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GEOLOGICAL DISTRIBUTION OF MINERAL RESOURCES IN SOUTHWESTERN NIGERIA

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ABSTRACT

The occurrence and distribution of the resources of southwestern Nigeria are intimately associated with the geology of the area. The basement complex of southwestern Nigeria lies to the east of the West African Craton, an area that has undergone late Precambrian to early Palaeozoic orogenesis. To the east and south, the Mesozoic-Recent sediments of the Dahomey and Niger Coastal Basins cover the Basement Complex.

The mineral resources of southwestern Nigeria are grouped into three, namely; metaliferous, industrial and energy minerals. These minerals can also be grouped into economic mineral deposits, which reserves are known or approximated and occurrences to which tonnage cannot be imputed. The basement complex of southwestern Nigeria hosts important deposits of gold, in the Ife-Ilesha schist belt and tin-tantalum-niobium in the pegmatites of Ijero and Iregun. Gemstones such as aquamarine, zircon, rutile and emerald are illegally mined at Ofiki and Olode. Occurrences of nickel and chromite are known in Ife-Ilesha area. Feldspars and quartz occur widely in Ogbomosho area.

Extensive deposits of talc are found at Apomu and Ilesha. Feldspars and quartz occur widely in the pegmatites of Olode, Osogbo, Iwo, Iregun and Ijero. There is an important deposit of marble within the migmatite-gneiss complex of Igbeti. Construction aggregates are widely distributed. Similarly are occurrences of bauxite in Orin Ekiti and Oyan, sillimanite in Orin Ekiti, Oyan and Ibadan, while molybdenum in Ikere-Ekiti.

In the sedimentary terrain of southwestern Nigeria, there are important deposits of limestone at Shagamu, Ewekoro, and Ibese; silica sands at Aiyetoro, Ijebu-Ife, Okitipupa, Ijero, Lekki and Igbokoda. Extensive deposits of kaolin are found at Ebe, Ibese, Imeko among others. Brick clay deposits are ubiquitous. There are occurrences of phosphates at Oshosun, Serikl-Oko, Idogo, Akinside and Fagbohun. These occurrences are associated with gypsum and are radioactive. Important deposits of tar sand are found at Yemoji, Iwopin and Agbabu.

Some of the mineral deposits are small in size and not suitable for large-scale mining enterprises. With interest in small-scale mining increasing and as the industrial infrastructure in southwestern Nigeria grows, small low-cost mining ventures can contribute to economic development of the study area by providing raw materials that would otherwise have to be imported. In order for government or private entrepreneurs to reap maximum benefits from their investment in mining ventures, the problem of illegal mining, particularly of gold and gemstones will have to be addressed.

INTRODUCTION

Mineral resources are the major sources of raw materials in several manufacturing industries such as iron and steel, tin smelting, glass, chalk, fertilizer, cosmetics and construction to mention a few. The Geological Survey of Nigeria has played an active role in the exploration for these mineral deposits, which dates back to 80 years. An important parameter in determining the importance of mineral resources in Nigerian economy and national development is the usefulness of these minerals in the manufacturing industry and their place in international trade. The metallic mineral deposits such as gold and tin for example, have high unit values and are marketed internationally. On the other hand, non-metallic minerals (industrial) have high place values and rarely enter international markets.

The degree of industrialization of a nation is directly related to the level of utilization of its mineral resources. Fortunately, the Nigerian government has recently focused its attention on the development of solid mineral, whose production has been declining over the years. Since the materialization in any area is influenced by its geology, it will be appropriate at this point to review the geology of southwestern Nigeria.

GEOLOGICAL ENVIRONMENT OF MINERAL RESOURCES

Southwestern Nigeria in this presentation covers, Lagos, Ogun, Oyo, Osun, Ondo and Ekiti States. However, where necessary allusion is made to neighbouring states of Kwara and Kogi. The southern part of the region, which is bounded by the Atlantic Ocean, and constitutes about 25% of the total area, is covered by sedimentary rocks of the Nigerian sector of the Dahomey (Benin) basin. The remaining 75% is underlain by crystalline rocks of the Precambrian basement Complex of Nigeria.

Basement Complex

The basement complex consist of four broad groups of rocks as follows:

(i) Gneiss-migmatite-quartzite complex
(ii) Schist belts
(iii) Pan-African granites (Older Granites) and associated granitic rocks
(iv) Minor felsic and mafic intrusives

Gneiss-migmatites-quartzite complex

This group of rocks constitute more than 70% of the basement complex. It is made up essentially of high grade metamorphic rocks, which comprise schists, gneisses, migmatites, marbles and quartzites of Precambrian age (over 2 billion years). The gneisses and migmatites are so intimately associated that they are hardly separable on the field. They are ubiquitous and form the bulk of the rocks in the group. A characteristics feature of these rocks is a display of banding of varying width, at least in part. The migmatite is a mixed rock composed mainly of a gneissic host and intruded granitic and pegmatitic rocks.

Both the quartzite and the marbles occur as relatively minor concordant layers within the gneiss-migmatite units. Because the quartzites are resistant to weathering and erosion, they tend to stand out, sometimes as prominent hills and ridges within the basement complex in places such as Ibadan, Iseyin and Ilesa areas.

All the rock types in the gneiss – migmatite complex are sources of construction materials for roads, building, bridges, dams, airport, e.tc. The marbles can also provide valuable raw materials for chemical industry.

Schist belts

The schist belts consist of approximately N–S trending narrow zones of low to medium grade metamorphic rocks of mainly sedimentary and minor igneous origin which were deposited previously on the pre-existing gneiss – migmatite – quartzite basement. The rocks of the schist belts are also described as 'Younger Metasediment', composed of phyllite, schist, quartzite, amphibolite and flaggy gneiss of Paleoproterozoic age (about 2 billion years). Associated with the schist belts in several localities, are talc-bearing schist, which are considered to be remnants of mafic ultramafic complexes. Economic minerals associated with the rocks of the schist belts are gold in Ilesha area and talc in Apomu, Iregun and Iseyin districts.

Pan-African granites (Older Granites)

These granites occur as intrusive bodies of various dimensions in the pre-existing basement rocks, i.e. the gneiss – migmatite – quartzite units and the schist belts. They are widely distributed in southern Nigeria and are found in all the states of the region except Lagos, which is entirely covered by sedimentary rocks. They consist of a suite of porphyritic and non-porphyritic granite rocks of different textures. However, the medium to coarse – grained porphyritic variety is more common. One of the striking features of the Older Granites is their occurrences as picturesque inselbergs that is, prominent hills rising sharply above their surrounding plains. Such granite hills occurs as Olumo rock in Abeokuta, as Idanre Hills in Idanre; Ikere Hills in Ikere, etc.

In some places, a bluish – green rock, known, as charnockite, and minor syenite are associated with the Pan African granites. The charnockite features prominently in Akure and Ekiti areas while the syenites are found mainly in Shaki area.

The Older Granite and associated rocks are sources of construction materials, particularly rock aggregates and powder, used for making roads, building, bridges, dams etc. Both the granites and the charnockites are used for making polished stones.

Minor felsic and mafic intrusive

These consist of concordant and discordant dykes, veins and irregular bodies of pegmatite, aplite, quartz, dolerite, gabbro, pyroxenite and serpentinite. They

ntrude in places all the pre-existing rocks, namely, the gneiss – migmatite – quartzite complex, the schist belts and the pan African or Older granites. They are thus the youngest members of the Basement complex of Nigeria. A variety of pegmatites, known as complex pegmatites are associated with the Older Granites in Oyo, Osun, Ekiti and Ogun States. These pegmatites host tourmaline and beryl gemstones, tantalite, columbite and cassiterite (tin ore). They also contain feldpar and micas in exploitable quantities.

Eastern Dahomey Basin

The sedimentary rocks of southwestern Nigeria extend from the Nigeria/Benin boundary in the west of Makun-Omi and Irokun in the east. The stratigraphical relationship between these rock units is discussed below.

Abeokuta Group is the oldest, and it consists of sands and intercalations of argillaceous sediments, which lie unconformably on the crystalline basement. The group, which was formerly known as Abeokuta Formation, has been recently sub-divided into three formations (Omatsola and Adegoke, 1981), namely,

(a) Ise Formation, which overlies the basement complex and consists of pre-drift sediments of grits and siltstones and over-lain by coarse to medium grained, loose sands interbedded mostly with kaolinitic clays;

(b) Afowo Formation, which consists of transitional to marine sands and sandstone with variable but thick interbedded shales and siltstone. The shale to sand ratio increase upwards with the sediment becoming highly fossiliferous. The entire sequence represents paralic sedimentation; and

(c) Araromi Formation that is the youngest of the stratigraphic sequence and is composed of shales and siltstones with interbeds of limestone and sands. It is richly fossiliferous.

Overlying the Abeokuta Group is the Ewekoro Formation, comprising of grayish, white and greenish limestone, sandy at the base. Microfauna study of the limestone shows that the sediments were deposited in a shallow marine environment. It is Paleocene in age. Akinbo, Oshosun, Ilaro and Benin Formations in turn overlie Ewekoro Formation successively.

Akinbo Formation consists of fissile and well-laminated shales. It is the western equivalent of Imo Formation in eastern Nigeria. Its age is lower Eocene.

Oshosun Formation is Eocene in age and is characterized by a dull, red siliceous sandy mudstone with sandy pockets. There are inclusions of phosphoric and glauconitic material in the lower part of the formation and the upper part is made up of medium to coarse-grained silty sandstone.

Ilaro Formation is made up of both marine and continental yellowish massive and poorly consolidated sandstones, which are fine to medium grained and poorly sorted. Fossils are rare because of its continental character. It is Eocene in age.

Benin Formation, also known as Coastal Plain Sands, is the youngest unit and consists of soft, very poorly consolidated pebbly sands, lacking in fossils. It is Eocene to Recent in age.

MINERAL RESOURCES OF SOUTHWESTERN NIGERIA

It is pertinent to state at the beginning that it is customary of geologist to distinguish between mineral resources and mineral reserves.

The term resource refers to hypothetical and speculative undiscovered, sub economic mineral deposits or an undiscovered deposits of unknown economics (Peters, 1981). Reserves on the other hand, are concentrations of usable mineral or energy commodity which can be economically and legally extracted at the time of evaluation. The scope of this study embraces both resources and reserves. The mineral resources of Southwestern Nigeria can be classified into metallic, non-metallic (industrial) and energy minerals. The metallic minerals include gold and tantalite – columbite, while the non-metallic minerals comprise limestone, marble, talc, feldspar, mica, sillimanite, gemstones, bitumen, clays, phosphate, silica sand, gypsum, yellow ochre, coal laterite and gravel, and rocks for construction materials and polished stones. It is clear from the foregoing that Southwestern Nigeria is more endowed with non-metallic minerals, some of which are currently being exploited in different places.

Gold

God occurs in Ilesa area and is associated with the younger metasediments (schist belts). Notable deposits are located at Itagunmodi, Iperindo and Ibodi. Other occurrences are found at Ifewara, Ibokun, Ijana and Idoka. These deposits are of two types, namely, primary and alluvial gold deposits. The primary deposits consist

essentially of tiny auriferous quartz veins and stringes which have invaded sheared zones in granite gneiss at Iperindo and in amphibolites at Itagunmodi and Ibodi. The alluvial gold deposits are derived from the erosion of primary deposits in the country rocks and the concentration of the eroded gold in the channels of tributaries of Rivers Osun and Owena in Ilesa district (Adekoya 1978). The primary deposits are impersisitent and low grade while the alluvial deposits are richer and more widespread. The latter thus constitutes the main source of gold exploited in Ilesa area. Both old and current river channels, as well as flood plains in the gold bearing area are still a good source of alluvial gold.

Annual reports of the Department of Mines (1922 – 1980) show that almost 90% of Nigeria's total gold production of 12,000kg since 1914 has been from alluvial deposits derived from primary gold mineralization in the western part of the basement rocks, where the schist belts are best developed. Gold reserve in the Ilesa area is now estimated at 120,000 troy ounces. The total gold reserve over an area of 94.6 hectares in the Itagunmodi area is 186kg (6,000 troy ounces). Primay gold in the Itagunmodi and Iperindo areas have grades varying from 5.3 gramme / tonne to 62.2 gramme/tonne with an average of 20.2 gramme/tonne. Investigations to establish occurrences of gold in Ibadan and Apomu are still in progress. Gold is used for monetary purposes in which it is kept as bullion, in reserve; to stabilize paper money and ease settlement of international trade balances. It is also used as ornaments in jewellery due to its softness (hardness is 2.5-3.0).

It is pertinent to mention that gold also occur in Isanlu-Okolun area of Kwara Sate, which is located north of Ilesa district. The metasediments with which the gold is associated are actually a northern continuation of the Ilesa schist belt.

Tantalite–Columbie–Cassiterite

These three minerals are commonly associated together in granitic rocks including pegmatites. Both columbite and tantalite occur together as end-members of the columbite – tantalite isomorphous series. Columbite, when it is pure, is iron – niobium oxide ($Fe\,Nb_2\,O_6$) and tantalite is iron tantalum oxide ($FeTa_2\,O_6$). Since both substances are naturally associated, any occurrence of the mineral would contain a certain proportion of the two end – members. The ratio of columbite to tantalite in samples will vary depending on the ratio of niobium (Nb) and tantalum (Ta) in them. Because Ta attracts a higher price than Nb at present, the miners are more interested in tantalite or Ta-rich samples.

The columbite – tantalite mineral occurs in the Older Granite pegmatites which are found predominantly at Ofiki, Igbo Ijaye, Idiko, Ile and Shaki in upper Ogun area, Oyo state at Olojoro, Olode, Lamolo and Wofun Iyana Church in Ibadan area, Oyo State; at Awo, Ede, Odeomu, Ife-Odan, Ikire, Ile-Ife etc. in Osun State, at Ijero Aramoko and Oye in Ondo state; and at Mamu area of Ijero in Ogun State. The pegmatites as mentioned earlier are complex pegmatites because they contain exotic minerals such as the columbite – tantalite, tourmaline and beryl in addition to the common pegmatite minerals (quartz, mica and feldspar). However, it would appear that not all the pegmatites are columbite/tantalite – bearing. Tantaline has been won by illegal miners from Ofiki, Idiko Ile, Igbojaiye, Wofun/Iyana Church and Awo. Recently, the itinerant miners have shifted to Oro, Kwara state, where tantalite is currently being mined illegally.

Cassiterite occurs in the older granite, pegmatite at Ijero, Ekiti State. The deposit was extensively mined during the colonial era and it would appear that the richer ores have been depleted.

There are yet no figures to indicate the reserves of tantalum and columbite available in Southwestern Nigeria. There are no local markets for columbium mineral concentrates at present and production is mainly geared towards export.

Sulphides

A variety of sulphide minerals including pyrite pyrrhotite, pentlandite, bornite and chalcocite occur in small amounts in the gabbro-intrusions and the metavolcanics of Ilesa schist belt (Bafor, 1981; Elueze, 1981). They commonly occur in association with chromium, nickel and cobalt. Although most of these occurrences are only of mineralogical importance, however, they may be indicative of petrological environments favourable for economic mineralization. Nickel is an alloy metal and is chiefly used in production of nickel steel and nickel cast iron. Cobalt is used for the manufacture of carbide, magnet steel and steelite steels. Chromium is also an alloy metal and a refractory.

Iron

Iron occurs as medium to coarse grained magnetite quartzite at Ajase, Iponrin, Gbede Oko and Otamokun in Ogbomoso district (Arcelloni and Maranzana, 1965; Adekoya and Oladeji, 1986). The magnetite quartzite exists in narrow (< 1 – 8m wide) bands which vary in length from a few hundred meters to a few kilometers. Assaying of the iron bearing quartzite yielded Fe values ranging from 34 – 41% (IPCO, 1965). Previous investigation by the Geological Survey of Nigeria indicated inferred reserves of 100,000 tons of iron in Ajase area. There is evidence in form of several old workings and smelting furnaces in Iponrin to show that these iron deposits had in precolonial times supported an iron smelting and fabrication industry that once thrived in Oyo province. Although, a previous field investigation suggests that the Ogbomoso deposits have prospect for small scale mining, it is desirable to carry out more detailed investigation of entire Ogbomoso district using modern geophysical equipment. It is hoped that more of the ferruginous quartzite buried under an overburden of thick lateritic soil will be revealed.

It is useful to mention that large iron deposits of commercial value have been found in Okene and Lokoja areas in the neighbouring Kogi State, located north of Ondo State.

These deposits include:

(i) Precambrian banded iron formation (Older BIF type) of Itakpe, Ajabonoko, Chokochoko, Agboido Okudu, Ebija-Ero and others, whose aggregate reserve are over 600 million tons of iron-ore, and

(ii) Lorraine of Minette type ironstone of Maestrichtian age which occurs in three areas namely; Agbaja, Koton Karifi and Bass-Nje and contains total iron ore reserves of over 2 billion tons.

Unfortuantely, however, the Lokoja deposits are characterized by high contents of phosphorus, which is deterious to iron.

Iron, which is the backbone of industrialization, is used to manufacture plants and machinery employed in industry for producing various goods. It is also extensively used for the construction of vehicles, buildings, bridges, office equipment and furniture. Other uses include fabrication of cutlery, kitchen utensils, lamps, pressing iron, water pipes, casings etc.

Talc

Several talc occurrence have been found at the Wonu and Laduntan in Apomu area and at Asegbo, Obaluru and Iregun in Ilesa area, all in Osun State, and at Iseyin, Oyo state. Also, it occurs in Ife and Ijero-Ekiti where they are associated with the amphibolites of the schists belts (Kehinde-Philips, 1973 and Elueze, 1982). The talc bodies area a part of magnesian products of alteration or metamorphism of mafic ultramatic complexes, which are associated with the schist belts. Varying percentages of talc are present in the talc bodies. For example, Wonu, Obaluru and Asegbo deposits contain 65%, 70% and 85% respectively of talc with minor or subordinate amounts of tremolite, anthophylite and chlorite.

Chemical analysis has revealed that magnesium oxide (MgO) contents of these talc bodies vary from about 31.7% to 32.3% (Durotoye and Ige, 1991). These MgO values are comparables with those of commercial talc that range from about 26.1% to 34.5. In addition to the chemical composition, the physical properties of the talc deposits indicate that they are suitable raw materials for ceramic, paper, rubber, plastics, paints, cosmetics, pharmaceutical and fertilizer industries. However, because the western Nigeria talc deposits are generally small, their reserves being only a few thousand tons, up to several tens of thousand tons, they can only be considered for small scale exploitation.

In the neighbouring Kwara state to the north, a relatively large deposit occurs at Odogbe in Isanlu Makutu. The deposit, whose estimated reserve is put at over 250,000 tons, has suitable chemical and physical properties for industrial application in most of the industries listed earlier.

Sillimanite

Sillimanite is aluminium silicate (Al_2SiO_5), which is trimorphous with kyanite and andalusite. It is a product of high-grade metamorphism and it is highly refractory. Two occurrences have been located at Olode, near Ibadan, Oyo State and at Odo-Ijesa, Obafemi area, near Abeokuta, Ogun state. In both cases the sillimanite is associated with quartzites that are interbanded with a gneiss migmatite unit. The deposits are currently being investigated by the Geological Survey of Nigeria. Sillimanite is used in the manufacture of insulators, refractories and ceramics.

Feldspar and Quartz

Feldspar and quartz are abundant in granitic rocks of Southwestern Ngleria. Potash feldspar is the most important and commercial supplies are usually derived from pegmatite dykes. Feldspar and quartz deposits occur in Osogbo, Ijero Iregun and Abeokuta. Also, some of the complex pegmatites mentioned above sometimes contain large crystal of feldspar, commonly microcline, which can be quarried for use. Example of such pegmatites have been found around Ode Omu, Ede and Awo in Osun state and Igbolua and Iworoko in Ekiti State.

Large deposits of microdine feldspar also occur in neighbouring Kogi State (Osara forest and Okene) and in Okpella area of Edo state. Feldspar is used for glass making, in the pottery industry, ceramics, wall and floor tiles and manufacture of artificial teeth among other uses.

Marble

Marble is metamorphosed limestone. The only known marble deposit in the six states of southwestern Nigeria is that at Igbeti, Oyo State. It is interbanded with other basement complex rocks such as gneisses, quartzite and schists. The marble forms an elongate body that stretches for about 120km in the N-S direction and varies in thickness from less than 0.5km in Igbeti area in the northern part to about 1km south of Alagutan in the southern portion of the marble body. A small marble deposit that has not been investigated also occur in Ibani, Ondo state.

The Igbeti marble is dolomitic as it contains up to 21% MgO (Magnesium oxide) and 30% CaO (calcium oxide) which correspond to nearly 44% $MgCO_3$ (magnesium carbonate) and 55% $CaCO_3$ (calcium carbonate) in the deposit (Oluyide et al., 1998).

About 70km east of Igbeti another dolomitic marble deposit exists in Elebu in Kwara State. Other large marble deposit found west of the Niger are located at Makura, Osaa forest and Ubo River area in Kogi state and at Igara and Ukpila in Edo state. The deposits of Kogi and Edo states are largely calcitic, containing not less that 51% CaO that translates to over 90% $CaCO_3$.

Bauxite

Bauxite occurs at Orin in Ekiti State and Oyan in Oyo State. No major exploration for bauxite has been carried out yet and the reserve is not known. It is an ore of aluminium and it is also used as abrasive among others.

Molybdenum

There are reported traces of molybdenum in Ikere area in Ekiti State (Makanjuola, personal communication). There is need for further investigation.

Zircon

Zircon occurs in traces in the pegmatitic intrusions within the basement rocks in Ekiti and further investigation is needed.

Limestone

Limestone is a bedded sedimentary deposit, which is made up dominantly of calcium carbonate (calcite). It occurs in the Tertiary sediments of the Nigerian sector of the Dahomey (Benin) Basin and in the Upper Cretaceous sedimetnas of the western most portion of the Anambra Basin. In western Nigeria, the Tertiary limestone, known as Ewekoro limestone, forms a bed at least 16m thick and 120km long in an E-W direction. It can be traced from Yemoji valley, southeast of Ijebu Ode through Sagamu, Ofada, Papa Alanto, Ibese, Owode, Igan-Egugua and Ijeun all in Ogun State, to the Benin Republic border. Adekoya (1982) has made a forecast reserve of over 100 billion tons within a 10 metre thickness of the limestone in the entire E-W belt.

Ewekoro limestone is overlain by a shale sequence called Akinbo Formation, and underlain by sandstone and grits of Araromi Formation (former Abeokuta Formation). The limestone dips gently udenrneath the Akinbo shale, extending like other formations to the Atlantic continental shelf. Currently, Ewekoro limestone is being exploited by the West African Portland Cement at Sagamu and Ewekoro. On account of its large reserves and wide distribution, the Ewekoro limestone belt still offers great opportunities for exploitation in many places along the belt.

Limestone also occurs as thin lenses intercalated within Nkporo Shale of upper Cretaceous age in the Okeluse-Arimogija district of Ondo State. The limestone lenses extend for a few hunded meters and vary in thickness from 1.5 – 3.4m in Okeluse area. A total reserve of over 7 million tons of limestone has been estimated for three occurrences located around Okeluse. (Ojo 1971; FUTA CONSULTS, 1988). The

estone is essentially calcitic as it contains about 87 – 0% calcium carbonates. In addition to being used for the manufacture of cement and as fluxing agent, it is also used for the manufacture of industrial lime, which is utilized in agriculture.

Clay

Clay deposits of Southwestern Nigeria fall into two categories, viz' primary or residual clays and secondary or sedimentary clays. Chemical weathering or hydrothermal alteration of crystalline rocks in situ forms primary clays. Such clays are present in lateritic weathering profiles developed on the basement complex rocks in southwestern Nigeria. Consequently, they are ubiquitous and can be found in Oyo, Osun, Ekiti; and parts of Ogun and Ondo State underlain by the basement complex rocks, notably gneisses and migmatites, granites and schists. There is hardly any local government council in these areas that does not have at least one primary clay deposit. Most of such clay deposits are brownish red fire clays, although some are white, kaolinitic clays. This type of primary fire clay is used for making clay bricks, local ceramic pots and traditional houses in many town and villages. Notable primary fire clay deposits occur in the following localities.

(i) Ibadan and surrounding villages, Oyo, Saki, Iresadu and Iresapa, Eruwa, Kishi in Oyo state,
(ii) Iwo, Ede, Awo, Ile-Ife, Ilesa, Erin Oke, Ikire and Apomu In Osun state.
(iii) Ikere, Ado, Osi, Oye, Ikole, Omuo, Ode, Ire, Ise Igara Odo, etc in Ekiti State.
(iv) Ondo, Ile Oluji, Ore, Oniparaga, Oba-Akoko, Afin-Akoko, Isua-Akoko, Isua Akoko, Idoani, Ipele, Owo, Akure, etc., in Ondo State; and
(v) Oslele, Egbeda, Oru, Oke-Eri, Ipara, Imope, Ijebu-Igbo, etc. in Ogun state.

White kaolinitic clays of residual origin have been found in some localities in western Nigeria. These Includes several localities around Ibadan and Akinlabi (Ado Awaiye), Oyo State; Abeokuta, Osiele, Onibode and,Bamajo, Ogun State; Ara, Isan and Ikere, Ekiti State and Akure, Ondo State.

Secondary clays are associated with sedimentary deposits in sedimentary basins and drainage systems where clay materials eroded from primary sources are deposited with other sediments. These clays occur in southwestern Nigeria in the Nigerian sector of the Dahomey (Benin) Basin. They include white kaolinitic clays and material suitable for fire clay. Sedimentary kaolinitic clays occur at Sogbon (near Okitipupa), Ode Aye and Ifon, Ondo State; Elefun-Totogangan (near Meko), Orifo, Ayiyetoto, Ilogun, Ijumo Abule Ogun, Sotubo (near Sagamu) and Ibonwon Imagbon (near Ijebu-Ode), Ogun State.

Majority of the sedimentary clays is fire clay suitable for brick making. A major source of such fire clays is the Akinbo Formation, a shale sequence, overlying the Ewekoro limestone. The shale forms good fire clays at Itori, Ofada, Ibese, Ifo junction and Seriki Oko in Ogun State. Greyish and brownish clays interbedded with the Benin Formation (Coastal Plain Sands) and Recent alluvium in the near coastal areas are good sources of fire clay. Such clays have been found at Epe, Ejirin, Tomoba, Ikeja and Oni (Lekki area), Ebute Onega (Ikorodu area) in Lagos State; Ifonyintedo and Onifo in Ogun State and Ode Aye in Ondo State. Many of the deposits have large reserves and are mined locally for pottery and crude bricks.

Phosphate

Sedimentary phosphate also called phosphorite, forms part of Eocene Oshosun Formation, which also contains shales and lignitic beds. The Oshosun beds overlie the shales of Akinbo Formation in the Nigerian sector of the Dahomey (Benin) Basin. The phosphorite, which is intercalated with the shale and clayey sandstone, outcrops along the Lagos – Abeokuta railway at Ifo junction and near Oshosun village. Reserves of about 20,000 tons of phosphate rocks have been estimated in the Ifo junction phosphate deposit. A phosphate layer up to 1m thick also overlies the Ewekoro limestone.

Also, phosphate occurrences have been investigated at Oshosun, Seriki-Oko, Akinside, Idogo and Fagbohun. In terms of morphology, three types are recognized, namely; granular, nodular and vesicular phosphates. The nodular and vesicular types have higher P_2O_5 content (Kehinde-Philips 1974). Phosphate is a raw material for the chemical fertilizer industry. These occurrences are radio-active.

Kaolin

Kaolin deposits are widely distributed throughout Nigeria. In southwestern Nigeria, it can be found in Ede, Ibese and Imeko among others. The reserve at Ede is estimated at 1.5million tons, while that of Ibese

and Imeko are 3 and 4 million tons respectively. Other deposits are found at Osiele, Ibamajo, Onibode, Aiyetoro, Eleffun-Totoganga, Onifo, Ilogun, Ijuno, Abule-Ogun, Ishan, Lamu, and Ifon. Deposits can satisfy national demand for precessed kaolin and it is used mainly in paper making, rubber, plastics, paints and refractories.

Silica Deposit

Three types of silica deposits occur in the southwest, namely loose silica sand deposits formed by sedimentary proceses; quartzite, which is metamorphosed sandstone; and quartz crystal of vein or pegmatite origin. The loose silica sand include construction sand and glass sand. Construction sand, which is used extensively for building houses, making sandcrete blocks and sand filling, is found in both present and ancient flood plains and river channels. It is also found in the near – shore areas of the Atlantic ocean and lagoons (Lagos and Lekki) in Lagos, Ogun and Ondo states.

Glass sand, also called silica sand occurs extensively in southwestern Nigeria. High quality silica sands are found in Aiyetoro, Ijebu-Ife, Okitipupa, Ijero Makun-Omi, Igbokoda, Badagry and Lekki. The chemical analysis of silica sands indicates that SiO_2 content ranges from 99.01% - 99.6%. Silica sand is the major raw material for the manufacture of glassware and bottles. The deposits have been fully explored and exploitation is going on. The reserves are 16 million tons at Okitipupa, 1 million tons at Igbokoda 4 million tons at Ijero and 3 million tons at Ijebu-Ife. The deposits adequately satisfy the requirement of glass industries. Deposits have the potential of replacing the imported sands used in gravel parking.

Quatzites of varying purity, which can be used as a source of silica, are present in the basement complex of southwestern Nigeria. They are associated with either the schist belts or the gneiss – migmatite-quartzite units. Enormous reserves of such quartzite bodies are found as prominent hills and ridges in Ilesa, Esa Oke, Erin Oke, Itawure, Ipetu Modu, etc., in Osun State; and in Imesi, Ofon Alaye, Erinjiyan in Ekiti State. Others are prominent hills of Iseyin and Ibadan in Oyo State.

The quartizites can be quarried and processed to produce silica for various purposes such at metallurgical, refractory, glass and chemical uses. Clean grade quartzite gravel and sand produced under close textural control are used as water filter.

Gypsum

There are occurrences of gypsum in Ogun State associated with the radio active phosphate. Gypsum occurs in specks and traces and is used mainly in the manufacture of plaster of Paris, cement, paint and chalk.

Laterite

Laterite is a product of tropical weathering of rocks. The term is used to cover lateritic soils (commonly clayey) and iron rich crust (hardpan) present in the lateritic weathering profiles. Laterite is ubiquitous, particularly in areas underlain by the basement complex in southwestern Nigeria. Enormous quantities of laterite are available particularly in areas of deep weathering in all the states of southwestern Nigeria. Laterite can also be used with minor benefication for making compacted laterite blocks with or without cement or lime stabilization. This weathering product is used extensively for road and building construction.

Construction Aggregates

Available construction stones in the southwestern Nigeria fall into three categories – laterite, gravel, quartizite, rubble and crystalline rocks. Laterite gravel consists of iron concretions, which are formed as part of lateritic iron crust and are subsequently disaggregated as the laterite disintegrates in site. The lateritic concretions are particularly abundant in laterites developed on charnockites such as those of Ekiti and Ondo States. When separated from the loose soil, the laterite gravel constitutes very durable aggregate for road works.

Quartzite rubble is made up of quartizite fragments of varying sizes, which are derived from the physical weathering of quartzite bodies within the gneiss-migmatite units of the basement complex. It is formed in areas where quartzite ridges are abundant such as Ibadan, Iseyin, Ikire, Ilesa, Oke Imesi-Ijero area, etc. Such quartzite rubbles are used extensively as gravels for building houses. Small quartizite bands within the gneiss-migmatite units are often quarried manually in many localities and used as building stones.

Hard crystalline rocks of the basement are crushed into aggregates for various construction works. Gneisses and migmatites as well as granites are the common rock types used for producing crushed stones of different sizes for constructing buildings, roads, dams, airports, bridges, etc. These rock types are abundant in all the

reas of southwestern Nigeria underlain by the basement complex.

Rock for Polished Stones

Most of the basement complex rocks are suitable for producing polished stone of varying colour tones and quality (Elueze, 1995). However, when the availability of large rock reserves for economic exploition is considered along with the rock physical properties, the number of rock types that can support viable polishing project is reduced to a few which include gneisses, granite, charnockites and possibly, syenites.

Gneisses are widespread and constitute over 60% of the basement complex. Large gneiss outcrops occur in Ibadan, Oshogbo, Ogbomoso, Erin Oke, Ore, Ijebu-Igbo, etc. The older Granites, which occur in differing textures and colours, exist as plutons of various dimensions in all the states of southwest Nigeria except Lagos. They are particularly abundant in Abeokuta area, Ogun State; Idanre, Akure, Iju-Itaogbolu and Akoko area (Akungba, Ikare, Oka, etc), Ondo State; Ikere, Ado and Osi, Ekiti State; and Eruwa, Ibadan, Ikoyi (near Ogbomoso), Igbeti, Oyo State.

Charnockites and syenites are much less common than the older granites with which they are nevertheless associated on the field and even consanguineous. The charnockites occur as plutonic bodies, sometimes of batholithic dimensions, in Ijare and Iju, Ondo State and in Ikare, Ado, Oye and Osi area, Ekiti State. A notable occurrence of syenite is at Shaki, and Iseyin, Oyo State. These two rock types are good source materials for polished stones. It should be noted that the Igbeti marble could also be polished and used as floor or wall tiles, although its dolomitic property confers on it a greater value for use in the chemical industries.

Ochre

Ochre is normally a naturally occurring powder, composed essentially of iron oxide, commonly hydrated iron oxide such as limonite and goethite. It commonly exists in three varieties – yellow, brown and red ochres. Yellow ochre occurs sporadically in Sagamu and Ilesa areas. The Sagamu yellow ochre forms irregular bodies within the grits or sandstone of Abeokuta Group that outcrops in Sagamu. The mineral, which was once used for painting houses in the locality, can be applied in the manufacture of paints, linoleum, rubber, etc. In Ilesa area, yellow occurs within a weathering profile derived from gneisses amphibolites. Red to brownish ochre has been observed in Igarra area, Edo State, where intense lateritic weathering of phyllite has produced variegated, banded ochreous profiles.

Gemstones

Beryl and tourmaline gemstones of semi precious to precious quality, occur in the Older-Granite pegmatites, which as earlier mentioned also contain columbite-tantalite minerals. Beryl is beryllium alumino-silicate ($Be_3 Al_2 Si_6 O_{18}$). It exists as a marine blue variety called "aquamarine", as a semi-precious pale blue type commonly known as "beryl" but locally called "beruit" by the local miners; and as a green variety described as "emerald".

Emerald and semi-precious beryl occur in the compelx pegmatities of Olode, Olojuoro and Wofun/Iyana Church in Ibadan area, Oyo State and Lamolo, near Mamu, Ogun State. Aquamarine has been reportedly found at Awo and Ede areas. Tourmaline is a complex borosilicates (boron-bearing silicate) of aluminium together with alkali metals, iron and magnesium. Three varieties of tourmaline gemstones are found in the Older Granite complex pegmatites of western Nigerian. These include the green variety (emeralite or Brazilian emerald), the pinkish red variety (rubellite) and the blue type (indicolite or Brazilian spahlite). The black tourmaline (schorl), which is ubiquitous, is rarely of gem quality, but large columnar schorl appears semi-precious.

Emeralite tends to be more common in the pegmatites of Ekiti and Osun States. It occurs predominantly in Ijero, Ikire and Ile-Ife. On the other hand, the rubellite seems to predominate in the pegmatites of upper Ogun area, Oyo States. It has been found at Ofiki, Idiko Ile, New Target and other areas in Shaki-Kishi region. The blue tourmaline is rare but it was reportedly obtained at Oro in Kwara State. The various gemstones are cut, polished and employed in making exquisite jewellery.

Tarsand/Oil Sand

Sandstone heavily impregnated with bitumen occurs in a narrow E-W belt, which extends from Ijebu Ife in Ogun State through Ondo State to the western margin of Edo State. It is not yet explored in Ogun State which is suspected to have greater reserve than the deposit in Ondo State. The bitumen outcropping belt is over 120km long and 6km wide. Outcrops occur at Ijebu-Ife,

Yemoji, Iwopin, Agbabu, Afaluko, Ajebandele area, some localities north of Lekki Lagoon, Ilutitun area, Odo Aye area, Foriku, Aiyadi, Agbabu area and Ofosi. The bitumen occurs as impregnation of Upper Cretaceous arenaceous sediments with an oil saturation of 12 wt% percent (Adegoke et. al., 1980). Adegoke and his co-workers estimated an area of about 17km² around Agbabu to contain 1534 million metric tonnes of bitumen, which is to yield 1022 million barrels of heavy oil. The Ondo state sector of the bitumen belt was reckoned to contain not less than 42 billion barrels of derivable oil reserves.

Oil and Gas

The occurrence of bitumen and oil shale in the bitumen belt just discussed above is an indication that hydrocarbon accumulation occurs down dip of the Cretaceous sediments in the Dahomey (Benin) basin in western Nigerian. As a matter of fact, oil and gas are currently being exploited in the near-shore area of Ondo State.

SUMMARY AND CONCLUSIONS

A summary of all the minerals discussed in the foregoing account and their uses is presented in Table 1. The Table shows that the states of southwestern Nigeria are endowed more with non-metallic than metallic minerals. The economic deposits of gold, gemstones and marble as well as occurrences of bauxite, nickel and chromite are hosted by the Precambrian to Paleozoic. Basement complex of Southwestern Nigerian while the Cretaceous sediments are host to deposits of limestones, silica sands, kaolin and oil sands as well as occurrence of radioactive phosphate and gypsum.

On the basis of available geological information, some of these minerals are reckoned to occur in very large quantities and could support viable mineral industry in different parts of the states. However, further studies are still going on in order to discover more mineral resources in southwestern Nigeria and assess the possibilities of their exploitations.

Table 1. Mineral Resources of Southwestern Nigeria

MINERAL	TYPE	LOCALITY	RESERVE (Tons)	USES
Columbite-Tantalite	Pegmatite	Igbojaiye, Wofun, Iyana Church, Awo, Oro	–	Tantalum and niobium contained in this mineral are used for heat and corrosion resistant steels and alloys applied in space ships and gas turbines.
Iron Ore	Ferruginous Quartzite	Ajase, Iponrin, Gbede, Oko, Otamokun, Ajinopa,	100,000 (Ajase)	For steel manufacture.
	Older BIF	Itapke, Ajabonoko, Chokochoko, Agbado, Okudu, Ebiya, Ero, etc.	600 million	-ditto-
	Ironstone	Agbaja, Koton Karifi, Bassa-Nge	Over 2 billion	-ditto-
Gold	Alluvial and Primary	Iperindo, Itagunmodi, Ifewara, Ibodi	–	For ornaments, monetary purposes, most of it being used as bullion in reserve for notes issued, dentistry, etc.
Marble	Dolomitic	Igbeti	>40 million	For fluxing stone in steel making; for soil replenishment and acidity correction; for glass and paint making; for use in paper mills, in sugar refining; for construction materials such terrazzo, palladiana, etc.
	Dolomitic	Elebu Idoani	150,000 ND	

Limestone	Fossiliferous	Sagamu, Oke, Ate, Papa, Alanto, Ewekoro, Ibese, Owode, Igan-Egungua, Ijeun	>100	For Portland cement manufacture, lime production, animal feeds, water treatment, construction materials, carbide production, fertilizer and for other purposes mentioned for marble above.
		Okeluse	7 million	
Clay	Fire Clay	Ibadan, Saki, Iresapa, Iresadu Eruwa, Kishi, Iwo, Ikire, Apomu, Ikere, Ado-Ekiti, Ire, Igbara, Odo, Oba-Akoko, Ipara, Imope, Itori, Ofada, Ibese, Ifo junction, Seriki Oko, Oke-Eri.	ND	For making bricks, floor tiles and refractories.
		Onibode	>2.5million	
		Ilogun	5 million	
		Abeokuta	Large	
		Oslele	ND	
		Elefun Totogangan	ND	
		Aiyetoro	ND	
		Akinlabi (Afo Awaiye)	3.5 million	
		Ibadan	ND	
Kaolin		Isan-Ekiti	7 million	For making chinaware, for use as fillers, extenders and carriers in paints, rubber, plastics, textiles and paper industries; for making drugs, etc
		Ara-Ekiti	4 million	
		Akure (NE)	> 10 million	
		Sogbon	ND	
		Odo Aye	ND	
		Ifon	ND	
		Abule O	ND	
		Gun	ND	
		Ibonwon Imagbon	ND	
		Sotubo	ND	
Phosphate	Phosphorite	Ifo junction Oshosun, Fagbohun Oja Odan, Seriki Oko, Akinside, Idogo.	20,000	For making fertilizer, matches and chemicals.
Bitumen	Semi-Solid Hydrocarbon	Ijebu, Ife, Afaluko, Ode Aye, Foriku, Aiyadi, Agbadu, Ofosi, Iwopin, Yennoji	1534 (Agbadu)	As a source of heavy oil which can be cracked to make other products such as diesel, fuel oil, lube oil, asphalt, pitch and motor spirits; can also be a source of sulphur, ammonia, phenol, Ni and V.
Ochres	Primary Yellow Ochre	Ilesa	ND	For paints, plastic, rubber, linoleum, wood and paper stains
	Secondary Yellow Ochre	Sagamu	ND	-ditto-
Feldspar	Pegmatite	Ijero	>6 million	Employed in pottery, enamels, tiles and porcelain
		Edo	ND	
		Awo	ND	
		Ode Omu	ND	

		Ide Odan	ND	
		Igbolua	ND	
		Iworoko	ND	
		Abeokuta	ND	
Talc	Alteration products of mafic to ultramafic rocks	Wonu-Apomu	16,500	For powder, ceramics, tiles, pharmaceuticals, etc; applied as carrier for insecticides and a filler in paper, rubber and roofing material industries.
		Laduntan-Apomu	3,180	
		Asegbo	5,495	
		Obaluru	55,650	
		Iseyin	<250,000	
Silica	Construction Sand	Flood plains and large river channels in the southwest	Large	For building houses, sandcrete blocks, sand filling etc.
	Glass Sand	Badagry, Lekki, Aiyetoro, Igbokoda, Ikorodu, Makun-Omu, Ijebu Ife	Large	For glass making. Can also be applied as foundry sand, etc
	Quartzite	Ilesa, Esa Oke, Erin Oke, Imesi-Ile, Efon-Alaiye, Iseyin, Ijero.	Large	Can be processed to produce quartizite pebble and sand that can be applied for metallurgical, refractory and glass making purposes.
	Crystal Quartz (Rock Crystal)	Ijero, Igbojaiye, Ofiki	ND	Used in electronics
Sillimanite		Olode, Odo-Ijesa-Obalemi area	ND	For making refractory bricks
Gemstones	Beryl (Aquamarine, Emerald)	Olode, Olojuoro, Wofun/Iyano Church, Lamolo, Awo	ND	For making polished ornamental stones
	Tournaline (Emralite, Rubellite and Scholite)	Ijero, Ile-Ife, Ikire, Ofiki, Idiko, Ile, New Target, Oro	ND	-ditto-
Construction Stones	Laterite gravel	Present in all States of the southwestern except Lagos	ND	Employed in road, dam building and other civil engineering construction
	Quartize rubble	-ditto-	ND	-ditto-
	Rocks	-ditto-	ND	-ditto-
Laterite	Lateritic Soil and hardpan	Present in all States of the southwest		-ditto-
Rocks for polishing	Gnelsses, Granites, Charnockites, Syenite	Rock present in Basement Complex area; Charnockite abundant in Ondo and Ekiti States; Syenite at Saki.	Large	Polished stones used as floor and wall tiles, statues and other embellishment
Oil and Gas	Liquid and Gaseous Hydrocarbon	Near shore area of Ondo state	ND	Used to produce fuel, and chemicals for various domestic and industrial uses.
Gypsum	Sedimentary	Ososun, Abule Onire	ND	Manufacture of cement, paint, chalk, plasters

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