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Petrostructural and Mineralogical Assessment of the Precambrian Rocks in Ikere Area, Southwestern Nigeria

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Abstract

Petrological and mineralogical evaluation of the basement rocks in Ikere Ekiti, southwestern Nigeria was carried out with the aim of determining the petrological characteristics and mineral composition of the various rock units dominating the study area in an attempt to unravel the pattern of deformation on the rocks. The method of investigation includes systematic geologic mapping to determine the underlying rock units, petrographic studies of the thin sections using light transmitting Petrological Microscope and; analysis and interpretation of the structural elements inherent in the rocks using rosette diagrams. Seventeen (17) rock samples were collected on the field out of which ten (10) fresh rock samples were selected and prepared for thin section studies using standard procedures. Geologic mapping of the studied area revealed that the rocks occured as plutons (older granite) while the charnockites and granites occur as pegmatitic intrusions into the older rock sequence. The granites and charnockites were extensively dissected by a network of intersecting or crosscutting quartzo-feldspathic stringers or veins/veinlets of various widths and dykes, which is an indication of the relevant post-tectonic deformation episodes and deuteric alteration in the evolutionary history of the rocks. Also, the rocks are rich in quartz and feldspar with significant amounts of heavy minerals such as zircon, tantalite, tourmaline, heamatite, topaz and opaque minerals such as casiterite, chalcopyrite, sulphide and pyrrhotite.

Keywords: Rock units, Petrography, Rosette diagram, Photomicrographs, Minerals, Structures.

Contents

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1. Introduction

The basement complex of southwestern Nigeria lies within the reactivated part of the Pan-African mobile belt between the West African and Congo Cratons [1, 2]. The basement complex is believed to have evolved as a result of at least four major orogenic cycles of deformation, metamorphism and remobilization corresponding to the Liberian (2,700Ma), Eburnean (2000Ma), Kibaran (1,100Ma) and the Pan-African cycle (600Ma). The first three cycles were characterized by intense deformation and isoclinal folding accompanied regional metamorphism, migmatization and extensive granitization and gneissification which produced syntectonic granites and homogeneous gneisses [3]. The lithologies in the studied area are highly weathered making it difficult to identify minerals and possible geologic structures that could be used to determine the geologic history as well as collection of fresh rock samples.

Several geoscientists have worked in the study area and similar areas, some of which are; Rahaman [4], Grant [5], Anifowose and Borode [6] amongst others giving account of the geology of the area. Anifowose, et al. [7] noted that joints ranging from minor to larger ones are found in all the rock types. Some of them are filled with quartz, feldspar, or a combination of both. They lie generally in the NW-SE direction with minor variation in NNE-SSW and NE-SW direction, while Boesse and Ocan [8] reported that the basement complex of south western Nigeria has been affected by three phases of deformation namely D_1, D_2, D_3. The first phase D_1 produced tight to isoclinal folds, followed by the second phase D_2 which is characterized by more open folds of variable styles and large vertical NNE-SSN trending faults. Okunlola and Jimba [9] carried out petrographic and geochemical evaluation of pegmatite bodies around Aramoko, Ara and Ijero area and concluded that majority of the samples are lepidolite sub class while some pegmatite bodies may have undergone mild post magmatic alteration, especially those outcropping around Ijero area. Caby and Boesse [10] have also indicated the presence of nappes from shallow dips of foliations, shear zones, low angle thrusts and associated recumbent folds in the Ife-Ilesha area. Oyinloye [11] also worked on the geology and geochemistry of banded and granite gneisses in Ilesha area and concluded that the elements used to discriminate between tectonic settings for volcanic rocks are vulnerable to metamorphic alteration.
However, this study attempts to carry out petrographic and mineralogical studies of the various rock units through thin sections, using the Research Petrological Microscope under transmitted light and assess the impact of tectonic deformation in the study area.

2. Location of the Study Area

The studied area is situated within Ikere and its environs. It is located between latitudes 7^0 00'N and 7º35N and longitudes 5º10'|E and 5º15'|E respectively covering a total area of 346.5km^2. The mapped area is generally accessible with network of footpaths linking parts of the towns and to the outcrops. The settlement pattern in the area is nucleated and the major occupation of the inhabitants are farming and hunting (Fig.1).

2.1. Local Geology of Ikere Ekiti

Ikere- Ekiti and its environs is dominated by crystalline rocks such as migmatite-gneiss-quartzite complex, older granites, charnockites, fine-medium grained granite. There is close association between the charnockitic rocks and non-charnockitic granitic rocks due to their field relations as explained in the geology of the basement complex rocks of Nigeria [12]; Rahaman [13]; [14, 15] and Hubbard [16]. The underlying rock units are as follows;

2.2. Migmatite-Gneiss-Quartzite Complex

The migmatite-gneiss-quartzite complex is the oldest of the rock types in Ikere-Ekiti. It occupies about 80% of the study area and appears to be undifferentiated in pattern within the area.

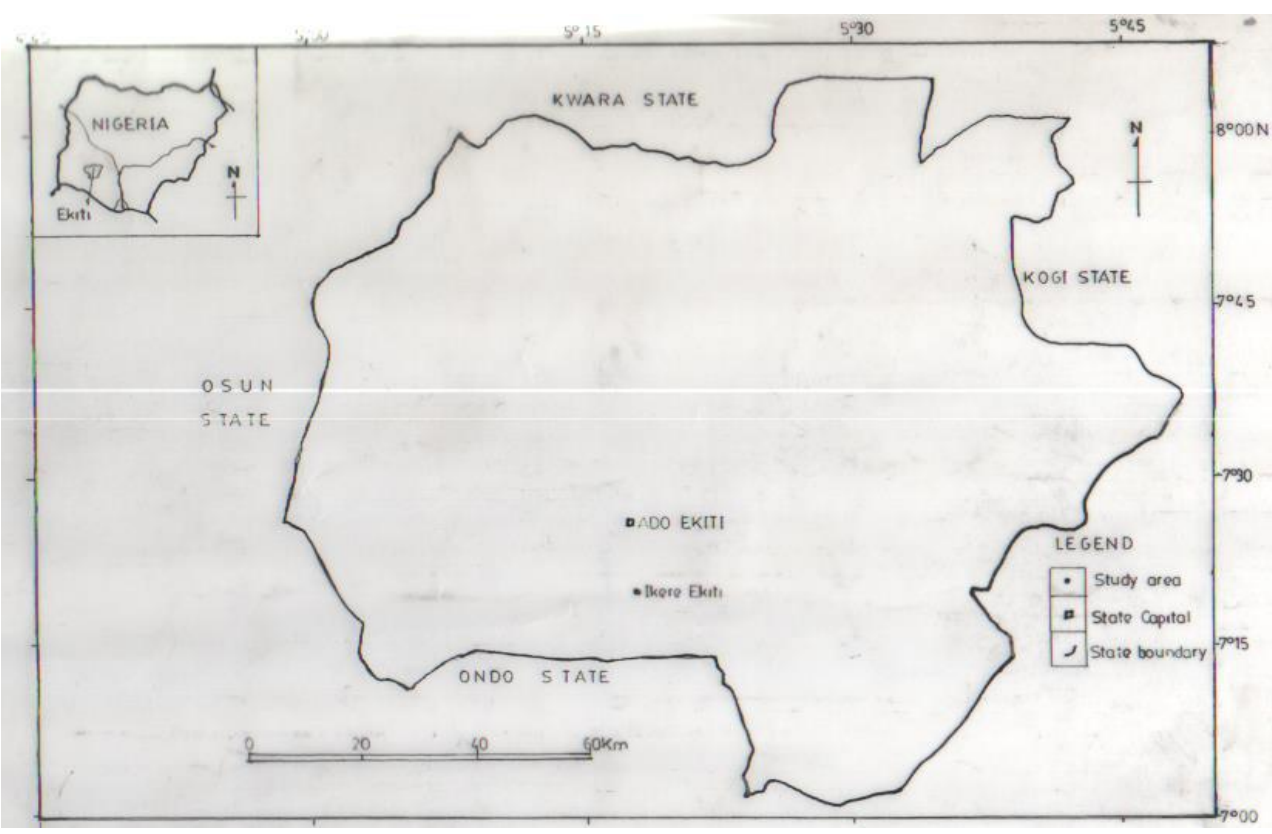

Fig-1. Map of Ekiti showing the Study Area.

It is characterized mostly by alternating light and dark coloured bands of minerals. The minerals are hornblende or biotite. According to Olarewaju [17], quartz and plagioclase feldspar constitutes large percentage of minerals in the migmatite while the gneiss is medium grained and strongly foliated. The quartzite occurs as ridges and range from massive to schistose types. The schistocity is as a result of the presence of flaky minerals such micas and chlorite. They have simple mineralogy with quartz occurring as one of the essential minerals in addition to biotite, mymakite and microcline feldspar in the rock.

3. Charnockites

Charnockites also abound in the study area. The geological map of the area produced by Olarewaju [12] revealed that the charnockites occupy more than 70% of the land mass of Ikere-Ekiti. The prominent outcrops are found around Ikere- Ise road, comprehensive high school, Afao, Temidire Ikere- Ekiti (Fig.2). The three main textural types of charnockites distinguished on the field conforms with Olarewaju [18] classification and are coarse grained porphyritic charnockite, fine-medium grained charnockite and fine grained charnockite. Most charnockite bodies in the basement complex of Ikere- Ekiti occur as low –lying outcrops in form of smooth elongated rounded boulders.

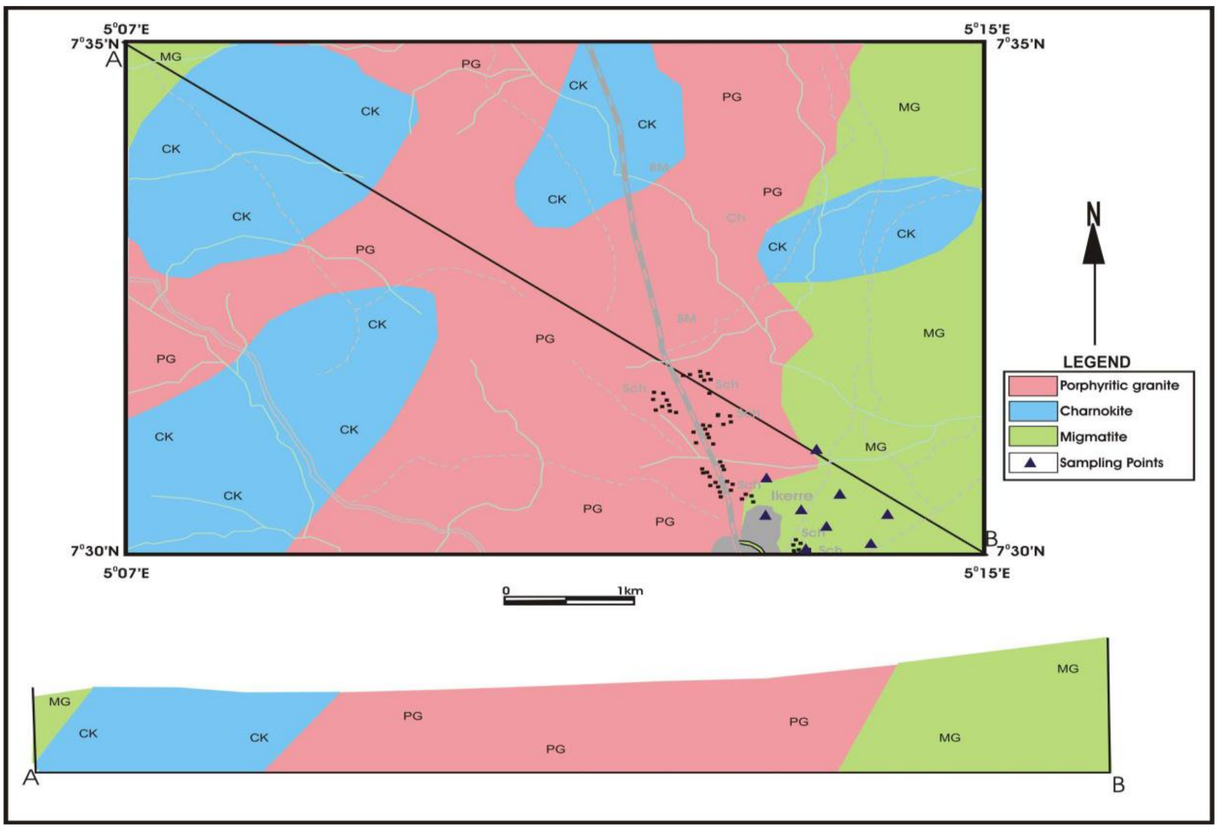

Fig-2. Geological and cross-sectional map of the study area

3.1. Method of Study

The method adopted for this research includes field examination of the rocks and structures; and laboratory preparation of the rocks for thin sections. Grid sampling method with the aid of base map of the study area, and at a scale of 1:50,000 was adopted, coupled with the use of Global positioning system (GPS) for accurate geographical location of the various localities, and at a sampling density of one sample per 5 square km. Seventeen (17) rock samples were collected from the studied area, which were clearly labeled and put into sample bag to avoid mix up. The general trend, attitudes of the rocks were observed and measured using compass clinometer. Mega and micro structures such as folds, fractures, joints, veins and solution holes were also observed. All measurements were recorded in the field notebook and photographs of identified features on the outcrops such as joints, folds, fractures, xenoliths, solution cavities, tension gashes and foliations were taken. Also, the orientations of structures such as veins, fractures and joints were plotted and represented in rosette diagrams. Ten (10) fresh rock samples were selected from the bulk samples collected and were prepared for thin sectioning in other to identify the minerals embedded in the rocks using standard procedures of preparation. The slides were later mounted for microscopic studies using the Research Petrological Microscope.

4. Results

Table-1. Field Data

S/N	Location	GPS Reading	Rock type	Lithology	Texture	Structure
1	First Baptist Church Ise-Road	7029′53.55″N 5013′50.39″E	Metamorphic rock	Migmatite	Coarse grained	Foliation , Jointing fracture
2	Iroke-Ikere Equity	7029′54.68″ N 5014148.4511E	Igneous rock	porphytic granite	Medium grained	Fracture joints
3	Irokin, Ise-Road	7029′55.86″ N 5014′50.38″E	Igneous rock	Charnockite	Medium grained	Joint Fracture
						Continue

4	Temidire area	7029′55.08″ N 5014′48.02″E	Igneous rock	Granite	Coarse grained	Fracture, Cracks, Joints
5	Irokin, Ikere-Ekiti	7029′56.46″ N 5014′50.57″E	Igneous rock	Light-coloured granite	Fine grained	Veins, Joints, Cracks
6	Keepers Church Araromi	7029′59.03″ N 5014′52.21″E	Igneous rock	Granite	Coarse grained	Fault, Joints, Xenoliths
7	Araromi Area	7029′53.27″ N 5014′51.95″E	Igneous rock	Charnockite	Fine grained	Joints, Cleavages
8	State Specialist Hospital, Ise-Equity	7029ꞌ42.50 ʺ N 5015ꞌ15.64 ʺ E	Igneous rock	Granite	Medium grained	Joint, Fracture
9	Oke-Ikere	7029′50.15″ N 5013ꞌ38.85 ʺ E	Igneous rock	Charnockite	Medium grained	Xenolith, Dyke
10	Oke-Kajola	7030’18.395”N 5013’39.66 “ E	Igneous rock	Charnockite	Medium grained	Joints, Xenolith, Solution cavity
11	Oke-igbo Olobe	7030’18.30 “ N 5013’37.37 “ E	Igneous rock	Charnockite	Medium grained	Dyke, veins, Joint
12	Temidire Afao	7030’14.97 “ N 5013’35.96 “ E	Igneous rock	Charnockite	Medium grained	Dyke, vein, joint
13	Oke Igbogbeyin	7030’8.47 “ N 5013’40.81”E	Igneous rock	Charnockite	Medium grained	Dyke, solution cavity ,
14	Ijoka area	7029’33.81” N 5013’41.55 “ E	Igneous rock	Porphytic granite	Coarse grained	fracture, Joints

Table-2. Modal analysis of the rock samples

Minerals	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}
Quartz	58	56	70	54	60	63	68	74	65	68
Plagioclase	15	13	10	11	12	13	8		15	8
microcline			2	4	5					4
Myrmekite				4	5					
Biotite	23	25	4	15	12	19	20	26	20	8
orthoclase			5	5						3
Opaque	4	6	3	2		5	4			7
Hornblende			2	4	11				2	

Table-3. Description of Samples

S/N	Slide	Rock Name	Location
1	S_1	Charnockite	Araromi
2	S_2	Charnockite	Temidire Afao
3	S_3	Charnockite	Oke-kere
4	S_4	Pegmatite dyke	Oke-gbogbeyin
5	S_5	Porphyritic granite	Ijoka
6	S_6	Porphyritic granite	Araromi Ise-road
7	S_7	Fined-grained granite	State speacialist hospital
8	S_8	Coarsed-grained granite	Iroki-Ise road
9	S_9	Medium-grained granite	Ise-road
10	S_{10}	Fine-grained granite	Keepers church araromi

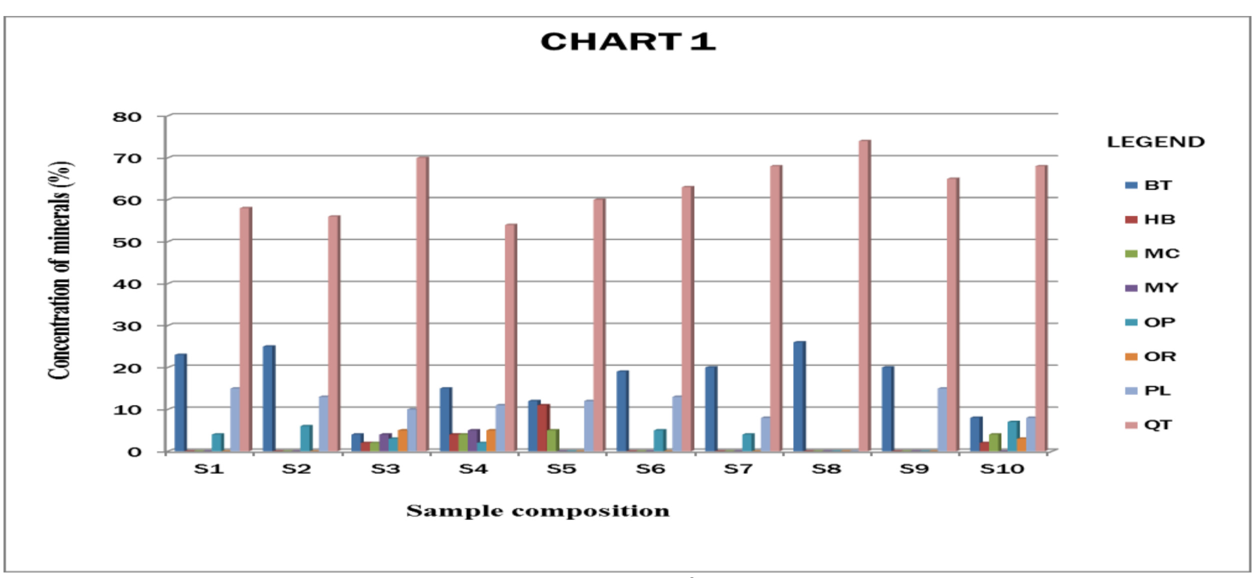

Fig-3. Chart showing (%) concentration of minerals in various samples.

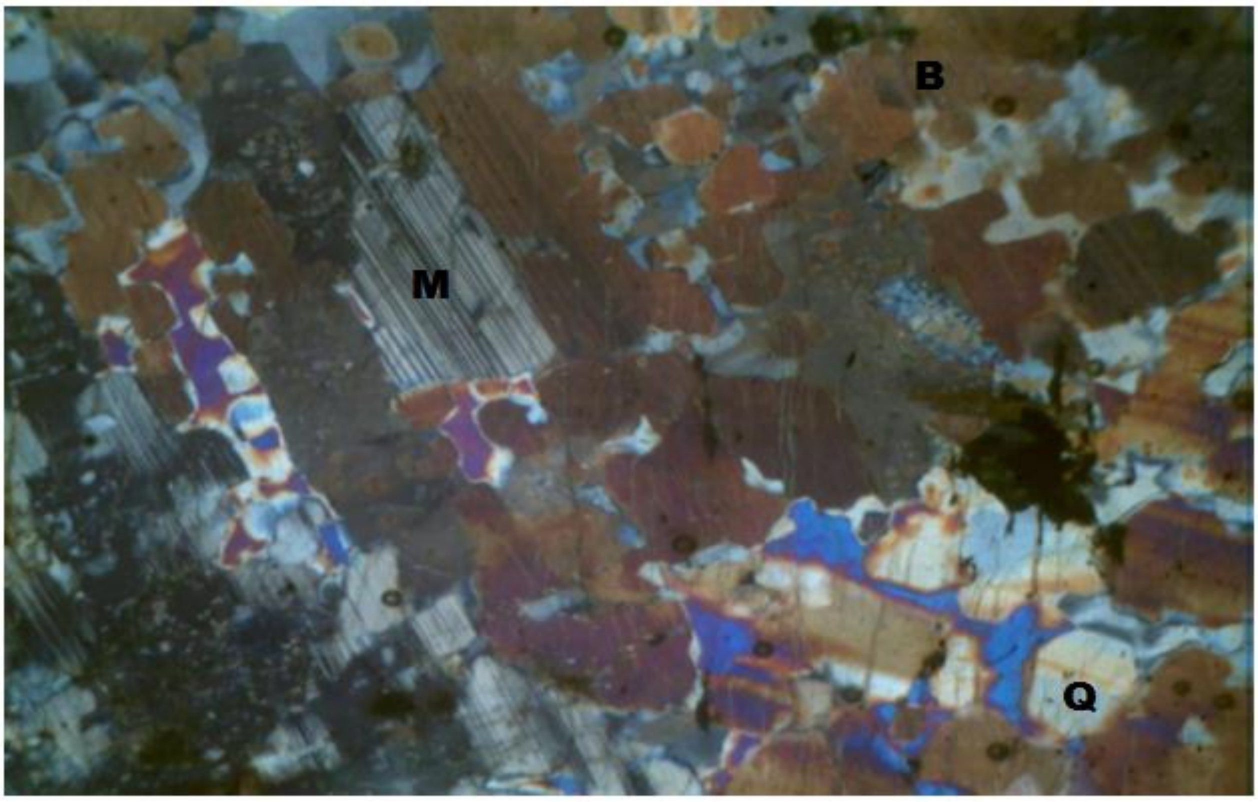

Fig-4a. Photomicrograph of medium grained granite slide under PPL X40

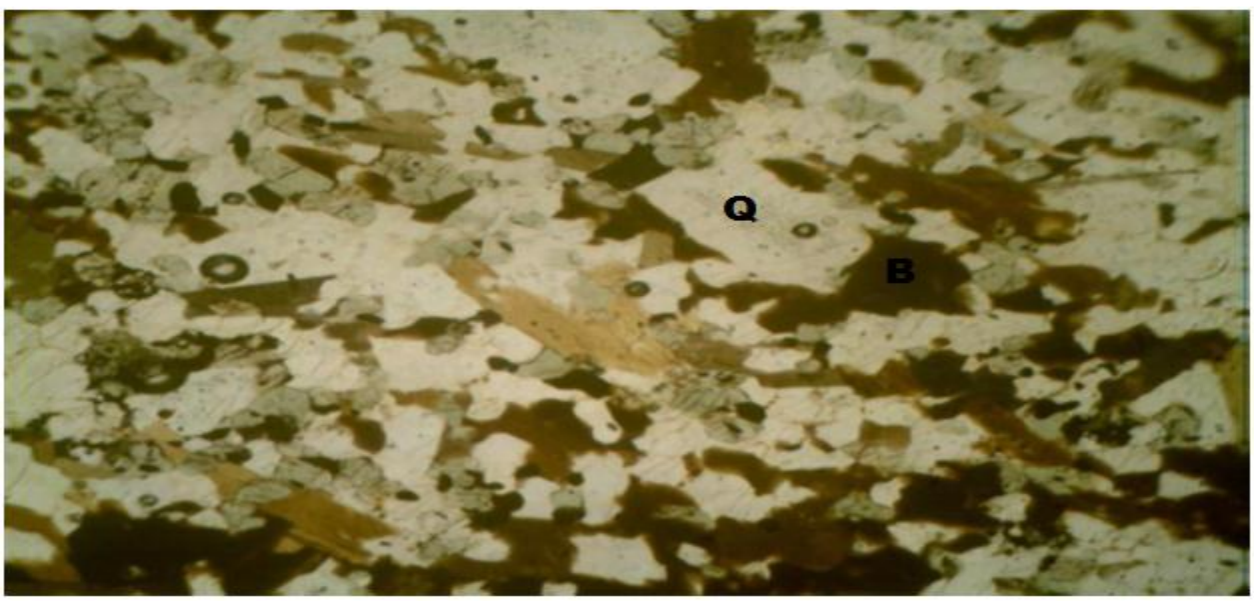

Fig-4b. Photomicrograph of medium grained granite slide under PPL X40

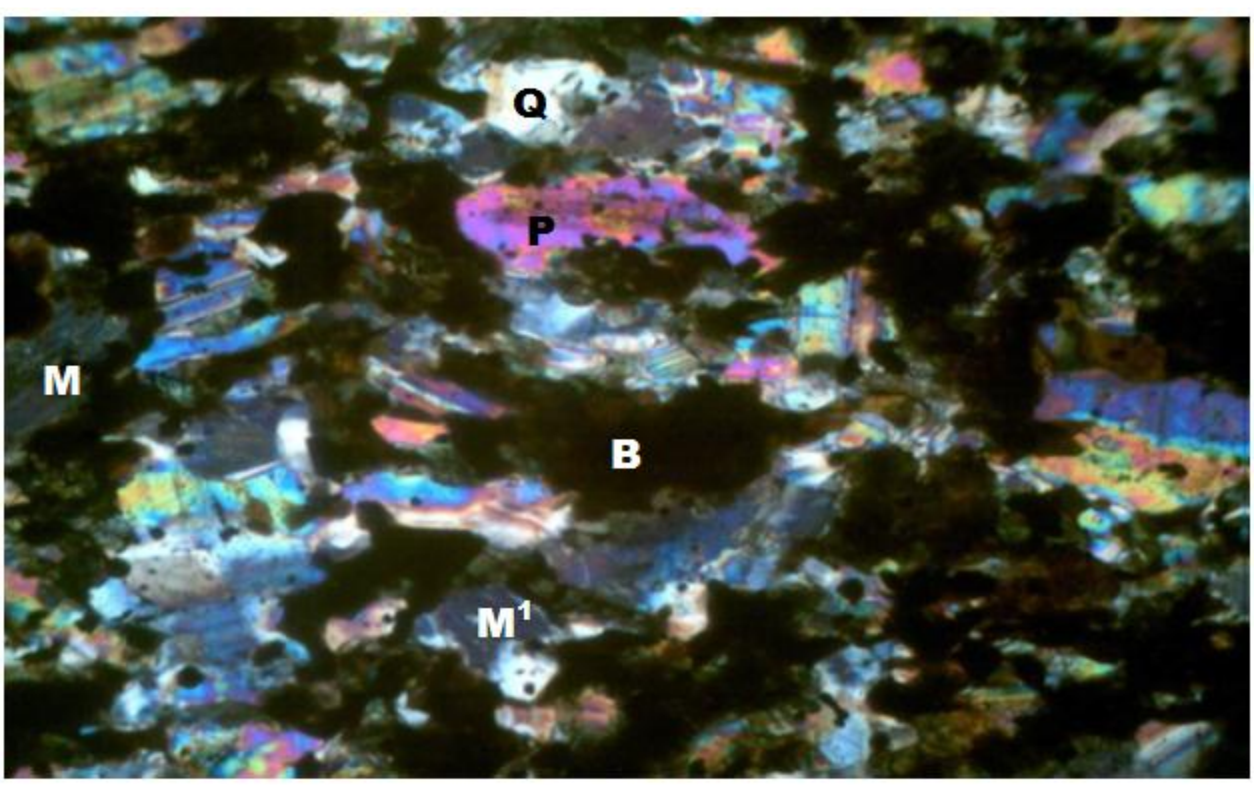

Fig-5a. Photomicrograph of fine grained granite slide under CNL X40

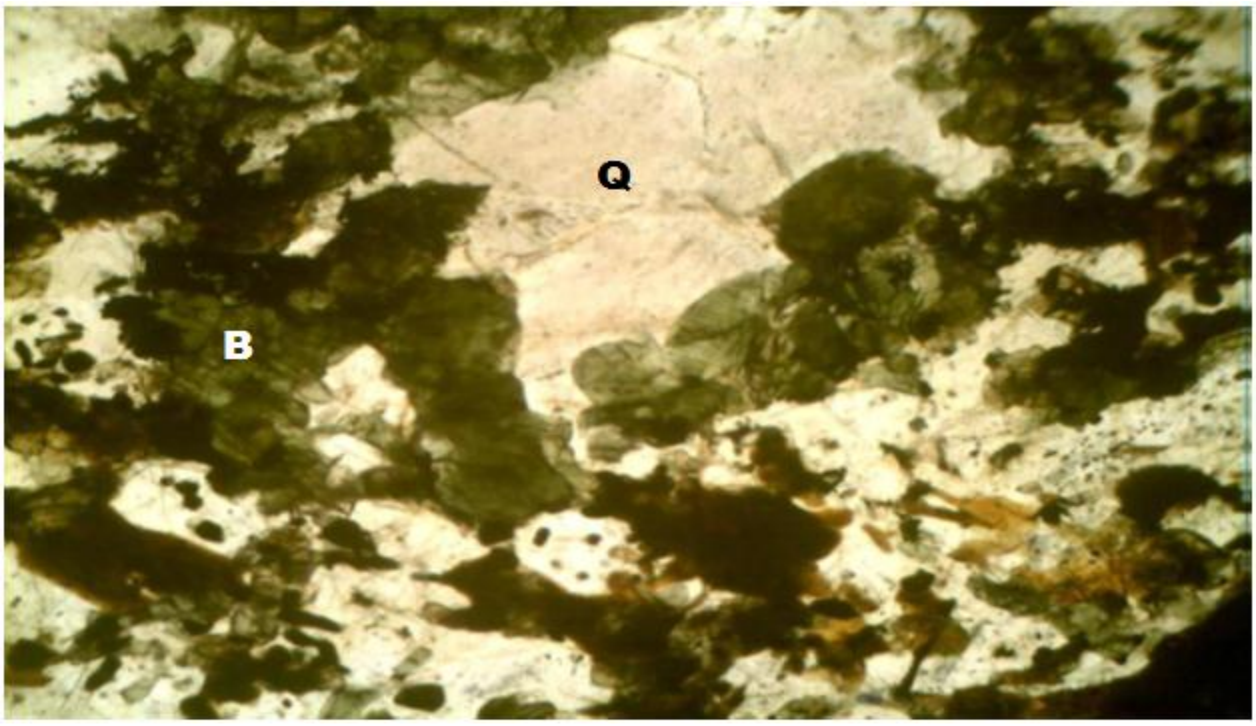

Fig-5b. Photomicrograph of fine grained granite slide under PPL X40

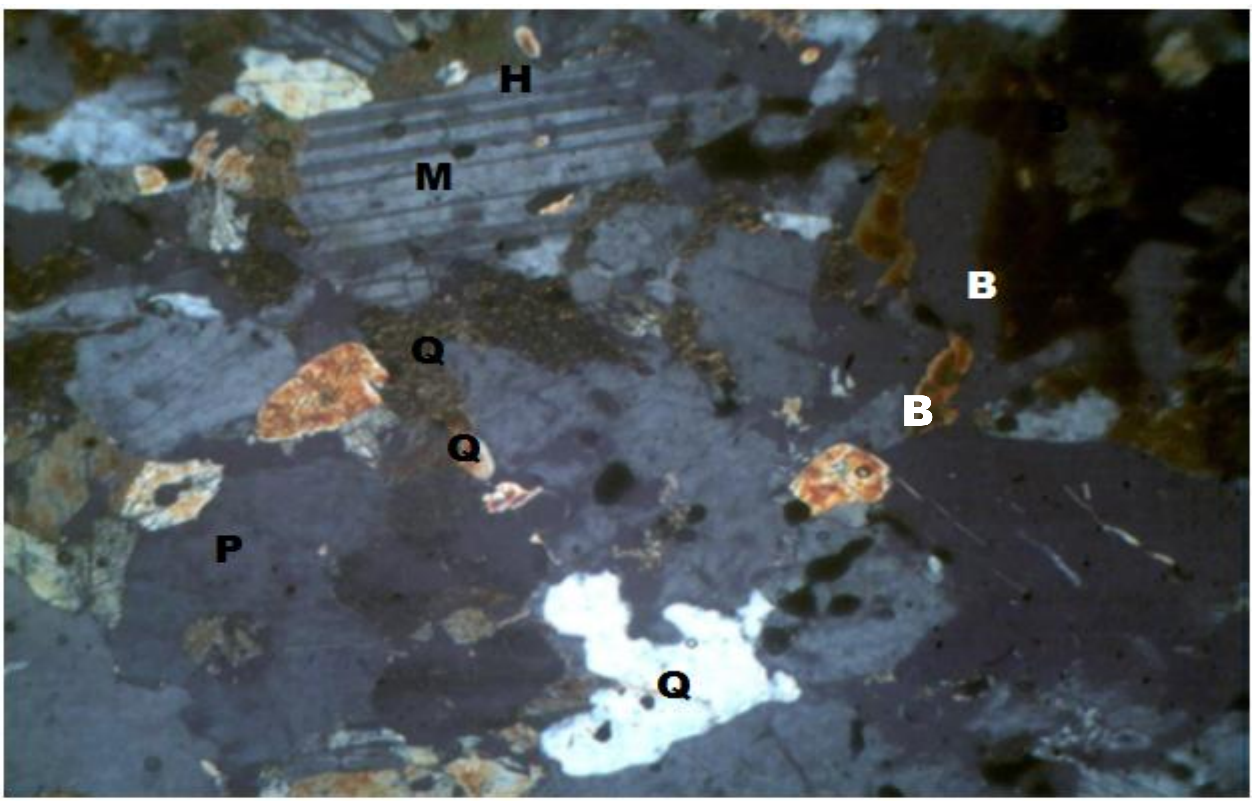

Fig-7a. Photomicrograph of porphyritic granite slide under CNL X40

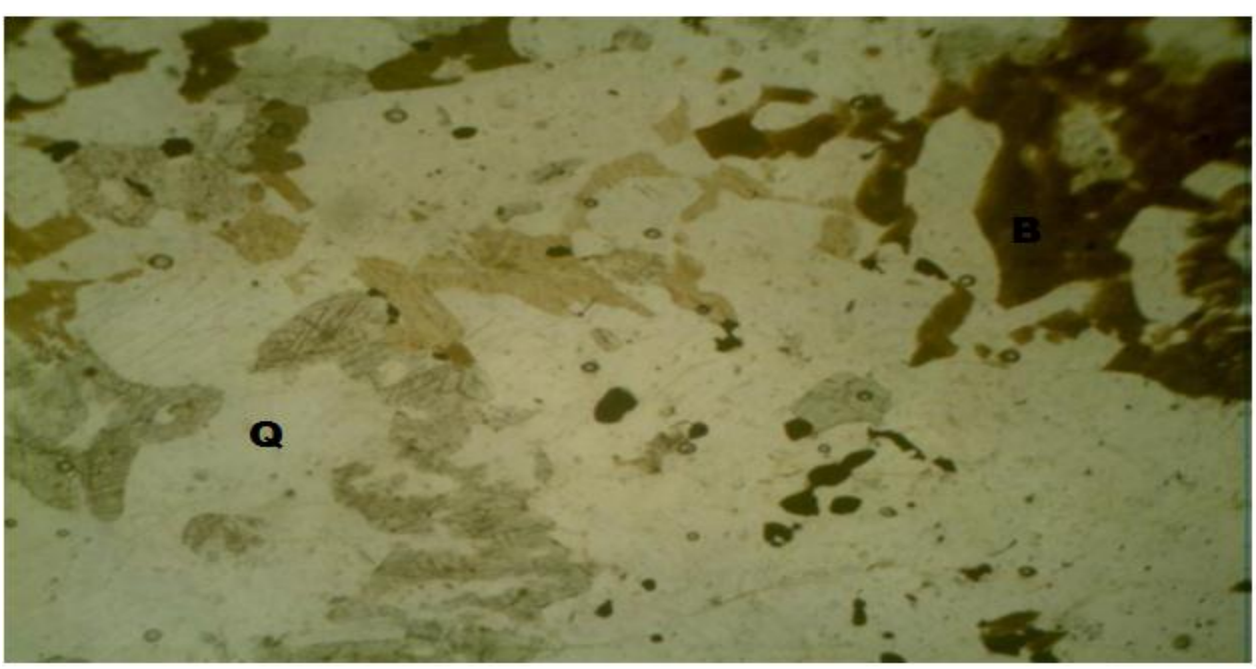

Fig-7b. Photomicrograph of porphyritic granite slide under PPL X40

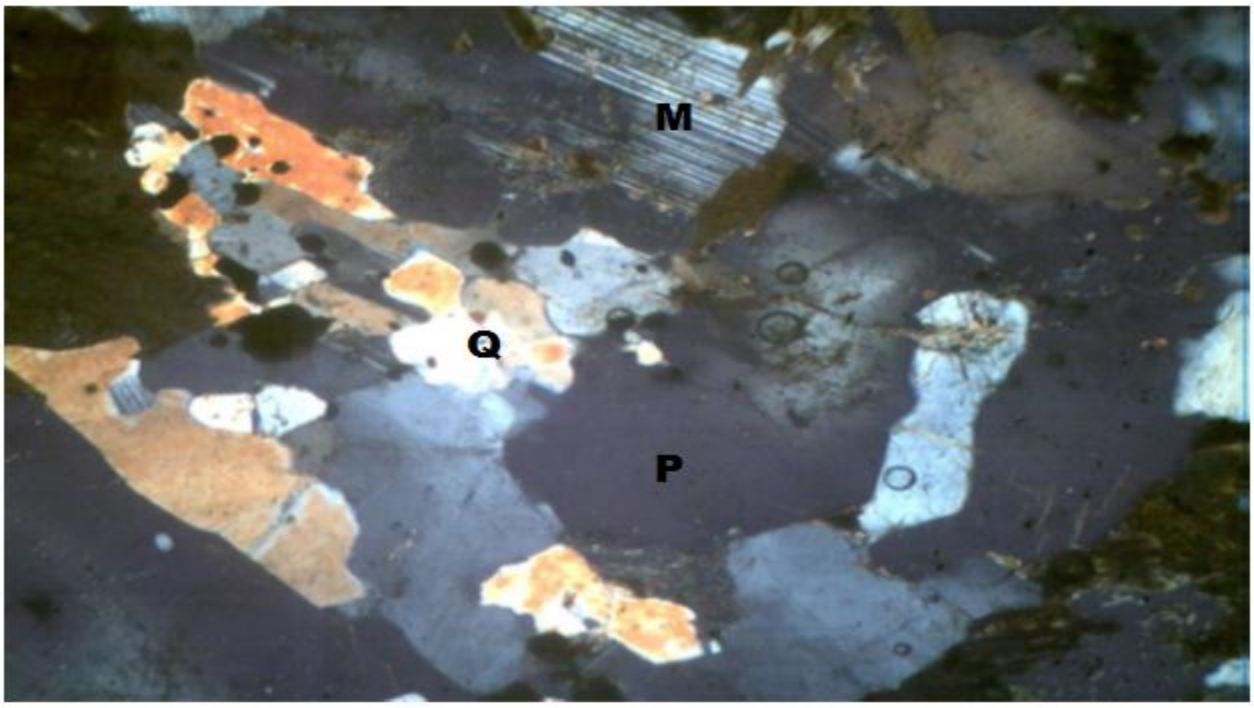

Fig-8a. Photomicrograph of porphyritic granite slide under CNL X40

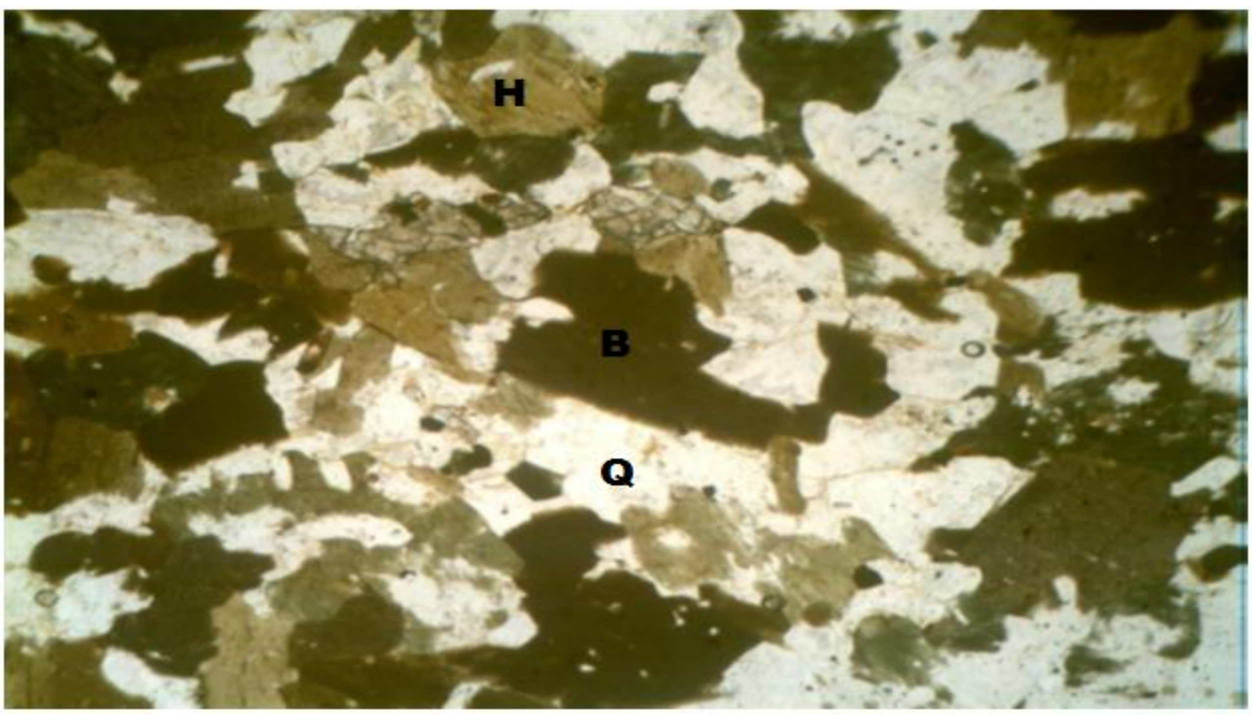

Fig-8b. Photomicrograph of porphyritic granite slide under PPL X40

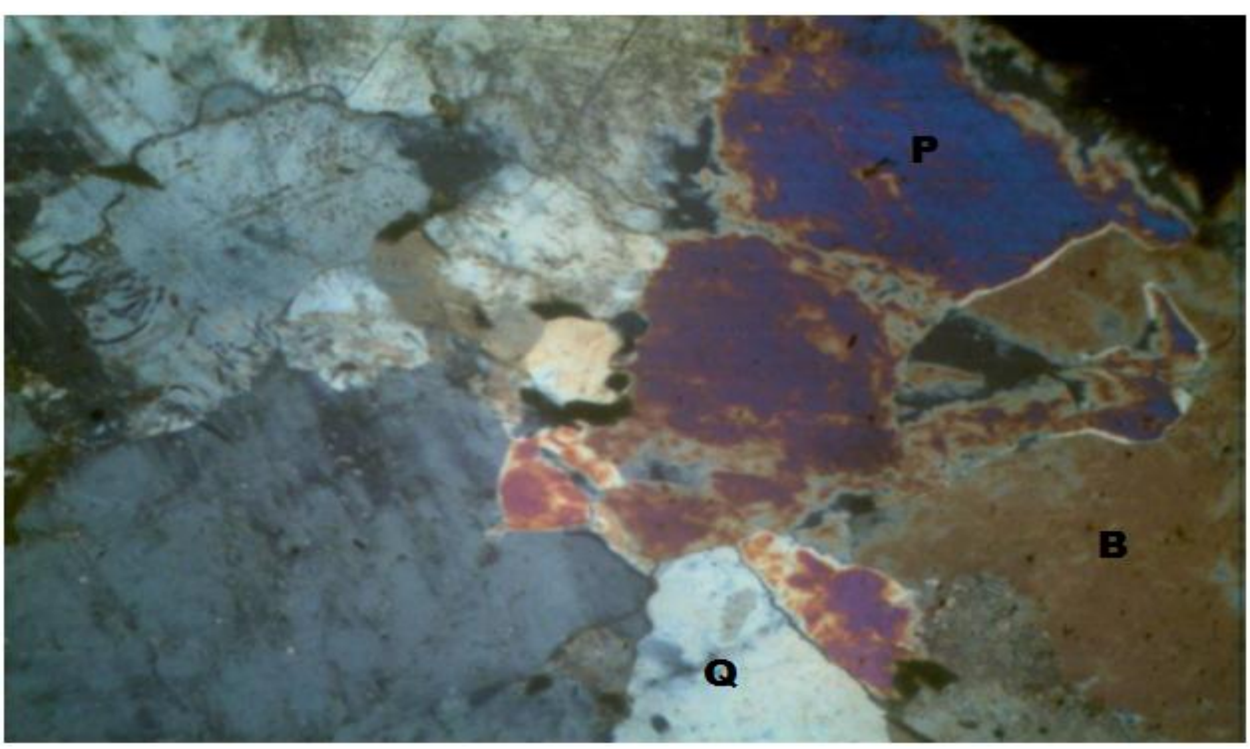

Fig-9a. Photomicrograph of charnockite slide under CNL X40

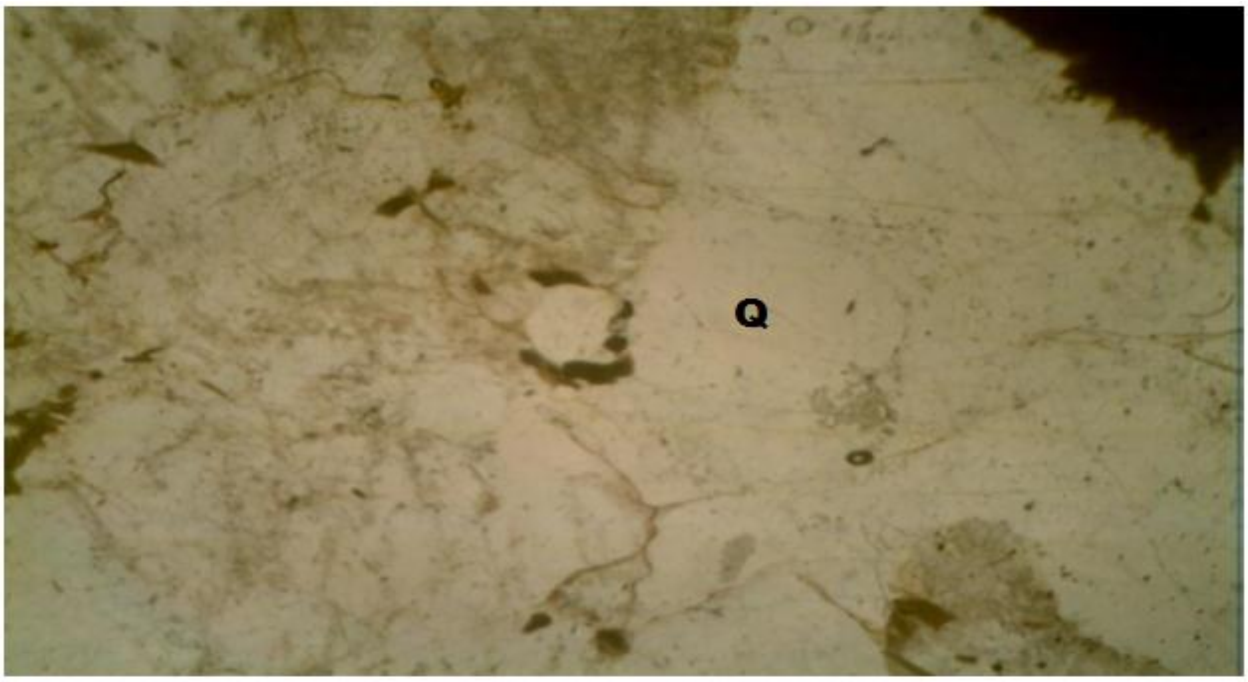

Fig-9b. Photomicrograph of Charnockite under PPL X40

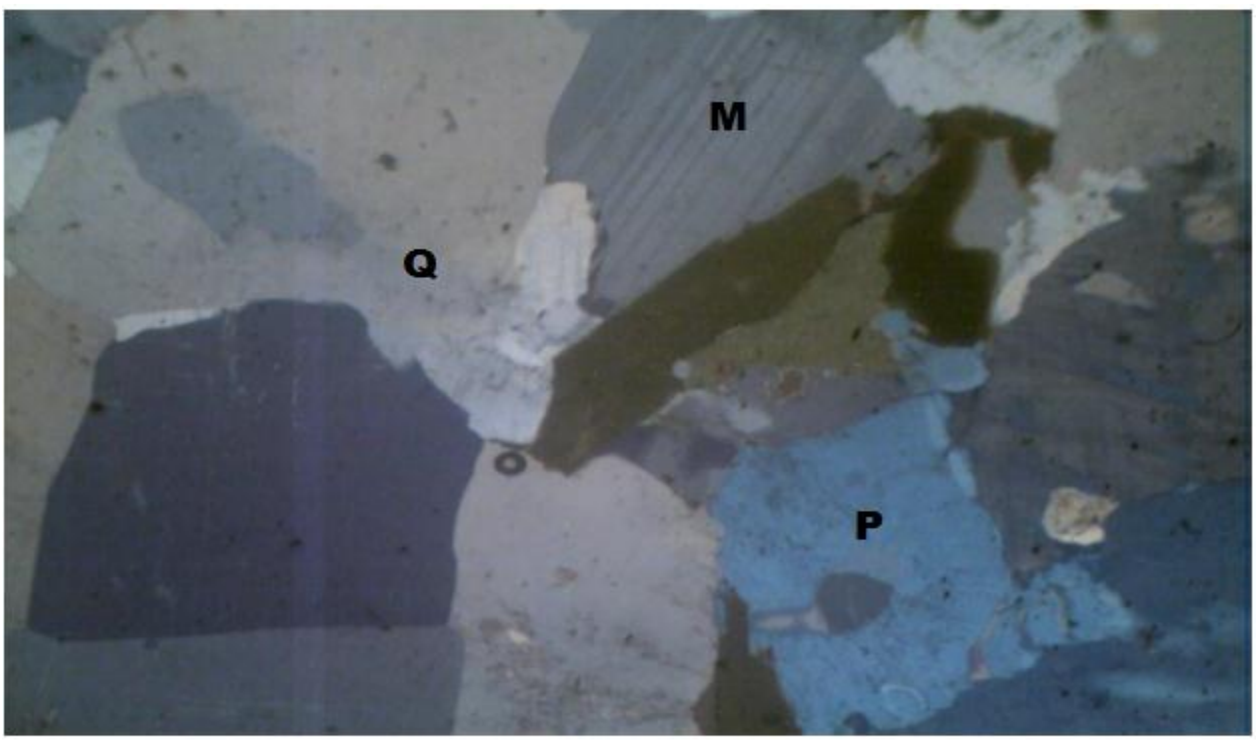

Fig-10a. Photomicrograph of Charnockite slide under CNL X40

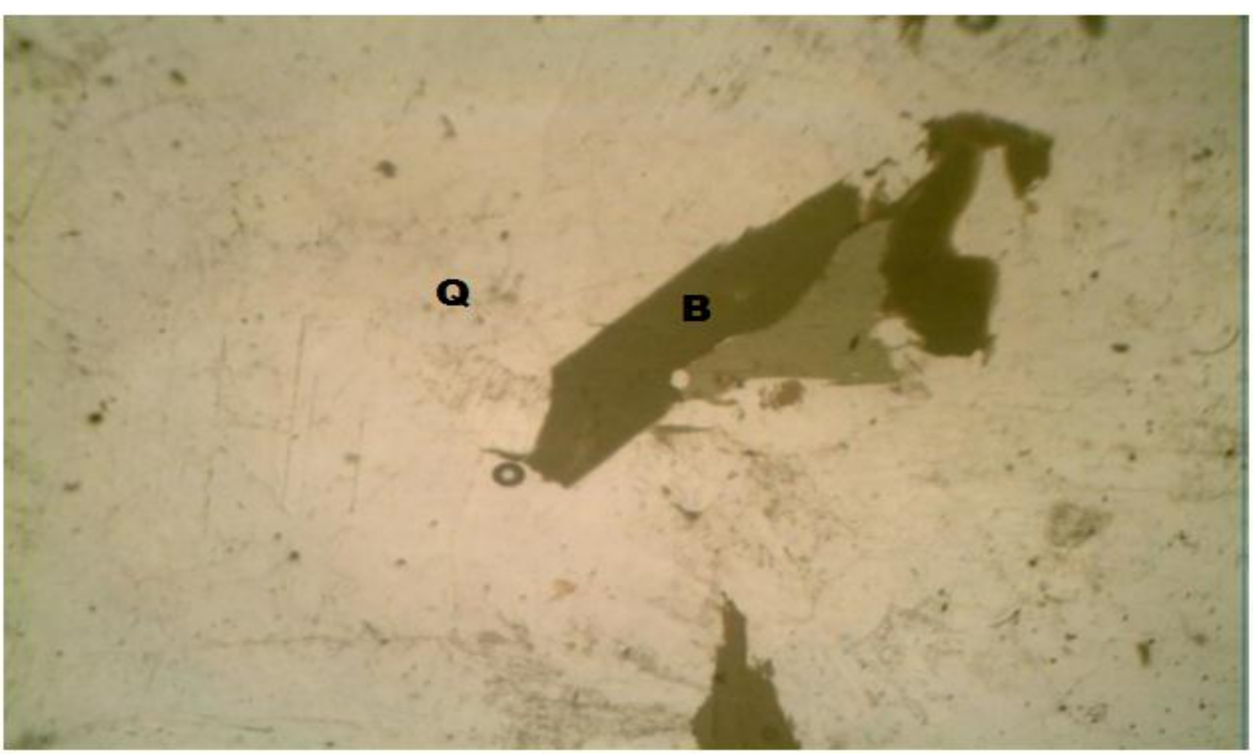

Fig-10b. Photomicrograph of Charnockite slide under PPL X40

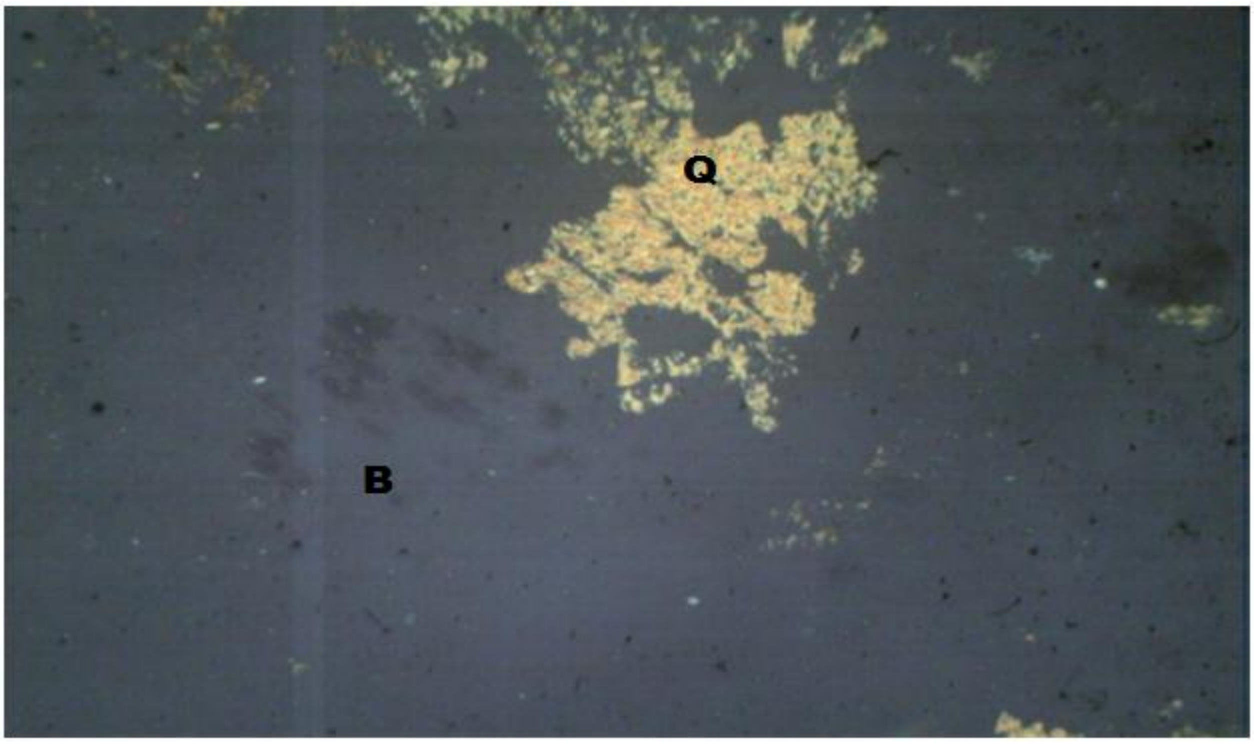

Fig-11a. Photomicrograph of charnockite slide under CNL X40

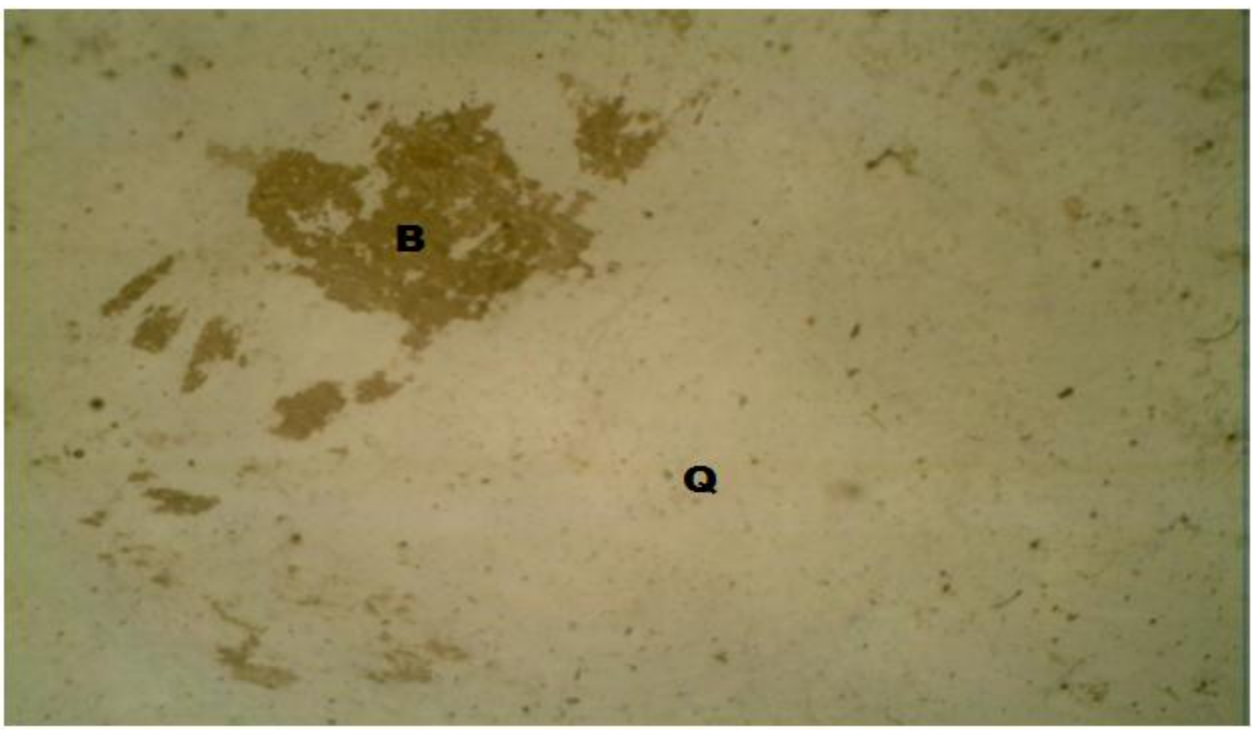

Fig-11b. Photomicrograph of Charnockite slide under (PPL) X40

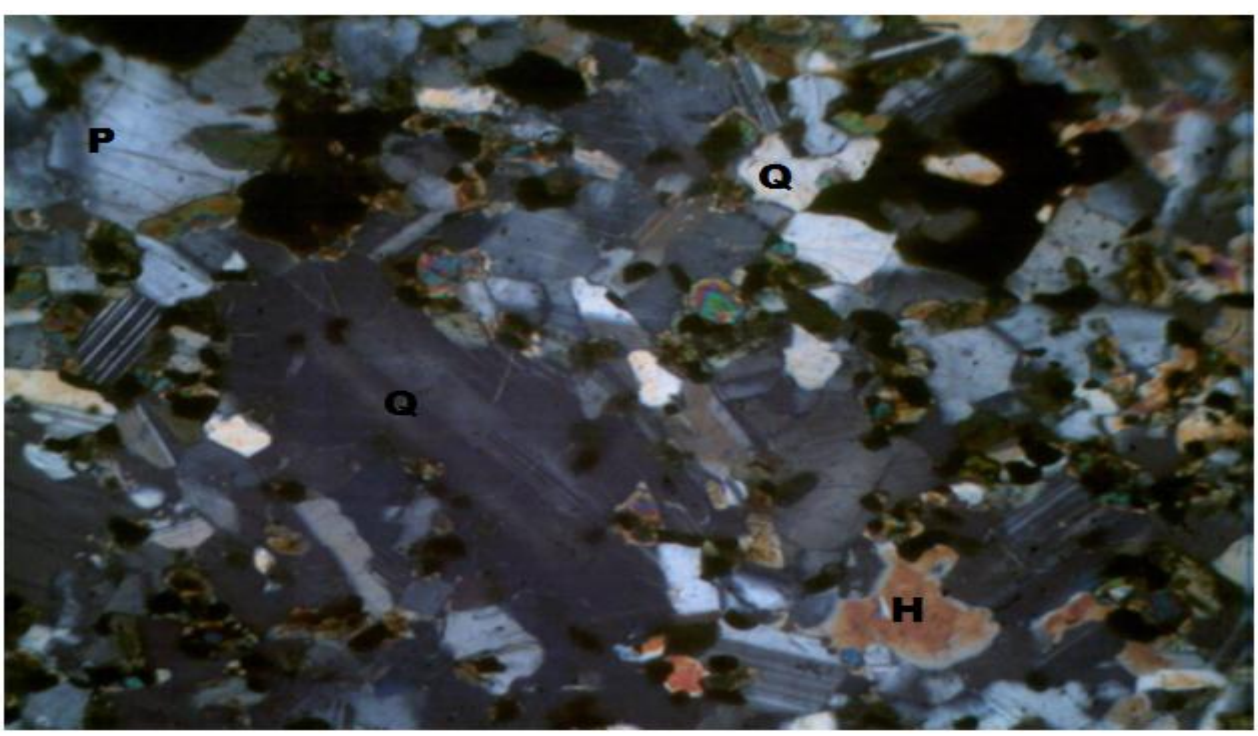

Fig-12a. Photomicrograph of pegmatite slide under CNL X40

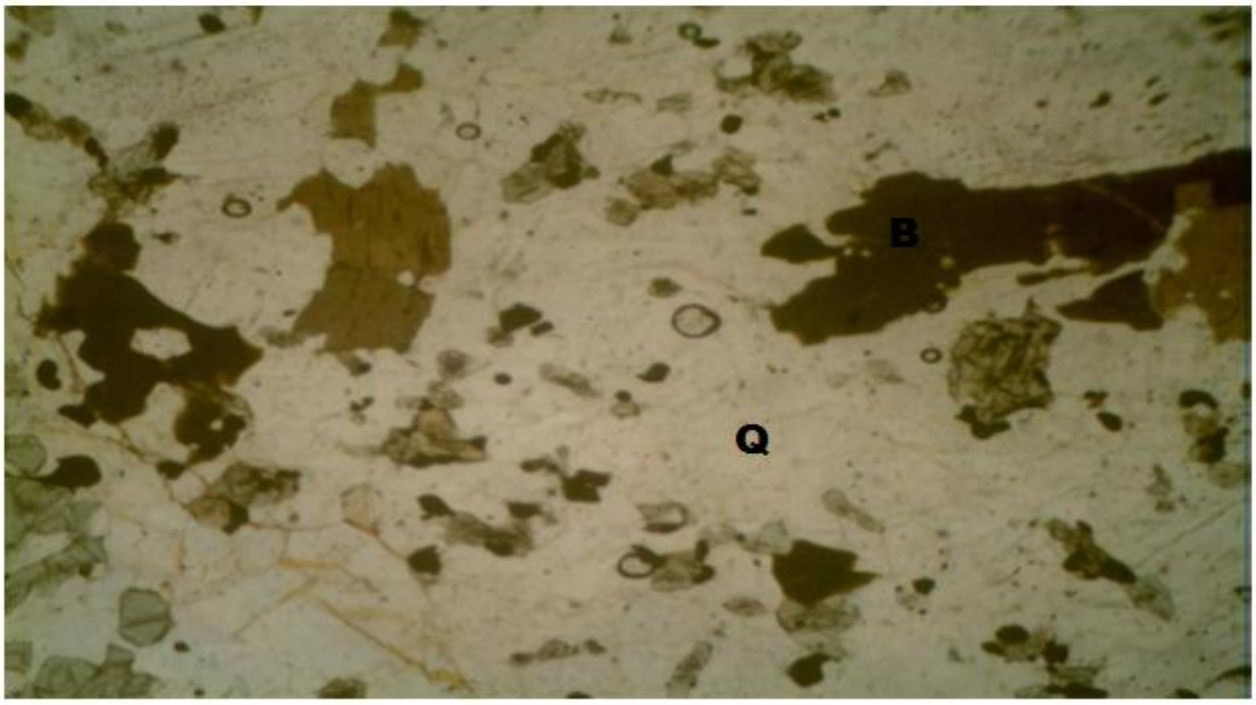

Fig-12b. Photomicrograph of pegmatite slide under PPL X40

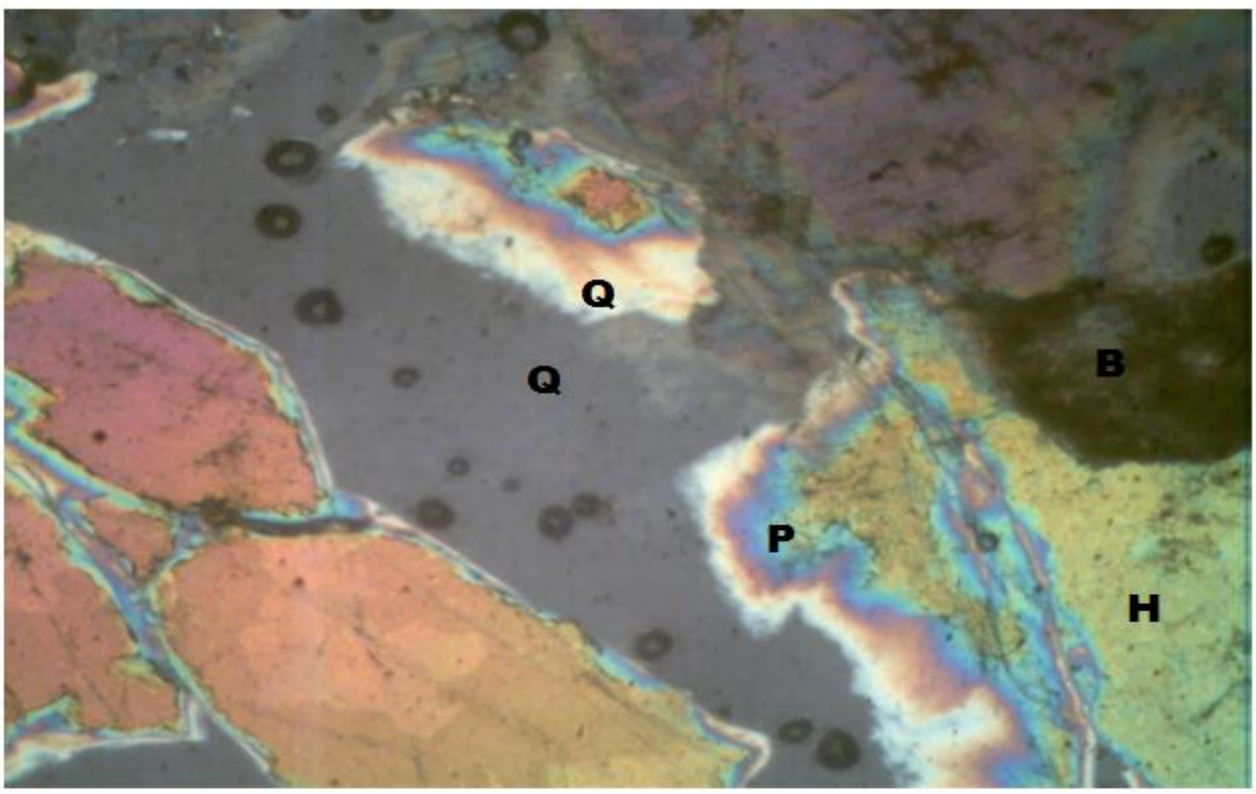

Fig-13a. Photomicrograph of coarse grained granite under CNL X40

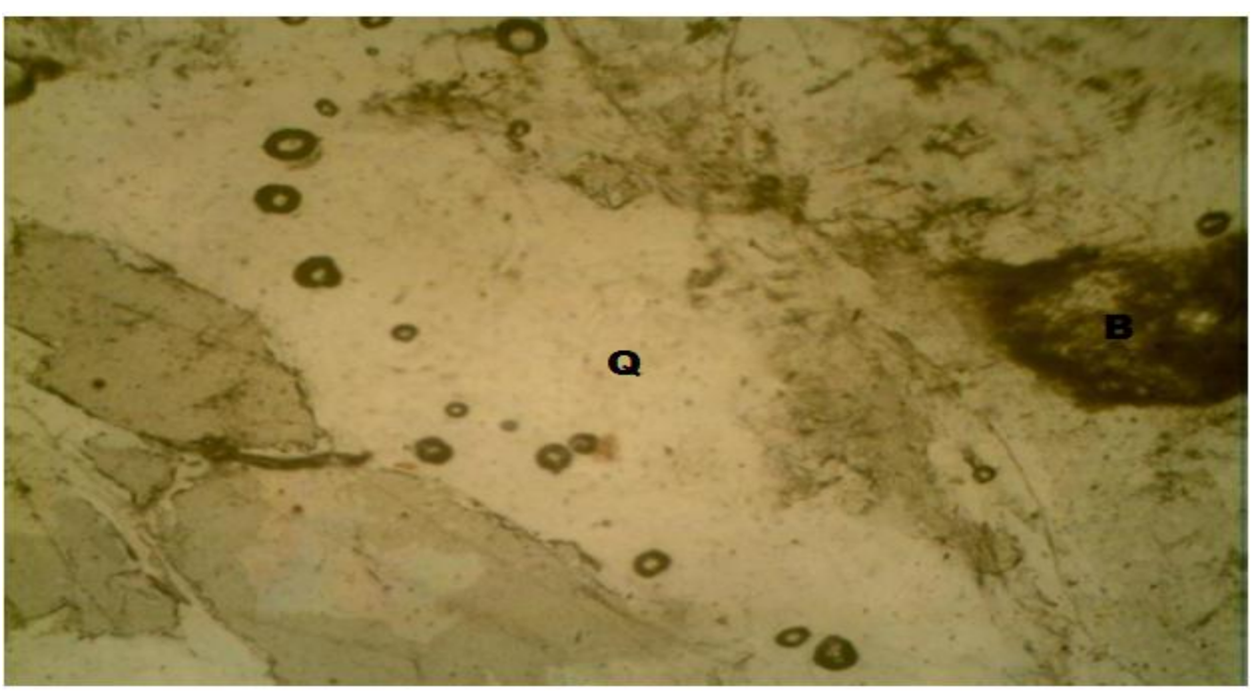

Fig-13b. Photomicrograph of coarse grained granite under PPL X40

Fig-14. Joint on charnockite at Araromi, Ikere

Fig-15a. Quartz veinlet on charnockite at Oke-Ikere

Fig-15b. Quartz vein on chrnockites at Temidire, Afao.

Fig-16a. Pegmatite Dyke on Charnockite at Ijoka

Fig-16b. Pegmatite Dyke on granitic rock at Temidire.

Fig-17. Cross-cutting relationship between a dyke and a vein at gbogeyin

Fig-18. Solution cavity on granite at Afao, Ikere-Ekiti

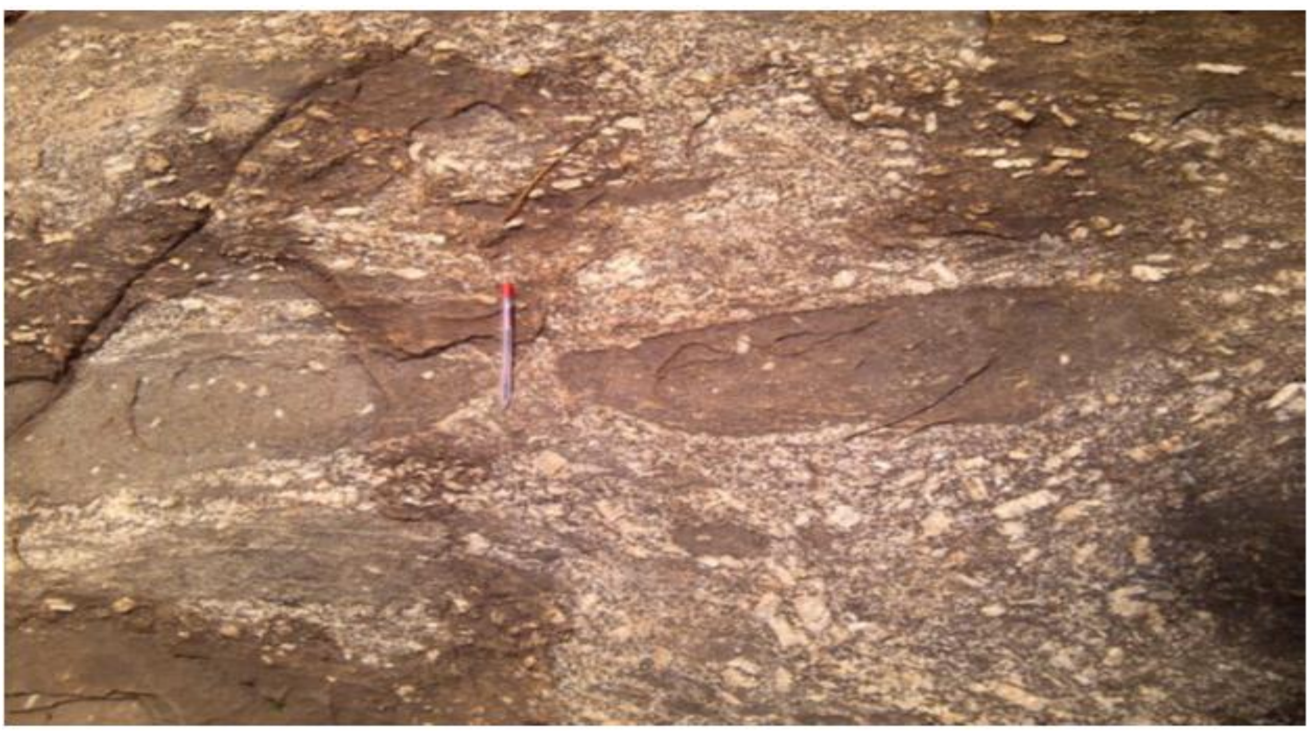

Fig-19. Xenolith on granitic rock at Afao, Ikere Ekiti

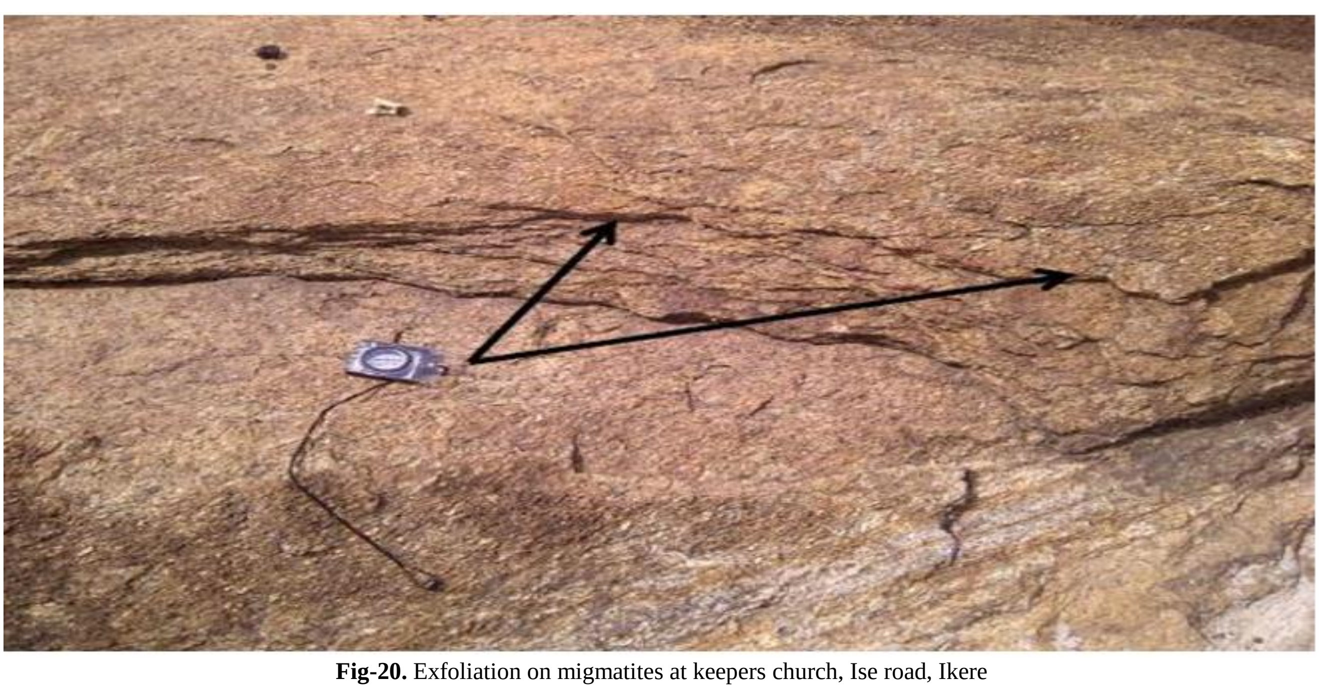

Fig-20. Exfoliation on migmatites at keepers church, Ise road, Ikere

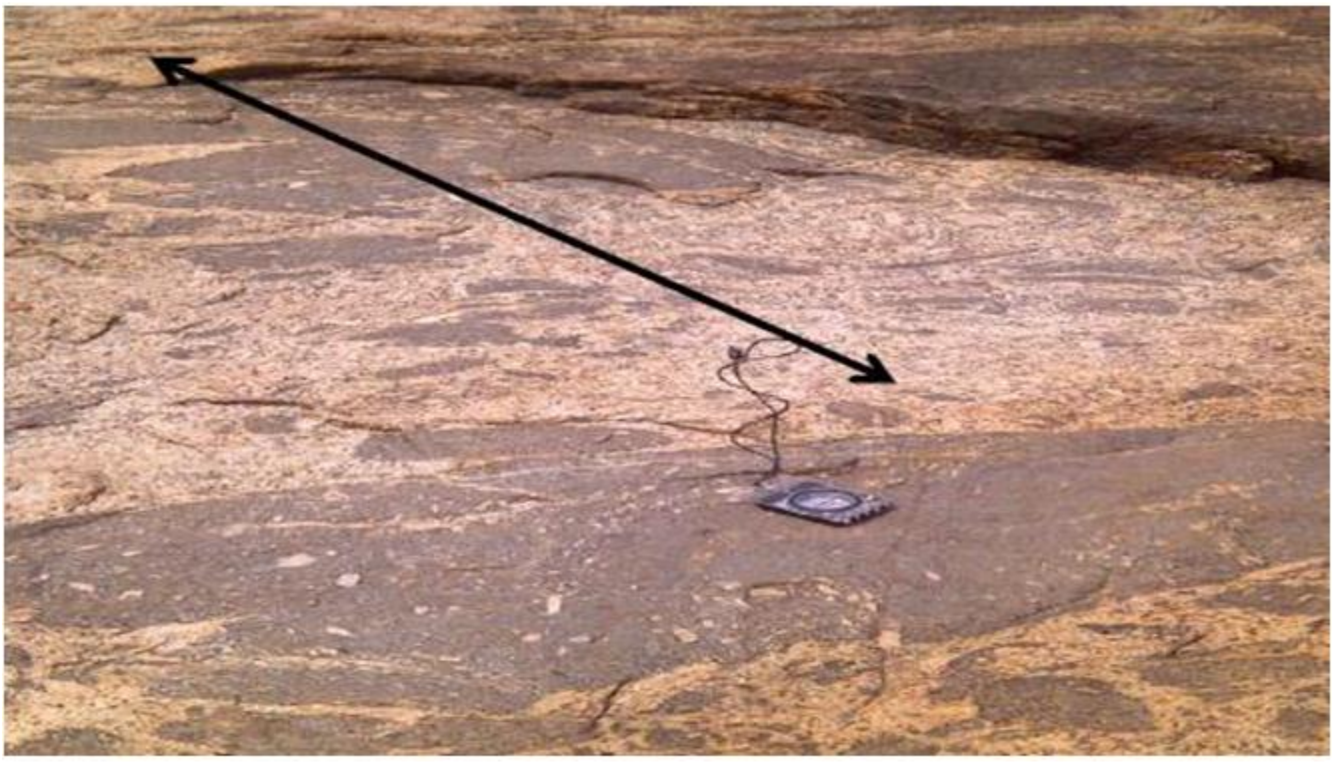

Fig-21. Tension gashes on charnockite at Ijoka

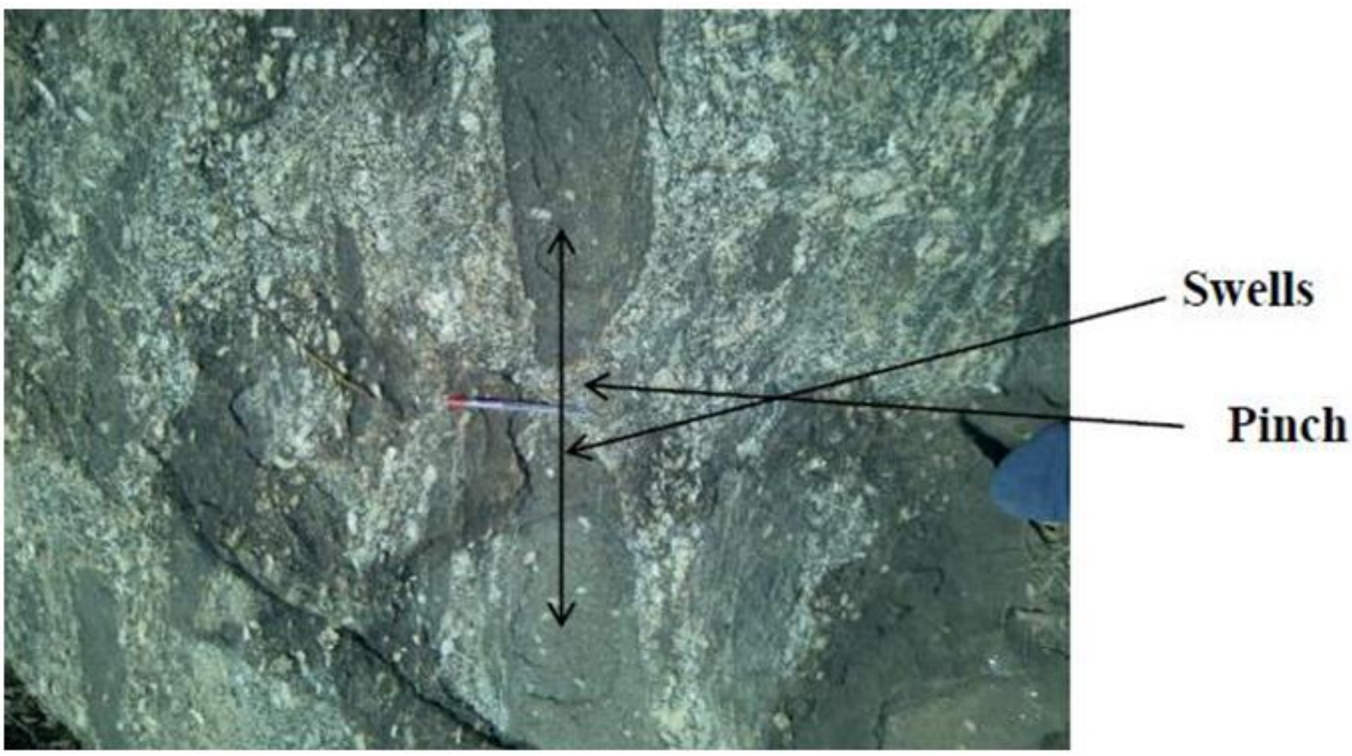

Fig-22. Pinch and swell structure on charnockite at Afao

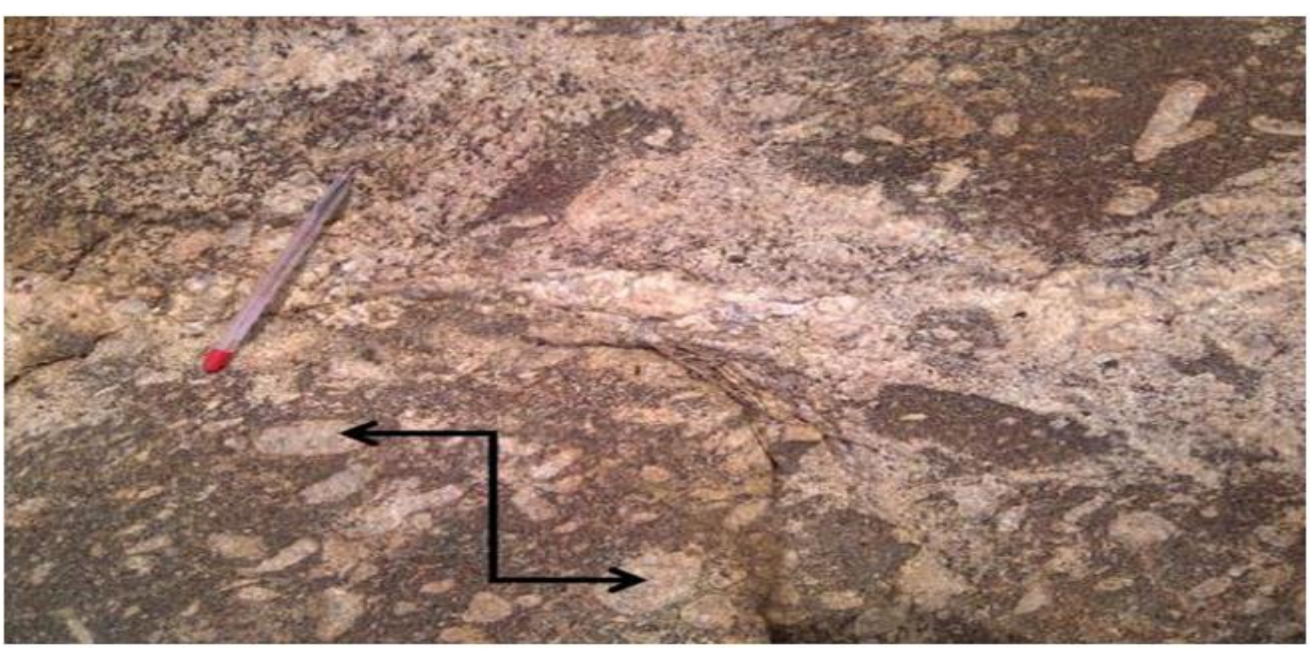

Fig-23. Mineral Inclusions on charnockites at Oke-Ikere

Fig-24. Ptygmatic Fold on charnockitic rock at Araromi.

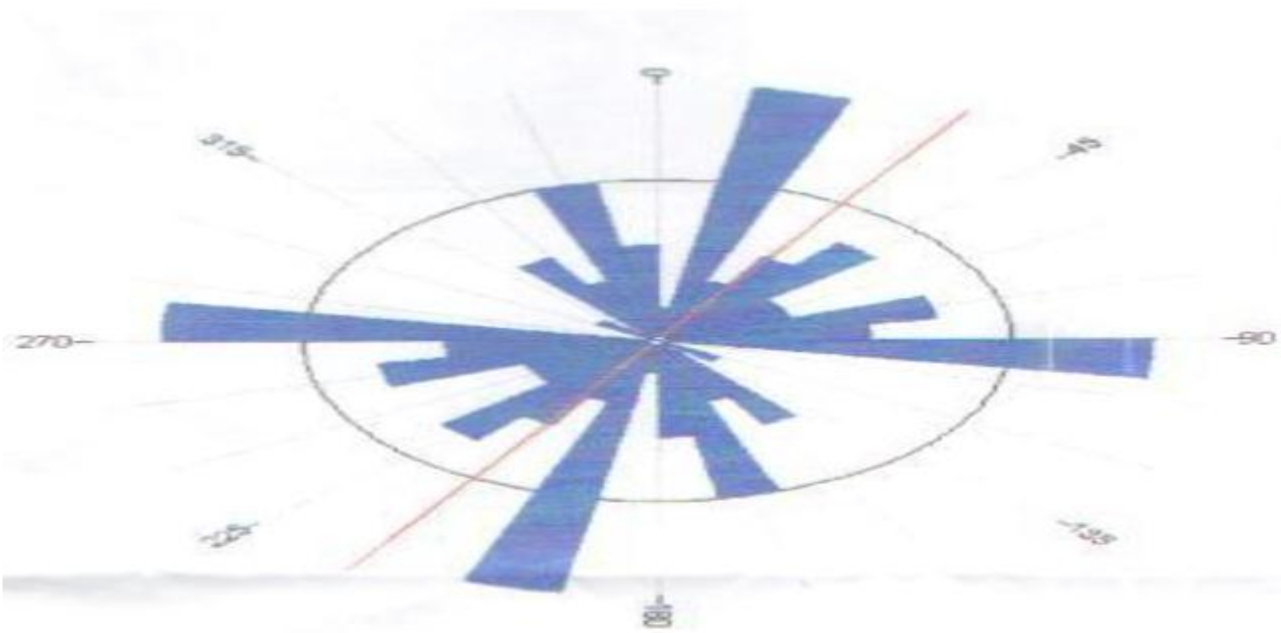

Fig-25. Rosette Diagram of veins in the study area

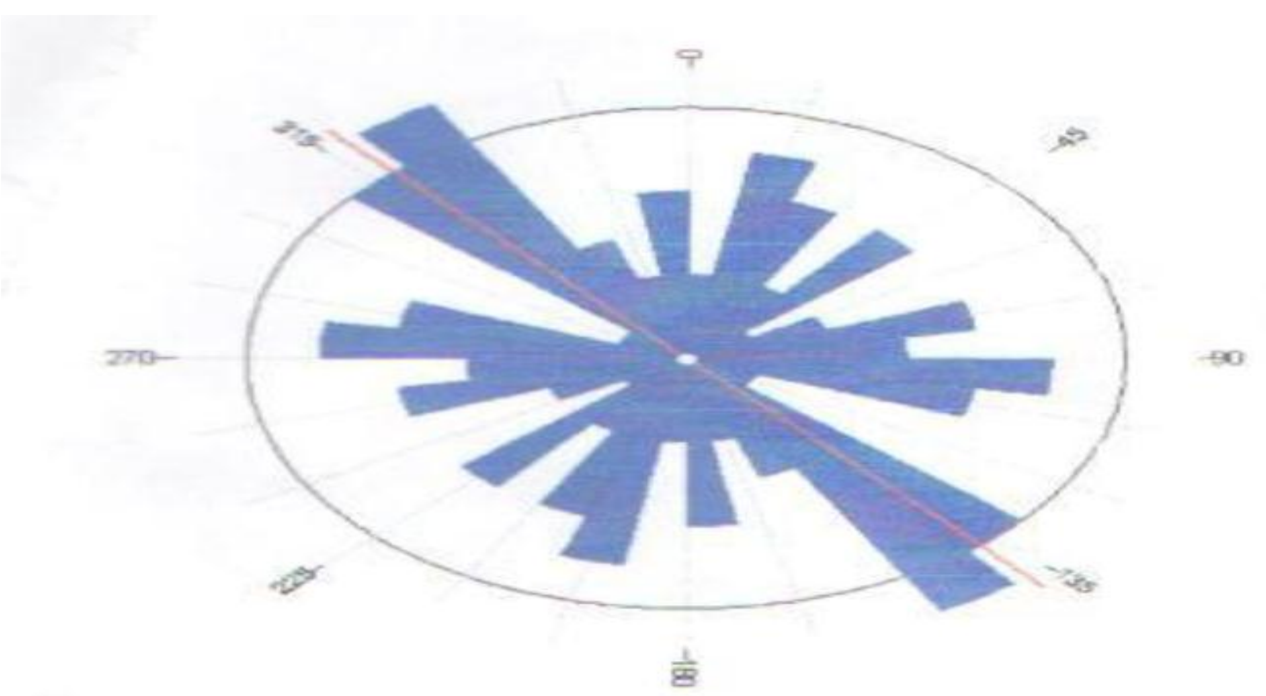

Fig-26. Rosette diagram of Joints in the study area

5. Discussion

The result of the field data acquired is presented in Table.1. Modal analysis of the different rock samples are shown in Table.2, while Table. 3 presents the sample locations and the % concentration of minerals in various samples. The photomicrographs of the thin section from the rocks are also shown (Figs4-13), while the photographs of the various structural elements identified are presented (Figs14-24) and the rosette plots of the veins and joints in the study area are shown (Figs 25-26) respectively.

5.1. Petrographic Description of some Prominent Minerals in the Slides

The thin section was studied with the aid of Petrological Microscope and the slides were analyzed under plane polarized light and crossed nicols.

5.2. Quartz (SiO_2)

The mineral quartz is colourless under the plane-polarized light, with no pleochroism, and twinning. The habit is subhedral to anhedral. Birefringence is also 1st order with extinction angle occurring at ~30°, 40° and 80°. Habit is anhedral to subhedral. Birefringence is 3rd order with extinction angle at angle ~37°, 30° and 32°. The hornblende is deep green, pleochroic prismatic crystals in thin section with 1st order birefringence. Twining and extinction angle are totally absent.

5.3. Biotite $(Mg,Fe)_3\ AlSi_3O_{10}(OH,F)_2$

Biotite shows grey to brown coloration, with subhedral to anhedral habit and no twining. Birefringence is 1st order and the mineral possess no extinction angles. Biotite forms interstitial lamellae with brown pleochroism. Commonly, an inner zone of deep green hornblende is surrounded by an outer biotite and quartz; this is shown in the digitized sketches of the slides in (plates 1-10). Biotite has some inclusion of accessary minerals like apartite, zircon, rutile and mymrkite.

5.4. Plagioclase Feldspars ($NaAISi_3O_8$-$Ca_2AI_2Si_2O_8$)

The crystals of plagioclase are colourless in plane polarized light but exhibit first order grey colour when the polar is crossed. It can be distinguished from other types of feldspar because of its polysynthetic twining visible in the crystals. Plagioclase occurs in some slides as phenocrysts. The more prevalent twining in the plagioclase is the albite with an extinction angle parallel to the cleavage direction.

5.5. Hornblende ($Ca_2(Mg,Fe)_5(AI,Si)_8O_{22}(OH)_2$

It appears as greenish black under plane polarized and shows pleochroism from green to brown. Under plane polarized light, a few hornblende crystals showed the characteristics shape and two cleavages at 120º. In crossed polar, twinnings were seen in a few of the hornblende crystals and the highest interference colour seen, is a second-order blue.

5.6. Interpretation of the Thin Sections

The petrographic examinations of the thin sections revealed the various mineral distribution such as quartz, biotite, hornblende, opaque, mymakite and feldspar (orthoclase, plagioclase and microcline). Quartz and feldspar alone constitute up to 78% of the thin section. Quartz is the most abundant and dominant mineral in all the slides and this indicated that the rocks are products of acidic magma crystallization. Feldspar is second to quartz in abundance while ferro-magnesian and opaque minerals constitute the coloured minerals. This is illustrated in slide 1-10 (table 2) which depicts the sketches of the Precambrian rocks around Ikere-Ekiti and their mineralogical components.

5.7. Q-Quartz, P-Plagioclase, B-Biotite, O-Orthoclase, Op-Opaque, M-Microcline, My-Mrmykite, PPL- Plane Polarized Light, CNL-Cross Nicol

5.7.1. Rosette Diagrams

This is a diagram that shows the direction and minor images of joints and veins. Rosette diagram are essential histograms into a circle to give a true angular plot. The data for plotting a rosette diagram was obtained from the field. Rosette diagram is aimed at displaying the direction of the dominant tectonic force responsible for the deformation of the outcrops. The veins and joints data obtained on the field were used in plotting the rosette diagrams (Figs 25&26) using Grapher and Rosetta sotwares.

5.7.2. Interpretation of the Rosette Diagrams

The structural feature observed includes veins and joints. These were measured and plotted on a rosette diagram and consequently used in the interpretation of the direction of the major tectonic forces or stresses that caused the deformation of the rock in the mapped area. The largest arc from the rosette diagram plotted represents the direction of the major tectonic force, so the rosette diagram of all the structures indicate a NE-SW direction and NW-SE direction which is an indication of the direction of dominant tectonic forces prevailing in the studied area.

5.7.3. Economic Geology of the Study Area

The economic potentials of the various lithologic units in the studied area can be used as dimension stones . Granites of the studied area which is composed of red potassium-rich feldspar orthoclase feldspar, white and cream-colored plagioclase feldspar, dark and shiny flakes of biotite mica and gray irregular quartz grains of vitreous luster. The fact that the mineral grains are tightly interlocked gives it a greater strength and makes it a good material for buildings and sculptures as well as for construction purposes. The petrographic analysis has shown that quartz occur abundantly in the studied area and this makes quartz very useful in the silica industries, gemstone, wrist watch, floor tiles and many other compounds of commercial importance. Also, The varying colours of charnokites as seen in the photomicrograph (Fig.11a) explains its chances and usefulness as a dimension stones especially in the building of houses, tiles making, slabs and kitchen tops etc.

6. Conclusion

The petrological and mineralogical characteristics of the Precambrian rocks in Ikere Ekiti have been carried out and the results presented in preceeding chapters. However, the magmatic origin of the precursor rocks of Ikere-Ekiti area is hereby established by the following lines of evidence: 1. The intrusive nature of the rocks, which is amply supported by the sharp contact relationship displayed by the various granitoid bodies with the country rocks; 2. The presence of a more coarser crystallinity in the core than at marginal areas of each of the granitoid bodies; 3. The incorporations of numerous xenolithic blocks that are often associated with slight displacements and/or rotations; 4. The developments of myrmekitic intergrowths at the plagioclase–alkali feldspar–quartz triple junctions, which also suggested the relevance of late magmatic/deuteric crystallization in the evolutionary history of the rocks. 5. The occurrence of microcline microperthite and complete absence of antiperthitic features in all the thin sections examined;

6. The parallel alignment of flaky and platy minerals in a manner that suggest control by magmatic flux. The presence of xenoliths in a rock body does not only indicate the magmatic character of the parent granitic rocks, but also give indication of the mode of emplacements of the rock. It was observed that magma could shoulder aside country-rocks or "roof" in making space for itself and in so doing is seen to be charged with xenoliths of the displaced country-rocks. Xenoliths are actually evidence that a rock body was emplaced by the process of stopping. The modes of emplacement of magmatic rocks include shouldering aside and updoming of country rocks, a combination of cauldron subsidence and cauldron upheaval and stoping. The granite and charnockite of Ikere-Ekiti area are charged with numerous xenolithic lenses, rafts and blocks of the country rocks, therefore one of the mechanisms of emplacement of the parent granitic rocks may have been the process of stopping; and most likely, piecemeal stopping. The petrographic investigation shows that a distinct boundary can be drawn between the granite and charnockite in the studied area based on the textures and mineralogical composition. The texture of the pegmatite analyzed revealed a coarse grained type which is indicative of plutonics. It cooled very slowly close to the earth surface which resulted in its coarseness. Also, the petrology and petrographic investigation of the study area revealed that quartz has the highest percentage modal composition in all the thin sections (Table.2, Fig.3). The rocks are characterized by the assemblages of quartz, biotite, hornblende, plagioclase, orthoclase, microcline, mymakite and opaque minerals. The structural features displayed on the rocks in the studied area (Figs 14-24) are manifested on the charnockites and granitic rocks with structures such as joints, dykes, xenoliths, veins and veinlets seen on the outcrops mapped. The petrographic investigation indicates that the granites consists of minerals like quartz, biotite, plagioclase, and microcline, charnockite consists of minerals like quartz, plagioclase, and biotite while pegmatite consists of minerals like quartz, plagioclase, biotite, and microcline.

It also showed that the rocks formed in the studied area were emplaced tectonically, based on the styles and magnitudes of structures detected and their disposition as seen in the rosette diagrams (Figs 25&26). These structures are believed to be the product of the Pan-African orogeny which affected the rocks in the studied area and are imprints of various stages of deformation in the area. Field and petrographic characteristics confirm that the granitic parent rock and charnockites most likely had magmatic origin, and that one of the mechanisms of emplacement of the parent granitic rocks may have been the process of piecemeal stopping. Both syn-tectonic and post-tectonic emplacements were probably relevant in the evolutionary history of the rock unit(s). It is hoped that further research work on the area, including geochemical, isotopic and geothermobarometric studies, will throw more light on the evolutionary history and tectonic setting of the rock unit(s).

6.1. Recommendation

The detailed petrographic and mineralogical investigation of the basement rocks in Ikere-Ekiti, south-western Nigeria has shown that the study area belongs to the Precambrian basement complex of Nigeria. In view of the research conducted in the studied area, the following recommendations are proposed to improve on the present study such as detailed geological mapping should be carried out to discover other secondary structures of importance which could elucidate further the manner and styles of deformation in the study area. Further research should be carried out in Ikere-Ekiti in other to delineate the impact of the various deformational episodes on geodesy and environment.

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