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THE STRUCTURAL FRAMEWORK UNDERLYING THE METAMORPHIC EVOLUTION OF THE KAZAURE SCHIST BELT, NW NIGERIA

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ABSTRACT

The structural framework underlying the metamorphic aspect of the various rocks in Kazaure schist belt (KZSB) was studied. The KZSB consists of metasediments and metavolcanics that are bounded by Older Granites and gneisses. Detailed structural analysis of the Kazaure schist belt revealed the occurrence of structures that resulted from ductile as well as brittle failure.

On outcrop scale, isoclinal, open to tight, overturned and upright folds are observed in the study area. The rocks of the Kazaure schist belt have experienced a minimum of two major ductile deformational events. The first of which involved the development of a NNE-SSW trending S_1 schistosity and recumbent isoclinal folds (F_1). The second event formed nearly upright isoclinal folds with gently to moderately North plunging fold hinges. Evidence for brittle deformation is also recognised within the Kazaure rocks, throughout the area there are numerous fractures, joints and faults characterised by steepply dipping NE-SW and NW-SE trends.

The study of microscopic texture domains of the rocks has allowed the identification of two periods of apparently prograde metamorphic recrystallisation (M_1 and M_2) and one retrograde period (M_3). The metamorphic mineral assemblages show evidnce of being either syn-D_1, and syn or post-D_2 related to some plastic style of folding.

Key words: Schist belt, deformation, metamorphism, texture, recrystallisation.

INTRODUCTION

The Basement complex of NW Nigeria consits of Younger low to medium grade metasediments and metavolcanics which form distinct NNE-SSW trending belts within the migmatite-gneiss complex. The Kazaure schist belt (KZSB) is one of the most easterly schist belt in the NW Nigerian basement (Fig. 1), and is among the least studied.

Reconnaissance geological mapping of parts of the Kazaure belt has been carried out by Turner and Webb (1974) and Aderotoye (1977). Good and continuous exposures are generally limited and mainly confined to river valleys. As such, a regional remote sensing interpretation was first carried out in order to establish the overall structural pattern of the area.

The geology of the KZSB is comprised of gneisses, older quartzites, and Younger Metasediments and metavolcanics, that are intruded by early and late tectonic granites of Pan-African age (Fig. 2). The

Younger Metasediments include quartzites, metaconglomerates, pelitic rocks, meta-rhyolites and rare ferruginous quartzites (Danbatta, 1999). Locally overlying all the lithologies are deposits of Tertiary and Quaternary age.

The present study was carried out in order to show for the first time how the structural and metamorphic frameworks of the KZSB evolved. The small scale structural analysis was based on detailed field and petrographic observation of minor and micro-structures.

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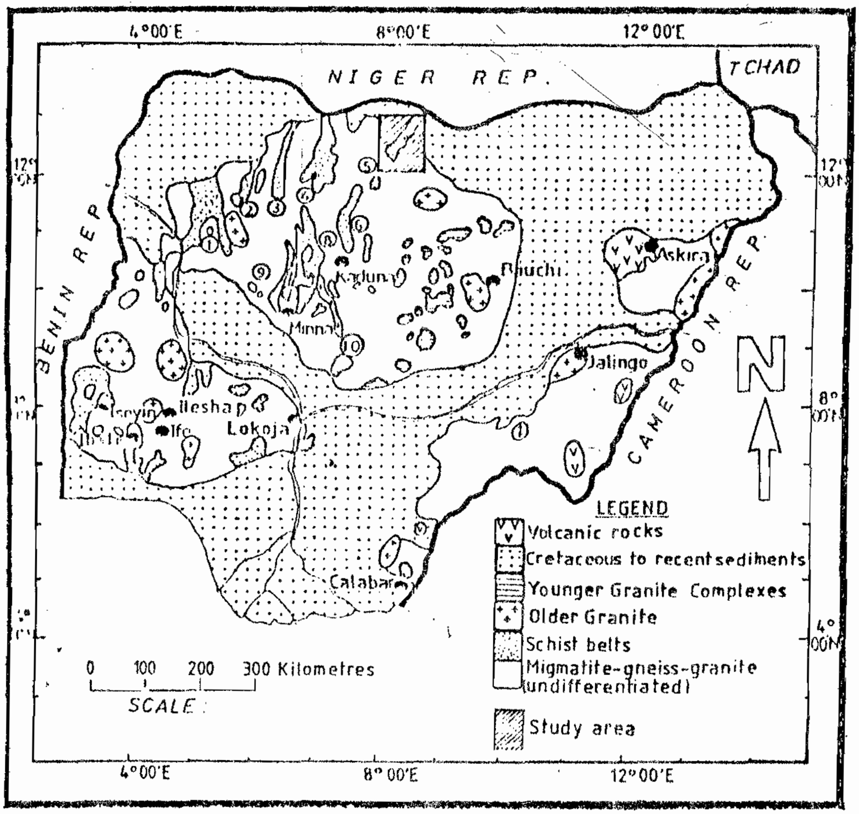


Fig. 1. Simplified geological map of Nigeria showing the distribution of the schist belts and the location of the study area. (1) Zuru, (2) Anka, (3) Maru, (4) Wonaka, (5) Kazaure, (6) Malumfashi, (7) Birnin-Gwari. (8) Kushaka, (9) Ushama, (10) Toto. (Modified after Ajibade et.al. 1987[a]).

STRUCTURE

The general structural trend in the study area varies from N-S to NNE-SSW with westerly dips ranging from 45° to the vertical. Localized E-W trends are also recorded around granitoid intrusions and could be products of forceful magmatic emplacement. The major structures in and around the Kazaure region were mapped using air photos and Landsat-Multi Spectral Scanner (MSS) imageries (Fig. 3). The air-photo remote sensing technique was used in studying some sub-areas for greater details (Fig. 3).

The KZSB rocks have experienced a minimum of two major ductile deformational events, D_1 and D_2, with their respective structures designated as F_1 and F_2; S_1 and S_2; and L_1 and L_2). The ductile deformation events were followed by a later brittle deformation event that formed fractures, joints and faults.

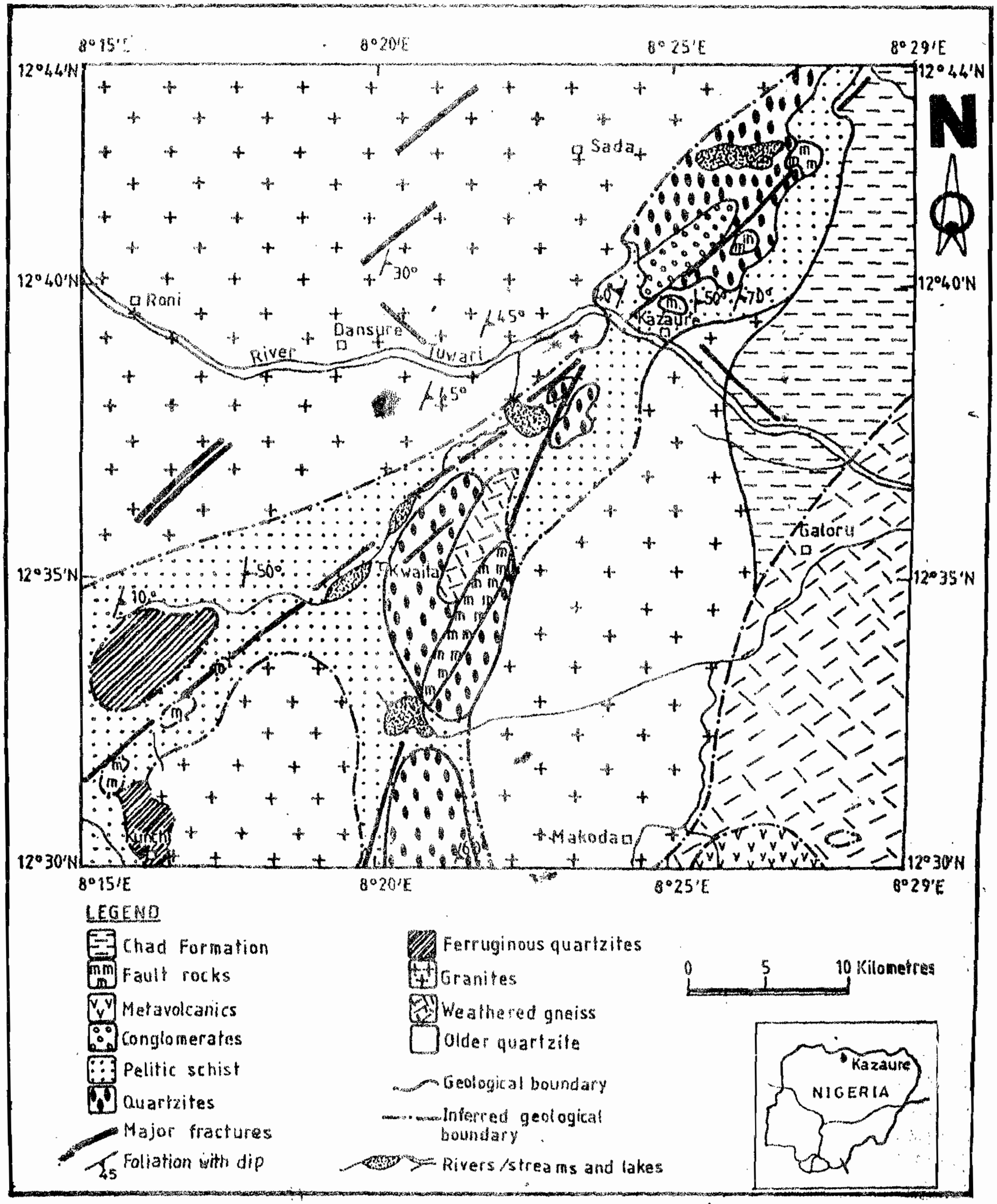
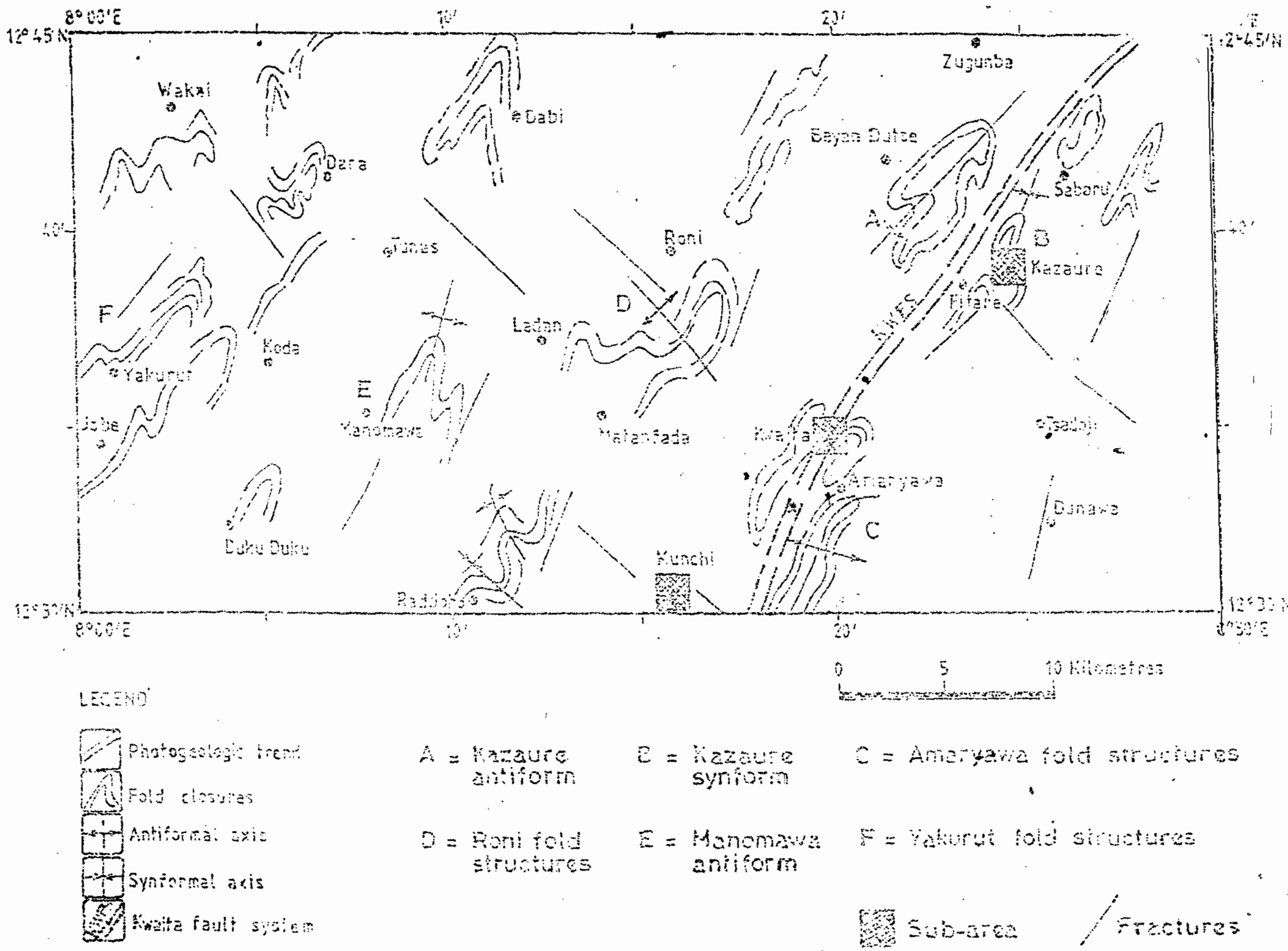


Fig. 2: Geological map of the Kazaure area.



Location of some areas and major structures in the Kazaure region

(a) Ductile deformation

D_1 Episode

S_1 forms NNE-SSW trending foliation planes but are largely obliterated by later deformation. In pelitic and finer grained clastics, S_1 is an axial planar slaty cleavage which is now deformed into an S_2 spaced crenulation cleavage. In the coarse grained clastics it occurs as S_1 subhorizontal schistosity planes trending NNE-SSW. L_1 is defined by a weak N-S gently plunging clast elongation lineation in the metaconglomerate and the coarser quartzites (Fig. 4).

The first recognised tight to isoclinal F_1 folds, have thickened noses and limbs and are largely obliterated by later deformation. They now occur as relict flatlying folds with NNE-SSW axes and related S_1 schistosity. Distinct minor F_1 folds are restricted only to the quartzites where at map scale the area is characterised by large lenses defining tight and recumbent fold closures (Fig. 4). The F_1

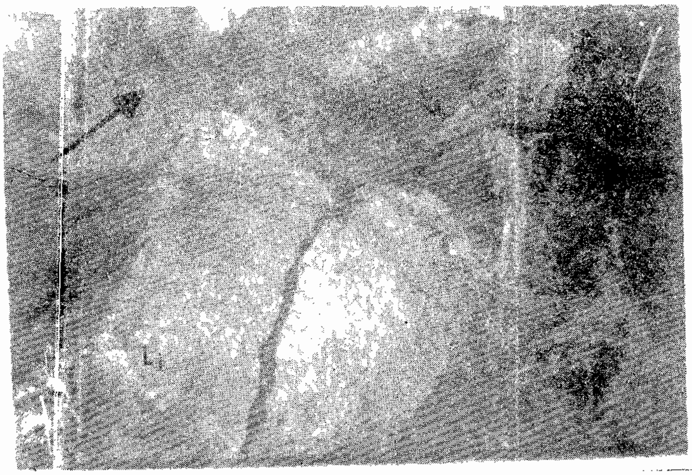


Fig. 4: Photograph of quartzite defining tight and recumbent fold closures at Kwaita. Note the clast elongation defining L_1 lineation in the left hand side of the picture

and S_1 were probably recumbent in nature with NNE-SSW trending horizontal hinges (Fig. 5).

D_2 Episode

Folding of the S_1 foliation has produced steeply dipping to upright N-S trending structures. F_2 folds are tight to isoclinal in the fine-grained clastic rocks and more open in the coarse clastic types, and their axial planes strike N-S with moderate to steep dips (Fig. 5). These folds are upright, non-cylindrical and shallowly plunging, with variable wavelengths in the range of 10cm - 10m. The F_2 folds have refolded F_1 folds and S_1 segregation banding with the F_1 folds now occurring as relict flatlying folds (Fig. 5).

There is a regional development of N-S trending S_2 fabrics which are sometimes axial planar in areas of high strain F_2 folds. The S_2 foliation is not well developed in the massive quartzites, though very regular foliations are present in the schistose ones and the schists. S_2 is an axial planar slaty cleavage in pelitic and finer grained psammites. In the quartzites and quartz schists S_2 is a spaced crenulation fabric defined by platy and prismatic minerals (Fig. 5). At some localities this S_2 foliation is superimposed on earlier NNE-SSW trends, but in most places the S_1 foliation has largely been obliterated or transformed (Fig. 5). When the poles to foliations are plotted on a stereographic projection (Fig. 6), they show a well-developed S-pole girdle generally arranged about an almost horizontal NNE- trending axis.

Mineral lineations are mosty parallel to the regional structural grain. An associated L_2 mineral lineation is the dominant regional linear fabric, and is more common in the metasediments where it forms a subhorizontal stretching fabric in the X-direction. The D_2 event was moderately intense, with tight and upright folds being developed.

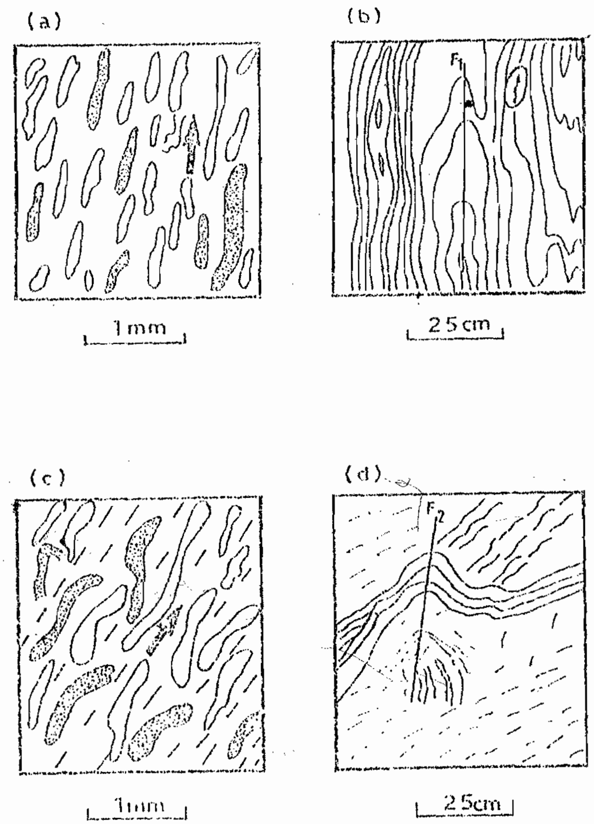


Fig.5. Sketch diagrams drawn from the field and thin-sections showing fabric relations in quartz-muscovite-schist at Kazaure (UD49). A = S_1 cleavage; B = tight to isoclinal F_1 folds C and D = S_2 cleavages and F_2 folds.

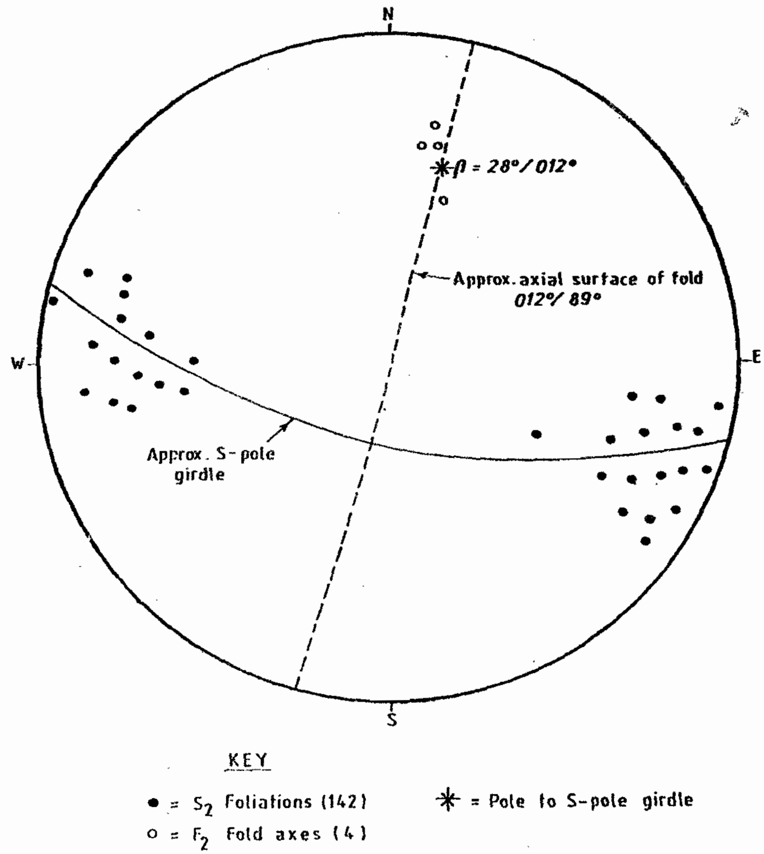


Fig. 6 . Lower hemisphere equal area projection of poles o foliation of Kazaure major antiform and minor F_2 fold axes

(b) Brittle Deformation

The topography of Kazaure region is also influenced by zones of dislocation (shear zones, fractures, joints and faults) forming valleys and elongated lakes. The Kalangai Fault System (Truswell and Cope, 1963) of Birnin Gwari-Malumfashi Schist Belts is shown to extend into the KZSB and even beyond. It has produced fault rocks (breccia and mylonites) which have played a prominent role in the development of the present disposition of the Kazaure terrain.
Two main linear elements/fracture systems cutting all the rocks in the area can be identified striking NNE-SSW to NE-SW and NW-SW (Fig. 3).

Trends of all linear features more than 2 km long in the study area have been plotted on a rose diagram (Fig. 7), where three main peaks are identified. The trends of the peaks are NNE-SSW, NE-SW and NW-SE, and are well developed. The first and second peaks consist of NE-SW to NNE-SSW trending fractures which are generally parallel to the alingment of the Kazaure belt. The third peak formed the second fracture system with a NW-SE trend but is not as prominent as the former one.

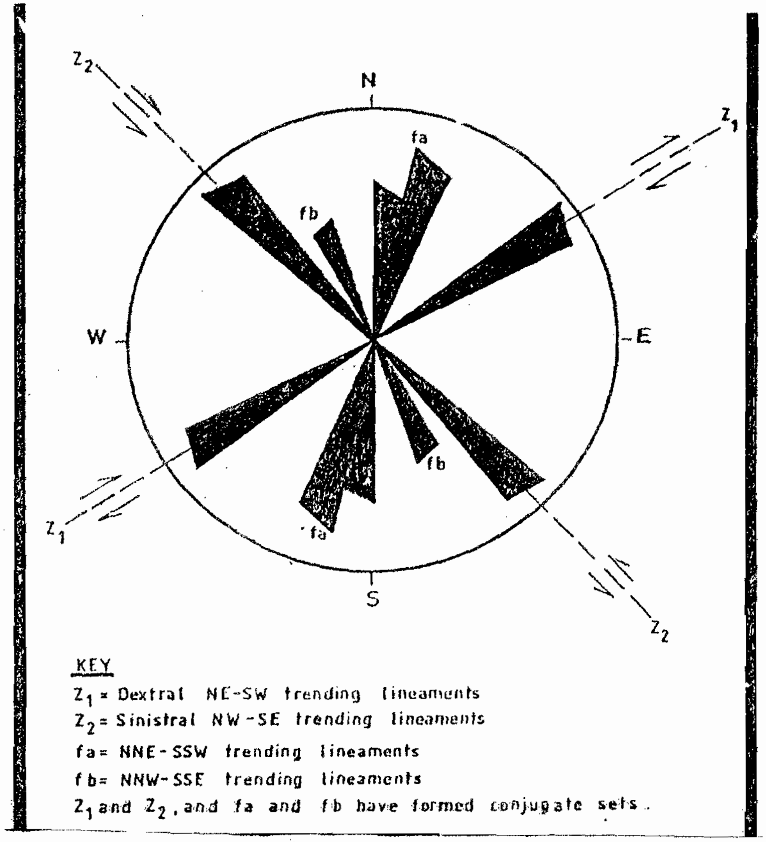


Fig. 7 . Rose diagram of lineaments/ fractures more than 2 km long in the mapped area.

These lineaments/faults are interpreted as conjugate transcurrent system because their slip vectors are approximately horizontal.

METAMORPHISM

Following Winkler (1967; 1979), the equilibrium mineral parageneses in the Kazaure rocks have been characterised into three groups:

(a) Low grade amphibolite facies (M_1):
Biotite-Gneiss: oligoclase-microcline-quartz-biotite green hornblende-almandine garnet-epidote.

(b) Low grade greenschist facies (M_2):

Biotite-Gneiss :albite-microcline-quartz-biotite-muscovite.
Phyllites : quartz-sericite mica-albite-muscovite.
Mica shists : quartz-muscovite-albite-chlorite-biotite - epidote.

The above mineral assemblages give an insight into the P/T conditions of the regional metamorphism that affected the Kazaure area. The only records of the amphibolite facies metamorphism are preserved within the biotite gneisses and the older quartzites.
The presence of plagiolase (Albite, $An_{10}Ab_{90}$), brown biotite, green hornblende and garnet in these rocks suggest a lower amphibolite facies of metamorphism, which has largely been retrograded to low grade greenschist facies with abundant development of biotite.

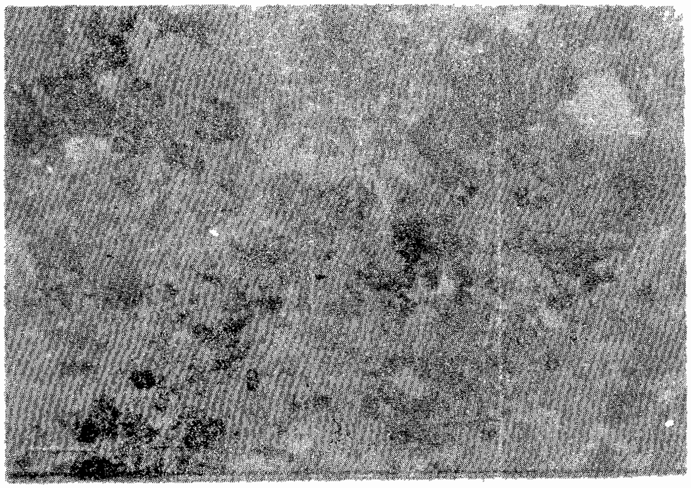


Fig. 8: Photomicrograph of a mica schist showing a hybrid mineral assemblage marked by static late tectonic growth of biotite (B) porphyroblasts across pre-existing schistosities.

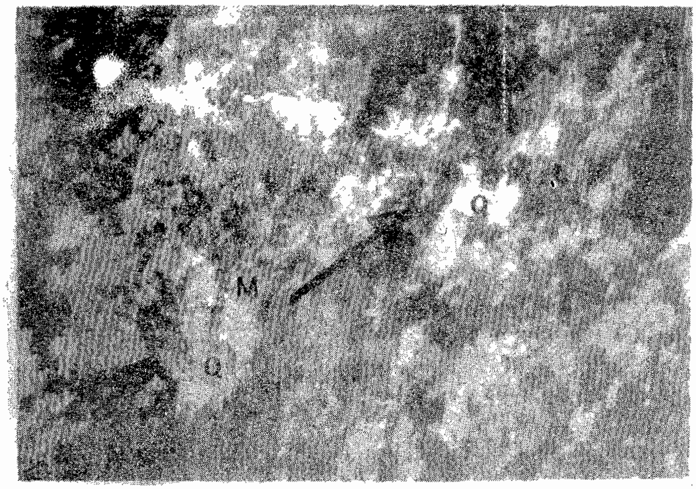


Fig. 9: Photomicrograph of S_2 cleavage marked by preferred growth (arrow) of quartz (Q) and mica (M).

The greenschist facies is defined by the widespread occurrence of secondary albite, muscovite and chlorite in the above equilibrium mineral parageneses. It is the lowest grade in the area and led to the growth of chlorite, muscovite and biotite. Apart from the equilibrium mineral assemblages, a hybrid (disequilibrium) assemblage is also preserved in some places (Fig. 8). It is mainly characterised by static late tectonic growth of biotite porphyroblasts across pre-existing schistosities (K-metasomatism), which is very common.

RELATIONSHIP OF METAMORPHISM TO THE DEFORMATION EPISODES

The study of microscopic texture domains of the rocks has allowed the identification of two generations of progressive metamorphism, M_1 and M_2, and a static one (M_3). The mineral assemblages show evidence of being either syn or post-D1, and syn or post-D2 (Barker, 1990, Ekwueme, 1993). The earliest identified metamorphic event (M_1) is a syntectonic progressive phase defined by the formation of D_1 structures and very fine micas. It reached lower amphibolite facies conditions in both the basement gneisses and pelites. It also produced an S_1 schistosity parallel to the fold axial planes (Fig. 5).

The second metamorphic event (M_2) is the main metamorphism in this area, and was syntectonic with isoclinal D_2 folding. It is a regional metamorphism under a progressive phase of low grade (greenschist facies) metamorphism. The M_2 caused the preferential growth of S_2 penetrative schistosity which is marked by preferred orientations of quartz, chlorite and mica (Fig. 9).

A static low grade (M_3) metasomatism related to a second generation growth of biotite under lower greenschist facies conditions is the next documented event. It is mainly characterised by the late tectonic growth of biotite porphyroblast across pre-existing schistosities. The retrograde domains are mainly in and around shear zones and high strain zones of F_2 folds. No other metamorphic mineral growth is associated with the M_3 event.

DISCUSSION AND CONCLUSIONS

The Younger Metasediments and basement rocks in the KZSB have originally been formed at different times and under different conditions. The gneisses which formed basement to the Younger Metasediments have initially been formed under different deformational and metamorphic fields. All the KZSB rocks were later subjected to at least two intense phases of ductile deformation (D_1 and D_2), which conform to a pattern of recumbent N-S trending F_1 folds locally refolded by NNE-SSW trending upright F_2 folds affected by granite intrusion and heterogeneous strain related to faulting.

D_1 was the most intense with its isoclinal and recumbent folds and D_2 was moderately intense with tight and steeply dipping to upright folds (Fig. 10). This relationship is common in poly deformed Precambrian terrains (e.g. Turner and Weiss, 1963; Hobbs, et al., 1976; Shackleton, 1976; Ekwueme and Kroner, 1994). The deformation events were accompanied by two phases of progressive regional metamorphism (M_1 and M_2), followed by a static metamorphic phase (M_3).

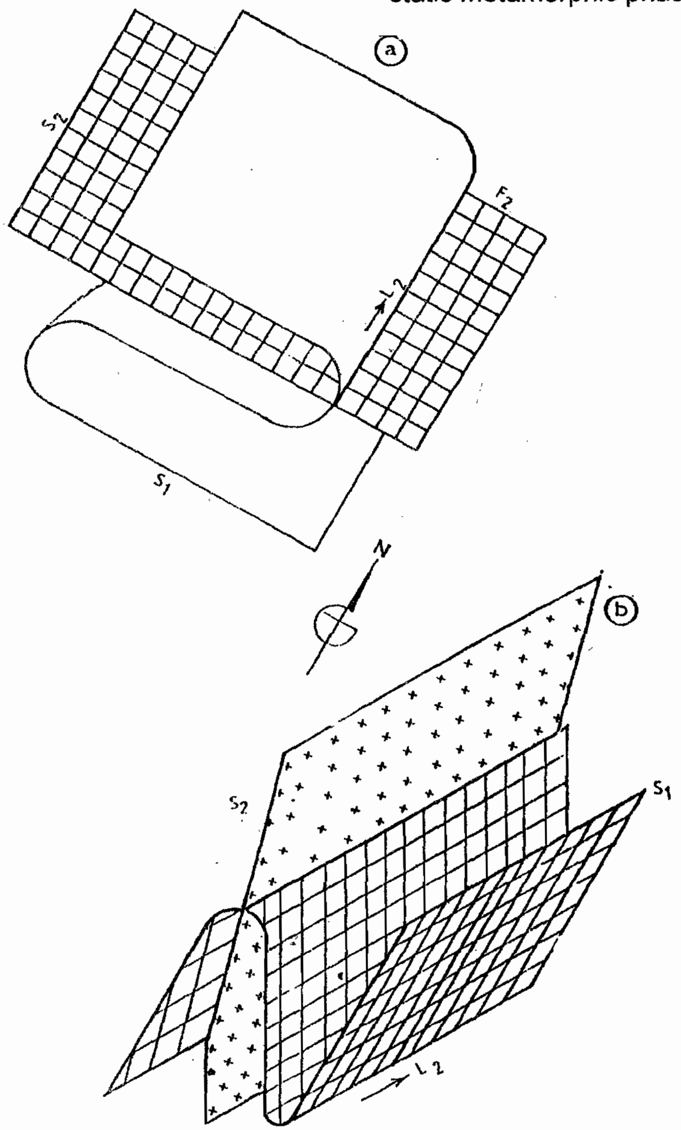


Fig. 10 Schematic block diagrams showing the major style of folding (a) N-S recumbent F_1 phase of folding (b) NNE-SSW upright F_2 phase of folding

M_1 attained amphibolite facies grade and was synchronous with D_1, while M_2 is a greenschist facies metamorphism and is the main metamorphism in this area. It is related to the NNE-SSW trending fold structures (D_2 event) and were probably simultaneously formed. The M_3 event is a static low grade metasomatism on a local scale. The study area displays metamorphic mineral assemblages that suggest a bimodal distribution of metamorphic facies similar to those of adjacent areas of NW Nigeria (e.g., McCurry, 1970, 1976; Miyashiro, 1973; Ajibade, 1976; 1980; Egbuniwe, 1982 and Ekwueme, 1983). The M_2 greenschist metamorphic grade is one of the lowest in the whole of NW Nigeria.

The KZSB has an overall linear regional structural trend which suggest a tentative correlation with other NW Nigeria schist belts (Annor and Coker, 1994). The northern Nigeria schist belts (Fig. 1) have been interpreted as sedimentary cover rocks now infolded into the basement as a series of north-south synclinoria (Oyawoye, 1964; 1972; McCurry, 1971; 1976; Ajibade, 1971; 1976; Grant, 1978, Annor, et al., 1998).

According to the present work, the Kazaure schist belt was once a continuous sedimentary supracrustal cover rocks deposited in a single basin which evolved through ensialic processes. The basin and its sediments are now regionally infolded into the basement and intruded by Older Granites. The recognition of several phases of deformation in the KZSB constitutes a significant departure from the previously accepted idea of gentle folding of the belt (e.g Turner and Webb, 1974, Grant, 1978).

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