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Tourmaline and Lithium Ore Mineral Deposits of Oke Ode–Shagbe Area of Ifelodun LGA Kwara State, North Central Nigeria

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Abstract: *The pegmatites of Oke Ode-Shagbe areas are located within longitude 5^0 10' 00'' and 5^0 6' 00'' and latitude 8^0 36' 00'' and 8^0 39' 40''. This investigation is aimed at identifying possibility of mineralization with respect to tourmaline and lithium bearing minerals and other minerals in the study areas. Geological, petrographic and geochemical studies conducted identified five main rock types; the muscovite schist, biotite gneiss, biotite granite, porphyritic granites and pegmatites. The pegmatites show that the grade and quality of minerals within them increases from those close or hosted within the probable parent granitic rocks to those in the swarm of pegmatites further away in the area. Petrographic studies revealed quartz, plagioclase feldspar, microcline, muscovite, whilst the accessory minerals constitute of black tourmaline (schorl), green colour tourmaline (elbaite), muscovite, sericite sphene and zircon in the pegmatites. Comparing the results of geochemical analyses obtained from previous work samples collected on the surface of the pegmaites and present work samples collected at depth of 2-4 m shows the lithium ore (Li_2O) progressively increases in content (Li_2Owt%) as follows; SH1(0.21) > SH3 (0.30) > FM1(0.35) > FM3 (0.45) > FM5 (0.39) > FM8 (0.58) (surface sample) and SH1(0.23) > SH3 (0.33) > SH4(0.44) > FM1 (0.47) > FM2(0.48) > FM3 0.52 > FM4 0.56 > FM5 0.66 > FM7 0.68 >FM 8(1) 0.78 > FM 8(2) 0.78 > FM 8(3) 0.88 > AO1 (1.11) (samples at depth of about 2-4m) respectively. This suggests possibility of high grade lithium bearing minerals in most of the veins at greater depth. Generally, black tourmaline (schorl) and green colour (variety) are found to be in abundance both at surface and at depth of about (2-4m). However; variety of colourful tourmaline (green) were mostly observed at depths of 2-4 m in some pegmatite veins. This also suggests potentiality of high grade tourmaline in most of the pegmatites of the area at greater depth. The relatively low ratio of MgO/(MgO+FeO), high ratio of Na2O/Na2O+CaO) and high Al_2O_3 contents of the samples indicate the pegmatites being sedimentary in origin (provenance). Comparatively, the pegmatites in the study area appear to favour occurrence of tourmaline to lithium ore minerals.*

Keywords: *pegmatite, mineralization, gemstones, lithium ore, tourmaline.*

1.0 INTRODUCTION

This geological investigation was carried out with the view to identify potentials for Lithium bearing minerals, gemstones and other minerals around Oke Ode –Shagbe areas. This is a follow up investigation to a previous work done where samples were collected at the surface of the veins.

1.1 Aim of the study

The main aim of this study is to identify possibility of mineralization with respect to Lithium bearing minerals, gemstones and other minerals within the study area.

1.2 Location and Accessibility

The area covered Oke Ode-Shagbe-Famoli-EriAlaji-AlagbeOja villages in Ifelodun Local Government Area of Kwara state. The site is located within sheet No. 203 SW (Lafiagi), Longitude 5^0 10′ 00′′ and 5^0 6′ 00′′ and Latitude 8^0 36′ 00′′ and 8^0 39′ 40′′. This area covers about 72.6 km^2 and it is access by major roads and foot paths. The sample location coordinates is shown in (Table 1.1).

Table 1.1 Sample Locations and Coordinates

S/NO	COORDINATE		LOCALITY
	LONGITUDE(E)	LATITUDE (N)	
1	5° 4′ 39.12″	8° 38′ 16.67″	Shagbe (SH1)
2	5° 5′ 23.71″	8° 38′ 15.42″	Shagbe (SH4)
3	5° 1′ 55.47″	8° 38′ 31.65″	Famoli (Fm2)
4	5° 1′ 02.54″	8° 39′ 03.13″	Famoli (Fm3)
5	5° 2′ 06.10″	8° 39′ 08.54″	Famoli (Fm4)
6	5° 2′ 07.98″	8° 39′ 06.71″	Famoli (Fm5)
7	5° 1′ 57.04″	8° 38′ 11.07″	Famoli (Fm7)
8	5° 2′ 4.42″	8° 38′ 01.61″	Famoli (FM8(1)
9	5° 2′ 4.49″	8° 38′ 01.69″	Famoli (FM8(2)
10	5° 2′ 4.43″	8° 38′ 01.65″	Famoli (FM8(3)
11	5° 4′ 21.97″	8° 37′ 30.80″	EriAlaji (ER1)
12	5° 4′ 12.79″	8° 37′ 25.41″	EriAlaji (ER2)
13	5° 1′ 42.29″	8° 36′24.27″	AlagbeOja(AO1)

2.0 REGIONAL /GEOLOGICAL SETTING

The general geology of the Nigerian Basement Complex has been described by many authors (e.g. Jones and Hockey, 1964; Rahaman, 1971, 1988; Ajibade, 1980; Dada, 2006). The Nigerian Basement Complex is situated between the West African and Congo Cratons and south of the Tuareg shield (Black, 1980).

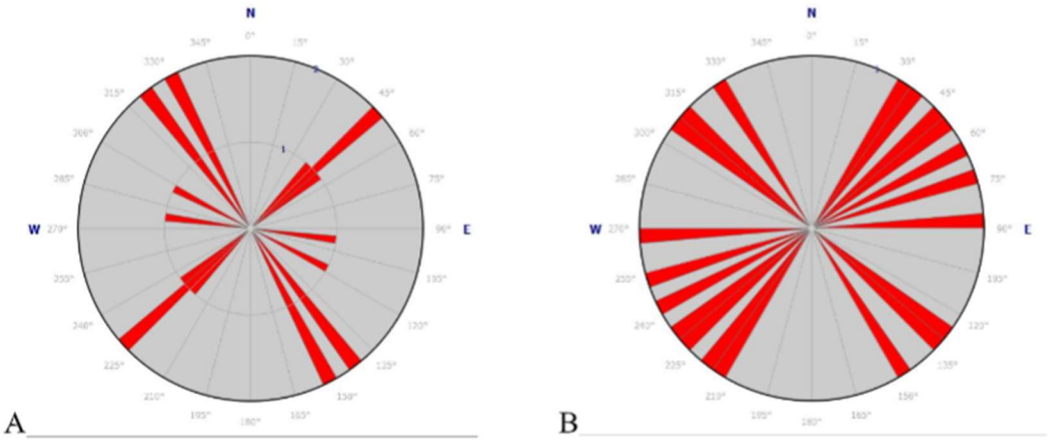
It is described as polycyclic in nature (Ajibade, 1980). Burke and Dewey (1972) suggested that, the Pan African mobile belt evolved by the collision between the passive continental margin of the West African craton and the active continental margin of the Tuareg shield about 600 Ma ago. Dada (2006) concluded that the belt has experienced deformation, thermal reactivation, metamorphism and emplacement of large volumes of granitoids (magmatism) typical of a Himalayan-type during the Pan African Orogeny (600±150 Ma).

3.0 GEOLOGY OF THE STUDY AREA

The Oke Ode-Shagbe-Famoli-Eri Alaji-Alagbe Oja villages lie within the North Central Basement Complex of Nigeria characterized by different rock types consisting of gneisses, muscovite schists, porphyritic granites, and pegmatites. Based on field relationship, the gneisses are found underlying the schist in the area, both the gneisses and schists were intruded by the granites and pegmatites. The veins and dykes of pegmatites are seen in swarm and at other places crosscutting one another. The main structural features observed in the area are folds, fractures, joints and penetrative tectonic foliations. The fractures and joints trend are mainly in the NW-SE, N-S, NE-SW directions (Figure 3.1). These directions in most cases define the trend of the pegmatites in the study area (Figure3.2).

Table 3.1: Fractures and joints readings in rocks of the study area

Fractures			**Joints**		
S/N	**Strike (000^0)**	**Frequency**	**S/N**	**Strike (000^0)**	**Frequency**
1	142	3	1	134	7
2	152	7	2	127	3
3	049	6	3	030	5
4	040	5	4	054	4
5	097	2	5	085	8
6	152	5	6	035	5
7	140	2	7	048	7
8	117	6	8	071	4
9	046	4	9	060	6
10	051	5	10	148	4



Figures 3.1(A &B): Rose diagrams for fractures (A) and joints (B)

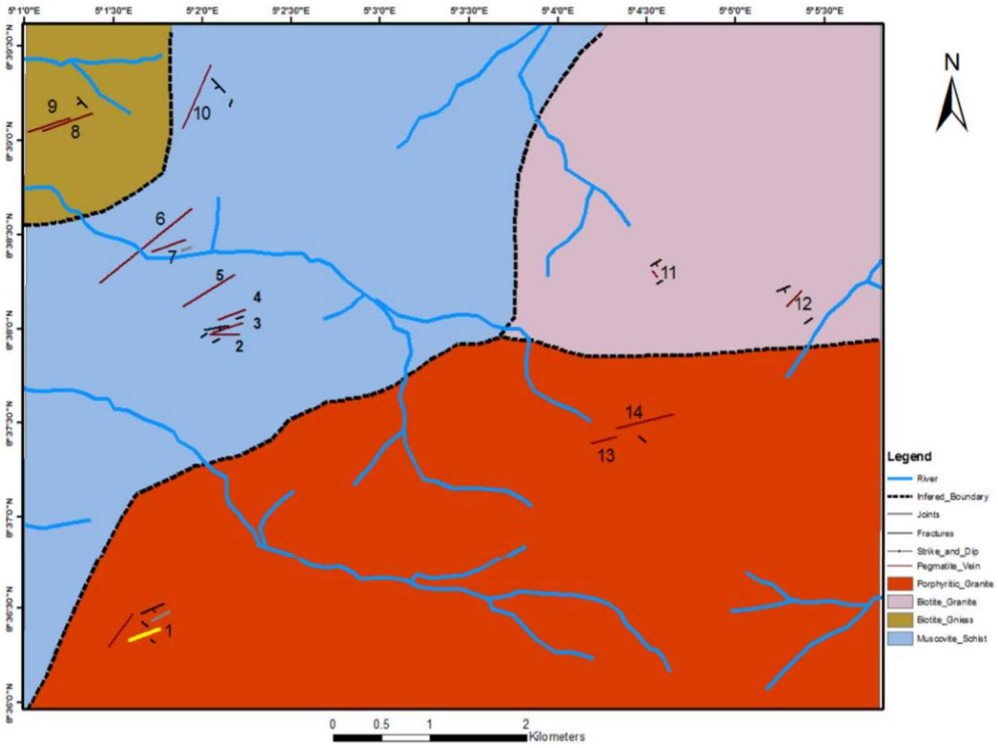


Figure 3.2: Geological map of the study area

4.0 FIELD DESCRIPTION AND PETROGRAPHIC STUDIES OF THE PEGMATITES

Field mapping was carried out to establish the field relationships amongst the rock units in the area. Field features were also identified and their lithology, structure, mineralogy, texture, structures and homogeneity were identified, measured and recorded using some tools such as topographic map, geologic hammer, compass-clinometer and global positioning system (GPS).Twenty-four (24) rock samples were collected, but fourteen (14) were selected and prepared for thin section and analysis. Thin section preparation for petrographic analysis was conducted at Geology and Mining laborato.ry, Nasatawa state university Keffi.

Locality: Shagbe pegmatite (SH4)
Coordinate:5° 5′ 23.71″; 8° 38′ 15.4″
Altitude: 286m
Description of Outcrop:

Dimension: Length about 800m; Width 5m
*Vein trend***:** NE-SW, Strike 40° NE; Dipping 55°SE
*Host rock***:** granite with a sharp contact with the pegmatite.

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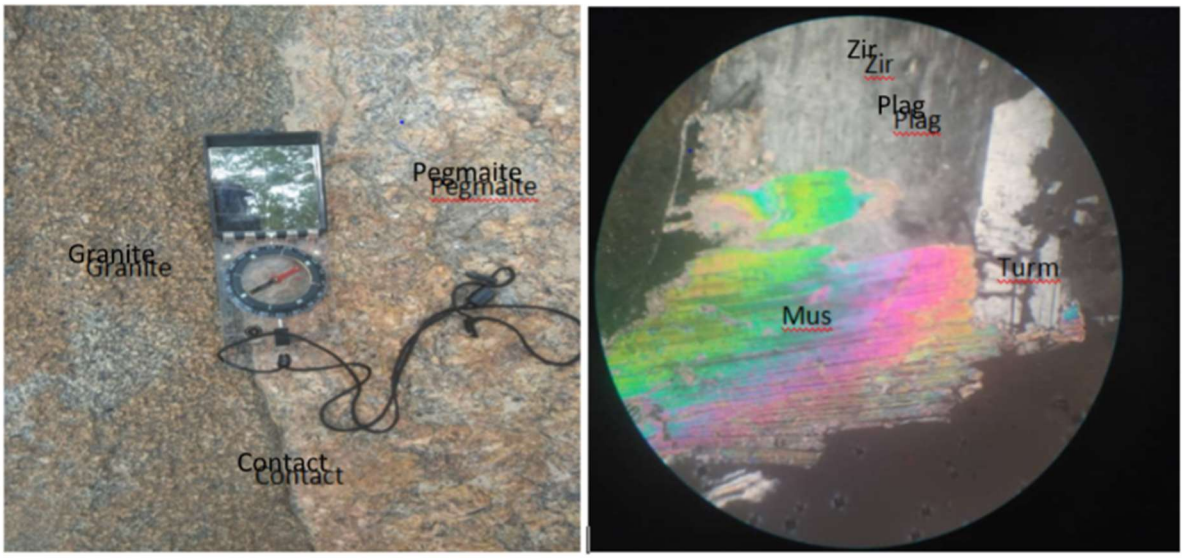


A B

Plates 4.1 (A&B): Field Photograph of contact between host rock (granite) and Shagbe pegmatite (SH4) and Photomicrograph of cross polarized light (XPL)

Thin sections of these samples reveal main minerals such as quartz, plagioclase feldspar, microcline, muscovite, whilst the accessory minerals constitute of black tourmaline (schorl), green colour tourmaline (elbaite), muscovite, sericite, sphene and zircon. These samples showed both primary and secondary mineralizations with the secondary minerals overgrowing the primary minerals. Intergrowths of most mineral crystals are observed especially the early formed crystals of feldspar, muscovite and quartz being cross cut by the younger (later) generations of secondary minerals such as the tourmaline, sericite, sphene and fine specks of muscovite plates 4.1 (B). These later generation minerals are also found interstitial between early crystals and along grain boundaries and microfractures.

This pegmatite vein stretches for about 1km away from the probable parent granitic rock; this pegmatite marks the beginning of the appearance of green coloured tourmaline. This indicates

that the farthest pegmatites are highly evolved containing variety of coloured tourmaline and other associated accessory minerals such as tin and tantalite may be found.

Locality: Famoli pegmatite (FM2)
Coordinates:5° 1′ 55.47″; 8° 38′ 31.65″
Altitude: 229m
Description of Outcrop:

Dimension: Length about 100m; Width 2.5m
*Vein trend***:** NE-SW, Strike 42° NE; Dipping 40°NW
*Host rock***;**muscovite schist.

A B

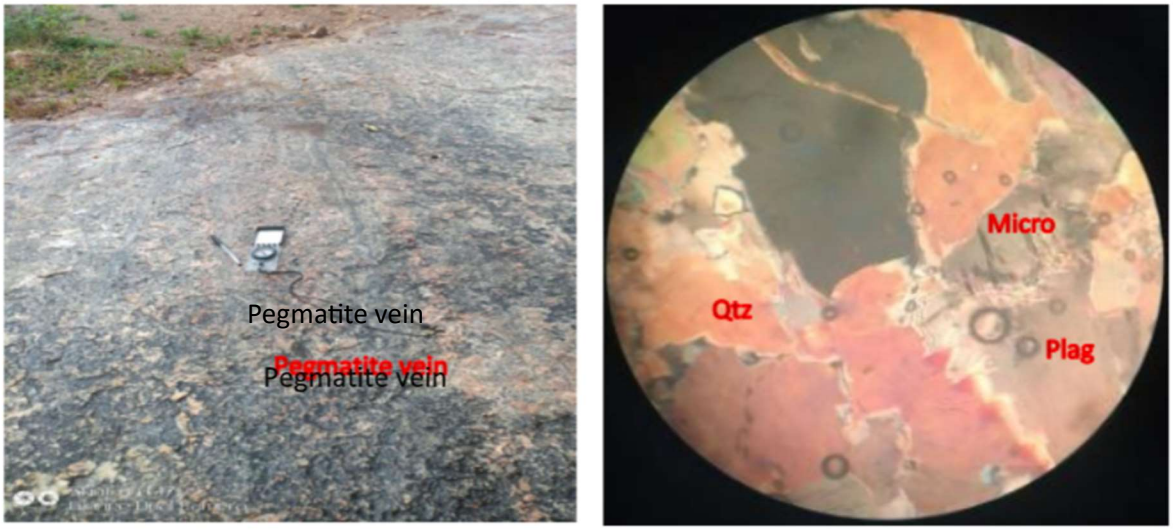
Plates 4.2 (A&B): Field Photograph of (FM 2) and Photomicrograph of cross polarized light (XPL) of (FM 2)

Petrographic analysis reveals main minerals to consist of plagioclase feldspar, microcline, muscovite, quartz whilst the accessory minerals are black tourmaline (schorl), muscovite, sericite plates 4.2 (A& B). Green coloured tourmaline was not observed in this pegmatite sample. These samples showed both primary and secondary mineralizations, with the secondary minerals overgrowing the primary minerals. Intergrowths of most minerals are observed especially the early formed crystals of feldspar, muscovite and quartz. Later generations of secondary minerals such as the tourmaline, sericite, sphene and fine specks of muscovite are found interstitial between early crystals.

The vein was exposed towards the southwestern end. Samples were collected at a depth of about 3-4m. The pegmatite vein is located adjacent to FM1 with a distance of about 30-40 m all trending in NE-SW directions.

Locality: Famoli pegmatite 3 (FM3)
Coordinates:5° 1′ 2.54″; 8° 39′ 3.13″
Altitude: 281.3m
Description of Outcrop:

*Dimension***;** Length about 500m; Width 3m
*Vein trend***:** NW-SE, Strike 150°SE; Dipping 20°NE
*Host rock***;** granitic



A B

Plates 4.3 (A & B): Field Photograph of (FM3) and Photomicrograph of cross polarized light (XPL)

Thin section analysis reveals FM3 to contain major minerals such as quartz, plagioclase feldspar, microcline, black tourmaline (schorl), muscovite, whilst the accessory minerals consist of sericite and opaque minerals. This sample showed occurrence of relicts of large crystal of primary minerals altering to secondary minerals. Some of the secondary minerals contain inclusions of older ones plate 4.3 (B). This pegmatite is hosted by granitic rock. Samples were collected at about 2m depth. Samples from this vein were collected from a hand dug pit at a depth of about 2m.

Locality: Famoli pegmatite 5 (FM 5)
Coordinate: 5° 2′ 7.98″; 8° 39′ 6.71″
Altitude: 284.4m
Description of Outcrop:

*Dimension***;** Length about 700m; Width 3m
*Vein trend***:** NE-SW, Strike 20° NE; Dipping 45°NW
*Host rock***;** muscovite schist

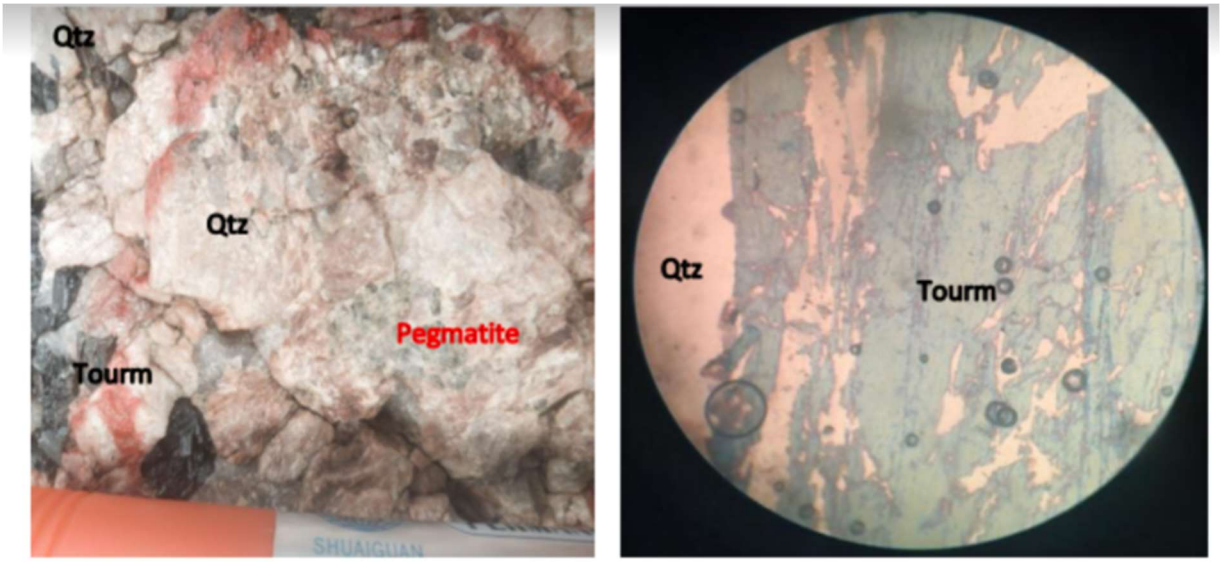
A B

Plates 4.4 (A & B): Field Photograph of (FM 5) and Photomicrograph of cross polarized light (XPL)

Thin section analysis reveal FM5 to contain major minerals such as quartz, microcline, plagioclase feldspar, black tourmaline (schorl), muscovite, whilst the accessory minerals consists of zircon, sericite, sphene and opaque minerals plates 4.4 (A & B). These samples showed occurrence of both older and younger (secondary) minerals resulting from alterations of older crystals. The crystals are tabular and equigranular. It also shows relicts of older crystals of microcline altering to plagioclase and quartz.
This pegmatite is hosted by granitic rock. The pegmatite vein was not exposed and samples were collected by digging to a depth of about 2m.

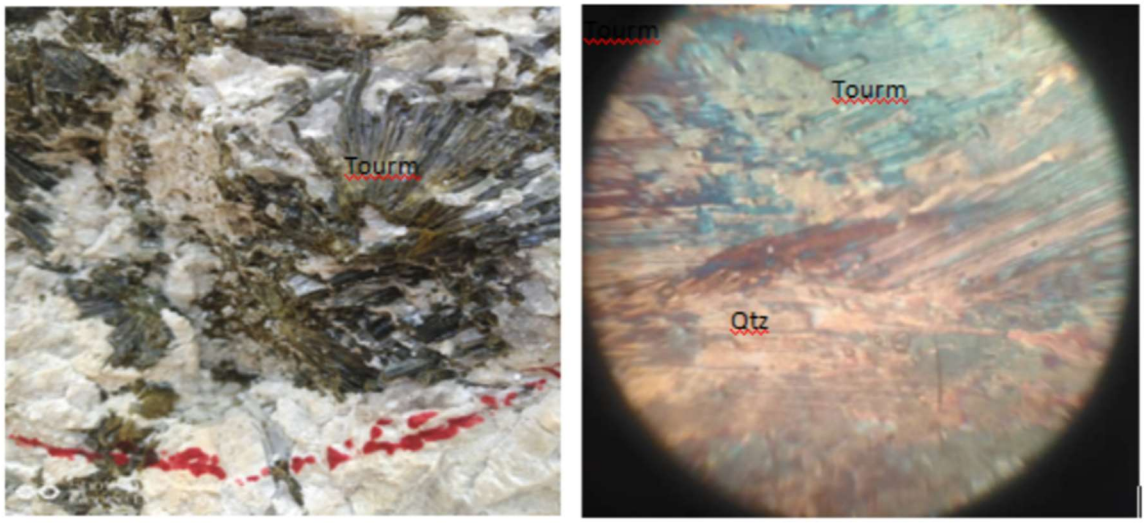
Locality: Famoli pegmatites 8 (FM8 (1)), (FM8(2)), (FM (83)),
Coordinates: (8° 38′ 1.61″; 5° 2′ 4.42″); (8° 38′ 1.69″; 5° 2′ 4.49″);
(8° 38′ 1.65″; 5° 2′ 4.43″)
Altitude: 271.3m
Description of Outcrop:

*Dimension***:** Length about 400m; Width 3.5m
*Vein trend***:** SE-NW, Strike 178°SE; Dipping 75°SW
*Host rock***:** muscovite schist.



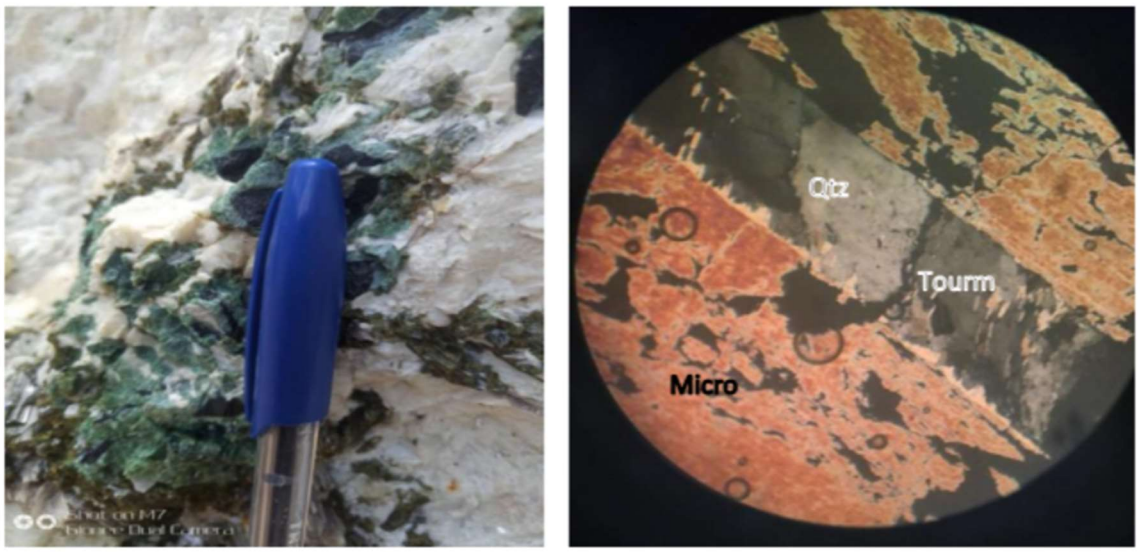
A B

Plates 4.5 (A & B): Field Photograph of FM 8 (1) and Photomicrograph of cross polarized light (XPL)



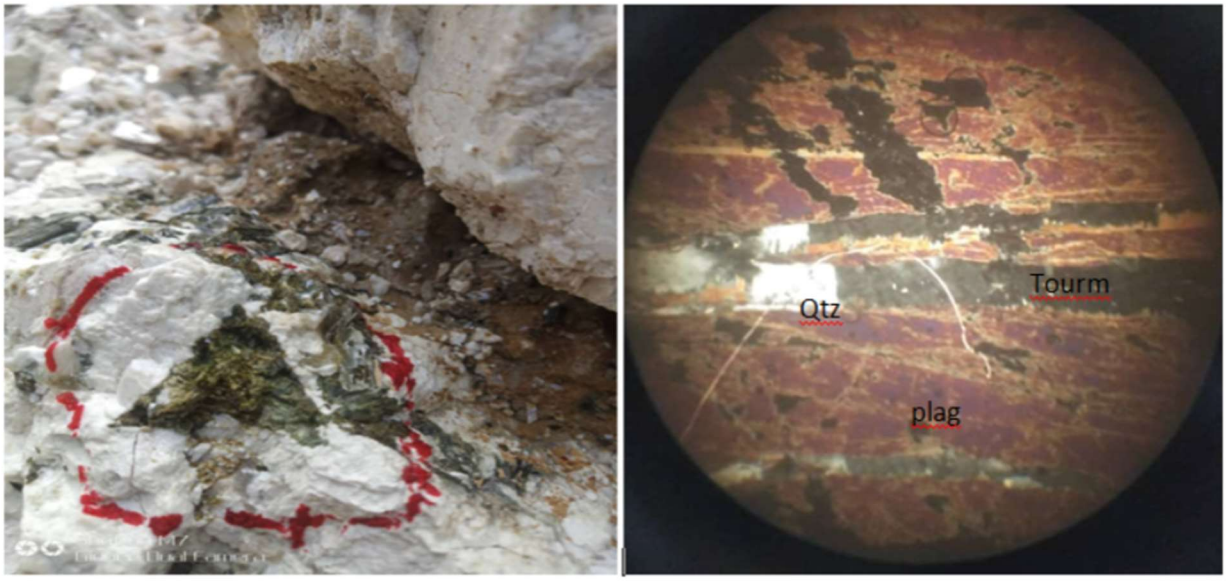
C D

Plates 4.5 (C & D): Field Photograph of FM 8 (2) and Photomicrographof cross polarized light (XPL)



E F

Plates 4.5 (E & F): Field Photograph of FM 8 (3) and Photomicrograph of cross polarized light (XPL)



G H

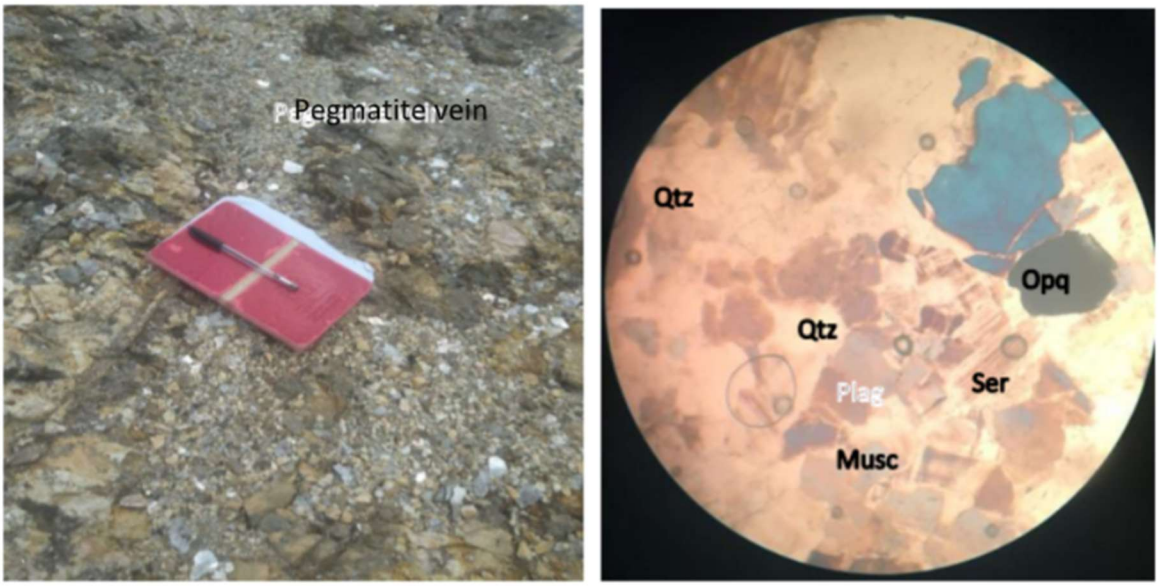
Plates 4.5 (G & H): Field Photograph of FM8 (3)and Photomicrographof cross polarized light (XPL)

Thin section of three samples collected along the veins upper, middle and lower portions. The upper portion is characterized by large crystals of schorls (black tourmaline), and the middle shows abundance of green coloured tourmaline in specks and radial forms at depth of about 4-6m, whilst the lower part contains small crystals of both black and green coloured tourmaline interlocking with fine specks of yellowish muscovite. The middle portion of this pegmatite appears to be more fractionated with predominantly green coloured tourmaline. Other minerals identified in the pegmatites include quartz, feldspar (plagioclase and K-feldspar) and muscovite.

The pegmatite vein was opened from all sides of the pegmatite (i.e. hanging and footwall). The pegmatite vein stretches for about 300-400m with a thickness of 3.5m. The vein exhibits pinch and swell structure with the swelling portion having more tourmaline mineralization (greenish in colour). The tourmaline occurs in radial forms (plates 4.5 (C, D, E & F)) and few reddish coloured tourmaline were also observed.

Locality: Eri Alaji pegmatite 2 (ER2)
Coordinate:5° 4′ 39.12.80″; 8° 37′ 25.40″ Altitude: 271.3m
Description of Outcrop:

Dimension: Length about 700m; Width 10m
*Vein trend***:** NE-SW, Strike 140°SE; Dipping 45°NE
*Host rock***:** porphyritic granite.



Plates 4.6 (A & B): Field Photograph of Eri Alaji pegmatite (ER2) and Photomicrograph of cross polarized light (XPL)

Pegmatite vein

Observation from thin section studies shows the major minerals consist of quartz, plagioclase feldspar, microcline, muscovite, whilst the accessory minerals consists of black tourmaline (schorl), sericite. This sample showed intergrowth of large equigranular crystals altering to secondary minerals. It also contains opaque minerals. This pegmatite is highly jointed/fragmented with scattered boulders all over the place.

Locality: Eri Alaji porphyritic granite1 (ER1)
Coordinate:5° 4′ 21.97″; 8° 37′ 30.80″ Altitude: 271.1m
Description of Outcrop:

*Dimension***:** Length about 50m; Width 3.5m (massive)
*Vein trend***:** NE-SW, Strike 145°SE; Dipping 54°NE
*Rock type***:** porphyritic granite.

Plates 4.7 (A & B): Field Photograph of Eri Alaji porphyritic granite1 (ER1) and Photomicrograph of cross polarized light (XPL)

Thin section studies reveal that the major minerals found are quartz, plagioclase feldspar, microcline, whilst the accessory minerals consist of muscovite, sericite sphene. This sample showed intergrowth of most minerals with quartz. The large grain sizes of feldspar and quartz are generally tabular (phenocryst) whilst the matrix is mainly muscovite, quartz and plagioclase. These are observed especially the early formed crystals of feldspar, muscovite and quartz plates 4.7 (A & B). This porphyritic granite based on proximity and similarity in mineral and chemical composition with the pegmatites appears to be the parent rock to the swarm of pegmatites in the area.

5.0 GEOCHEMISTRY

Fourteen (14) selected pegmatite samples collected at depth (2-4m) were analyzed for Li_2O wt % content using Flame photometry(Flame Photometer PN7) analytical technique, whilst eight whole rock samples were analyzed for major and trace element contents in (wt % and ppm) using EDXRF analytical technique conducted at geochemical laboratory, Geology Department Gombe State

University, Nigeria. The results obtained were processed and presented in Tables 5.2 and 5.3 whilst, table 5.1 is the result of the previous work (obtained from samples at the surface) for comparison.

Table 5.1: Concentration of Li_2O in some Pegmatites samples collected from the surface in the study area (Previous work)

S/N	Sample ID	Li_2O CONC.IN MASS%	Type of rock
1	SH1	0.21	Pegmatite vein
2	SH3	0.30	Pegmatite vein
3	FM1	0.37	Pegmatite vein
4	FM4	0.45	Pegmatite vein
5	FM5	0.39	Pegmatite vein
6	FM8	0.58	Pegmatite vein

Table 5.2: Concentration of Li_2O in some pegmatites samples collected at depth of about 2-4m of the study area

S/N	Sample ID	Li_2O CONC.IN MASS%	Type of rock
1	SH1	0.23	Pegmatite vein
2	SH3	0.33	Pegmatite vein
3	SH4	0.44	Pegmatite vein
4	FM1	0.47	Pegmatite vein
5	FM2	0.52	Pegmatite vein
6	FM3	0.78	Pegmatite vein
7	FM4	0.48	Pegmatite vein
8	FM5	0.68	Pegmatite vein
9	FM7	0.56	Pegmatite vein
10	FM8(1)	0.78	Pegmatite vein
11	FM8(2)	0.88	Pegmatite vein
12	FM8(3)	0.66	Pegmatite vein
13	AO1	1.11	Pegmatite vein

Table 5.3: Major and trace element concentration in (ppm) of the rocks of the study area

S/N	Sample ID	Na_2O	Al_2O_3	Si_2O	K_2O	CaO	MgO	Fe_2O_3	P_2O_5	MnO	TiO_2	Li_2O	$Na_2O/(Na_2O+CaO)$	$MgO/(MgO+Fe_2O_3)$
1	ER2	2.07	11.5	71.0	8.94	1.49	1.34	1.42	ND	ND	0.0164	0,53	0.59	0.49
2	SH1	1.48	11.6	67.1	10.9	1.94	0.93	0.88	2.81	0.32	0.003	0.44	0.43	0.51
3	SH3	1.25	9.3.6	72.0	9..90	2.04	1.57	1.14	3.10	0.41	0.024	0.35	0.38	0.58
4	SH4	1.94	10.6	71.1	11.9	0.94	2.11	0.68	2.28	0.I0	ND	0.44	0.67	0.76
5	FM1	1.48	10.5	33.9	14.5	0.75	0.75	0.36	2.01	0.024	0004	0.93	0.67	0.68
6	FM2	0.77	12.4	73.0	7.82	1.17	1.21	1.87	2.01	0.001 5	0.0823	0.52	0.40	0.39
7	FM3	1.57	7.84	78.6	2.33	1.08	2.02	4.44	1.89	1.13	0.0172	0.78	0.60	0.31
8	FM4	2.09	11.0	63.1	2.31	1.08	1.85	3.27	2.98	1.53	0.0032	0.83	0.66	0.36
9	FM5	2.27	10.8	73.2	1.73	0.98	2.24	4.85	2.27	2.81	0.0677	0.68	0.70	0.32
10	FM7	2.55	9.55	68.0	17.9	0.84	0.63	1.21	1.87	0.21	0,002	0.73	0.75	0.34
11	FM8(1)	3.94	15.7	71.9	2.28	0.77	0.53	1.52	2.48	0.281	ND	0.78	0.84	0.26
12	FM8(2)	1.98	12.6	63.8	17.5	0.45	0.83	0.44	1.87	0.054	ND	0.88	0.82	0.65
13	FM3(3)	2.38	8.56	82.1	2.71	0.69	0.68	0.55	2.10	0.896 1	ND	0.66	0.78	0.79
14	AO1	3.11	9.01	69.4 5	2.02	0.44	0.83	0.21	1.94	0.55	0.043	0.42	0.87	0.80

Cont'd

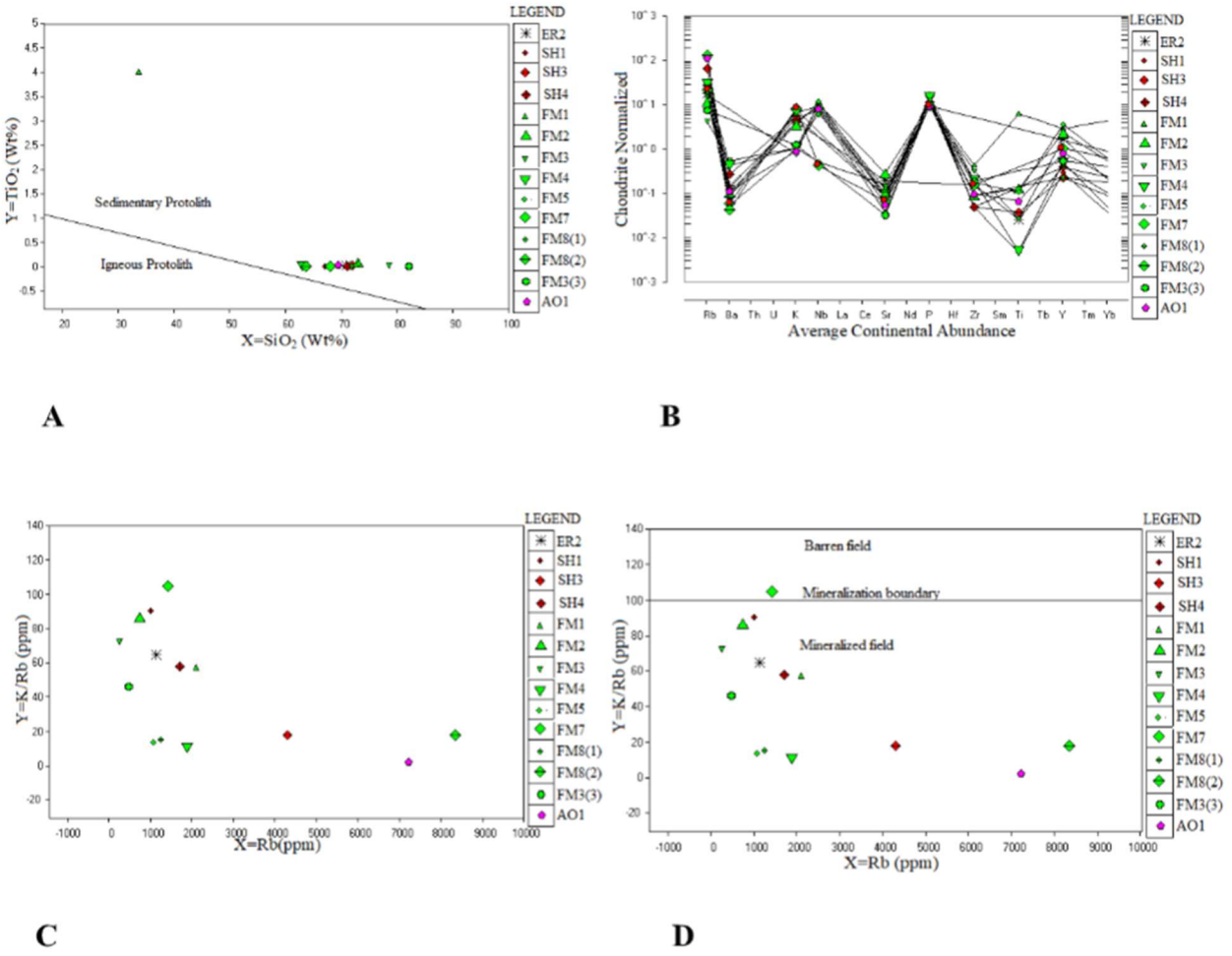
Table 5.3: Major and trace element concentration in (ppm) of the rocks of the study area

S/N	Sample ID	Ta	Zr	Ni	Y	Pb	Ba	Ag	Zn	Cu	Rb	Cs	Ga	Sn	Nb	Sr
1	ER2	ND	35.3	8.41	25.2	338	111	38.2	53.8	4270	1150	ND	53.8	7.77	ND	103
2	SH1	72.9	10.9	26.3	4.33	65.9	101	52.1	48.9	39.97	1002	54	62.0	12.3	103	19.8
3	SH3	56.8	10.9	26.3	3.32	42.1	65	9.32	34.0	112	4310	43.9	110	16.8	124	43.2
4	SH4	ND	10.9	26.3	5.87	71	202	11.9	12.9	47.5	1720	ND	39.2	17.2	ND	45.2
5	FM1	83.1	98..0	34.3	43.0	61.2	66.3	10.2	20.1	25.9	2119	52.0	42.1	18.2	129	44.8
6	FM2	ND	20.1	34.4	34.5	42.1	79.6	10.5	24.6	230	752	ND	76.9	19.0	147	153
7	FM3	36.3	71.8	35.1	6.07	66.7	407	14.9	28.0	555	268	ND	37.3	17.1	143	67.5
8	FM4	114	43,9	9.67	7.3	5,43	321	12.8	34.8	329	1896	11.8	63.1	18.5	89.7	53.1
9	FM5	108	39.2	27.9	52.7	88.4	ND	7.82	224	48.4	1070	10.5	67.9	10.5	163	51.2
10	FM7	41.0	34.2	21.8	15.1	54.2	43.8	9.23	198	38.9	1420	9.76	43.9	12.3	5.87	34.8
11	FM8(1)	39.8	19.8	21.4	3.33	66.5	39.8	11.1	164	85.9	1250	23.9	155.0	23.9	7.05	84.3

12	FM8(2)	ND	ND	6.45	ND	73.2	32.9	11.6	ND	42.1	8370	17.6	40.3	17.6	ND	45.2
13	FM3(3)	ND	41.4	30.0	8.17	30.0	ND	10.9	2.67	118	491	3.53	33.8	3.53	ND	17.5
14	AO1	52.1	21.9	23.0	12.3	54.8	84.9	10.43	9.22	184	7231	4.10	28.9	15.8	112	29.9

6.0 THE PROVENANCE AND RELATIONSHIPS AMONGST THE ROCKS OF THE STUDY AREA

This section shows the provenance/origin and relationship of amongst the rocks of the study area



Figures 6.1 (A, B, C &D): (A) the plot of TiO_2 vs SiO_2 (Chappell and White, (1974)). showing the provenance of the rocks, (B) the spider diagram showing Chondrite Normalised vs Average Continental Abundance (C) the plot of K/Rb vs Rb and (D) the plot of K/Rb vs Rb showing the relationship amongst the rocks

The plots of TiO_2 vs SiO_2 (Figure 6.1(A)) shows that the granite and pegmatites fall within the sedimentary protolith field, and the spider diagram of Chondrite Normalised vs Average Continental Abundance (Figure 6.1(B)) suggest that both the granites and the pegmatites, have sedimentary provenance. The plots of K/Rb vs Rb (Figures 6.1 (C)) and (D) also shows the relationships amongst the rocks of the study area as well as their potential for mineralization.

7.0 MINERALIZATION POTENTIALS

Field observations show the relationship amongst pegmatites and granitic rocks within the study area (Figures 3.2 & 6.1(C). The pegmatites occur as swarms with the main veins trending mainly in the NE-SW and minor off shoots mostly trending in the same direction with the main veins, whilst at other places crosscutting obliquely in the NW-SE or E-W directions. The major veins stretch for about 500-800m and 2-10m thick exhibiting thin and swell shapes where hosted by schists, and tabular and sharp contacts characterized by schorls if emplaced within granitic rocks. The pegmatites are mostly dipping in varying angles ranging from 40-80° in both SW and N directions.

7.1 Lithium Ore Minerals Potential

In the study area mineralizations with respect to lithium ore are mainly restricted to the pegmatite veins. Although not all the pegmatite veins in the area are mineralized with respect to lithium ore bearing minerals (lepidolite, spodumene or amblygonite), however even those that show presence of lithium ore minerals (spodumene) also indicate possibility of having higher concentration at greater depths. It was also observed along the veins that concentration varies; it is highest within swells and low where it pinches out. Samples of impure spodumene (kunzite) show white to dirty white colour (Figure 4.4A). The crystals also changes with depth, and becomes more compacted and hard.

Since it is observed that the grade of the lithium contents progressively increases from the surface (Table 5.1) to a shallow depth of about 2-4m (Table 5.2). It therefore implies that more mineralized lithium ore minerals (lepidolite or spodumene) may be encountered at greater depths. This is evident by the progressive increase in concentration of Li_2O wt% comparing the results of the previous work (Table 5.1) to present work (Table 5.3) which ranged from 0.21-0.58wt% (samples collected from the surface) and 0.23-1.11wt% (samples collected at depth of 2-4m) respectively. It is also observed that associated minerals such as feldspars (plagioclase and orthoclase) and mica are found to contained significant concentrations.

7.2 Gemstone (tourmaline) Mineral Potentials

From the geological, petrographic and geochemical analyses it is observed that there is a prevalence of variety of tourmaline in most of the pegmatites in the area. It appears there are two generations of tourmaline variety in most of the pegmatite veins; the first is the schorl (black) tourmaline commonly found intergrowing with the early formed crystals of feldspars and quartz (plates 4.5 (A&B). Whilst the second generation is the elbaite (geen coloured) variety, mostly found overgrowing the early crystals of quartz, feldspars and muscovite. (plates 4.5 (C&D) and (plates 4.5, E&F). Both field and Petrographic analyses show almost all the pegmatite veins in the area contain tourmaline (plates 4.1-4.5). However the green variety of tourmalines are mostly found in the core of pegmatite veins such as FM5, FM8(1), FM8(2) FM(3).

Geochemical results show that most of the rocks in the area are peraluminous that is having aluminous content (Al_2O_3) higher than (Na_2O+K_2O+CaO) suggesting S-type granitoids sources, which commonly known to be associated with tourmaline mineralization (Tanko, 2014). Also the relatively high content of Li_2O in almost all the pegmatites of the study area suggest possibility of

occurrence of high grades and more colourful varieties at greater depth as it is common with most north central pegmatite fields (Tanko, 2013;Tanko, 2014; Tanko *et al*., 2015). From table 5.3 above it is also seen that trace elements concentration ranges as follows Mn (0.0015 to 2.81ppm), Cu (42.1 to 4270ppm), Zn (2.67 to 224ppm), Sr (17.5 to 153ppm), Sn (3.53 to 23.9ppm) , Ba (32.9 to 407 ppm), Pb (30.0 to 338 ppm), Ni (6.45 to 35.1ppm), Ga (33.8 to 155.0ppm). These relatively high contents of trace elements in the pegmatites of the study area further suggest potentiality of tourmaline occurrence. Furthermore, the low ratio of MgO/(MgO+FeO), relatively high ratio of (Na_2O/Na_2O +CaO) and high Al_2O_3 contents of the samples suggest the pegmatites being sedimentary in origin.

8.0 CONCLUSION

The preliminary investigations of the site for this project has been successfully carried out. Based on the results of the preliminary investigations carried out the following conclusions are made:

1) The investigations show that grade and quality of mineralization in the pegmatites of the study area increases from the probable parent granitic rock to the swarm of pegmatite further away in the area.

2) Comparing the results of geochemical analyses obtained from previous work (Table 6.1) samples collected on the surface of the pegmaites and present work (Table 6.2) samples collected at depth of 2-4 m of the pegmatites show the mineral being sought for lithium ore (Li_2O) progressively increase in content (Li2O wt%) as follows: SH1(0.21) > SH3 (0.30) > FM1(0.35) > FM3 (0.45) > FM5 (0.39) > FM8 (0.58) (surface sample) and SH1(0.23) > SH3 (0.33) > SH4(0.44) > FM1 (0.47) > FM2(0.48) > FM3 0.52 > FM4 0.56 > FM5 0.66 > FM7 0.68 >FM 8(1) 0.78 > FM 8(2) 0.78 > FM 8(3) 0.88 > AO1 (1.11) (samples at depth of about 2-4m) respectively. This suggests possibility of high grade lithium bearing minerals in most of the veins at greater depth.

3) Generally, black tourmaline (schorl) and green variety (elbaite) are found to be in abundance both at surface and at depth of about (2-4m). However; the green tourmaline were mostly encountered at depth of about 2-4 m at core of most pegmatite veins. This also suggests potentiality of high grade tourmaline in most of the pegmatites of the area at greater depth.

4) The relatively low ratio of MgO/(MgO+FeO), high ratio of Na_2O/(Na_2O+CaO) and high Al_2O_3 contents of the samples suggest the pegmatites being sedimentary in origin (provenance).

5) Comparatively, the pegmatites in the study area appear to favour occurrence of tourmaline to lithium ore minerals.

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