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Petrography, Structural Characteristics and Mineral Resources of Igue Oke Igarra Area Southwestern Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Author NE designed the study, literature, wrote the protocol and wrote the first draft of the manuscript. Author SMA performed the statistical analysis and managed the analyses of the study. Both the authors read and approved the final manuscript.

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ABSTRACT

Igue Oke is located in the SW of Igarra Auchi sheet 266 SW, southwest basement complex of Nigeria. The rock types are made up of meta-sediments which includes marbles, migmatitic schists, meta-conglomerates, amphibolites, calc-silicate rocks which have undergone several deformations, metamorphism and also intruded by syn-tectonic plutonic granitic rocks in Pan-African time. This orogeny is the longest and lasted for about 300 million years. Minerals in the rocks consists of quartz, k-feldspar, biotite, albite-plagioclase, micas, dolomite and calcite as the major minerals while the opaque minerals are major accessory. There are two phases of deformational episodes which have been identified in the rocks of this area. A regional foliation F1 with open, close, tight to isoclinal folds. Secondly, deformation followed which gave rise to shear zones, slickensides and fault features in an environment of extensional tectonics. The dominant major folding in the area is the NW-SE trend and the foliation F2 is associated with slickensides and faults superimposed on the earlier formed structures. The structural element in the study area shows multidirectional orientations. Rocks in the area have a general and consistent trend as

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revealed by the statistical data on rose diagrams and stereographic projection plots in NNW–SSE, and a few N-S to NE-SW directions. There is also an E-W and EEN-WWE orientation which are probably relicts of Pre-Pan-African orogeny. Exploitation of granites for aggregates has been going on with established quarrying firms for granites, while mining of marble by small-scale miners has been going on without proper design or plan for Health, Safety and Environment HSE causing badland topography, a three bench mine design with reclamation procedures will be appropriate for the area.

Keywords: Petrography; structural characteristics; mineral resources; Igue Oke area; Igarra Sheet Southwestern; Nigeria.

1. INTRODUCTION

Igue Oke and its environs in the Igarra SW, lies within the southwestern Basement Complex of Nigeria Fig. 1. The study area are parts of Agor (Sebe Ogbe), Ikpeshi, Ojukutu and Igue Oke. The Nigeria Basement Complex is located within the mobile belt, towards the eastern part of West Africa Craton (WAC) and northwards of the famous Gabon Congo Craton (GCC) [1,2]. Two terrains has been identified; the western comprising mainly narrow meta-sedimentary rocks (schist) which trends North-South, forming the popular schist belt of Nigeria. There are other rock types migmatitic schists, gneisses, marbles and muscovite-schists and calc-silicate rocks which were intruded by granitoids. The northern portion are made up of migmatites which has been highly deformed and metamorphosed by intrusions of more volumes of granitoids in places by the younger granites of Jurassic age with its characteristic ring complexes in Jos Plateau central Nigeria [3].

Field evidence from workers of the basement rocks shows that Pan African belt is as a result of plate tectonic processes which gave rise to some of the similarities and differences in the geology of the eastern Nigerian basement, western Cameroon basement and western Nigerian basement complexes [4]. The Nigerian Basement Complex NW and SW has received more attention by workers of the basement goelogy than the east. They have identified two episodes of deformation, the Pan-African episode being the longest for about 300 million years is most pervasive.

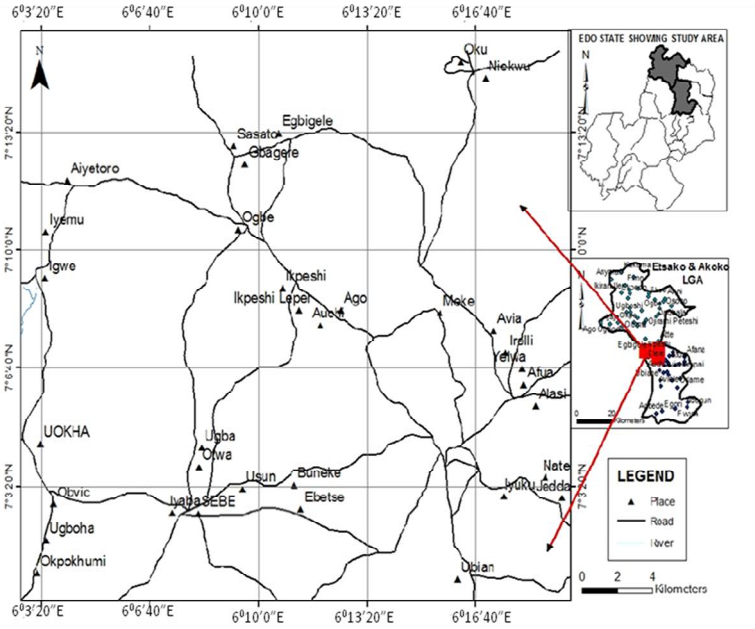

Fig. 1. Topographic map showing parts of Igue Oke, Agor (Sebe Ogbe), Ojukutu, Ikpeshi, Iyuku and its environs

The deformation and structural patterns of the Nigerian Basement Complex have been reported by Grant, [5]. Udoh, [6] using satellite imagery concluded that NE-SW and NW-SE diagonal lineaments are preponderant over other fractures reflected on the Nigerian basement and they increase from west to east that is, towards the Bamenda massif of the Cameroon. The extractive industry in Nigeria need to know, where did we go wrong? Oti, [7] to enable Nigeria enhance its minerals exploration and production from its present stage to a more cost-effective mineral exploration strategy. Therefore, there is need to update and evaluate the rocks and mineral resources of the study area as more information are obtained from recent exploration and mining activities in Igarra mineral district.

1.1 Geology of the Study Area

Igue Oke, Agor, Ikpeshi and Ojukutu lies within the Pre-Cambrian Basement Complex of southwestern Nigeria. The area probably was an ancient sedimentary basin with limestones, shales, mudstones, conglomerates and sandstones which were deformed, metamorphosed and finally intruded by magamtitic rocks. The rock types includes meta-conglomerates, quartzites, amphibolites, schists, calc silicate rocks, marbles, meta-sediments and granites. Migmatitic schists identified are foliated in NW-SE, while some some others N-S, there is also field occurrences of veins some filled with quartzites, joints open and healed, fractures and exfoliation features are present in the granites. The area is part of the southwestern part of Igarra town, granites can be located on the eastern and western parts of schist belts [1]. The geology of the area have received attention of workers such as [8,9,10 11,12].

The Igarra schist belt consists of Precambrian Basement Complex rocks. The migmatite- gneiss complex, the meta-sediments, migmatitic schists, calc-silicaterocks, quartzites, marbles, metaconglomerates; and the porphyritic older granite which are discordant and association with non-metamorphosed syenite dyke (Fig. 1).

Fig. 2, is the field photograph of marble at Igue Oke, while Fig. 3 is geological map of the Igue Oke area showing large deposits of granitoids to the western parts of Ikpeshi, which traverses northwards to Ojukutu area and eastern side to Iyuku and its environs.

Fig. 2. Field photograph of marble at Igue Oke

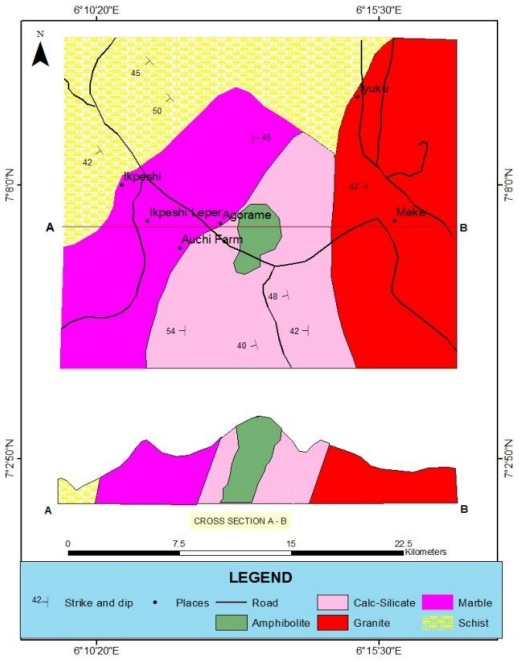

Fig. 3. Geological map of Igue Oke area [9]

2. METHODOLOGY

Field and laboratory methods were used for the study. The traverses include streams and river channels, mining pits and outcrop of the rocks exposed to the ground surface. The petrographic analysis included field description of the rock samples macroscopic features: Colour, texture, structure field relationship and laboratory

description of the microscopic features such as mineralogy. Measured parameters strike, dip amounts and directions were plotted on rose diagrams and stereonets for stress determination.

3. RESULTS AND DISCUSSION

3.1 Petrography

The rocks at Igue Oke area are marbles, calc silicate rocks and amphibolites; Agor market area are meta-conglomerates, quartzites and schists; at Ojukutu is porphyritic biotite granite while the Ikpeshi rocks are marbles, schists, amphibolites, dolerites and granites. Some of the granites in the area has dome-shaped structures while others do not. The minerals are colourless, white and/or flesh pink coloured phenocrysts of quartz, plagioclase and orthoclase respectively. The rocks are well exposed on the ground surface. The exposure is about seventy five percent at Iyuku, fourty five percent at Ojukutu and twenty percent at Ikpeshi. In comparison with the Igarra Town granitic rocks they are dome-shaped intrudes migmatitic schists and rarely meta-conglomerates, marbles and calc-silicate rocks. Unlike the Igarra granite which are dark-coloured and over 526 m high they are about 168 m high and light-coloured with very large phenocrysts of quartz and feldspar 2-6 cm.

3.2 Metamorphic Rocks

The schists are dark coloured highly deformed, metamorphosed and foliated. Some are banded while others are homogeneous rock unit with veins of quartzite particularly in the south at the boundary between sedimentary and basement rocks contact. They can be easily identified along drainage channels were the superficial deposits have been removed. The schist at Agor market area were metamorphosed with meta-conglomerates and quartzites. The pebbles of in the meta-conglomerates are stretch in N-S direction. They have varieties, trend depends on the degree of deformation, metamorphism and magmatism. The minerals are particularly lamellar and elongated with prismatic habit, such as micas and hornblende and also schistocity is also present. Fig. 4a is a field photograph showing a vein of faulted quartzite in schist near the sedimentary/basement contact.

4.3 Amphibolites

Amphibolites are present at Ikpeshi and Igue Oke areas rocks. They can be easily observed in river channels and consists mainly amphibole and plagioclase with crystalloblastic texture. Some of the amphibolites grades into hornblende-plagioclase gneiss with addition of quartz. Amphibolites were associated with dolerite dyke at Oyami river area Fig. 5.

4.4 Marble and Calc-silicate Rocks

Marble deposits are present at eastern and western parts of Igue Oke Town and several other locations around Ikpeshi. They are being mined by several small-scale miners for industrial minerals and rocks. Calc-silicate rocks are derived from either quartz bearing dolomites and limestones or from carbonate rock metamorphosed by siliceous solutions from abutting granitic intrusions. The former is probably the case in the study area. The photomicrograph indicates 63% of calcite, 12% of quartz, accessories 10% and opaque minerals 3% (Figs. 6 and 7) and Table 1.

Fig. 4a. Field photograph showing quartzites vein faulted in schist see hammer head

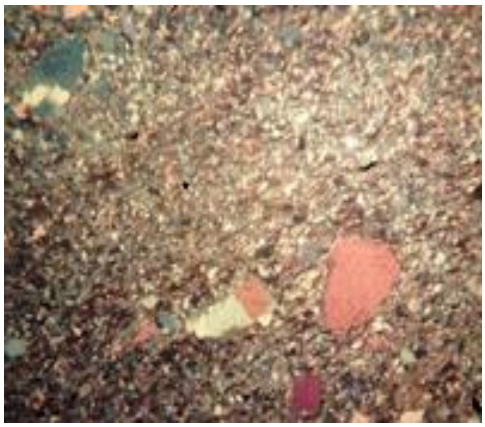

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Fig. 4b. Photomicrograph of showing mica-biotite, quartz, and feldspars

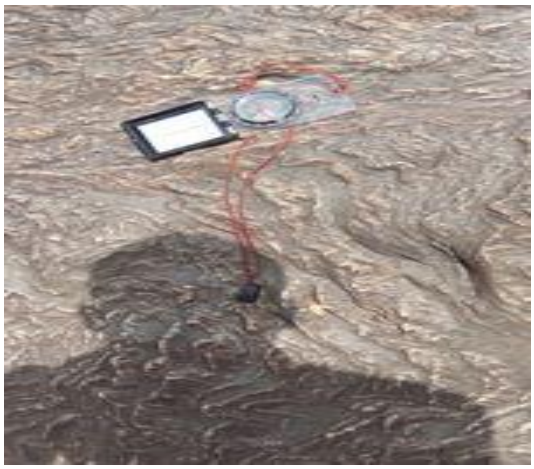

Fig. 5a. Field photograph showing amphibolites at Ikpeshi

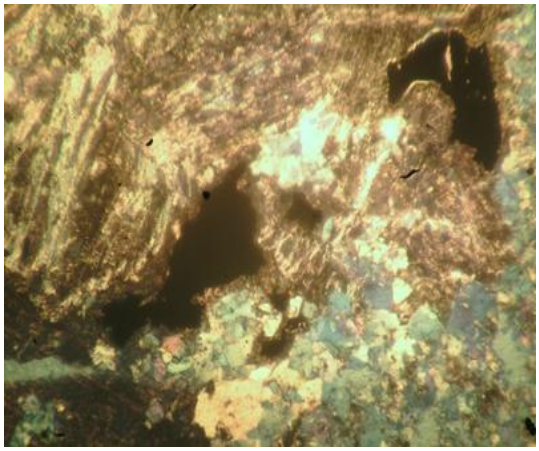

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Fig. 5b. Photomicrograph showing amphibole and plagioclase prefered minerals orientation and opaque minerals

Fig. 6a. Field photograph showing small-scale marble mining pit at Igue Oke

Fig. 6b. Field photograph showing a 5 m hole drilled before blasting at Igue

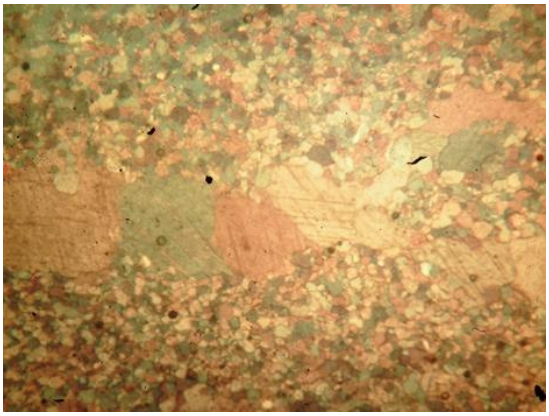

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Fig. 6c. Photomicrograph showing major minerals calcite with high average modal percentage of 65%

4.5 Igneous Rocks

The granites are plutonic igneous rocks composed of quartz, feldspars and biotite/hornblende. Large exposures can be observed in the extreme eastern part, and also reasonable exposure are present in the western and southern parts of the study area (Figs. 8 and 9).

4.6 Structural Characteristics

4.6.1 Planar Structures

The geometrical relationship between the fabric of the rocks were studied for major and minor geological structural features which help to determine the deformational history of the rocks in the field and laboratory. The amphibolites at

Ikpeshi area and its environs have varieties of beautiful structural styles. In comparison with all the rock types, the granites have the least of these structures, since they are unmetamorphosed rock types. More than one deformation, metamorphism and magmatism have after the rocks to various degrees. This is evident in the presence of multiple deformational features which are sometimes superimposed on others such as foliations, fractures and different types of folds.

Fig. 7a. Field photograph marble and calc-silicate truncated with a fault in NE-SW at Igue Oke

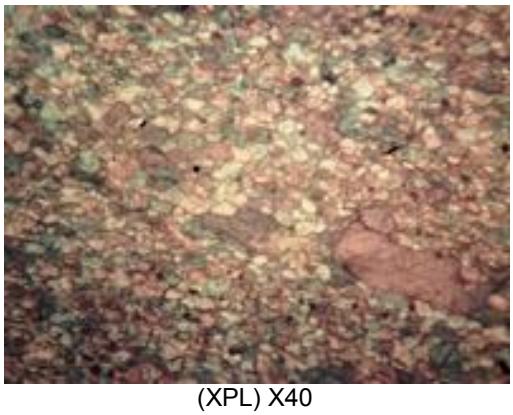

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Fig. 7b. Photomicrograph of calc-silicate showwing garnet, plagioclase and epidote

Fig. 8a. Field photograph showing biotite granite with open joints, very important for drilling and blasting for aggregates and dimension stone at Iyuku.

Fig. 8b. Field photograph showing biotite granite with exfoliation surface at Iyuku.

Fig. 8c. Field photograph of Ikpeshi granite

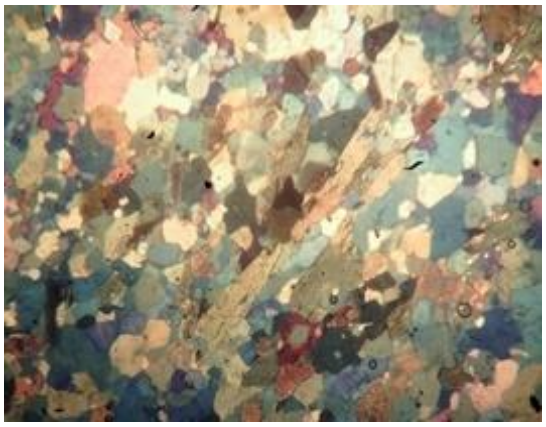

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Fig. 8d. Photomicrograph showing major minerals, quartz, K-feldspar and biotite

Fig. 9a. Field photograph showing Ojukutu porphyritic biotite granite

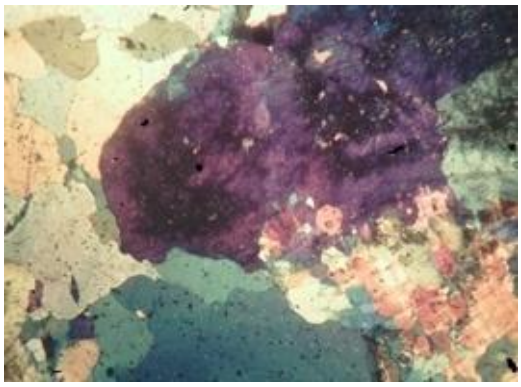

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Fig. 9b. Photomicrograph showing quartz, microcline feldspar, biotite and plagioclase with perthitic features

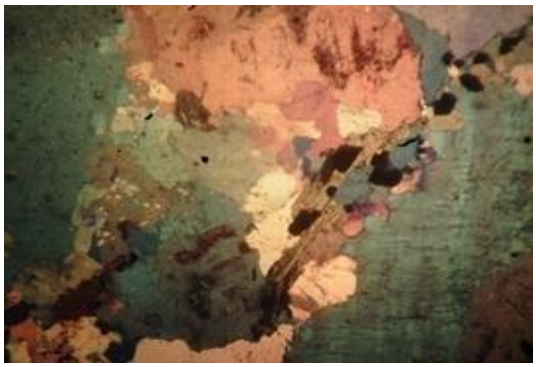

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Fig. 9c. Photomicrograph showing quartz, orthoclase K-feldspar, biotite, accessories opaque minerals

Table 1. Average modal composition of minerals from the rocks from the area in percentage (%)

Minerals	Rock samples						
	Schist Ikpeshi	Amphibolites Ikpeshi	Calc-silicate Igue Oke	Marble Ikpeshi	Marble Igue Oke	Granite Iyuku	Granite Ojukutu
Quartz	23	22	12	2	5	36	38
K-feldspar	15	-	-	-	-	30	25
Plagioclase	20	-	-	-	-	10	15
Biotite	8	-	-	-	-	7	10
Muscovite	10	-	-	-	-	4	-
Hornblende	4	60	-	-	-	-	-
Alumina	8	10	-		-	-	-
Calcite	-	-	63	65	75	-	-
Dolomite	-	-		9	5	-	-
Serpentine	-	-	12	-	-	-	-
Garnet	-	-		-	-	-	-
Pyroxene	-	-		-	-	-	trace
Accessory minerals	7	-	10	20	9	8	9
Opaque minerals	6	8	3	4	6	4	3

The structural characteristics of rocks varies, some are exposed to the ground surface others are below less than one meter. However, major direction is in the NNW-SSE. The superficial deposits cover of meta-sediments in places, which the older granites (Pan-African) granites intruded are very thin. There are some fold types present in the area, chevron, kink bands, conjugate pair, similar, box and recumbent folds which were due to the extensional ductile deformational episodes of rocks in the area (Figs. 5, 10 and 11). The folds (F1) are associated with close 30° to isoclinals 10°, and the dip direction is consistent towards the north at Ikpeshi while Igue Oke area is towards the east.

Fig. 10. Field photograph showing similar folds type of fold at Oyami river

Fig. 11. Field photograph showing chevron folds at Oyami River

4.6.2 Linear Structures

Lineament features in the area is thought to be a reflection of crustal structure like fault lines, straight river channels and fold axes. The major ones are NNW-SSE direction other small-scale structures are variable. Minerals stretching resulted in the preferred alignment of quartz, feldspar and mica is present in the study area (Fig. 12).

Field analysis of all the measurements, planar and linear were made. They are displayed as statistical features on rose diagrams and stereonets and are indicated on Figs. 13 – 17 and Figs. 18 and 19.

Some fold types were identified and measured. The measurements made for the folds are left limb (LL), fold axis (FA), and right limb (RL), displayed as rose diagrams on Figs. 15-17.

Fig. 12. Field photograph showing stretching and preferred alignment of platy minerals of schist

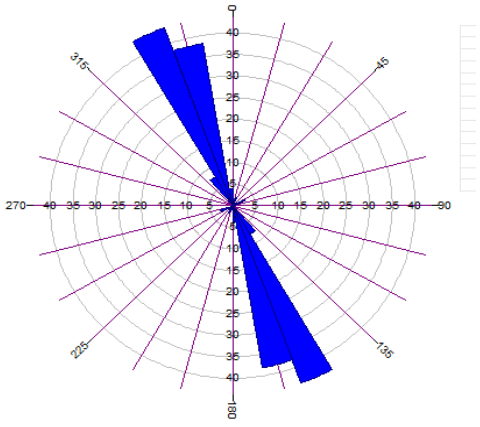

Fig. 13. Rose diagram showing mineral lineations major NNW-SSE trend (n=105).

4.7 Discussion

The rocks, based on the information obtained from petrography, field relationships, rose

diagrams and stereonets are economical. The structural characteristics of the small-scale geological features shows multidirectional orientations [10,11,12,13]. The schistose rocks opposite the granitic rocks have sharp contact and in some cases xenoliths where piecemeal stoping have occurred. The granites at Ojukutu and Ikpeshi close to the sedimentary and meta-conglomerates at Agor (Fig. 20) are very coarse grained and when compared with Iyuku and Igarra Town granites. This may be probably adequate time for the cooling of the rocks to form good crystals. However, the sharp contact between schists and granites in many places is probably due to temperature and pressure similarity at the time of cooling. Quartzite veins are present in the schists while quartz veins were identified in the granitic rocks. Pegmatites and aplite veins were not identified on the rocks.

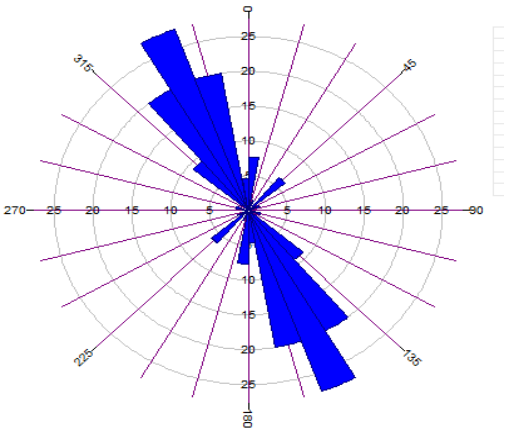

Fig. 14. Rose diagram showing mineral lineation minor NE-SW and NW-SE major (n=120)

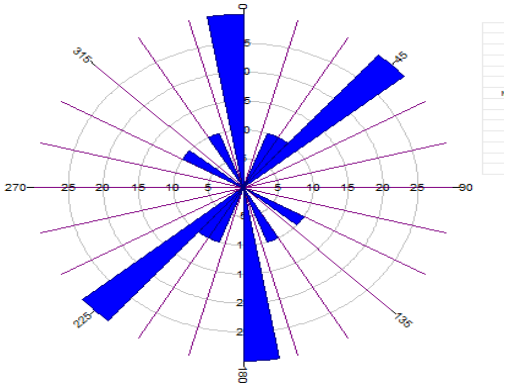

Fig. 15. Rose diagram showing fold left limb (LL) with predominant NNW-SSE and NE-SW and minor NW-SE (n=150)

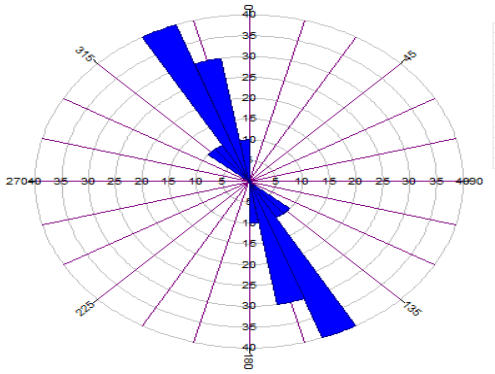

Fig. 16. Rose diagram showing fold axis (FA) NW-SE trend (n=130).

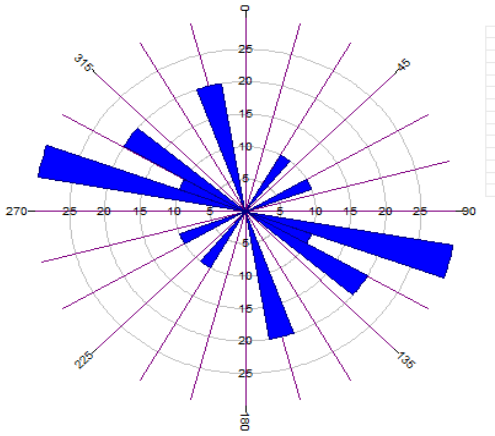

Fig. 17. Rose diagram of fold right limb (RL) strike NW-SE and minor NE-SW trend (n=170)

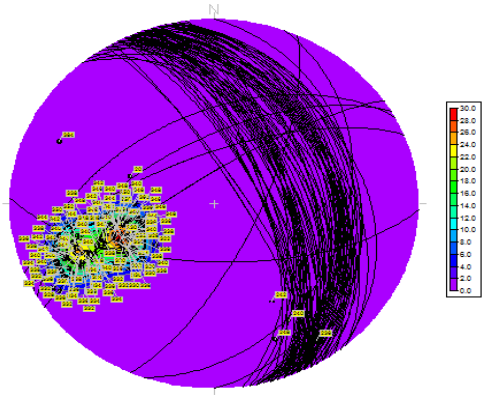

Fig. 18. Stereonet with strike and dip amounts showing the hotspot in the SW.

These small scale geological structures observed are important in exploration and exploitation of the rocks for engineering of good pavements [14].

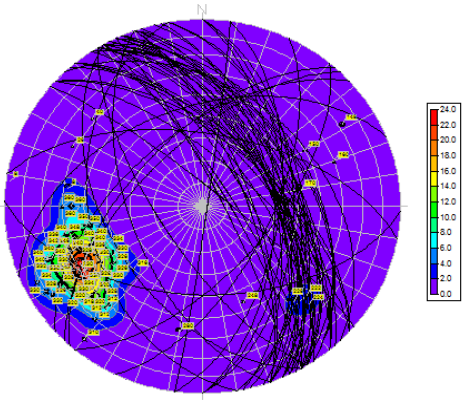

Fig. 19. Stereonet of strike and dip amounts of foliations at the second location showing the hotspot in the SW

Fig. 20. Field photograph of meta-conglomerates with minerals in N-S direction at (Sebe Ogbe) Agor area

The production of dimension stone which are stone cut or quarried in accordance with specific dimensions has huge potentials in the area [15]; [16] observed that a typical semi-mechanized marble quarry site at Igue Oke produces about 300 metric tons of high quality unprocessed dimension stone at N 2, 500 per ton. It will equally generate huge employment opportunities if fully mechanized with more near surface Geophysical prospecting procedures. However, mineral exploration at depth of 500 m+ is challenging. In recent time, more sensitive exploration technologies for direct deposit targeting are coming up for example EU (Smart Exploration), Canada (Metal Earth), Australia (CRC Projects) and Africa [17].

5. CONCLUSION

The rock types presently of more economic importance in the area are, marbles which are being quarried on small-scale and semi large-scale at Igue Oke and Ikpeshi areas while granite are being quarried in a large-scale at Ojukutu and Iyuku areas for agregates. Small-scale and large-scale structures observed are as result of more than one orogeny in the area. The Pan-African which is the last and longest orogeny did not completely erased all the earlier structures, we observed with the intrusion of granite plutons relicts of older structures. The very coarse grained forms are the porphyritic granites of Ojukutu and Ikpeshi while Igarra Town and Iyuku areas granites are coarse grained.

The NW-SE and N-S trends predominates minor E-W and NE-SW directional trends are also present. There is a huge potentials for dimension stone production in the area. In Nigeria, this observation should not be truncated by interests in importation of poor quality finished and synthetic products from Asia, Europe and America.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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