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# Provisional Dating of Metasedimentary Rocks in South Katsina State, Northwestern Nigeria: Studies in Proterozoic Crustal Evolution

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## ABSTRACT

**On the basis of available isotopic data the schist are assumed to be of two (2) types: the metasediments which are mainly found in southwestern Nigeria and the low grade schist (the younger metasediments) mainly found in northwestern Nigeria. In this research, age relationship among the schist and quartzite belts of Nigeria and perhaps the study area which is Northwestern Nigeria is unresolved, as various ages have been assigned. Paleoproterozoic was an important activity which occurred when crust was formed in Africa. It is a fact that terrains with similar chronology and geochemical features formed in different geographical areas were juxtaposed in a late orogenic activity. In that, comparisons of metasedimentary series which are schist and quartzite according to time of formation imputable to different sequences can provide a better understanding to terrain accretion models.**

**Key words:** Proterozoic, Crust, Age, Northwestern Nigeria.

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## INTRODUCTION

The reconstruction of the palaeo-environment of deposition for the younger metasedimentary rocks, which consist of schist and quartzite in the study area, is difficult from direct field evidences, as there is no actual reality of the precise bedrock structure directly under the metasediments within the older metasediments' palaeo-basins. However, few observations on the protoliths and palaeo-environment types can be made based on the evaluation of the characteristics of the different lithologic types. Although most of the original sedimentary structures have been destroyed, one can still argue for a sedimentary origin for the metasediments (Ogeizi, 1977). A distinct negative gravity anomaly to the metasediments in the Kazaure area is known. Turner (1983) also briefly described the Kazaure Belt and concluded that it has a simple structural style and is free from central granite intrusion. He also suggested the possible similarities of the Kazaure rocks to those of Malumfashi Belt. The study of Kazaure Schist noted the occurrence of quartzite and mica schist. Some parts of the area are unconformably overlain to the north by Cretaceous sediments of Iullemmeden Basin, and to the northeast by Tertiary sediments of the Chad Basin (Turner, 1983).

## STUDY AREA AND FIELD GEOLOGY

The area is part of Lower Paleozoic terrain of North West

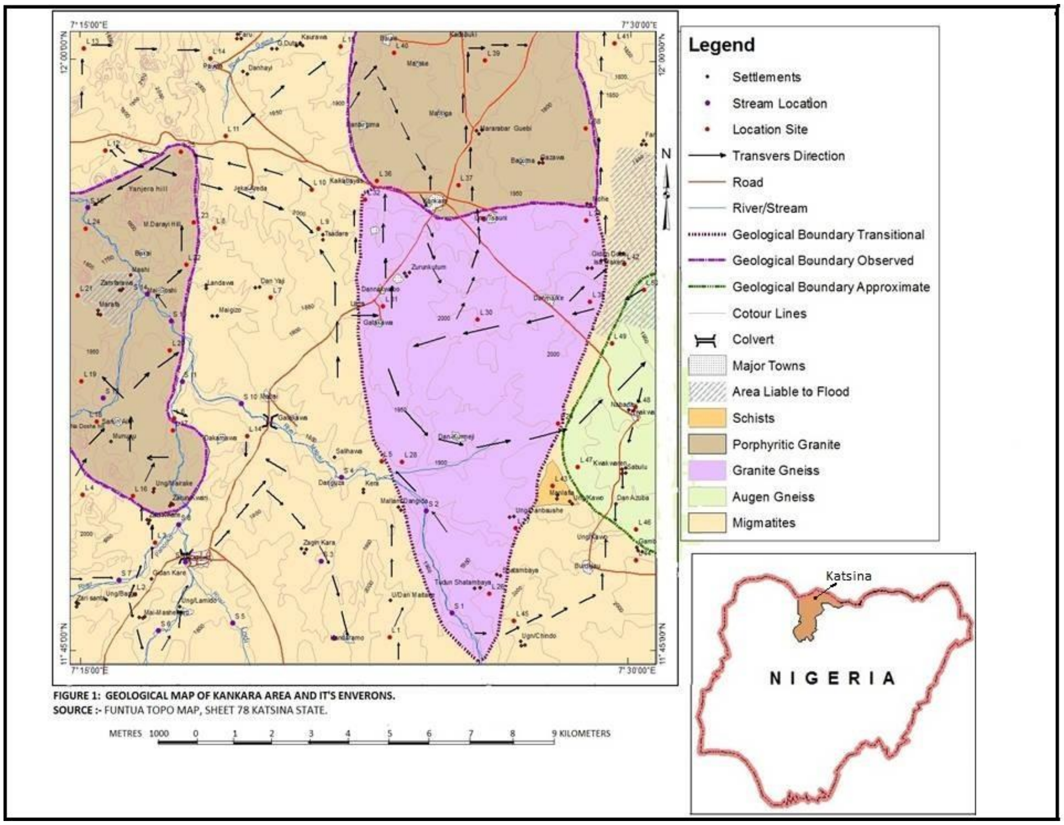


**Figure 1.** Geological Map of Funtua Sheet 78, NW; Scale: 1:50,000. Source: Field Mapping, 2007.

**Plate 1.** Peniplanation/mesas at Anguwan Danbaushe in the Funtua North-East. Source: Field work, 2007.

Nigeria. Geographically, it cut across Kankara, Bakori, Malumfashi and Faskari Local Government areas in Katsina. It falls within longitudes and latitudes $7^0$ 15' to $7^0$ 30' and $11^0$ 45' to $12^0$ 00' (Figure 1) The area is characterized by series of discontinuous ridge of inselbergs (gneiss and granite) in the western side which made it a slightly rugged landscape, with nearly rolling to peniplanation/flat surface towards the southern part (Plates 1 and 2). Some areas around far western and eastern parts are inaccessible due to intense flooding especially in the rainy seasons. The study area is however easily accessible through some federal roads: two well tarred roads of trunk 'A' and 'B' which link the area from Maimashekari village on Sheme-Kankara road and the other one passes through Danmarke to Burdugau in the south east (Kankara, 2014). Field evidences and characterization of the mica schist samples have revealed that the metasediments in the

**Plate 2.** Tudun-Sha-Tambaya village that characterize the southern part of Funtua Sheet 78 NE. Source: Field work, 2007.

study area are metamorphosed shale-greywacke sequence.

Sampling and hand specimen have shown that the mica schist are quartz-rich and have abundant plagioclase and biotite, with small amount of muscovite. The quartzite rocks are detrital and their protoliths were most likely quartzwackes approaching fine-grained quartz arenites in some places. The conglomerates and arenaceous particles were rapidly laid down in an ancient ecology whose level of temperature was higher than those in the pelites. A possible environment were the schist were deposited was a shallow basinal continental or littoral environment. This probably allowed for the deposition of the coarse clastic sediments as basin margin alluvial fans, clastic wedges and prograde deltaic sequence. However, the conglomerates were probably debris flow deposited through slumping. The metapelite represent a sequence of poorly bedded mudstones and shale.

## ORIGIN AND PALEOENVIRONMENT OF SCHIST BELT

Schist belts of the study area and northwestern Nigeria occupy generally N-S trending synformal troughs, which later transformed into migmatite and subordinate gneiss rocks and which are mostly prominent in the south western part of the country (Plate 3) Seventeen main belts have so far been identified (Turner, 1983). They define the structural grain of the basement. They are largely sediment-dominated and the most important lithologies are pelites, semi-pelites and quartzite (Long et al., 2008). In some belts chemical sediments are now present as marbles and banded iron formations (BIF) Mafic to ultramafic rocks are present as amphibolites and ultramafic. Minor felsic to intermediate metavolcanic rocks and greywacke has also been described. The Schist belts are about the best-studied group of rocks in Nigeria because of the known mineralization such as gold, BIF, Marble, manganese etc associated with them. Yet fundamental questions pertaining to the age, geodynamic setting of the belts remain unresolved.

The geochemistry of the schist belts confirm the sedimentary nature of most of them but the geochemistry of the mafic to ultramafic rocks within them has led to great controversy. Metapyroxenites in the Ife Ilesha schist belt were identified as Komatites and showed that the metabasalts possess a primitive geochemical signature typical of similar rocks formed early in the earth’s history (Rahaman et al., 1988). There was a similar conclusion, of rocks of Egbe-Isanlu area 65 km east of the Ife-Ilesha schist (Annor et al., 1996). Based on these results, the authors stated that the metavolcano-sedimentary sequences in these belts show a close similarity to Meta volcano-sedimentary sequences in Achaean gneiss-greenstone terrains such as in the Baberton Mountain land in South Africa, Pilbara belt in Australia and Yellowknife district in Canada.

These sequences are known to host important precious metal mineral deposits. They concluded that these schist belts are thus Achaean (Danbatta, 1999). Based on structural contacts some researchers such as suggested that some of the schist belts are of Kibaran (1100+200 Ma) and older age whilst others are of Pan-African age (ca 600 Ma) There has been a disagreement on the structural evidence, where a Pan-African age for the schist belts was proposed (Turner, 1983) The available geochronological data preclude an Achaean age for the

**Plate 3.** River Fetsa with numerous Schist outcrops, 10 km south of Kankara.

schist belts (Holt, 1982) Thus the age of the schist belt remains largely unknown as dates varying from the Achaean to late Proterozoic have been proposed. There is also no agreement on whether or not individual belts represent different depositional basins (Rahaman, 1976; Turner, 1983) or relics of a single supracrustal cover. The geodynamic setting of the schist belts is also controversial. Ogezi (1977) favored large processes in the origin of schist rocks, and the importance of ensimatic events in schist origin was observed (Ogezi, 1977).

## AGE OF SCHIST

Although age relationship of the Nigerian schist belts is unresolved, as various ages have been assigned (Danbatta, 1999). On the basis of available isotopic data the schist are also assumed to be of two types: the older metasediments (mainly found in southwestern Nigeria) and the low grade schist or younger metasediments mainly found in northwestern Nigeria. Archean (Paleoproterozoic) age was assigned to the schist belt and the Ile-Ife belt were assigned Kibaran event (110 Ma) and the Ibadan belt to Eburnean event (2,000 Ma). However, the schist were known to be mid-proterozoic and Eburnean (2,000 Ma) and Pan African events (Kankara, 2014). All the radiometric age interpretations reported from the schist belt of northwestern Nigeria are significantly different. These could be assign to three schools of thought on the age of schist belt apart from the minority view proposed that the whole basement experienced a single Gwarian (Pan African episode) of deposition, deformation and metamorphism (Danbatta, 1999).

One of the radiometric data for the schist belt was reported by Ogezi (1977) who obtained an 11- point Rb-Sr isochron age of 1,064 + 64 Ma for Maru Phyllites. This age was confirmed by Ajibade et al. (1979) who re-analyzed the same samples from Maru belt. This is the first and only data suggesting a Kibaran metamorphic age for these schist belts, and of course many models for the evolution of the schist have been based upon. Mc Curry's (1976) proposal was based on K-Ar mica and whole rock data which varied from 600 to 450 Ma, as determined from a range of samples of metasediments and volcanic, and by interpreting all the geological relations in the Malumfashi belt and in other northwestern Nigeria schist belts, as Pan African in age. Ogezi (1977) has also obtained a 4-point Rb-Sr whole rock which gave an errorchron age of 496+50 Ma on the metasandstones of Sado area. In addition, several other workers have obtained pan African Rb-Sr isochron age of 566+17Ma on phyllites from Birnin Gwari schist formation. He however interpreted the Birnin Gwari belt as having Kibaran and Pan African ages.

The existence of Pan African age in the Anka schist belt by obtaining a Rb-Sr age of 762 Ma on tonalities which are intercalated with phyllites and volcano clastics in the belt was demonstrated, with the Anka belt volcanic, of probable Kibaran age as they were affected by Pan African deformations. On the basis of available information, Ajibade et al. (1987) concluded that the schist belts of northwestern Nigeria are all of the same age (Archean) and that they were deformed and metamorphosed for the first time during the Pan African event. More recent studies (Olabaniyi, 2003) have assigned pre-Neoproterozoic age to some of the belts. These workers used established chronostratigraphic markers (where they occur), as reliable clues in constraining the age of the Nigerian schist belts. Algoma-type BIF has been reported from Maru, Malumfashi, Birnin Gwari, Kushaka, Muro and Igarra-Kabba-Lokoja schist, was also used as a chronostratigraphic marker. According to this hypothesis, D1 deformation and metamorphism in Nigeria schist belts with documented occurrence of Algoma BIF's is pre-Neoproterozoic.

## CRUSTAL EVOLUTION FROM LITHOLOGICAL STUDIES

### Older Metasediments (Schists)

Occurences of schist are most commonly observed as scattered and highly weathered relics of feldspatic schists outcrops along Kankara-Zango, Kankara-Katoge and Kankara-Sheme roads and at Kwakware-Gambo Karfi feeder roads. Field relationships reveal this type of older schists as low-lying outcrops in the peneplain of the area. The schist occurs as small lenses usually only exposed along river valleys where they have been deeply weathered (Plate 3).

They constitute about 2% of the total rocks and are fine grained with foliation of the constituent minerals affected by intense weathering so that these features which often reveal the presence of several directions of schistosity are almost completely obliterated (Kankara, 2014). Gradational boundaries within the schist are ubiquitous and they grade into the adjacent gneisses for which they also exhibit conformable relationships such as observed at Kwakwaren-Nabadau.

A number of geological observations in the schist rocks have important regional implications in the Funtua north east area. Therefore, for accurate interpretation and modeling of the overall regional geotectonic evolution of the schists, the outcome of the present research shall be compared to earlier works deduced on the other NW Nigeria Schist Belts. This can allow the formulation of a geotectonic model that will show how the geologic and structural framework of the schist and its adjacent areas has evolved.

An attempt has also been made in this chapter to contribute to the evolutionary framework of the schist rocks. Deformational and metamorphic activities were associated to rock lithologies of Funtua NE. The Migmatite-gneiss basement complex seems to be the oldest rock unit and considered to be derived from a pre-existing sedimentary series of schist (paragenesis), possibly Archaean, through several tectono-metamorphic episodes.

The schist lie on the migmatite-gneiss basement, and subsequent compressional tectonics led to at least two episodes of deformation (Boher et al., 1992) The intense deformations and isoclinal foldings along N-S and NNE-SSW axes re accompanied by regional metamorphism and extensive migmatization of the basement. Granite gneiss and Augen gneiss rocks that are associated with the schist are certainly derived from pre-existing rocks.

### Younger Metasediments (Quartzites)

The younger metasediments consist of at least six distinct metasedimentary and metavolcanic rocks. These are: quartzites, metapellites, metaconglomerates, metasandstones, metavolcanics and feruginous quartzites. The quartzites and metaphyllites are the most expensive rock types among the younger metasediments, with the metapelites the least exposed. Only a small proportion of the metasediment is formed by the metaconglomerates and metavolcanics. Poorly exposed ferruginous quartzite occured in the vicinity of Kwakwaren-Nabadau, Tudun-Sha-tambaya ridge, Kaurawa-Pauwa road, an area north-east of Bagoma amongst a number of other places such as at Locality number 16 in the Funtua North East. Other older metasediments include feldspathic quartzites which outcrops as boulders interbedded with N-S striking and elongated gneissic bodies, with the biotite-gniess badly weathered and transformed to laterites in most places. It occur as large boulders in laterites, especially those observed along Kankara-Bagoma feeder road.

In some other places the feldspathic quartzites outcrops are found occurring as large bodies within highly weathered hills, as long as 5 x 15 m. Much of the migmatite-gneiss separating the metasediments are regarded as basement to the metasediments. This is further supported by the presence of already deformed boulders of migmatitic gneisses in the conglomerate. The presence of schist boulders in the conglomerate has proved the existence of older schist material predating the younger metasediments.

The ferruginous quartzite outcrop as 1 to 3 m thick discontinuous sheets typically occurring in a N-S treading lateralized ridges. The lateralized ridges which consist of unbanded pisolithic ironstones are not studied in detail in this project, attention was only given to quartzite bands even in the study area. The exposed width of the ferruginous quartzite on the ridges is about 15 to 50 m, and the strike length of the ridges is in the order of 1 to 3 km. In some areas, the ferruginous quartzite is bounded by outcrops of hornblende granite, while towards the northeast the lithologies had been eroded away.

The quartzite is fractured and broken up into boulders and pebbles at the top of the ridges, and, the eroded pieces littered the surrounding plains. However, in places outside the area of study, the quartzite occurred as a poorly outcropping dense rock in association with mica schist. The quartzite shows textural gradation from a massive to well foliated varieties and quartz-schist through the quartz schist also vein intermingled with bodies of phyllites. The quartz schist are also seen associated with the schist at Kwakware in areas to the southern part. The massive quartzite outcrop on top of the NNE-trending ridges, adjacent to some coverage of metapelite intercalated with layers of these younger metasediments. However, the quartzite is in fault-contact with the vertical layers of beds of conglomerate rocks which dips towards eastern end of Gambo-Karfi area.

There is a sharp contract between these two lithologies in this place. The quartzite rocks are cut by quartz veins in several exposures, some of which seem to be geometrically related to small folds (Kankara, 2014). Fine-grained laminated metapelite and the ferruginous quartzite indicate quiet and shallow water environment, as the oxide facies iron formation is characteristically found in the shallow parts of a depositional environment. The interbedded nature of occurrence between the fine and coarse clastics (especially schistose quartzites) suggests that at least part of the metapelites were deposited together with the coarse clastics, during a local quiet water conditions. The younger metasediments are interlayered with the capped laterites at the center of Funtua NE, around Kwakware K., where as in other areas they are inter layered with other rocks and may represent an igneous rock, probably microtonalite.

A reagional metamorphism (of low amphibolite facies) must be connected with the formation of iron and metasediments due high rising temperature. The protoliths include mud-like sediments derived from volcanic exhalations. The quartzite formation near Bagoma, east of Kankara is interpreted as a metamorphic equivalent of the suiphide facies deposited under anoxic conditions in the area. The quartzite is chert-bearing and has a high silica-iron ratio (except in the sulphide facies).

## DISCUSSION

It has been suggested that the meta-sedimentary rocks occurring within the Funtua North East basement geology, and probably the neighboring northwestern and eastern Nigeria and western Cameroon basement area are possibly relicts of a once widespread cover of sedimentary rocks deposited in a single basin, and having differences that resulted from facies changes in the more or less continuous basin. Field investigation reveals that high-grade gneisses and schists belonging to the migmatite-gneisses complex of Nigeria dominate the Basement lithology of Funtua northeast. The presence of pelitic index minerals like muscovites together with frequent inter-banding with quartzitic layers and lenses is an indication that migmatites are most likely associated with gniesses and schists derived from sedimentary protoliths. This fact is also supported on the widely used $Na_2O/Al_2O_3$ versus $K_2O/Al_2O_3$ discrimination. Moreover, high silica contents in the protoliths, together with their peraluminous nature are consistent with derivation from precursor rocks that were rich in both $SiO_2$ and $Al_2O_3$ components. Such precursor rocks suffered moderate chemical alterations. Like similar gneisses and schists elsewhere in the Basement Complexes of Nigeria, the metasedimentary rocks of Funtua northeast are characterized by paragenetic mineral assemblages that reflect mostly upper amphibolites facies metamorphism.

Rock association and bulk geochemical affinity in Funtua northeast in the northwestern Nigeria is practically identical to the Superior Lake rock, especially BIF's. But it has high amount of Aluminium and Manganese oxides, $Ti0_2$, Zr Sr, Co and Ba. The assemblages of other rocks with metasediments, supported by geochemical evidence, suggest that it has been evolved from a deeply weathered environment that is nearly pediplained. The interpretation and detailed examinations were made on actual outcrops and occurrences in the field with the analytical data from the feild. These gave an idea of the basic elements, which were resolved as more of the alteration sequences due to intense metamorphism. It is however difficult to determine in detail the outline and extent of the pegmatite veins which are believed to be controlled by fractures in the mica schist. From the mode of occurrence of the deposits, the pegmatite veins are irregular in nature. These observations suggest, on one side, closed system behavior during metamorphism, and on the other side, a co-magmatic origin of the igneous protolith (with the possible exception of the two samples with high silica percentages) $5K_2O$ and $5Rb_2$ (not shown), Barium and Strontium are more variable, but as these elements are more susceptible to open system behavior during metamorphism, they cannot be used to argue for differences amongst samples from the FTNE terrene. Comparisons of metasedimentary series according to time of formation imputable to different sequences can provide a better understanding to terrain accretion models.

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