The characterization of Talcose rocks by X-Ray Diffraction in Tegina Sheets 142, North Central, Nigeria

OJO ADEOYE AKINTOLA[1]; OGUNTUASE MARY ADERONKE[2] JONAH JONATHAN[1]

[1]Department of Geology, Faculty of Physical Science, Ahmadu Bello University, Zaria, Nigeria.
[2]Science Laboratory Technology (Geology Option), Faculty of Science, Ekiti State University, Nigeria.

*Corresponding author. E-mail: adeoye.akintola@yahoo.com

Abstract

The identification of mineral in talcose rock requires definitive analytical methods due its similar structure in silicates and associated minerals. The used of microscopy and X-ray diffractometry have been found useful, practical for both exploratory and determinations of mineral matrixes in talcose rock in the study area.

Talcose rock, migmatite gneiss, granitic gneiss, meta-arkose rock, amphibolite, banded gneiss, phyllite, porphyritic granite, fine-medium grained granite, granodiorite and pegmatite constitute the major rock types in the study area. The major minerals present in the porphyritic granite, fine-medium grained granite, migmatite gneiss, meta-arkose rocks and pegmatite were quartz, biotite, plagioclase and microcline, while epidote dominated as accessory mineral. Talcose rock contains talc, chlorite, magnesite, anthophyllite with magnesite and quartz forming the accessory minerals. X-Ray Diffraction of the talcose rock also revealed talc as major mineral. Other constituent minerals of the talcose rock are chlorite, tremolite, actonlite, magnesite, and magnetite while spinel and quartz are the accessory minerals.

KEYWORD: talcose rocks, mineralization, microscopy, mineral paragenesis, metamorphisms.

INTRODUCTION

The north-central part of Nigeria form falls within the Pan – African complex (PAC) of where the study lies, which is a part of an Upper Proterozoic mobile belt, extending from Algeria across the Southern Sahara into Nigeria, Benin and Cameroon.(Elueze, 1981, Olobaniyi and Annor, 2003).The talcose rocks falls within Archean - Paleoproterozoic blocks of West African Craton in the west, the Congo Craton in the southeast and the east Sahara block in the northeast (Durotoye and Ige, 1991) (Figure 1).

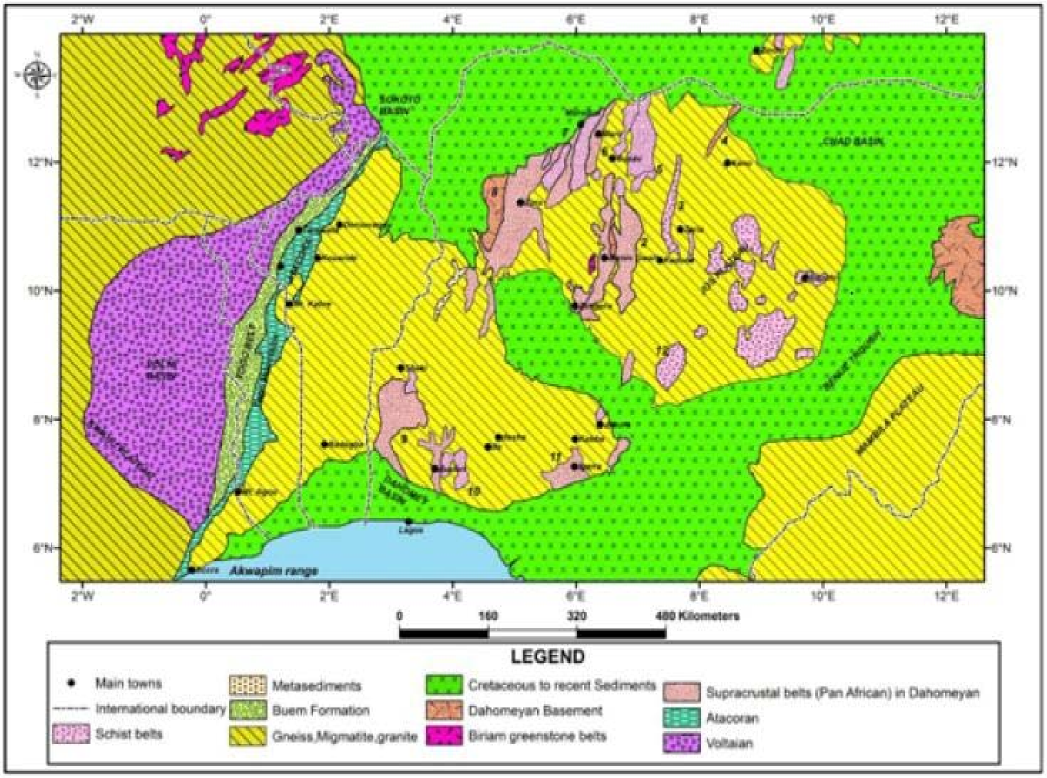

Figure 1: Generalized geological map of Nigerian- Dahomeyan sub region: The Migmatite–Gneiss complex (mgc); Schist Belts (Sb); Older Granites (og), (after Woakes et al., 1987).

The basement complex of Nigeria made up of Precambrian migmatite and gneisses and minor rocks of low to medium grade supracrustal rocks are infolded which belts of N-S trending (Figure 1)(Ajibade *et al.,* 1987).This supracrustal rocks are of low to medium grade meta-sediments of pelitic to semi-peliticin nature, belonging to carbonates, psammitic rocks as well as mafic and ultramafic (talcose) rocks. Field observation revealed the area to be lenticular to ovoid with the metasediments intercalated. In the study area, the basement and supracrustal sequence have suffered polyphase deformation and metamorphism and are intruded in some places by Pan- African granitoids.

Talc is a hydrated silicate of magnesium $Mg_3Si_4O_{10}(OH)_2$. It is an alteration product of original or secondary magnesian minerals or rocks resulting from mild hydrothermal processes, aided by simple dynamic metamorphism but never from weathering (Hecht *et al.,* 1999).

Minerals commonly associated with talc are serpentine (3MgO.2SiO2.2H2O), chlorite (MgO.FeO.Al2O3.3SiO2.4H2O), quartz (SiO2), Scheelite (CaWO4), Calcite Ca(CO2)3, anthophyllite (7MgO.7FeO.16SiO2.2H2O), phlogopite (5MgO.8SiO2), Enstatite (5MgSiO3) among others depending on the rocks from which the talc is derived (Piniazkiewicz *et al.*, 1994; Virta, 2009). The major unique characteristics are lamellarity, softness, chemical inertness, affinity for organic chemicals, and whiteness. Talc properties that are considered most important for possible applications include mineral composition, chemical composition, dry brightness, whiteness, oil absorption, particle size distribution, and density (Schandl *et al;*1999). Tegina area is bounded by latitudes 10° 00′N and 10°15′N and longitudes 6°10′E and 6°30′E in Kushaka Schist belts (Figure 1). The study area is assessable through Lagos - Tegina - Kaduna highway. The numerous untarred roads, foot paths, cattle tracks as well as streams and rivers channels are also provide easy accessibility in the area during the dry season. The study area is generally undulating lowland.

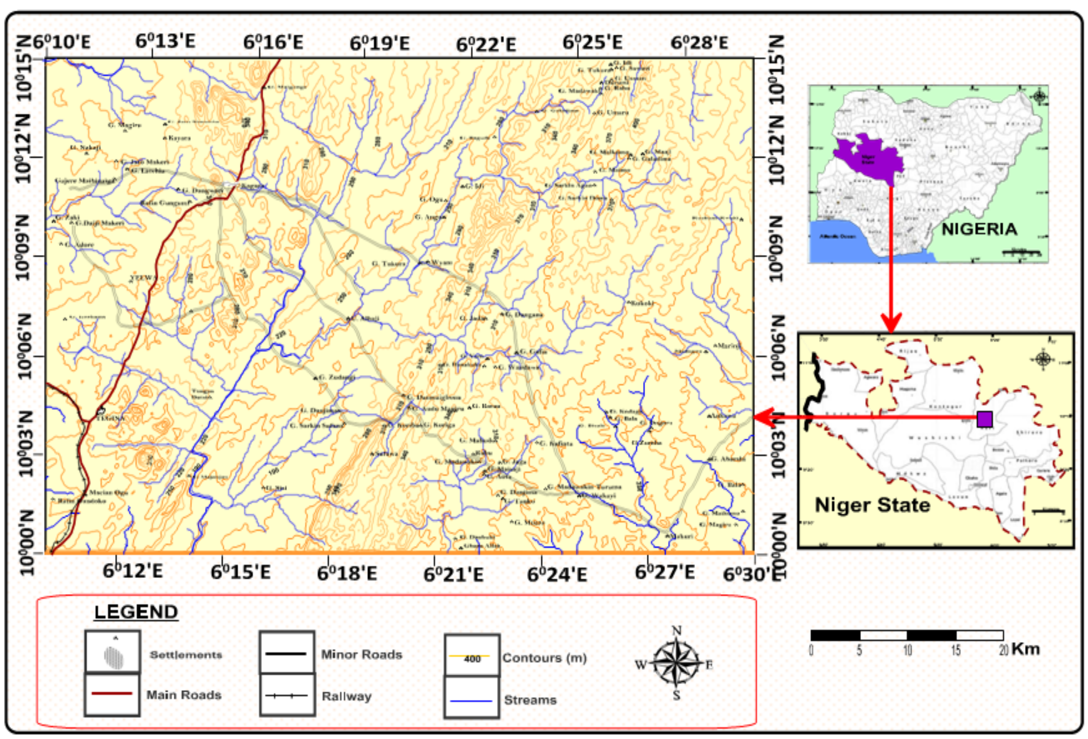

Figure 2: Location map of the study area.

PREVIOUS WORK

Earlier workers like Truswell and Cope, (1963); Elueze, (1982); Elueze and Dosunmu (1987); RMRDC, (2010). Elueze (1983; 1986) have previously been reported the occurrence of talcose rocks by were speculated on tectonic affinity of the amphibolites in the area. (Ajibade, (1982) reported the geochemistry and general geology of the area. Ihaza *et al.,* (2014) assessed the talcose bodies in the area with emphasis on its industrial application while Amoka (2000); Ogunbanjo and Amoka (2005, 2006; 2010) worked on decolourization of talcose rock from Kagara using magnetic separation and acid bleaching as route for colour enhancement. The aim of this study is to determine its minerals compositions of the talcose rocks through X- ray diffraction analysis.

MATERIALS AND METHODS

The methodology adopted for this consists of work of field study and laboratory analyses. The field study involved the geological mapping of the area on the scale of 1:50 000 using geologic hammer, compass - clinometers and Global positioning system (GPS). The laboratory work involved sample preparation and petrographic study. Microscope was used for petrographic study at petrographic laboratory in Department of Geology, Ahmadu Bello University, Zaria. Two (2) samples of talcose rock were prepared for petrographic study and two (2) selected samples of talcose rock were shipped to Activation Laboratories Limited (ACTLAB), Ancaster, Ontario, Canada for x-ray diffraction (XRD).

FIELD INVESTIGATION

Detailed geological mapping on a scale of 1:50,000 using traverse method. Four (4) representative rock samples were collected from exposures in the study area. In the field, each outcrop was observed and described based on its mode of occurrence, macroscopic characteristics, structural elements and field relation with adjacent outcrops.

Fresh samples were taken during the field work with the aid of sledge hammer and chisel and examined with hand lens. Germain Global positioning system (GPS) was used to determine the elevation, longitudes and latitudes of the samples. Careful observation of lithological boundaries was made by observing changes in rock exposures, nature of soil, vegetation and topography. A Silva compass clinometer facilitated traversing and was also used to take strike and dip values of the various structures. Linear measurements were taken with the aid of meter rule. Other materials that were used for the field work are digital Camera to obtain photographs of the rocks and important features where possible. The field note book was used to record the daily activities and rocks description on the field. All the samples were labelled so as to prevent mis-identification and later bagged for sample preparation.

X-RAY DIFFRACTION ANALYSIS

Two (2) representative's samples of talcose rock were analysed for x-ray diffraction (XRD). About 1 kg of each sample was broken into pieces with a hammer and crushed into smaller piece with a jaw crusher. The samples were thereafter pulverized in a disc mill for about two minutes. Each pulverized sample was thoroughly homogenized to obtain a representatives portion. The samples were thereafter shipped for X-ray diffraction analysis at ACTLAB analytical Laboratory Ontario in Canada.

X-ray diffraction analysis was performed on a Panalytical X'Pert Pro diffractometer, equipped with a Cu X-ray source and an X'celerator detector, operating at the following X-ray settings: voltage: 40 kV; current: 40 mA; range: 5-70 deg 2θ; step size: 0.017 deg 2θ; time per step: 50.165 sec; divergence slit: fixed, angle 0.5°. The crystalline mineral phases were identified in X'Pert High Score Plus using the PDF-4 Minerals ICDD database.

RESULTS AND DISCUSSION

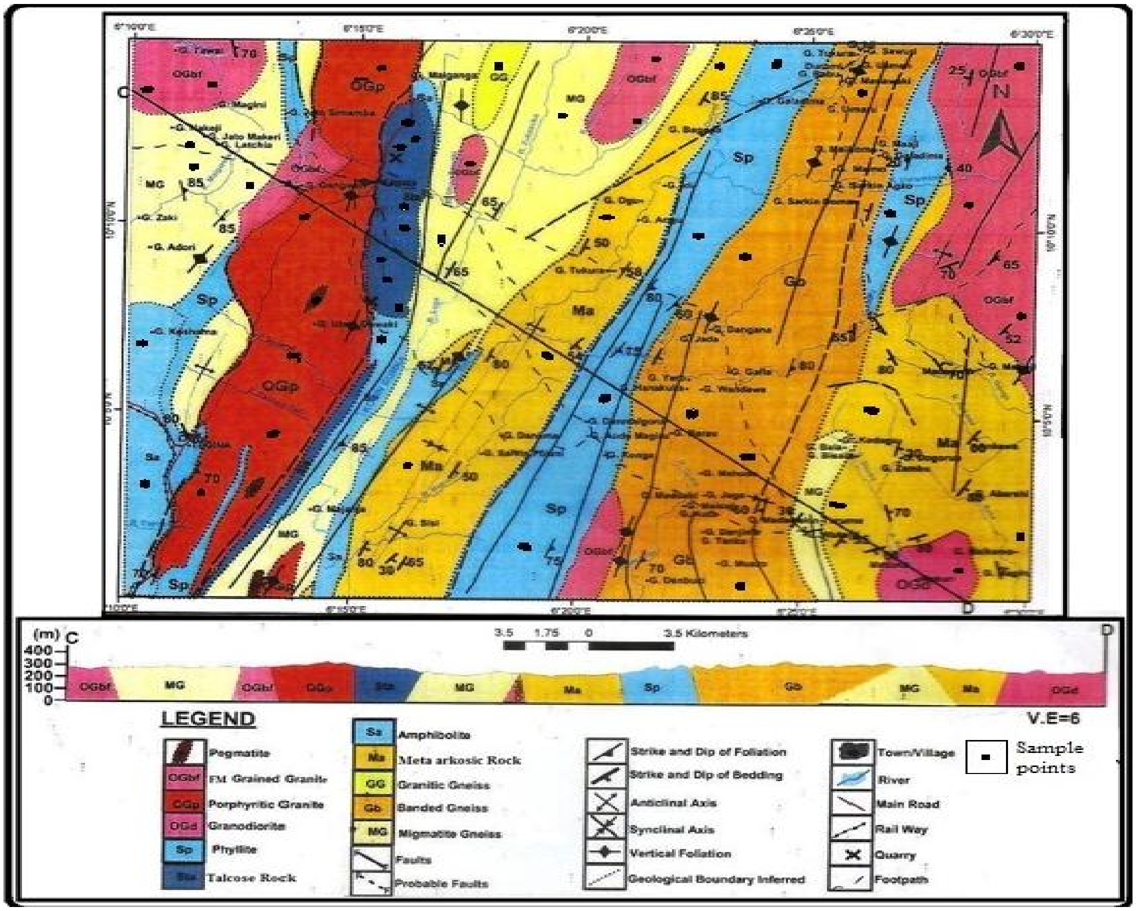

Figure 3: Geological map of the Kagara area.

X-RAY DIFFRACTION ANALYSIS

X-ray diffraction were carried out for mineralogical compositions of talcose rock and the host rocks. The mineralogical compositions of talcose rock (Table 1) and the host rocks from Kagara are shown in Table (2) while the mineral assemblages developed in individual samples including talcose rocks are presented in Appendices (I-II)

X-ray diffraction result revealed conspicuous peaks of talc, chlorite and magnetite in assemblage of the talcose rock. Ferroan and quartz are minor constituents in the amphibolites. Other minor peaks include those with spinel structure, magnesite and biotite minerals from biotite group (Table 2).

Table 1: Composition of the Samples from the XRD Analysis.

Sample Code	Fomula	Mineral	Percentage (%)
$L13a_2$ (talcose rock)	$Mg(CO_3)$	Magnesite	20
	$(Mg,Fe)Al)_6(Si,Cr)_4O_{10}(OH)_8$	Clinochlore,/ Ferroan	40
	Fe_3O_4	Magnetite	3
	$Mg_3Si_4O_{10}(OH)_2$	Talc	38
$L15_a$ (talcose rock)	SiO_2	Quartz	5
	$(Na,Ca)Al(SiAl)_3O_8$	Albite	3
	$KMg_{1.3}Ti_{0.3}Fe_{1.7}Al_{1.2}Si_{2.8}O_{11(OH)}$	Biotite	7
	$(Mg,Fe,Al)_6(Si,Al)_4O_{10}(OH)_8$	Clinochlore	37
	$Mg_3Si_4O_{10}(OH)_2$	Talc	45
	$KA_{l2}(Si_{3Al}O_{10}(O)_{10}(OH,F)_2$	Muscovite	3

Table 2: Mineral paragenesis of talcose rock from the study area

Samples	Mineral Paragenesis
$L13_a$(Talcose rock)	talc + tremolite+ chlorite + magnesite + anthophyllite + magnetite
$L8_a$(Talcose rock)	talc + actinolite + chlorite + anthophyllite + quartz

MINERALIZATION PROCESS OF TALCOSE ROCK IN THE STUDY AREA

The coexistence of talc and chlorite indicated that the study area is a typical metamorphic terrain. The constituents mineral of talcose rocks are talc, chlorite, anthophyllite, tremolite /actinolite, and magnesite. Though Tremolite and actinolite are slightly to moderately altered to chlorite and or talc, where fine relics of actinolite laths are randomly distributed within the talc matrix as shown in Plate (1). Chlorite occurs in the form of disseminated euhdral plates and massive lenses of very fine-grained mineral.

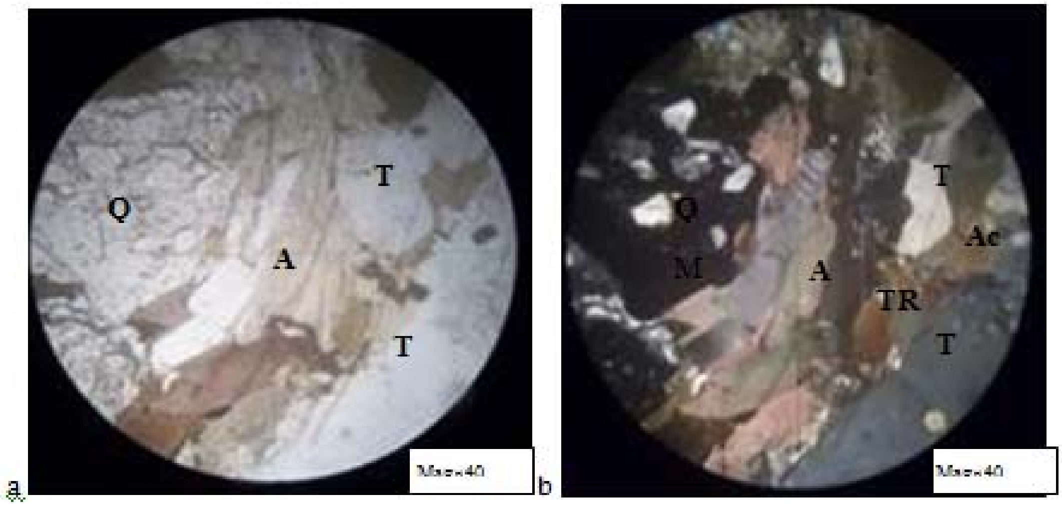

Plate 1: Photomicrograph of talcose rock in (a) plane polarized light (PPL) and (b) crossed polarized light (XPL); (A) = Anthophyllite; (C) = Chlorite,(M)=Magnetite; Ac= Actinolite, Q=Quartz, (TR)=Tremolite

The surrounding rocks have excess water that circulates, scavenge and transport minerals to the sites where they can be precipitated as talcose rock Plate l). Temperature variations also affected the grade of metamorphism and with low temperature, hydrous minerals recrystallized into new, higher temperature, anhydrous minerals. The phases order ranges from primary phases through alteration to final products as actinolite and clinochore altered to chlorite with talcose rocks as the final product from chlorite.

Partial pressure of carbon (iv) oxide within the metamorphic fluid is the major factor that control the mineral assemblage which support talcose mineralization in Talcose rocks.

The role of mixed volatiles as a factor of metamorphisms has been highlighted by Winkler (1979) who observed that metamorphism of basalts to chlorite-green schists or amphibolite is impossible if sufficient amount of water is present during metamorphism. Decarbonation and dehydration reactions are examples of solid—> solid + vapour reactions.

The potential sources of the fluids are through dehydration and decarbonation processes, which occur during the metamorphic event in the area. In the study area, the effects of metamorphism on clinochlore at a low pressure proceed to the right. The crystallization of the tremolite was contemporaneous with reactions as successive metamorphic reactions have replaced or dissolved all primary minerals in the study area in the presence of carbon (iv) oxide that form magnesite ($MgCO_3$).The possible reactions are shown below;

$$5Mg_5Al_3Si_3O_{10}(OH)_8 \longrightarrow 7Mg_2SiO_4 + 2Mg_3Si_4O_{12}(OH)_2 + 5MgAl_2O_4 + 18H_2O \text{.....(i)}$$

Clinochlore ——> forsterite + talc + spinel + Vapour

CONCLUSIONS

The study area is underlain by meta-arkose rock, amphibolite, talcose rock, migmatite-gneiss, banded gneiss, phyllite, granitic gneiss, porphyritic granite, fine to medium grained granite, granodiorite, and pegmatite. Two distinct varieties of talcose rock are distinguished by colour (white and black). Green chunks of chlorite and bands of quartz veins were also observed in the field as megascopic examination shows typical greasy lustre and basal cleavage of talc.

Mineralogically, the talcose rock contains in addition to talc, appreciable amounts of chlorite, magnesite, and anthophyiltes with quartz and magnetite forming the accessory minerals. Talc mineralization is controlled by many factors particularly silica activity in the liquid phase. Fluid coming from the surrounding was most probably rocks may be rich in dissolved SiO_2

In the study area, the effects of metamorphism on clinochlore at low pressure proceed to the right as crystallization of the tremolite was contemporaneous with reactions as successive event. During metamorphism some of all primary minerals in the study area were replaced or altered the presence of carbon (iv) oxide that produced magnesite ($MgCO_3$). The possible reactions are as shown in equations (i)

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Clinochlore ——> forsterite + talc + spinel + Vapour

On the basis of the physical, mineralogical characteristics of the talcose rock, this works has established the coexistence of chlorite with talc is not detrimental to talc for many applications because they have similar mineralogical composition.

ACKNOWLEDGEMENTS

The writers express their appreciation to Professor Saidu Baba for critical reading of the manuscript of the main work. We also wish to thank Professor. P.O. Ogunleye for his constructive criticisms and contributions during the course of the work. Akintola wishes to acknowledge the co-operation of the many people involved in making available the specimens used in this investigation. Prof. I. Garba, useful pieces of advice and corrections during field work. Dr O.O Akintola and Mr Yahaha Ibrahim are specially thanked for their financial assistance and to thank Dr. I.S. Amoka for helpful discussions.

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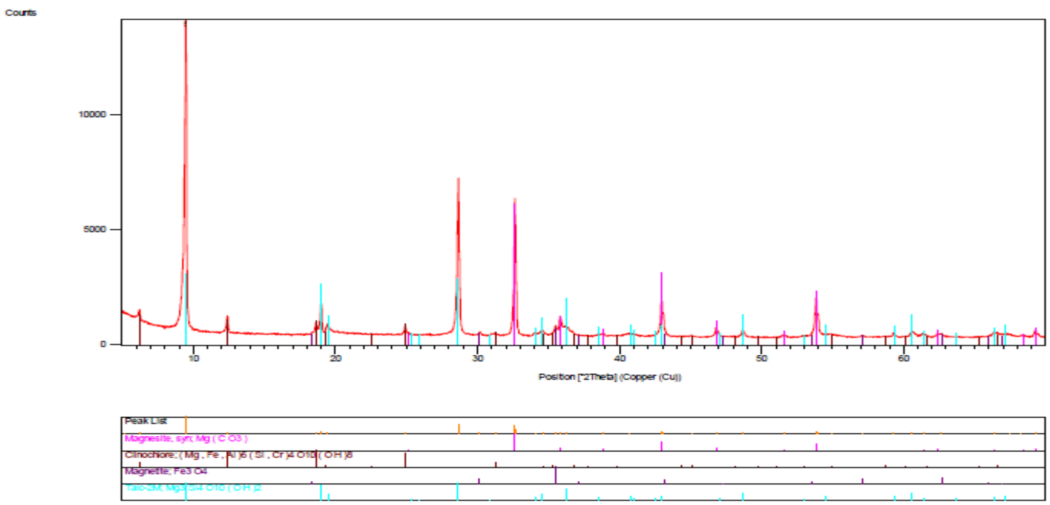
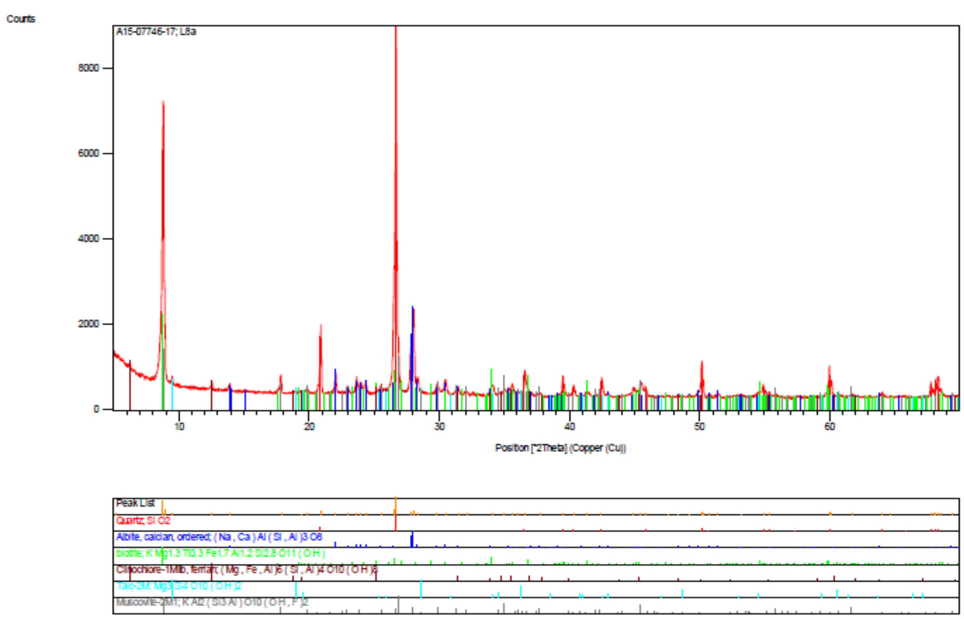
APPENDIX 1

X-ray diffraction (XRD) pattern for talcose rock: Sample (a)

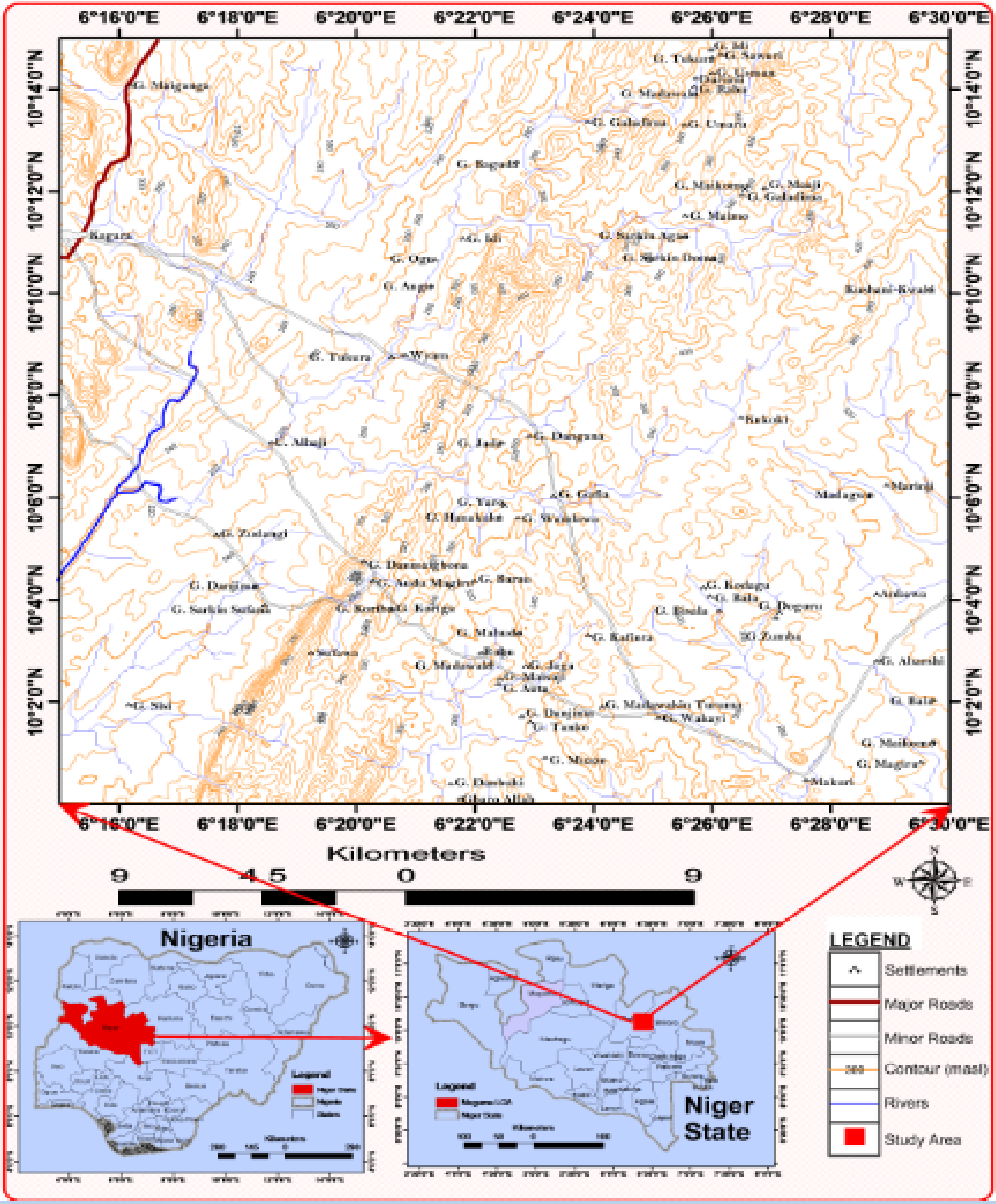


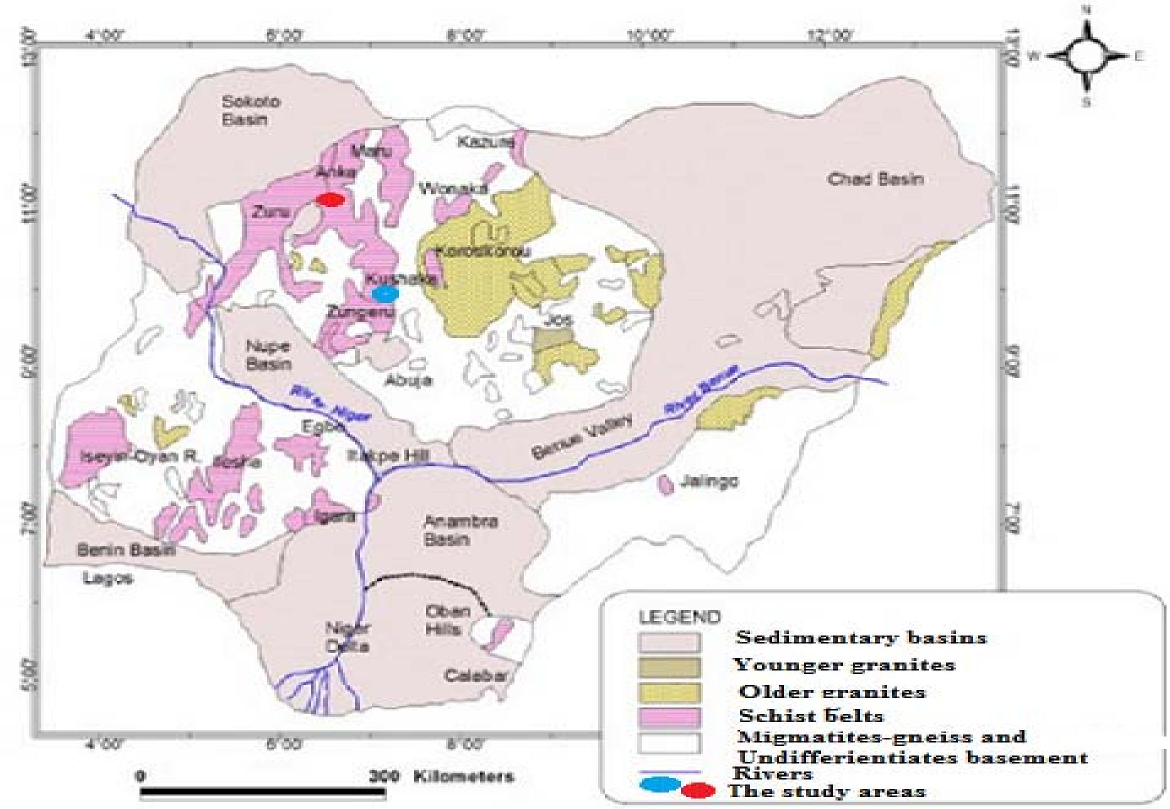
APPENDIX 1I

X-ray diffraction (XRD) pattern for talcose rock: Sample ($_b$)

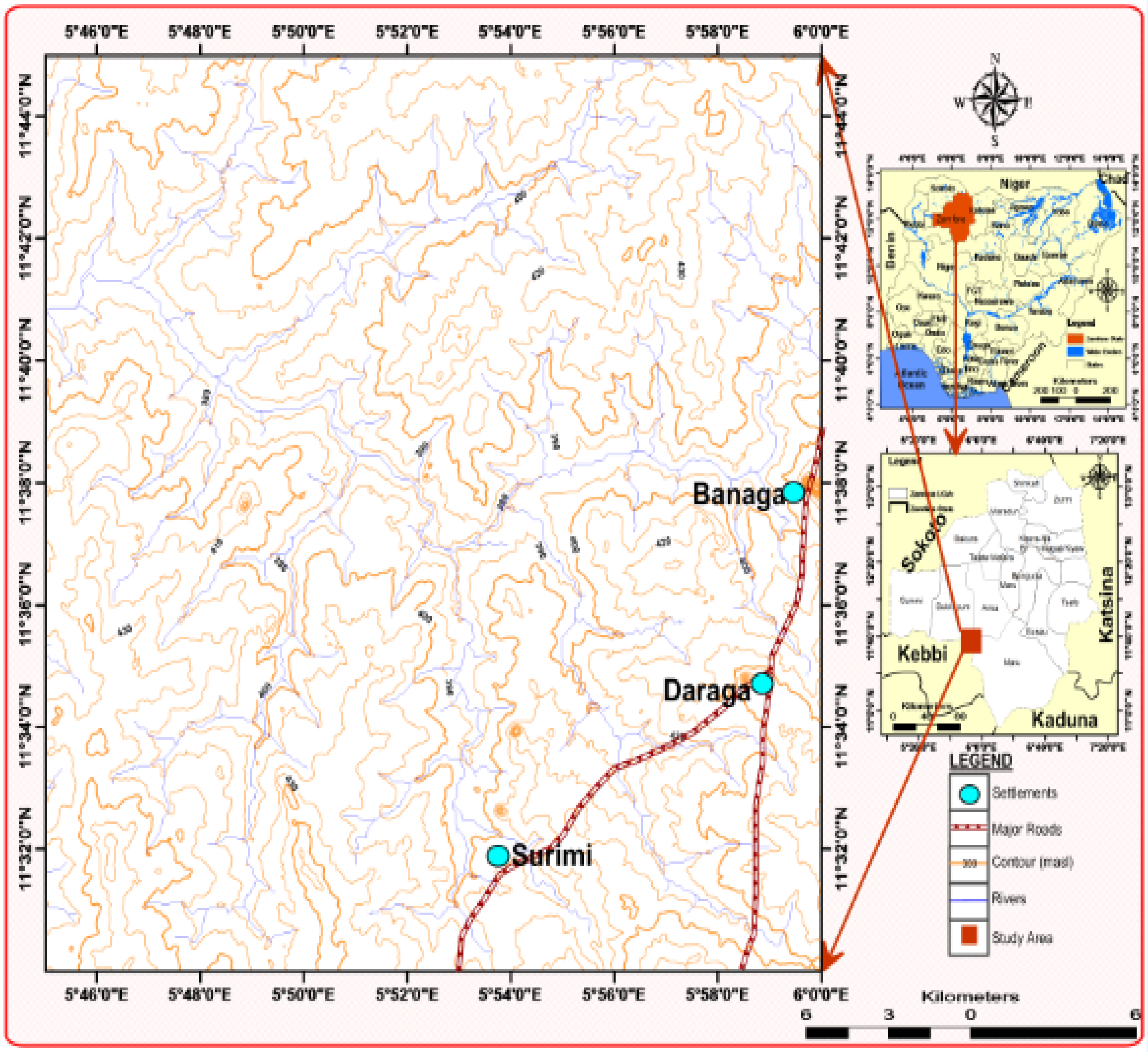


In the Anka area, though fairly close together, the main lithologies are dominantly phyllitic and small lenses of metaconglomerate to the north and some granitic intrusions around Derita and the proportion of coarser metasediments is significantly greater (Holt, 1982). The Bukasau area comprises of metasedimentary/metavolcanic pile intruded by dykes and high-level intrusions of several affinities, and by plutonic rocks of the Pan-African "Older Granite Suite". Other rocks found in the area are semi-pelite and psammite with meta-conglomerates as minor components





Sokoto Basin
Maru
Anka
Zuru
Kazure
Wonaka
Chad Basin
Kushaka
Zungeru
Jos
Nupe Basin
Abuja
River Niger
River Benue
Benue Valley
Egbe
Itakpe Hill
Iseyin-Oyan R.
Jalingo
Igarra
Anambra Basin
Benin Basin
Lagos
Oban Hills
Niger Delta
Calabar
0
300 Kilometers
LEGEND
Sedimentary basins
Younger granites
Older eranites
Schist belts
Migmatites-gneiss and Undifferientiates basement
Rivers
The study areas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Banaga
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Study Area
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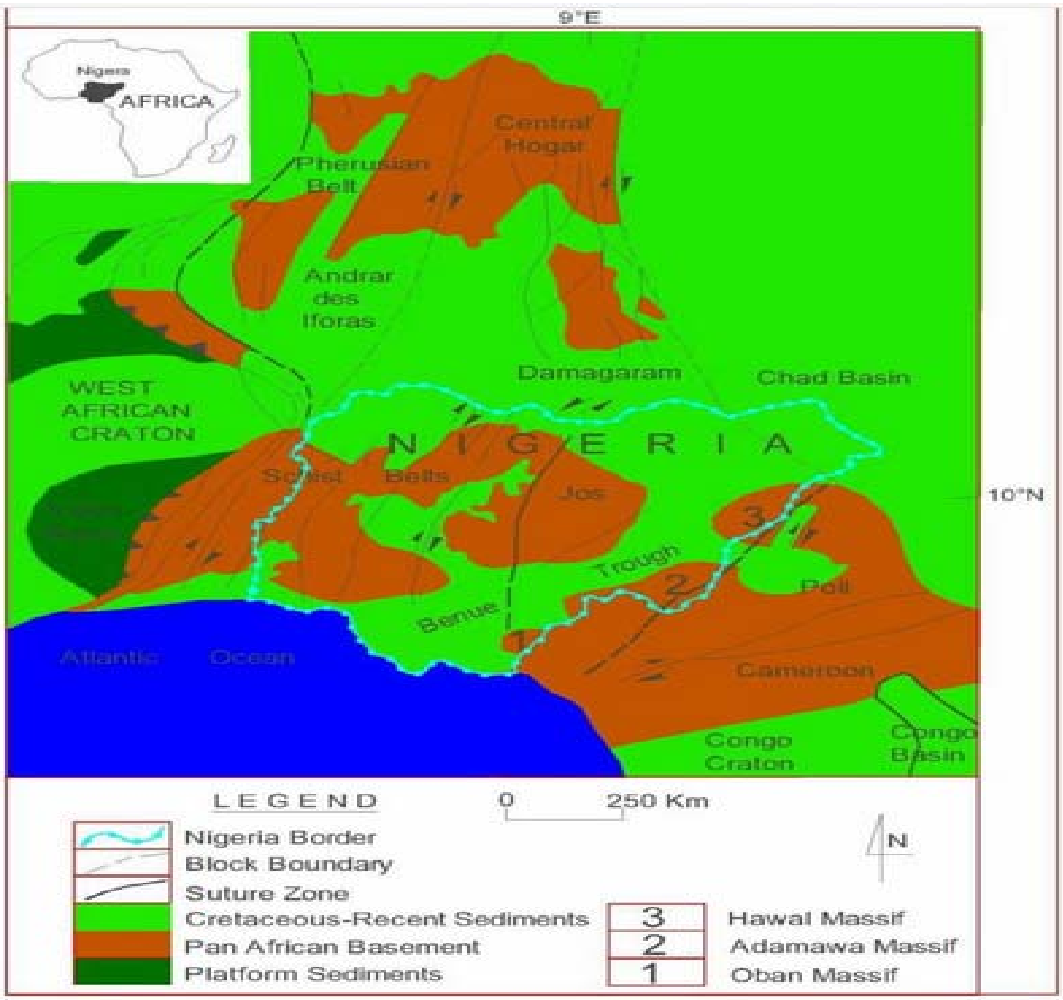
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Damagaram
Chad Basin
WEST AFRICAN CRATON
N I G E R I A
Schist Belts
Jos
Trough
Benue
Poli
Atlantic Ocean
Cameroon
Congo Craton
Congo Basin
LEGEND
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Pan African Basement
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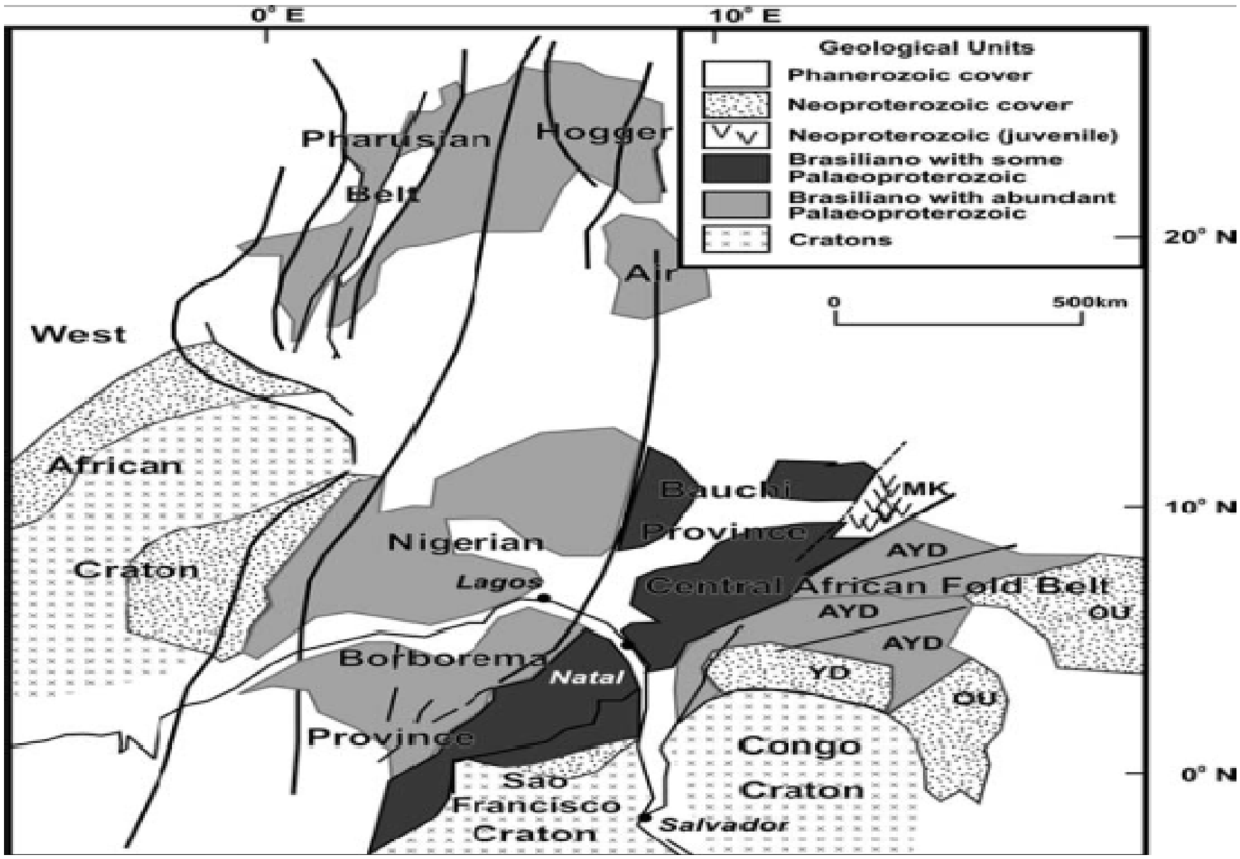
2 Adamawa Massif
1 Oban Massif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Geological Units
Phanerozoic cover
Neoproterozoic cover
Neoproterozoic (juvenile)
Brasiliano with some Palaeoproterozoic
Brasiliano with abundant Palaeoproterozoic
Cratons
20° N
10° N
0° N
0
500km
Pharusian Belt
Hogger
Air
West African Craton
Nigerian
Lagos
Bauchi Province
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AYD
Central African Fold Belt
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YD
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Natal
Sao Francisco Craton
Congo Craton
Salvador

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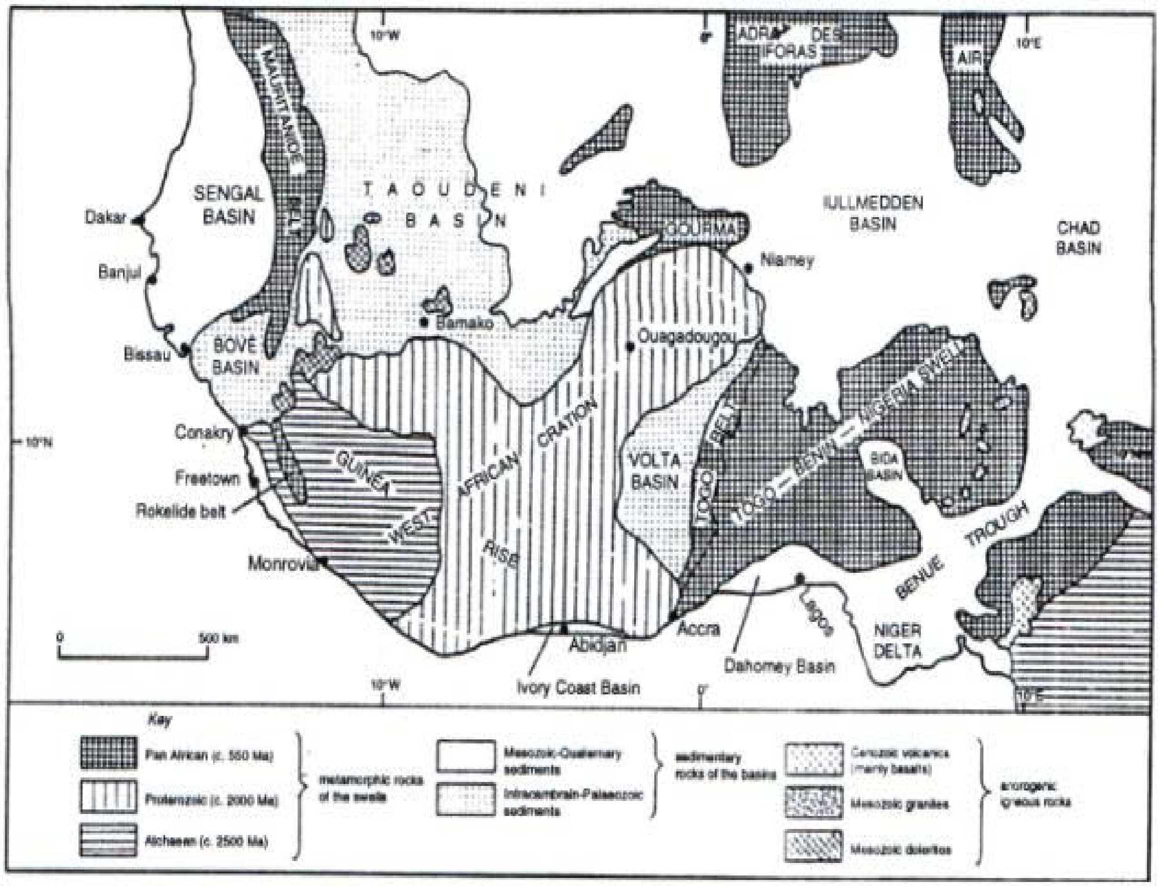
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ADRAR DES IFORAS
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GOURMA
Dakar
Banjul
Bissau
Bamako
Niamey
Ouagadougou
BOVE BASIN
Conakry
Freetown
Rokelide belt
Monrovia
10°N
GUINEA
WEST AFRICAN CRATION RISE
VOLTA BASIN
TOGO BELT
TOGO – BENIN – NIGERIA SWELL
BIDA BASIN
BENUE TROUGH
NIGER DELTA
Lagos
Accra
Abidjan
Ivory Coast Basin
Dahomey Basin
0
500 km
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Key
Pan African (c. 550 Ma)
Proterozoic (c. 2000 Ma)
Archaean (c. 2500 Ma)
metamorphic rocks of the swells
Mesozoic-Quaternary sediments
Infracambrain-Palaeozoic sediments
sedimentary rocks of the basins
Cenozoic volcanics (mainly basalts)
Mesozoic granites
Mesozoic dolerites
anorogenic igneous rocks