Original Research Article

PETROGRAPHIC AND STRUCTURAL STUDY OF PRECAMBRIAN PEGMATITE VEINS IN THE IGARRA SCHIST BELT, SOUTHWESTERN NIGERIA

ABSTRACT

Precambrian Pegmatite veins in Igarra were studied and analyzed in order to group the veins based on their structures, orogenic episodes and modal composition. Pegmatite veins are found more in granodiorites, Migmatite-Gneiss and undifferentiated mixed rocks in the study area. The studied veins were predominantly dykes and sills while some were folded into irregular shapes. Exposed studied veins have minimum length of 2.5m and maximum of 10m. A minimum width of 43cm and maximum of 2m were also recorded. Elements like strike directions analyzed using rose diagrams suggest that the emplacement of pegmatite veins is related to a dominant structural control orogenic event. Two major deformational episodes were recorded on the pegmatite veins studied. The irregular recumbent folded pegmatite veins represent a ductile phase deformation which resulted in the formation of planar structures in the study area. The second deformation that impacted the pegmatites was a brittle phase deformation that resulted to fractures found in basement rocks many which were filled with pegmatites and quartz veins. Results showed that the dominant strike directions of veins were mainly in the NE-SW and N-S directions. Also recorded were few veins which trend in the NW-SE direction both which were likely the imprint of Pan-African orogeny in the study area. Modal composition of minerals from thin section results on samples shows they are predominantly feldspathic pegmatites with k-feldspar between (32 to 46%) with mean value of 40.9% and plagioclase (18 to 30%) with mean value of 21.5%.The NE-SW veins have more biotite than the NW-SE pegmatite veins. Perthitic structures (mask effect of albitic plagioclase) were recorded in the NE-SW veins.

Sericitization of feldspars (hydrothermal alteration) was also seen in the NE-SW pegmatite veins. The mineral Tourmaline is associated with NE-SW veins as seen in thin section petrography while Sphene (Titanite) can be found in the NW-SE pegmatite veins.

Key words: Pegmatite veins, Mineralogy, potentials, Rose diagram, Modal composition, Tourmaline.

INTRODUCTION

The word pegmatite is derived from Homeric Greek (pegnymi) which means “to bind together”, in reference to the intertwined crystals of quartz and feldspar in the texture known as ‘graphic granite’ (London, D.; Morgan, G.B.2012). They display gray-whitish to pink colorations which suggest the presence of potassium feldspars in greater percentage than other minerals. Crystal size is the most striking features of Pegmatites, with crystals usually over 5cm in size. Individual crystal over 10m (33ft) long has been found, and many of the world’s largest crystals were found within Pegmatites. These include spodumene, microcline, beryl and tourmaline. (Schwartz, G.1928). Pegmatitic textures can develop in any intrusive igneous rock type from ultramafic, to granitic, to syenitic in composition. Most commonly, the term is used to refer to granitic pegmatites and is generally understood to refer to rock of overall granitic composition when it is used without a qualifying adjective e.g. gabbroic pegmatite (Simmons W.B; Webber K.L 2008).

Characteristically, they are inhomogeneous and show zones of different mineral assemblages. In some cases, crystal size and mineral assemblages are usually oriented parallel to the wall rock or even concentric for pegmatite lenses (London, D.; Kontak, D.J. 2012). Most pegmatites appear to form from a single intrusive magmatic event, but undergo a complex internal crystallization history that can result in a large range of grain sizes; consistent changes in mineral chemistry from wall zone to cores; increasing concentrations of fluxes, volatiles and rare elements and, in rare instances, the formation of pockets containing gem-quality crystals (Simmons W.B; Webber K.L 2008). Depth-zone classification of granitic rocks has influence the classification of pegmatite in recent times. This is evidence in the articles published by Buddington (1959), and the Ginsburg & Rodionov (1960) and Ginsburg et al. (1979).These classifications categorized pegmatites according to their depth of emplacement and relationship to metamorphism and granitic plutons. (Simmons W.B,Webber K.L, 2008).

Cerný's (1991) revision of that classification scheme is the most widely used classification of pegmatites today. Cerný's (1991) pegmatite classification, which is a combination of emplacement depth, metamorphic grade and minor element content, has provided significant insight into the origin of pegmatitic melts and their relative degrees of fractionation. They are based on the pressure (and, in part, temperature) conditions that characterize their host-rock suites.

The major structural features of Igarra Schist Belt on the map are series of overturned antiformal and synformal overturned folds with approximately N-S trending axes (Hockey et al. 1986, Odeyemi, 1988). V.I.Megwara and N. Egesi 2017, reported in Lankpeshi area of the schist belt that the structural elements in the area include those formed due to brittle deformation (brittle structures) and ductile deformation (ductile structures). There are publications on Igarra pegmatites but not much dwell on indentifying pegmatite structures, their modal composition and deformational episodes. This work therefore is an attempt to structurally analyze pegmatites veins and group them base on the deformational episode they represent in the study area.

1.0 GEOLOGICAL BACKGROUND

Nigeria is underlain by Precambrian Basement Complex rocks, younger granites of Jurassic age and Cretaceous to Recent sediments. The Basement rocks, which occupy about half of the landmass of the country, forms part of the late Archaean to early Proterozoic Pan-African mobile belt, situated between the West African Craton and the Congo Gabon Craton (Black1980).

Within the context of the geology of the Nigerian Basement Complex, three broad lithological units are distinguishable. These are the migmatite-gneiss complex, the schist belts and the Pan-African older granite series (Elueze, 2000). The migmatite gneiss complex is a heterogeneous assemblage of predominantly amphibolite facies migmatites, orthogenesis, paragenesis and basic to ultrabasic rocks (Rahaman, 1988). The migmatite – gneiss is dominantly made up of quartzo – feldspathic gneiss that are predominantly biotite and / or hornblende – bearing and rarely pyroxene (Ekwueme and Kroener, 2005; Ukwang et al., 2003)

Igarra schist belt lies within the easterly end of the southwestern Nigeria basement complex around the Okene migmatite nucleus fig 1. The schist belt occurs as N-S trending zone of low to medium grade metasediments such as phyllite, semi-pelitic to pelitic schist, metagreywacke, metaconglomerate, quartzite and basic to ultrabasic metavolcanics (Rahaman, 1988; McCurry, 1989; Annor, 1998).

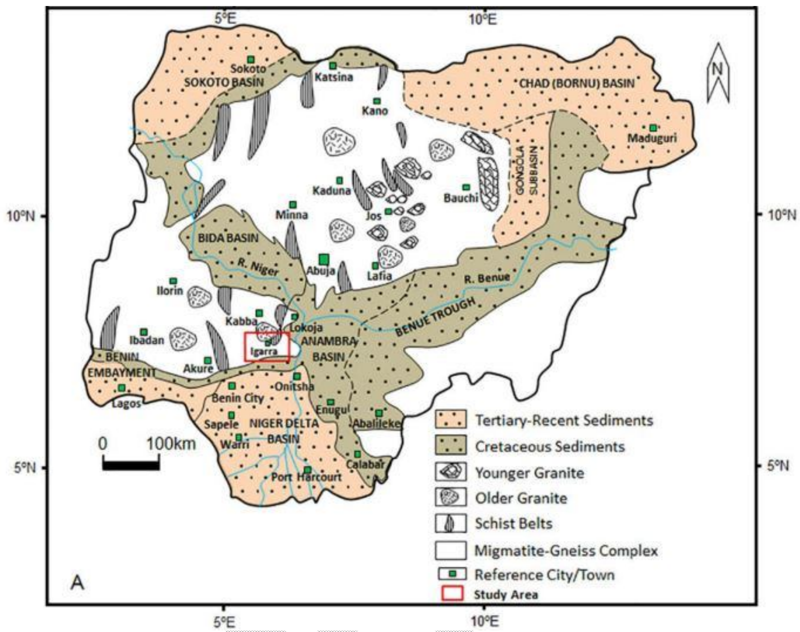

Fig.1 The study area in a geologic map of Nigeria (after Ogbe *et al, 2018*)

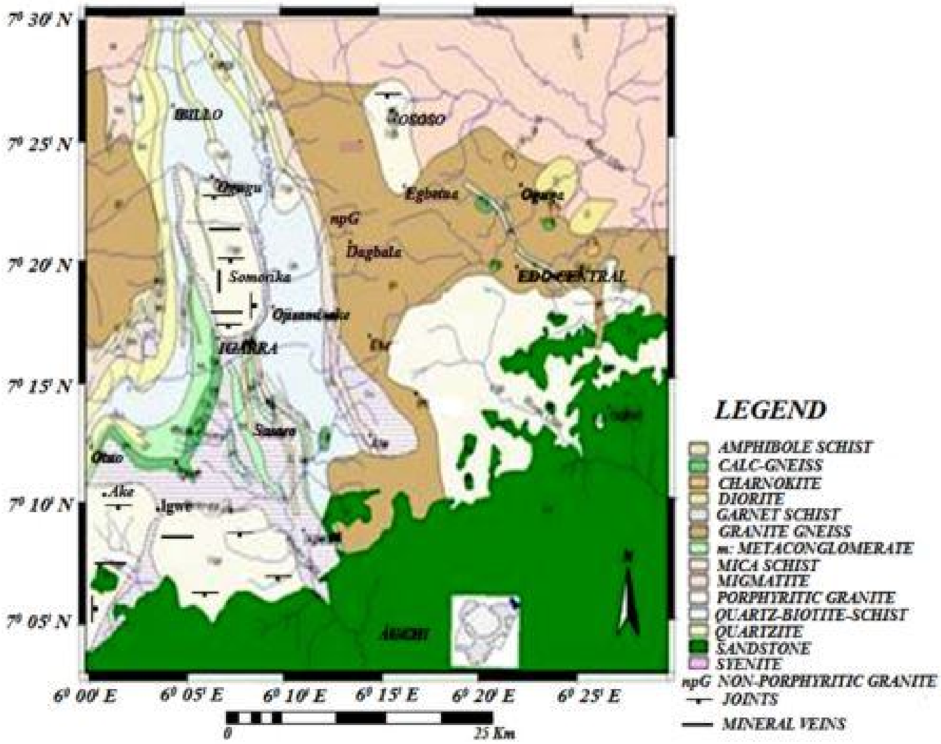

Fig. 2 Geologic map of the study area (after Anifowose A.Y.B. *et al* 2006)

The local geology of the area can be divided into three major groups: (a) Migmatite and biotite hornblende gneiss, (b) Low grade metasediments (schists, calc-gneiss, marble, meta-conglomerate and quartzites) and (c) Syn-to late tectonic porphyritic biotite-hornblende granodiorite, adamelites, charnockites and gabbros, while undeformed dolerite, pegmatite, aplite and syenite representing minor lithologies fig2 (Oloto I.N., D.E.. Anyanwu, 2013.Isotopic data have revealed that the Basement Complex has been involved in several tectonothermal events, which include from the oldest Liberian, Eburnean, and Pan African orogenic events (Grant et al. 1972; Ekwueme, 1987; Rahaman, 1988; Ekwueme and Kroener 2005).

2.0 MATERIALS AND METHODS

This study included both field and analytical works. Samples were collected from pegmatitic veins. Collections of samples were carefully performed, ensuring that samples were fresh and not altered by weathering. Efforts were made to make sure that sample sizes collected will be adequate for their intended use which includes petrographic analysis in order to achieve the aim of this study.

2.1 FIELD WORK

Structural elements such as dip and strike direction were recorded using compass Clinometer. Length and width of exposed pegmatite veins were measured with measuring tape and recorded on field note. Samples were collected from various sites visited. The samples were labeled and their locations were also marked (fig.3) and table 1 using a Garmin Montana 650 gps garget. Samples for petrographic analysis were collected in a pattern to represents all the rock types in locations considered important in achieving the objectives of the study. Some of the factors put into consideration for the samples selected includes freshness, size (>2kg), location (geographic spread), rock types.

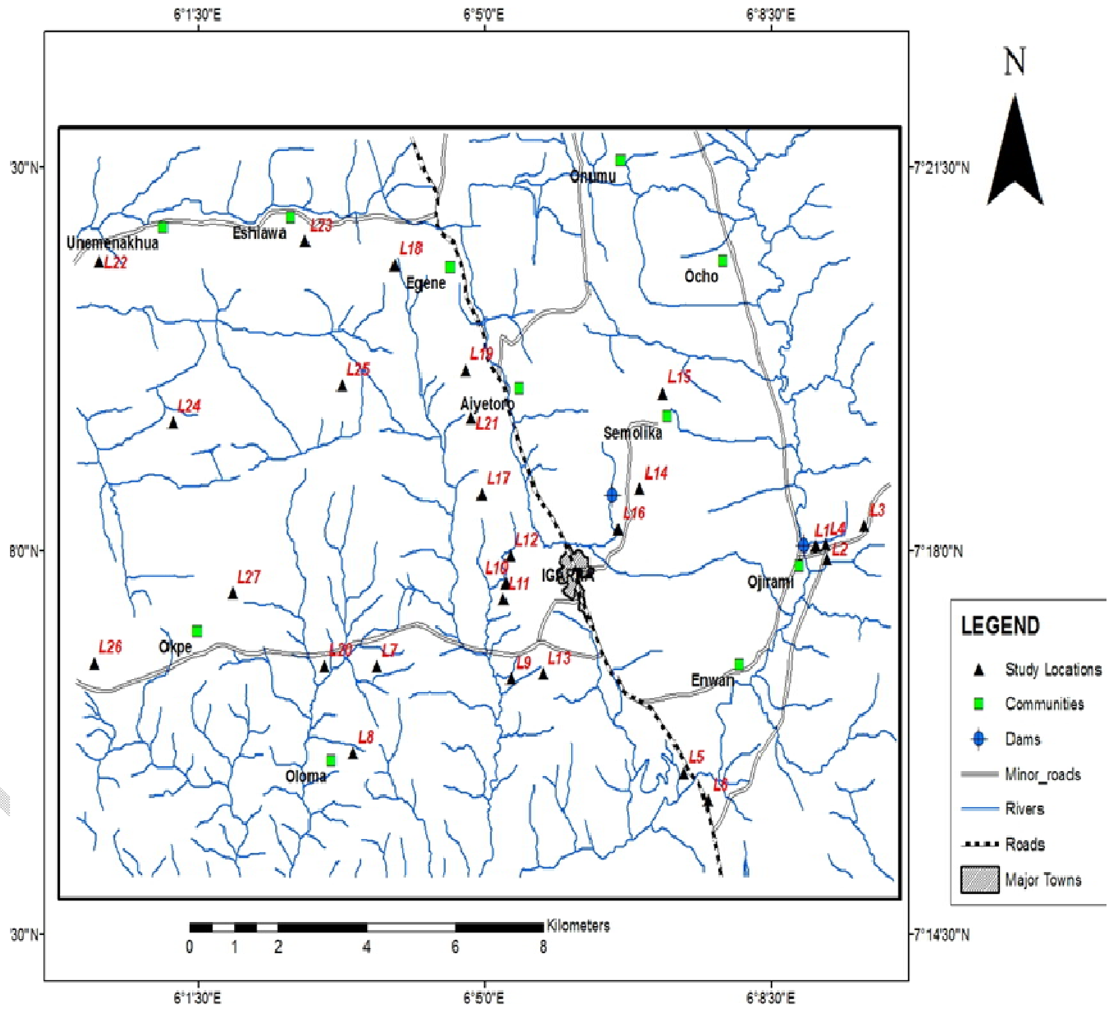

Fig.3 Drainage map of Igarra showing locations where samples were collected.

Table 1.Locations of sampled pegmatite veins.

Strike	Structure	Gps	Location	Length	Width
$N15^{o}E$	dike	$N07^{O}16^{I}\ 48.26^{II}$ $E006^{O}01^{I}\ 38.92^{II}$	Okpe	4.6m	43cm
$N38^{o}E$	dike	$N07^{O}16^{I}\ 48.26^{II}$ $E006^{O}01^{I}\ 38.92^{II}$	Okpe	6.2m	51cm
$N45^{o}E$	sill	$N07^{O}16^{I}\ 72.16^{II}$ $E006^{O}01^{I}\ 68.92^{II}$	Igarra	3.8m	47cm
$N18^{o}E$	dike	$N07^{O}16^{I}\ 52.26^{II}$ $E006^{O}01^{I}\ 41.29^{II}$	Okpe	2.7m	38cm
$N354^{o}W$	sill	$N07^{O}\ 20^{I}\ 54.\ 41^{II}$ $E006^{O}\ 02^{I}\ 38.40^{II}$	Eshawa	12m	2.0m
$N20^{o}\ E$	sill	$N07^{o}\ 25^{I}\ 06.88^{II}$ $006^{O}\ 04^{I}\ 54.\ 09^{II}$	Ibilo	10m	1.5m
$N20^{o}\ E$	sill	$N07^{o}\ 25^{I}\ 06.88^{II}$ $006^{O}\ 04^{I}\ 54.\ 09^{II}$	Ibilo	14m	88cm
$N350^{o}W$	sill	$N07^{O}\ 20^{I}\ 54.\ 31^{II}$ $E006^{O}\ 02^{I}\ 38.32^{II}$	Eshawa	12m	72cm
$N40^{o}E$	sill	$N07^{O}16^{I}\ 72.28^{II}$ $E006^{O}01^{I}\ 68.42^{II}$	Igarra	4.6m	64cm
$N20^{o}E$	sill	$N07^{o}\ 25^{I}\ 78.43^{II}$ $006^{O}\ 04^{I}\ 59.\ 39^{II}$	Ibilo	8m	52cm

2.2 LABORATORY ANALYSES

Samples of extracted pegmatites were selected and thin section petrography was prepared in the laboratory of Geology Department University of Calabar Cross River State Nigeria. The laboratory preparation of samples to be viewed and analyzed with polarizing petrographic microscope, followed close monitored standard procedure. The aim of the petrographic analysis was to study the mineral compositions (in percentage) of the pegmatite samples. Samples were cut to size with a diamond saw and ground flat. It was then mounted on a glass slide with balsam and then ground smooth using Carborondum powder. Progressively finer abrasive grit of diamond powder was used until the sample is only 0.03mm thick. The method involved uses the Michel-Lévy interference colour chart. Quartz was used as the gauge to determine thicknesses as it is one of the most abundant minerals with considerable high percentage. High cleanliness was observed throughout the entire process because a single grain of coarse material rubbed against the slide at the wrong time will surely damage the slide. A thin section properly grained normally shows a remarkable degree of transparency. Lastly the smoothly grounding surface of the chip was then mounted on a glass slide employing poxy resin as cementing material. Modal composition was determined by point counting per thin section using a MEIJI TECHNO Petrographic microscope with 1.3MP 1/3 inches color USB 2.0 APTINACMOS SENSOR and x40 magnification.

3.0 **RESULTS AND DISCUSSION**

They studied veins were predominantly dykes (fig.7) and sills while some were folded into irregular shapes (fig.4). Most times, they are emplaced concordantly to the host rock in tabular bodies injected in fault controlled fissures. They studied veins trend mostly in the NE-SW and occasional NW-SE directions (table1). In summary, two major deformational episodes were recorded on the pegmatite veins studied. The irregular recumbent folded pegmatite veins represent a ductile phase deformation which resulted in the emplacement of planar structures in basement rocks. The limbs of the recumbent folds are not equal and the axial planes measured are not equidistant from the limbs (fig4). This may be due to compressional forces to which these rocks have been subjected overtime (V.I.Megwara and N. Egesi 2017). The folded pegmatite veins were characterized by asymmetrical limbs, and exhibit tight to open fold with vertical axial planes, trending NW-SE. Like the Lankpeshi area the dominant axial trends of the folds were E-W with few trending NNW-SSE. This represents the D_2 deformational episode recorded at Ojirami area of the Schist Belt. Folds at the Ojirami area vary in style from open to tight to isoclinical with well developed, steeply dipping NNW-SSE trending axial plane foliations (Ocan O.O. 2016).

The second deformation that impacted the pegmatites was a brittle phase deformation which gave rise to the numerous fractures in the basement rocks filled with pegmatites and quartz veins. This probably represents the D_5 deformational episode in the area. The D_5 deformation was semi-brittle shear emplaced approximately parallel to the regional structural grain resulting in the development of fault breccias seen south and southwest of Igarra and probably controlled the emplacement of syenite dykes south of Igarra (Ocan O.O. 2016).

The field generated data were used in plotting a Rose diagram on RockWorks17 software that showed the trends of the pegmatite veins (fig.5). Ukaegbu 2003 reported the occurrence of pegmatite generally in N-S and NNE-SSW trend pattern in the Obudu area southeastern Nigeria basement complex. Akintola and Adekeye (2008) also reported the concentration of Pegmatites in a NE-SW trend extending from Ago-Iwoye in the southwest through Wamba-Jema'a to Bauchi area. Okunlola, O. A and Jimba, S. (2006) reported that Nigeria has a pegmatite belt which is beyond the confines of 400km NE-SW trending belt from Abeokuta, southwestern Nigeria to North Central Nigeria.

Fig.4 Recumbent folded pegmatite vein migmatite-gneiss. The length of the compass is 14cm

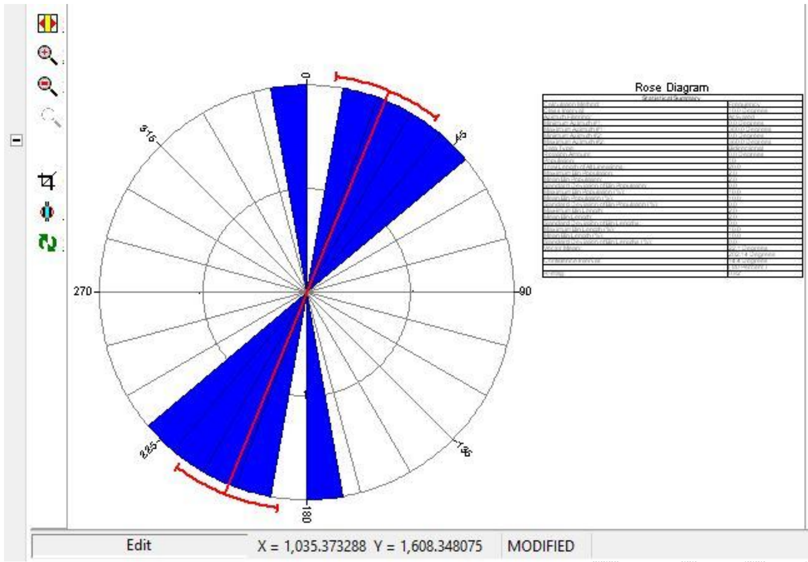

Fig.5 Rose diagram plot of pegmatite veins orientation in the study area

Exposed studied veins have minimum length of 2.5m and maximum of 10m. A minimum width of 43cm (fig.7) and maximum of 2m were also recorded. Structural elements like strike directions analyzed using rose diagrams suggest the pegmatite veins were emplaced in fault controlled pattern. Results showed that the dominant strike directions of veins are mainly in the NE-SW direction (fig.5). Also recorded were few veins which trend in the NW-SE direction which are likely the imprint of Pan-African orogeny in the study area.

Fig. 6 Close-up view of a pegmatite vein with coarse interlocking grains and mica minerals in migmatite gneiss

Modal composition of minerals from thin section results on samples shows they are predominantly feldspathic pegmatites with k-feldspar mainly microcline and orthoclase between (32 to 46%) with mean value of 40.9% and plagioclase (18 to 30%) with mean value of 21.5% (table 2). A large amount of orthoclase in the rock is concealed by the mask effect of albitic plagioclase lamellae superimposed on it to form Perthitic structures.

Fig. 7. Multiple pegmatite dykes in migmatite gneiss. The length of book is 23cm

Table 2 Modal composition of minerals from samples of pegmatites

	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**

K-F(microcline+ orthoclase)	40%,	32%	45%	42%	46%	40%	45%	41%	38%	40%
Plagioclase	25%	18%	21%	18%	20%	22%	30%	20%	21%	20%
Biotite	15%	12%	10%	10%	8%	14%	10%	8%	12%	10%
Muscovite	5%	8%	2%	-	1%	3%	-	2%	-	2%
Quartz	15%	25%.	22%	30%	24%	21%	15%	29%	22%	25%.
Tourmaline		5%								
Sphene (Titanite)					<1					

3.1 NE/SW VEINS

The Northeast/Southwest pegmatite veins were predominantly sills and few recorded as dykes and represent brittle structures formed by brittle deformation in the area. The strike of the studied veins averages between 15^{o}E and 45^{o}E (table 1). In the course of studying the petro-micrograph, it was noticed that large amounts of orthoclase were concealed by the mask effect of albitic plagioclase lamellae superimposed on it to form Perthitic structures (fig.8). Sericitization of feldspars were also well displayed in most of the studied samples. Sericitization is the decomposition product of orthoclase feldspar to a secondary mineral that is a combination of potassium/mica. Sericite is produced by the alteration of orthoclase or plagioclase feldspars in an area that has been subjected to metamorphic transformation. K-feldspar dominates over plagioclase and occurs in the larger crystal size sub-population in most of the studied samples. Cleavages were visible on the feldspars in PPL view. Quartz occurs in the smaller mineral grains, growing especially between the feldspars, and lacks well-formed crystal faces. Except for the micas which show some form of alignment, the grains generally lack fabric elements. There is also presence of **tourmaline** (fig.9) in the sample and the crystals range from euhedral to subhedral forms.

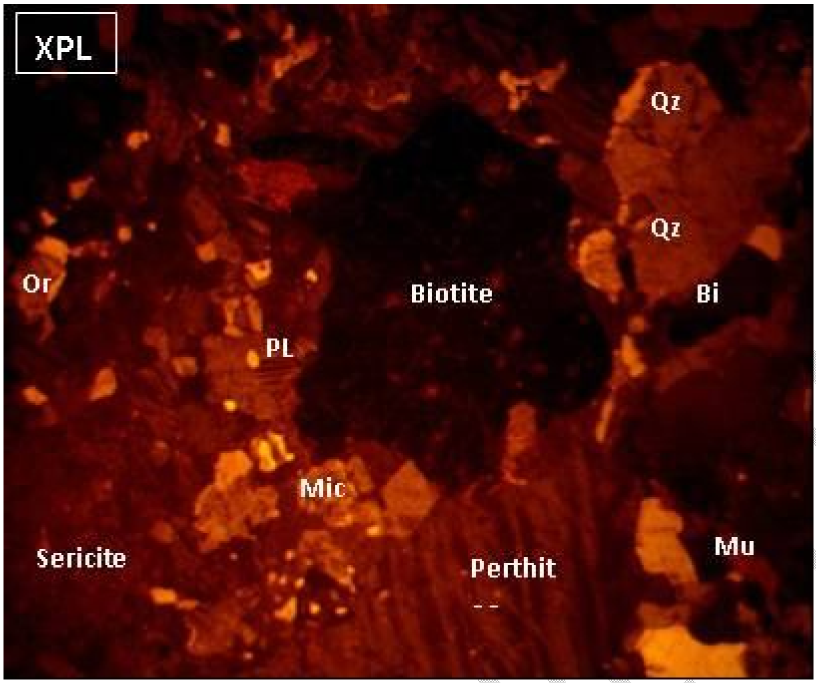

Fig.8 Photomicrograph under xpl showing mask effect of albitic plagioclase and Perthitic structures.

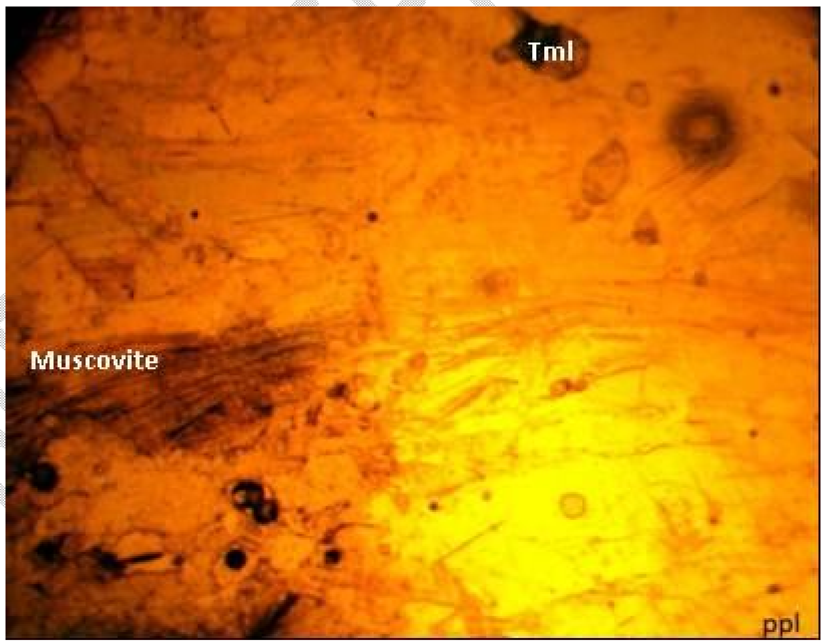

Fig.9 Photomicrograph under ppl showing the mineral **tourmaline**

There is also presence of vermiform intergrowth of quartz in plagioclase creating a myrmekitic feature in few of the studied photomicrograph. Such structures are typical of late stage activities in igneous rocks if the two minerals grew simultaneously, or indicate replacement activity driven by hydrothermal alteration when they develop at different times.

3.2 NW/SE VEINS

The Northwest/Southeast pegmatite veins were predominantly sills and are fewer. They are also products of major brittle deformation. The strike of the studied veins averages between 350^{o}W and 354^{o}W (table 1).The samples studied were typically coarse-grained and bears a few spindle-shape grains of **Sphene (Titanite)** characterized by high relief (fig10). Muscovite in its usual high interference colour was also studied occurring commonly as an inclusion with quartz in feldspar. Microcline Feldspars predominate in the studied samples. Feldspar microstructures such as two-feldspar intergrowths and growth twinning were quite noticeable. The untwinned orthoclase was distinguishable from quartz in PPL by its surface alteration features which was not present in quartz. Quartz grains were nearly equigranular, with feldspar surrounding quartz crystals (fig10).

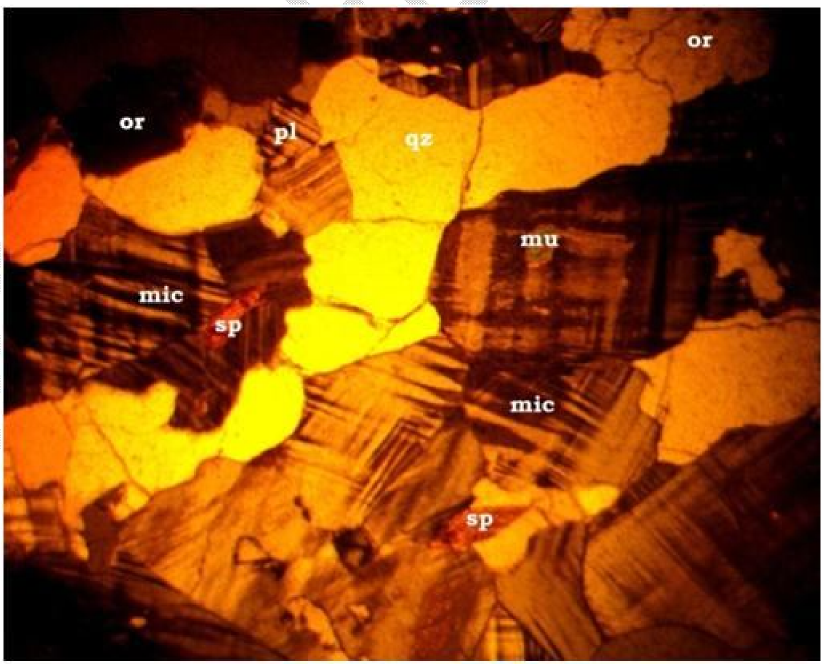

Fig.10 Photomicrograph under xpl showing spindle-shape grains of **Sphene (Titanite)**

4.0 CONCLUSION

Igarra metasedimentary terrain falls within the eastern part of the South-Western block of the Nigerian Basement Complex believed to be Precambrian in age. The area is believed to have evolved as a result modern plate tectonic processes (Burke and Dewey, 1972; Affaton et al, 1992). Igarra is believed to have undergone multiple thermo-tectonic events in the past resulting to the deformation and emplacement of the formations as seen the area. Sericitization and decomposition of feldspars as a result of hydrothermal alteration were all pointers to the impact and effect or indications of the polycyclic deformations that have taken place in the study area in a micro level. Since the Nigeria basement complexes have similar deformation history, and it has been researched and recorded that pegmatite veins in other areas trend similarly in same directions, research should be carried out to ascertain their mineralogy and the deformational episodes they represent. Further works should also be carried out in the area to find out if the pegmatite veins are of the same age. Similarly, research should also be done to know if some of the veins we tag as pegmatites were originally hydrothermal veins deformed by the polycyclic thermo-tectonic events in the area.

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