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Application of Fry Strain Analysis Technique on Metasediments Arround Danko Area, Sheet 74sw, Part of Zuru Schist Belt, Northwestern Nigeria

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Abstract

The study area (Danko) is a part of the Zuru Schist Belt that comprises of Archean and Proterozoic rocks bearing the imprints of the Liberian, Eburnean and Pan-African orogenic events. Three deformational events have been identified (D1, D2 and D3) to have affected the rocks of the study area. The study uses Fry strain analysis method to digitize the center of the grains from which axial ratios and angles to reference lines of fifteen photomicrographs from low grade metasedimentary rocks (quartzites and muscovite schist) so as to understand their deformation pattern and strain history. Quartzite recorded a more intense strain history while muscovite schist recorded a slightly constrictive strain. This study attributes the discrepancy in strain values to be the result of a ductily contrast between the rock types. The majority of the strain in these rocks appears to come from D2 deformation due to the nearly vertical long axis of strain and corresponding field evidence and also shows that there is heterogeneity in bulk strain.

Keywords: Fry strain; Deformation; Archean, Proterozoic; Photomicrographs

Introduction

Nigeria, lying within the vast Pan-African mobile belt, which separates the West African Craton and Congo Cratons, [1,2] well-endowed with metasediments within its basement complex that are highly deformed. The deformation patterns of the basement rocks of Nigeria are so complex [2-6] and hence require a detailed study to understand their strain history. Goki [7] undertook a strain estimation of gneisses in central Nigeria and concluded that in response to the general NW-SE tectono-metamorphic ductile deformation that produced the steeply dipping gneisses of the area, there is heterogeneity in the bulk strain. This paper examines samples of metasediments from within the study area in order to see how the internal fabric of the rock compares to the recognized deformation events, thus providing a better understanding of the regions tectonic history. The study was within Latitude 110 30' 00"N and 110 45' 00"N and Longitude 50 00' 00"E and 50 20' 00"E which is a part of the northwestern part of the Zuru Schist Belt, northwestern Nigeria.

Methodology

A total of twelve samples for the quartzite and three samples for the muscovite schist making a total of fifteen samples were employed for this analysis. Each sample was field oriented with respect to metamorphic cleavage in order to facilitate the strain analysis. The thin sections were cut parallel to foliation planes to accomplish this task. The Fry [8] method of strain analysis was employed. This technique is based on the asumption that initially anti-clustered distribution of points will change after deformation into a non-uniform distribution. Based on this assumption, the centre of the entire quartz grains screen were digitized on selected micrographs of the rocks, using the Ellipsefit software version 3.2.1 and a vacancy was created called the Fry hallow (Figures 1 and 2) of ellipsoid shapes which gave the long and short axes (Table 1). The orientation of the ellipses also gave the orientation of the strain ellipse. The finite strain ellipsoid that is almost circular suggest a low degree of grain deformation, while the flattened type suggested a greater degree of grain deformation (Figures 3 and 4).

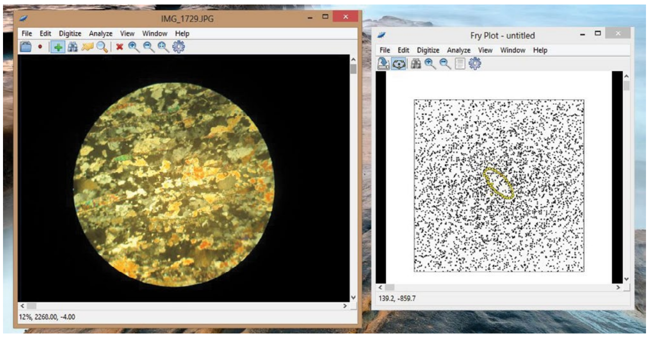

Figure 1: Digitization screen of Fry halos using the Ellipsefit software version 3.2.1.

Results and Discussions

Structural development

Three phases of tectonic deformation D1, D2 and D3 have been recognized in the rocks of this area and are described below.

First phase of tectonic deformation (D1)

The D1 event was associated with the development of S1 schistosity and an F1 folding. The earlier planar structure S1 is generally parallel to the bedding surface S0 and is defined by the preferred orientation of muscovite minerals on the S0 surface (Plate II).

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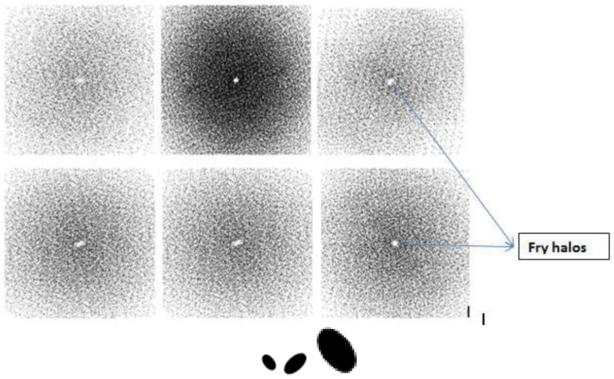

Figure 2: Fry hallows obtained from some of the samples within the study area.

S/N	Slide Numbers	Angle to Reference Line (θ) degrees)	Average Ratio
1	AL4	036	1.14
2	AL5	038	1.62
3	AL7	040	1.77
4	AL9	068	1.38
5	AL13	034	1.54
6	AL15	052	1.63
7	AL17	068	1.38
8	AL18	052	1.10
9	AL25	056	1.86
10	AL4i	052	1.08
11	AL14	056	2.48
12	AL 23	042	2.08
13	AL12	058	1.91
14	AL2	048	1.69
15	AL8	060	1.44

Table 1: Slide numbers, angle to reference line and axial ratios of halos.

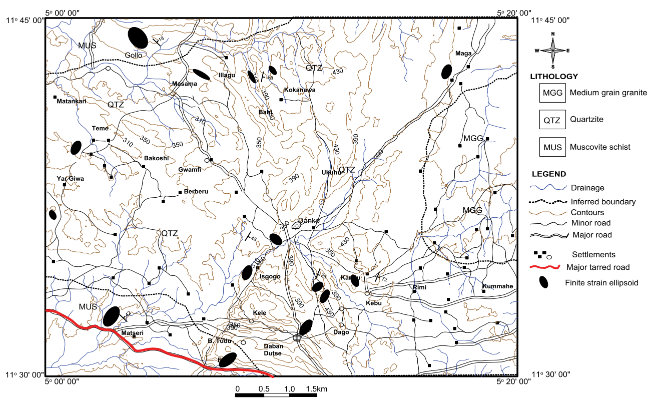

Figure 3: Strain ellipsoid and orientation distribution map of the study area.

F1 folds were rarely seen as they occurred as flat lying minor folds on the muscovite schist; they had an ENE-WSW trend of axial plane. The dominant foliation S1 occurs as axial planar cleavages to this folds. This relationship occurred around Matseri where quartzite veinlet invaded schist (Plate I). No major folds of this generation have been recognized.

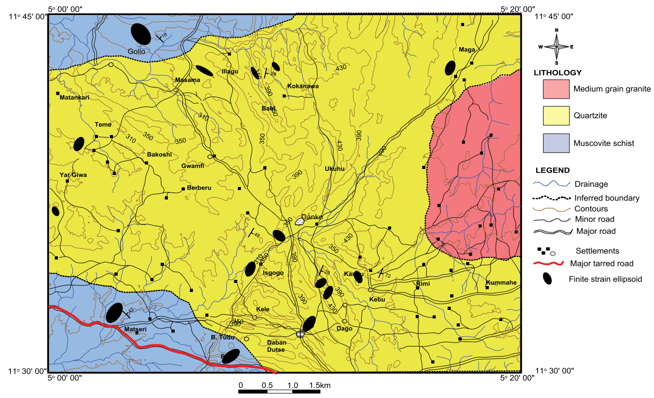

Figure 4: Strain ellipsoid and orientation distribution map of the study area superimposed on the geological map.

Second phase of tectonic deformation (D2)

This tectonic phase is well developed in both the muscovite schist and the quartzites. It is characterized by a heterogeneous deformation affecting the previous D1 fabric. D2 deformation is associated with the development of an S2 crenulation cleavage and F2 major folds.

The S2 cleavage cross cut the S1 cleavage into small regular crinkle folds that has an asymmetric form called the crenulation cleavage (Plate III).

F2 folds occur as large scale upright tight to isoclinal folds with a NE-SW to NNE-SSW trend of axial plane (Plate IV). In other areas they occur as open to isoclinal folds were they forming a continuous series of antiforms and synforms (Figure 5).

Late stages of tectonic deformations (d3)

Late stages of deformation can be attributed to brittle tectonics marked by late sub-vertical fractures which are trans- current faults with a dextral shear sense, granitic veins, pegmatites and joints (cross and longitudinal joints). These veins are generally filled with quartz materials and trend in a NE-SW direction, joints displayed two main orientations which are NE-SW and NW-SE with a minor E-W trends.

Strain estimation and interpretation

A total of fifteen (15) photomicrographs were used for strain analysis. Angle to reference line and axial ratios were determined (Table 1). Ellipsoidal shapes of the grains generated using the Geo Fry package suggest a heterogeneous deformation and varying grain orientations majorly in the NE-SW direction and minor NW-SE directions. The shapes of the Fry hallow range from the near circular type mainly in the northwestern, southwestern and extreme southern parts of the study area thus suggesting a low degree of deformation to the flattened type in the northern parts of the area which showed the highest degree of deformation (Figure 2). The discrepancy in the measured strain is probably due to ductility contrast between the rock types which makes the rocks types deform differently along the same deformation path.

The orientation of long axis of strain was found to be neither vertical nor horizontal but inclined with values of phi (θ) between 0.36 and 0.68 degrees. The halos were inclined majorly NE-SW and secondarly NW-SE. The strain therefore cannot be associated with D1 deformation events; this is because D1 deformations are majorly horizontal and associated with trends in an E-W to ENE-WSW directions with folding

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Plate I: Quartzite veinlet invading schist showing F1 folding and S1 Schistosity

Plate II: S1 Schistosity on S0 surface on muscovite schist

Plate III: S2 crenulation cleavage fabric

Plate IV: F_2 tight to isoclinal fold.

Figure 5: Different phase of tectonic deformation.

about sub-horizontal axes. The strain must be primarily from D2 which matches field evidence of rare, nearly vertical dipping tight to isoclinal folds F2 with trends in NE-SW to NNE-SSW directions.

Conclusion

This study has led to an improved understanding of the regional deformational history as it has shown that the long axis of strain in the area are inclined in the NE-SW and NW-SE trending directions providing support that D2 was the primarily fabric producing event. Also, there is heterogeneity in the bulk strain evident from the differences in the sizes and orientation of halos.

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