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Deformational History Reconstruction of Basement Complex Rocks in Okomita, Ojirami and Environs, South Western Nigeria

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ABSTRACT: Deformation histories aid in remodeling the forces related to rock formation. Hence, the objectiveof this paper as to examine the deformational history of the Basement Complex rocks in Okomita, Ojirami and Environs, South Western Nigeria using appropriate standard methods. Results of the field work embarked upon revealed that the major rocks encountered include older granite and metasediments like mica schist, quartzite and gneiss. The analysis of the structures contained in the rocks was achieved by plotting the orientation of the structures on rose diagrams and stereonet. The results show that the rocks were subjected to polyphase deformation, comprising of pre-Pan African and the Pan-African orogeny. While the Pan African orogeny left imprint of NE-SW trend as observed in all the rocks, the pre-Pan African orogeny generally has a NW-SE trend which was observed to be associated more commonly with only the metasediments.

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Analysis of deformation history helps to understand the structural evaluation of a particular area due to plate tectonics. Foliation is a planar fabric that develops in rocks subject to compressional stress. It also results from the reorientation, recrystallization and growth of sheet silicate minerals so that their sheets become oriented perpendicular to the compressional stress direction. Individual minerals align themselves perpendicularly to the stress field such that their long axis are in the direction of least stress. All rocks are under pressure as a result of burial. The confining pressure increases with respect to depth.

Fractures are commonly caused by stress exceeding the rock strength, causing the rock to lose cohesion along its weakest plane. Tectonic fractures when found on any rock indicate that the rock has been subjected to some of stresses. By analyzing the fractures and foliation presents on rocks, the type, amount and episodes of deformation suffered by the rocks can be understood. Hence, the objective of this paper work is to examine the deformational history of the Basement Complex rocks in the Okomita, Ojirami and environs, South Western Nigeria.

MATERIALS AND METHODS

The outcrops in the study area Igarra were studied and the attitude of foliations, fractures and veins were measured using standard structural analytical tools. The accurate positioning of the rocks was obtained using the Global Positional System (GPS). The orientation of the fractures and veins were obtained using the compass-clinometer. Rose plots and stereonets for the foliation trends were generated, and

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these were all put together to constrain the tectonics of the study area. The methodology employed for this research includes;

Fracture and Foliation Mapping: This was done through a field survey and by traversing along footpaths using materials such as a base map, GPS and compass clinometer to measure the trends of the various outcrops which was used to create a dataset.

Plotting of Data Set: The available data set which includes the orientation of the structures were plotted in the GeoRose software. This was used to generate rose plots for the structures within the basement rocks of the study area. The analysis of the various plots helps in the interpretation of the happenings, the rocks in the study areas must have undergone. The generated plots are presented in Fig. 3 and Fig. 4.

Structural Analysis: The fracture and foliation analysis were derived from the rose plots and used to determine the deformational history of the study area.

Study area: The study area is located in the regions of Ojirami, Okomita and its environs, at approximately latitude N 7°17'35.4"- N 7°21'3.7" and longitude E 6°5'25.6" – E 6°14'1.2". (Fig. 1 & 2).

The area lies within the basement complex of Igarra and its environs in Edo state, South West of Nigeria (Fig. 2). The Igarra basement complex is part of the Precambrian Southwestern basement complex of Nigeria hosts series of rock types with the most prominent plutons of Pan-African granites which contain fractures and mineral veins with information on the deformational history of the region (Hockey *et al*., 1986). The Precambrian basement complex of Southwestern Nigeria is polycyclic in nature (Ajibade and Fitches 1988). The Four major orogenesis it has undergone includes; The Liberian 2700+200Ma, The Eburnean orogeny (Early Proterozoic), 2000Ma-2500Ma, The Kibaran orogeny (Mid Proterozoic), 1100Ma - 2000Ma (Fitches et al., 1985) and The Pan African Orogeny, 450Ma-750Ma (Mc Curry, 1976; Rahaman, 1976). However, the Eburnean and the Pan-African are major events which modified the Precambrian Geology Southwestern Nigerian basement complex (Rahaman, 1988). The study area and its environs, contains about four main groups of rocks which are the migmatite-gneiss complex, the metasediments composed of schists, calc-gneisses, quartzites and metaconglomerates, the porphyritic Older Granites and the late discordant non-metamorphosed syenite dykes (Odeyemi, 1976).

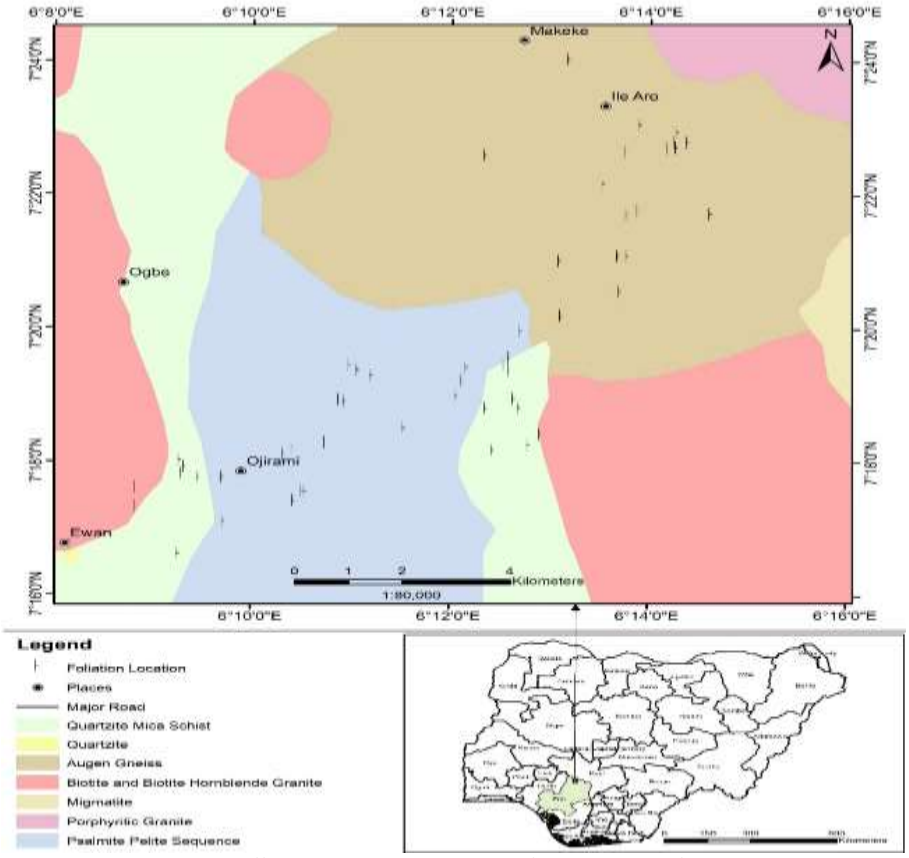

Fig.1: Map showing different rock types and location of study area with foliation distribution

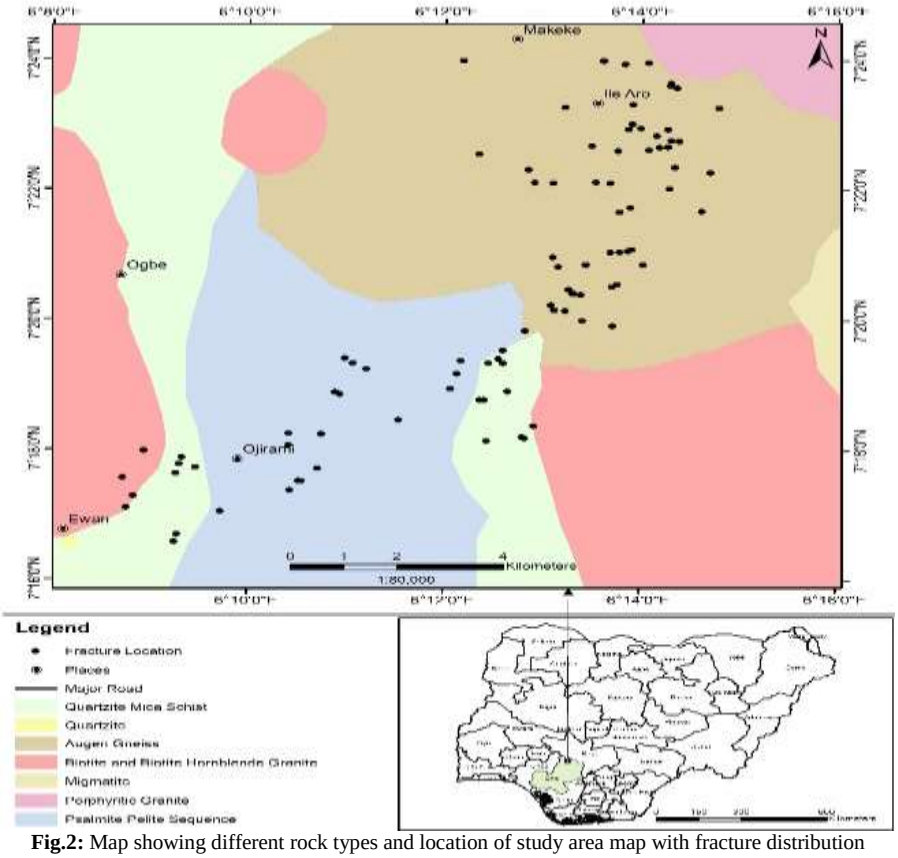

Fig.2: Map showing different rock types and location of study area map with fracture distribution

RESULTS AND DISCUSSION

Fracture Analysis: A total number of 95 fracture orientations were acquired from field mapping of the study area. Results indicate that three major fracture trends exist in the study area. The major trends are in the NE-SW directions, N-S direction and NW-SE directions. There are also presence of minor fracture trends which are numerous and they intersect with the major ones. This result tells the polycyclic deformation that has occurred within the study area. Joint analysis undertaken on all the locations shows an E-W, NW-SE, NE-SW and N-S directions in all the individual lithologic units. The muscovite schist shows a NNE-SSW and a slight NNW-SSE trend, the quartzite rock had a NE-SW and a NW-SE trend suggesting polydeformation, while the granite had a dominant NE-SW trend. The spatial distribution of these structural features in rocks tend to occur in relation to the stress configuration that form them as they conform to the law of mechanics and prevailing tectonic regime (Aydan and Kawamoto, 1990). The N-S joints are usually associated with the axes of folds and are perpendicular to the direction of maximum principal stress (Oden *et al*, 2016). Structural analysis has revealed that the study area was subjected to polyphase deformation which resulted in orientations of structures in the N-S, NE-SW, E-W and NW-SE directions. Similar orientation and fracture trends have been recorded in other parts of the Nigerian basement (McCurry, 1976; Onyeagocha and Ekwueme, 1982; Ekwueme, 2003). As stated by McCurry, 1976; Rahaman, 1976, the Pan African/Brasiliano orogeny reconfigured and overprinted older Precambrian imprints. The E-W collision of the West African craton and westward moving plate created N–S to NE-SW trending structures parallel with the edge of the West African craton (Black et al., 1979; Champenois et al., 1987; Oluyide 1988; Egesi and Ukaegbu, 2010). The dominant Pan African fabrics include N-S and NE-SW oriented structures as opposed to Achaean or pre-Pan African orogeny trends oriented differently to these directions in the basement (Onyeagocha and Ekwueme, 1982; Toteu *et al.*, 1990). From the result we can tell that only one major episode of deformation took place within the igneous rocks of the study area since its major fracture trend is in the NE-SW direction showing that it was affected by a Pan African orogeny. However, the presence of the two other trends (N-S and NW-SE) in the metamorphic rose plot which is absent in the igneous rose plot shows that the metamorphic rocks must have undergone more than one episode of deformation and was also affected by the Pan-African orogeny. According to (Onyeagocha and Ekwueme, 1982; Toteu *et al*., 1990), the N-S and

NE-SW structures are presumably associated with the Pan-African orogeny, while pre-Pan-African structures are oriented differently to these directions in the basement complex rocks.

Foliation Analysis: The orientation of the foliation planes measured and plotted on the rose diagram shows that the foliation trends are continuous and are generally in the N-S direction, with variations in the NNW-SSE and NW-SE direction (Fig.3a). As observed in Fig.3b, a stereographic projection of the foliation trends and the directions of dip; the foliation, trends generally run from N-S, NNW-SSE and NW-SE, dominantly having dip directions towards the SW and minor variations to the NE region of the stereoplot hemisphere. Figure 3c and 3d are stereographic projection of poles and density stereoplot respectively, of the foliation showing concentration of the poles in the NE portion of the hemisphere.

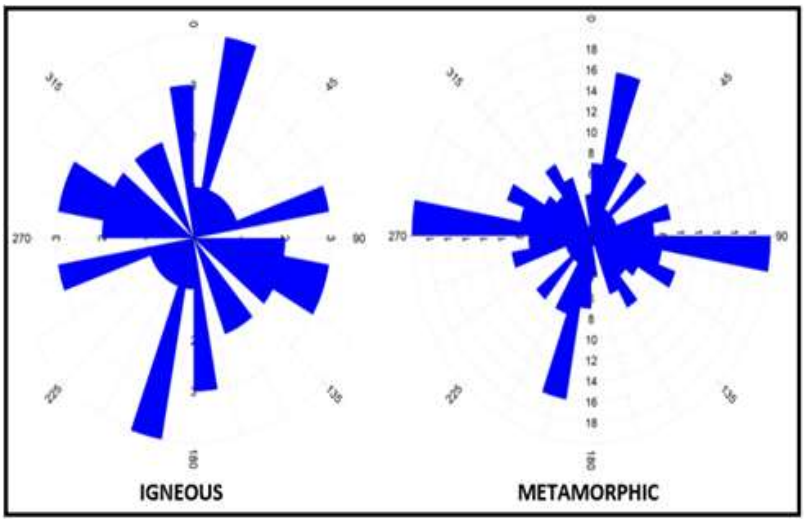

Fig.3: Rose plots showing the fracture trend for the igneous rocks, the metamorphic rocks in the study area.

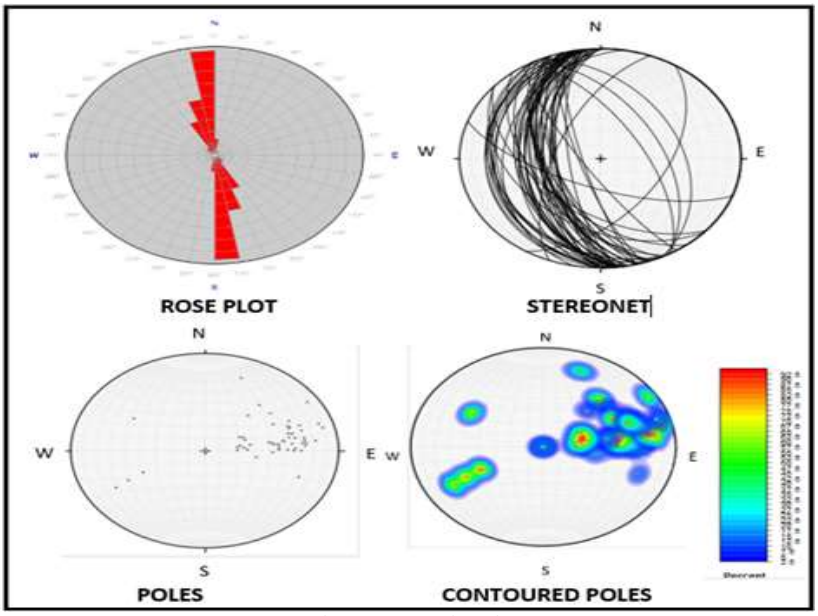

Fig.4: Result of the analysis of the foliation planes

According to Omosanya *et al., 2015*, the N-S and NE-SW oriented structures are presumably Pan African imprints while other differently oriented structures are precursory Precambrian fabric associated with Liberian, Eburnean and possibly Kibaran orogenies. However, the NE-SW foliations and compression are thought to be unrelated or completely obliterated by the Pan African orogeny. Analysis of foliations on the stereoplots show that they have a NW-SE trend, and this is confirmed by the construction of stereographic

projections of poles to foliation surface which shows that the poles are concentrated in the NE and SW axis. The NE-SW trend which is persistent with some of the foliations, lineations, joints, veins, pegmatites and axial plane of folds shows that they are also Pan African orogenic structures while the E-W, NW-SE trends of this structures are likely pre-Pan-African; thus suggesting that they are associated with an earlier D1 deformation phase.

Conclusion: Okom-ita, Ojirami and environs is part of the Nigerian Basement Complex, believed to have undergone polyphase deformation. Structural analysis of linear and planar features revealed a variety of structural orientations in the study area. The findings revealed that the N-S and NE-SW are the most penetrative structural orientation and are attributed to the pervasive Pan-African deformation, which are prevalent on the igneous rocks. Whereas the E-W and NW-SE are relict of Pre-Pan African deformation episode are predominant on the basement rocks.

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