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Structural Composition and Significance of Sedimentary Formations in Nigeria

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Abstract

The paper examines the structural composition of sedimentary formations in Nigeria. The study adopted an historical approach with emphasis on the review of related papers. The states along the basins were used as the basis of collating geological information about the basins. The data were from the late Mesozoic era to the present. Formations were initially composed of clay, silt, mud and sand. These have metamorphosed (mineralised) overtime into metasediments like shale, hydrocarbon, limestone, gypsum, phosphate, coal, quartz sand, feldsparthic sand, micaceous sand, tar sand among others. These met sediments are presently the major resource base of the country. There is therefore the need to take inventories of these natural wealth and plan for the most efficient ways of using them to promote the development of related agriculture and industrial activities, diversify the national economy and as well create of geological reserved areas.

Keywords: *Sedimentary, Formation, Structure, Composition, Significance.*

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Background to the Study

Sedimentary rock is the rock type formed through the sedimentation of particles. Sedimentation is a collective name for processes that cause organic particles (detritus) to settle and accumulate or minerals to precipitate from a solution. It is formed by the deposition of particles at the surface of the earth and within water bodies (sedi rock 2015). The dominant constituents of sedimentary rock include: (1) quartz-common and extremely hard, resistant and chemically stable rock grain (csmres 2015), (2) calcite and dolomite-cementing agents in shale and sandstone (3) clay- residual product from the weathering of silicate mineral, (4) rock fragments- unweathered remnant of weathering including feldspar and mica, (5) evaporates like halite (salt) and gypsum, and (6) organic matter like the remnants of plant and animal (silt) (EEsc 2200, 2008).

Basically the primary components of sedimentary rocks are clay, silt, mud, sand, gravel, and conglomerate. When these primary components got exposed to prolonged heat and pressure, they changed (metamorphosed) in physical form and chemical composition into other rock forms animal remain $\rightarrow$ limestone $\rightarrow$ marble. Plant and animal remain $\rightarrow$ mud/siltstone $\rightarrow$ shale or lignite $\rightarrow$ limestone, coal or hydrocarbon. Metasediment is the term used for sediment or sedimentary rock that appears to have been altered by metamorphism (Venon, & Clarke 2008). In this study, both the primary component and their metasediment equivalents were collectively treated as sedimentary rock.

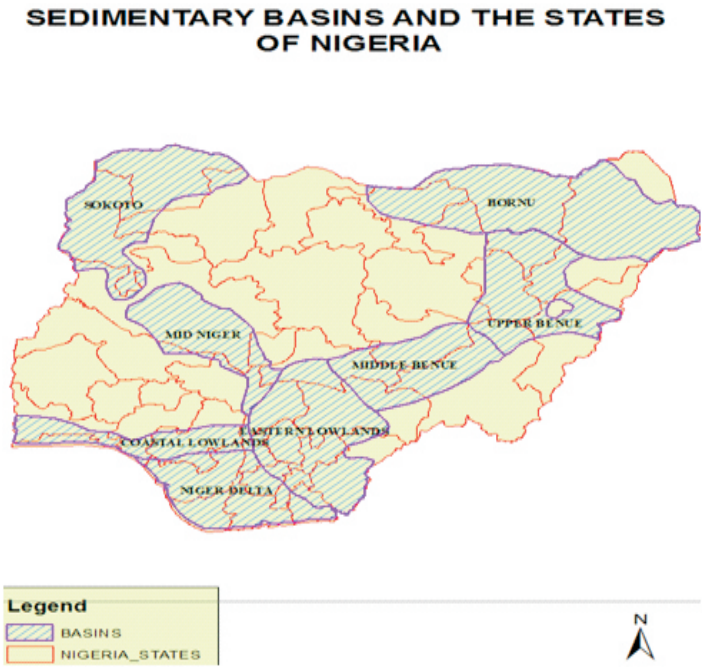
There are three basic types of sedimentary rock. These are the classic, chemical and organic categories. The classic sedimentary rock formed through mechanical weathering (sedi rocks, 2015), biological/organic sedimentary rock forms from the accumulation of plant and animal remains (Nelson S.A, 2015), and chemical sedimentary rock forms when dissolved material (chemical) precipitate from solution (Sedi rocks, 2015). It forms when a mineral constituent in solution become super saturated and inorganically precipitate (Nelson 2015), noted that clearly defined classification of sedimentary rock is a little difficult to achieve; the rock forms through a diversity of processes (Sedi rocks, 2015). In essence, it is possible to have more than three types of sedimentary rock. We can equally have a combination of two or more processes at a time.

Sedimentary rock forms in layers (bed or strata). A bed is defined as a layer of rock that has a uniform lithology and texture (Sedi rock, 2015). Series of beds made up a strata and a sequence of strata that is sufficiently unique to be recognized on a regional scale is termed a formation (Nelson, 2015). The setting in which a sedimentary rock forms is referred to as its environment. A marine environment is that where rock formed inside the sea or ocean while the continental environment refers to rocks which formed on the land (Sedi rock, 2015). The word structure as used here, refer to the arrangement of sedimentary formations in order of their geological age. Generally one way of establishing the similarities and differences of the formations is by examining their components. In essence the paper employed the word structure in the sense of arrangement and composition of sedimentary formations in Nigeria.

The Study Area

Nigeria occupies the south eastern end of West Africa. It is located approximately between latitudes 4° and 14° north of the equator and longitudes 3° and 15° east of the prime meridian. The area size is 923,768 square kilometres. The climate varied from equatorial in the south, tropical in the centre and semi arid in the north east (Encarta 2005). Where large scale sedimentation takes place is called sedimentary basin. In Nigeria, four sedimentary basins are in existence Ogun-Osse, Cross river, Bornu and Niger/Benue basins. Niger/Benue basin can still be grouped into six sub units, these are: (i) Upper Niger (Rima) Basin, (ii) Middle Niger (Kaduna) Basin, (iii) Upper Benue (Gongola/ Yola) Basin, (iv) Middle Benue (Katsina Ala) Basin, (v) Lower Niger (Anambra) Basin and (vi) the Niger Delta.

The states along each of the basins are 1. Ogun-Osse basin (Lagos, southern Ogun, southern Ondo and Southern Edo states). 2. Bornu basin (northern Bornu, northern Yobe and Eastern Jigawa state), 3. Upper Niger basin (Sokoto, Kebbi, Western Niger and western Zamfara states), 4. Middle Niger basin (Southern Niger and Western Kogi states), 5. upper Benue basin (Gombe, Western Bauchi and Western Adamawa states), 6. Niger Delta basin (Bayelsa, Rivers, Southern Delta States). 7. Middle Benue (Eastern Taraba, North eastern Benue, and South East Nassarawa states), and 8. The Lower Niger and Cross river basins were treated together here as Eastern lowland (Southern Cross river, Ebonyi, Northern Akwa Ibom, Abia, Northern Imo, Anambra, Enugu, South Eastern Kogi, Western Benue states). See figure I below



Source: Oyelami A.A 2016

Benue basin is believed to form by the rifting of the central West Africa basement. Anambra sub-basin forms as a second round of deformation within the Benue basin (Metasediment, 2016). Gongola basin is one of the two sections that forms the upper Benue basin. Rima basin is the Nigeria section of lillumeden basin (Sokoto state, 2003). Ebonyi state lies in the Aboine (Ebonyi) river basin and part of the Cross river plain (Enugu, 2003). Ikom depression is in Cross river state (Cross river, 2003). Bornu basin is an area that was subjected to prolong continental and lake sedimentations as a result of the down warp of the Chad basin (Bornu, 2013).

Methodology

Data were gathered using states as points along the basins. The chronological order in the establishment of sedimentary formations in each of the affected states was stated. Later the composition of each layer (formation) was enumerated. States with similar formations (in terms of naming) were later grouped together. The paper was generally organised in the following order: (1) sequence in the built up of sedimentary formations over the past geological ages (2) resources significance of sedimentary formations in Nigeria and (3) the conclusion.

Sequence in the Establishment of Sedimentary Formations in Nigeria

The sequence in the formation of the sub-surface stratigraphic units that constitutes the bedrock of the present sedimentary surfaces of Nigeria is summarized on table II. Table I below provides the clue needed to interpret table II.

Table I: Geological Age involved in the Establishment of Sedimentary Formations of Nigeria

	Era	Epoch	Geological Age (in millions)	Formation Environment
1a.	Quarternary	Holocene	0.0117-0126	Continental
b.		Pleistocene	0.126-01.80	Continental
2a.	Cainozoic	Pliocene	2.58-3.600	Marine, continental
b.		Miocene	7.246-20.44	Marine, continental
c.		Oligocene	23.03-28.1	Marine
d.		Eocene	33.9-56.0	Transition
e.		Paleocene(Nadian)	56.0-66.0	Marine
3a.	Cretaceous	Maastrichtian	66.0-72.1	Continental
b.		Campanian	72.1-83.6	Marine
c.		Santonian	83.6-86.3	Marine
d.		Caniacian	86.3-89.8	Marine
e.		Turo nian	89.4-93.9	Marine
f.		Cenomanian	93.09-100.5	Transition
g.		Albian	100.5-113.0	Continental

Source: https://en.wikipedia.org/wiki/geologicalage

Table II: Spatial Pattern in the Formation of Sedimentary Rocks in Nigeria

	ANAM-BRA	IMO	ABIA	ENUGU EBONYI	DELTA EDO	RIVERS BAYELSA	AKWA IBOM	CROSS RIVER	BORNU	JIGAWA GOMBE YOBE	BENUE NASSARAWA	ADAMAWA	SOKOTO	BIDA LOKOJA	ABEOKUTA ONDO
1a	Allu-vium	Allu-vium		Allu-vium	Ogwash /Uku	Allu-vium			Sand dunes	Allu-vium/ sand dunes			Alluvium		
1b	Benin	Benin	Benin	Benin	Agbada Akata Benin	Benin Agbada Akata	Allu-vium		Down-warp (chard)	Chad			Alluvium		
2a	Benin				Agbada/ Akata			Cross river Delta	Chad	Chad	Volcanic Alluvium				
2b	Benin	Benin	Benin	Benin	Benin	Benin	Benin		Gombe	Gombe					Benin
2c	Onitsha/ Nnewi	Akata / Agbada	Bende Ameki	Folding	Akata/ Agbada	Akata / Agbada	Ameke	Folding	Gombe	Gombe					
2d	Nianka/ Ameke	Akata	Bende Ameki	Nsukka	Akata/ Agbada	Akata / Agbada	Imo		Gombe	Kerri kerri Alkaleri, Lamja		Volcanic Alluvium	Gwandu		
2e	Imo	Imo /Akata	Nsukka	Nsukka	Akata	Akata	Imo		Gombe	Gombe			Gamba, Dange, Kalabaina		Lagos-Ore
3a	Ajali	Owerri	Igali	Mamu / Ajali	Nporo	Nporo	Nsukka	Ikom depres-sion, Mamfe-rift		Gombe	Lafia	Gombe Numanha	Taloka Dukamaje	Agbaja patti, Batati Enagi, Sakpe	
3b	Nporo Mamu/ Enugu		Nporo	Enugu / Awgu					Fika	Fika (Nafada)		Fika		Jima Doko , Bida, Lokoja	
3c									Warping	Warping	Akiri Folding				

3d				Awgu/ Ndea-boh				Agbani	Fika	Pindiga	Makurdi				
3e	Nka-lagu	Nka-lagu	Nka-lagu	Nka-lagu		Nka-lagu		Ezeaku	Gongila	Pindiga Lajal Dukul	Agbada Agbani	Pindiga Sekuliye			
3f	Ezeaku	Ezeaku	Ezeaku	Ezeaku		Ezeaku/ Odu-kpani		Calabar / Odu-kpani Agala	(Blin) Yolde	Yolde/ Mamme /Jessu/ (Bam-bam)	Keana, Awe Ezeaku, Konshisha Wadata	Yolde , Jessu.			Abeokuta /Ijebu ode
3g	Asuu river (An-cient Delta)	Asu river	Asu river	Asu river		Cross River		Ogoja, Aba-kaliki Mfa-masing	Bima	Bima	Asu river (Gboko, Uombia, Asufa)	Bima Lamurde	Gundumi		

Sources: Compiled from Various Sources

Sedimentary Formations of Albian (Cretaceous) Age

The era marked the first set of sedimentary formations in Nigeria. By then, the present sedimentary basins of Nigeria were under the sea. In essence, there was inland extension of the Gulf of Guinea by the way of Benue valley (Udo 1982, Iloeje 1981). The Cross river plain witnessed the sedimentation of the Asu formation which is now composed of thick sequence of sandstone, shale, limestone, micaceous siltstone, mudstone and clay. The formation is about 1800 metres thick and it outcropped along the course of Asu river (Ebonyi, Enugu, Cross river 2003).

Bima formation of the Gongola/Yola area is presently composed of coarse to medium grained sandstone, carbonaceous clay, shale with limestone intercalations and mudstone. The formation is feldsparthic and about 2000 metres in thickness (Obaje 2009). Udo (1970) had it that the Bima sandstone consists of continental grit, sandstone and clay which were laid down in the southern end of the Chad basin. Exposure of the Bima coarse sandstone featured extensively in the south eastern part of Gombe state (Gombe 2003) particularly along the course of river Bambam. Gundumi formation of Sokoto basin is made up of sandstone, clay, basal conglomerate, gravel, sand and cross bedded grit (Sokoto 2003). Outcrops of the formation are observable at Kora Rolga north of Talata mafara in Sokoto state and Tureta in Kebbi state. Illo formation of Kebbi state is made up of interbedded clay and grit (Obaje 2009), pebbly grit, sandstone and clay (Kebbi 2003). Other formations of Albian age in Nigeria are the Ogoja, Abakaliki, and Mfamosing formations in eastern Nigeria, Lamude in Adamawa state, Gboko, Uombia and Arufu formations in the middle Benue region. (Ebonyi, Adamawa, Benue 2003)

Sedimentary Formations of Cenomanian Age

It is the second cretaceous era of deposition in Nigeria. It started as continental and ended as marine. Awe formation in Nassarawa state is composed of calcareous sandstone, Keana formation is made up of feldsparthic sandstone, occasional conglomerate, bands of shale and limestone, particularly towards the top. In the Eastern part of Nigeria, Ezeaku (Ortesh) formation is presently composed of black-shale, micaceous sandstone, feldsparthic sandstone and limestone (Obaje 2009). Others in eastern Nigeria are the Odukpani and Calabar formations. In the western part of Nigeria, Abeokuta formation is composed of sandstone, siltstone, silty clay, mudstone and shale. The overlying sand is clayey and micaceous. Thin layer of lignite with high content of bitumen and clay was discovered around Shagamu/ Ijebu-ode/Ore area (Ogun, Ondo 2003). Yolde formation along the Gongola basin is composed of sandstone, limestone, shale and clay, Yolde and Jessu formations succeeded the Bima towards the western part of Gongola basin. Bima is found in the south eastern area (Gombe 2003). The formation is observable along Pantami river in Gombe town (Obaje 2009).

Sedimentary Formations of Turonian Age

Major formations of the period are presently constituted as follows: In Ebonyi state, as in other eastern region we have the Ezeaku formation. In Enugu state the synclinal basin between river Niger and Ezeaku contains shale, siltstone, sandstone and limestone (Enugu 2003). In Gombe state the shale and limestone formations labelled the Pindiga (Gombe 2003). The formation is presently made up of carbonaceous (dark) shale and limestone with

some sandstone. The Gongila formation of the Bornu basin is composed of calcareous shale and silty sandstone (Obaje 2009). Other formations of the Turonian age are the Agala formation in the middle Benue, sekuliye and Dukul formations in the upper Benue region, among others. All formations of the period took place under an inland sea.

Sedimentary Formations of Caniacian Age

In the east, the sediments that form the Awgu-Ndeaboh shale were deposited during this era. It is presently made up of carbonaceous shale, shally limestone, sandstone, siltstone and coal (Obaje 2009). The fika formation which is composed essentially of shale and occasional limestone equally formed along the Gongola basin (Gombe 2003). Other formations of Caniacian age include the Agbani formation of the cross river basin, Pindiga formation of Gombe/Yola area, and the Makurdi formation of Benue state. All formations occurred under the sea.

Sedimentary Formations of Campanian Age

In the eastern part of Nigeria, major formations are the Enugu shale and Awgu sandstone. The Anambra basin witnessed the sedimentation of materials that later metamorphosed into paralic shale of the Enugu (Nporo/ Leru) formation, which was later overlaid by the coal deposit (the Mamu formation). Mamu formation outcropped along the slopes of Miliken hills in Enugu state (Enugu 2003).

In the middle Niger basin, marine shale is presently found around Lokoja where it developed to about 300 in metres thickness. It is composed of conglomerate, sandstone, siltstone, claystone, cobble, pebble, quartz sand and feldspar sand (Kogi 2003). Bida formation is made up of pebbly arkose, sandstone, siltstone, claystone, quartz sand and feldspar sand. In the western part of Nigeria, the sedimentation of Araromi formation took place and is presently made up of sandstone, shelly limestone and shale (Obaje 2009). Other formations of Campanian age in Nigeria are the Awgu, Fika, Jima and Doko formations. All sedimentary basins in Nigeria were, by the period, covered by the continental sea.

Sedimentary Formations of Maastrichtian Age

The era witnessed the sedimentation of Nsukka formation along the Cross river plain region. It is presently composed of shale in association with sandstone and limestone. The formation appeared at the surface around Nkari, Obotme and Itu LGAs in Akwa Ibom state (Akwa Ibom 2003). Ikom depression in Cross river state is composed mainly of sandstone and mudstone. Calabar flank is a thick sequence of shale and mfamosing limestone (Cross river 2003). In Enugu state the sedimentation of materials now constituting the lower coal measure (Mamu formation) and the false bedded sandstone (Ajali formation) continued. Formations of repute along the middle Niger basin were those of Patti, Enagi and Agbaja (south of Bida). Patti and Enagi are composed of sandstone, siltstone, claystone, shale and ironstone. Agbaja is made up of sandstone, ironstone and claystone (Obaje 2009). Patti and Enagi formations are made up of ironstone deposited within the continent to a shallow marine environment, Patti and Enagi were overlaid by Agbaja and Batati formations.

Taloka formation along the Sokoto basin is composed of multiple layers of sandstone and shale (Sokoto 2003). It is composed of fine grained friable sandstone, siltstone and carbonaceous mudstone. It outcrops around Goronyo, Taloka and Takarau. It is the oldest formation in the Rima sub group. Dukamaje layer is shally and non aquiferous. It is composed essentially of shale with limestone and Shelly/fossiliferous mudstone. Wurno formation is more of one layered sandstone (Sokoto 2003). The sediments consist of sandstone, siltstone and mudstone, with carbonaceous materials. Wurno formation outcropped at Gada. In Kebbi state, the Rima group is made up of mudstone and siltstone (Kebbi 2003). Gombe sandstone also formed during this era along the Gongola basin (Gombe 2003) and it is made up of coal, lignite, shale, siltstone and ironstone (Obaje 2009). Other formations of maastrichtian age in Nigeria includes, Owerri, Igali, Ogwashi/Asaba, Nporo. Ikom and Lafia formations.

Sedimentary Formations of Paleocene (Early Nadian, Cainozoic or Tertiary) Age

It marks the first set of sedimentary formations during the Cainozoic era. By then part of Sokoto and Bornu basins were covered by large inland seas. Later the continental seas retreated and eventually led to massive sedimentation north of the equator. This marked the commencement of the Niger delta formation (Udo 1982, Iloeje 1981). Akata formation in the Niger delta region started to form. It is presently composed of clay and shale, with minor sand intercalations (30%). Akata shale was by then deposited in the south western section of the Niger delta basin (Metasediments 2016). It was the period when marine shale of Imo, Nsukka, Akata and Agbada formations originated. During the period, river Benue and Niger valleys were transgressed by the water of the Atlantic Ocean. The deposited marine sediments have undergone varying degrees of metamorphism, and the resulting metasediments are dominantly sandstones with shale, siltstone, limestone and quartzite (Benue 2003).

In the cross river region, the cross river delta built out onto the continental shelf and the ocean floor (Cross river 2003) . In Akwa Ibom state, Imo shale and the phosphatic Ameke formation started to form (Akwa Ibom 2003). Imo shale is a sequence of grey shale, occasional clay, ironstone and sandstone (Benue 2003), it is the dominant sedimentary rock along the surface (Anambra 2003). Imo shale extended to the eastern part of Anambra state, particularly the Ayamelum, Awka north and Oruma LGAs (Anambra 2003). The period was also marked by the continuation of Nsukka formation which is composed of upper coal measure, coarse sandstone, fragments of ironstone and ferruginised shale. The formation was uplifted later to form Enugu-Okigwe escarpment. Nsukka formation is observable along the surface at Udi- Nsukka plateau where differential erosion has left the resistant portion standing out as rounded conical hills (Enugu 2003).

Along the Rima basin, Dange, kalambaina and Gamba formations started to form. They consist of slightly indurated bluish-grey shale, interbedded with limestone. The Dange formation appeared at the surface along the slopes of Dange, Sokoto and Wurno hills. The shale is with bands of gypsum and phosphatic nodules .Kalambaina formation is made up of limestone and it is acquiferous (Sokoto 2003) . It is composed of marine white clayey limestone and calcareous shale Gamba consists of shale, and like Dange, it is associated with phosphatic pellets below the ironstone (Obaje 2009). Lagos-ore coastal lowland formed

during this period. This fact is supported by Udo (1970) when he wrote that the basement complex is overlaid by sandstone of tertiary age in areas around the coast, along the southern end of Oyo high plain.

Sedimentary Formations of Eocene Age

In Eastern Nigeria, thick sequence of clay, sand and gravel called Ameke formation continued to form. And in the north eastern area of Akwa Ibom state, these gravel beds and pebbly sand are exposed on hill sides, road cuttings and stream channels (Akwa Ibom 2003). In Anambra state, Ameke formation outcropped on higher cuestas around Abagana, Nsugbe, Nanka, Oko, among others, where it is called Nanka sand. The fomation is made up of sandstone, calcareous shale and shelly limestone (Anambra 2003).

In the Niger delta region, Akata and Agbada formations continue their development. Akata formation is composed of continuous shale (90%) and about (10%) sandstone. It is up to 7000 metres in term of thickness and it underlies the entire delta region (Clay, 2015). Agbada overlies the Akata layer and it is more of an alternation of sandstone and clay of partly marine origin which eventually grades downward into marine clay (Rivers 2003). It is consisted of paralic siliciclastics of over 3700 metres in thickness. Shale and sandstone were deposited in equal proportions, sometimes shale could be minor (Clay 2015), Obaje (2009) had it that sand is 30 to 70 percent.

Along the Gongola basin, Kerrikerri formation is composed of sandstone, siltstone, ironstone and gritty clay (Gombe 2003). In the Sokoto basin, the forth sedimentary layer, the Gwandu group, formed. It is presently made up of clay, occasional peat bands, mudstone and sandstone (Sokoto 2003). It contains a number of ridges and flat topped steep sided hills capped by ironstones. The formation appeared at the surface around Birnin kebbi and Argungu (Obaje 2009). Other formation of Eocene age is the Bende-Ameki formation Akwa Ibom area.

Sedimentary Formations of Miocene Age

The major sedimentary rock of the era is the Benin formation, a continental deposit of alluvial and upper coastal plain sand. The sand is loose, poorly sorted and unconsolidated with little hydrocarbon (Delta 2003). It is composed of 90 percent sand and 10 percent shale/clay. The sand bear lignite streak and wood fragment (Mica 2005). In Anambra state the formation is made up of yellow and white sands particularly in Ihiala local government area (Anambra 2003). In Akwa Ibom state, Benin formation has been weathered into lateritic layers around Ini, Ikono, Etinan, Ikot-Ekpene, Ibiono and Itu Local government areas (Akwa Ibom 2003). It varies from 1800m to 2000m in thickness (Delta 2003). Gombe sandstone also continues to form. Others are Onitsha/Nnewi, Akata/Agbada and Bende/Ameki formations.

Sedimentary Formations of Pleistocene Age

According to Udo (1982) continental and marine alluvial deposits continue along the Niger delta region. This was corroborated by Iloeje (1981) that the Atlantic ocean withdrew to its present boundary, Sokoto lake dried up completely, Bornu lake shrank to the present size of Lake Chad while the Sahara became drier. It was the era when Bornu formation came into

existence, a sequence of continental silt and clay of Lake Chad origin. Bornu formation covers the northern Bornu, northern 1/3 of Gombe (Gombe 2003), the north eastern part of Jigawa state (Jigawa 2003), and northern Yobe state (Yobe 2003). Other formations of the period are Benin, Agbada and alluvium deposits.

Sedimentary Formations of Holocene Age

Influence of climatic fluctuations led to the presence of superficial deposits of dunes around Yunusari, Yusufari, Machina, Geldam and Bade Local government areas of Yobe state (Yobe 2003). The north eastern part of Jigawa state is covered by sand dune with no surface outcrop of the underlying formations (Jigawa 2003). Recent alluvium and beach ridges occupy the surface along the coastal areas, Imo river estuary, Qua Iboe river and the flood plain of creeks in Akwa Ibom state (Akwa Ibom 2003). Flood plain of the Benue river is with alluvial deposit comprising an assortment of clay, sand, gravel and pebble (Benue 2003). Holocene deposit is also found in the western part of Anambra state, particularly north and south of Onitsha (Anambra 2003), Niger/Anambra floodplain (Enugu 2003), and the coastal margin of Nigeria (Lagos 2003).

Rivers state lies on the recent coastal plain and its surface geology consists of fluvial sediments transported by the Niger, Andoni, Bonny and new Calabar rivers. Sand form the major rock types while mud constitutes all the polluted brackish water of the riverine area (River 2003). Bayelsa state is believed to have formed during the holocene era through the accumulation of sediments. The major geological characteristic is the sedimentary alluvium, and the entire state is characterized by abandoned beach ridges (Bayelsa 2003).

Resource Significance of Sedimentary Formations in Nigeria

Alluvium

Extensive flood plains are the most fertile agricultural lands in Nigeria. In the gongola basin area, the most productive soils are found along the narrow flood plains. Fertile silt from the flood allows for annual farming without fallow along the fresh water zone of the Niger delta. Alluvial deposit areas of agricultural repute in Nigeria includes the valley of river Niger, particularly around Birnin Kebbi, and Yelwa Yauri in Kebbi state, as well as Borgu, Bida, Agaie, Lepal, Mokwa, Lavin, Gbako and Wushishi LGAs of Niger state (Niger 2003). According to Obaje (2009), flood plain of river Niger is one of the largest and most fertile agricultural land as well as the best area for rice production in Nigeria. (Obaje 2009). The upper Niger basin had been officially commissioned by President Muhammad Buhari for commercial production of rice in Nigeria as a means of reducing the nation's dependence on food imports. Carrot, onion, sugarcane, cereals, vegetables and other agricultural plants that are of traditional repute along the Fadama areas of Nigeria can be commercialized.

All rivers in Nigeria are associated with flood plains particularly along the lower course of flow. These alluvial areas are liable to the formation of shale, limestone and other metasediments in the geological future.

Clay/Siltstone/Mudstone

Major deposits of clay in Nigeria includes Kankara in Katsina state, Naraguta near Jos, Alkaleri in Bauchi state, Shabu and Lafia areas of Nassarawa state, Ahoko near Lokoja (Obaje 2009, Kogi 2003). Clay is employed for pottery, plumbing, fixture, tile, ornament, brick, furnace lining, cement ingredient, electric conductor and insulator. In Jigawa state, aeolian deposit from the Sahara desert form substantial part of the soil. The mixing of the subsoil with aeolian deposits had given rise to clayey subsoil which dominates the northern end of the state. The chard formation is made up of sandy beds which formed over the impervious clay and as a consequence form the main water source in the dry season (Jigawa 2003).

Mudrock can host ore metals such as Lead and Zinc. Mudrock can preserve petroleum and natural gas due to their low porosity (Mudrock 2003). Clay, siltstone and mudstone are the initial sediments which later metamorphosed into slate, phyllite, lignite, shale, limestone, coal, hydrocarbon and other carbonated rocks. Shale is used in the preparation of tiles, roof, terra cotta pot, and as crushed limestone (Kebbi 2003), it contain organic materials (black organic shale) that sometimes breaks down to form natural gas and oil (Kogi state 2003).

In Nigeria, limestone is majorly employed in the production of cement. In this respect the Odukpani formation of the Calabar flank forms the quarry for Calabar cement and Ezeaku formation is the quarry for Nkalagu cement. The Pindiga, Jessu and and Dukul formations constitutes the quarry for Ashaka cement. Quarry of Sokoto cement is on kalambaina formation (Obaje 2009). Gongila and fika formations have been established as potential petroleum source rocks. Marble is significant as building stone, monument, whiting material in toothpaste, paint, filler in paint, paper and plastic (University of Auckland).

Phosphate is associated with limestone in the Dukamaje, Kalambaina (Dange/shuni), Pindiga and Ewekoro formations. It is a sedimentary rock used in the production of phosphoric acid and ammoniated phosphate fertilizer, feed additive for livestock, chemicals for industrial and home consumers, among others. Gypsum also occurs in close association with phosphate in the Dukamaje, Wurno, Dange, Nafida, Potiskum and Gboko formations. Gypsum is used locally in the production of cement.

Graphite, the highest rank of coal, is used in the preparation of pencils and lubricants. Nigeria is rich in coal deposits derived from terrestrial organic matter. They formed in brackish mashes which are later covered by coarse sands. Coal is used in the generation of electricity (Encarta 2005). Lignite is used as an ornamental stone, as an effective absorbent for fuel and oil spills, and as conditioner for soil water retention capacity. Coal is found in the Anambra basin and in the upper Gongola basin (Metasediments 2016), particularly in Enugu, Okaba, Ogboyega, Orukpo, Lafia-obi, Gombe and Chikila areas.

Sandstone

Sandstone is the ideal rock for groundwater as it hosts substantial aquifers. The sandstone portion of Gundumi, Gwandu and Taloka formations contain a lot of water and are currently being harnessed through boreholes (Sokoto, Kebbi 2003). Bornu formation is the main source of groundwater in Nigeria section of the Chad basin (Obaje 2009). Quartz is found in abundance to the north east of Akwa Ibom state among clay, sand and gravel of thick

sequence (Akwa Ibom 2003). Quartz is also associated with middle Niger (Bida) formation. Black mica is used as filler in paint and additive in drilling. White mica (muscovite) is needed in the production of electrical equipment. Workable quantity of mica is found in Lokoja (Kogi state), Wamba, Gidan kwano and Toto areas of Nassarawa state. (Obaje 2009). Sandstones along Ezeaku, Ortesh and Abeokuta areas are rich in mica mineral (Clay 2005). Feldspar is used in the production of glass, ceramic, paint, plastic and rubber (Britannica.com). Sandstone of Bima, Keana, Ezeaku and Bida formations are rich in feldspar.

Tar sand is found along the West-East belt from Lagos to Edo state. It is an important raw material used in the production of non-convectional petroleum products like lubricant, grease, wax, bitumen and asphalt. Oil and gas in the Niger Delta region is principally produced from sandstone and unconsolidated sands of the Akata/Agbada formation.

Character of the Landscape

Rock structure determined the type of soil in an area. In the south eastern area of Nigeria, for instance, the parent materials are the cretaceous and tertiary sediments. As such three, soils types are found. These are acidic, lateritic and alluvial soils. All the soils in the region are acidic in reaction. Acidic sands are derived from sandstones and they occur on plateau surfaces. Lateritic soil (ferruginised sandstone) develops along flat and gently sloping surfaces. Alluvial soils are found along the major river valleys (Udo 1970). There are has two rock types in Zamfara state, granite and metasediment. The metasediments consists of phyllite, quartzite and meta-conglomerate. They are resistant to erosion and give rise to more fertile soils, because the schists content are rich in magnesium minerals (Zamfara 2003). A close relationship also exists between rock geology and surface morphology. In the scarpland of south eastern Nigeria for instance, the main plateau surface are associated with false bedded sandstone (Ajali formation) while the middle and lower faces of the north and east slopes are associated with the lower coal measure (mamu formation) (Udo 1970). According to Jarrett (1980), young sedimentary rocks have been laid down over the older rocks and considerable thicknesses of more recent sedimentary rocks are the basis for the occurrence of scarp slopes which signifies marked change in slope erosion. In greater part of Benue state, particularly the Muri plain area, sedimentary areas are with flat topped hills, due to lateritic capping, while dome shaped hills or erosional survivals are found in the granite (crystalline) areas. This is the situation in all parts of Nigeria. According to Filani (1995), quartzite gave rise to impressive ridges and hills in the west, southern Sokoto and Benue areas.

Other Sedimentary Minerals

Some chemically formed sedimentary rocks are equally known for some forms of minerals. A good instance is Baryte found in Abakaliki, Ishiagu, Azara (Benue), Keana, Gbande, Aloshi, Akiri, Wuse (Nassarawa) and Dadiya areas in the North East. Brine field/ salt deposit is also found in Abakaliki, Keana, Awe, Mutin Daya areas. The detached synclinal area formed by localised folding in the southern part of Nassarawa state is associated with salt bearing rocks around Awe, Keana, Azara, Akiri, and Bamonda. The brine springs are associated with anticlinal edges where the salt bearing beds within the syncline get exposed to the surface (Nassarawa 2003). Galena is closely associated with salt deposits in Nigeria.

Generally, sedimentary rocks are not known for metals, but it need be emphasized that they played a significant role in the formation of scarn deposits. Scarn deposit formed when hot magma, already charged with silica, aluminium and magnesium, heated up the calcium carbonate (sedimentary) solution. In this way the carbonate solution may mixed up with the mamga and get converted to metals in a metamorphic process. The resulting minerals are usually in form of iron, zinc, lead, gold, iron ore among others (Skarn 2015). Lead and zinc for instance are associated with the cretaceous Asu river formation around the Abakaliki and Zurak provinces (Obaje 2009). Iron ore along the middle Benue basin and gold in the Sokoto basin are the other examples. This is likely to be a factor why the metals along the basement complex regions are associated with alluvial areas

Conclusion

Nigeria as a country depends on primary commodities for sustenance. The country's experience with agriculture and mineral resources had not been all encouraging over the last 55 years of independence due to incessant and unexpected drop of price in the world market. Unfortunately, other sectors where national growth can be maintained like industry and technology have not been developed. What is important now is for the country to diversify its primary resources base and the sedimentary area of the country is still a hopeful target, particularly the sub surface cretaceous and tertiary metasediments, as well as the surface alluvium.

Shale appeared to be ubiquitous along the sedimentary basins in the country, giving an insight that greater part of Nigeria lowlands are still in the intermediate stage of metamorphism/mineralization. With the present fall in the price of fuel mineral, government may have to focus on other earth resources like fine sand, Concretional ironstone, mica sand, feldspar sand, quart sand and metals. Limestone and hydrocarbons may have to be employed for other uses apart from cement and fuel. Local consumption pattern can be studied to understand the needed investment options.

The river basin development authorities were establish as a means of harnessing the water and agricultural potentials of the basin areas. These bodies can be made more functional than at present, possibly by privatization or the adoption of government/private partnership. The operational area can be redefined to incorporate the more productive areas. Further studies can be carried out along areas of illegal mining as a way of assessing their present commercial value. There is the need to take inventories of Nigeria sedimentary resources and plan for the most efficient ways of using them for the diversification and consolidation of the national economy.

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