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Research Article

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The Structural Geology of Eshiawa in Igarra Area, Southwestern Nigeria

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Abstract The Nigerian Basement complex has undergone polyphase metamorphism and polycyclic deformation during the Late Proterozoic and Early Phanerozoic Periods. The structures of the Pan- African belt in the southwestern Nigeria (Eshiawa area of Igarra) are the result of a succession of several events. Igarra environ provided detailed information on the structures and the following deformations were identified: (1) the original bedding surface (S0) undergoes the first episode of deformation (Di) and produced folds (Fi). This indicates an early Pan-African stage (Di) of tangential movement. (2) Mineralogical banding (Si) produced in first episode of deformation (Di) undergoes second episode of deformation (D2) to produce disharmonic folds (F2). (3) The axial plane cleavage (S2) formed as a result of second episode of deformation undergoes third episode of deformation (D3) to produce asymmetric folds (F3). D2 phase is heterogeneous simple shear in dextral transpressive context and D3 tectonic phase, also marked by dextral transpressional movements, is the phase of superposed folding with a NNW-SSE, kinematics direction. D2 and D3 are associated with medium-grade amphibolites facies metamorphic. (4) The Fourth episode of deformation (D4) is responsible for the emplacement of granitic veins, faults and joints. The first three episodes of deformations were related to ductile deformation while the latter was related to brittle deformation. The similarities of these last phases with the central Cameroon shearzone suggest that the D3 and D4 stages are controlled by transcurrents tectonics. Transpressive tectonic seem to be the main deformation style in major shear zones of Igarra.

Keywords Structural Geology, Eshiawa, Southwestern Nigeria

Introduction

Eshiawa area is part of Igarra environ situated in Southwestern, Nigeria. The study area forms part of Precambrian Basement Complex of the Igarra Schist Belt) [1]. It is located within longitudes 6°00’E - 6°15’E and latitudes 7°081N-7°15’N. The area has elevation of about 200m to 850m.

Aim and Objectives

This exercise is aimed at structural geology with detailed geologic mapping as it relate to the field, the different rocks types, their field relations of the area covered.

Method of Study

In this study, classical field methods were used. The major tectonic structures are recognizable at a metric or centimetric scale and their orientation (strike and dip) were measured and the data statistical analyzed using steronett. The deformation history and kinematic analysis of the study area were deduced from the field study and detailed mapping of foliation and lineation were done. Sketches of the outcrops and other geologic structures were made in the field. The study was carried out in three phases, namely;

i) Field work
ii) Laboratory studies

iii) Interpretation
The field mapping exercise, which was done and lasted for six days. During the trip, we familiarized ourselves with the area using the topographic map and then carried out detailed mapping exercise of the area.

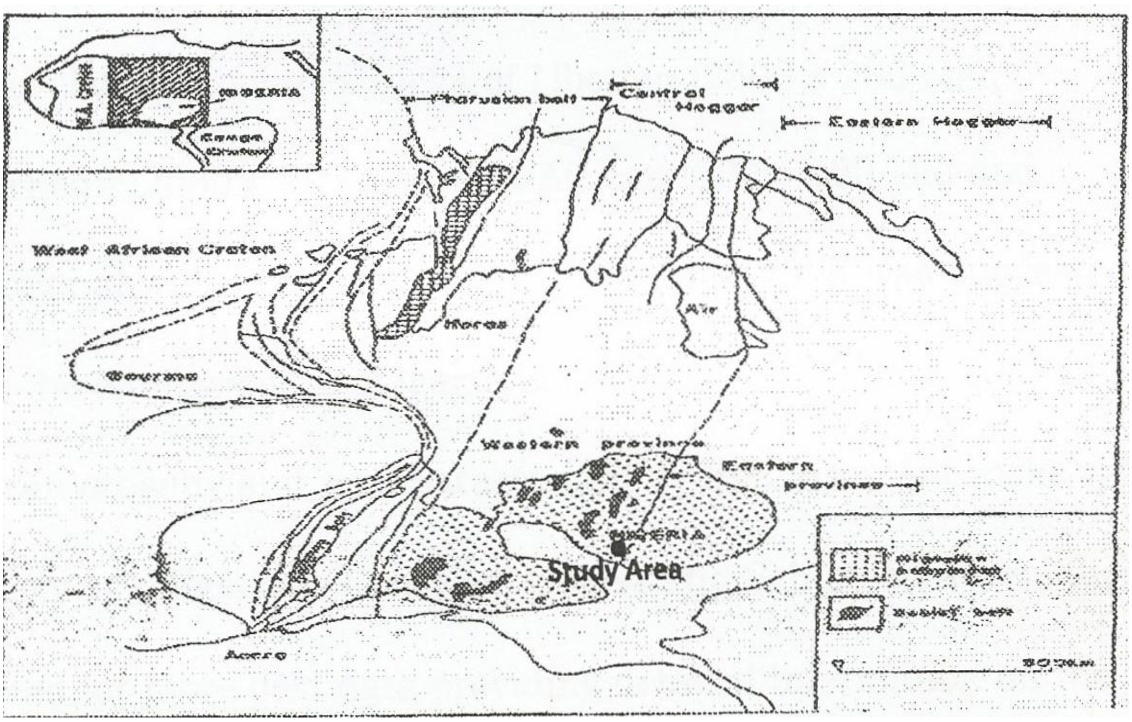

Figure 1: General1zed geological MAP of the Pan-African Belt East of West-African Craton Reflecting the Study Area (Modified from Caby et al. 1 91)

Results and Interpretation

Structural Geology

Structural geology is the study of the three-dimensional distribution of rock units with respect to their deformational histories [1]. The primary goal of structural geology is to use measurements of present-day rock geometries to uncover information about the history of deformation (strain) in the rocks, and ultimately, to understand the stress field that resulted in the observed strain and geometries.

This understanding of the dynamics of the stress field can be linked to important events in the regional geologic past; a common goal is to understand the structural evolution of a particular area with respect to regionally widespread patterns of rock deformation (e.g., mountain building, rifting) due to plate tectonics [2] . The movements that affect solid rocks result from forces within the earth, causing folds, joints, faults which determine the various structures associated with the different rock types found in the area of study. These structures include planar and linear structures, lineation, folds, fractures, joints, shear zone and faults.

Planar Structures

These are dominant especially in gneisses and schists trending N-S to NW-SE with well-developed foliation marked by parallel alignment of mica, amphibole, feldspar and quartz crystals by compositional banding. Well-developed schistosity forms in the schists (Fig. 7) and generally less developed gneissosity which is the prominent foliation in the gneisses. Subordinate ex-foliation trends are in the NE-SW, NW-SE, and E-W and NNW-SSE directions.

The Foliation Planes dip steeply, especially in the schists more than the gneisses. About 500 measurements of strikes and dips of foliations were taken and analyzed statistically. The poles to the planes of foliations show mostly NNW-SSE and NW-SE cluster on stereogram plot (Fig. 2) indicating a general NW-SE trend for major folds in the area.

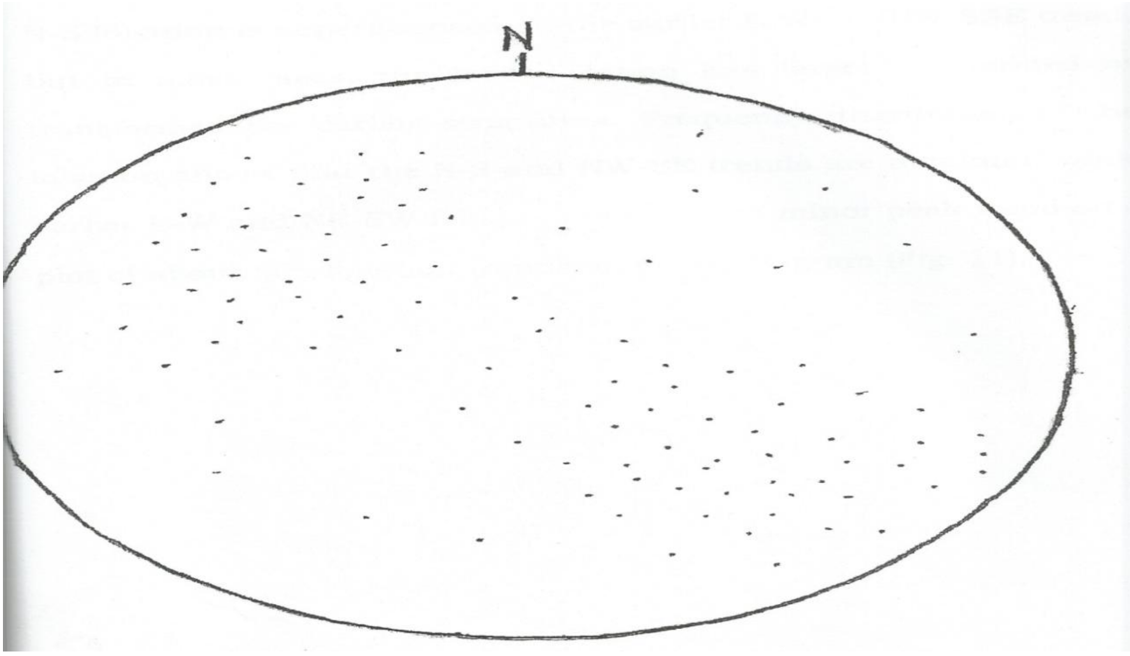

Figure 2: Stereogram Plot Foliation Structures in the Study Area

In the study area, the foliation is axial planar to the folds, later N-S foliation is superimposed on the earlier E-W to NNW-SSE trend, but in most cases, the later foliation has largely obliterated or transformed the earlier structures. Frequency distribution of the foliation shows that the N-S and NW-SE trends are dominant while earlier E-W and NE-SW foliation planes form minor peak trend on a plot of about 500 foliation trends on a rose diagram (Fig. 3).

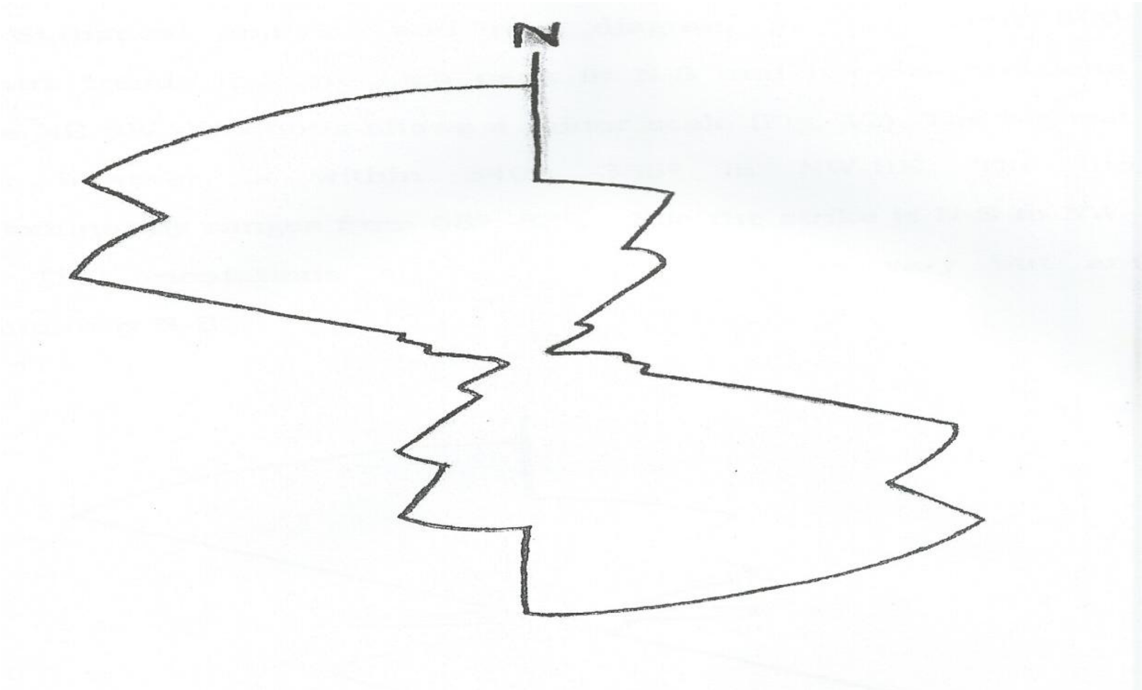

Figure 3: Rose Diagram of the Foliation Trends (N=500)

Linear Structures

Statistical analysis and rose diagram plot of about 600 fracture trends indicate high peak in N-S and NW-SE directions while NE-SW directions shows a minor scale. The highest peak however is within 3400 3550 in NW-SE. The dip predominantly ranges from 68° -88°, while the strike is N-S to NW- SE. The orientations of the linear structures vary but are dominantly N-S.

Lineation

A mineral lineation due to the preferred alignment of minerals and orientations of minerals such as biotite, amphibole, and quartz is the most common type [3]. A second type is the orientations of the foliation by the crests and troughs of minor folds giving rise to a crenulations foliation. These two types are generally parallel to one another.

Folds

Folds are best displayed by stratified formations such as sedimentary or volcanic rocks or their metamorphosed equivalents [4]. The crystalline complex has been completely deformed to flat-lying axial plane, series of tight, open to close isoclinals and asymmetrical folds with axes trending mainly N-S, NE-SW. The folds are common in the migmatites, gneisses and schists (Fig. 4-6). The axes and axial planes of the folds are approximately parallel to the regional foliation trend of N-S direction. In the migmatites, Kink folded structures also occur. Where both the E-W and N-S folds occur together the E-W reduced folds are usually refolded by and overturned in the N-S upright folds.

Figure 4: Showing f1 folds with flat-lying axial planes in biotite schist at ebigere

Figure 5: showing typical similar and harmonic fl fold in biottte schist due dl at ikao. (the original bedding surface (5) undergoes the first episode of deformation (d) and produce fold (f1) which is isocunals recumbent fold)

Figure 6: showing asymmetric and disharmonic f2 folds in migmattte due to d2 at ebigere (mineralogical baning (s_1) produced in the first episode of deformation (d_1) undergoes second degormation (d_2) and produce fold (f2) which is isoclinals recumbent fold)

Therefore, three main fold phases which differ in orientation and style occur in the study area which can be observed on the rose diagram of fold plotted . The oldest E-W trending Pre-Pan African fold which was refolded by the NW-SE trending Pre-Pan African and the younger N-S trending Pan-African deformation phase isolated tight fold closures, showing as tectonic fissures which marked the intense folding, occur in the study area.

The migmatites exhibit magmtitic structures and complex ptygmatic and disharmonic drag folds [5-6]. This is probably as a result of differential stress-inducing plastic movements during the peak of high grade metamorphism of the multilayered competent and incompetent migmatites bands.Pinch-and-swell structures represent quartzo-feldspathic grains that show linear alternation of thick and thin mineral concentrations.

Fractures and Faults

These structures are widespread in the basement rocks of the study area. They are generally vertical or near vertical. Their main directions are N-S, NW-SE and NE-SW. Several dexra and sinistral strike slip faults occur in the area (Fig. 7).

Figure 7: showing strike-slip fault at unemeneknua

Joints

Joints are everywhere in the area of study. These structural features occur mostly in the granites and schists. In most cases, the schist bad joints that are perpendicular to the foliation plane of the rock body. Field relations indicate that they trend mainly in the N-S to NW-SE and NE-SW directions (Fig.8).

The density of the joints is highest in the brittle quartzo-feldspathic rocks [7]. Most of the joints are the open type; however some have healed by recrystallization of secondary quartz (Figs.8-9).

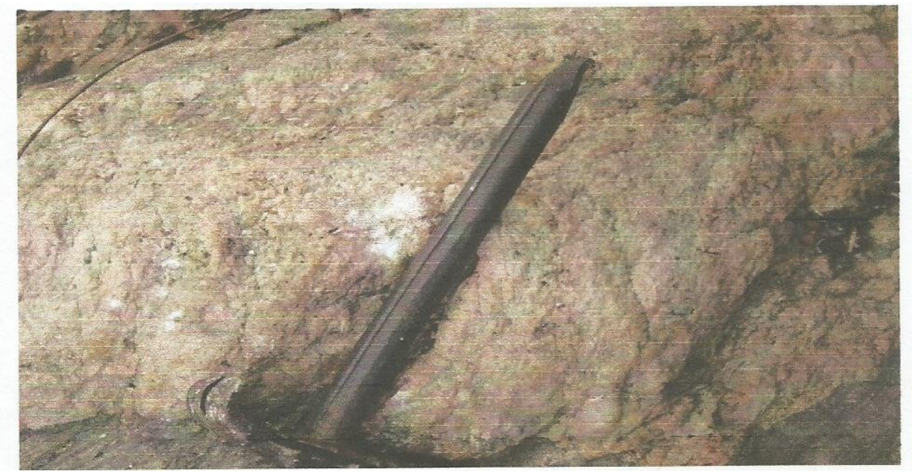

Figure 8: Showing Quartzo-Yeldspathic Vein Intrusion Into Gneisses At Aiyegunle

Shear Zone

Semi-ductile shear zones cut through all pre-existing structures. The st exple is located in a river section about 3 west of Iga (Fig. 9). Here, the folded lithological layering, S0/S1 is dragged down into the sub-vertical shear zone; without its being truncated. Near the shear zone argin, there are boudin structures as well as possible relict cross bedding.

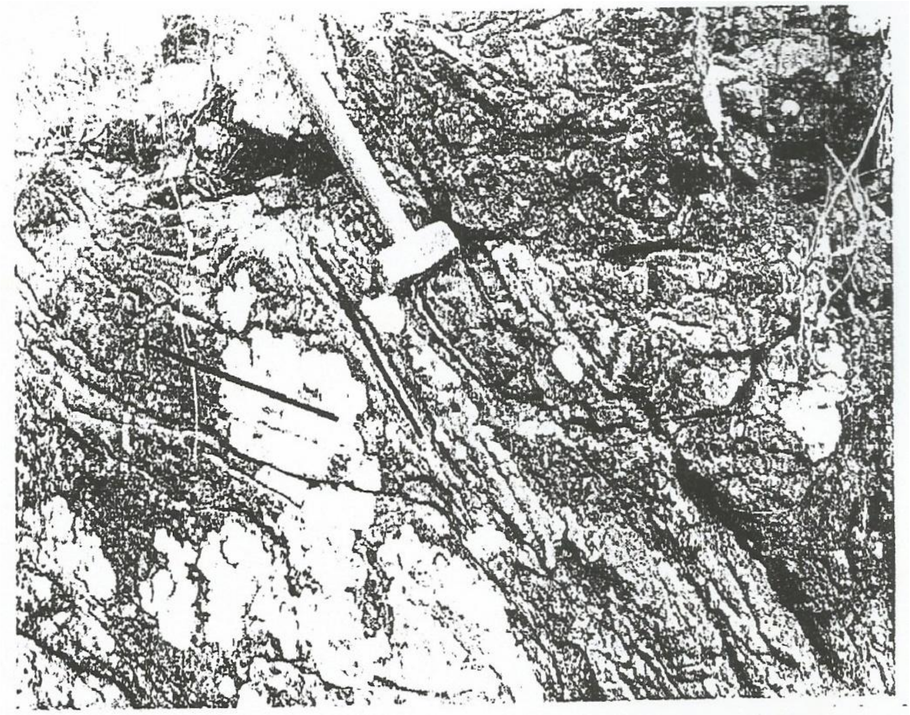

Figure 9: showing shear zone in quartzite west of igarra. The flat-lying foliation (left of the picture) has been dragged into steeply dipping shear zone (right of the picture)

Petrography

Schlst:

Schist is strongly foliated which is characterized by the alternation of light bands and dark bands [8-9] . The light band is made up of minerals like quartz, feldspar and muscovite and the dark band is made up of minerals like biotite and amphibolites.

Also from the laboratory studies, the modal composition of the schist shows dominance of quartz (10%), Biotite (32%), Hornblende (48%), Opaque mineral (10%). Mineralogically, the schist can be classified into biotite-hornblende schist (Fig. 10).

Gneisses

Modal analysis of the gneisses shows quartz (25%), biotite (50%), k-fedspar (10%), hornblende (12%), Garnet (1%) and opaque mineral (2%). Mineralogically, the gneisses can be classified into Garnet-hornblende-biotite gneisses (Fig. 11).

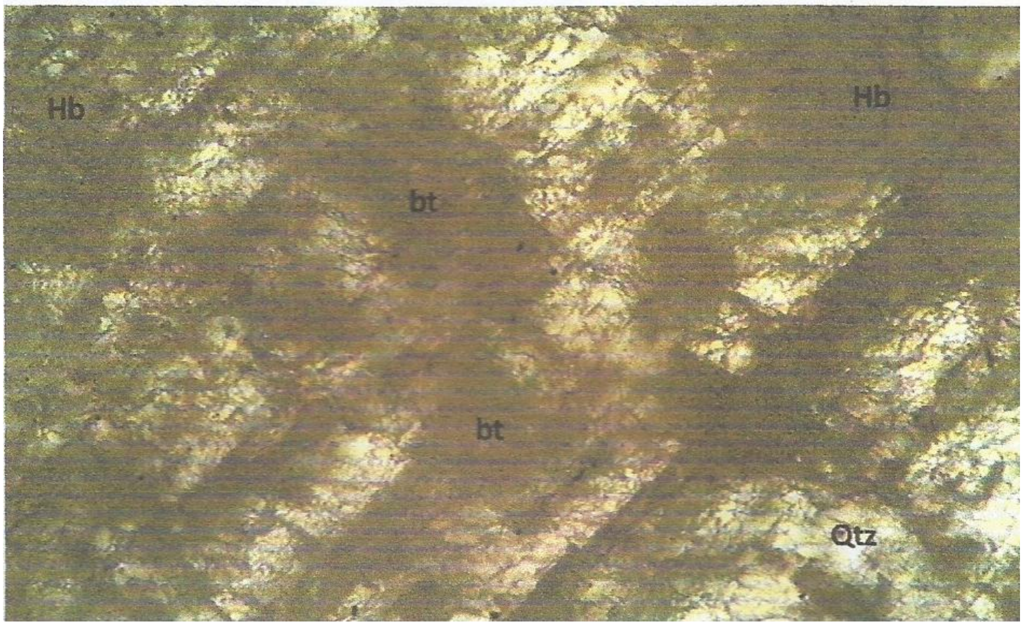

Figure 10: microphotograph of biottte schist under plane polar at unemenekhua

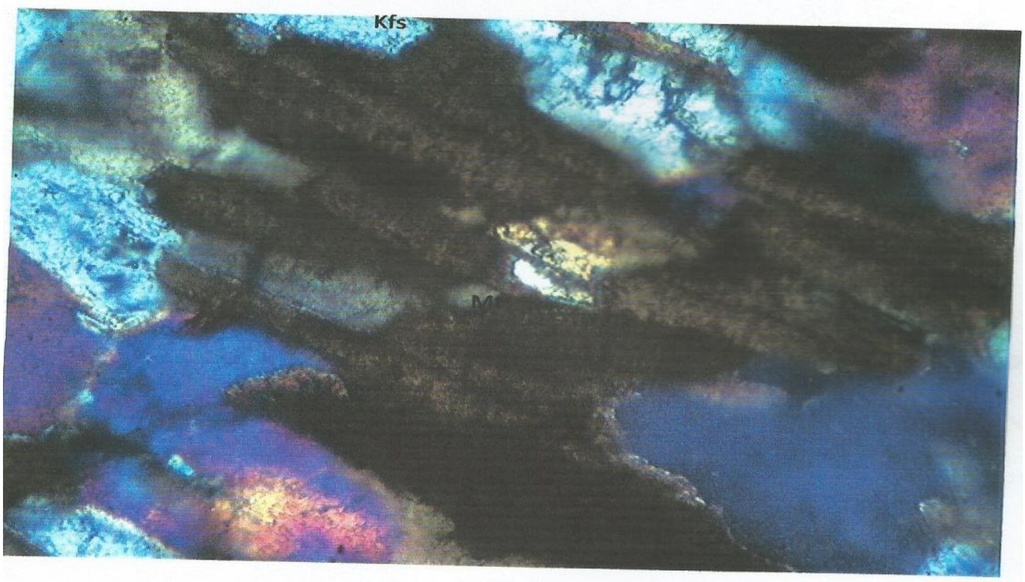

Figure 11: mcirophotograph of biottte gneiss under cross polar at eshiawa

Optical Properties of the Mineral

Quartz: It occurs as anhedral to subhedral grains with no cleavages or twinning [10]. The crystals show maximum interference colours of white faintly yellowish. Extinction could not be determined because of the absence of cleavage and relief or alteration [3-4]. This absence of relief may be due to refractive index being little above the mounting cement. Quartz is colourless both in plane and cross polar.

Plagioclase: It forms euhedral crystals and showed imperfect in one directional cleavage. They showed low relief and exhibit twinning according to the Albite law with twin lamellae moderately wide [6]. The interference colours are pale yellow and grey.

Microcune: The distinguishing feature of microcline in thin section is its tartar- pattern and cross hatched twinning produced by the combination of Albite and pericline twinning. They showed crystal of more or less perfect shape in the thin section. Perthitic feature (intergrowth of plagioclase k-feldspar) was observed.

Biottte: In the thin section, biotite displayed high relief, high interference angle and showed parallel extinction. The crystals are pleochroic in yellow and yellow-brown, dark-brown and red-brown. It has one directional cleavage.

Muscovite: It shows greyish to brown glittering colour and exhibits an anhedral crystal shape.

Hornblende: Hornblende also displayed pleochroic in pale green to yellow-green and light brown. It has high relief on plane polar. It also displayed two directional cleavages in 010 at about 124° and 560 It showed low interference angle compared to biotite.

OPAQUE. Information on the opaque minerals was obtained by lifting the microscope lamp and shinning it down obliquely on the top of the thin section. Under the condition, a black feature with some tingly shinning spots was observed which indicate the presence of magnetite. Some of the opaque showed yellowish- white which implied that ilmenite is present in the sample.

Micro Structure

Micro-structures (joint and fracture) were identified in the microphotograph of quartzite at Eshiawa (fig 12)

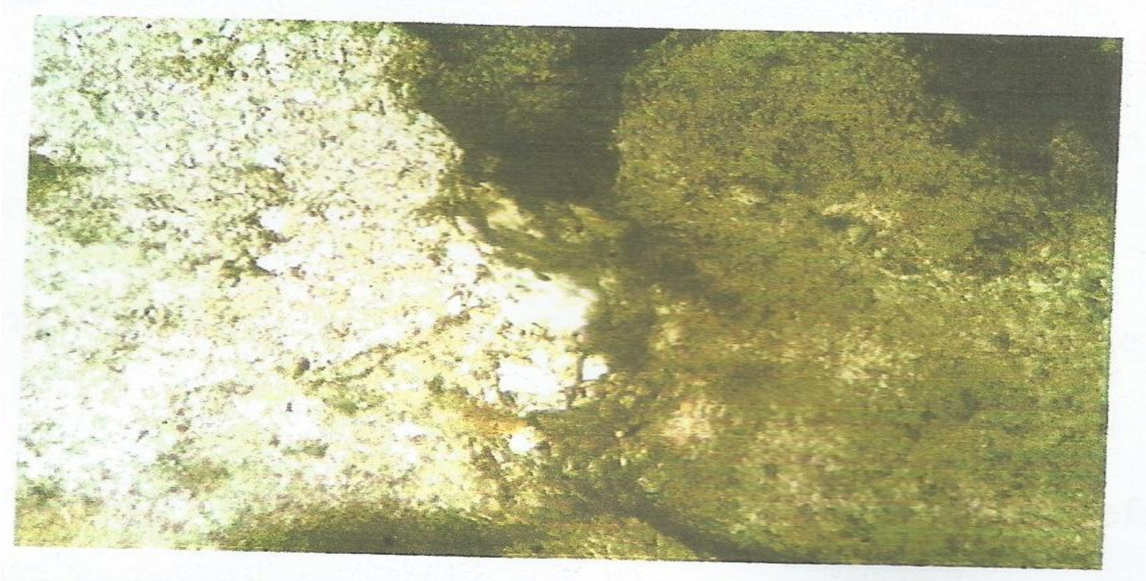

Figure 12: microphotograph of joint in quartzite at eshiawa

Discussion

Tectonism

The rocks in the study area were deformed during four main tectonic events.

1) The original bedding surface (S0) undergoes the first episode of deformation (Di) and produced folds (Fi) which are isoclirial recumbent folds. There is also an indication of ductile deformation due to mylonitic foliation in sheared granite.
2) A folding event F2 which refolded S1 surface and produced S2, F2 etc.
3) The F2 elements were refolded by F3. F2 and F3 folds from type
4) Interference patterns. These events are also a phase of ductile deformation
5) The fourth deformation leads to the formation of crenulation cleavage fold produced from the strike-slip crenulation.

Based in the structural study, the earliest deformation Di only affects the metamorphic basement rocks. During mylonitisation, minerals in the rock underwent dynamic crystallization with th result that a reduction in grain size took place, and strong patterns of preferred orientation of crystals (e.g. quartz, feldspar and amphibole) were developed. Kinematic indicators found in the study area include mylonites, asymmetrical minor folds and porphyrociast systems. These indicators point to a dominant dextral sense shearing.

The D2 tectonic phase is characterized by a diversity a structural element such as: (a) the F2 folds with different morphology (b) an axial plane schistosity S2, associated to c) mineral and stretching lineation and (d) C2 shear zone with dextra movement. The spatial distribution of the L2 stretching lineau&: and the axis of the F2 folds give an average direction of translatx2 as NNW-SSE. With this multiplicity of the structural elements, the D2 phase of deformation is the main tectonic phase in the study area. The principal mechanism of the deformation is a heterogeneous simple shear in transpressive context. The major direction of the L2 stretching lineation parallel to the F2 folds axes allow us to determine the sense of the translation of the nappe which is NNE-SSW. According to all the structural characteristics, the D2 phase of deformation is a dextral transpressive tectonics.

The D3 tectonic phase is fundamentally a phase of tectonic superposition. it is essentially made of F3 folds resulting in the refolding of the earlier F’2 folds. The other structures acquired during this phase (S3 schistosity, L3 lineation and C3 shear zone) come from the redistribution or the reorganization of their equivalents of the D2 phase, in the sense that some remain parallel and others sub-parallel or oblique. The D3 dextral shear movement is similar to that of the D2 tectonic phase and the similarity of the D2 and D3 structures testify of a progressive deformation during the activity of a major ductile shear zone. The D3 tectonic phase, like that of D2 is a phase of dextral transpressive tectonics. The D3 determined large regional variations.

The D4 is a phase of brittle tectonics with sub-vertical fractures and regional scale faults. These fractures show three main directions, all corresponding to the main directions of the shear zones. Also, the fourth deformation leads to the formation of crenulation cleavage fold produced from the strike-slip crenulation.

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