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Some Industrial Mineral Deposits in Niger State (Nigeria) and their Raw Material Potentials for Mineral-based Industries

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ABSTRACT
Physical mapping and geochemical characterization of some industrial mineral occurrences in Nigeria's geopolitical State of Niger have been undertaken as a basis for assessing their economic quantities, modes of occurrence and physico-chemical characteristics as raw materials for mineral-based industries and industrialization.Physical mapping-surveys have been carried out on **clay**, marble and talc deposits. Economic deposits of clay have been mapped at Mashegu,Kutigi and Lemu, marble and clay at Kwakuti and talc at Kagara. All the mapped industrial minerals occur in economic quantities, although the exact reserves have not yet been measured. The clays at Kutigi have high content of kaolinite (on the basis of XRD examination) while those at Lemu and Masheguhave been diminished by high silica content (XRD and XRF measurements). The marble deposit at Kwakuti is highly calcitic (very lowly dolomitic) with significant content of Cu, Pb, Zn, and Ba traces; the associated clays at the same locality have high alumina content and a significant content of Zr traces.The content of iron oxide (Fe_2O_3) in the talc at Kagara and clays at Lemu and Mashegu may constitute obstacles in their industrial applications. The clays at Kutigi have the required economic quantity and chemical parameters for exploitation as raw materials for a ceramic/sanitary ware industry while those at Mashegu and Lemu are more suited for pharmaceutical industry. The marble deposits at Kwakuti can support a large size cement factory with raw material supply for 35 years (at presently mapped occurrences; additional reserves may be booked with time). The large talc deposits at Kagara can support an equally large cosmetic factory.

Keywords: Industrial minerals, Niger State, Industrialization, Raw materials, Mineral deposits

I. INTRODUCTION

With declining fortune for crude oil, particularly in the current era of energy transition, there is the need to develop strategies that can take advantage of the opportunities available for the development of the nation's solid mineral resources within the context of a diversified economy where mining (including petroleum!!), industrial agriculture and manufacturing will be the key players. Nigeria as a nation is blessed with appreciable solid mineral resources distributed fairly in all the states of the federation. According to reports by the Nigerian Geological Survey Agency (NGSA), Nigeria has some 34 known major mineral deposits distributed in locations across the country that offer considerable attraction for investors. The geological setting of Niger State is made up of igneous and metamorphic rocks of the Nigerian Basement Complex and sedimentary rocks of the Bida Basin (Fig. 1). Industrial mineral deposits of economic to sub-economic quantities are associated with each of the components of the geology of Niger State. The industrial minerals under investigation (Clay, Marble, Talc, Mica, and Feldspar) occur in different proportions in different or similar geological modes of occurrence, with different or similar geochemical characteristics (grades) and quantities.

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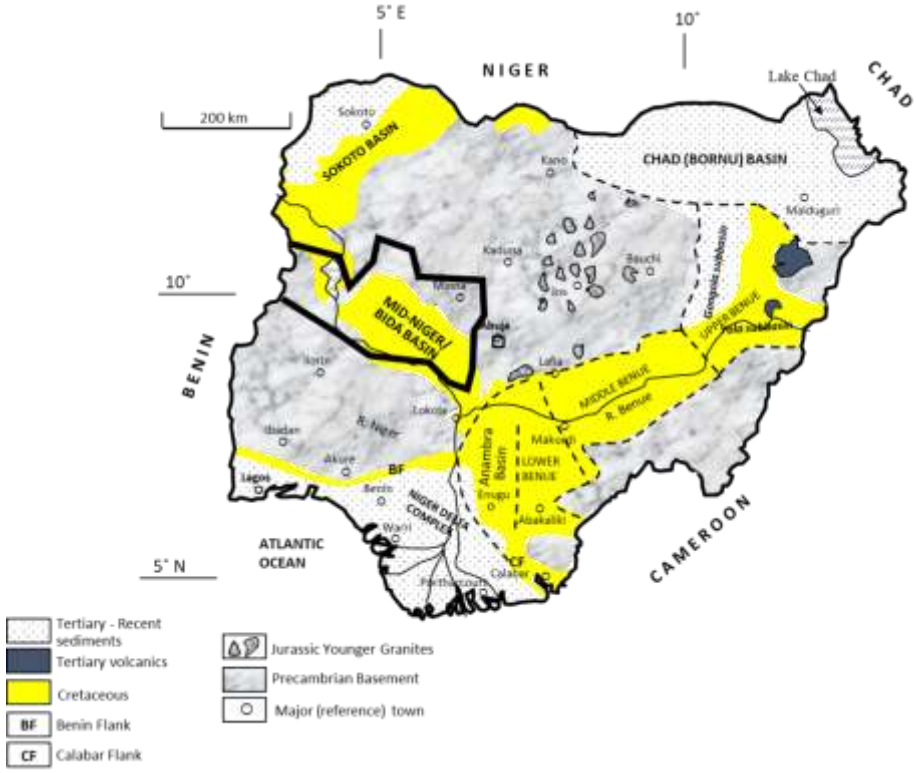

Fig. 1. Generalized geological map of Nigeria showing half of Niger State to be made up basement and the other half sedimentary rocks of the Bida Basin

II. LITERATURE REVIEW

Geological Setting

Dada (2006) and Obaje (2009) gave a vivid account of the geology of the study area to be made up of the Basement Complex and the sedimentary rocks of the Bida Basin (Fig. 1). The Nigerian Basement Complex forms a part of the Pan-African mobile belt and lies between the West African and Congo Cratons and south of the Tuareg Shield (Rahaman, 1988). It is intruded by the Mesozoic calc-alkaline ring complexes (Younger Granites) of the Jos Plateau and is unconformably overlain by Cretaceous and younger sediments. Within the basement complex of Nigeria three major petro-lithological units are distinguishable, namely:Migmatite–Gneiss Complex (MGC), Schist Belt (metasedimentary and metavolcanic rocks) and Older Granites (Pan African granitoids).

Based on the works of Adeleye (1974), Braide (1992a, b), and Obaje (2009),and Obaje et al. (2020), sedimentary rocks in the Bida Basincomprise Cretaceous successions. The stratigraphic successions documented in Obaje (2009) are shown in Figure 2 below.

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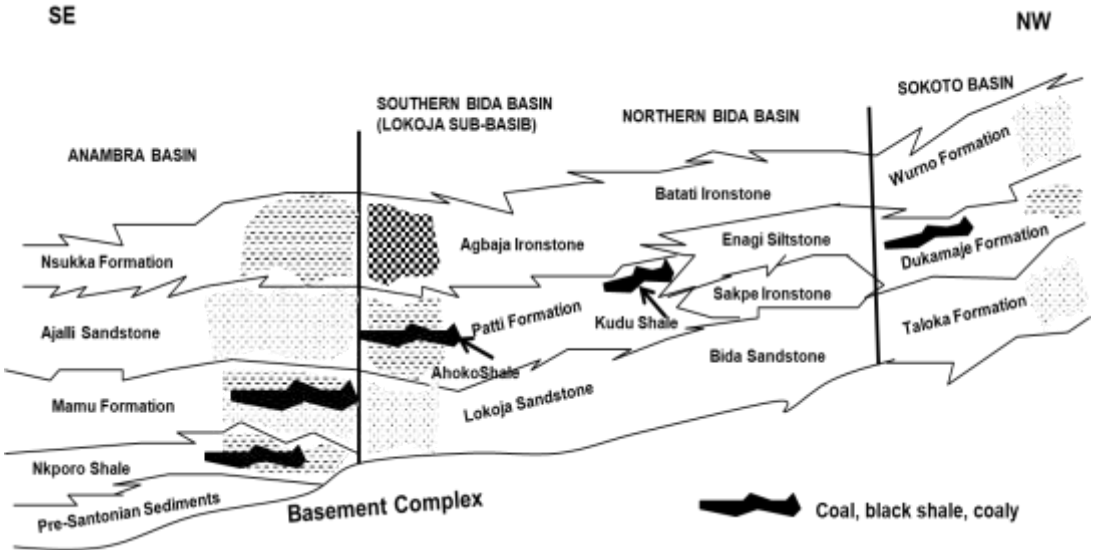

Fig. 2. Stratigraphy of Campanian-Maastrichtian formations in the Bida Basin correlated to the Anambra Basin and the Sokoto Basin (after Obaje, 2009).

Industrial Minerals

According to Hosterman and Patterson (1992), industrial mineralsare geological materials which are mined for their commercial value, which are not fuel (fuel minerals or mineral fuels) and are not sources of metals (metallic minerals). They are used in their natural state or after beneficiation either as raw materials or as additives in a wide range of applications. Typical examples of industrial rocks and minerals are limestone, clays, sand, gravel, diatomite, kaolin, bentonite, silica, barite, gypsum, and talc. Some examples of applications for industrial minerals are construction, ceramics, paints, electronics, filtration, plastics, glass, detergents and paper. In some cases, even organic materials (peat) and industrial products or by-products (cement, slag, silica fume) are categorized under industrial minerals, as well as metallic compounds mainly utilized in non-metallic form (as an example most of the titanium is utilized as an oxide TiO_2 rather than Ti metal). The evaluation of raw materials to determine their suitability for use as industrial minerals requires technical test-work, mineral processing trials and end-product evaluation

The main aim of the study is to carry out geological survey/appraisal of selected industrial minerals in Niger State(Nigeria); characterize the minerals, carry out beneficiation as may be necessary and move to pilot stage trials for the use of the minerals as appropriate high quality raw materials for industrial clusters in the region.

Methods of Study

i) Literature search and visitations to Ministries, Departments and Agencies of government responsible for mining and mineral development in Nigeria in general and Niger State in particular to obtain available information on the level of available data on the selected industrial minerals;
ii) Geological mapping of known locations of occurrence of the selected industrial minerals Niger State (Fig. 3) to estimate the areal and possible stratigraphical extents of the deposits as well as sample collection;
iii) Laboratory geochemical analyses of the collected samples comprising X-Ray Fluorescence (XRF) and X-Ray Diffraction (XRD);
iv) Interpretation and discussion of the results.

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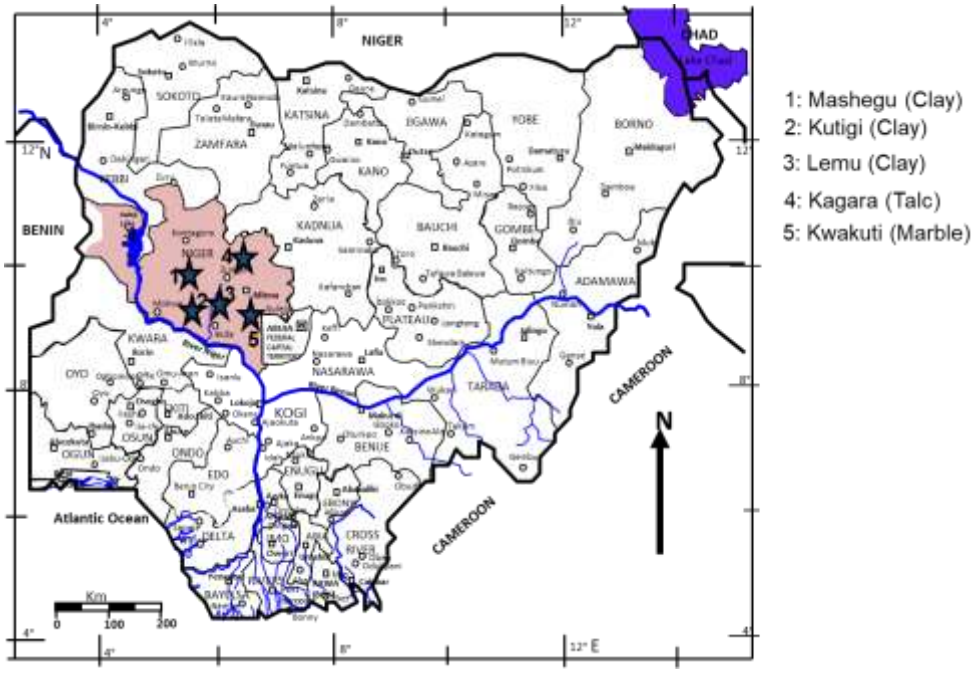

Fig. 3. Political map of Nigeria showing locations of industrial mineral deposits studied in Niger State

III. RESULTS AND INTERPRETATIONS

Clay deposits at Mashegu (on the Tegina-Mokwa road), Kutigi (on the Bida-Mokwa road) and Lemu (on the Bida-Wushishi road) as well as Talc at Kagara (on the Tegina-Kaduna road) and Marble at Kwakuti (on the MInna-Suleija road) (Fig. 2) have been physically mapped and the field surveys are shown in Figures 4-9. Geochemical analytical results carried out as basis for their characterization are presented in Figures 10-13.

Clays

The clay deposits at Mashegu, Kutigi and Lemu occur in economic quantities, although actual reserves have not yet been evaluated. These clay deposits constitute the greater portion of the Enagi Formation of the Bida Basin. They are generally whitish to grey white. The clays occur in a sequence of alternations of clays, siltstones and sandstones in a generally fining upward sequence, whereby the siltstones and claystones dominate the sequence. The clays at Kutigi have high content of kaolinite (on the basis of XRD examination) while those at Lemu and Mashegu have been diminished by high silica content (XRD and XRF measurements). The clays at Kutigi have the required economic quantity and chemical parameters for exploitation as raw materials for a ceramic/sanitary ware factory while those at Mashegu and Lemu are more suited for pharmaceutical industry. The clay deposits associated with marble deposits at Kwakuti resulted from weathering of basement schistose rocks. Geochemically, these clays have very high alumina content and can serve as needed raw material inputs in cement manufacture. The clay is characterized by a significant content of Zircon (Zr) traces.

Marble

Economic quantity of marble occurs at Kwakuti. These marbles are whitish calcitic and slightly brownish dolomitic. The marble occurs in a basement terrain associated with schists, granites and gneisses. A company exploiting the marble for a small scale cement and fertilizer production gave estimated reserves of 45 million tons for the marble deposit and capable of providing raw material for a medium to large scale cement production for 35 years. The sampled deposit (Kwakuti-1m-Adama and Kwakuti-1m-Dantoro) is highly calcitic (CaO 37-38%) and negligibly dolomitic (MgO 0.03-0.07). The deposit has significant content of Cu, Pb, Zn, and Ba traces.

Talc

The talc deposit at Kagara occurs large talc schist intermingled with granites, migmatite and gneisses of the basement complex. It was not possible to get to mine site (quarry) at the time of the mapping (for security reasons) but samples

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were collected from around the quarry. The talc is characterized by high silica content with significant amount of alumina (Al_2O_3) and Magnesium oxide (MgO). Iron content is also relatively high and may diminish the quality of the talc but can be ameliorated by beneficiation. The talc can support a cosmetic factory as well as a paper production industry.

Fig. 4. Assessing the clay deposit at Mashegu. Note excavated portions mined by local miners.

Fig. 5. Conducting textural examination on the clay deposit at Kutigi. Geochemical results show that this clay deposit (top-most layer 3) has the best quality (highest alumina and least silica content) amongst the clay deposits studied

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Fig. 6. Conducting acid test on samples from different layers of the Lemu clay deposit

Fig. 7. Mapping, logging and sampling of the Kwakuti alumina-rich clay (top 4 pictures) and marble deposits (the boulder) (bottom picture)

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Fig. 8. Marble and clay industrial minerals at Kwakuti processed for production of cement and fertilizer by Kaffo Mines on a small scale at Kwakuti

Fig. 9. A large chunk of talc schist collected at Kagara

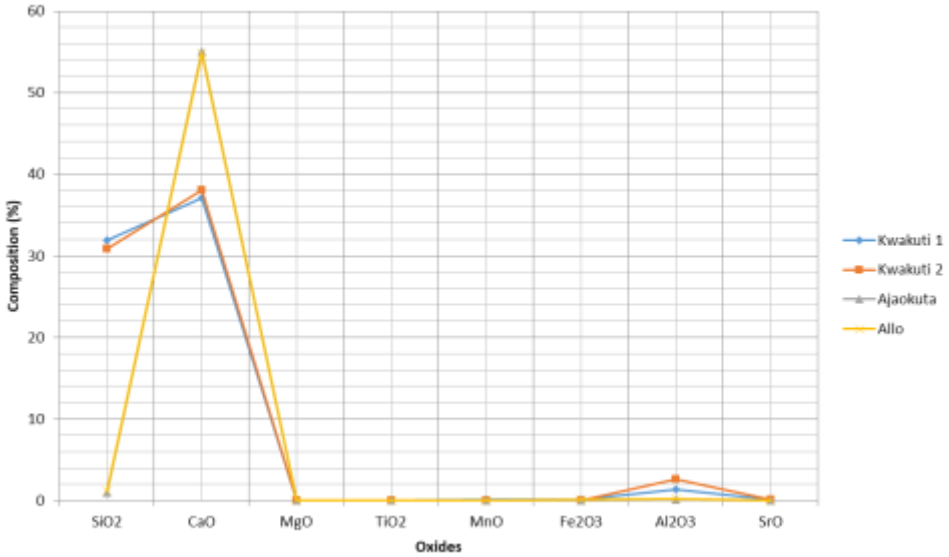

Fig. 10. Major oxides distribution in Marble from Niger State (Kwakuti 1 and 2) plotted against earlier results obtained on Marble from Kogi State (Ajaokuta and Allo)

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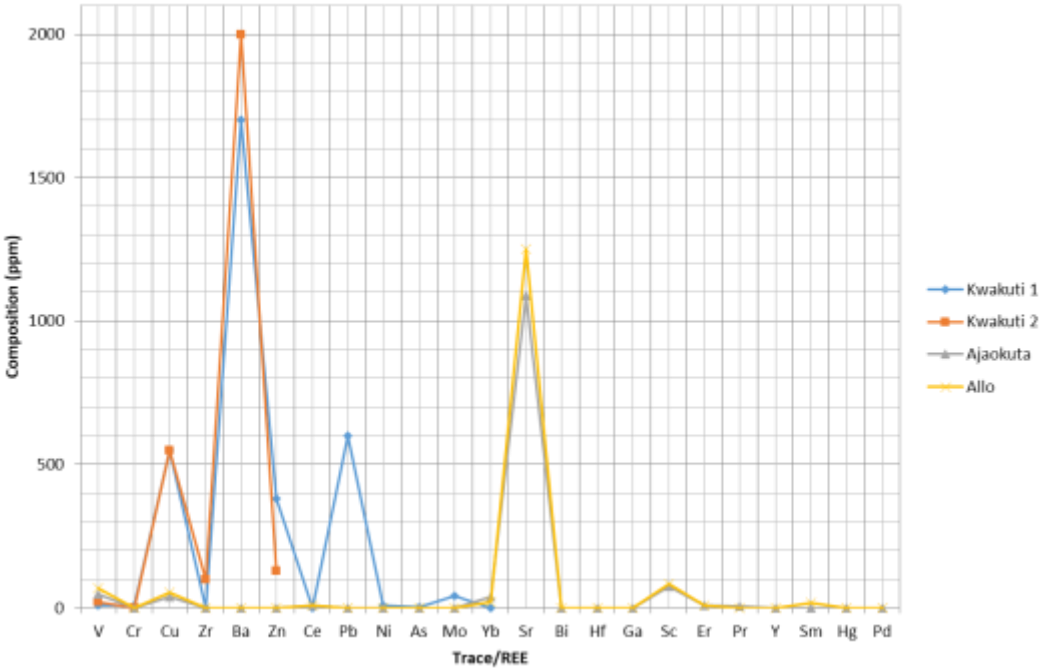

Fig. 11. Trace elements distribution in Marble from Niger State (Kwakuti 1 and 2) plotted against earlier results obtained on Marble from Kogi State (Ajaokuta and Allo)

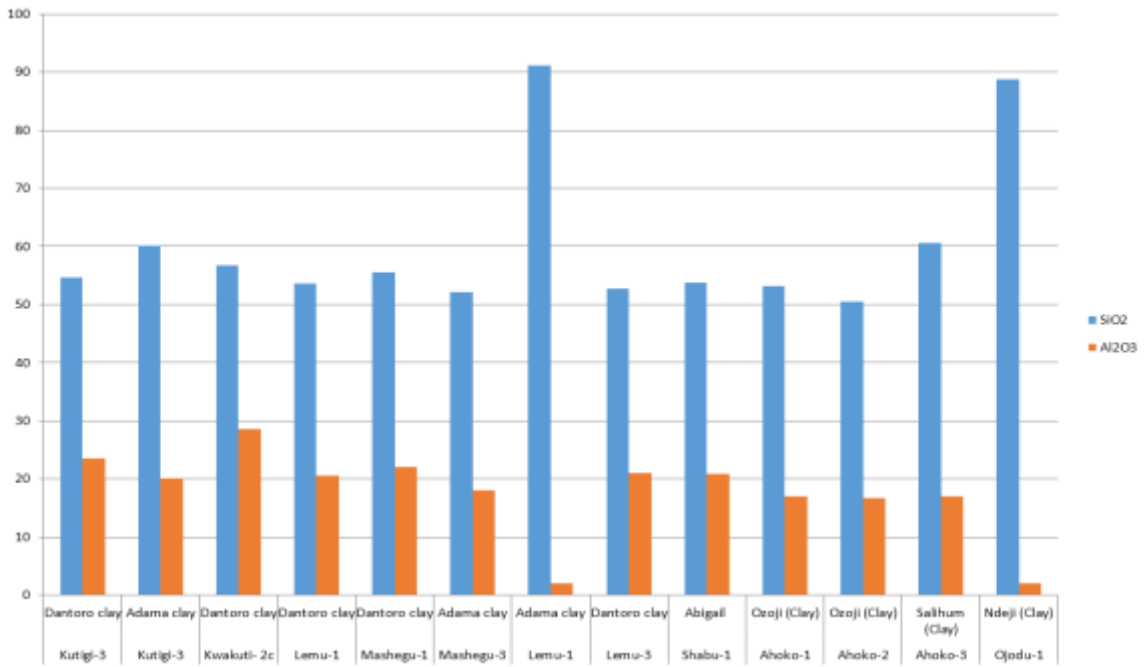

Fig. 12. Silica to Alumina ratios in clay deposits from Niger State plotted against earlier results obtained on clay deposits from Nasarawa State (Shabu) and Kogi State (Ahoko)

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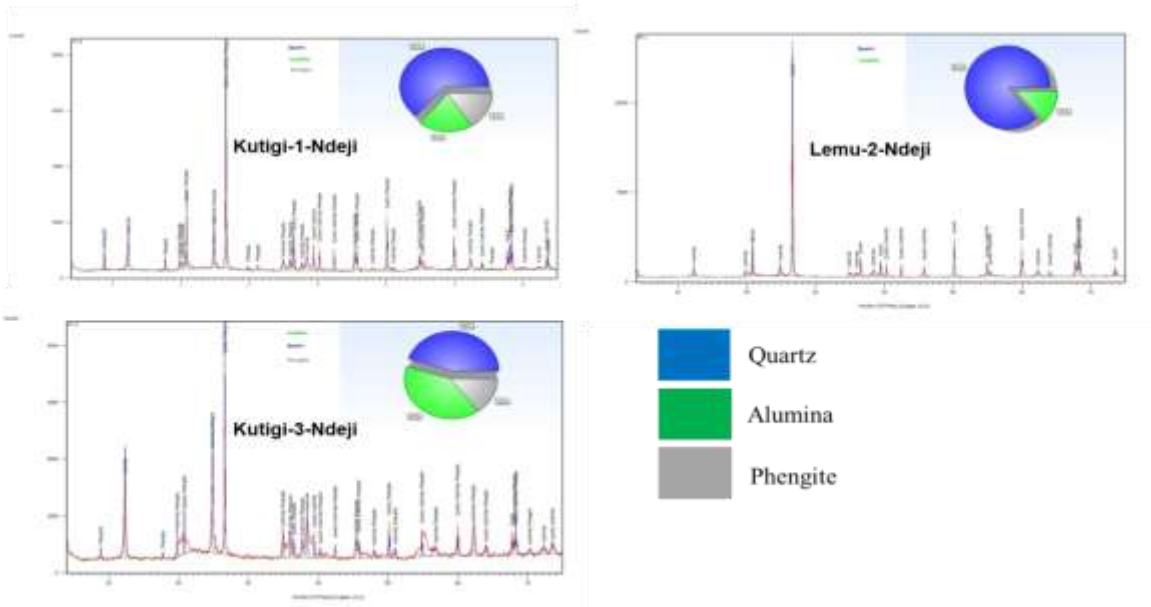

Fig. 13. XRD characterization of lower layer of the Kutigi clay showing high quartz and low kaolinite content, upper layer of the Kutigi clay showing high kaolinite content and middlelayer of the Lemu clay showing very high quartz content

IV. CONCLUSIONS

The study has assessed the occurrences and quality of some industrial mineral deposits in Niger State.Mashegu, Kutigi and Lemu host economic deposits of clay of varying qualities. Marble and clay occur at Kwakuti and talc at Kagara. All the mapped industrial minerals occur in economic quantities, although the exact reserves werenot established. The clays at Kutigi have high content of kaolinite while those at Lemu, Mashegu and Ojodu have been diminished by high silica content. The marble deposits at Kwakutihave high content of CaO and little MgO making them heavily calcitic and less dolomitic. The clays associated with marble at Kwakuti have high alumina content and a significant content of Zr traces. The content of iron oxide (Fe_2O_3) in the talc at Kagara and clays at Lemu and Mashegu, may constitute obstacles in their industrial applications. The clays at Kutigi have the required economic quantity and chemical parameters for exploitation as raw materials for ceramic/sanitary ware industries while those at Mashegu and Lemu can be used for same purpose but with some beneficiation. The marble at Kwakuti can support a large size cement factory with raw material supply for 35 years. There are prospects to book additional reserves. The talc at Kagara can support a cosmetic factory and a paper industry.This report will serve as a road show for investment drive for industrialization in Nigeria's geopolitical State of Niger which will lead to more employment generation and wealth creation.

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