigeria. Journal of Tropical Animal Health and Production, Volume 46, Issue 6, 1097-1092: August 2014.

[24] Ishaq S. Eneji, Rufus Sha'Ato and Paul A. Anune (2012). An Assessment of Heavy Metal Loading in River Benue, in Markudi Metropolitan Area in Central Nigeria. Journal of Environmental Measurement and Assessment, Volume 184, Issue 1, pp. 201-207. January 2012.

[25] Daniel N. Obiora, Adeolu E. Ajala, and Johnson C. Ibuot (2015). Evaluation of Aquifer Protective Capacity of Overburden unit and Soil Corrosivity in Makurdi, Benue State, Nigeria Using Electrical Resistivity Method. Journal of Earth System Science, Volume 124, No. 1, pp. 125-135.

The state is centrally located having land boarders with (and accessible through) five states spread across north-east, north-central, south-east and south-south states – Nasarawa, Kogi, Taraba, Enugu and Cross River states. The Benue rive has about 1,000 kilometers of navigable length[24] which passes from northern Cameroon through north east to central Nigeria in Lokoja, which also links up with the Niger River and connects with southern Nigeria. The state is linked by a rail line that runs through Enugu, Kaduna and Jos.[25] Benue State also has an airport, which makes the state accessible by land water and air.

Geology

The geology of the area is mainly the result of sedimentary formation made up of sandstones, mudstone and limestone.[26] Basement Complex rocks can be found in the southern part of the state. Tropical soil rich in iron content is found in the state with its variants found in the flood plains. The sedimentary plain is believed to have been formed during the quaternary (about 2.5 million years ago) period. The geology of the area, which falls within the Benue Trough, is classified as (1) the Awgu group which comprise the Awgu Shale and Agbani Sandstone: the former is high in carbon content is made of of limestone and sandstone; the later contains silt, sandstone and limestone; (2) the Eze Aku group which in turn comprise the Eze Aku Shell (Formation) and the Makurdi Sandstone (Formation). The first contains mudstones, limestones, siltstones and sandstones, while the Makurdi Formation is dominated by sandstone. Ancient igneous and metamorphic rocks, which contains granite, migmatites and gneiss (3) the Basement Complex.[27]

BENUE STATE

MINERAL COMMODITY	LOCATION
1. Limestone	Yandev, Igumale, Ukpa, Ugba, Aliade (Asongo)
2. Salt/Brine	Oku Lake, Moi Igbo Lake
3. Kaolin	Kwadoma
4. Iron Ore	Opi Ukehe, Aforo Odugbo, Aforo Odugbo
5. Gypsum	Umogidi, Adoka, Edumaga Amoda
6. Coal	Owukpa
7. Barite	Lessel, Gboko

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[26] Ocheri M. Idoko (2010). Seasonal Variation in Iron in Rural Groundwater of Benue State, Middle Belt, Nigeria. *Pakistan Journal of Nutrition,* 9(9): 892-895, 2010.
Ocheri M. Idoko, Temi E. Ologunorisa and Aderonke A. Okoya (2012). Temporal Variability of Heavy Metals Concentration in Rural Groundwater of Benue State, Middle Belt, Nigeria, *Journal of Sustainable Develoment*, Volume 5, No. 2, February 2012.

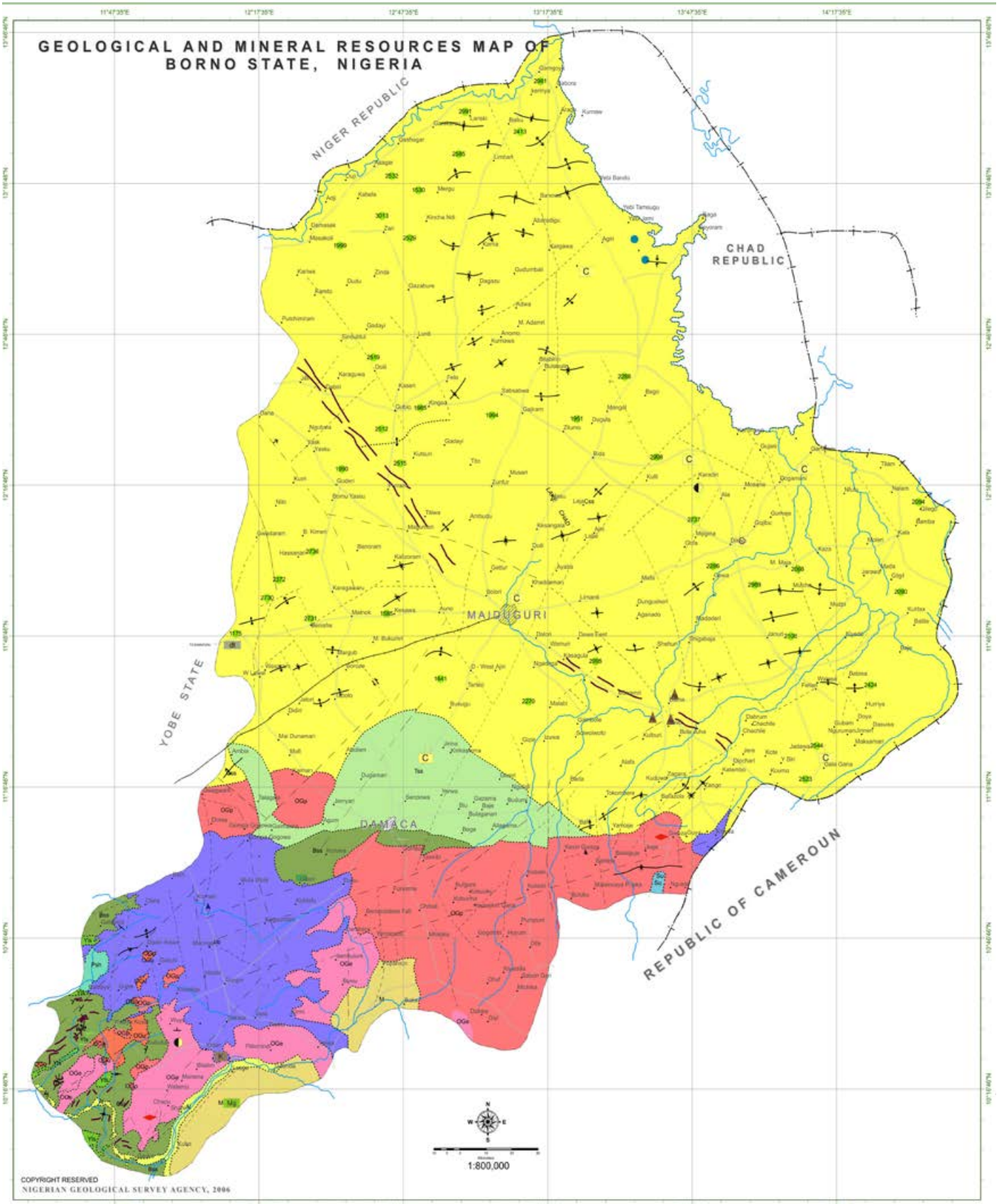


Figure 15: Geological Map of Borno State

BORNO STATE

Brief History

Old Borno State was created in 1976 along with 18 other states that were created at the time. However, the present Borno State acquired its new boundaries in 1991 when parts of the state were carved out to form Yobe State.

Borno State is located in north-east Nigeria and shares physical boundaries with Gombe, Yobe and Adamawa states all in the north-east. It also shares boundaries with three other African countries – Chad, Niger and northern Cameroun, with its northern border mostly straddling the Chad Basin.

In terms of relief the area consists of highlands (Biu Plateau and Madara Mountains) in the south and the Lake chad plains in the north. The highlands occur up to a height of 650 meters above sea level while the plains rise up to 300 meters.[28] The Biu Plateau features a rugged terrain of hills, craters and escarpments owing to incidence of volcanic activities in ancient times. The mountains are uneven owing to cycles of erosion. They are dissected by several rivers with deep channels. Central and northern Borno which constitute about three-quarters of the state consists mostly of vast, open, flat undulating plains. The vegetation consists of Sudan savannah

[28] Muhammad Waziri (2009). Issues in the Geography of Borno State. Kano: Adamu Joji Publishers.

[29] Ibid.

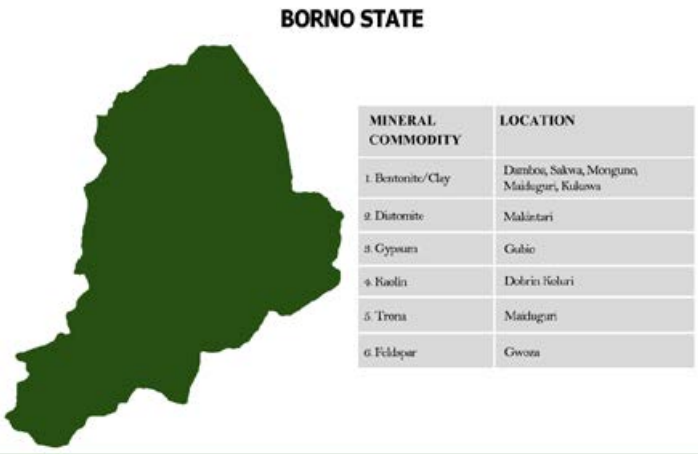
[30] Maduabuchi C. Faye S. and Maloszewski P. (2006). Isotope Evidence of Paleorecharge and Paleoclimate in the Deep, Confined Aquifers of the Chad Basin, Northeast Nigeria, *Science of the Total Environment*, 370:467-479 In Nuhu George Obaje (2009). Geology and Mineral Resources of Nigeria. Berlin: Springer Books.

[31] Obaje, N. G. (2009)..

in the south and Sahel savannah in the north. The climate consists of wet and dry seasons, with average daily temperature of 25°C to 44°C.[29]

Geology

Borno state sits on the Bornu Basin,[30] which is the Nigerian section of the Chad Basin, a sedimentary formation believed to have been formed during the Cretaceous era (145-66 million years ago).[31] In particular, the Bornu Basin



Nigeria Mineral Resources

The Chad Basin which is believed to have been formed during the late Aptian (between 125 – 113 million years ago) and Albian (113 – 100 million years) period.[32] The Bornu Basin is made up of: (a) The Bima Sandstone which was formed from the weathering of basement rocks and contains stratified feldspathic sandstone; (b) the Gongila Formation formed on the Bima Sandstone and contains moderately-thick shales with calcium carbonate content. It also contains silty sandstones which are found in shallow marine environment; (C) the Fika (Shale) Formation, an overlay of the Gongila Formation, and contains blue-black shales with gypsum content, found in shallow to deep marine environment; (d) the Gombe Sandstone – made up of siltstones, ironstones and shales deposited in estuaries and deltas; (e) the Kerri-Kerri Formation – found in the southern part of the state and contains sandstones with iron oxide and gritty clay of different colors; and (f) the Chad Formation which is the topmost layer of rock formation, is found in the bottom of the lake and contains clays, sand and diatomite.[33]

[32] Olabode Solomon O., Adekoya John A. and Ola Peter S. (2015). Distribution of sedimentary formations in the Bornu Basin, Nigeria. Petroleum Exploration and Development, Volume 42, Issue 5, October 2015.

[33] Obaje N. G. (2009).

CROSS RIVER

Brief History

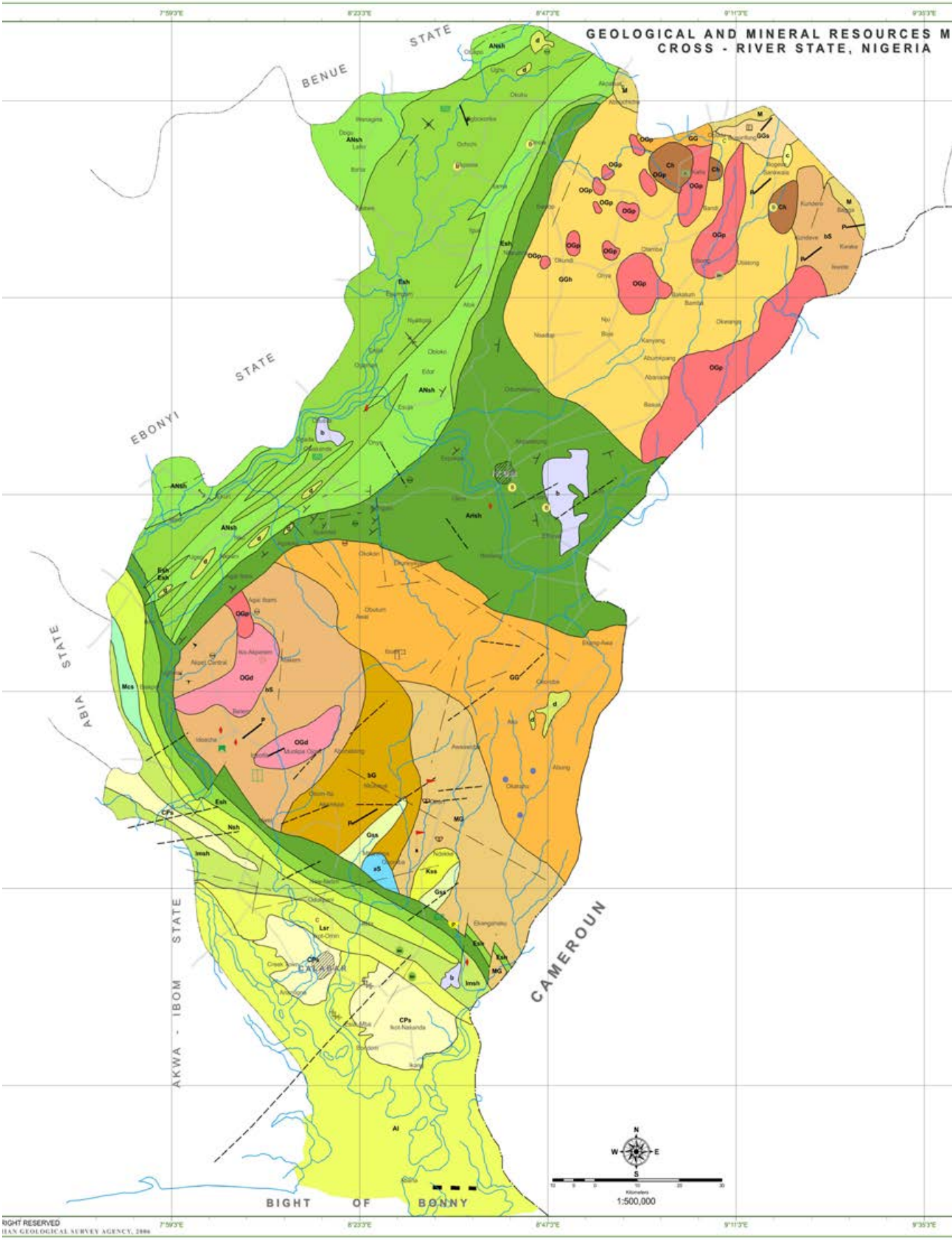
Cross River was created in 1967 and existed in its 1967 structure until 1987 when its south-western part was carved out to form a new (Akwa Ibom) State. It is sometimes situated (geographically) within the south-eastern region of Nigeria, even though it is more conventionally classified (geo-politically) as part of the south-south region. It is a coastal state which with southern sharing its southern boundaries with Akwa Ibom State in the south-south of Nigeria and the Atlantic Ocean. It also shares land boundaries with Benue state in the north, Ebonyi and Abia states in the west and the Republic of Cameroon to the east. The state lies in the tropical rainforest and characterized by humid, tropical climate. Apart from Obudu in northern Cross River which has a temperature of 15°C to 23°C, the rest of the state recording average temperature of 30°C. Average rainfall in the state range from just under 2000 to little above 3000mm. The relief varies from low-lying to high elevations south-ward of the state. From a height of 100 meters in the (Mamfe Embayment) areas around Ikom, the elevation rises up to more than 500 meters above sea level in the (Oban Massif) area around Akamkpa-Calabar axis.

Geology

The geology of Cross River State is characterised by the Oban Massif and the Obudu Plateau which sit on the Nigerian Basement Complex, the Cross River Plain and the Calabar Coastal Plain, the Southern Benue Trough, Mamfe Embayment, the Calabar Flank and the Niger Delta Plain which sit on the Sedimentary Basin. The Oban Masif and the Obudu Plateau are made up largely of crystalised metamorphic rocks bearing platy minerals, schists, amphibolites, granites, dolerites, etc. The Mamfe Formation consists of mostly sandstones and mudstones, while the Southern Benue trough is made up of sandstones and shale. The Calabar Flank consists mostly of sandstones, mudstones and shale. The constituents of the Niger Delta Basin exist as described previously in this paper under the geology of Bayelsa State, in South-south Nigeria.

Cross River State is the nation's remaining rain forest and wildlife sanctuary. Except for the Sahel, all the other ecological zones in Nigeria are represented in this State, having a landscape that descends precipitously from the Oban-Obudu rugged foothills (1000 – 2000 metres) of the Cameroon Mountains to the east, into the Cross River Plains (30 metres) to the west, and down to the Bight of Bonny coastal plains to the south. Coastal mangrove wetlands, interlaced with creeks, a virgin rainforest on the Oban-Obudu hills, a montane parkland on the Obudu Plateau, and derived Savannah on the Cross River Plain, are all parts of the State's vegetation and scenery.

From its name, it is apparent that the State occupies the catchment of the Cross River, which courses down the Cameroon Mountain, across the flat lying Cross River basin, into a vast estuary located along the southern Nigeria-Cameroon border.


GEOLOGICAL AND MINERAL RESOURCES M
CROSS - RIVER STATE, NIGERIA
BENUE STATE
EBONYI STATE
ABIA STATE
AKWA - IBOM STATE
CAMEROUN
BIGHT OF BONNY
CALABAR
1:500,000

AP OF

EXPLANATIONS

- Al Alluvium
- CPs Sands and Clay
- Lst Lignite,Claystone and Shale
- Imsh Clay and Shale with Limestone Intercallation
- b Basalt
- Mcst Coal,Shale,Sandstone and Mudstone
- Nsh Shale and Mudstone
- Aish Shale and Limestone with Sandstone Intercallation
- Esh Shale,Limestone and Sandstone
- Arish Shale and Limestone
- OGd Biotite and Biotite hornblende Granodiorite
- OGp Porphyritic Granite/Coarse Porphyritic Biotite and Biotite hornblende Granite
- Ch Charnockitic Rocks
- bS Biotite,Garnet, Gneiss and Schist
- Kss Sandstone,Shale and Clay
- Gss Sandstone,Siltstone,Shale and Ironstone
- aS Amphibole Schist,amphibolite
- D Dolerite
- GG Granite Gneiss
- M Migmatite
- GGh Hornblende Granite Gneiss
- bG Biotite Gneiss
- mG Migmatitic Gneiss

Sediment	Recent	QUATERNARY
Coastal Plain Sand	Pleiocene	
Lignite formation	Eocene	TERTIARY
Imo clay shale	Paleocene	
Late younger granitoids	Tertiary volcanics	
Lower coal measure (Mamu)	Senonian	CRETACEOUS
Asata Nkporo shale		
Awgu Ndeaboh group	Coniacian	
Eze Aku group	Turonian - Cenomanian	
Asu River group	Albian	
Pan African (Older) Granitoids		
Meta - Sedimeent Meta - Igneous rocks	PRECAMBRIAN TO CAMBRIAN BASEMENT COMPLEX	
Migmatite - Gneiss Complex		

- Baryte
- Limestone
- Clay
- kaolin
- Mica
- Graphite

INDUSTRIAL MINERALS

- Manganese
- Pyrite
- Rutile
- Cassiterite
- Ilmenite
- Monazite

METALLIC MINERALS

- Corundum
- Tourmaline
- Tantalite
- Quartzamethyst

SEMI - PRECIOUS MINERALS

- Granite

DIMENSION STONE

- Borehole.
- Major Faults
- faults from airborne
- Geological boundary definite
- International boundary
- Pegmatite
- Sandbars
- Strike and dip of bedding
- Synclinal axis..
- Strike and dip of foliation

- State boundary
- International boundary
- Roads
- River

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Director General
N.G.S.A.

CROSS RIVER STATE

MINERAL COMMODITY	LOCATION
1. Barite	Oshia, Gabu
2. Limestone	Mfamosing, Agri Ibam, Ikot Ana
3. Salt	Ogoja
4. Silica Sand	Iwuo Ulem
5. Uranium	Adimdomi

Nigeria Mineral Resources

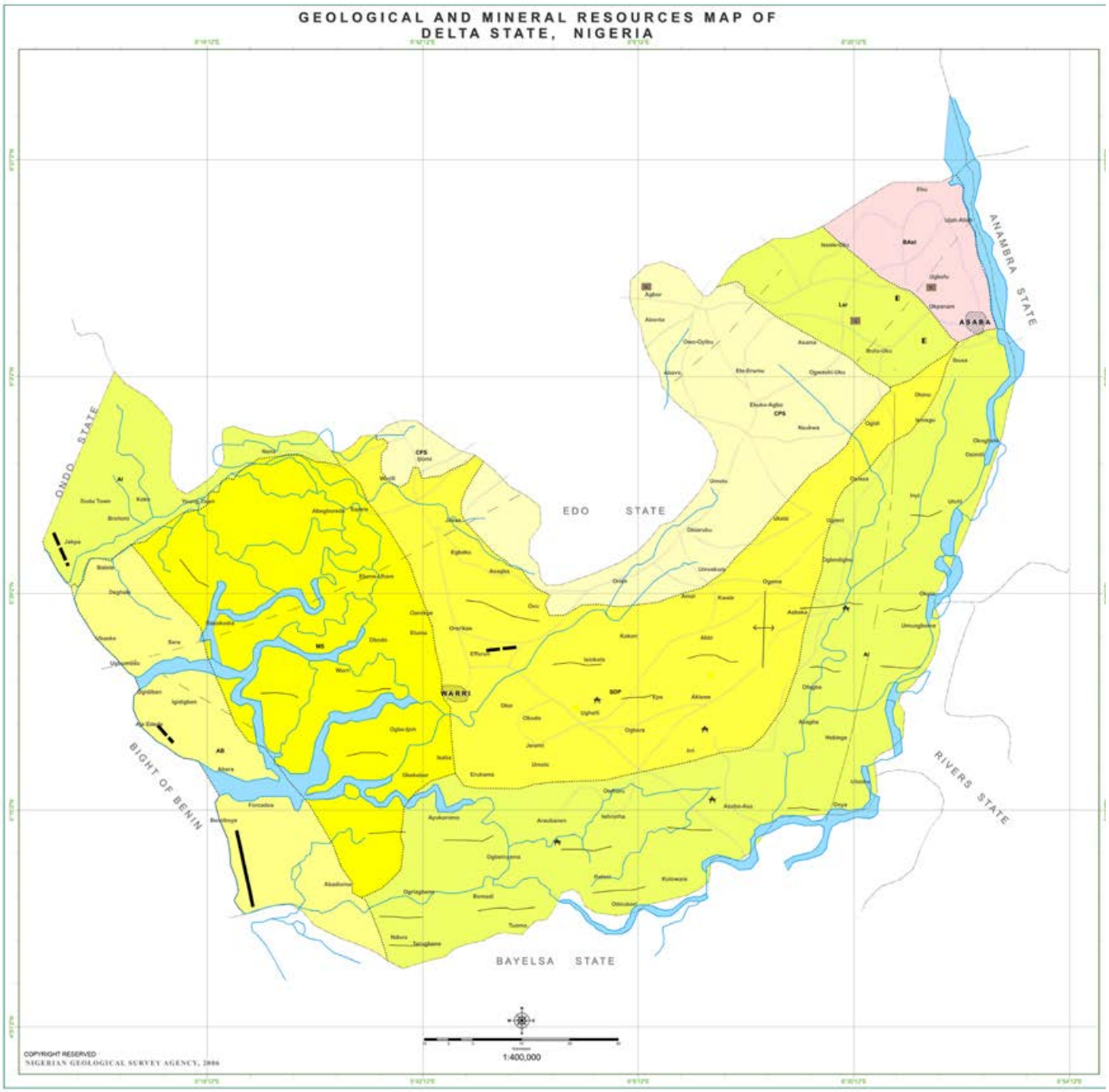
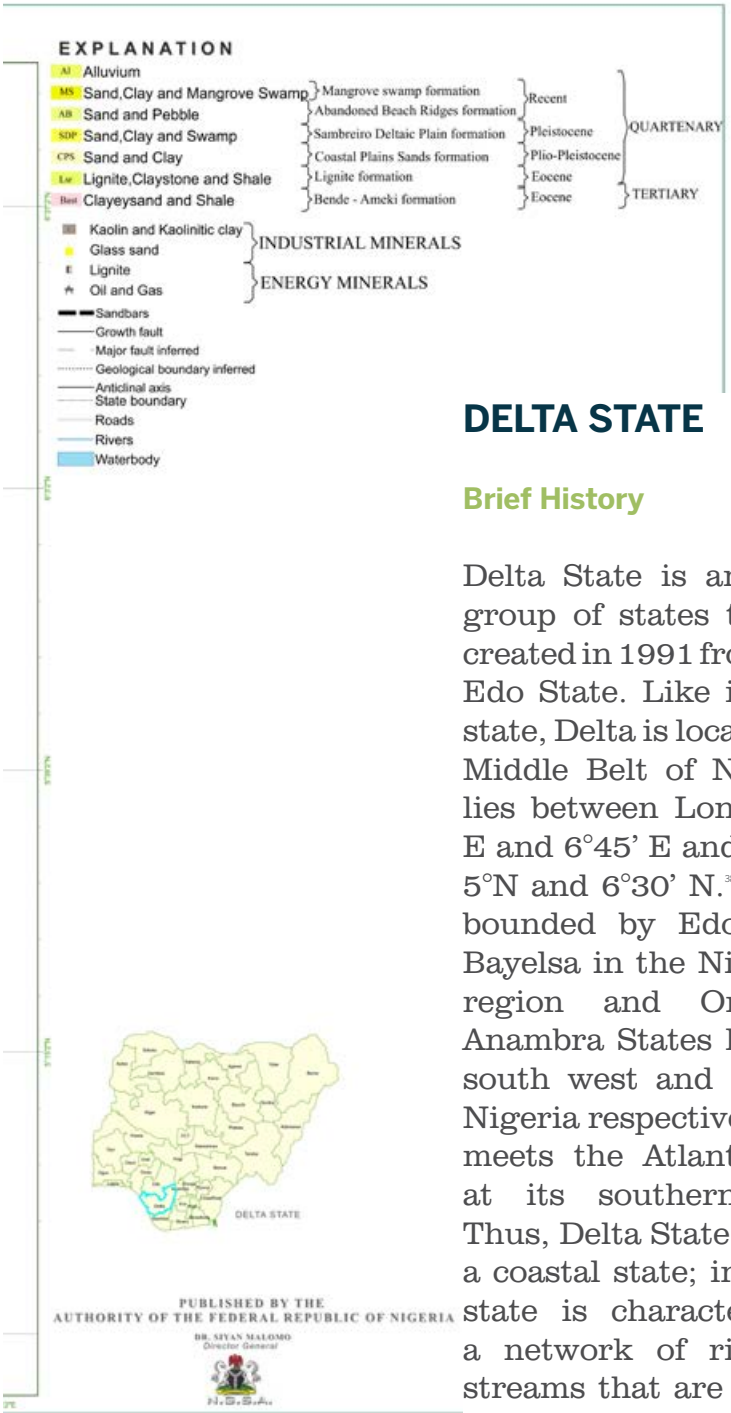


Figure 17: Geological map of Delta State

[38] S. I. Efe (2006). Quality of Rainwater Harvesting for Rural Communities of Delta State. Environmentalist Journal, 26:175-181



Nigeria Mineral Resources

DELTA STATE

Brief History

Delta State is among the group of states that were created in 1991 from the old Edo State. Like its parent state, Delta is located in the Middle Belt of Nigeria. It lies between Longitude 5° E and 6°45' E and Latitude 5°N and 6°30' N.[38] Delta is bounded by Edo, Rivers, Bayelsa in the Niger Delta region and Ondo and Anambra States located in south west and southeast Nigeria respectively. It also meets the Atlantic Ocean at its southern border. Thus, Delta State is mainly a coastal state; inland, the state is characterized by a network of rivers and streams that are generally found in the Niger Delta region. The terrain is mostly low-lying with no hill of significant height found in the area. Its coastal plain is mostly upland and swamp. It lies between the flood plain and the Benin Lowlands. The rest of the state is made up of freshwater swamp and the mangrove swamp.

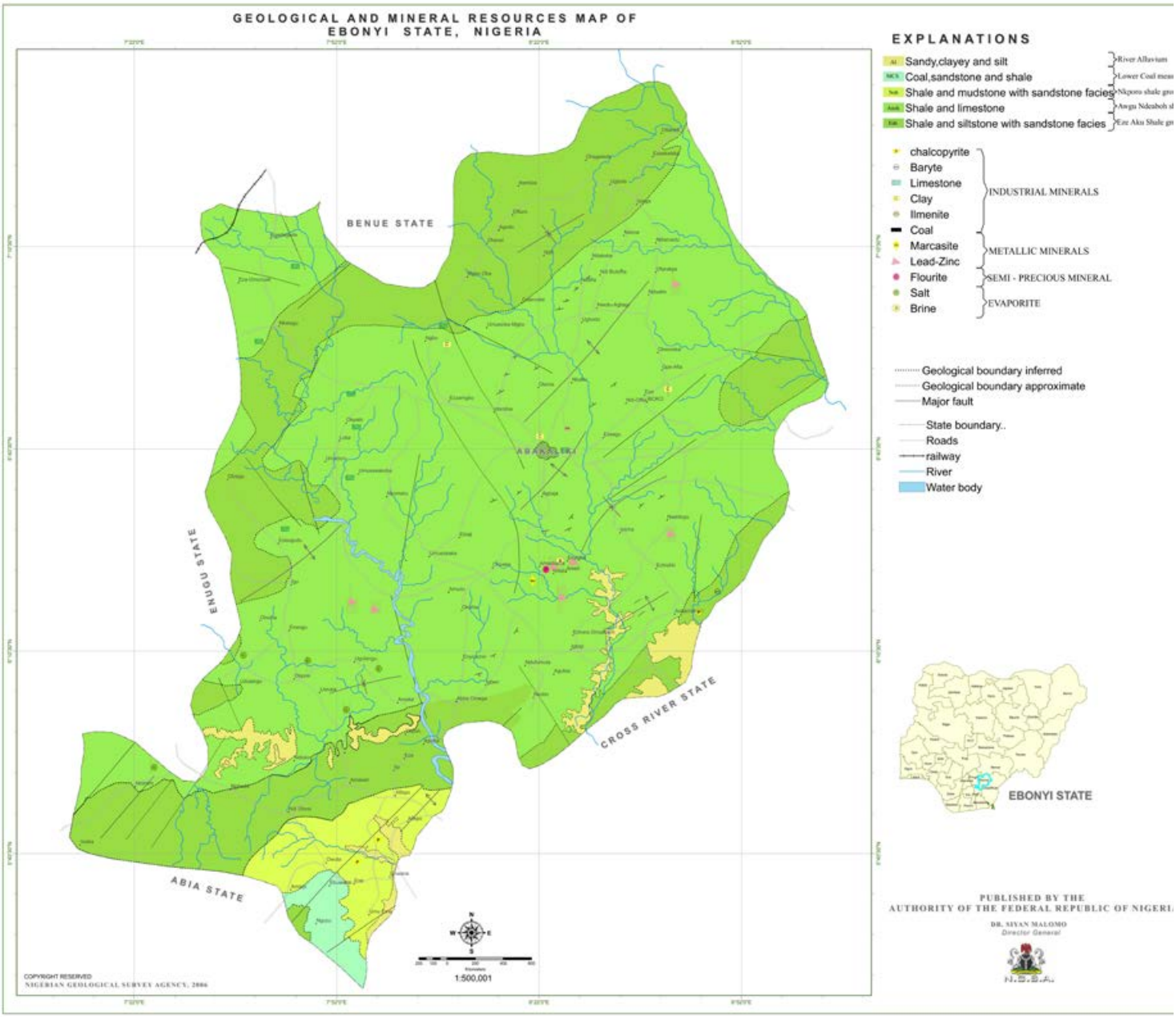
Geology

Like most of the Niger Delta, Delta State is underlain by the by the Benin, Agbada and Akata Formations.[39] The constituents of these formations have been described previously in this paper under the geology of Bayelsa State which lies in the same Niger Delta Region. These formations are made up of sands and sandstones with intercalation[40] of clays and shales.[41]

[39] S. I. Efe (2006).

[40] Intercalation in geology describes the infusion of a minerals deposits into another.

[41] A. E. Edet (1993). Groundwater Quality Assessment in Parts of Eastern Niger Delta, Nigeria, Journal of Environmental Geology, 22:41-46.



[42] E. N. Ogbodo (2013). Assessment and Management Strategies for the Receding Watersheds of Ebonyi State, Southeast Nigeria. *Journal of Environmental and Earth Science*, Vol. 3 No. 3, pp. 18-27.

Figure 18: Geological Map of Ebonyi State

EBONYI STATE

Ebonyi State is in the southeast of Nigeria. The area was formally part of the old Anambra State but was carved out as a separate political and administrative tier of government in 1996. The state lies between Longitude 7°30' and 8°30' E and Latitude 5°40' and 6°45N.[42] Ebonyi is an entirely land-locked state, sandwiched between Enugu and Abia States in the southeast, Cross River State in the South-South (although geographically, Cross River actually lies side-by-side to the east of Ebonyi State) and Benue State in northern Nigeria. Its vegetation falls within the low rainforest and wooded grassland savannah region. Average temperature ranges from 27°C to 30°C, while average annual rainfall is between 1750mm to 2250mm.[43] Land elevation in the area ranges fro 15 meters to 162 meters above sea level. Hydrogeologically, the state is located within the Cross River drainage basin, with the Eastern and Western Ebonyi Rivers as the main tributaries. Its water bodies are characterized with very high salt content.

Geology

Ebonyi is found within the Asu River Geologic Group, the Eze-Aku Shale Formation and the Nkporo Formations. The Eze Aku formation, believed to have been formed from the extension of the oceanic shoreline (transgression) about 100 million years ago, is composed of shales of calcium carbonate content, mica-bearing sandstones and occasionally shelly limestones.[44] The Asu River Group, which consist of the Arufu, Uomba and Gboko Formations, contain limestones, shales, mica-bearing siltstones, mudstones and clays. The Nkporo Formation is made up of marine sandstones and shales. It soil type reflects hydromorphic, (soil developed from incidence of high moisture content) shallow-depth clay soil ranging in color from reddish brown to pale.

[43] Federal Department of Agriculture and Land Resources (1985), "The Reconnaissance Soil Survey of Anambra State Soil Report 1985", In E. N. Ogbodo (2013).
[44] See Obaje (2009).

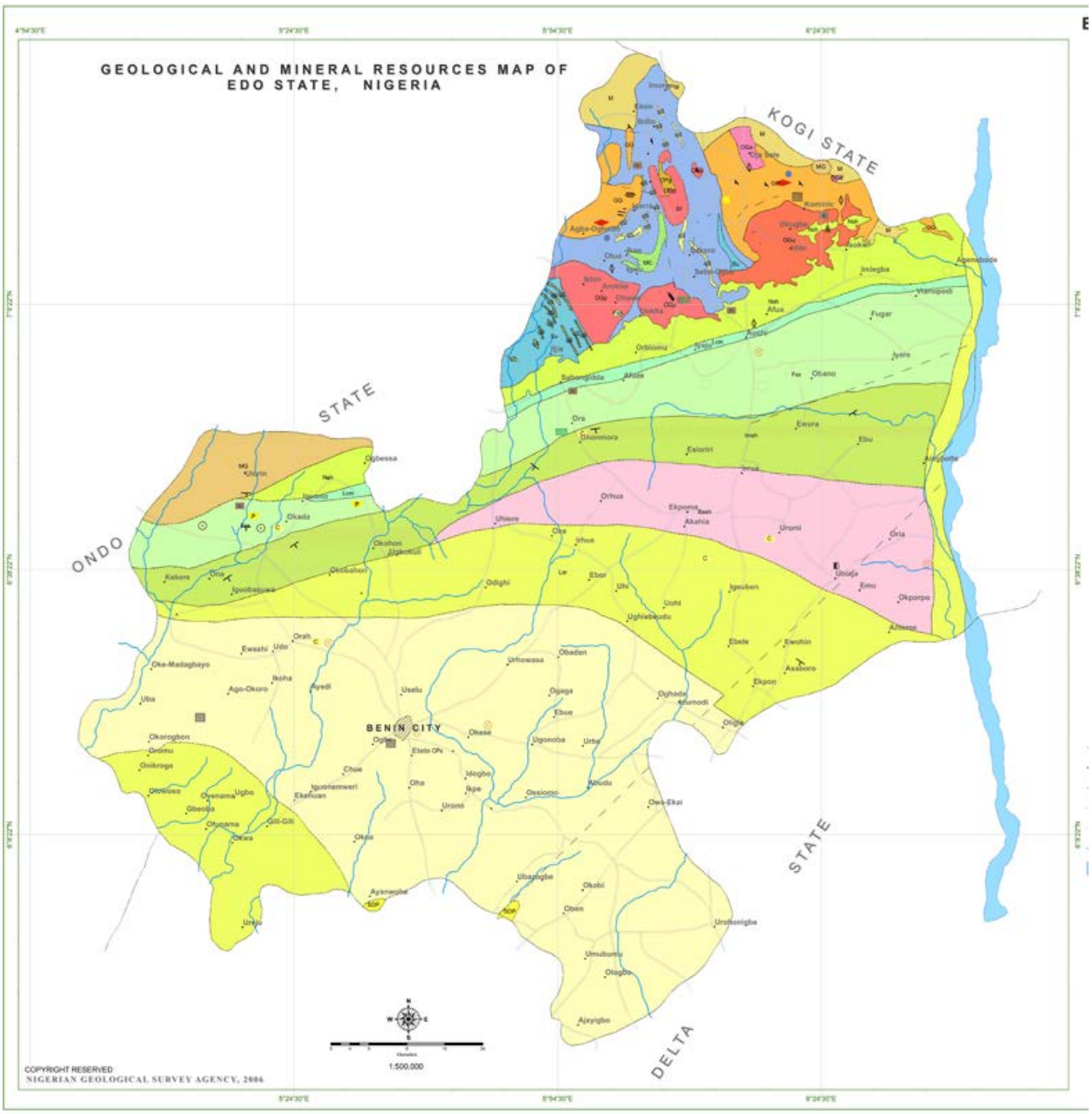
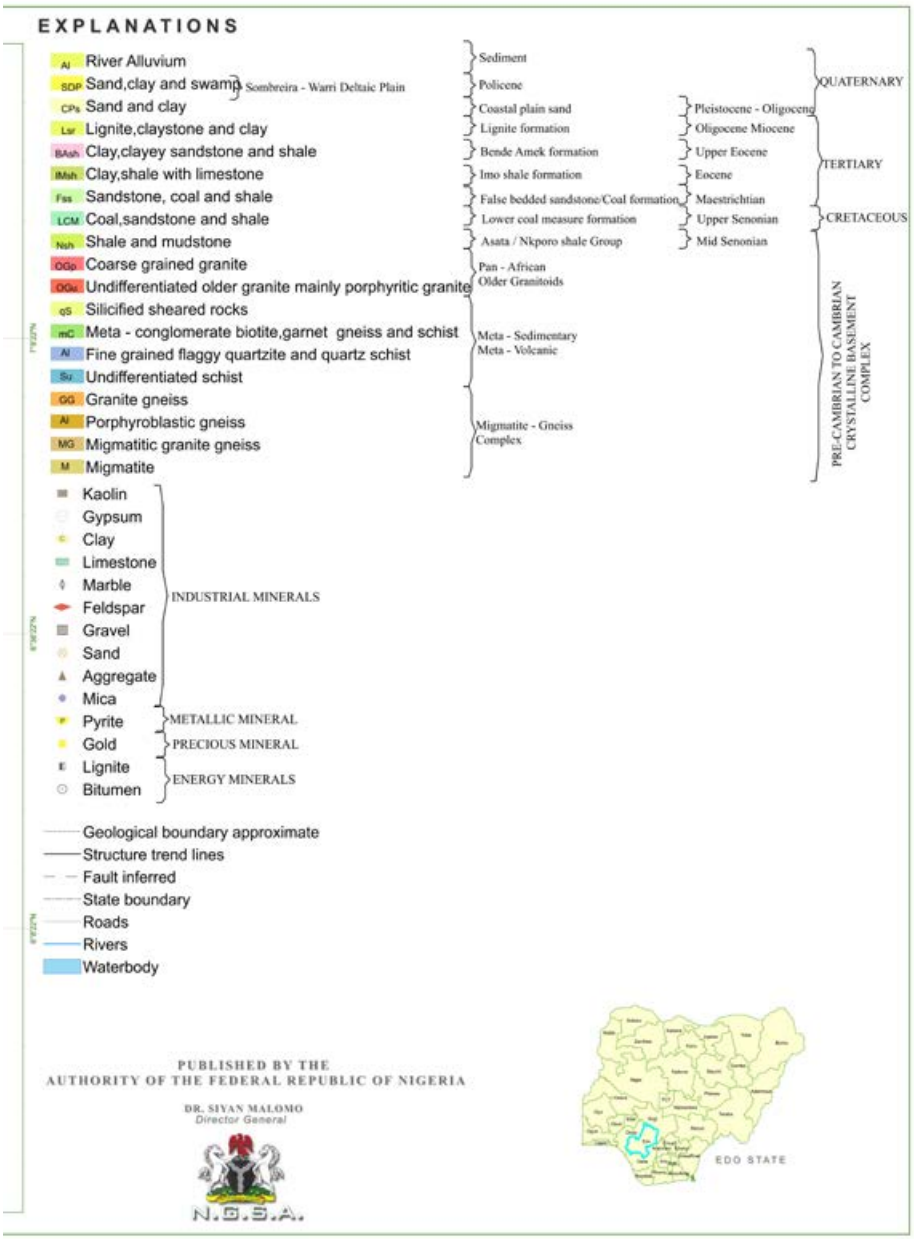


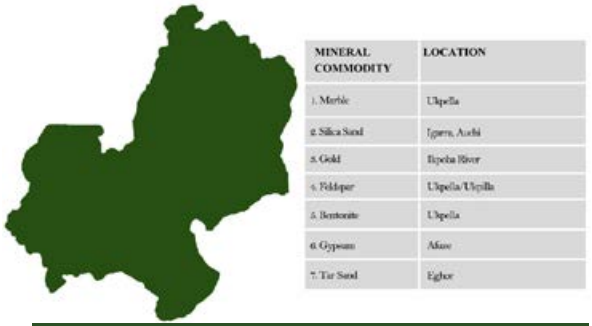
Figure 19: Geological map of Edo State

EDO STATE

Edo State is located in the political South-South of Nigeria and the geographical Niger delta. The area existed as part of the former Bendel state, but was created as one of two autonomous entities in 1991. It is located between Latitude 5°30' N and Longitude 5°00' and 6°50' E. It shares land borders with Delta, Anambra, Kogi and Ondo states. The surface land is undulating with the relative relief height of about 12 meters. The vegetation is largely that of tropical rainforest.[45] The terrain is relatively flat at 466m above sea level.[46] The relief consists of swamps, creeks, plateau and dissected uplands.[47]

[45w] Famous I. Aziegbe (2006), Channel and Morphological Response of Two Watersheds to Urbanisation in Benin City, Edo State Nigeria. Journal of Human Ecology, 20(3):177-182.





Nigeria Mineral Resources

Geology

Geologically, Edo State is underlain by deposits which were formed between 146 million and 2.6 million years ago. The underlay of the area consists of the Benin Formation, the Bende Ameki Formation, the Ogwashi Asaba Formation, the Imo Formation and Nsukka formation.[48] The Benin, Bende, Ogwashi, and Nsukka Formations have previously been described in the geologies of Imo, Delta and Anambara States. The Benin Formation consists of a deeply-weathered sedimentary rock which is part of the southern sedimentary basin.[49] The soil characteristics if generally the red-yellow kind with iron content. There are however some variations of shallow, stone reddish clay at the feet of inselbergs, clay and sandy soil in the upper table of lateric slope and reddish-brown soil containing iron-oxide on the crystalline acid rocks of the basement complex.[50]

Generally, the geological constituents of the Edo State area include sands, clay, grit, shale and lignite. Nsukka and Imo formations are most noted for marine shale deposits.

[46] Magnus O. Ojeifo and Joseph O. Eseigbe (2012). Categorisation of Urban Centers in Edo State, Nigeria. Journal of Business and Management, Vol. 3, Issue 6, pp.19-25.
[47] Ogunleye O, S. and Jegede A. (2010). Determinants of Rural Development in Edo State, Nigeria: An Overview. International Multidisciplinary Journal, 4(1): 298-308. January 2010.
[48] O. M. Alile, W. A. Molindo, and M. A. Nwachokor (2007). Evaluation of Soli Profile on Aquifer Layer of Three Locations in Edo State. International Journal of Physical Sciences, Volume 2, Issue 9, pp.249-253, September 2007.
[49] Aziegbe (2006)
[50] Ogunleye and Jegede (2010).

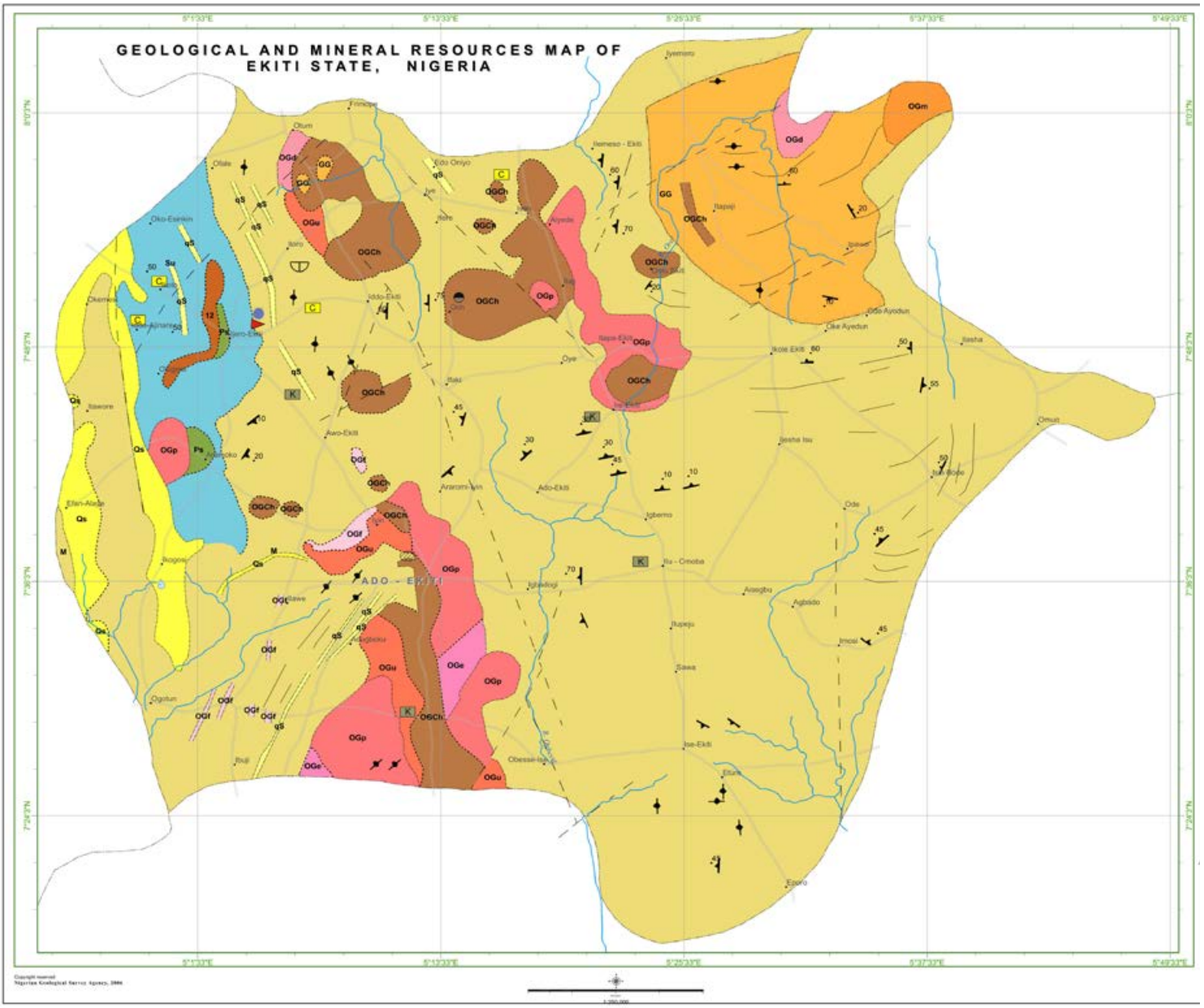


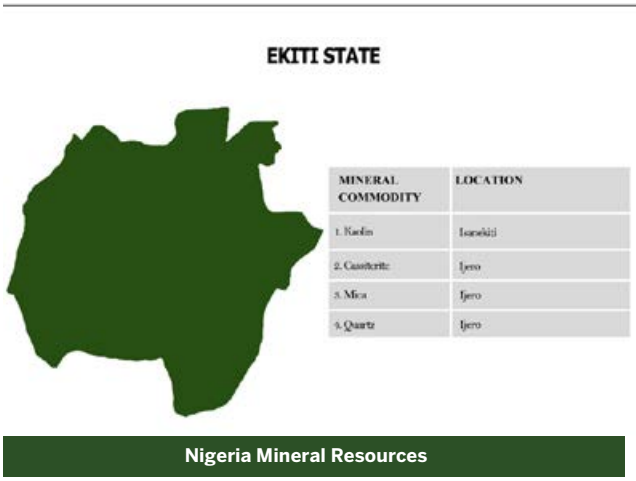
Figure 20: Geological map of Ekiti State

EKITI STATE

Ekiti was one of six states created 1996. It was carved out of the old Ondo State, The State presently comprises the Ekiti Central, Ekiti North, Ekiti South and Ekiti West divisions. Before being founded, the territory now known as Ekiti State comprised twelve local government areas (LGAs), but at its creation, four more local councils were formed, bringing the number to LGAs in the State to sixteen. Ado-Ekiti is the State capital.

Geology

In general, Ekiti State is underlain by metamorphic rocks of the Precambrian basement complex, the great majority of which are very ancient in age. The rocks



Nigeria Mineral Resources

are gneisses and schists, consisting essentially of quartz, with small amounts of white micaceous minerals. The rocks are strongly foliated and occur as outcrops, especially in the Efon-Alaaye and Ikere-Ekiti areas (Smyth and Montgomery, 1962).

Ekiti State has no coastal boundary, and hence it has no coastal relief. Indeed, the term, Ekiti, denotes an interior or hinterland area, as opposed to a maritime area (Oguntuyi, 1979). It also means mound. This name invariably implies that Ekiti State is mainly an upland area.

In the main, the relief of the State is rugged with undulating areas and granitic outcrops in several places. The notable hills are Ikere-Ekiti Hills in the southern part of the State; Efon Alaaye Hills to the western boundary; and the Ado-Ekiti Hills in the central part of the State. Most of these hills are well over 250 metres above sea level. The drainage system over the areas of basement complex rocks is typically marked with the proliferation of many small river channels, which are dry for many months, especially from November to May.

In Ekiti, there is no major river. However, the State serves as the watershed and source region for three major rivers that flow into the Atlantic Ocean. These are the Rivers Osun, Owena and Ogbese. Other rivers in Ekiti are Ero, Ose and Oni. Another important aspect of the relief of the State is the prevalence of erosion gullies along hill slopes and valleys.

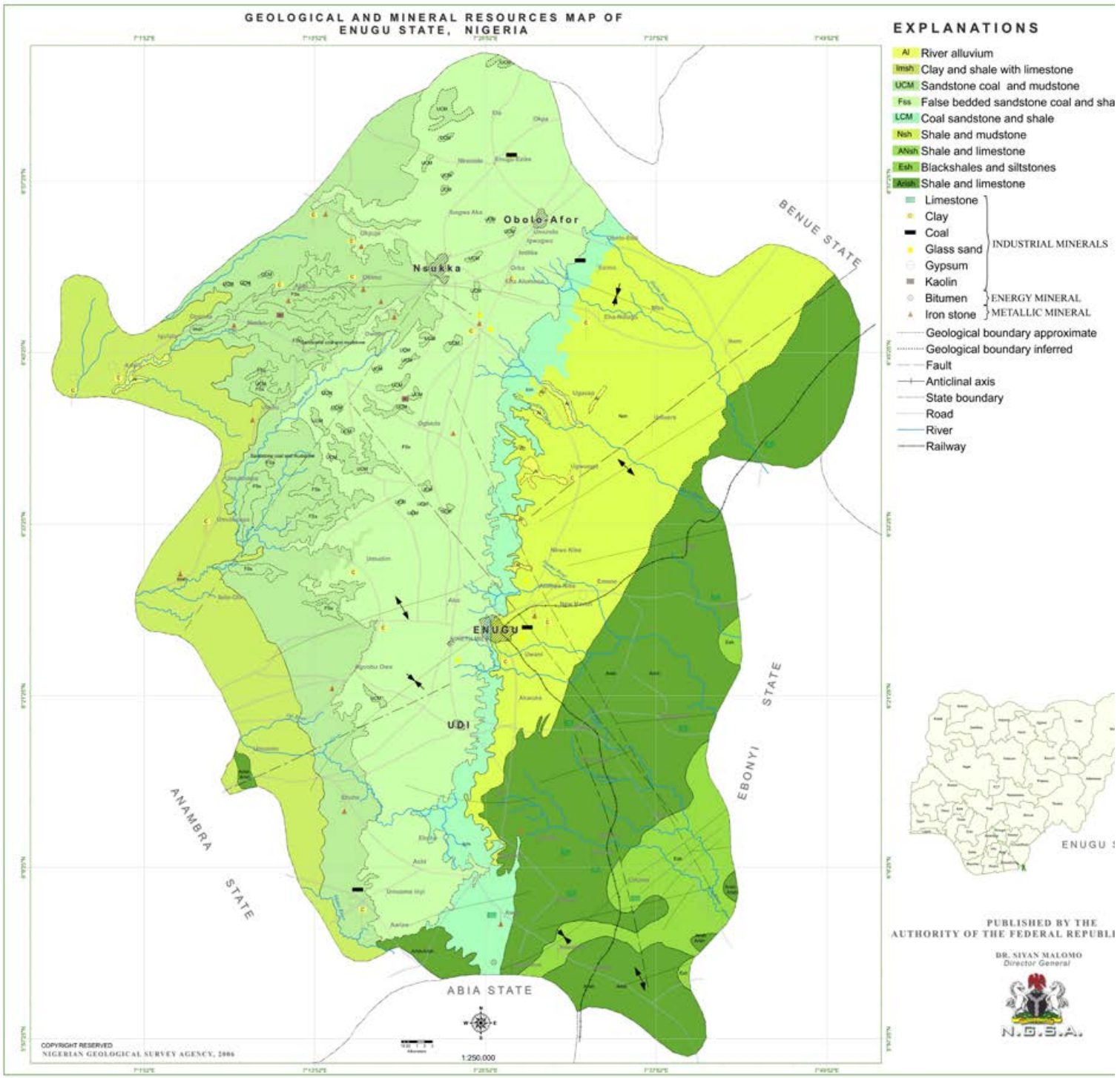


Figure 21: Geological map of Enugu State

[51] A. E. Agwu, J. N. Ekweme and A. C. Anyanwu (2008), Adoption of Improved Agricultural Technologies Disseminated through Radio Farmer Programme by Farmers in Enugu State, Nigeria, *African Journal of Biotechnology*, 7(9), pp.1277-1286, May 2008.

ENUGU STATE

Brief History

Enugu State lies between Latitude 5°56' N and 7°06 N, and Longitude 6°53' E and 7°55' E.[51] The state was created in 1991 out of old Anambra State. The state took its name from the city capital of the old state, which is also the capital of the new (Enugu) State. The citv has remained a very important political, economic and social center of activities as it has retained its status as capital city of the old Eastern region from 1929 up to 1967, was also the capital of Anambra State up to 1991 and of the new (Enugu) State to date. Enugu is most famously recognized as a major coal mining location. Although the state was created in 1991, the history of Enugu, the capital city dates back to 1912 when the city was established as a coal mining town. This perhaps contributed to the growth of the city as the major industrial, commercial and financial hub of south eastern Nigeria.

Geology

Enugu State occupies much of the highlands of Awgu, Udi and Nsukka. The hills are flanked by the rolling lowlands of Oji River, Adada and Anambra basins to the west, and the Ebonyi (Aboine) River basin to the east.

The relief of Enugu consists of high land with ridges and ridges which undulate across the breadth of the relief area, and a lowland area characterized by features of landslides and soil and gully erosion.[52] The soil type is mostly silty red, with very high density.

[52] Chukwudi I. Ezeh (2011). Geoelectrical Studies for Estimating Aquifer Hydraulic Properties in Enugu State, Nigeria. *International Journal of the Physical Sciences*, 6(14):3319-3329

GOMBE STATE

Brief History

Gombe is one of six states in north-east Nigeria. The multiethnic and multireligious state was created in 1996 out of the old Bauchi State. Gombe shares physical boundaries with all the other (five) states in the north-west namely Bauchi, Yobe, Borno, Adamawa and Taraba States. The physical layout of the state consists mostly of undulating mountains and hills in the eastern part of the state and open plains in the western part which are mostly flat. The mountainous area of the state is a collection of several rock formations consisting of the Tula, Bima, Faliya-Dadiya and Indinijam-Kargo hills. These hills together make up the Tangale (rock) Formation which has been described as "ideal for climbing and camping".[53] Majority of Gombe is situated along the valley of River Gongola on "some hills and mountain ranges".[54] The basin is also mostly lowland with heights ranging between 184 and 351 meters. Like most parts of Nigeria Gombe has two climate consisting of wet and dry seasons, with average annual rainfall reaching 850 mm. Average annual temperature is about 32°C. The vegetation is mostly savannah woodland with scattered shrubs and trees.

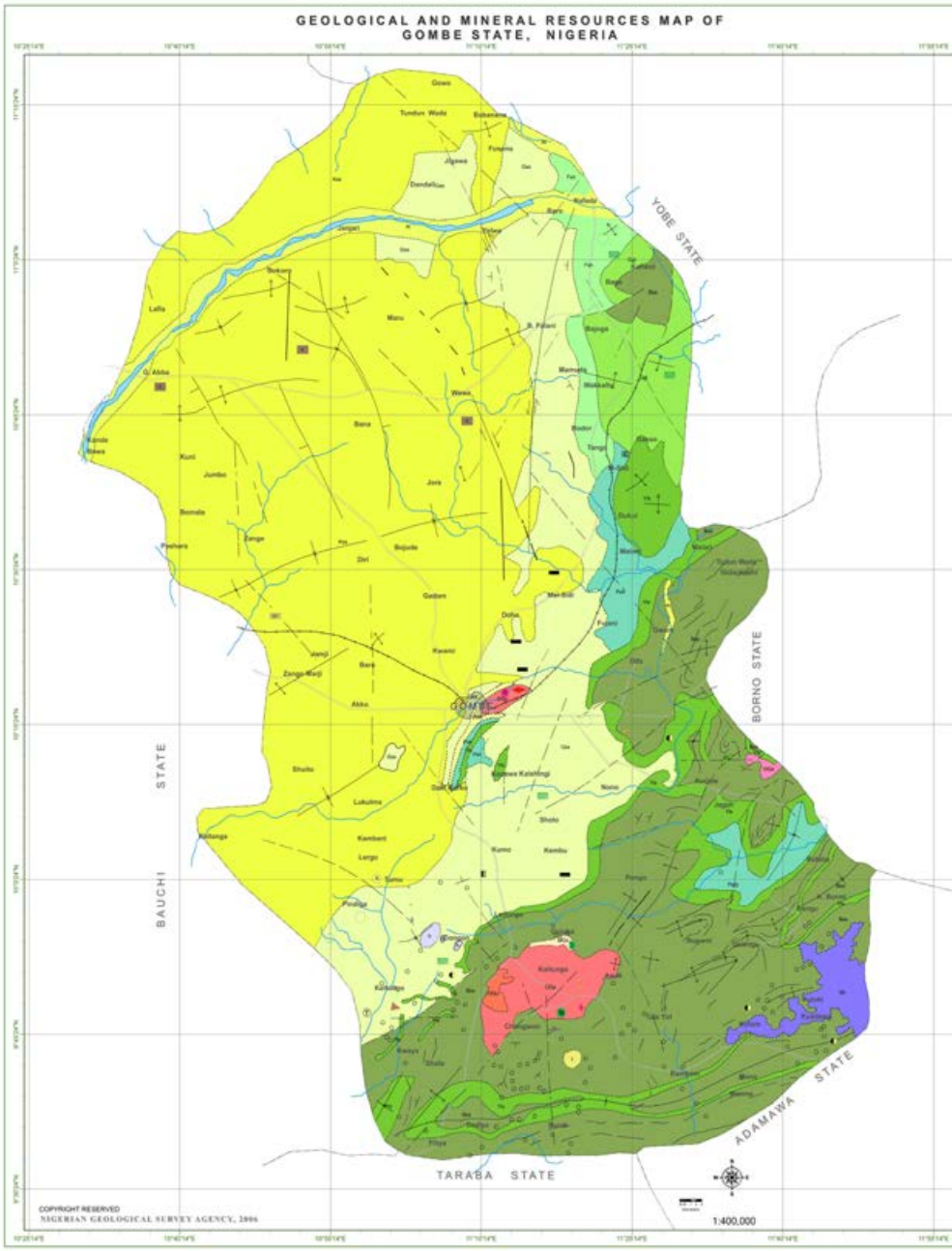
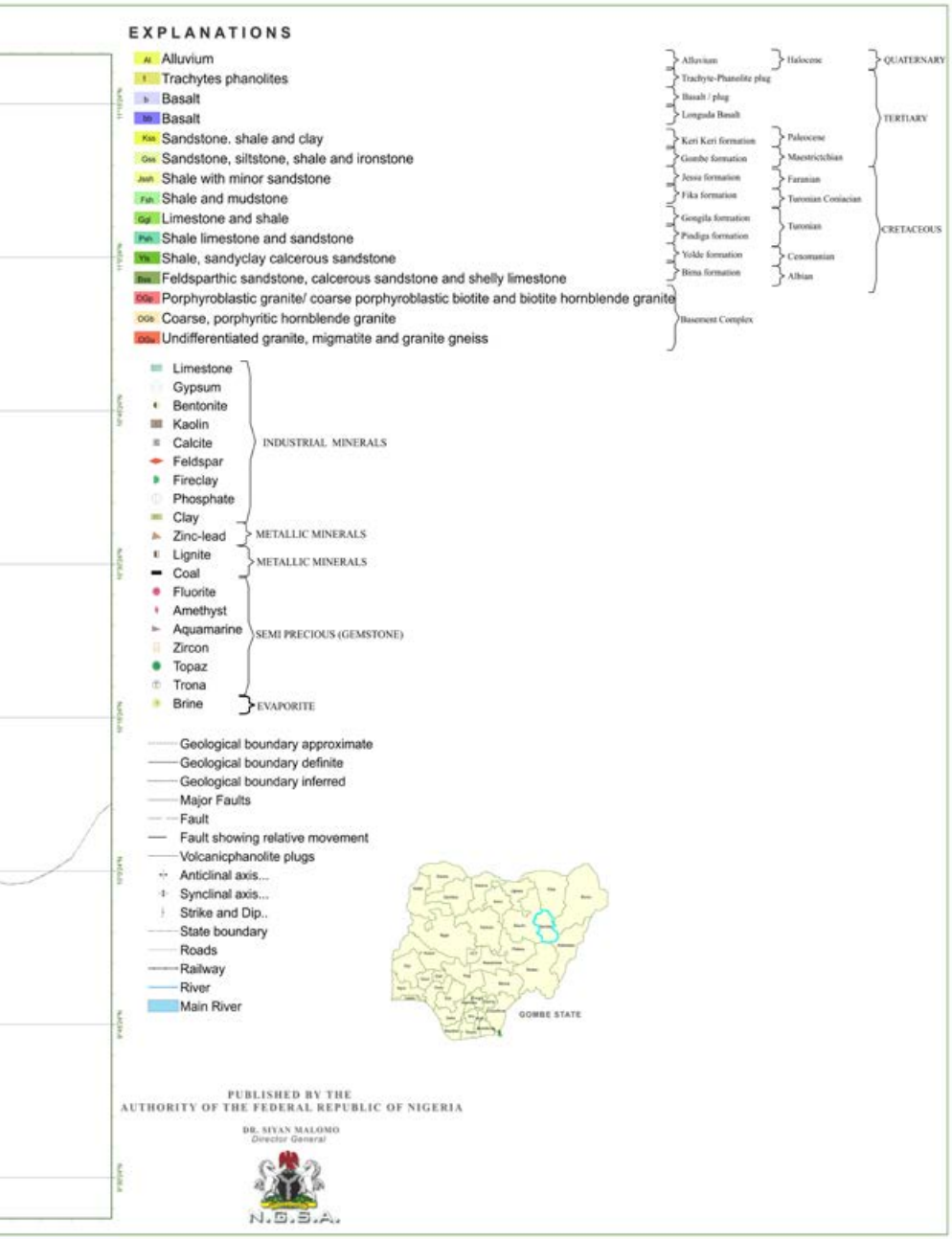


Figure 22: Geological Map of Gombe State

Geology

Gombe State is defined by 12 rock formations which give rise to 14 geological units. The rock formations include the Alluvium Basalt, the Basement Complex, the Pingiga, Bima, Yolde, Fika and Gngila Formations. There are also the Gombe (Sandstone) and

[53] Ikusemoram Mayomi, Didams Gideon and Michael Abashiya (2018), Analysis of the Spatial Distribution of Geology and Pedologic Formations in Gombe State, North Eastern Nigeria, *Journal of Geography and Geology*, Vol. 10, No. 1, pp. 82-108.
[54] Ibid.
[55] G. I. Obiefuna and A. Sherrif (2010), An Assessment of Shallow Groundwater Quality of Pindiga Gombe Area, Yola Area, Northeast Nigeria for Irrigation and Domestic *Purposes*, *Research Journal of Environmental and Earth Sciences*, 3(2): 131-141.
[56] Jalo M. Elnafaty (2015). Geology and Petrography of the Rocks around Gulani Area, Northeastern Nigeria. *Journal of Geology and Mining Research*, 7(5), pp 41-57, May 2015.



GOMBE STATE

MINERAL COMMODITY	LOCATION
1. Coal	Panachtal, Pindiga, Doka
2. Lignite	Gombe
3. Limestone	Ashaka, Kaldunga, Karawa, Ayaba, Lassri
4. Gypsum	Nafada, Ayaba, Pindiga
5. Kaolin	Bojude, Duldu, Gombe, Abba
6. Feldspar/Quartz	Billiri
7. Brines	Ayaba, Todi, Langa, Gujba, Pindiga, Tahalkra, Tumu
8. Gemstones	Billiri, Tal, Kaltungo
9. Lead/Zinc	Ayaba, Kaltula

Nigeria Mineral Resources

the Kerri- Kerri Formations. The geological composition of these formations include granite, gneiss, sandstone, mudstone, ironstone, limestone and shale. A description of three of the main Formations shows that the Pindiga Formation, which lies under the lowlands in the northern and eastern parts of the state[55] consists mostly of limestones and mudstones. It is also shows discontinuous layers of gypsum and fossil imprints like ammonites and Ostrea. The Gombe Formation, predominant in the western part of the state, lies above the Pindiga Formation. It (Gombe Formation) is subdivided into three types of rock characteristics which begins with alternately arranged layers of silt and shales at the base, and sandstones embedded with ironstones.[56] The Gongila Formation lies above the Birma formation and under the Fika Formation. it is therefore described as representing a "transitional sequence" between these two formations.[57] The Gongila Formation consists of grey, calcareous (contains calcium carbonate) shales of moderate thickness. It is also composed of sandstones, silt, and diorite sills.

[57] A. K. Adegoke (2014). Geochemical characterisation of Fika Formation in the Chad (Bornu)Basin, northeastern Nigeria: Implications for depositional environment and tectonic setting. *Journal of Applied Chemistry*, Volume 43, pp.1-12.

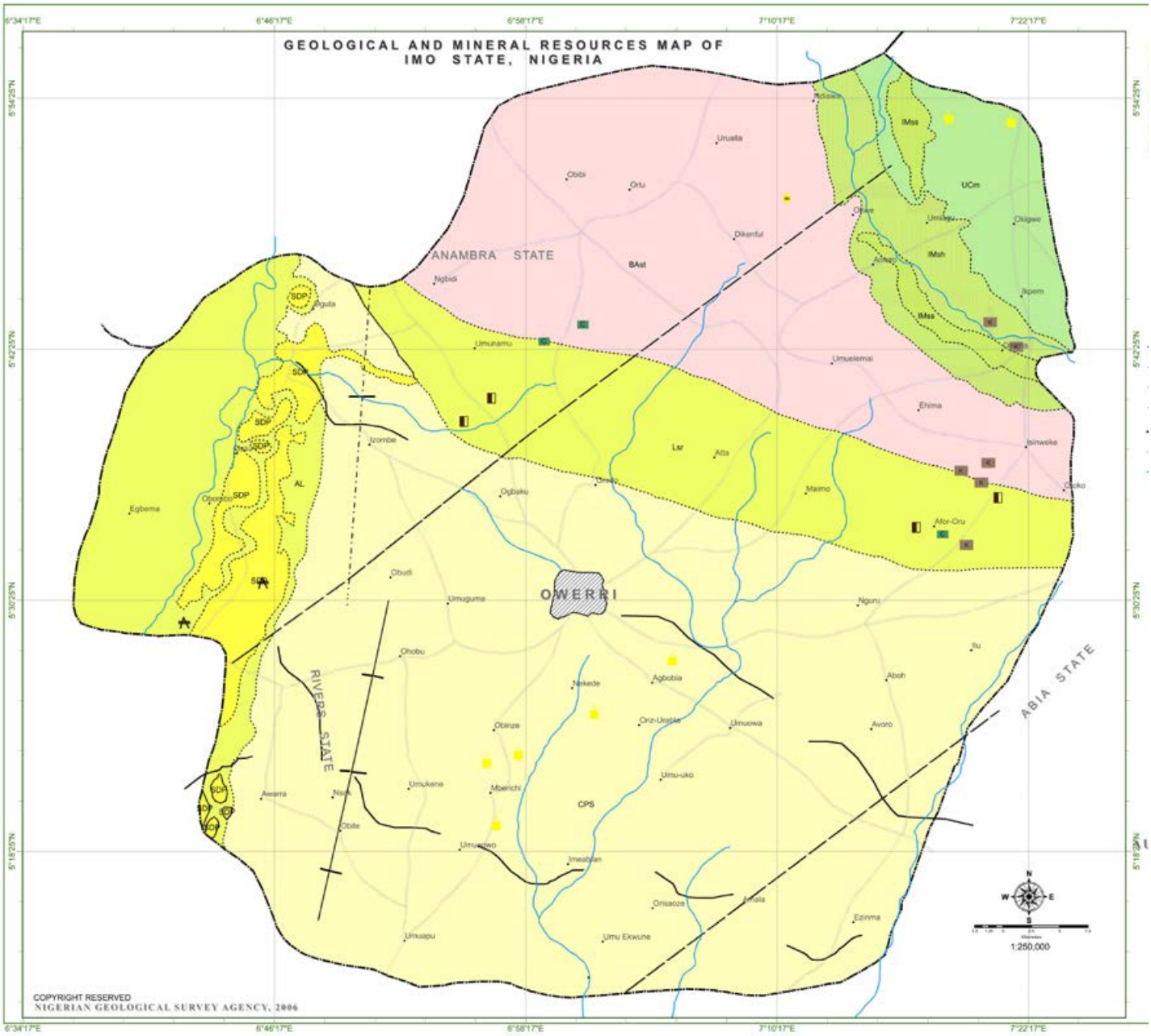


Figure 23: Geological map of Imo State

IMO STATE

Brief History

Imo State lied in south-eastern Nigeria as one of the five states in that region. The state was created in 1976. However, its current boundaries were established in 1991 when a

[58] B. C. Ejiogu et al. (2019). Estimates of aquifer geo-hydraulic and vulnerability characteristics of Imo State and environs, Southeastern Nigeria, using electrical conductivity data. *Journal of Environmental Monitoring and Assessment*, 191:238, pp.1-19.

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significant area of the state was carved out to form another (autonomous Abia) state. Imo is a landlocked state which shares boundaries with Abia, Rivers, Anambra, Enugu and Ebonyi States. Imo state's most prominent geographical feature is, not coincidentally, the Imo River which originates in Okigwe and flows for 240 kilometers, through three states, into the Atlantic Ocean. Like the rest of the locations within the Imo River Basin area, Imo state is found within the tropical rain forest belt. Annual temperature ranges between 25°C and 34°C. Annual rainfall is about 2,200mm. The area is drained by several rivers and tributaries. The topography is between low to moderate elevation and ranges from 53 meters to 255 meters above sea level.[58]

Geology

The Imo area seats on six geological formations – Benin, Ogwashi Ameki, Imo Shale, Nsukka, and Ajali Formations. The Benin Formation is made up of loosely formed coastal plain sands of white and yellow color, and a base consisting of pebbles and gravels. It is made up of sand slightly mixed with clay. The Ogwashi Formation is similarly made up of loose sandstones, carbonaceous mudstones, clay and lignite. The Ameki Formation consist of sandstones, shales and thin limestones. The Imo Shale Formation consists of sandstones and blue and grey shales. The Nsukka Formation is made up of sandstone, shale, thin limestone and subordinate coals. The constituents of the Ajali Formation is mostly shale and sandstones.

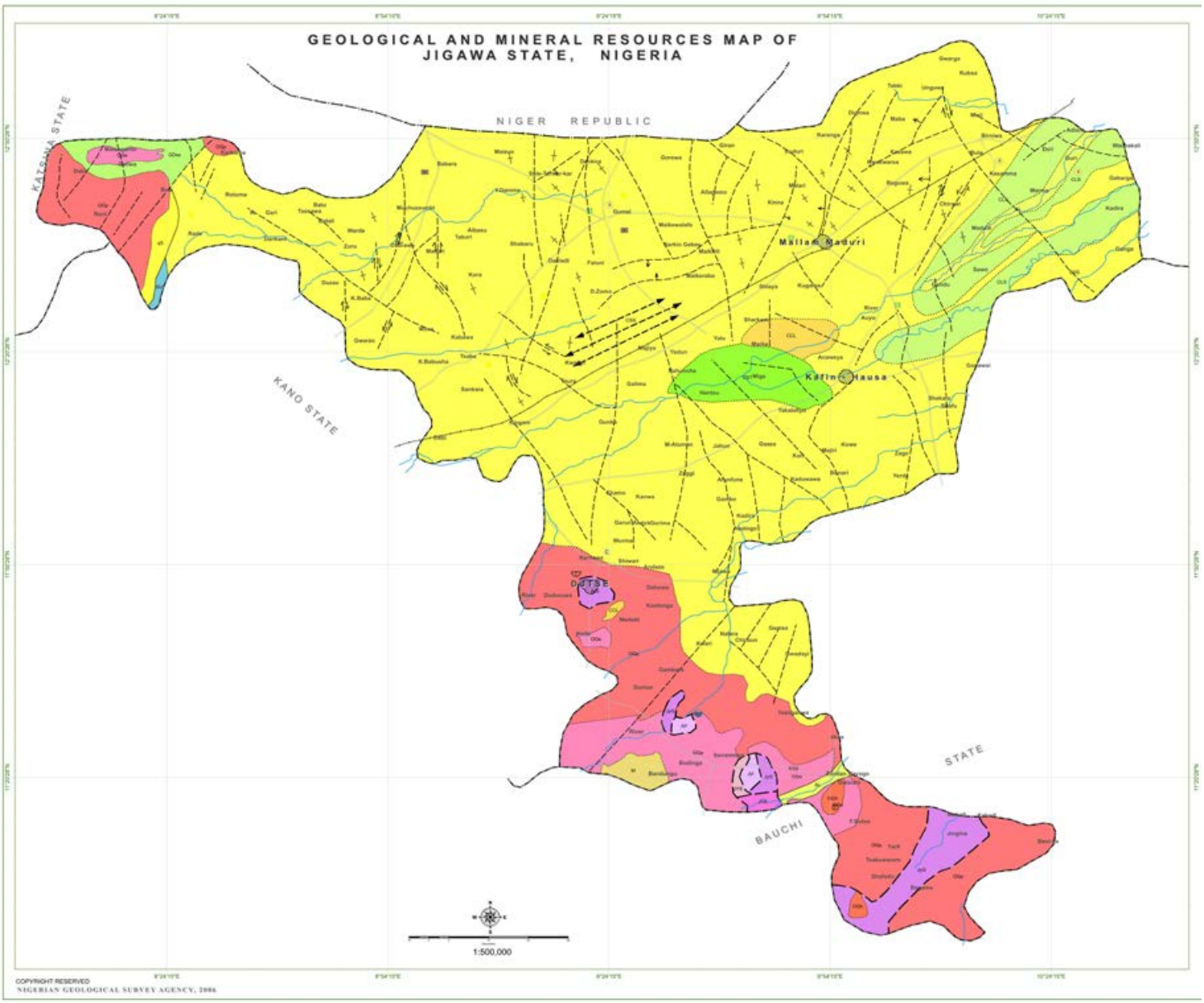


Figure 24: Geological map of Jigawa State

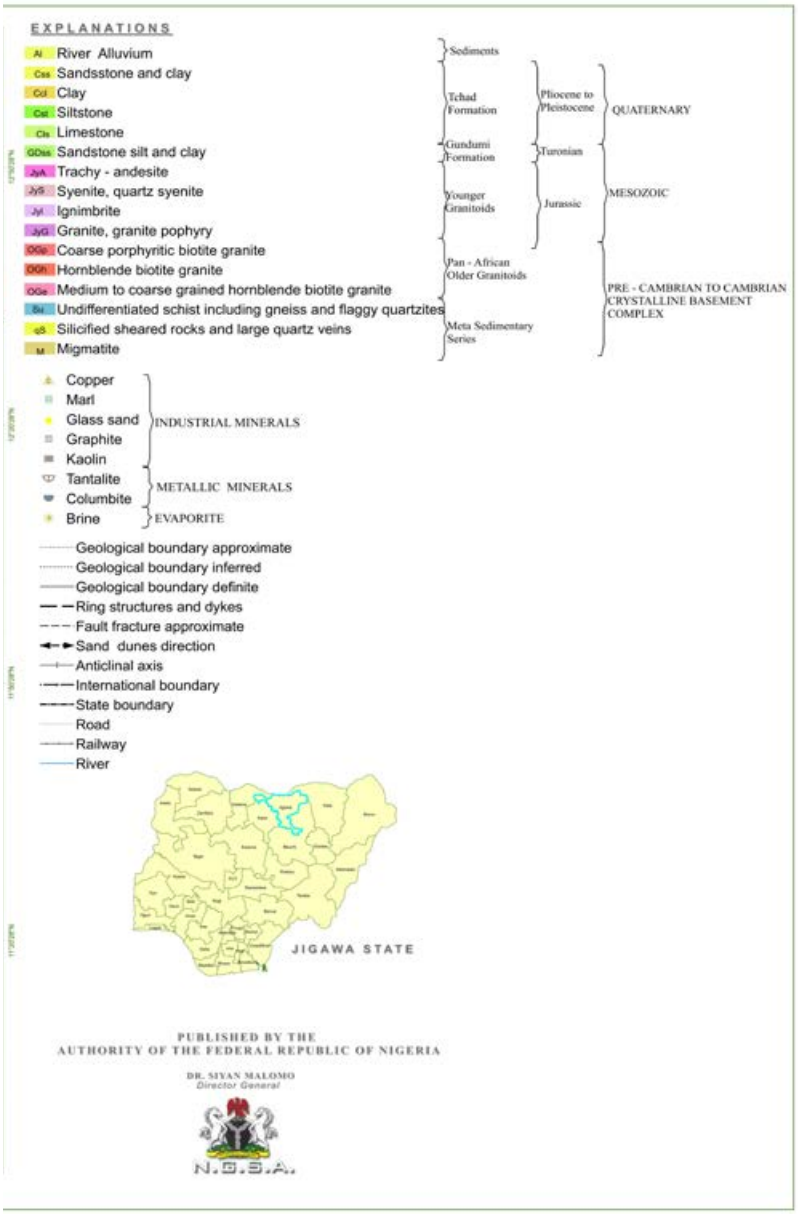
JIGAWA STATE

Jigawa State is listed as one of the seven states in north-western Nigeria. The state was created in 1991 from the old Kano State. It shares its borders with Katsina, Kano, Bauchi and Yobe States. Jigawa also shares international boundary with the Republic of Niger. This makes is a viable route for international trade, especially with the establishment of the Maigatari Border Free Zone in the state. Jigawa State belongs to the Sudan Savannah vegetation zone, and thus consists of short, straight grasses with

[59] E. A. Okunade (2012). Isopleths Of Subgrade Soil Properties For Jigawa And Kano States Of Nigeria. Continental Journal of Applied Sciences, 7(1):46-55.

[60] A. Mansur (2014). An Assessment of Gully Erosion in Dutse Sahelian Zone of Jigawa State, Nigeria, and its Adverse Consequences on the Socio-Economic Development of the State. Journal of Agriculture and Environmental Sciences, 3(3):17-25.

[61] Okunade (2014).



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isolated trees.[59] Both shrubbery of the Guinea variety and the Sahel variety are also found in the area. The state experiences average annual temperature of 27°C and average rainfall of 1000mm. Relative humidity is around 80%.[60] The soil type is mostly loose sandy soil. Mean monthly soil temperature measured at 1.2 meters during the wet season is between 27 - 32°C.

Geology

The northern part of Jigawa State falls within the chad Sedimentary Basin while the southern part falls on the crystalline Basement Complex.[61] The rock types consists of sandstones, grits, gravels and shale. The southern part is characterized by the Basement Complex rocks mostly gneiss. The Complex also shows intrusions of granites and basalt. Jigawa state is partly underlain by the Bornu Basin. The Bornu Basin. The topography of the areas is defined largely by flat pediments. The relief is generally undulating, ranging from 500 meters to 600 meters above sea level in the south.

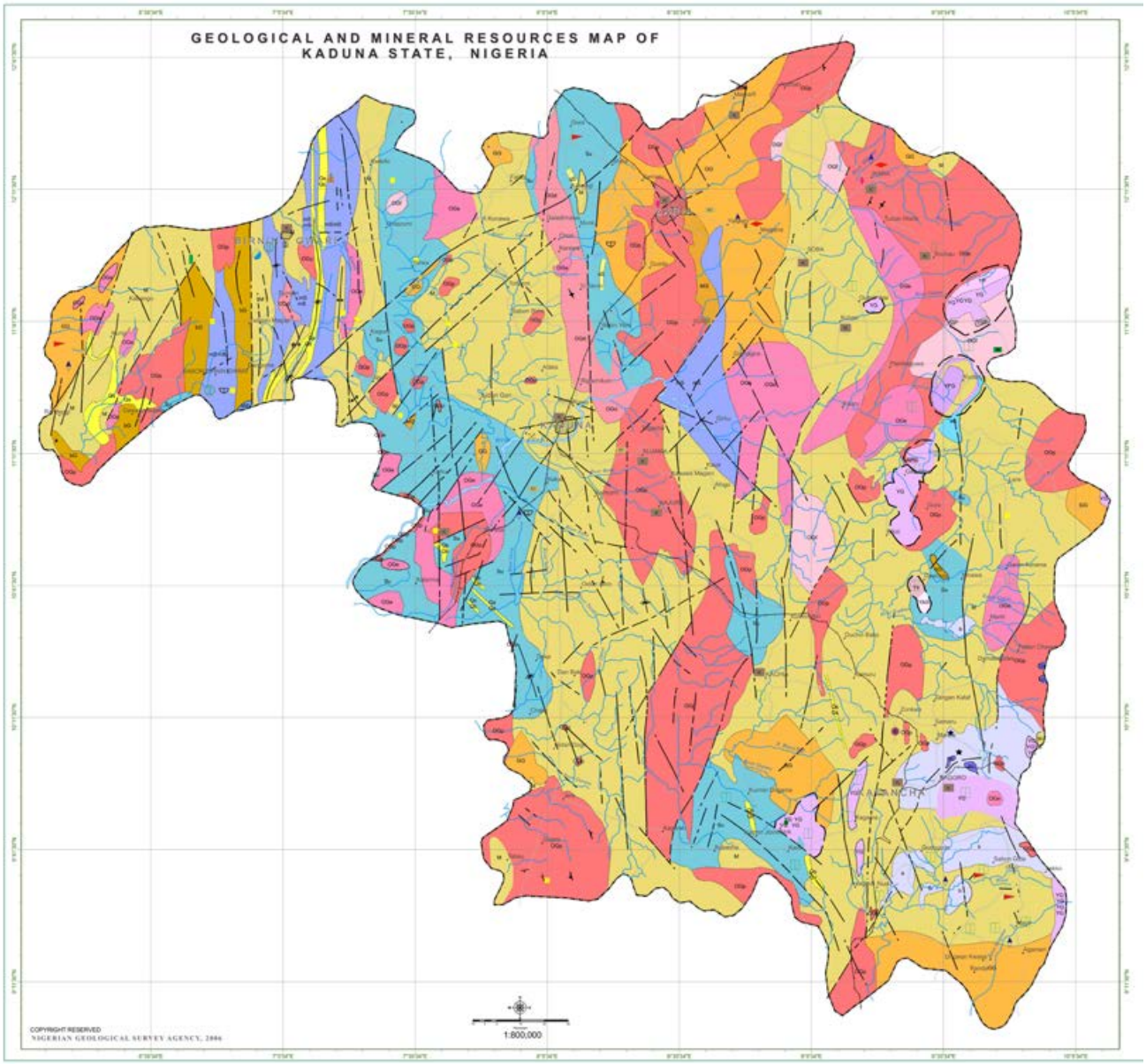
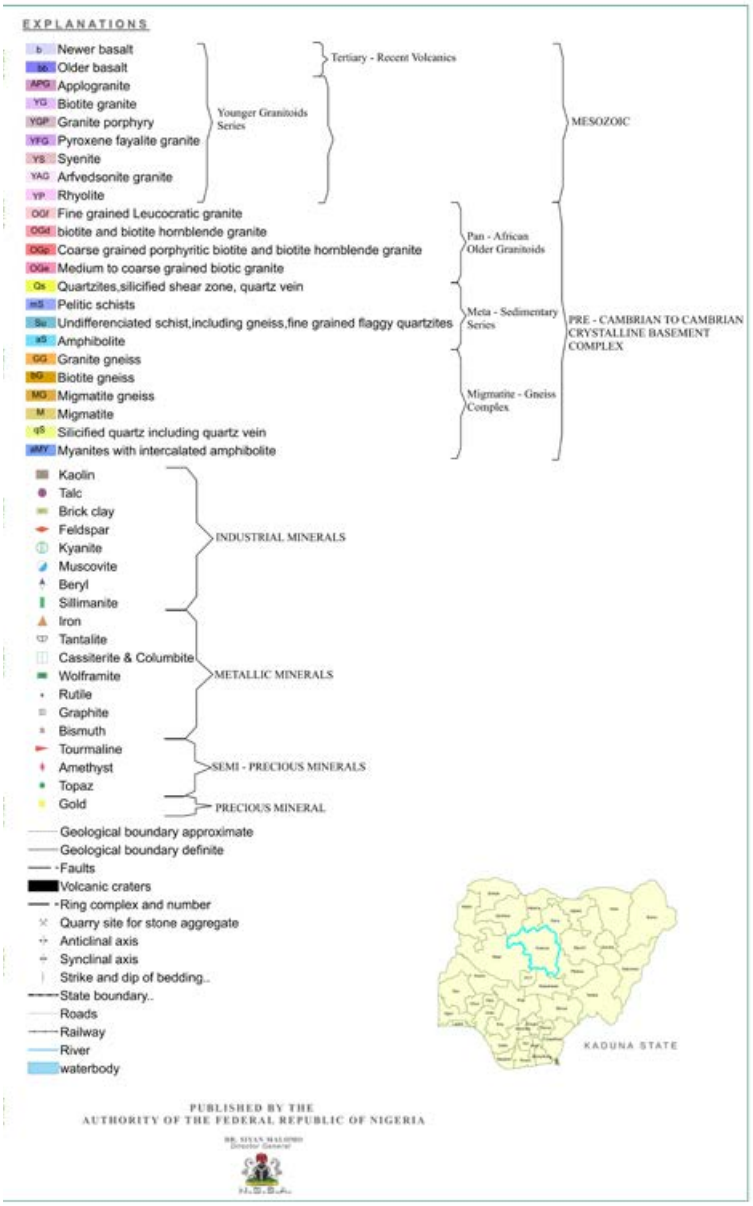


Figure 25: Geological map of Kaduna State

KADUNA STATE

Kaduna State is a very important city as a political and economic hub in northern Nigeria. It is renowned mostly for its commercial and industrial presence in the region. The old Kaduna State was created in 1967. In 1987 the northern part of the state was carved out to form Katsina State. Kaduna state is bounded by seven other states – Niger, Zamfara, Katsina, Kano, Bauchi, Plateau, Nasarawa – and the Federal Capital Territory. Kaduna State is therefore accessible to the most number of states and entities in Nigeria. To further stress the historical importance of the state, Kaduna was the capital of the old northern region, and took the title of North Central State when the region was split into six in 1967, from whence it became known as Kaduna



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State in 1976.

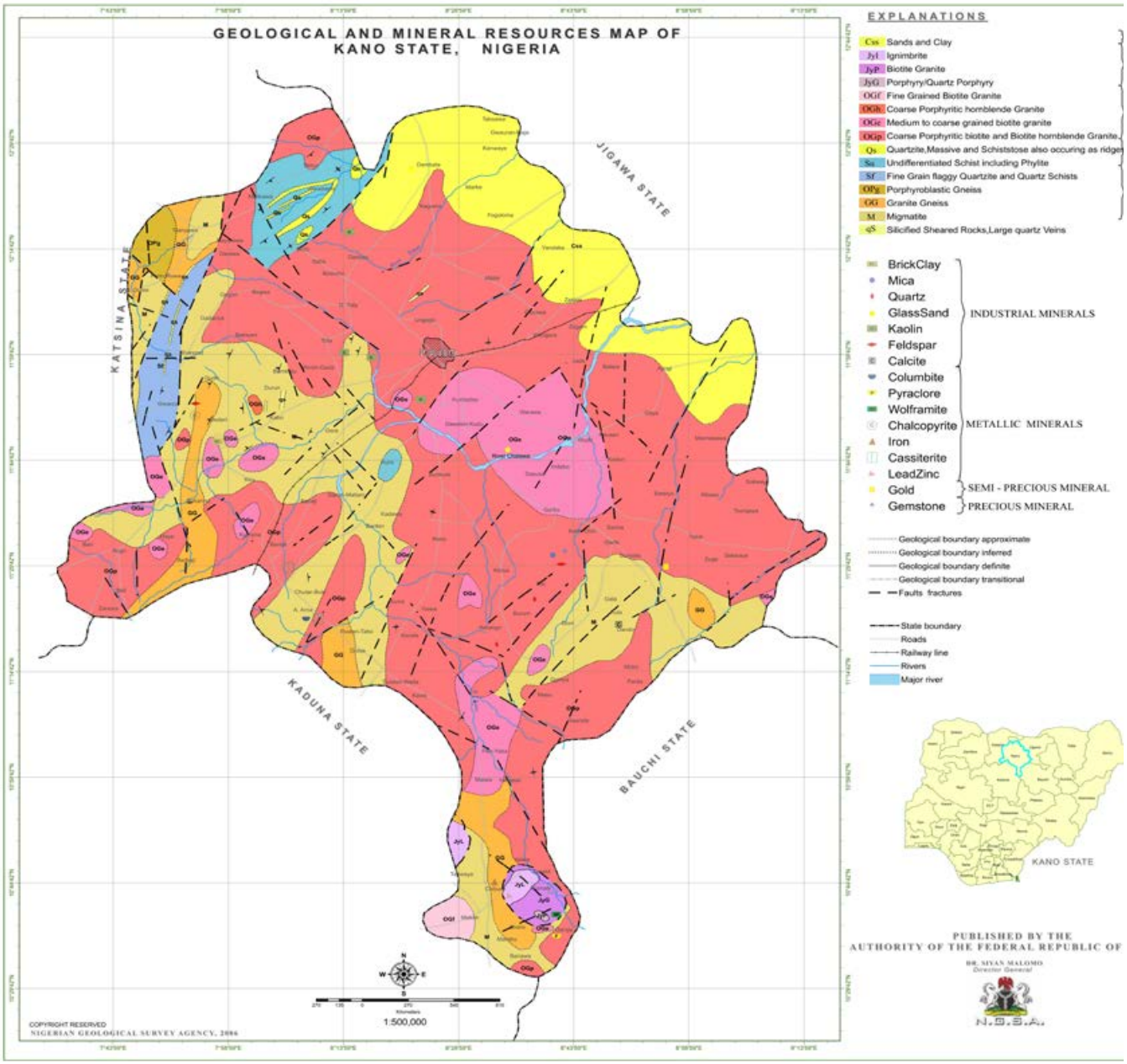
In terms of physical conditions, Kaduna State belongs to the tropical dry and wet region with the two seasons lasting for six months of the year each. Average annual rainfall is 1323mm, dropping to about 1032 in the northern part of the state and peaking at about 1733mm in the south of the state.[62] Temperature ranges from 23 to 29°C while humidity occurs at between 25 – 90% depending on the season of the year. Kaduna is dominated by the tropical grassland vegetation which decreases in density towards the north of the state. The topography shows an undulating plateau and the main water bodies of the state consists of Rivers Kaduna, Kagom, Gurara and Galma.

Geology

Kaduna State is underlain by crystalline formations of the basement complex. The crystalline rocks are mostly of the igneous and metamorphic types, and occur as gneisses, granites, schists, migmatites, phyllites, pegmatites or quartzites. Generally, and based on the above constituents, the crystalline rocks of the Basement Complex are divided into the Migmatites-Gneiss Complex, the metasedimentary rocks and the Pan-African granites. Kaduna State belongs to the migmatites-gneiss-quartzite complex. This formation consists mostly of migmatites, biotite and granitic gneisses.[63] The entire Kaduna land surface is covered with red, brown and yellow ferruginous tropical laterized soils.

[62] I. B. Abaje (2015). Assessment of Rural Communities' Adaptive Capacity to Climate Change in Kaduna State, Nigeria, *Journal of Environmental and Earth Science*, Vol.5 No. 20, pp.14-23.

[63] I. O. Olaniyan et al (2010). Lithologic Characteristics of Parts of The Crystalline Basement Complex of Northern Nigeria In Relation to Groundwater Exploitation. *ARPN Journal of Engineering and Applied Sciences*, Volume 5, Number 7, July 2010.



KANO STATE

Brief History

Kano State is second perhaps only to Kaduna State in the north, in terms of political and economic significance. Kano, like most other states in Nigeria, has had both old and new boundaries since it was first created in 1967. The state was split in 1991 to form Jigawa and the present Kano State. Kano is bounded by Jigawa, Katsina, Kaduna and Bauchi States. Official data by the National Population Commission shows kano with the highest population among the 36 states of Nigeria.

The state has an altitude of 500 – 700 meters

[64] I. J. Irohibe and A. E. Agwu (2014). Assessment of Food Security Situation among Farming Households in Rural Areas of Kano State, Nigeria. Journal of Central European Agriculture, 15(1):94-107.

[65] A. Mustapha et al (2014). Overview of the Physical and Human Setting of Kano Region, Nigeria. Researchjournali's Journal of Geography, Vol. 1 No. 5, July 2014.

[66] I. B. Abaje et al (2014). Is the changing rainfall patterns of kano state and its adverse impacts an indication of climate change? European Scientific Journal, Vol. 10, No. 2, pp.192-206.

Figure 26: Geological map of Kano State

above sea level. Its climate is the dry-and-wet tropical type. Annual rainfall varies from 300-600 in the Sudan Savanah, and between 600 and 1200mm in the Guinea Savanah. Average temperature is between 26°C and 31°C in the cool and hot seasons respectively.[64] The relief of the area is classified under three categories – the south and southeastern highlands, the middle and western high plains and the northeastern low Chad plains. The soil type is partly latosol ferruginous soil with loamy sand and a collection of poorly developed clayey soil in the alluvial plains. The vegetation shows "a mixture of Sudan, Savannah and Sahel thorn shrubs species, sparsely distributed over the entire area, with variation in density from place to place due to human imprint".[65]

Geology

The main geological formation underlying Kano State is the Nigerian Basement Complex. This Basement Complex rock formation predominates in the southern and western parts of the state while the Chad Formation occurs in the northern part.[66] The Basement Complex rock characteristics of the area is similar to that of Kaduna State described previously in this study. The Chad Formation is found on top of the other formations within its sphere of occurrence. This sedimentary sector of the Chad Formation consists of three layers of loose sandy sediments. These layers of sand are separated by thick bodies of clay originating largely from[67] alluvial deposits from rivers and floodplains.[68] The segregated layers of sand and clay are of variable colors of brown, yellow, white and grey, and contain quartz and diatomite

In their natural states, the soils of the State can be categorised into four main groups. The ferruginous tropical soils formed on crystalline acid rocks occupy about two-fifth of the State to the south, south-west and south-east; the brown and reddish brown soils and latosols occur in the northern half; the brown and reddish soils are in the northeastern corner; while the juvenile and hydromorphic soils occur along the alluvial channel complexes.

The soils largely reflect the influence of parent materials. Intensive use of the soils and addition of manure and chemical fertilisers have altered their character, profile, texture, structure and chemical characteristics.

KANO STATE

MINERAL COMMODITY	LOCATION
1. Cassiterite	Rirwai, Lavun
2. Gold	Birnin
3. Kaolin	Dawakin Tofa
4. Silica Sand	Bunsuru Bunsuru
5. Pyrochlore	Rirwai
6. Wolframite	Rirwai
7. Amethyst (Gemstone)	Saya Saya
8. Kaolin	Gezawa, Gwarzo

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[67] Agbaje (2009).

[68] A. I. Tukur et. Al. (2018). Groundwater Condition and Management in Kano Region, Northwestern Nigeria. Journal of Hydrology, Vol. 15, No. 1.

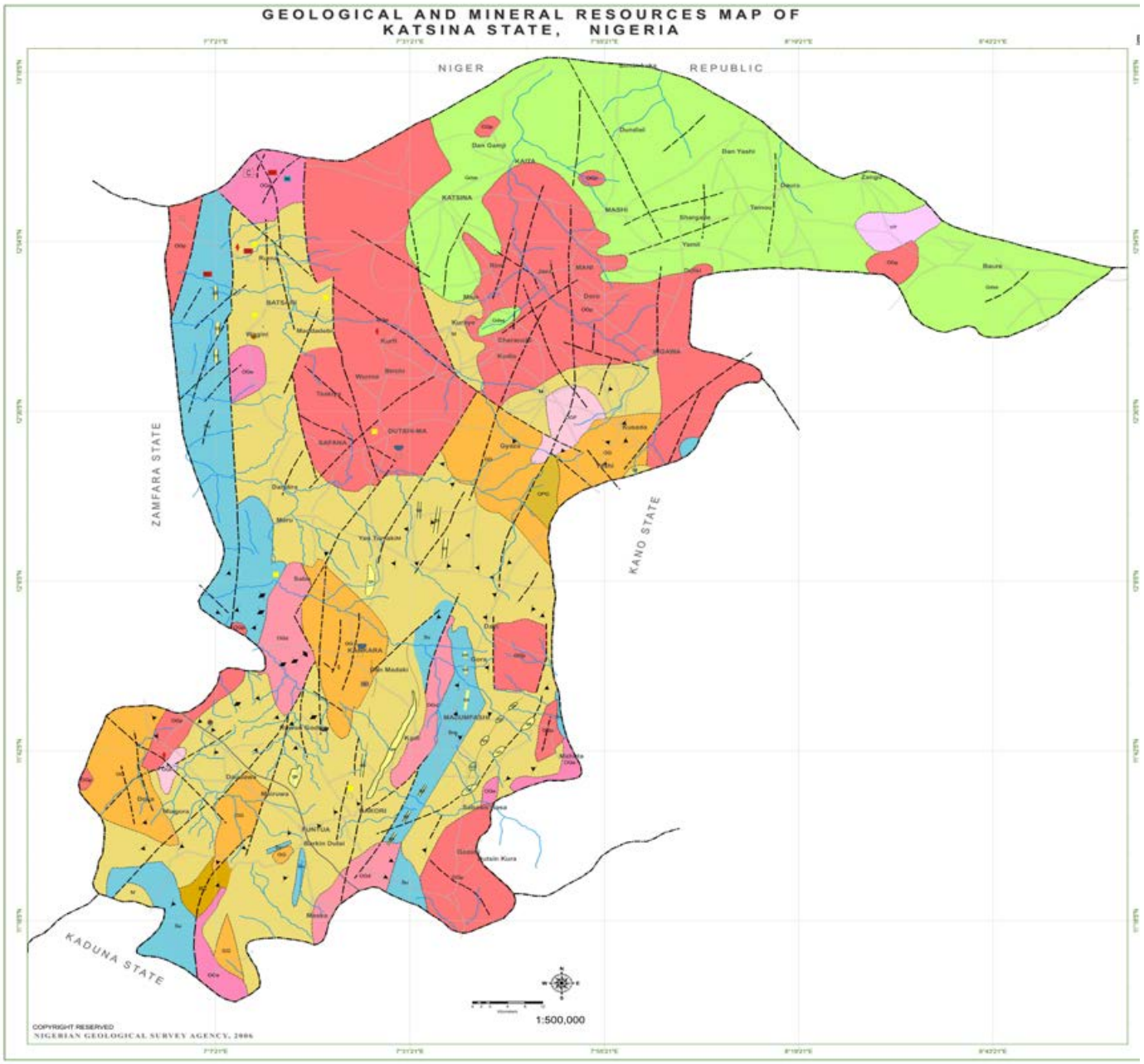


Figure 27: Geological map of Katsina State

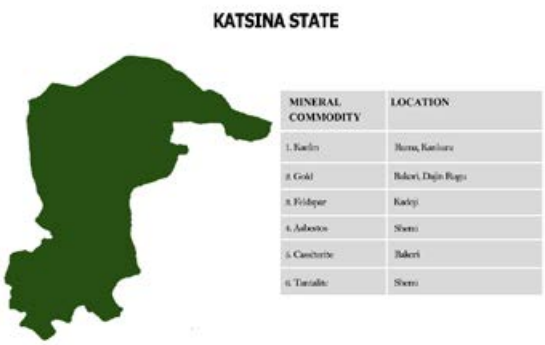
KATSINA STATE

Brief History

The area which constitutes Katsina State was created in 1987 as a separate, autonomous administrative unit from the old Kaduna State. Katsina, like its parent territory, is located in the north-west of Nigeria. Katsina shares land boundaries with other northwestern states namely Zamfara, Kaduna, Kano and Jigawa. It also shares an international border with the Republic of Niger to the north. It is among the top five (out of 36) states with

[69] S. Ladan (2011). Road Situation and the Development of Katsina State, Nigeria. *Journal of Research in National Development*. Vol 9. Issue 1.

[70] A. Tukur and A. Akobundu (2014). Fluoride Contamination of Shallow Groundwater in Parts of Zango Local Government Area of Katsina State, Northwest Nigeria. *Journal of Geosciences and Geomatics*, Vol. 2, No. 5, pp.178-185.



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the highest population. Katsina State has an extensive road transport network connecting all the 34 local governments and the border states. There are also several feeder roads connecting the rural communities. The state also has a rail transport network which terminates in Funtua.

In terms of climate, Katsina State is found within the tropical continental climactic zone. Average annual temperature is about 27°C. Annual rainfall is about 623mm. Its vegetation is the Sudan Savanna type characterized by short trees, shrubs and grasses. Most of its land consist of undulating plains and lie between 399 meters and 600 meters above sea level.[69]

Geology

Katsina State is made up of four rock formations. These are the Gundumi formation of the Sokoto Basin, the Chad Formation, the Basement Complex Rocks and the Younger Granite Suite.[70] The rock characteristics of the Chad Basin and Basement Complex are similar to ones described in the geological formation of Kaduna above. The rocks of the Basement Complex in the Katsina Sector also consist of granite and rhyolites (igneous rock rich in silica). The Gundumi Formation is made up of sedimentary rocks of the conglomerate type and gravels with sand and multi-colored clays.

Predominantly, the State has two geological regions. The south and central parts of the Katsina are underlain by crystalline rocks of the basement complex (from Funtua to Dutsin-Ma), but in the northern parts, cretaceous sediments overlap the crystalline rocks.

The Katsina Daura plains lie at a lower base level than other parts of the State. Southwards of these plains is the flat to gently undulating surface that is the end result of years of erosion of the surface rock. In areas around Funtua and Dutsin-Ma, there are numerous quarzitic and granitic hills, which rise about 200 metres above the surrounding plains. These hills are probably the result of the intrusion of older granites into the basement complex, which have undergone long periods of denudation.

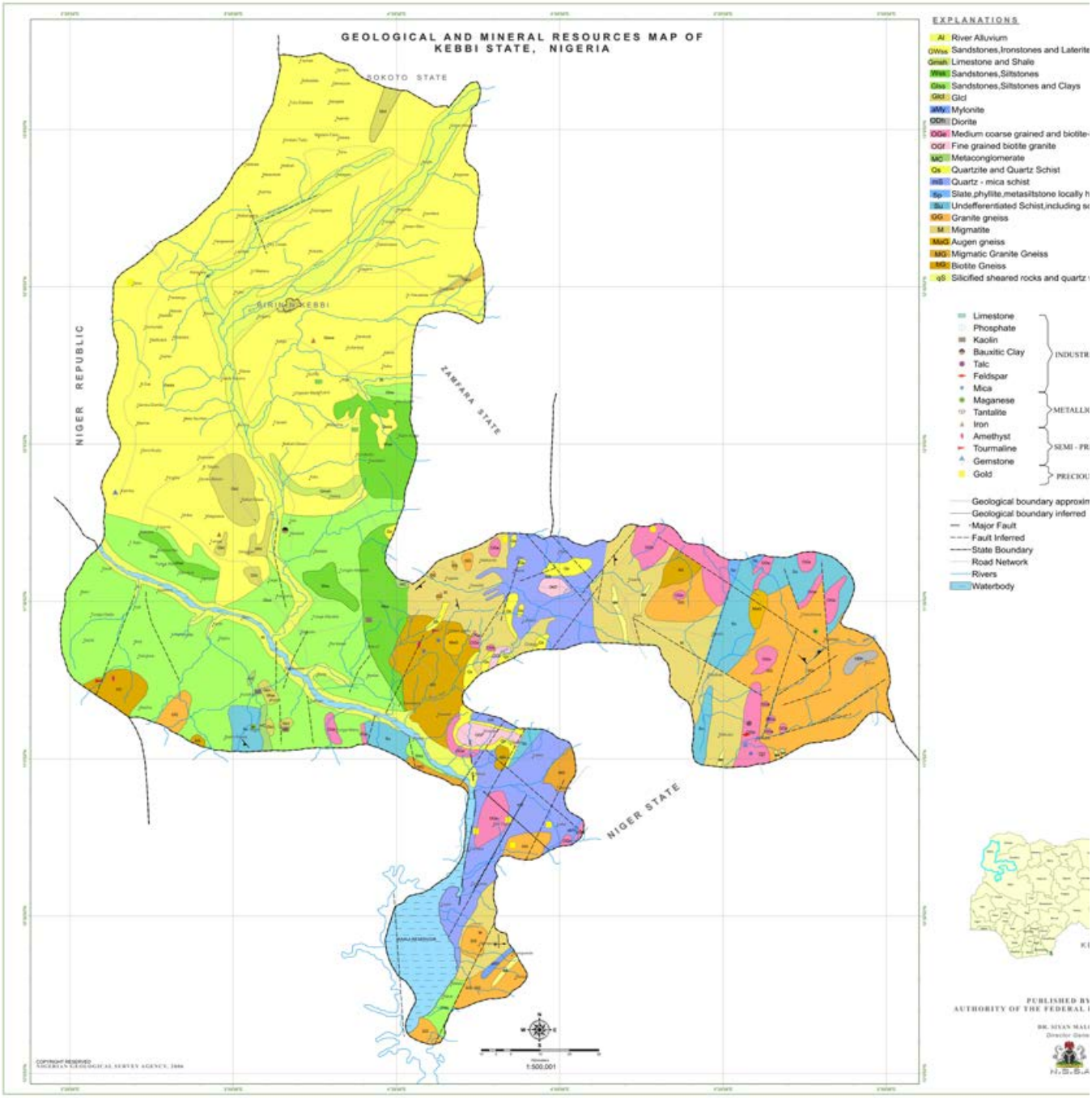

Figure 28: Geological map of Kebbi State

KEBBI STATE

Kebbi State, created out of the old Sokoto State in 1991, is located in the north-west of Nigeria. It shares land borders with Niger to the south, Zamfara and Sokoto states to the east and northeast respectively. Kebbi is an international border state, as it shares its

[71] About Kebbi State: http://www.kebbistate.gov.ng/about-kebbi-state
[72] S. U. Wali and D. Abubakar (2012). A Preliminary Assessment of Soil Characteristics and Ground Water Levels in Kebbi State, Nigeria. *Sokoto Journal of the Social Sciences*, Vol. 2, No. 2, pp. 115-125.
[73] C. A. Kogbe (1975). Petrographic study of Maestriehtian and Post-Paleoeene Formations of North-Western Nigeria (Iullemmeden Basin)
[74] Wali and Abubakar 2012.

MINERAL COMMODITY	LOCATION
1. Kaolin	Sadu/Fokku, Kaoje, Kamba, Giro
2. Iron Ore	Dabiagari
3. Gold	Lolo, Shashi, Malende, Bin Yauri
4. Clay	Pleaye
5. Brine/Salt	Bunza

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entire western border with the Republic of Niger in the northwest and Republic of Benin in the southwest. Kebbi State is marked famously by the Rima River which flows into the Niger, which itself flows south-westwards through the state. Kebbi is characterized by floodplains mostly associated with the Niger and Rima rivers. It is also host to most portion of the famous Kanji Lake.[71]

Kebbi has a hot, semi-arid tropical climate, with a long dry season[72] and short but intense wet season. The state belongs to the Sudan Savannah vegetation zone with thin to thick shrubs and trees which normally do not exceed six meters in height. In terms of relief, the state is defined by the high plains in the south which rise up to 700 meters above sea level; the plain land in the north which occur at about 300 meters above sea level; and the low land mostly found in the flood plains of the Niger and Rima rivers.

Geology

Kebbi State is underlain by the Basement Complex rocks and the sedimentary rocks of the SoKoto and Rima groups (Formations). The Basement Complex occur mostly to the in the southern part of the state while the sedimentary basins are situated in the north. These sedimentary formations consist of the Illo (partly consolidated sands and sandstones; grits and clay)[73], Gundumi (same constituents as Illo Formation), Kalambaina (clays and limestone), Dukamaje (clays limestone and shale), Taloka (fine-grained sandstone and siltstone), Gwandu (ferruginous sandstone and mudstone; marine shales and limestones), Wurno (same as Taloka) and Dange(same as Kalambaina) Formations.[74] Kebbi soil is mostly the tropical ferruginous type with sandy surface and clay subsoil. Alluvial (Fadama) soil is also found in the river plains.

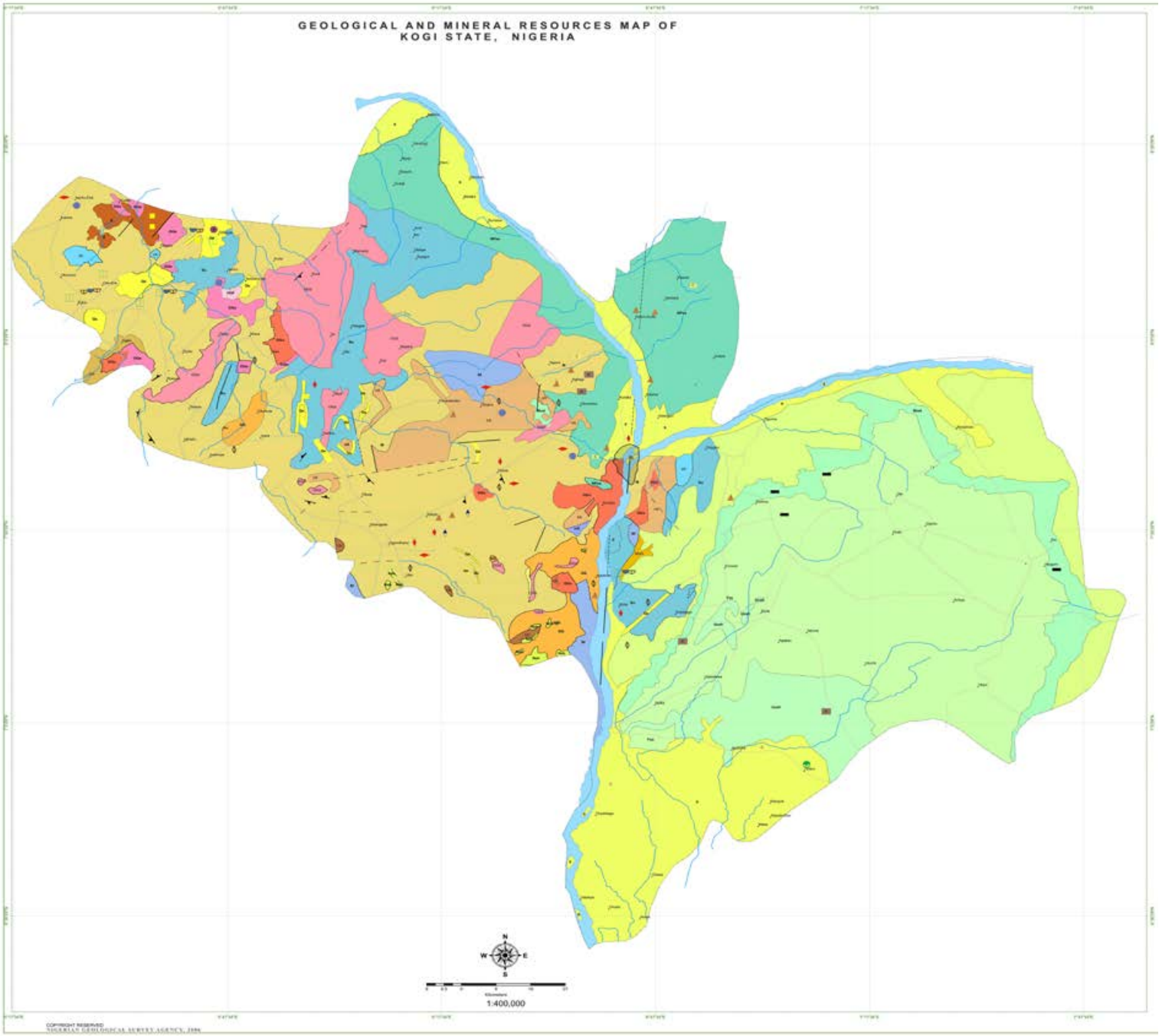


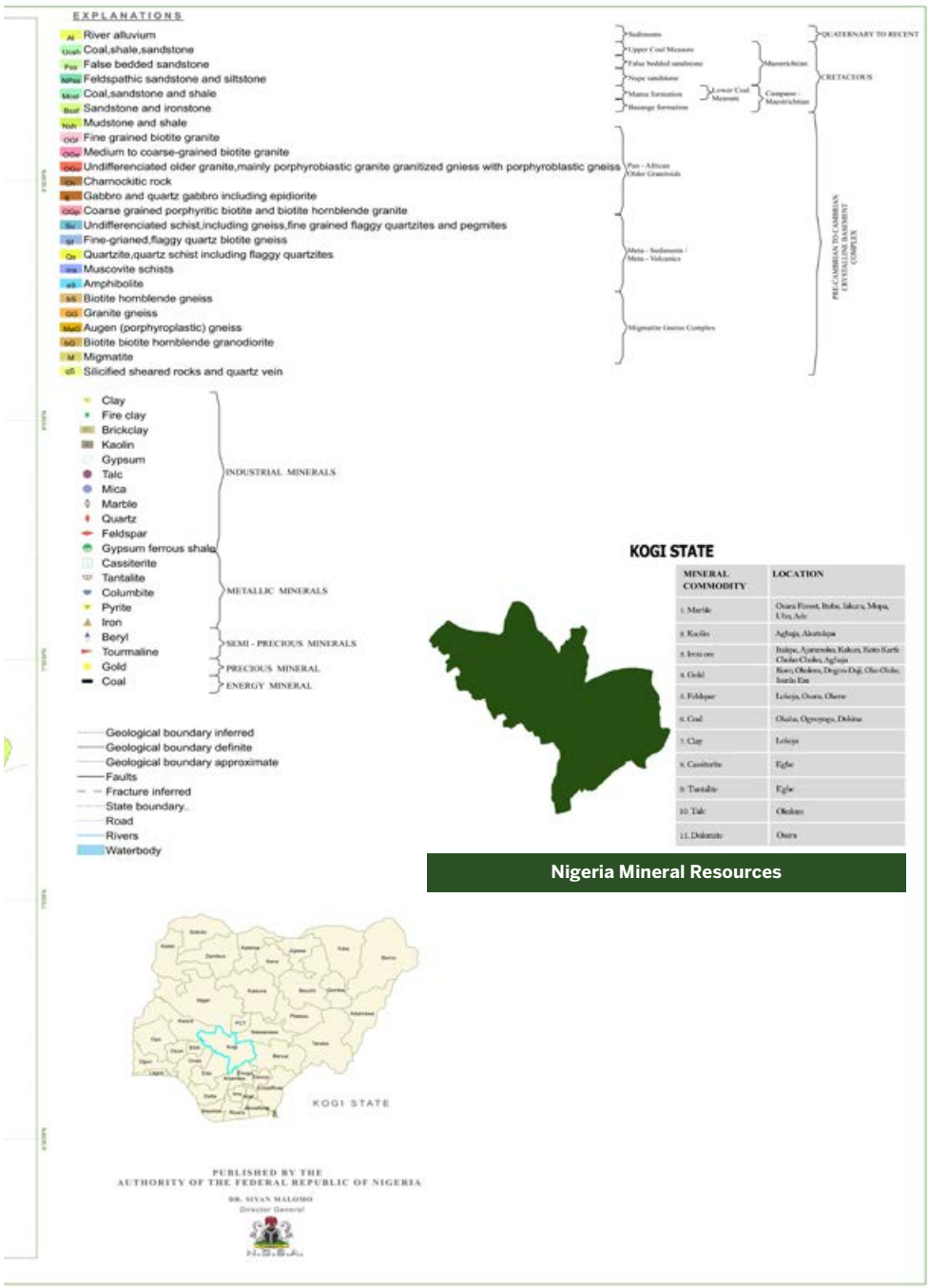
Figure 28: Geological map of Kebbi State

KOGI STATE

Brief History

Kogi State is centrally located in the 'heart' of Nigeria, and quite appropriately listed as one of the north-central states of Nigeria. Although the state was created in 1991, much of the state is steeped in historical symbolism. Its capital city was the first administrative center of Nigeria. The central location of the state Kogi shares borders with four northern states –

[75] J. E. Emurotu and P. C. Onianwa (2017). Bioaccumulation of heavy metals in soil and selected food crops cultivated in Kogi State, north central Nigeria. Environmental Systems Research, 6:21
[76] Ibid.



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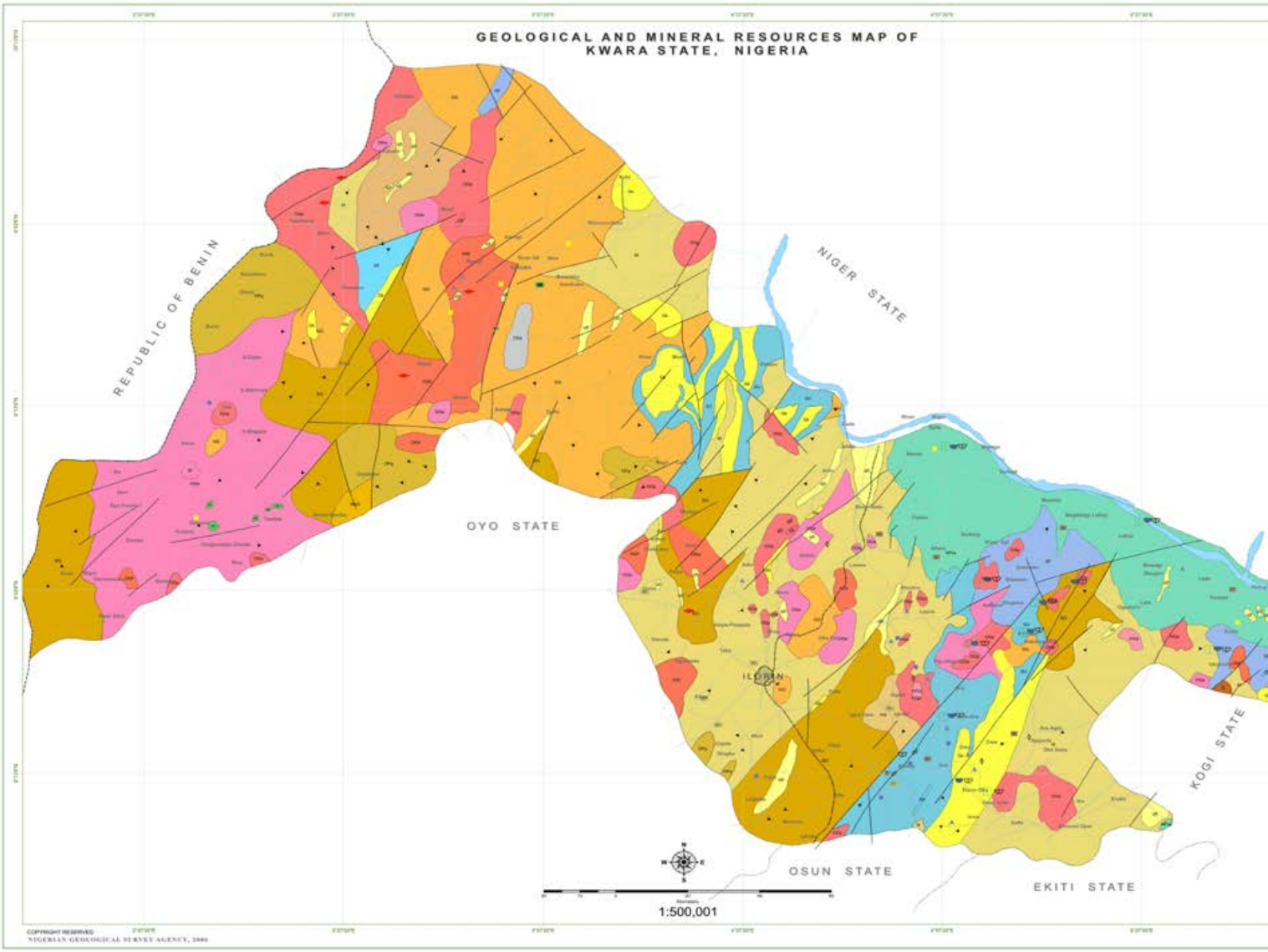
Kwara, Niger, Nasarawa Benue; two western region states – Ekiti and Ondo States; one south-south state – Edo; two south-east states – Enugu and Anambra; and the Abuja, the Federal Capital Territory of Nigeria. Kogi is thus the only state in Nigeria with direct physical, and consequently, social and economic links with all the geo-political regions of Nigeria. Kogi is also unique as the only state that was created as a result of the fusion of segments carved from two different Nigerian states – Benue and Kwara.

Lokoja, the state capital, is also famous as the location of the confluence of Nigeria's two largest rivers, which are also two of Africa's most important rivers. The state is drained by several other rivers and tributaries which channel water into the Niger river. The state experiences a tropical continental climate and average annual rainfall between 1200mm to 1500mm. Its vegetation is that of Guinea Savannah and mangrove rainforest.[75]

Geology of Kogi State

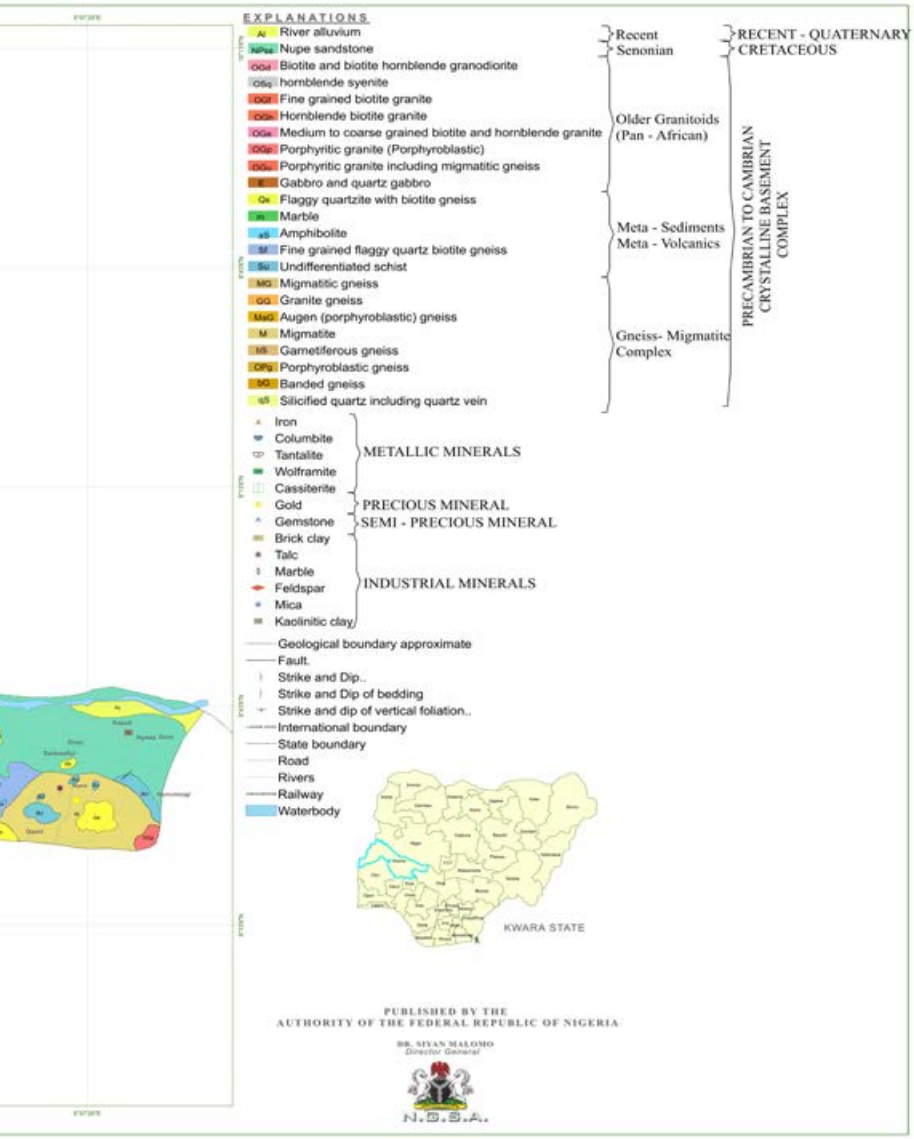
Kogi State sits on ingenious and metamorphic rocks of the Basement Complex on the west extending beyond the Niger Valley and the sedimentary formations of the Upper Cretaceous geological era in the east, extending along the Niger and Benue banks up to Udi Plateau, through Anambra and Enugu states.[76] The sedimentary formations consists of embedded shales, sand clays, sandstone and mudstones. The soil type is sandy, loamy and reddish acid soil with clay-rich horizon. Hydromorphic (developed under high moisture conditions) soils with alluvial deposits are also found in the flood plains of the Niger and Benue rivers.



KWARA STATE

The boundaries of Kwara State has undergone several mutations since 1967 when the state was first created out of the then Northern Region. Between 1967 and 1976, the 'first' Kwara State existed as a unit comprising of the present Kwara, Idah, Dekina, Oyi, Yagba, Okene, Okehi, Kogi and Borgu areas. In 1976 the 'new' Kwara was further shrunk to exclude the Ida-Dekina axis which became part of Benue State. Kwarra State attained its curerrent status and boundaries when the Oyi, Yagba, Okene, Okehi parts where carved out of the state to become part of another (Kogi) state. Kwara state is strategically positioned between the north and the south of Nigeria, with highly integrated social and cultural characteristics. It is thus described as the "gateway" state. The state shares boundaries with Niger and Kogi States in the North and Ekiti, Oyo and Osun states in the south of

[77] T. D. Akpenpuun and R. A. Busari (2013). Impact of Climate on Tuber Crops Yield in Kwara State. American International Journal of Contemporary Research, Vol. 3, No. 10, PP. 52-57.
[78] i. P. Ifabiyi and O. Omoyosoye (2011). Rainfall Characteristics and Maize Yield in Kwara State, Nigeria. Indian Journal of Fundamental and Applied Life Sciences, 1(3):60-65.
[79] M. N. Tijani (1994). Hydrogeochemical Assessment of Groundwater in Moro area, Kwara State, Nigeria. Journal of Environmental Geology, 24:194-202.



Geological Map of Kwara State

Nigeria. Kwara shares its western border with the Republic of Benin.

Kwara State is located in the tropical climate zone and experiences the typical wet and dry seasons each lasting six months of the year. Annual rainfall ranges from 1000mm to 1500 mm, while temperature starts from 25°C in the wet season and rises up to 34°Cin the dry season.[77] Relative humidity is between 65% and 80% across both seasons. The vegetation is that of Guinea and Derived Savannah characterized by tall grasses and short, scattered trees. The land elevation ranges from 273 to 364 meters above sea level. The state is drained by several rivers and tributaries flowing into the Niger River, which forms a natural border between Kwara and parts of Niger State.

Geology

Much of Kwara terrain is flat and undulating, with hills and valleys noticeable in the northern parts of the state.[78] The area is underlain by crystalline acid rocks of the Basement Complex, particularly the Older Granites and the (Migmatic) Gneiss Complex.[79] The Gneiss Complex consists of different types of metamorphosed rocks including migmatites, orthogneisses, paragneisses etc. The Older Granites consist of a series of tin-bearing granites and include tonalites, diorites, granodiorites, syenites and true granites.[80] This underlay is covered at the surface by largely tropical ferruginous topsoil usually dark, sandy and clayey-loamy with laterites and red soil.

A much smaller (northern) secor of Kwara is also partly underlain by the Bida Formation. The constituents of this formation include "fine to coarse-grained sandstone, conglomerates, siltstones, clay stones" and ironstones.[81] The alluvial deposits consist of gravels, fine sand, silts and clays.

[80] Obaje (2009).

[81] O. T. Olabode, M. O. Eduvie and I. O. Olaniyan (2012). Evaluation of Groundwater Resources of the Middle Niger (Bida) Basin of Nigeria. American Journal of Environmental Engineering, 2(6):166-173.

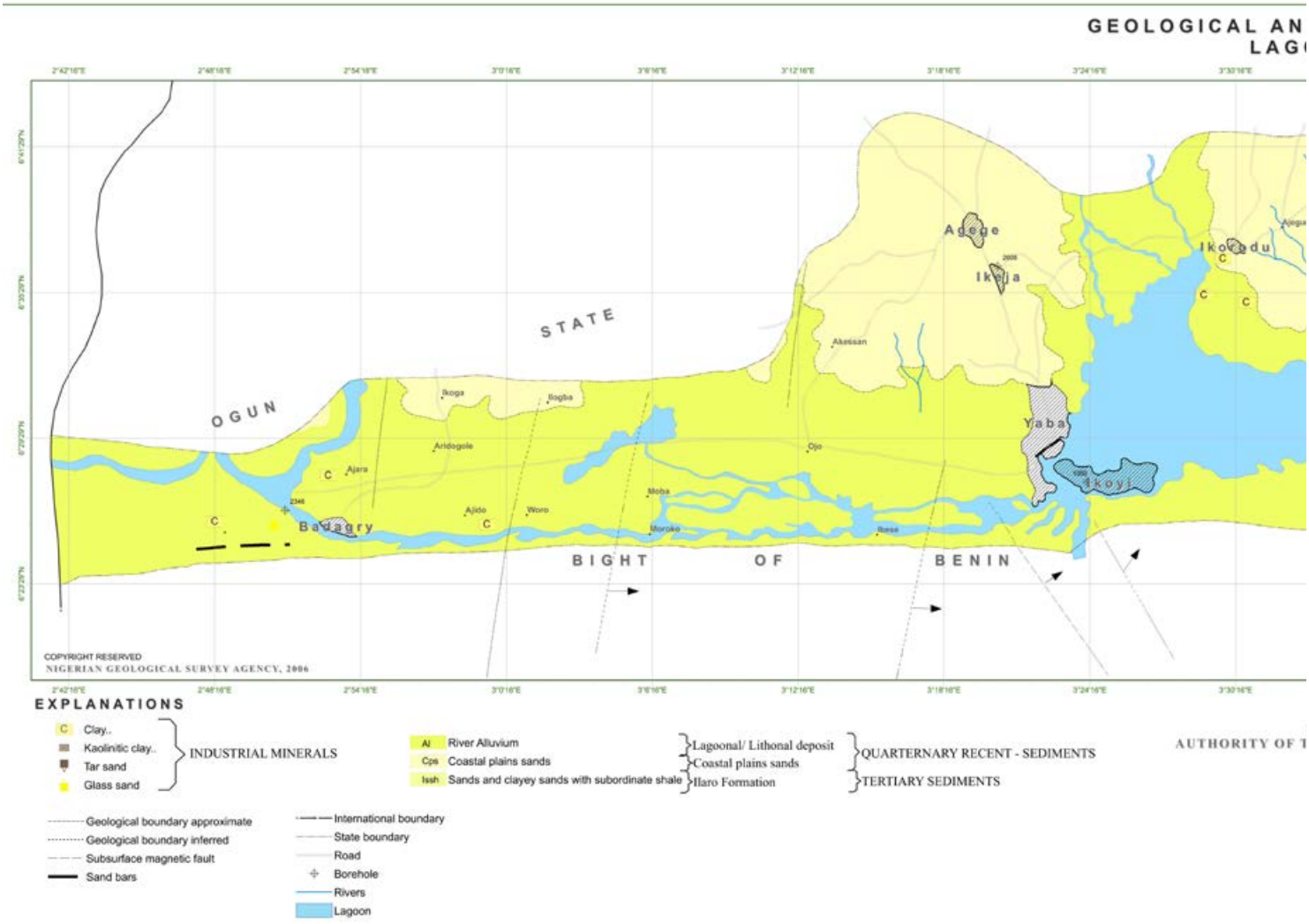


Figure 31: Geological map of Lagos State

LAGOS STATE

Lagos State was created as an independent administrative unit in 1967 being one of 12 states created by the central government at the time. The state is currently regarded as the commercial and industrial capital of Nigeria, and, until 1991, its political capital. Before the relocation of the capital city to Abuja in 1999, Lagos had been capital for almost a century, first during the colonial era through the post-independence period.[82]

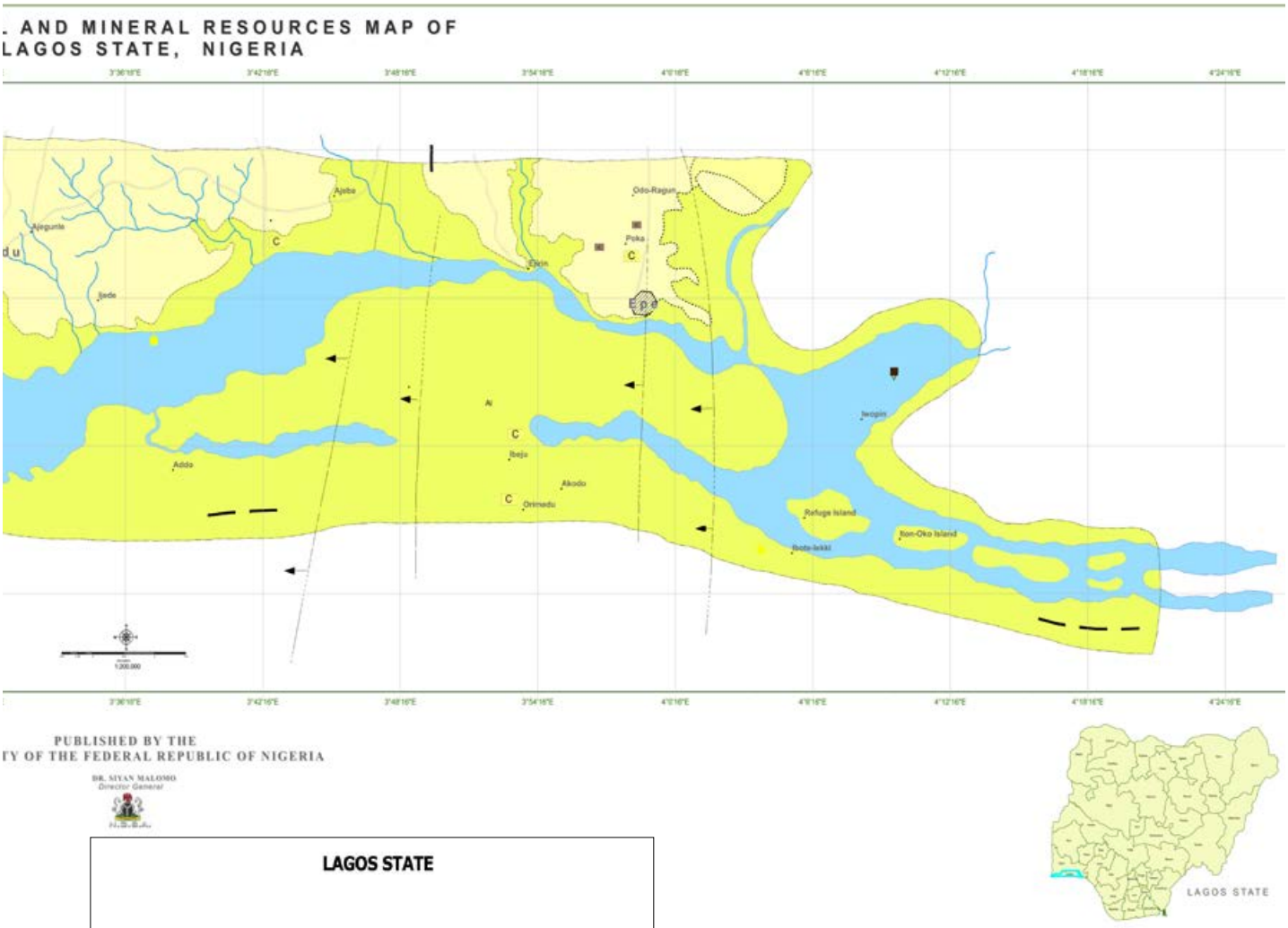
Today, Lagos sits as the industrial and financial center of the of Nigeria. The state shares a single domestic land border with Ogun State and an international boundary to the west with the Republic of Benin. The entire length of its 180 kilometers coastline forms its southern border with Atlantic Ocean.

Lagos land is generally flat, low-lying, and mostly covered by swamp. Area elevation range from as low as 9-24 meters above seas level in the coastal areas and rises

[82] J. Moore (1984). The Political History of Nigeria's New Capital. The Journal of Modern African Studies, Vol. 22, No. 1, pp. 167-175.

[83] A. O. Sojobi et al. (2016). Climate change in Lagos state, Nigeria: What Really Changed? Journal of Environmental Monitoring and Assessment. 188:556.

[84] J. C. Nwafor (1986). Physical Environment, Decision-making and Land Use Development in Metropolitan Lagos. GeoJournal, Vol. 12, No. 2, pp. 433-442.

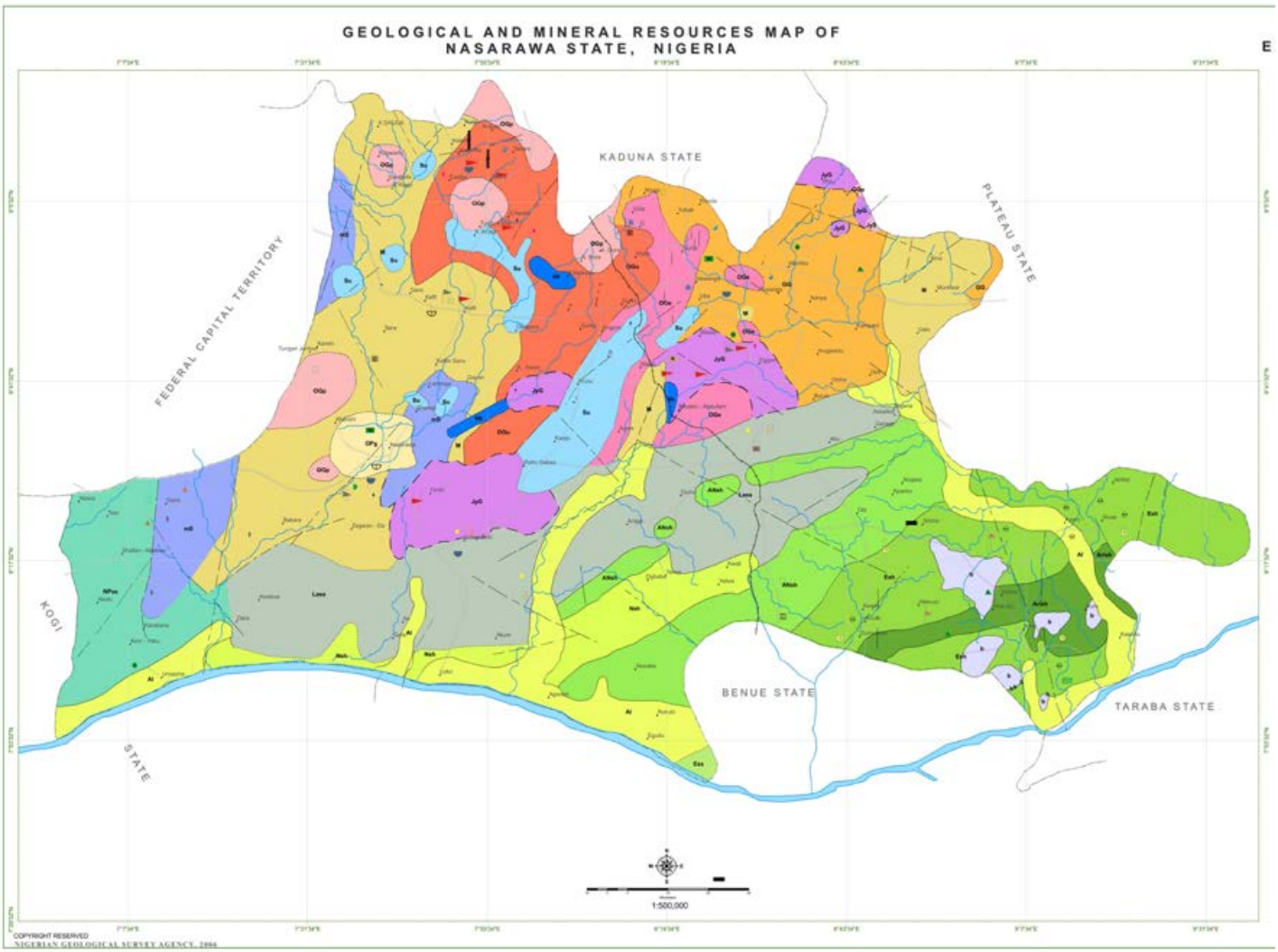


Geology

northwards up to 46 meters above seal level. The state lies in the tropical rainforest zone with mangrove swamps, freshwater swamps, lagoons and creeks.[83] Temperature ranges from 19°C (around August) to 30°C (around March). Relative humidity occurs between 70% and 100%. Average annual rainfall is about 1830mm.[84] The state is drained mainly by the Ogun, Adiyan and Ossa rivers, which flow into the Atlantic.

The geology of Lagos is made up of the Coastal Plains Sands and the Recent coastal deposits.[85] The Coastal Plains Sands consist of thick yellowish and white sands and gravel, interbedded with shale, clays and sandy clay with lignite. The Recent deposits lie on top of the Coastal Plains Sands, and consists of loose, whitish beach-like sands as well as clay and mud.

[85] E. O. Longe (2011). Groundwater Resources Potential in the Coastal Plain Sands Aquifers, Lagos, Nigeria. Research Journal of Environmental and Earth Sciences, 3(1):1-7.



NASARAWA STATE

Nasarawa State was created in 1996 from the old Plateau State. It is located in the central north of Nigeria close to the country's federal capital city. Is shares borders with Benue, Kogi, Kaduna, Plateau and Taraba States. The River Benue runs through the southern edge of the state, creating a natural boundary that separates Nasarawa from Benue State at four of its (Nasarawa's) local government areas. The land is also marked by several rivers which drains into the Benue River. Nasarawa land is also marked by hills, undulating plains and lowland. The hills and mountains range in height between 600 meters and 1,200 meters. Nasarawa State is falls within the tropical rainy climate, with annual rainfall of between

[86] Binbol, N. L. and N. D. Marcus (2010) Geography of Nasarawa State; A study of flora and Fauna. In Akinyemi, O (Ed) Studies in the history and culture of the people of Nasarawa State. (in press).

[87] Y. S. Agunleti et al. (2014). Structural Analysis of Digitized Lineament from Satellite Imagery and Vertical Electrical Soundings (VES) Studies for Ground Water Exploration in Part of Nasarawa State. The Pacific Journal of Science and Technology, Vol. 15, No.1, pp.345-354.

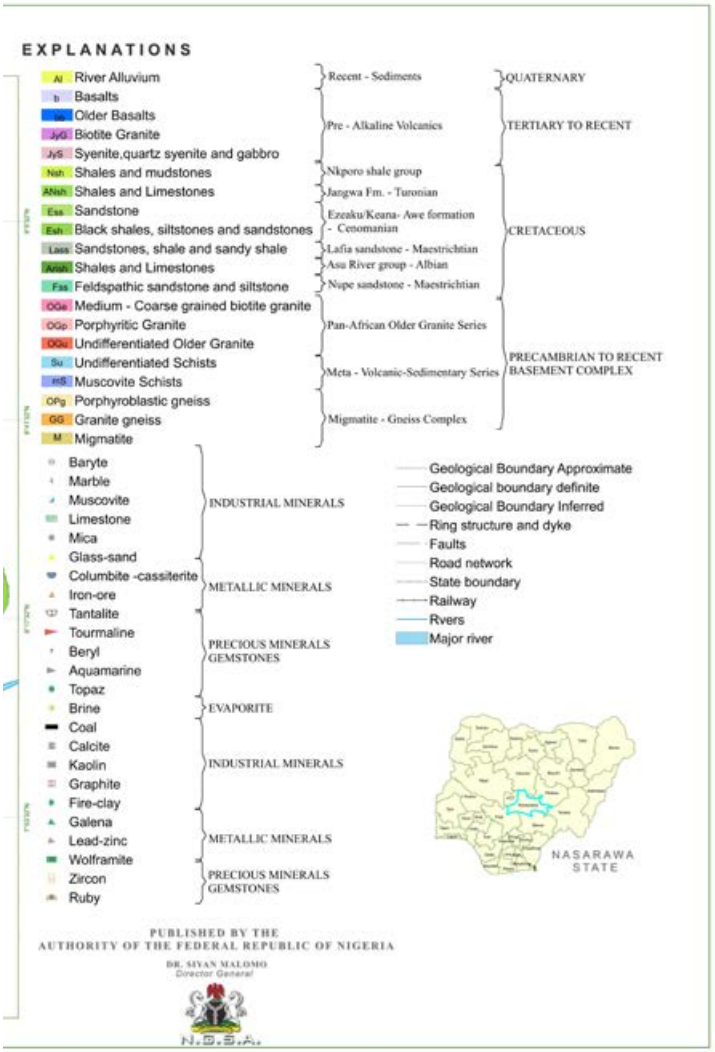


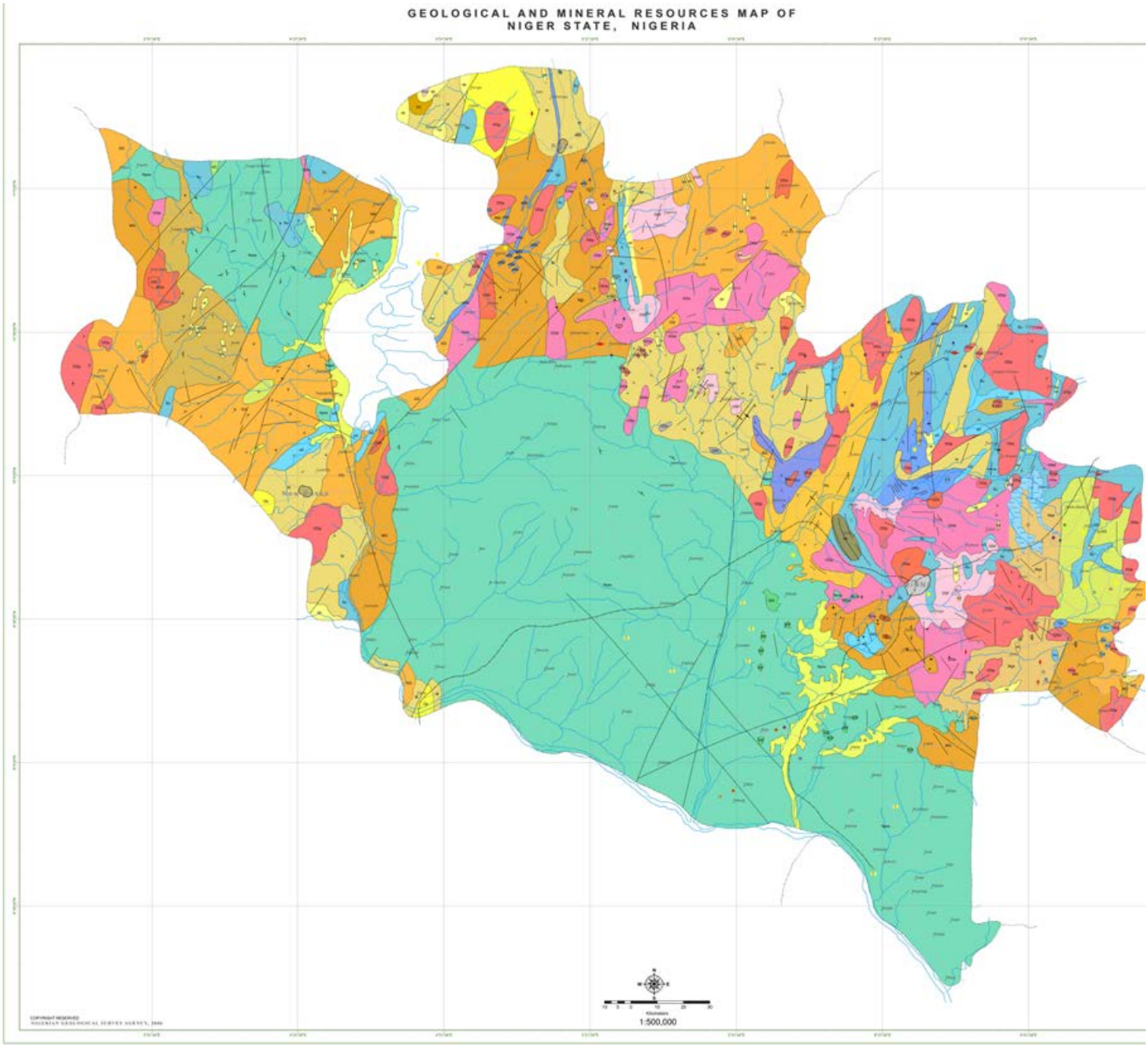
Figure 32: Geological map of Nasarawa State

1200mm and 2000mm. Temperature ranges between 22°C and 28°C, with humidity rising from 55% in the dry season up to 95% in the wet season. The vegetation is comprises of both forest savannah in the in the south and Guinea savannah in the north. The soil type is mostly fertile alluvial soil and volcanic loamy soils at foothills.

Geology

Most of Nasarawa State is underlain by the Basement Complex, although some parts of the state are also underlain by the Younger Granites and sedimentary basins. The north-central Nigeria sector of the Basement Complex within which Nasarawa is found consists of gneisses, migmatites, cysts and the older granites believed to be formed during one of the earliest periods of the earth's history.

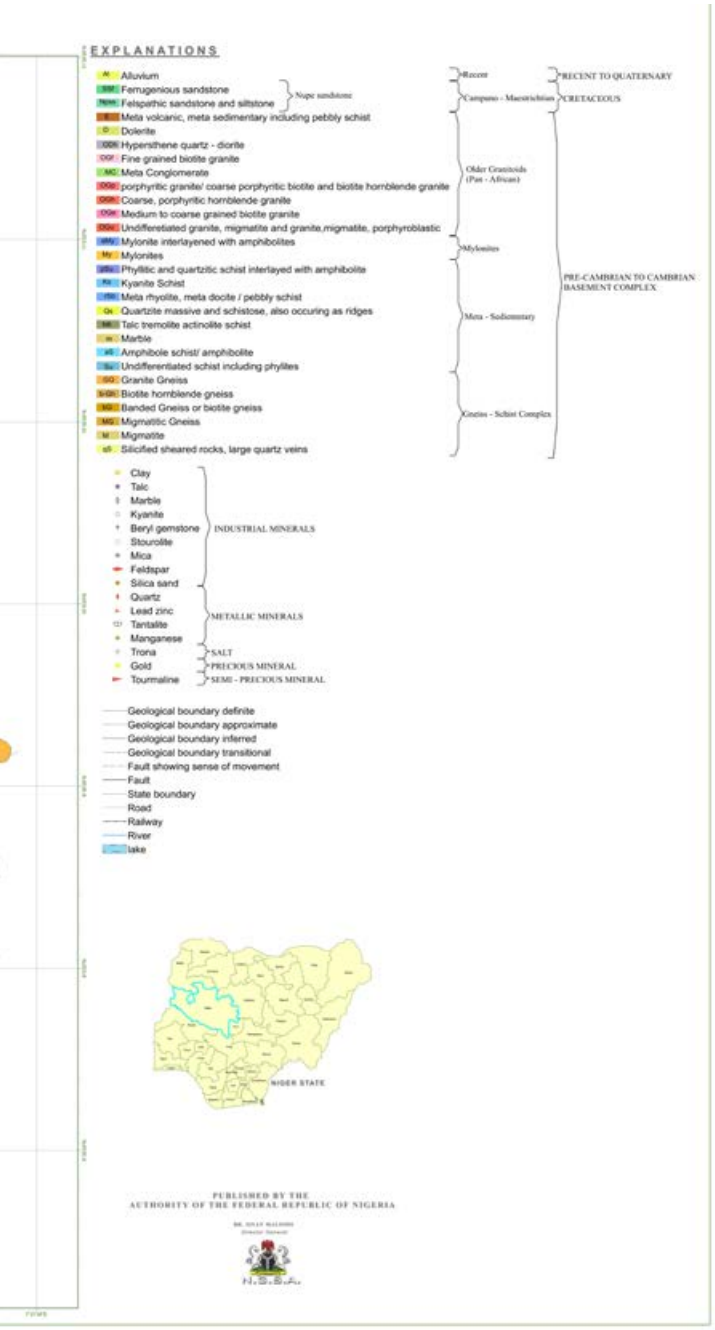
Nigeria Mineral Resources



NIGER STATE

Niger is a multiethnic and multicultural State listed in the North-central region of Nigeria. It was part of the Northwestern Region until 1976 when it became an autonomous political and administrative entity. It shares boundaries with Kebbi, Zanfara, Kaduna, Kogi and Kwara State. It also shares its southeastern boundary with Abuja, Nigeria's federal capital city, and an international border with the Republic of Benin in the west. The state occupies

[88] A. Jibrin and I. A. Jaiyeoba (2013). Characterization of Structural Composition and Diversity of Vegetation in the Kpashimi Forest Reserve, Niger State, Nigeria. Journal of Geography and Geology, 5(3):75-87.



the largest land area of all the states and territories in Nigeria.

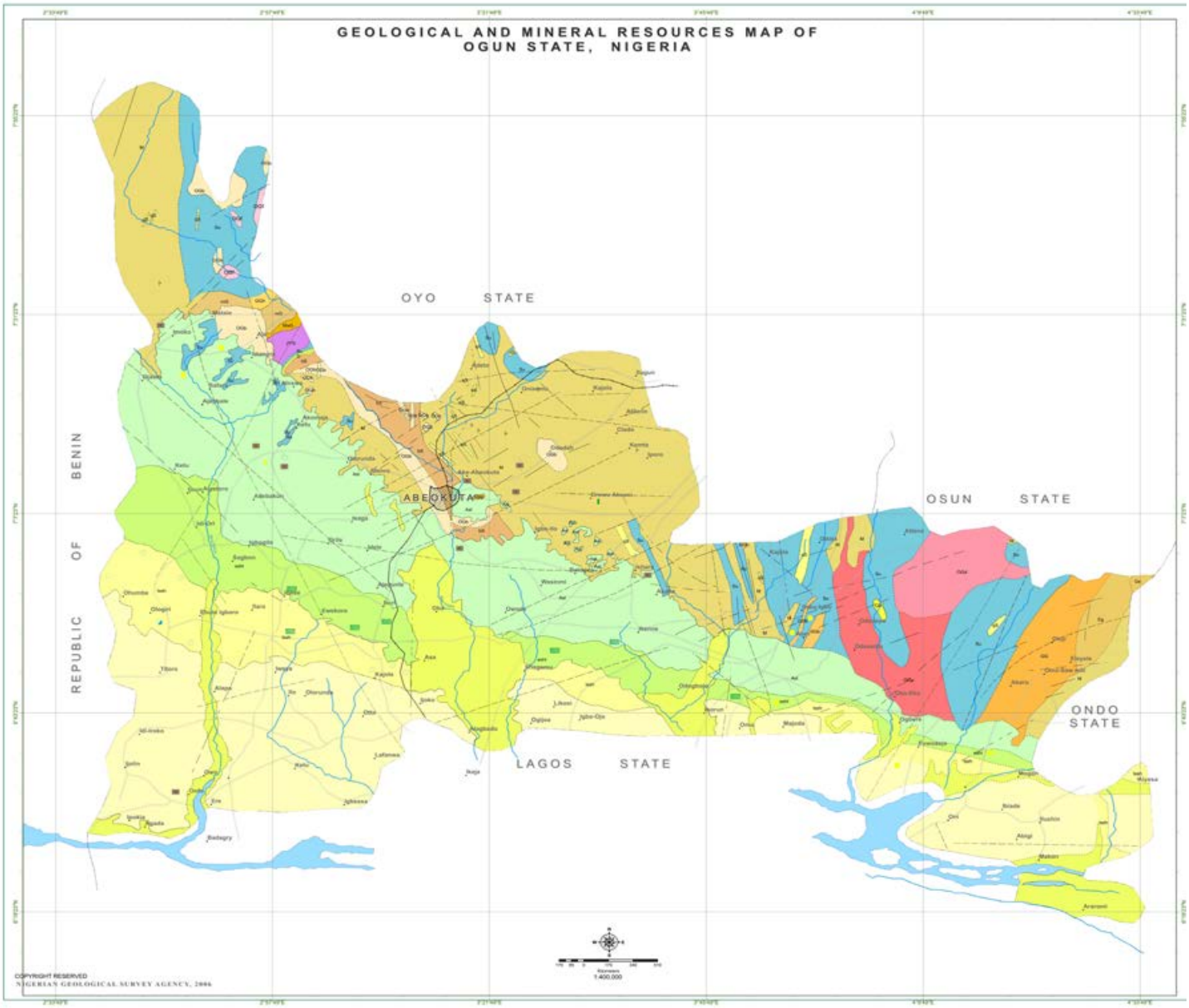
Niger state lies in tropical (hinterland) climate belt of Nigeria. Average annual rainfall is around 1300mm while average annual temperature is about 28°C. Much of the state is characterized by gently undulating and slopping topography. Niger States belongs to the woodland savannah zone, with annual grasses and scattered trees and shrubs. The soil is of the ferruginous tropical type, although hydromorphic soil can be found in the valleys and depositional areas.

In terms of infrastructure, the state produces most of Nigeria's electric power from the Kanji and Shiroro Dams, two of the country's main power sources, located in the state. Other notable attractions in the state include the Gurara Falls, the Kanji Lake and national park, and the Borgu and Zugurma Games Researves.

Geology

Niger State is underlain by two major rock formations namely, the Nigeria Basement Complex and the Sedimentary Basin. The Basement Complex occurs to the north of the state and it is characterized by outcrops of sedimentary rocks containing feldspars and quartz. The sedimentary Basin occurs to the south, and is composed chiefly of sandstones and alluvial deposits.

Nigeria Mineral Resources



OGUN STATE

Ogun is one of six states in the nearly homogenous, predominantly Yoruba-speaking, south-west region of Nigeria. It is one of only three Nigerian states that have largely retained its territorial boundaries since it was first created in 1976. It is bordered by Oyo and Osun States in the north, and Ondo state in the east. It is bordered entirely by Lagos State (Ogun is the only Nigerian state that shares a border with Lagos). Ogun is bordered by Republic of Benin on its western flank.

[89] A. A. Taiwo et al. (2018), Kinetics of potassium release and fixation in some soils of Ogun State, Southwestern, Nigeria as influenced by organic manure. International Journal of Recycling of Organic Waste in Agriculture. 7:251-259.

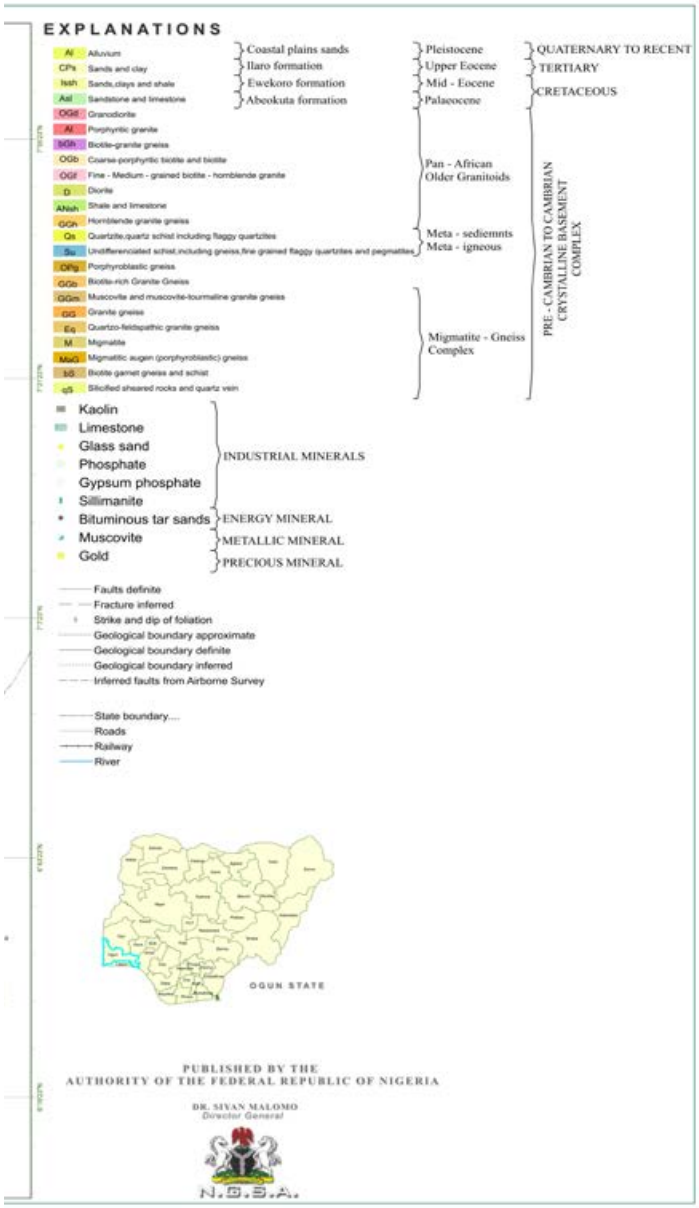


Figure 34: Geological map of Ogun State

Ogun State falls within the tropical rainforest. Rainfall in Ogun State is bimodal, meaning there are two cycles of rain in a year. Mean rainfall is between 105 and 128mm. Average monthly temperature is between 23 - 32°C. The vegetation consists of mangrove swamp in the southern part, rain forest in the central part and derived savanna in the northern area. Ogun State is drained by several rivers and streams which flow southwards in to the lagoons and finally into the Atlantic Ocean.

Ogun enjoys almost contiguous settlements with parts of Lagos. Like Lagos, Ogun State is reputed as a major industrial hub, hosting some of the world's global multinationals in Nigeria.

Geology

Ogun surface land is low and undulating. The geologic underlay of the state consists of the Basement Complex and the Sedimentary Basin. The Base Complex in the Ogun area is made up of both the younger and older granites found in the northern part of the state. The sedimentary basin in the area equally consist of the younger and older sedimentary rocks in the south. The outcrops of these formations are shown in the scattered hills mostly occurring as interfluves between valleys. Inselbergs can also be found in locations like Abeokuta.

OGUN STATE

MINERAL COMMODITY	LOCATION
1. Tar Sand	Ijebu Ode
2. Talc	Ilaro
3. Phosphate	Ilaro, Ososun, Oja Odan, Idogo
4. Limestone	Shagamu, Ewekoro
5. Kaolin	Abeokuta, Ajeyero, Ijebu Ode, Imeko
6. Clay	Onikoko

Nigeria Mineral Resources

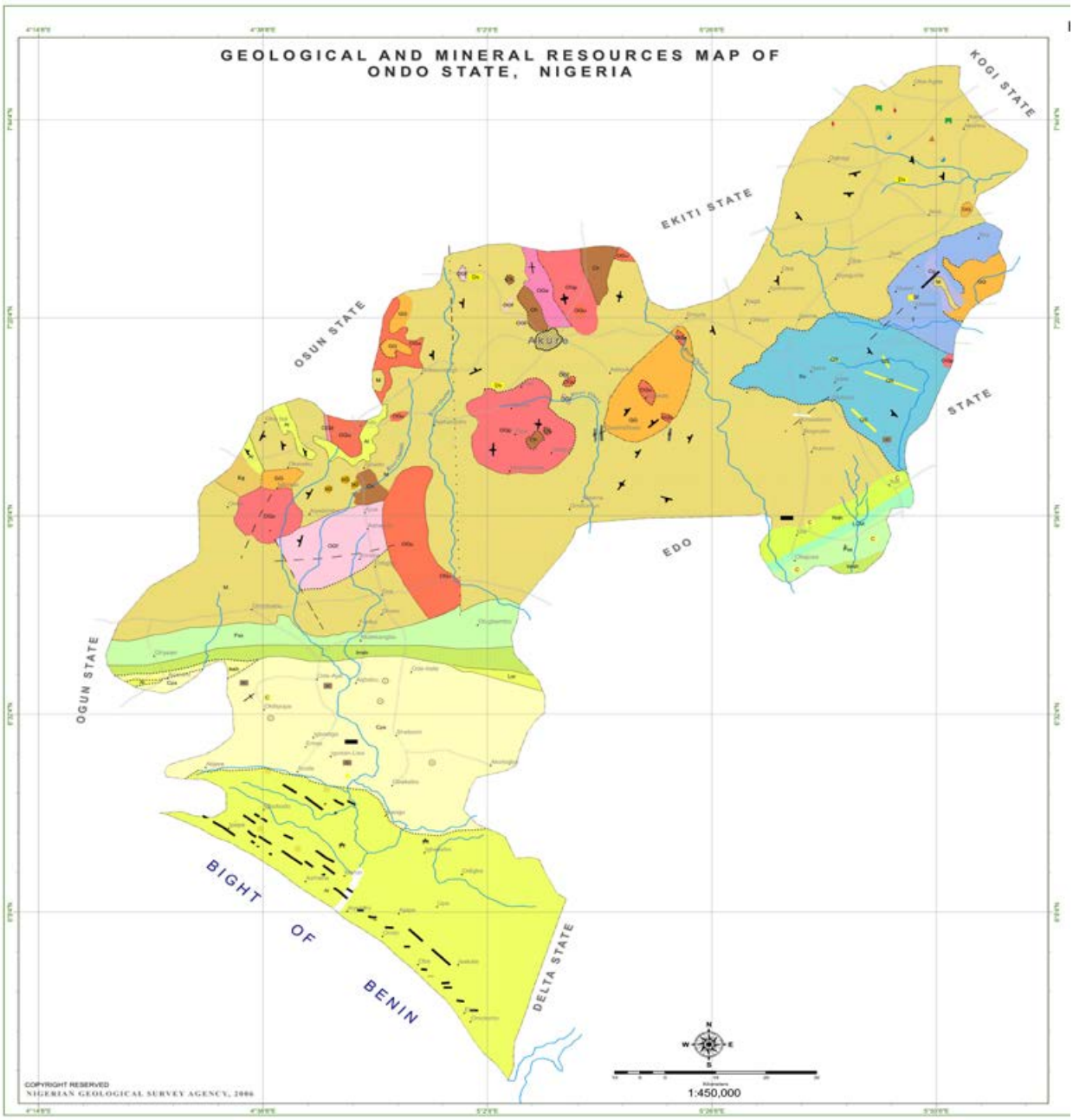
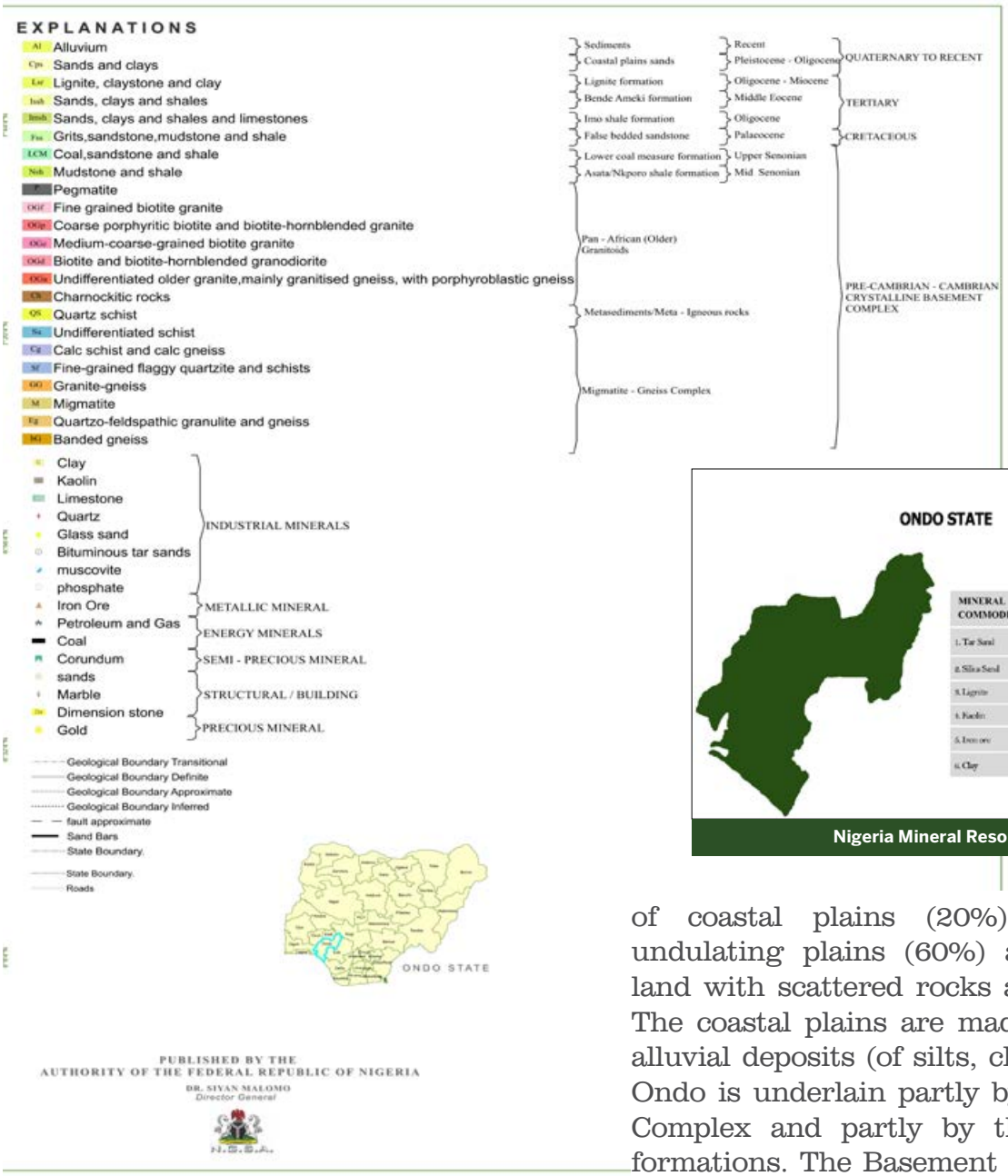


Figure 35: Geological map of Ondo State

ONDO STATE

As one of the seven states created on February 3, 1976, Ondo was another State carved out of the former Western State, covering the total area of the former Ondo Province, founded in 1915, with Akure as the provincial headquarters. In 1996 the state was further split in two to form Ekiti and present Ondo State. Ondo shares borders with Ogun, Osun and Ekiti on its western flanks and Edo and Delta states on the east. It is bounded by Kogi in the north and Atlantic Ocean in the south. Ondo falls within the tropical wet and dry / savanna

[90] Z. Monday (2013). Some Aspects of the Geography of Ondo State. A Field Trip



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climate region, with average annual temperature of 1500mm and 2000mm in tropical and savanna sectors respectively. Average annual temperatures is between 20°C and 34°C.

Geology

The area within Ondo State comprises of coastal plains (20%) lowland and undulating plains (60%) and undulating land with scattered rocks and hills (20%). The coastal plains are made up largely of alluvial deposits (of silts, clays and sands). Ondo is underlain partly by the Basement Complex and partly by the sedimentary formations. The Basement Complex, found towards the northern part of the state, constitute about 60% of the total geological underlay. It consists mostly of igneous and metamorphic rocks made up of granites, gneisses, schists and quartzites. Granite outcrops formed from igneous rock rise up to 266 meters above sea level. Granite inselbergs also occur at up to 463 meters above sea level.

[91] A. G. Omonijo et al (2013). Relevance of thermal environment to human health: a case study of Ondo State, Nigeria, Theoretical and Applied Climatology, 113:205-212.

[92] Omonijo et al. (2013).

[93] Strategies for Combating Urban Flooding in a Developing Nation: A Case Study from Ondo, Nigeria. The Environmentalist, Volume 14, Number 1, 57-62 (1994).

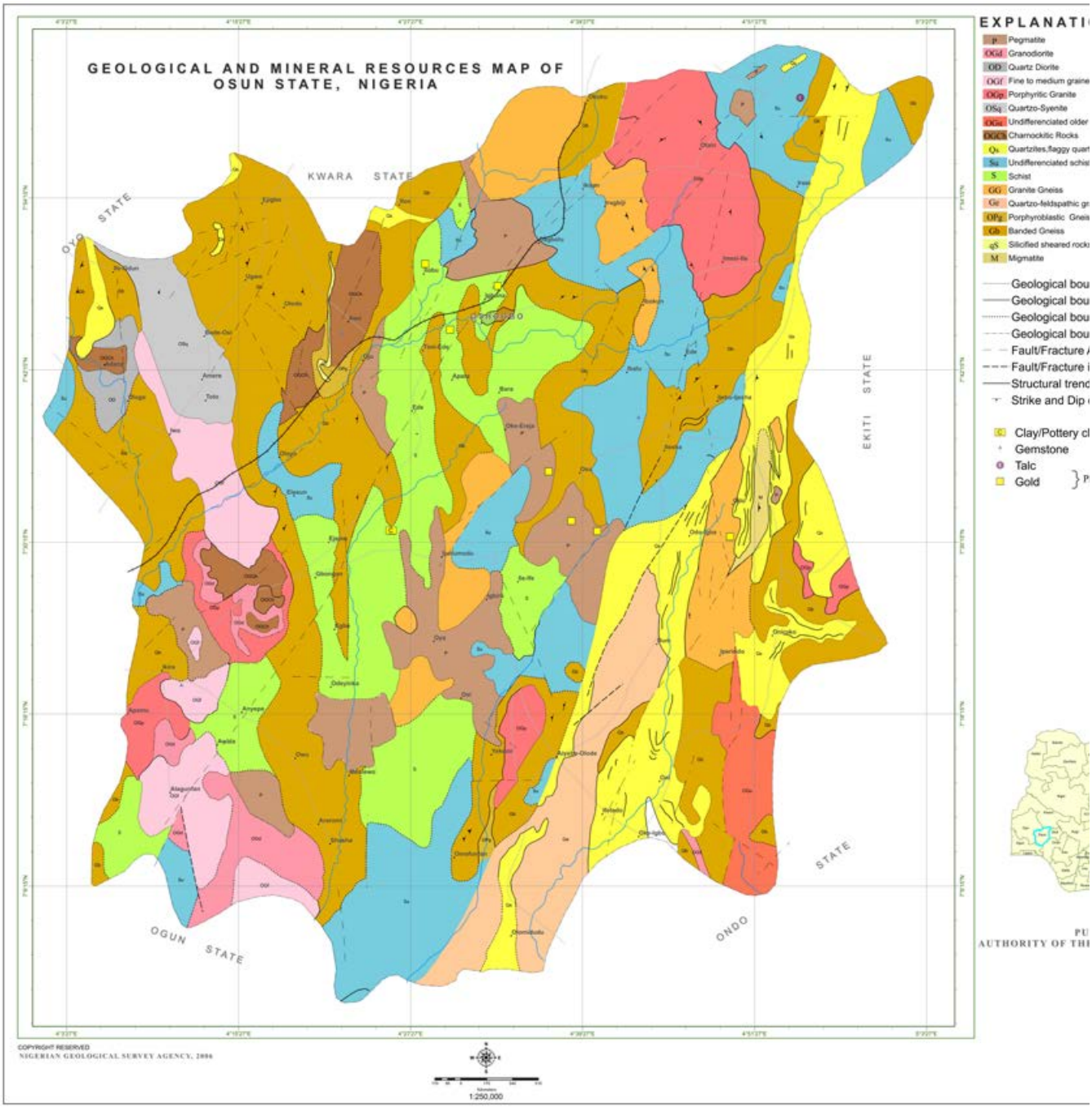


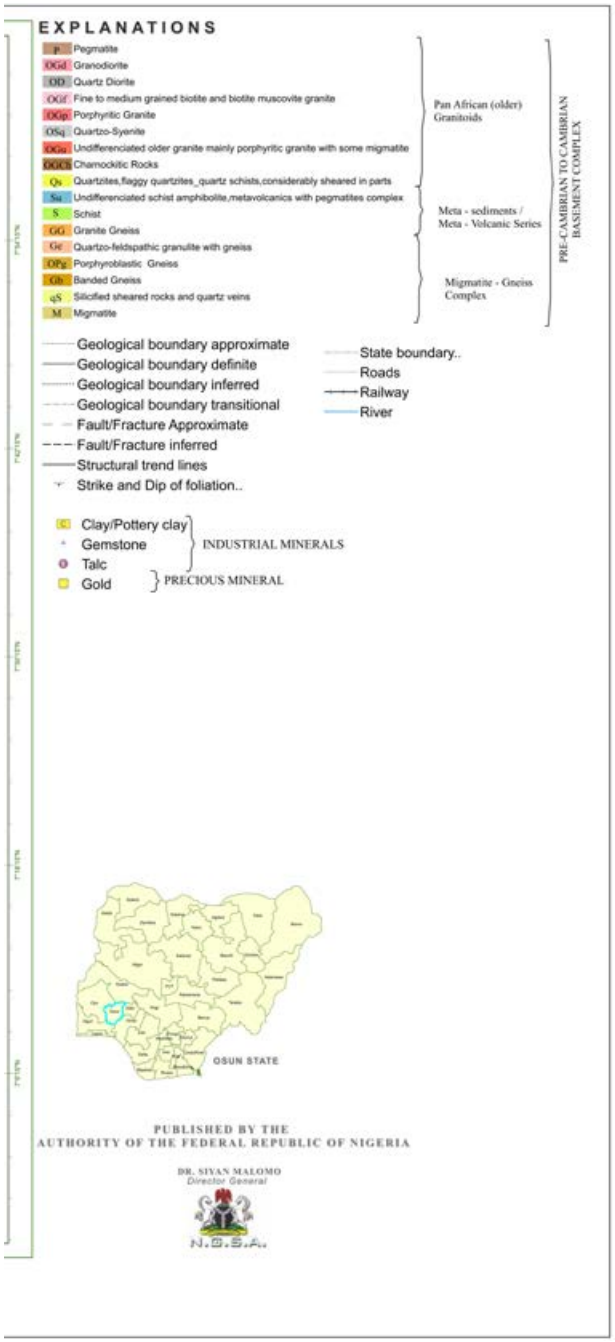
Figure 36: Geological map of Osun State

OSUN STATE

Osun, a linguistically (relatively) homogenous but multi-religious state, was created out of old Oyo State in south-west region of Nigeria in 1991. It is bounded by Oyo, Ogun, Ondo Ekiti and Kwara States. The state is one of the smaller states, but well known for vibrant mining activities. One of its major towns, Ile Ife is regarded as the birth place of

[94] World Bank (2014). Report of Environmental and Social Management Plan (ESMP). Available at: http://documents.worldbank.org/curated/en/699531468290473240/pdf/SFG1477-V3-EA-P095003-ESMP-Osun-State-Box393253B-PUBLIC-Disclosed-11-11-2015.pdf

[95] F. Oladipupo Geology of Osun State, Nigeria. Available at: https://www.academia.edu/33642774/Geology_of_osun_state_Nigeria.docx



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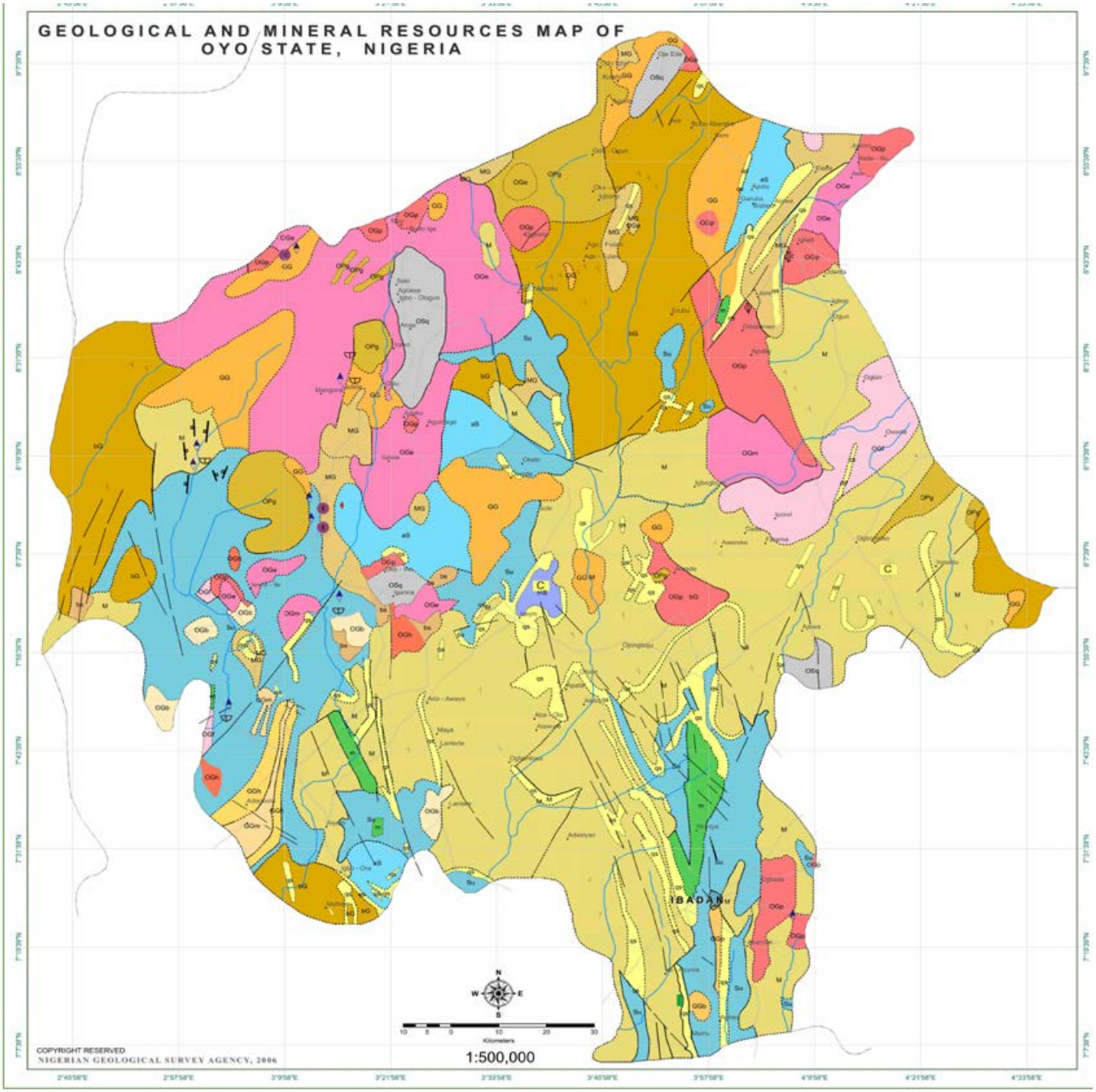
the Yoruba race which occupies the entire south-western region of Nigeria and parts of Kwarra and Kogi States.

Osun State has a tropical rainforest climate. Average temperatures range between 23°C and 34°C in the wet and dry seasons respectively, but can rise to 38°C in the hottest month of March. Average rainfall ranges from 234cm to 287 cm in the wet season. Relative humidity range between 57-78%. The vegetation consists of dense forest cover with short grasses of the rainforest variety. The land is gently undulating and has altitude between 150m and 450m above sea level. Osun state consists of two main relief regions of inselberg landscape and the coastal plains. The sharp drop in elevation in one part of the northern region created the Erin-Ijesha Waterfall.

Geology

Osun state is underlain by the Basement Complex. The rocks found in the Osun sector of the Complex are of the (crystalline) metamorphic variety. The rocks consist of migmatites gneiss, quartzites, pelitic schists, biotite granite, charoite, granite gneiss and porphyritic granites. This rock underlay is capped by reddish brown and laterised (deep)_clay, as well as sandy soils. Accumulated alluvial deposits also form the basis for extensive mineralization in the area. Outcrops of the metamorphic rocks are also found in many places in the state. Osun is drained by many rivers and streams, the most notable water body being the River Osun.



OYO STATE

Old Oyo State, which territory encompassed current Osun State was first created from the former Western State in 1976. The present Oyo State however assumed its new boundaries in 1991 when part of its territory was carved out to form Osun State. Oyo State is bounded in by Kwara, Osun and Ogun states to the north, east and south respectively. It

[96] R. G. Adeola et al. (2012). Climate Change and Cropping Techniques among Farmers in Oyo State: Implications for Extension Systems. Agricultural Journal, 7(5):339-342.

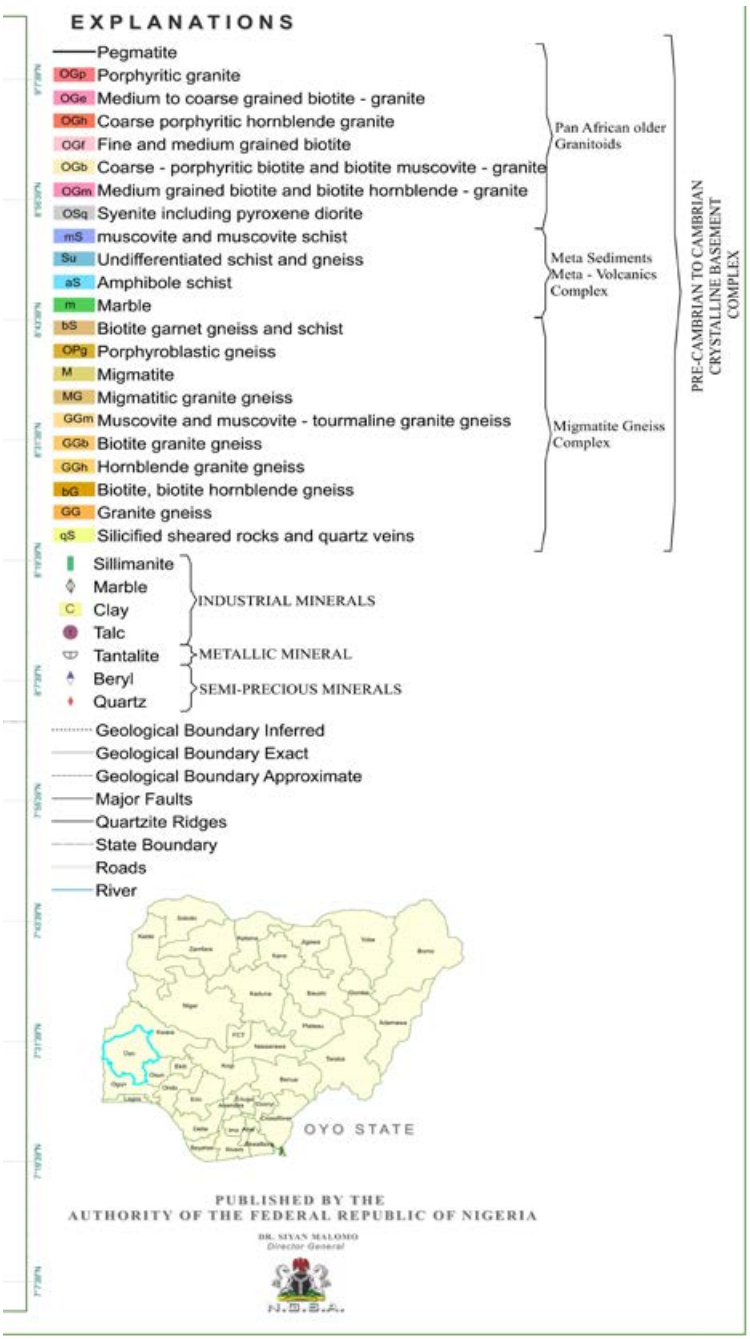


Figure 37: Geological map of Oyo State

shares its western border with the Republic of Benin. Oyo state has an equatorial wet and dry climate. Annual rainfall range from 1000 to 1500mm, while average temperature is between 25°C and 35°C. The vegetation comprise of equatorial rainforest of thick forest and Guinea Savanna comprising grassland interspersed with trees in the

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southern and northern parts of the state respectively. The land is gently slopping lowland in the southern part, which rises to about 40 meters of plateau. The land is drained from southwards by several rivers in the state, which have also created a number of river basins.

Geology

Oyo State is underlain by three units of the crystalline Basement Complex. These sectors are the Older Granites, the Older Meta-sediments and the Gneiss-Migmatite Complex (GMC). The Older Granites consist of granites, biotites, syenites, diorites and pegmatites. The Older Meta-sediments consist of quartz schists and mica schists. The GMC consists of granite gneiss and biotite gneiss. The Older granites occur towards the north of the state and manifest in smooth domed inselbergs. Some of the meta sediments occur towards the central part of the state. Outcrops of schists and quartzite inselbergs are also found across the state. The edge of the basement complex of the western highlands marks the boundary of the lowlands in the north, while the coastal deposits marks it in the south.

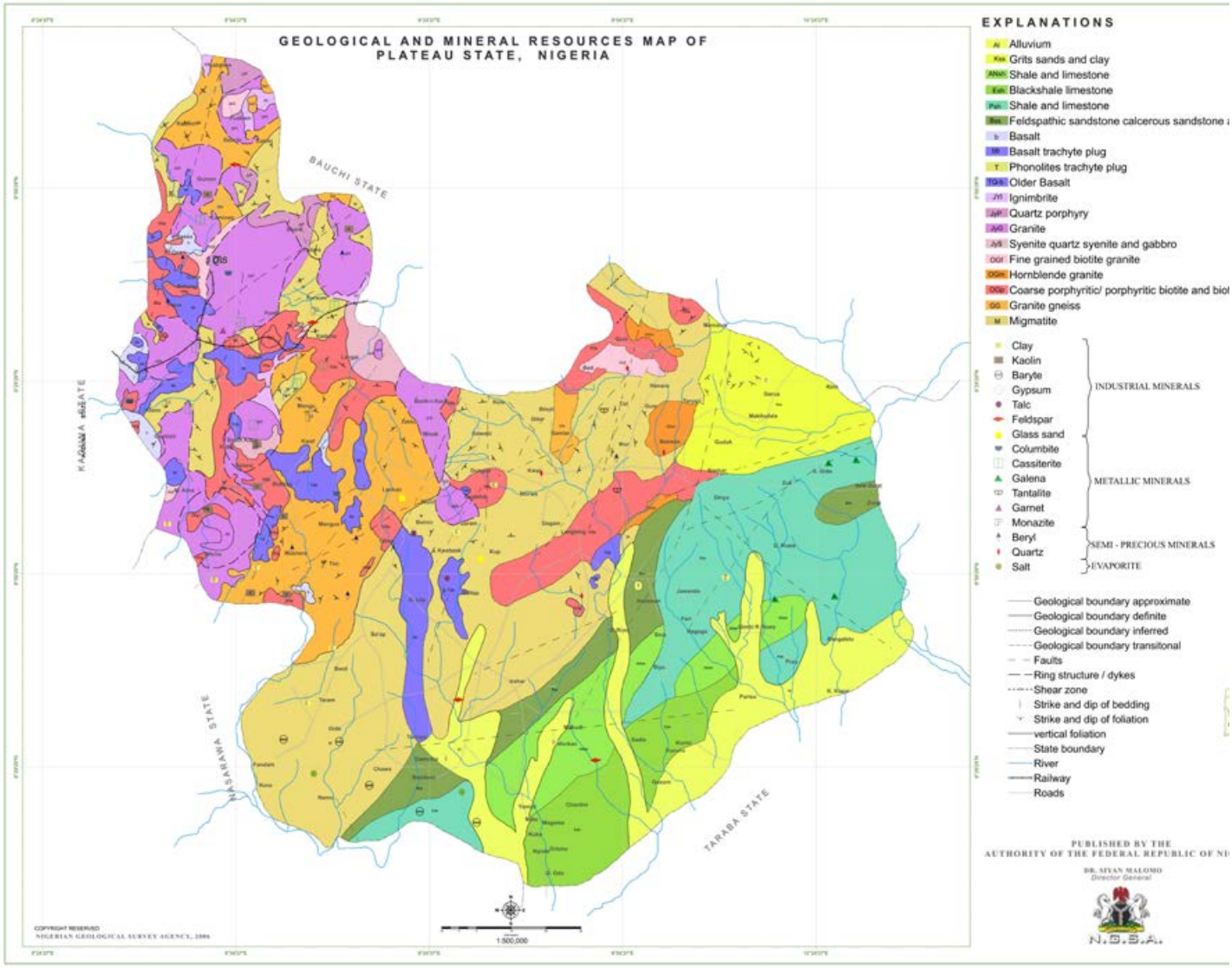


Figure 34: Geological map of Ogun State

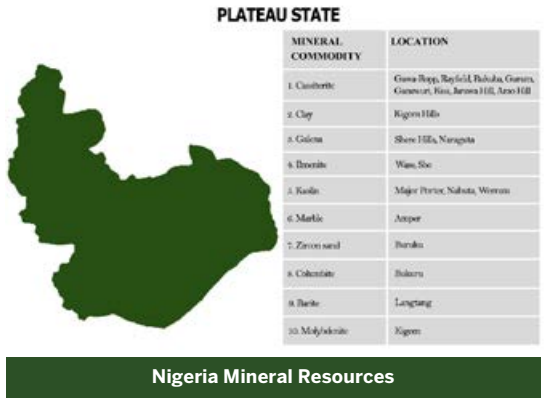
PLATEAU STATE

Brief History

The borders of Plateau State have been adjusted many times in the past before settling at its present territorial extents. In colonial times, the manipulation of the boundaries of the area was due to the desire to protect railway construction and guarantee the safe passage of mined tin to the coast.

The British had begun to exert colonial control over Nigeria in the early 20th century, and in 1926 Plateau Province was made up of the Jos and Pankshin Divisions. The border changed several times in subsequent years as the government purportedly refrained from splitting ethnic groups across boundaries.

However, in May 1967, the Benue and Plateau Provinces were merged to form the Benue-Plateau State, at a time that Nigeria was made up of twelve states. Following the civil war, the Benue-Plateau State was one of several large states that were



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split up following the pressure piled on the Federal Government. Hence, the military administration of General Yakubu Gowon, which divided the country into nineteen states in 1976, created Plateau State as an autonomous unit out of the erstwhile Benue-Plateau State that had encompassed the original Plateau Province.

Yet, in 1996, Plateau State was further subdivided to create Nasarawa State, which was carved out of the western half of the old Plateau State by the Sani Abacha military regime. Tin mining activities began under the British, in the area now regarded as Plateau State, in 1902 and continues to the present day.

Geology

The unique physical features of Plateau State are its high relief, especially in the north, and its geological history. The high relief, or more appropriately, the Jos Plateau, provides a hydrological centre for many rivers in northern Nigeria and confers on the northern part of the State a cool climate suitable for livestock rearing and the growing of exotic crops. The process of formation of the high relief made Plateau one of the mineral rich States in the country.

The Jos Plateau, an erosional relic covering an area of about 7,780 square kilometres is a product of distinct phases of volcanic activity, when younger granite rocks extensively intruded into the older basement complex rocks. Each phase of volcanic activity was followed by a long period of weathering and erosion, when tin bearing rocks were deposited in the valleys and buried by floods of basalt from subsequent volcanic eruptions.

The landscape of Plateau State rises steeply from 200 metres around the plains of River Benue in the south to an average height of 1,200 metres on the Jos Plateau. The topography comprises great peaks like the Shere Hills (1829 metres), extinct volcanoes and crater lakes on the Jos Plateau, which are also the source of great rivers like Kaduna, Gongola, Hadejia and Yobe.

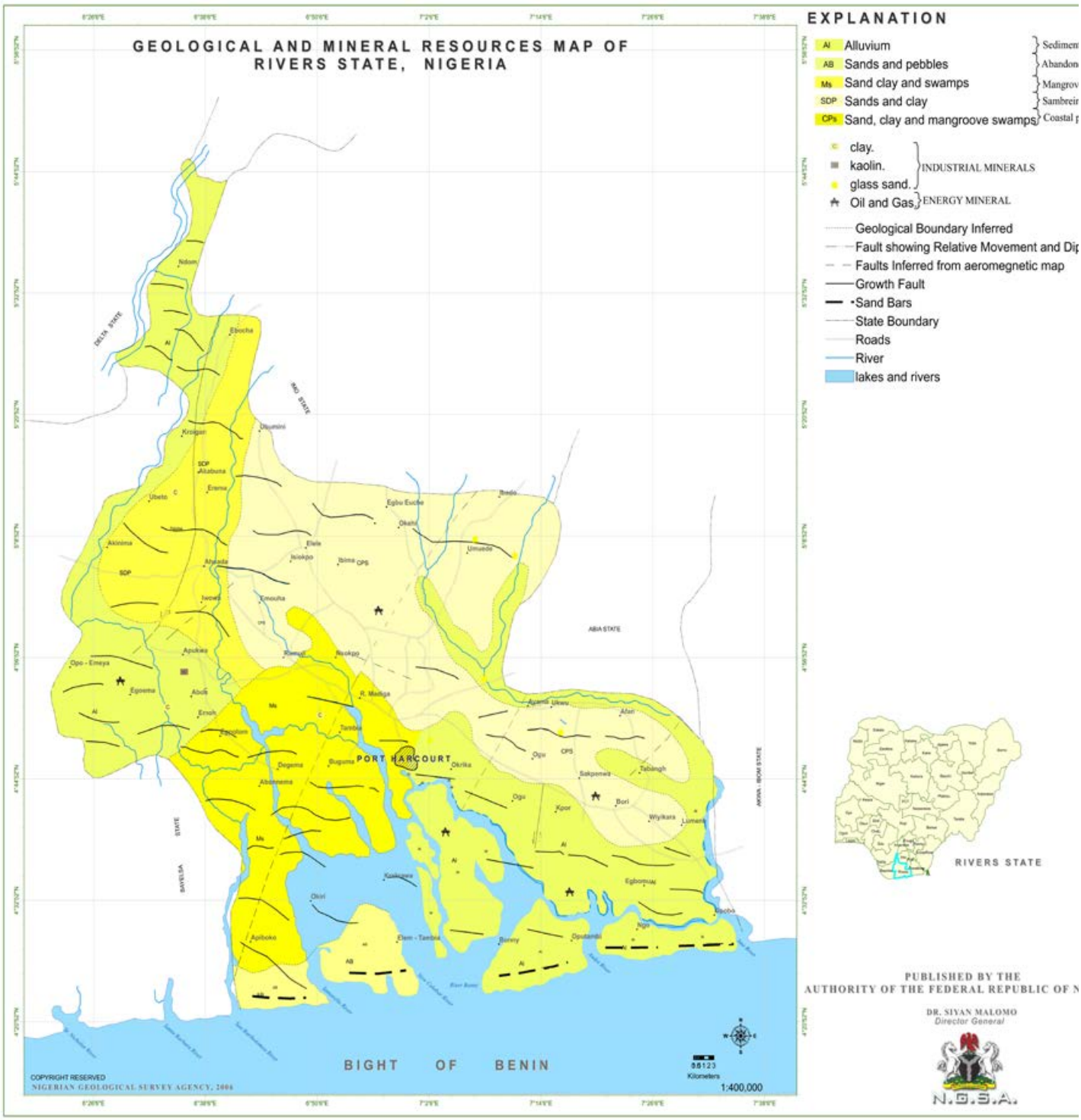
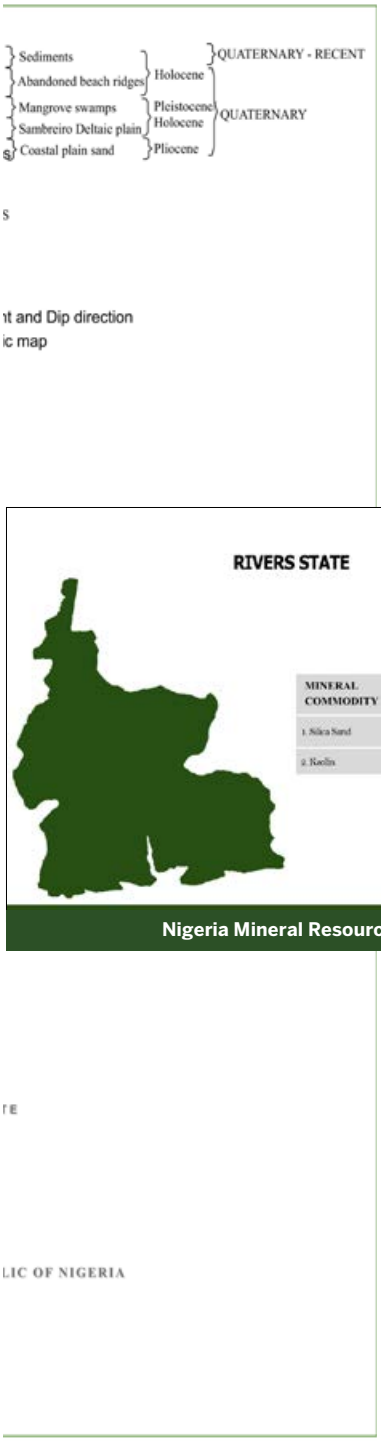


Figure 39: Geology of Rivers State



RIVERS STATE

Brief History

With Port Harcourt as its capital city, Rivers State is bounded to the south by the Atlantic Ocean; to the north by Imo, Abia and Anambra States; to the East by Akwa Ibom State; and to the West by Bayelsa and Delta States. The State is home to a variety of ethnic groups, including the Abua, Andoni, Ekpeye, Engenni, Etche, Ibani, Ikwerre, Kalabari, Ogba/Egbema/Ndoni, Okrika and Ogoni. The inland part of Rivers State consists of the tropical rainforest, while towards the coast there is the typical Niger Delta environment, featuring many mangrove swamps. Rivers State, named after the many rivers that border its territory, was part of the Oil Rivers Protectorate from 1885 till 1893, when it became part of the Niger Coast Protectorate. In 1900, the region was merged with the chartered territories of the Royal Niger Company to form the colony of Southern Nigeria. The State was formed in 1967 with the split of the Eastern Region of Nigeria into three units, and until 1996 it encompassed the area now known as Bayelsa State.

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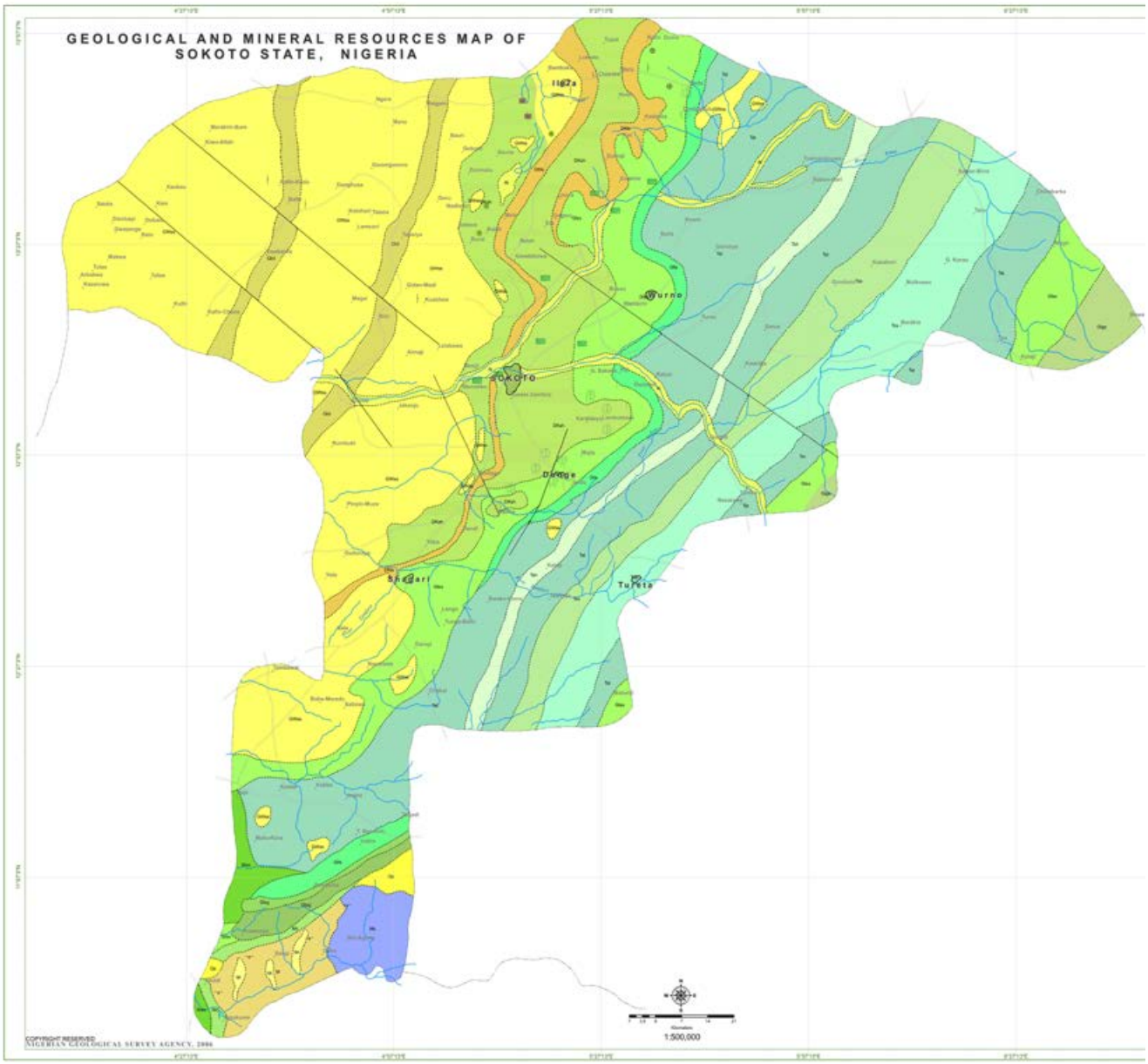
Geology

Rivers State lies on the recent coastal plain of the eastern Niger Delta. Its surface geology consists of fluvial sediments, including recent sediments transported by Niger River distributaries and other rivers, such as Andon, Bonny and New Calabar. The materials deposited as regolith overburden of 30 metres thickness comprise clays, peat, silts, sands and gravels.

The depositional sequence exhibits massive continental sandstones overlying an alternation of sandstones and clays of marginally marine origin, but eventually grading downwards into marine clays. Sands, by far, form the largest group of rock types in Rivers State, while mud constitutes all the polluted brackish waters of the riverine areas. However, peat forms the various vegetal and animal remains that lie in bogs and shallow pits. The gravel and pebbles equally form the last unit of the subsurface rock type, and are usually found at the base of the river channels.



SOKOTO STATE

Brief History

Located to the extreme North-Western part of Nigeria, between longitudes 4'8'E and 6'54E and latitudes 12'N and 13'58'N, Sokoto State shares common borders with Niger Republic to the north, Kebbi State to the south-west and Zamfara State to the east. The entire land area is about 32,000 square kilometres, while the total population projected in the 2006 census, of about 3.7 million people, is made up of two ethnic groups, the Hausa and Fulani, respectively.

In 1967, not long after Nigerian independence from the British, the region became known as the North Western State. However, that territory was, in 1976, split into Sokoto and Niger States. Later on, Kebbi State (1991) and Zamfara State (1996) were equally split out of Sokoto State.

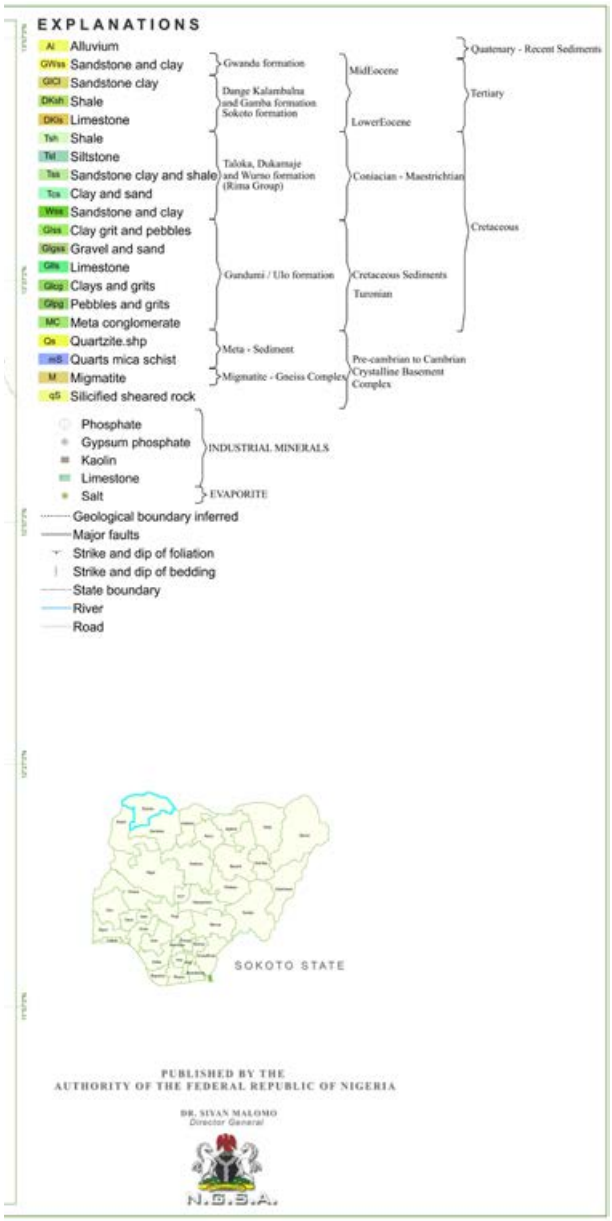
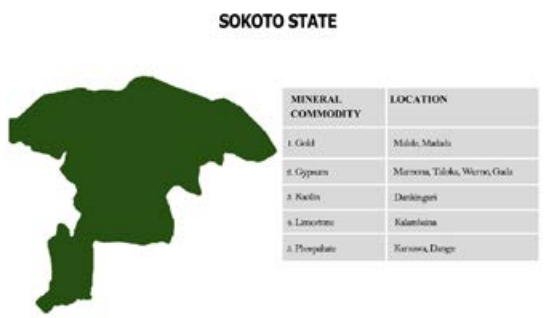


Figure 40: Geological map of Sokoto State



Nigeria Mineral Resources

Geology

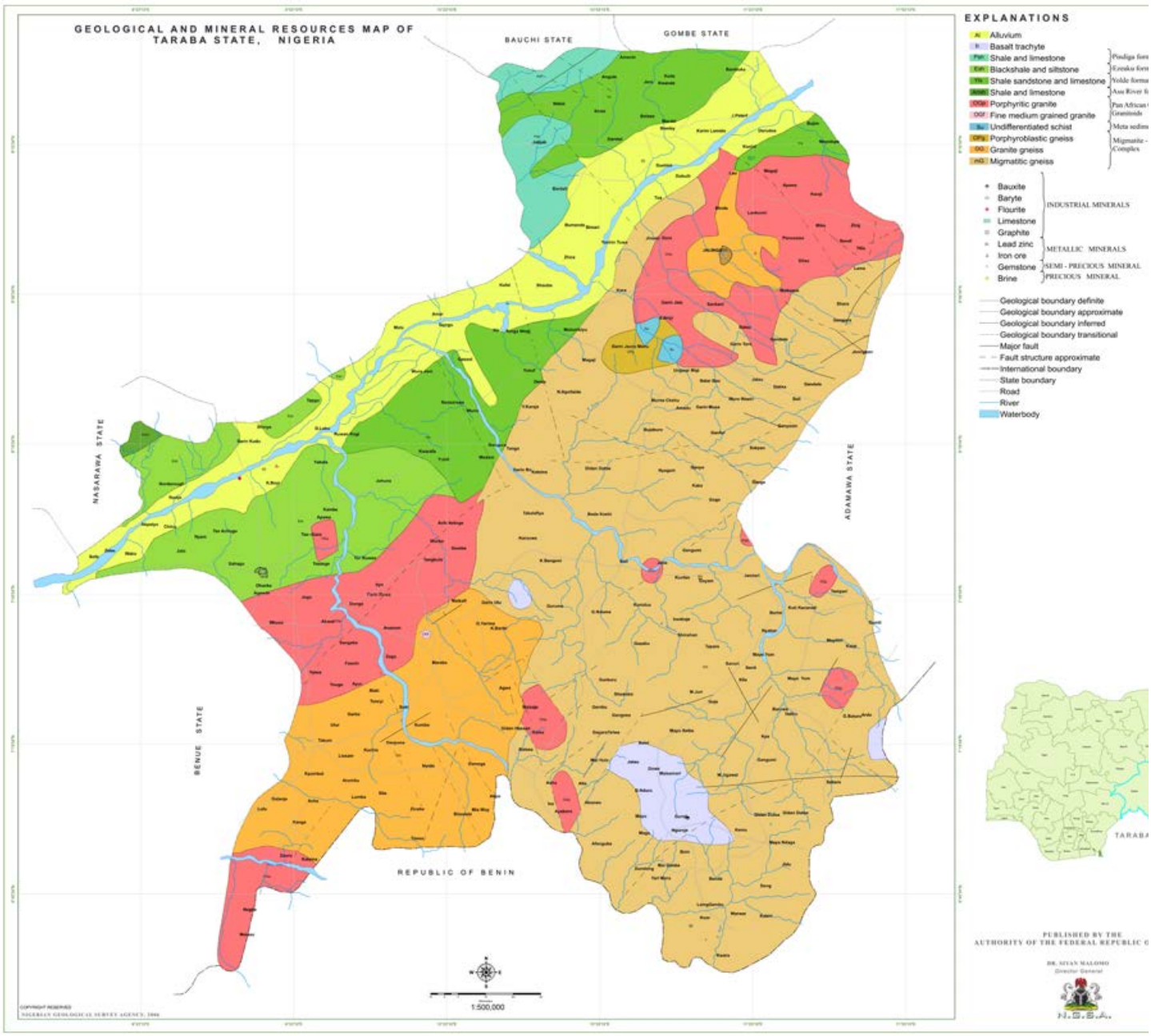
Sokoto State is located within the Illumined basin, which is surrounded to the east and south by the Precambrian basement complex. However, within the State, there is no outcrop of the basement complex; rather, it is covered by a series of deposited sedimentary rocks. These sediments were laid down under varied environmental situations, ranging from continental to marine events. The sedimentary rocks in Sokoto State have been classified into four major categories.

The first category is the Gundumi formation, which is the oldest sedimentary rock in the State, directly overlying the basement complex. It is made up of sandstones and clays, all of continental origin. The sandstone portion of the formation contains a lot of water and is currently being harnessed through boreholes.

The second category is the Rima group of three distinct marine sediments, namely, the Taloka, Dukamaje and Wumo formations.

The Taloka, which is the oldest formation in the Rima group, consists of multiple layers of sandstones and shales. The sandstones in this formation contain a lot of water. The Dukamaje formation is shaly and non-auriferous, while the Wurno formation consists of one layer of sandstone. The third category of sedimentary rocks in Sokoto State is referred to as the Sokoto group, which is of marine origin. It consists of two main formations - the Dange and the Kalambaina.

The Dange formation consists of clays and shales, while the Kalambaina formation, which overlies the former, is made up of limestones. This group is also auriferous. The fourth category of sedimentary rocks in the State is the Gwandu formation, which occurs in the north-western and southern parts of the State. This formation consists of clays and sandstones with a high potential for groundwater.



TARABA STATE

Brief History

Named after the Taraba River, which traverses the southern part of the State, and having Jalingo as its capital city, Taraba State was created out of the former Gongola State on August 27, 1991, by the military government of General Ibrahim Babangida. The State, with its numerous small ethnic groups and remote location, was a particularly neglected and grossly underdeveloped part of the former Gongola State. Because of its rugged topography, lack of access roads from other parts of the country, and indeed, the neglect it suffered from past administrations, the State still remains largely peripheral to the nation's economic and political life.

The need to diffuse centres of economic

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Figure 41: Geological map of Taraba State

growth and draw the peripheral population into the mainstream of the nation's economy, which were among the important reasons adduced to justify state creation exercises in the country, are still relevant to Taraba State.

Geology

The State is bounded to the west by Nasarawa and Benue States, to the northwest by Plateau State, the north by Bauchi and Gombe States, to the northeast by Adamawa State, and the east and south by Cameroon.

Taraba State lies largely in the middle of Nigeria and consists of an undulating landscape dotted with a few mountainous features, including the scenic and prominent Mambilla Plateau. The State lies largely within the tropical zone and has a vegetation of low forests in the southern part and grassland in the northern part. The Mambilla Plateau, with an altitude of 1,800 metres (6000 feet) above the sea level has a temperate climate all year round.

The Benue, Donga, Taraba and Ibi are the main rivers in the State. These water bodies rise from the Cameroon mountains, spanning almost the entire length of the State, from the North to the South, and linking up with the River Niger.

The Plateau, which developed on basement complex rocks, measures about 96 kilometres along its curved length and 40 kilometres in width, whilst bounded by an escarpment that is about 900 metres high in some places. The Mambilla Plateau serves as the watershed from which the major drainage systems in Taraba State take their source. Rivers Benue, Donga and Taraba (from which the State derives its name) are the dominant drainage systems, which flow across the Muri plains to drain the entire State.

Coupled with other minor rivers, such as the Lamorde and Mayo Randewo, they form extensive flood plains in the central part of the State, providing sufficiently fertile agricultural land, which is presently underutilised. The undulating hilly surface of the plateau is uniquely attractive for its scenic beauty.

The surface of the plateau, with its blend of an evergreen low growing grass vegetation, neatly demarcated into some kind of ranches/grazing reserves, and the sharply meandering road with hairpin corners across hill slopes, ravines and deep gorges, make driving to and from the plateau most astounding and interesting to a visitor.

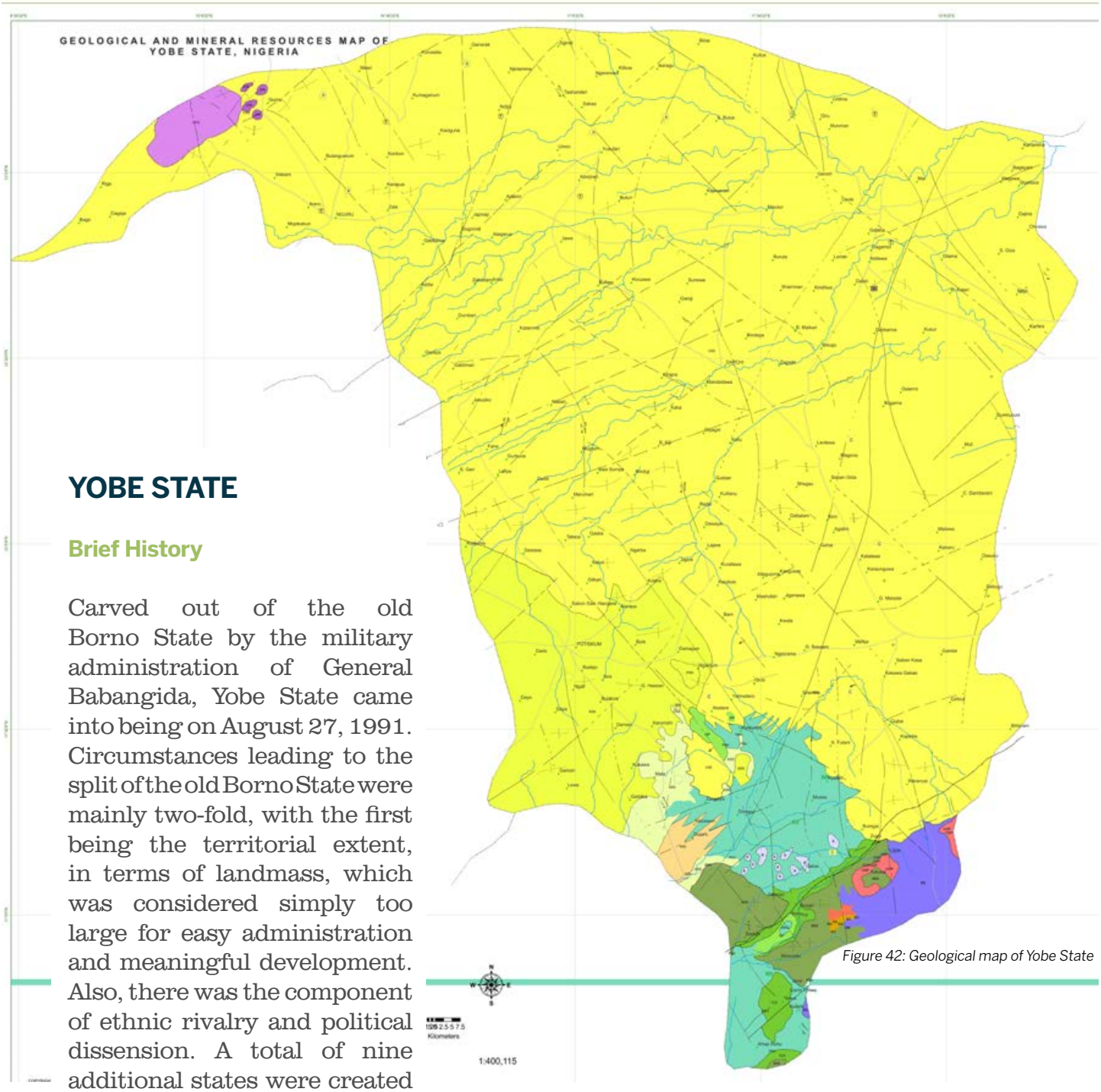

Figure 42: Geological map of Yobe State

YOBE STATE

Brief History

Carved out of the old Borno State by the military administration of General Babangida, Yobe State came into being on August 27, 1991. Circumstances leading to the split of the old Borno State were mainly two-fold, with the first being the territorial extent, in terms of landmass, which was considered simply too large for easy administration and meaningful development. Also, there was the component of ethnic rivalry and political dissension. A total of nine additional states were created at that time, bringing the total number of states in the country to thirty, from twenty-one. Today, Nigeria is made up of thirty six states and a Federal Capital Territory.

Geology

Yobe State principally comprises crystalline and sedimentary rocks, underlain by basement complex rocks. The crystalline rocks are represented by older granites found in pockets of places in the southern

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part of the State. Another crystalline rock formation of younger age is located in the northwestern tip of the State in the Machina area. The older granite is Precambrian in origin, consisting of metamorphic structures of gneiss and amphibolite rocks. The younger granitic rocks are of the Jurassic period, deposited between 195 and 135 million years ago. The sedimentary rocks that are found in most parts of the State were uncomfortably deposited on the basement crystalline rocks.

In the southern fringe of the State, the sedimentary deposits are made up of the cretaceous Bima, Pindiga, Fika and Gombe formations. The Karekare formation is also found in this part of the State. However, in the greater part of Yobe, all these sedimentary formations are uncomfortably overlaid by a large expanse of Quaternary Chad formation stretching into Jigawa and Borno States. The Biu basalts found in the southern end of the State are believed to have extruded during the Tertiary/Quaternary periods as lava flows. However, the influence of climatic fluctuations is reflected in the superficial deposits overlaying most of Yobe State. This, for instance, has led to the deposition of a series of longitudinal and traverse dunes around Yunusari, Yusufari, Machina, Geidam and Bade local government areas.These run in a north-east to south-west direction in response to the prevailing wind direction.

Yobe State generally lies between 300 metres and 600 metres above sea level, except in the southern part of the state where volcanic rocks occur. The rock formation also contains water-bearing aquifers from which much of the water supply of the State is derived. The River Yobe, giving the State its name, is the biggest water body in the State, flowing eastwards and draining into Lake Chad. It has a few tributaries, one of the most important being River Alkalam, in which the famous yearly Bade fishing and cultural festival takes place.

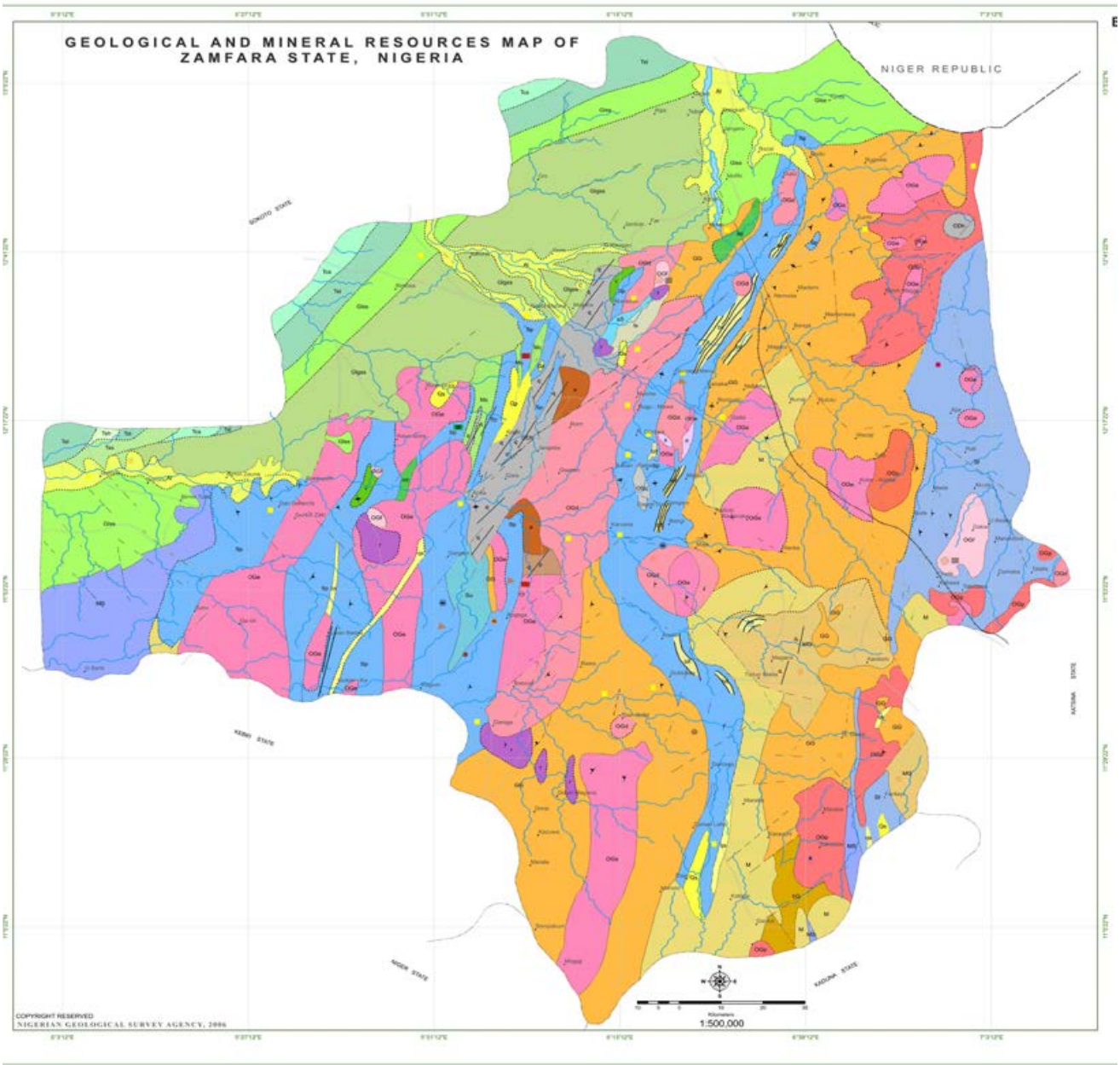
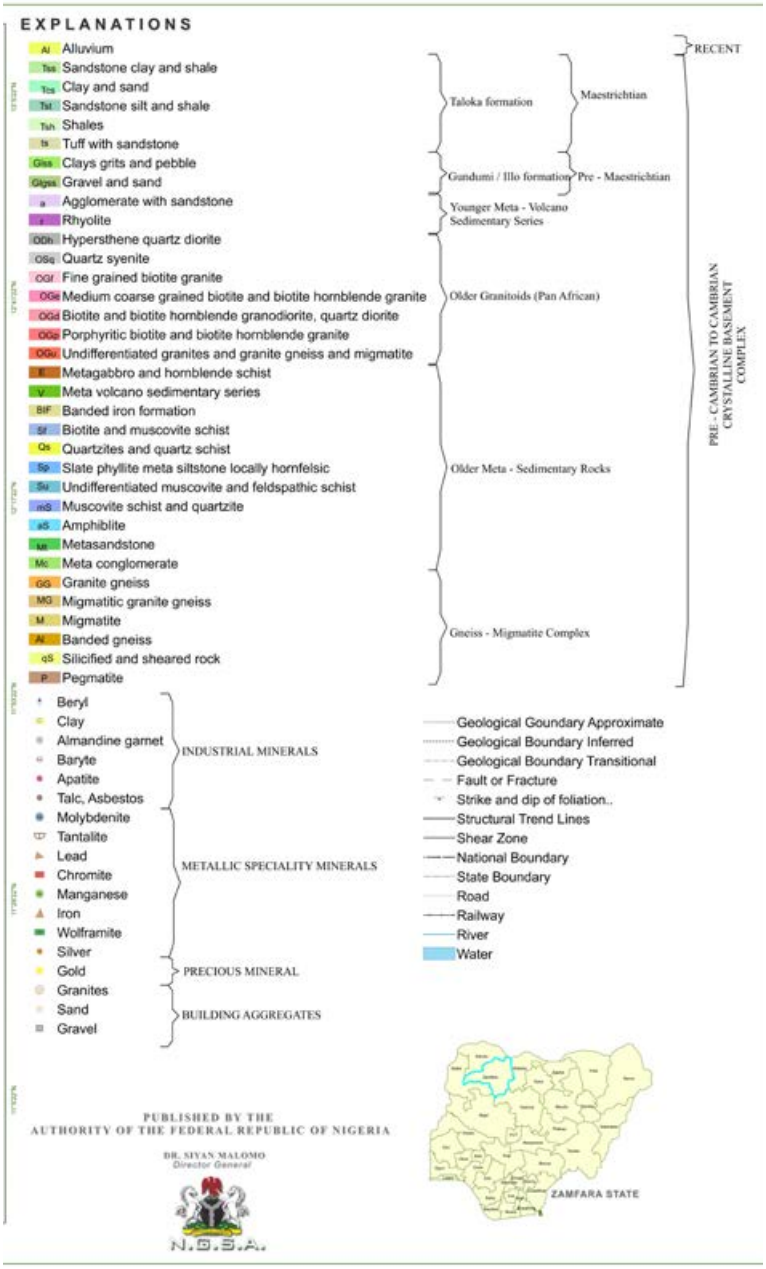


Figure 43: Geological map of Zamfara State

ZAMFARA STATE

Brief History

Deriving its name from Zamfarawa, a traditional appellation by which the people of Anka, former headquarters of the ancient Zamfara Empire, were referred, Zamfara was one of the states created on October 1, 1996 by General Sani Abacha as Nigerian Head of State. The emergence of Zamfara into statehood brought to an end one of the longest, unrelenting and tortuous agitations, which began before and continued after the Jihad of Shehu Usmanu Danfodiyo. The agitation also persisted through the colonial era to the tail end of the twentieth century.



Carved out of Sokoto State, at inception Zamfara consisted of 12 local government areas (LGAs), namely Anka, Bakura Bungudu, Bukkuyum, Gusau, Kaura Namoda, Talata Mafara, Maradun, Tsafe, Zurmi, Gummi and Maru. Currently, there are 14 local government areas in the State, with the creation of Shinkafi and Birnin Magaji LGAs.

Geology

The State is characterised by very old igneous and metamorphic rocks, formed during the Precambrian era. Two rock types found in the area are granites and metasediments. The granites (including undifferentiated granites), gneisses and migmatites are lively and resistant to erosion, but on weathering, they result in poor soils. The metasediments, on the other hand, consist of phyllites, quartzites and metaconglomerates.

Although metasediments are also resistant to erosion, however on weathering, they give rise to more fertile soils, on account of the fact that the schist are rich in m agnesium minerals. In general, the relief of the State bears relationship to its geology. The State's land surface is mainly made up of high plains (being part of the Hausa High Plains of Northern Nigeria).

The only exception to this is the ioda, extending north-eastwards from Talata Mafara and Moriki. There, dissected plateau crystalline rocks composed of a series or range hills around Maru, as well as the characteristic and large, steep sided smooth dome shaped hills calls , the inselbergs, exemplified by the Kotorkoshi Hill. It is Surrounding the inselbergs are plains which are used for farming. The general elevation of the land the ranges from 244m to 366m above sea level (Abd and Swindel, 1982).

THE FEDERAL CAPITAL TERRITORY (FCT)

Brief History

Abuja, Nigeria's Federal Capital Territory (FCT) was created in 1976, and it officially became the country's capital on December 12, 1991, when it replaced Lagos as the erstwhile federal administrative centre.

The site for the new capital was chosen because of its central location, easy accessibility, pleasant climate, low population density, and the availability of land for future expansion. Not only was the city designed, but the entire environment. Abuja is surrounded by abundant hills, highlands, Savannah grassland, and tropical rainforests.

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Geology

The FCT is almost predominantly underlain by high-grade metamorphic and igneous rocks of the Precambrian age. These rocks consist of gneiss, migmatites and granites. A schist belt outcrops along the eastern margin of the area, broadening southwards and attaining maximum development to the southeastern sector of the area, where the topography is rugged and the relief is high. In general, the rocks are highly sheared (Kogbe, 1978).

The lowest elevation in the Federal Capital Territory is found in the extreme southwest, where the flood plain of the River Gurara is at an elevation of about 70 metres above sea level. From there, the land rises irregularly eastwards, northwards and northwestwards. The highest part of the territory is in the northeast, where there are many peaks over 760 metres above the sea level. Hills occur either as clusters or form long ranges.

The most prominent of these hills include the Gawa range in the northeast, the Gurfata range southwest of Suleja, the Bwariaso range in the northeast, the Idon Kasa range northwest of Kuje and the Wuna range, north of Gwagwalada. Elsewhere in the territory, there are many rather roundish isolated hills, usually called inselbergs. In between the major hills are extensive plains, the most important of which are the Gwagwa plains, the lku Gurara plains, the Robo plains and the Rubochi plains. Indeed, about fifty two percent of the Federal Capital Territory consists of plains. Of these plains, the Gwagwa plain was selected for the building of the Federal Capital city (FCC).

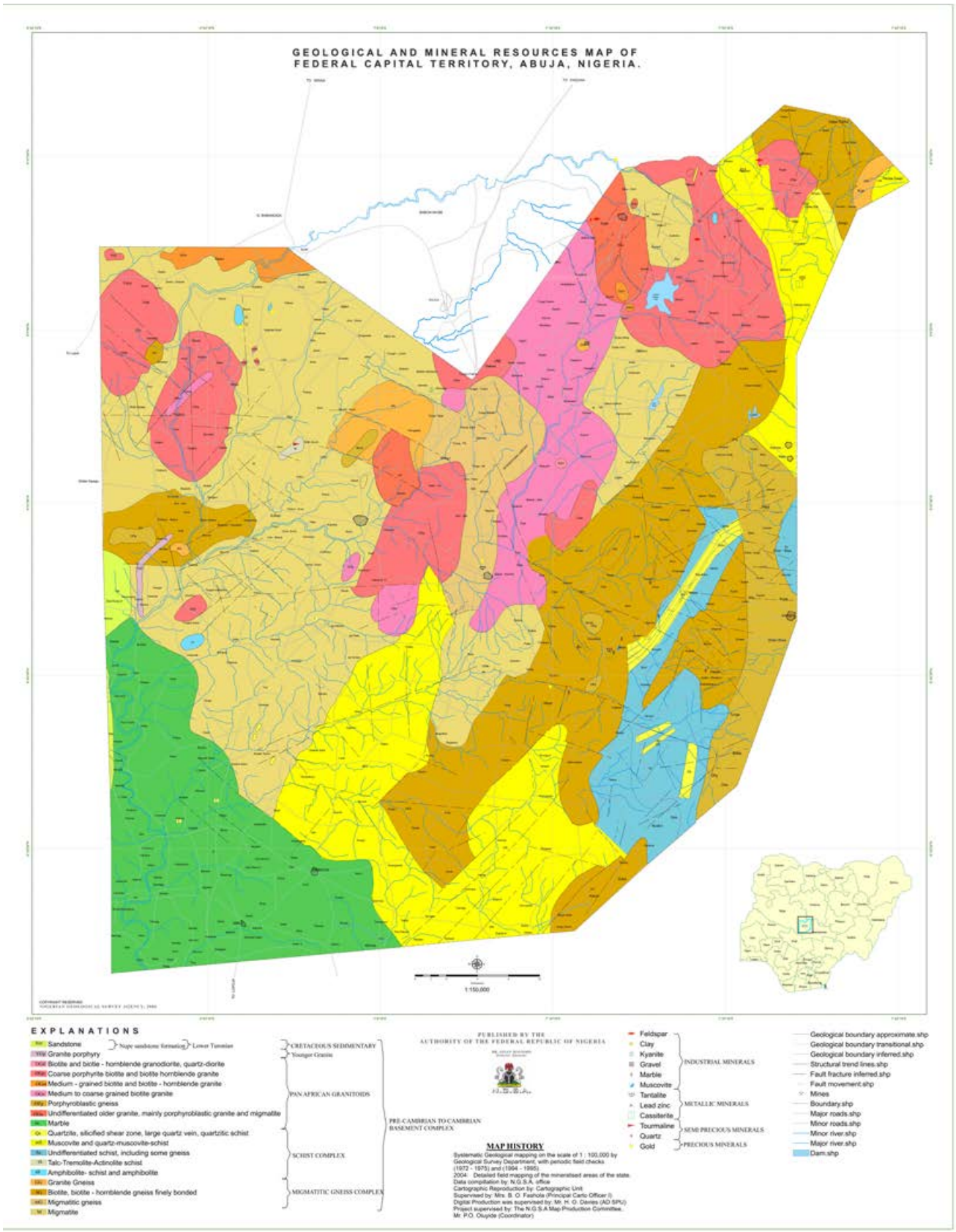

Figure 44: Geological map of FCT

CHAPTER SIX

Conclusion

Report has been able to show that all the states of the Nigeria are richly endowed with various mineral resources.

There is no doubt that Nigeria is endowed with a rich geology that supports a variety of mineralisation that can be harnessed on a commercial basis. This is able to lead the economic diversification efforts of the Federal Government, contribute sustainably to national economic growth, while becoming an expanding source of job creation in Nigeria. While the extractive sector is capable of making significant contributions to a nation's economy, the need for an understanding of the country's mineral endowments and attendant appurtenances for holistic utilisation and development, is also necessary. This will ensure that the real owners of the endowments, which are ultimately the people, are able to maximally benefit.

This report has been able to show that all the states of the Nigeria are richly endowed with various mineral resources. It is hoped that this information would encourage the various stakeholders in the extractive industry to seek out these potentials, with the private sector, governments, local and international investors, hopefully looking inwards to invest in the country's solid minerals sector.

Also, this study has provided a strong basis for the preliminary assessment of the expectations of returns from Nigeria's solid minerals sector, as exploitation and revenue accrues therefrom, and ultimately its immediate and potential contributions to the nation's Gross Domestic Product.

This study has provided a strong basis for the preliminary assessment of the expectations of returns from Nigeria's solid minerals sector

CHAPTER SEVEN

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