FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 7 No. 3, June, 2023, pp 311 - 317
DOI: https://doi.org/10.33003/fjs-2023-0703-1982

LITHOLOGY AND STRUCTURAL ANALYSIS OF *ZANGO-ANGWAN-LAMIDO* ENVIRONS, KATSINA STATE, NORTHWESTERN NIGERIA

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ABSTRACT

The study of lithological types and structural analysis of rocks of Zango-Kankara-Angwan Lamido on a scale of 1:50,000, Katsina State, northwestern Nigeria at longitudes 7^0 15' E and 7^0 30'E and latitudes 11^0 45'N and 12^0 00'N has been carried out. The area consist predominantly of migmatite, older granites and schist, associated with minor quartzite and gneisses. The methodology adopted for the study was mainly primary data in which extensive field visits were done and outlined structural analysis and field relationships were recorded between successive thermo-tectonic episodes The area underwent three phases of tectonic deformation denoted as D1, D2 and D3, whose ages were shown to be Pan-African. At least two intense phases of ductile deformation were identified in the rocks. The rocks have been strongly foliated (especially the gneisses) with crystals showing strong preferred orientations.

Keywords: Basement Complex, Lithology, Structural Analysis, South Katsina, Northwestern Nigeria

INTRODUCTION

The Basement Complex in Nigeria encompasses the older (ancient) metasediments, occurring mostly in the northwestern parts and consist of calc-silicate rocks, arkosic quartzites and high grade schists that occur as relicts on gneisses and migmatite (Bassey, 2009), the younger or newer metasediments, found mostly in the western and eastern parts of the country where they occur as discontinuous N-S trending schist belts within the basement and the migmatites, which were later intruded by Older granites during the Pan African Orogeny (600 + 150 my) The former are the oldest rocks in the basement.

The polyphase nature of the Nigerian Basement Complex has been studied in great detail and therefore makes it to have a complex structural history that have resulted into variable structural elements in which the initial sedimentary structures have been superimposed by later structures (Kankara, 2014) Based on the differences in genetic properties of the various rocks their response to different stress and strain conditions differ.

The Basement Complex have undergone polyphase deformation and polycyclic metamorphism during the Proterozoic and early Phanerozoic periods It witnessed a major thermal event about 600±100 Ma ago. Available isotopic data has shown that intermittent tectonic and thermal activities have taken place between the late Proterozoic to early Palaeozoic periods (Adighije, 1981) The rocks comprises of Archean and Proterozoic rocks which have been subjected to Liberian (2700±200 Ma), Eburnian (2000±200 Ma), Kibaran (1100±200 Ma), and Pan-African (600±150 Ma) events. The Liberian and Kibaran events are largely disputed, but available geochronological data showed that the Pan-African Orogeny is the only definite and guaranteed event that affected the Nigerian basement (Ajibade, 1980)

The geological structures here are very complex, varying widely in dips and strikes, which showed the polyphase nature of deformation of the area, involving three phases of regional deformation D1, D2 and D3. The structures can be described under two groups; the syn-tectonic, which include folds, foliation, lineation, banding and the post-tectonic which include joints and faults. The regional north-south basement trend is dominant in this area and represents the final imprint of the Pan African Orogeny which affected much of West Africa. Tight isoclinal major folding about steeply dipping north-south axes are evident. However, due to poor field exposure the description of fold geometry are incomplete. Available data show variety of events appearing in the fine structures which truly shows that there were three to two major deformational activities that was associated with the re-activated basement, with its later implaced and overlained quartzites, which together responded to stress as a single tectonic unit (Burke, et al, 1976) Quartz occur as most dominant minerals in mylonitic gneiss (Oyawoye, 1970)

The second phase of folding was of very high intensive magnitude. It almost completely obliterated many of the earlier structures. Major transcurrent faulting and development of system of joints in the area must have resulted from this second deformation (Okwonko, 1996) Joint statistics of the study area are shown below.

Field features of the fault outcrops showed that rocks in this area are transversed by major dextral transcurrent fault zones and a number of other shear zones, which are localized zones bearing imprints of intensive ductile and brittle transition (Plate iv; Kankara, 2022). This is shown on a regional scale and at outcrop scales. Some positions of the fault systems are defined by topographic elevations extending northeast from the extreme northern part of Kankara town. The fault system has affected the rocks in the area through dynamic metamorphism. It is noted by a series of discontinous ridges of country rocks composed of fault, breccias, sheared gneiss, cataclastic quartzite and silicified and mylonitized schists. The fault systems contains numerous steeply dipping, closely spaced planes that strike north-northeast and north-east (Adeleye, 1976) This defines a zone parallel to the host foliations, which is about 60-110 m wide to 400min some places.

In some areas, the fault system is sub-vertical with planes trending 040^0 and dipping about 38^0E in the basement complex rocks to almost N-S in the metasediments. There is an occurrence of porphyritic rhyolites which are brecciated and ferruginized with abundant quart-haematite veining. There are also narrow brecciated ridge of quartzite that show minor haematite and pegmatite infilling along most of them. The quartz-haematite veining is considered to have resulted from little deformation due to catastasis movements, and is independent of any temperature metamorphism (see Plate viii)

MATERIALS AND METHODS

Data Collection

Field relationships outlining the structural relationships between successive thermo-tectonic episodes were, showing that primary data approach was adopted. The area was mapped using a 1:50,000 scale and this covered a total land area of approximately $153km^2$.Using field observations and collected data it has been possible to describe the main structural patterns of the area. A number of structural elements were observed in the mapped area that are said to have appeared due to different tectonic processes that have affected the basement.

Field Geology and Geological Mapping

Eight (8) major lithological units were identified during the mapping exercise (Migmatites, granite gneiss, mylonitic gneiss, augen gneiss, banded gneiss, porphyritic biotite granites, quartzites and schist). The area is made up of Precambrian rock units, divided into two broad units based on changes in lithology between the differentiated basement complex sensu strict (porphyritic granite, gneiss) and metasediments. Usually in the area there are some intrusions of gneiss found on older granites but often exist rarely. The contact between metasediments and basement complex are sharp and covered many locations. There is a gradual change between augen gneiss and gneissic granites. There is also a sharp change between the gneisses because of the variation in color, textures, mineral compositions, poor exposure or weathering of augen gneisses.

Furthermore, structural geology of the mapped area was provided with details of the structural elements. .For the geological mapping, different lithological units were identified and as well, their structures, field and contact relationships.

RESULTS AND DISCUSSION

The Study Area and Accessibility

The study area is Zango-Kankara-Angwan Lamido and other neighboring environs in south Katsina State. It has a complex geology with almost all the eight (8) rock types that form basement complex. It is part of Lower palaeozoic terrain of NW Nigeria. Geographically, the area cut across Kankara, Bakori, Malumfashi and Faskari Local Government areas in Katsina State and covers a total land area of approximately $745.29km^2$ (Figure 1), falling within longitudes and latitudes 7^0 15',7^0, 30^0 and 11^0 45', 12^0 00^0 It is characterized by series of discontinuous ridge of inselbergs (gneiss and granite) in the western side which made it a slightly rugged landscape. Some areas around far western and eastern parts are inaccessible due to intense flooding especially in the rainy seasons, but easily accessible through some two federal 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.

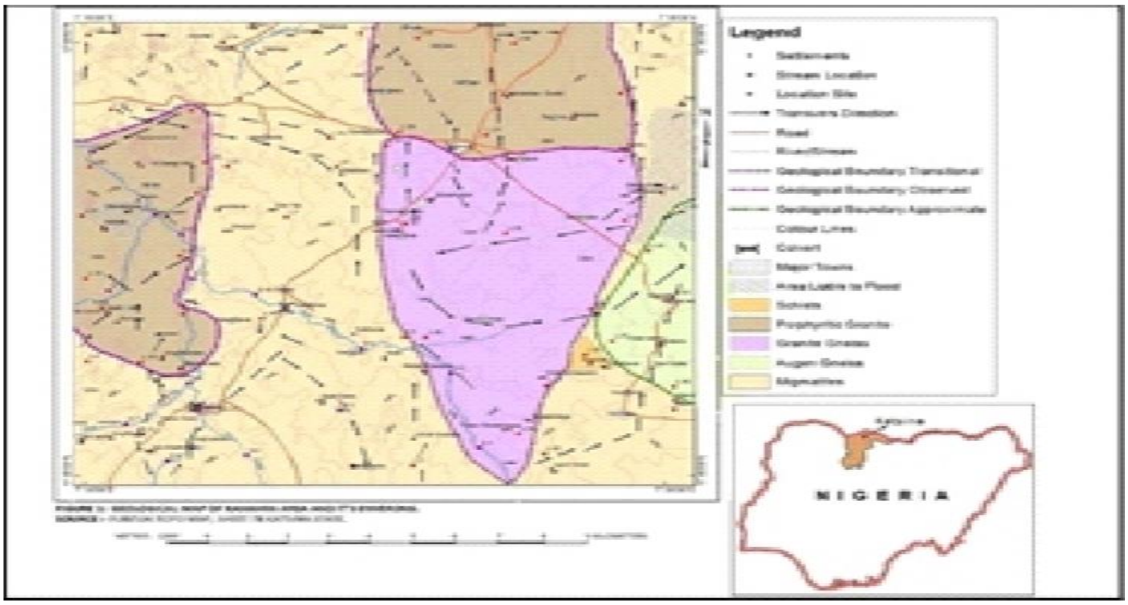

Figure 1: Geological map of the study area.

The Lithological Types

The Migmatites

The migmatites mainly outcrops like whale-back ridge, limited in occurrences but more frequently distributed around the area as indicated. They also occur along streams as small low-lying hills. They are found to occupy the largest area of about 50%, stretching from the north-western corner of the mapped area to the south-western portion, and it also occur further to the eastward (as shown: localities. The migmatite-gniess show evidences of partial melting (see Plate i)

The migmatite are generally medium grained, pink-grey banded, even textured rocks. The banding varying in size from microscopic to cm, and may be regular or discontinuous forming streaks, pinch and swell structures and mafic knots which demonstrated that the simple banding structures observed in most outcrops are as a result of the strong deformations and migmatic processes which have dragged units of different ages and compositions into parallelism. Different migmatite gneisses are formed, as a result of the different

Granite Gneiss

Large tracts of Funtua north east are underlain by poorly exposed and weathered gneisses often in association with the migmatites. This rock unit is not extensive. It sporadically occur in pockets within porphyritic biotite granite and migmatite along many traverses, say at Gatakawa village on Kankara-Sheme road and other outcrops at Kankara-Maigatari road. They are light to dark colored rocks which has gneissic foliation defined by felsic and mafic minerals (Table 4) The rock is medium grained in texture and has an ordered foliation. They consist of a heterogeneous group predominantly of granodioritic composition and varying degree of foliation.

The textural variations in these rocks are because of different textures and proportion of K-Feldspar porphyroblast which contained in them. In some locations the feldspar porphyroblast are numerous and fairly large, up to 2-3cm, well lineated augen-shaped tablets. The gneisses consist of an alternation of a micaceous laminae and more coarsely crystalline laminae of quartz and feldspar intergrowth. The micaceous laminae resembles the mica-schist, both in mineral composition and textural relationship. The gneissose structure of alternating banding of leucocratic and mafic minerals is prominent. It trends mostly in north-south direction.

Augen Gneiss

These rocks contain aggregates of grains that have a lenticular or elliptical shape; these aggregates are called Augen (German word for 'eye') and are common as a result of cataclasis (fracturing, granulation and rotation). These residual aggregates are produced within a granulated matrix. Some of these units are observed at locations at 1 kilometer west of Burdugau, 95 (3 kilometers SE of Yargoje), 96 (2 kilometers SW of Burdugau), 71 (Angwan Gambo), 145 (at Burdugau K), 150 (at NE of Angwan Tofa), 160 (at Dan Agajuwa village), 158 (1 kilometer east of Dan Agajuwa village), 64 (at Mainashi village). Augen gneiss comprises of the folded variety of gneisses which are almost degraded or highly weathered with folding ranging from tight isoclinal folds to small microfolds of the ptygmatic scale which are only visible on unweathered gneissic surfaces. Although in few places they are found to occur in association with either mylonitic gneiss, porphyritic biotite granite on banded gneiss. The post depositional features were affected by folding in these rocks (Rahaman, 1988) The example of micro quartz vein which is folded along with the main rock, likewise the banded lamellae in a banded gneiss often shows folding of the alternating light and dark bands.

Undiffrentiated Banded and Mylonitic Gneiss

The rocks are brownish to pinkish and also sometimes dark in appearance (see Plate iii) Some undergo shearing. The texture is medium grained and is slightly foliated. In hand specimen major minerals that are identified are: quartz, feldspar and biotite. It outcropped maily on elevated lands in high topographies, around Burdugau (G) (Plate I and ii). The textural descriptions shows that it has subhedral granular crystals which are composed mainly of quartz, orthoclase, biotite and microcline. Its mineralogy is: quartz-20%; chlorite-18%; biotite-18%, and minor amounts of: apatite, magnetite and zircon. Zircon significantly occur in amount up to 4%.Banded gneiss is second to the most abundant, found everywhere within the mapped area (see Plate i)

Porphyritic Biotite Granite (PBG)

There are grey to pink colored granitoids, which occur as inselbergs and low lying whale-backs. The granitoids occur as massive fractured plutons irregular shapes, roughly occupying two belts in the NW-SW parts of the map area (Kankara, 2014) The granites sharply intrude the metasediments and migmatite-gneiss unit, with the sharp contacts suggesting their younger age. There is a close contact between the granites and the gneiss (Ekerere and Barth, 2009).

Physical relations (example, sharp contacts) show clearly that porphyritic biotite granites in the study area were emplaced as liquid melts, and that the fine-medium grained varieties are older than the porphyritic varieties (plate iii). In addition to that, structural grain that dip in north-southdirection in the eastern neighbouring sheets has influenced the surfacing of phorphiritic granites.

Older Metasediments (Schists)

Occurrences of older metasediments are most commonly observed as scattered and highly weathered relics of feldspatic schist 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 occur as small lenses usually only exposed along river valleys where they have been deeply weathered. 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 (Table 3; Holt, 1982)

Younger Metasediments (Quartzites)

Here (Kankara, 2014) metaphyllites are the least exposed and only a small proportion of the metasediment is formed by the metaconglomerates and metavolcanics (Table 3) Poorly exposed ferruginous quartzite occur 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 16. 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 15m. 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.

Structural Geology and Data

There is also a sheared quartzite in the fault systems, which has defined a breccia zone. This zone is characterized by large angular fragments of pink colored quartzites cemented by white secondary quartz. Brecciation of the quartzite and infiltration by haematite must have taken place. The fault breccia are also commonly marked by the occurrence of some boudinage structures. Outcrops of mylonitized schists occur, while the conglomerate is foliated near the shear zone. Other mylonitized schists occur as north-south trending ridges (Table 1; Okwonko, 1992) They occur as highly sheared, foliated and well- lineated outcrops, with distinctive color appearing to be pinkish or yellow. The westernmost quartzite in this area has allocated and was distinguished by its lack of shearing (Fig. 2; Okwonko, 2001)

Table 1: Joint Statistics of the Study Area

Strike in Degrees	Number of Joints
0 – 30	16
30 – 60	11
60 – 90	24
90 – 120	16
120 – 150	29
150 – 180	42
180 – 210	20
210 – 240	18
240 – 270	17

Table 2: Foliation Statistics of Pegmatite Veins

Strike in Degrees	Number of Pegmatite veins
0 – 30	4
30 – 60	3
60 – 90	3
90 – 120	0
120 – 150	1
150 – 180	2

Table 3: Joint Directions in Metasediments (Joint Values)

16^0	52^0	40^0	82^0	16^0	108^0	15^0	84^0	74^0	59^0
42^0	19^0	15^0	14^0	16^0	100^0	82^0	85^0	13^0	17^0
86^0	10^0	13^0	24^0	43^0	06^0	08^0	103^0	82^0	25^0
12^0	103^0	108^0	50^0	19^0	50^0	108^0	18^0	11^0	104^0
14^0	48^0	37^0	79^0	18^0	136^0	13^0	94^0	81^0	64^0
39^0	17^0	13^0	11^0	19^0	121^0	79^0	98^0	08^0	23^0
82^0	08^0	11^0	21^0	48^0	09^0	12^0	126^0	88^0	30^0
07^0	99^0	100^0	43^0	29^0	48^0	129^0	22^0	13^0	125^0

Table 4: Joint Directions in Gniesses (Joint Values)

20^0	16^0	14^0	13^0	165^0	165^0	163^0	44^0	35^0	18^0
19^0	10^0	150^0	15^0	40^0	45^0	37^0	11^0	13^0	89^0
38^0	47^0	84^0	100^0	12^0	14^0	44^0	90^0	82^0	86^0
585^0	105^0	102^0	109^0	125^0	107^0	138^0	164^0	11^0	12^0
110^0	116^0	123^0	139^0	160^0	108^0	124^0	119^0	74^0	11^0
174^0	15^0	127^0	134^0	179^0	100^0	175^0	128^0	13^0	176^0
14^0	14^0	12^0	44^0	120^0	06^0	171^0	08^0	82^0	43^0
86^0	137^0	110^0	139^0	135^0	50^0	168^0	18^0	114^0	11^0
89^0	44^0	40^0	15^0	42^0	108^0	87^0	84^0	135^0	160^0
138^0	130^0	135^0	13^0	113^0	100^0	96^0	85^0	90^0	118^0
95^0	117^0	126^0	16^0	163^0	06^0	162^0	103^0	14^0	165^0
169^0	12^0	166^0	14^0	16^0	06^0	162^0	103^0	97^0	48^0
68^0	37^0	70^0	102^0	68^0	30^0	68^0	16^0	109^0	09^0
109^0	74^0	88^0	94^0	28^0	90^0	81^0	88^0	154^0	153^0
38^0	100^0	35^0	130^0	101^0	120^0	96^0	89^0	78^0	136^0
50^0	17^0	56^0	75^0	61^0	12^0	158^0	110^0	12^0	155^0
69^0	29^0	67^0	57^0	89^0	18^0	1185^0	113^0	100^0	59^0

Syn-Tectonic Structures (D1 and D2 Deformations)

Folds and Folding

They were observed most commonly in the gneiss. They are of various types ranging from asymmetrical and ptygmatic folds. They are mainly defined by light minerals, example quartz. From the axial trends of the folds, they can be said to have resulted from a compressive stress which was intense. This implies that they are probably tectonic folds and have developed during the Pan African Orogeny. Major and minor fold structures have been reported in this area in the past. Minor fold structures were actually observed at some locations during this study. The intense Alpine-type deformation during this period resulted to the formation of tight isoclinal folds with WE and NS fold axes. The tectonic foliation is defined as the parallel assemblages of minerals by compositional banding (Trumpette, 1979) Such mineral are platy, such as microcline megacrysts, mica and amphibole. The foliation is essentially parallel to the lithological boundaries, but in places it becomes slightly oblique to them, developing into an axial plane foliation which is observed to have been superimposed on earlier east-west foliation at some locations. Rodding, as well as pinches occur in all formation processes that are developed in quartz vein adjacent to the fold lines (Okwonko, 1996)

Very strongly rodded gneisses up to 1meterin diameter and about 20m long occur in isoclinal fold core northeast of Danmarke. The rodding, penetrative lineation and micro fold axes all have a north-south trend and normally shallow plunge. Intense weathering has obliterated the outline of F1 folds. The F2 folds are predominantly tight isoclinal with shallowly plunging north-south fold axes and medium to steeply westerly dipping axial planes. The foliation on the fold limb is parallel to the fold axial planes in tightly folded structures. Field and microscopic evidences of major and microfold structures observed in this area provide conclusive evidence that more than one deformational episode occurred in this area.

They support two stages of deformation in areas of Pauwa, Kaikabayas and Bakkai resulting to the structural complexities, as observed in the mapped area. The two deformations resulted into phases of folding which occur. Within the Basement complex of Nigeria, major fractures and lineament trend follow a NW-SE directions and NNE- SW directions.

Foliation and Banding

It is usually a continuous or discontinuous layer structure formed by the segregation of different minerals in streaks or lenticles or by the alteration of band of different textures (Fig. 3) Although variations from directions do occur, the dominant strike of the foliation follows the tectonic N-S trend defined within the different rocks (10^{o}NS, 9^{o}NS) The foliation are found in the gneisses and are shown by the parallel alignment of biotite. This is applied to a rock showing “stripping” that is, a linear structure. It is well defined in porphyroblastic gneisses. It occurs due to alternating layers of mica minerals (biotite, muscovite) and white or colorless minerals which are always dorminant (quartz and feldspar) minerals. They are found to be sub-parallel in the mafic mineral. The bands must have resulted from deformation process or metamorphic differentiation where by minerals become redistributed throughout the rock so as to define a new compositional layering.

Plate 1: Contact of a migmatite, banded and mylonitic gneisses at Tudun Amiru

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Plate 2: Banded Gneiss near Angwan Maikomo, SW of Kwakwaren-Nabadau

Plate 3: Banded Gneiss around Gidan Bala, south of Kwakwaren-Nabadau.

Plate 4: Major fault in a granite gneiss on Katoge road, 1km north of Kankara

Plate 5: A 30cm wide Pegmatite in a granite at Zango, western part of Funtua north east

Plate 6: Joint along a Pegmatite dyke at near Malali, western part of Funtua NE

Plate 7: Typical Fault, evidence of Post-tectonic effects, near Zango

Plate 8: Quartz-rich Pegmatite, along Zango-Bakarya road.

Post Tectonic Structures (D3 Tectonic Deformation)

Faults

Minor faults were observed in the mapped area especially those seen at the Granite gneiss in location 5 which is exactly on Kankara-Masaku road, NW of Kankara town. This is characterized by quartz in filling faults which displaced the pegmatite in the location showing a sinistral faults (plate vii). The area mapped consist of major and minor faults. Minor faults are found to occur in the gneiss displaying various movements. The area mapped consists of major and minor faults as. Minor faults however are found to occur in the gneisses displaying various movements (Plate vii; Pearce and Cann, 1973)

Joints

The jointing is more prominent in the gneisses and less prominent in the quartzites. All the observed joints can be referred to three genetic types, namely longitudinal, diagonal and cross-joints. The first two types are commonly developed. The longitudinal joints are vertical. Diagonal joints are steep surfaces and cross joints lie perpendicular to flow structures and dip at low angles to the north. Majority of the joints and fractures are within 40º – 60º, 80º – 100º and 100º –20º which correspond with the major lineaments of the area. Vertical joints are normally due to the effect of deformation such as folding and thrusting. Most of the joints in the gneisses intersect each other at various angles. Most of the quartz veins and pegmatite are cut by these joints. .Horizontal joints are mainly common in outcrops that are dome shaped. This is due to the exfoliation of the rock as a result of different diurnal heating.

Pegmatite Veins

Several small veinlets to large pegmatite veins with thickness range of about 1-5 meters abound in the crystalline rocks found in the project area (Plate vi) There are also some elongated pegmatites in micro-granites in the area. There are some exposed areas where quartzites occur in the study area. They occur as cross-cutting bodies with sharp contacts in the gneisses. The large ones which are dykes (emplaced vertically) range in length from a few meters to more than half a kilometer and usually exposed along river channels (Table 2; Plate viii) The pegmatites are coarse-grained with simple mineralogical composition of feldspar, quartz and mica. They are intimately associated with aplite dykes in the granite gneiss. They commonly show differentiation into coarser and finer facies within the same vein. Several stages of pegmatite development and evidence of shearing which is likely to have been a later activity that affected the whole area, are evident from field observations. The first stage, shows earlier injections parallel to the lithological banding of the crystalline rocks. They were later cut across by coarser pegmatoid adjacent to or along the elongated planes with little deformation. Both of these stages may be cut across later by yet another discordant pegmatite vein (Plate v)

Pegmatites close to Danmurabu village and those at Zango-Bakarya road extend for about 20m in general N- S to NNE–SSW direction. They are of striking interest because they are situated near a major fault and contain minor black tourmaline. Other pegmatites are found at Zango. They extend for about 20-60 metre in length, with some trending about NE-SW. They show zoning of minerals, with quartz crystal is at the center and orthoclase at the sides.

The pegmatite veins are oriented at nearly 205º/25º NE – SW, which conforms to the general foliation trend of the basement. The pegmatite veins range in width between 5cm to 50cm which moderately coarse to medium grained textures. Most of the pegmatite contains both microcline and Oligoclase. They commonly exhibit a graphic intergrowth with quartz and feldspar observed in thin section attest to signs of shearing. Foliation is defined by granulated secondary quartz and shredded muscovite or biotite and is deflected round feldspar, tourmaline and garnet. It is probable that many of the pegmatite, in the crystalline rocks have a similar origin with the granite pegmatite. There are large phenocrists of quartz minerals in the western side of the study area.

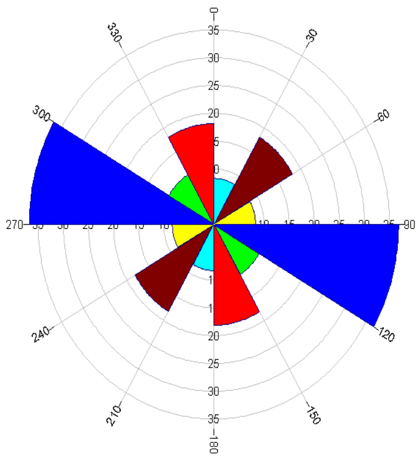

Figure 2: Rose diagram of joint statistics of the mapped area

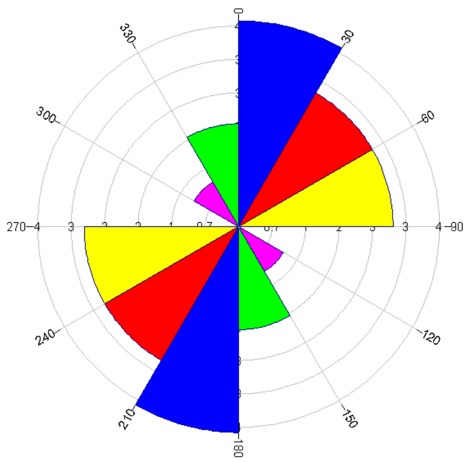

Figure 3: Rose diagram of foliation statistics of pegmatite veins (Scale = 1cm rep 3 units)

Other Related Features

Aplite Dykes and Quartz Veins

These occur intimately associated with the pegmatite veins in the gneisses. In some cases however, a sharp contact relationship was observed between an aplite dykes and an irregularly banded gneiss. They occur as light-colored fine -grained rocks having the same mineralogical contents as granites, but one that is rarely found is the Biotite. Aplite dykes in some gneiss were observed to occur as irregular pods. Intersecting aplite dykes were observed at some locations which resemble a microfault except for the offset whose amount and direction generally indicates formation along planes of shear. Aplite occurs as minor irregular dykes and veins in the granites, and sometimes the schists. The margins of the veins and dykes are coarser in grain size and more feldsphatic in mineralogy than the interiors. They have lengths ranging from 9cm to 60cm, which could be traced under several meters. Numerous and sparsely distributed pegmatites occur as veins, dykes and irregular bodies in the granites and gneiss, and sometimes in the schists. In the schist they often penetrate along foliation planes, but in most places they were seen obliquely crosscutting the schist as veins and dykes.

Quartz veins occur within the gneisses and quartzite. They occur mainly as infillings of cracks or fractures found in the crystalline rocks. They vary in size from few mm of minute threads filling irregular fractures to massive veins of about a meter generally parallel to the foliation and often strongly lineated. The quartz veins are irregular in size and seem to widen or thin out along their length. Quartz veins are widely distributed and occur in dimensions from a few centimeters to 50cm across. They are found in almost all the rock types, but are more common in the granites. Other quartz veins occupy fractures related to the regional joint pattern of the area. These types are found intercalated with the metasediments where they formed quartz bodies on Kankara-Zango road. They are not always concordant with the foliation of the metasediments. Sometimes, they are found strongly folded, boudinaged and elongated in a general NNE-SSW direction.

Field investigation reveals that high-grade gneisses and schists belonging to the Migmatite-gniesses dominate the lithology of South Katsina State, Nigeria. 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. Such precursor rocks are related. The metasedimentary rocks here are characterized by paragenetic mineral assemblages that reflect mostly upper amphibolites facies metamorphism.

CONCLUSION

An appreciation of aspect of structural relationship of the rocks appears to be relevant to the interpretation of their origin and co-existence with other adjacent rocks in northwestern Nigeria, and this is the geologic history. Lithologies here suffered polyphase deformations, with earlier structures completely absent or nearly deformed by later deformations. Then, later ductile deformational structures produced the regional tectonic fabric, S1. Again, subsequent heterogeneous deformations D2 collapsed on D1 deformations producing large scale F2 major folding with planar cleavages. This was followed by late brittle tectonics involving D3 structures and related, with the rocks having a NE-SW trend.

Also certain structural types produced in the rocks can be used to judge and interpret the conditions that prevailed at the time of re-crystallization of the rocks.

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