Petrochemical Characteristics of Granitic Rocks in Leiktho-Naplawkaw Area, Thandaung Township, Karen State

Chaw Su Hlaing[1], Myat Thuzar Soe[2] and Tun Tun Min[3]

Abstract

Leiktho-Naplawkaw area is situated in northern part of Thandaung Township in Karen State. It lies between latitudes 19˚13"30" N to 19˚15"00"N and longitude 96˚35'10"E to 96˚38'30"E in one inch topographic map number is 94 A/12. The total area coverage is about 17.92 square kilometers. The study area is covered by igneous, meta-igneous and meta-sedimentary rock units. The igneous rocks are biotite granite, porphyritic biotite granite with minor amount of gneissose granite, microgranite dyke, diorite dyke and microdiorite dyke. The granitic rocks in the study area are possible emplacement during the Late Cretaceous to Early Eocene. The representative igneous rock samples (including diorite, microdiorite and biotite granite) were selected for chemical analysis. By the petrochemical analysis data, the wt% of SiO_2 is high in granite (67.4-69.67) and all the granitic rocks from the study area fall in the calc-alkaline series and peraluminous field. The liquids temperatures are 705ºC, 710ºC, 720ºC and 920ºC for biotite granite, diorite and microdiorite, respectively. Biotite granite probably crystallized at the depth ranging from 22km to 24km, diorite differentiated at the depth 26km and microdiorite crystallized at the depth 34km.

Keywords: Leiktho, petrochemistry, paraluminous, calc-alkaline

Introduction

Location and Size

The present study area lies in the eastern most part of Yedashe Township, north-eastern part of Taungoo Township in Bago Region and northern part of Thandaung Township in Karen State. It is situated between latitudes 19° 13' 30" N to 19° 15' 00"N and longitudes 96° 35' 10" E to 96° 38' 50" E. The area is bounded by vertical grids 30 to 34 and horizontal grids 08 to 15 in one inch topographic map no. 94 A/12 (Fig. 1). It extends about (3.2km) along the N-S and (5.6km) along the E-W, with an approximate (17.92) square kilometers of aerial coverage.

Topography and Drainage

Topographically, most of the study area can roughly be regarded as a mountainous rugged terrain with the exception of a lower hilly region which is made up of metasedimentary rocks. The mountainous rugged terrains for the most parts are covered by granitic rocks. The highest peak of the study area is at 3750' (1143 m) and the lowest contour is at 2079' (663.7 m) above sea level. In the study area, dendritic patterns are well developed.

Zale Chaung and Thakho Chaung are the main streams of the study area. Zale Chaung is flowing from north to south and Thakho Chaung is flowing from east to west.

Regional Geologic Setting

The area under investigation is situated within the western margin of Shan Scarp., The area under investigation is generally bounded by the Eastern Highland, comprising Paleozoic units in the east, and bounded by younger Tertiary sedimentary rock units in the west. The study area can be divided into two units' viz., the older metasedimentary rocks in the

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easternmost part and the younger intrusive in the central and western parts. The granitic and metamorphic rocks of this area lie within the Mogok belt of Searle and Haq (1964) extending from Putao to Martarban, measuring about 1450 km in length and 50 km in width. Some metamorphic rocks of this area from a part of Mawchi belt: One of the seven metamorphic belts of Myanmar established by Maung Thein (1985), composed of schists, gneisses, quartzites and marbles. They are mostly low to medium grade and regarded as a northern continuation of the metasedimentary rocks of Mawchi area. In the eastern part, the older Paleozoic rocks and in the western part the younger Paleozoic rocks are exposed. They are so called Mawchi Series (Metamorphosed Lower Carboniferous rocks). The granitic rocks of the study area belong to Taungoo granitoids (Khin Zaw, 1986).

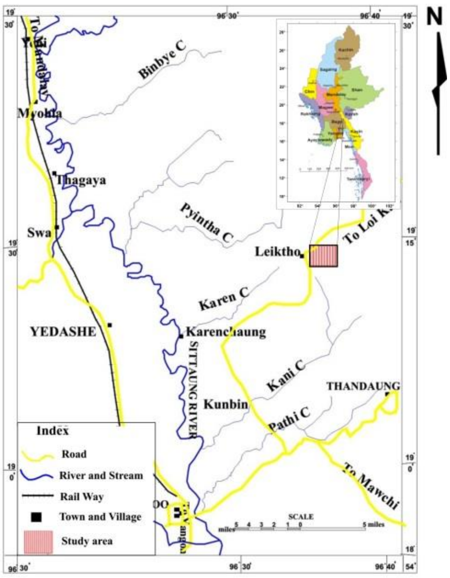

Figure (1). location map of the study area

Geology

Table (1). Rock sequences of the study area

Description	**Age**
Alluvium	Quaternary
~~ Unconformity ~~~~~~~~~	
Igneous and Metaigneous Rocks	
Diorite and Microdiorite dyke Microgranite dyke	Late Oligocene
Gneissose Granite Biotite Granite Porphyritic Biotite Granite	Late Cretaceous to Early Eocene
Metasedimentary Rocks	
Phyllite Quartz schists intercalated with phyllite Biotite schists intercalated with quartzite	Early Paleozoic

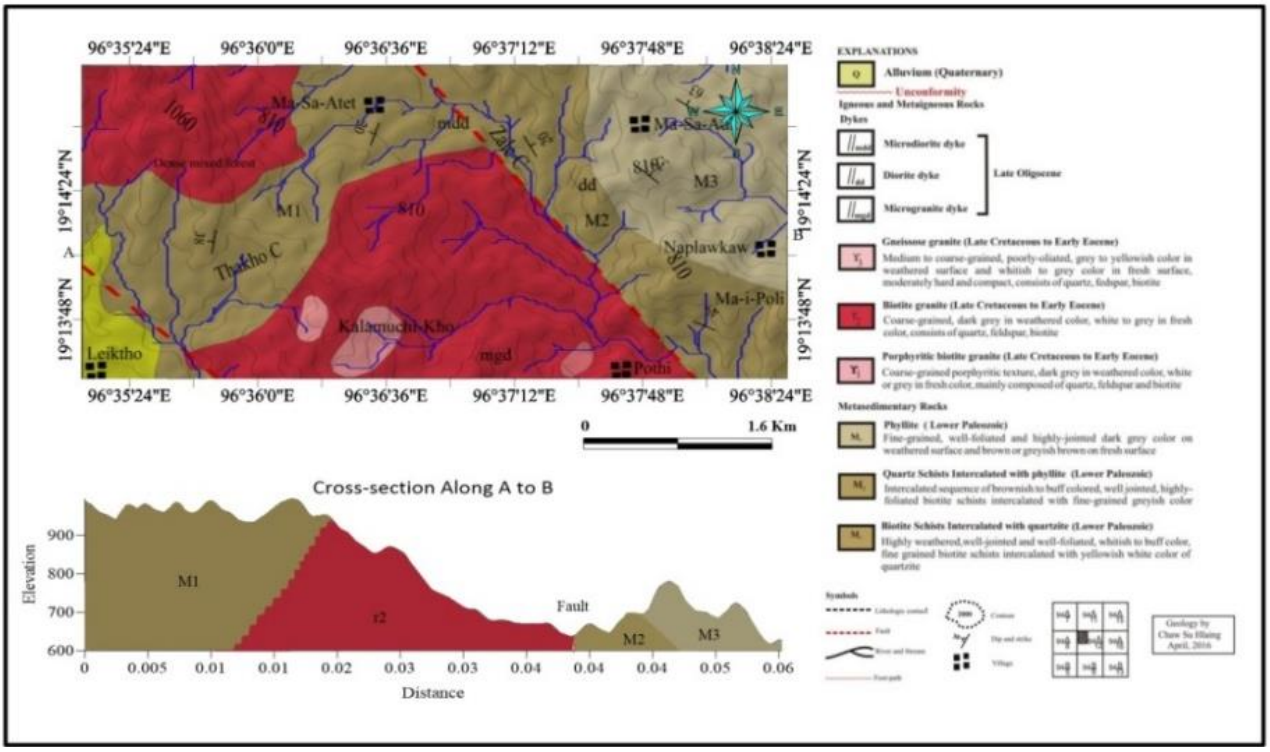

Figure (2): Geological Map of the study area

Petrochemistry

Analytical Methods

The representative igneous rock samples (including 4 biotite granite, 1 diorite and 1 microdiorite) from the study area were selected for analysis. Six samples were sent to the petrochemical laboratory of Geological Research Centre of Mandalay University. Fresh rocks were collected for analyzing XRF. The major oxide abundances were determined by X-ray fluorescence spectrometry.

Table (2). Location and rock type of the examined samples

Sample No:	Location	Rock unit
C3	N: 19° 13' 12.3" E: 96° 37'46.7"	biotite granite
C6	N: 19° 13' 15.1" E: 96° 36'35.7"	biotite granite
E1	N: 19° 13' 17.0" E: 96° 37'32.2"	biotite granite
D5	N: 19° 14' 49.7" E: 96° 37'3.3"	biotite granite
D2	N: 19° 14' 49.5" E: 96° 36'49.6"	microdiorite
D7	N: 19° 14' 41.4" E: 96° 37'10.5"	diorite

Table (3). Major oxide (Wt %) of the igneous rocks from the study area

Sample No	**C3**	**C6**	**E1**	**D5**	**D2**	**D7**
SiO_2	69.36	69.29	67.4	69.67	50.32	55.66
Al_2O_3	15.47	15.95	15.7	15.77	17.83	18.02
Fe_2O_3	2.19	2.58	3.5	2.14	95.5	7.36
MgO	0.36	0.43	0.5	0.32	4.22	2.79
MnO	0.06	0.052	0.1	0.07	0.19	0.17
CaO	1.59	1.74	1.8	1.54	6.86	5.34
Na_2O	4.53	3.31	3.5	3.30	3.15	2.29
K_2O	5.74	5.62	6.15	6.38	5.26	5.86
P_2O_5	0.12	0.16	0.21	0.16	0.56	0.67
TiO_2	0.19	0.024	0.3	0.32	1.34	0.96
Cr_2O_3	-	-	-	-	-	0.02
Total	99.60	99.87	99.16	99.67	99.3	99.13

Table (4). Standard CIPW Normative Minerals of the igneous rocks of the study area

Sample No	C3	C6	E1	D5	D2	D7
Quartz	17.982	24.822	19.663	22.810	0.000	6.375
Albite	38.476	28.242	29.861	28.021	12.158	19.541
Corundum	0.000	1.655	0.520	1.022	0.000	0.000
Diopside	1.369	0.000	0.000	0.000	3.141	0.000
Ilmenite	0.129	0.046	0.216	0.150	0.219	0.36
Sphene	0.302	0.000	0.000	0.000	0.000	0.377
Olivine	0.000	0.000	0.000	0.000	2.955	0.000
Orthoclase	34.049	33.489	36.645	37.822	16.777	34.922
Anorthite	4.944	7.650	7.620	6.615	10.243	21.766
Apatite	0.285	0.382	0.502	0.380	0.716	1.601
Hypersthene	0.265	1.080	1.256	0.800	0.000	7.007
Magnetite	0.000	0.101	0.000	0.000	0.000	0.000
Hematite	2.198	2.532	3.529	2.147	51.549	7.423
Rutile	-	-	0.189	0.242	-	0.621
Total	100.000	100.000	100.000	100.000	98.279	100.000
DI	90.507	88.209	86.688	89.666	30.143	60.838
CI	6.499	8.407	8.500	7.176	16.399	26.678

DI – Differentiation Index of Thornton and Tuttle (1960)

CI – Crystallization Index of Poldervaart and Parker (1965)

Table (5). Standard CIPW Normative Minerals with Biotite and Hornblende of the igneous rocks of the study area

Sample No	C3	C6	E1	D5	D2	D7
Quartz	18.625	25.494	20.798	23.696	1.191	6.801
Albite	38.393	28.230	29.760	27,922	20.292	19.362
Corundum	0.000	1.686	0.903	1.427	0.000	1.030
Ilmenite	0.129	0.046	0.215	0.150	0.218	0.363
Sphene	0.467	0.059	0.740	0.785	1.763	2.354
Olivine	0.000	0.000	0.000	0.000	0.000	0.000
Hypersthene	0.000	0.000	0.000	0.000	0.000	0.000
Hornblende	0.000	0.000	0.000	0.000	23.314	15.921
Biotite	1.191	1.431	1.659	1.056	12.471	10.205
Orthoclase	33.147	32.477	35.364	36.964	11.459	20.187
Anorthite	4.934	7.563	6.545	5.480	15.176	14.757
Apatite	0.285	0.382	0.500	0.379	0.711	1.586
Magnetite	0.000	0.101	0.000	0.000	0.000	0.000
Wollastonite	0.634	0.000	0.000	0.000	1.507	0.000
Spinel	0.000	0.000	0.000	0.000	0.000	0.000
Hematite	2.194	2.531	3.517	2.140	12.211	7.355
Total	100.000	100.000	100.000	100.000	100.000	100.000

Chemical Characteristics of Igneous Rocks

The igneous rocks of the study area are biotite granite, diorite and microdiorite. There are ten major oxides found in these selected samples. They are Na_2O, MgO, Al_2O_3, SiO_2, P_2O_5, K_2O, CaO, TiO_2, MnO and Fe_2O_3. The biotite granite from south western part of Zale Chaung show high composition of SiO_2 (67.4-69.67 wt %) and for the others, Al_2O_3, (15.7-15.95); Fe_2O_3, as total iron, (2.14-3.5); TiO_2, (0.19-0.34); MnO, (0.06-0.07); CaO, (1.54-1.8); Na_2O, (3.30-4.53); K_2O, (5.74-6.38) and P_2O5, (0.12-0.21) See Table 3. The diorite has different chemical compositions from the biotite granites. The diorite exhibit low content of SiO_2 (55.66 wt %) and TiO2 (0.96 wt %); high content of Al_2O_3 (18.02 Wt %), MgO (2.79 Wt %) and CaO (5.34 Wt %) See Table 3. The microdiorite exhibit low content of SiO_2 (50.32 Wt %) and high content of Al_2O_3 (17.88 Wt %), MgO (4.22 Wt %), CaO (6.86 Wt %) and TiO_2 (1.34 Wt %) See Table 3.

In Harker's variation diagram, figure (3), Al_2O_3, TiO_2, Fe_2O_3, CaO, MgO, MnO and P_2O_5 are negatively correlated with SiO_2. Na_2O and K_2O are positively correlated with SiO_2.

TAS diagram after (Cox *et.al.,* 1979) figure (4), shows four groups of igneous rocks and the dividing line between alkaline and subalkaline magma series. The igneous rocks from the study area generally range from acid to intermediate group and belong to alkaline affinity.

In the normative Ab-Or-An diagram (O' connor 1965) figure (5), biotite granite fall in the granite field and diorite and microdiorite fall quartz monzonite field.

The AFM diagram after (Irvine and Baragar 1971) figure (6), shows that the granites of the study area fall in the Calc-alkaline series.

The biotite granites are predominantly peraluminous with low aluminium saturation indexes (ASI) of A/CNK (Al_2O_3/ ($CaO+Na_2O+K_2O$) mol) and A/NK (Al_2O_3/ (Na_2O+K_2O) mol) ranging from (0.99-0.1.1) figure (7). The diorite and microdiorite displays a low alumina saturation index A/CNK (Al_2O_3/ ($CaO+Na_2O+K_2O$) mol) ranging from (0.75-0.9) while the A/NK (Al_2O_3/(Na_2O+K_2O) mol) ranging from 1.9 to 2; belonging to metaluminous (Fig. 8).

Type of Granites

Granite is a common type of intrusive, felsic, igneous rock which is granular in texture. This rock consists mainly of quartz, feldspar and mica.

Geochemical analysis data have been plotted on various diagrams to distinguish I-type and S-type granitic rocks of the study area. The molecular A/CNK vs SiO_2 diagram shows that the granitic rocks involve S-type. This diagram defines A/CNK>1.1 as S type and A/CNK<1.1 as I type. According to the Chappell and White, granite can be classified as S-type granite. By the petrochemical analysis data, the Wt% of SiO_2 is high in granite (67.4-69.67) and all the granitic rocks from the study area fall in the peraluminous field.

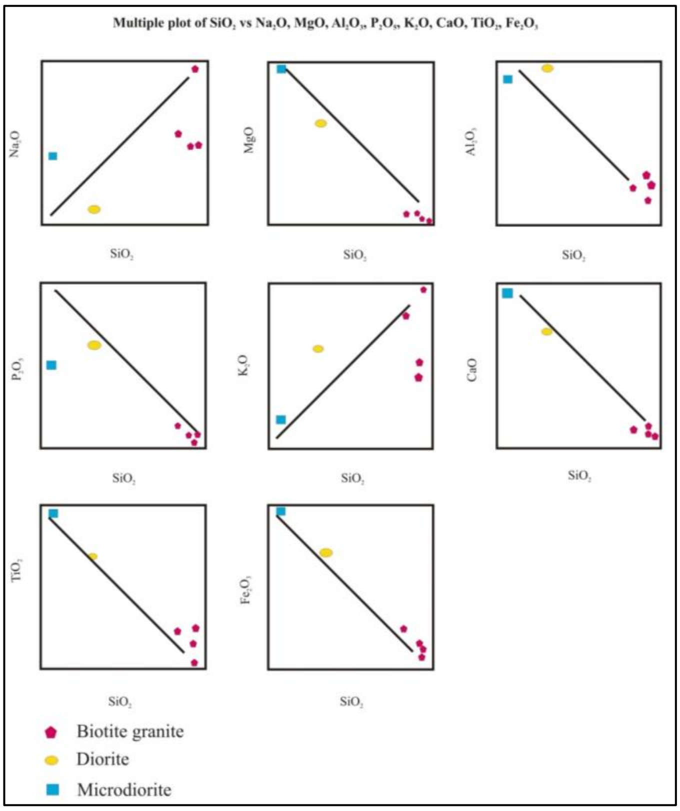

Figure (3). Haker's Variation diagram illustrating major oxides vs SiO_2 of the Igneous rocks from the study area

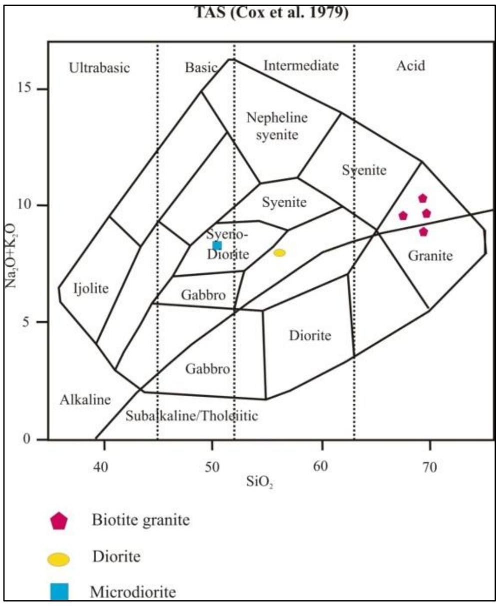

Figure (4). Total Alkali vs Silica (TAS) diagram, Cox *et.al*., (1979) showing alkaline series and the granitic rocks from the study area fall in the granite field

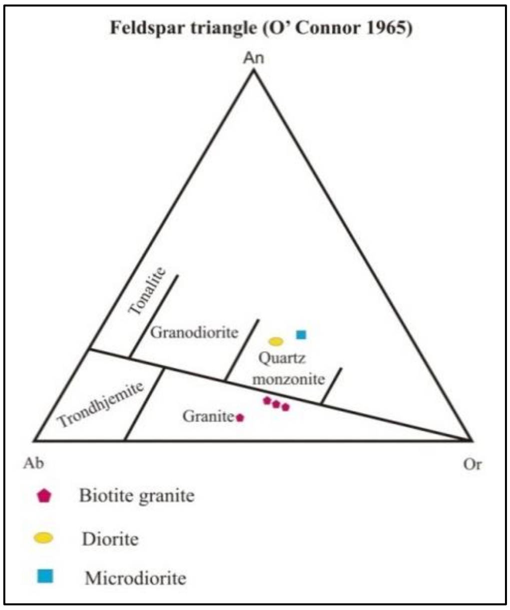

Figure (5). Normative Ab-Or-An diagram for the igneous rocks of the study area(After O' Connor, 1965)

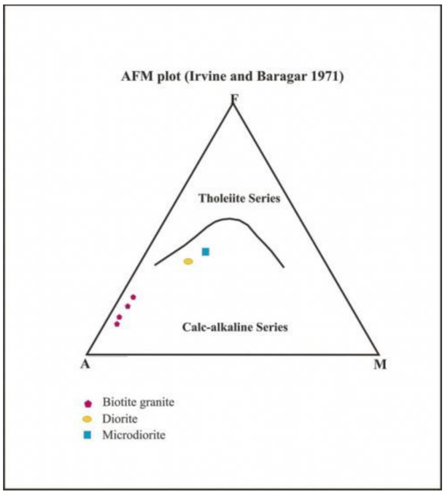

Figure (6). FeOl- (Na2O+K2O)-MgO (AFM) diagram distinguishing Tholeitic and Calc alkaline (after Irvine and Baragar, 1971)

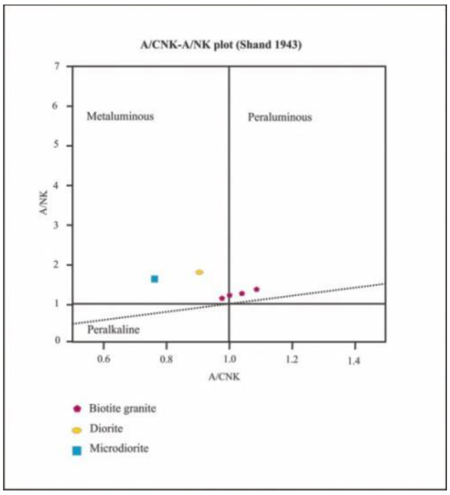

Figure (7). A/NK vs A/CNK diagram showing the peraluminous character of igneous rocks from the study area (after Shand, 1943)

Conditions During the Crystallization of Igneous Rocks

If the igneous rocks have crystallized at minimum pressure of 2kb, their liquidus temperatures can be estimated from the diagram showing the relationship between differentiation index and temperature at 2kb water pressure, figure (9). From this diagram, the liquidus temperatures are 705ºC, 710ºC, 720ºC and 920ºC for biotite granite, diorite and microdiorite, respectively.

Depth of the crystallization of the igneous rocks can be stated from the schematic depth-temperature (after Marmo, 1969), figure (10). Biotite granite probably crystallized at the depth range from of 22km to 24km, diorite differentiated at the depth 26km and microdiorite crystallized at the depth 34km.

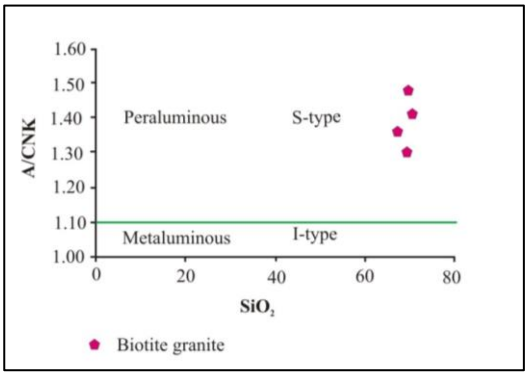

Figure (8). SiO_2 vs $Al_2O_3/CaO+Na_2O+K_2O$ (A/CNK) diagram for the igneous rocks of the study area, (after Chappell and White, 1974) Symbols as in Table 3

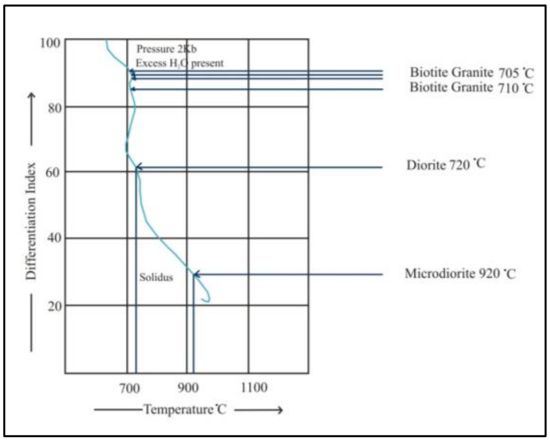

Figure (9). Temperature-differentiation index diagram for the igneous rocks of the study area, at 2kb water pressure (after Piwinskii and Wyllie, 1970)

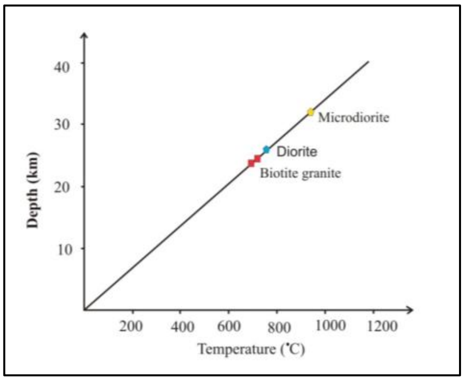

Figure (10). Schematic depth-temperature relation diagram for the igneous rocks of the study area, after Marmo (1969) Symbols as in Table (4)

Tectonic Discrimination of Granitic Rocks (Using Major Elements)

The chemistry and mineralogy of peraluminos granitic rocks indicate the tectonic settings and geologic occurrence. The tectonic environment for the granitic rocks of the study area, can be studied according to Maniar and Piccoli (1989). They categorized the granitic rocks by tectonic environments as follows:

Orogenic Granitoids

(a) Island arc granitoid (IAG)

(b) Continental arc granitoid (CAG)

(c) Continental collision granitoid (CCG)

(d) Post orogenic granitoid (POG)

AnorogenicGranitoids

(e) Rift-related granitoid (RRG)

(f) Continental epirogenic uplift granitoid (CEUG)

(g) Oceanic Plagiogranite (OP).

The tectonic discrimination of granitic rock is based on the major element chemistry. Various discrimination plots are presented which sequentially discriminate the different tectonic environments.

In SiO_2 versus K_2O variation diagram figure (11), the granitic rocks of the study area fall in the IAG+CAG+CCG+ REE+ CEUG+ POG field. Plots of MgO vs FeO[t] and CaO vs FeO+MgO variation diagram figures (12) and (13). show that the granitic rocks of the study area fall within the IAG+ CAG+ CCG and REE+CEUG field. According to the Shan's Index diagram, all granitic rocks fall in CAG and CCG field, figure (14).

According to the above mention facts, all granitic in the study area are mostly confined to the CCG field. It can safely be considered that the granitic rocks were formed on the continent owing to the subduction of an oceanic plate beneath the continent.

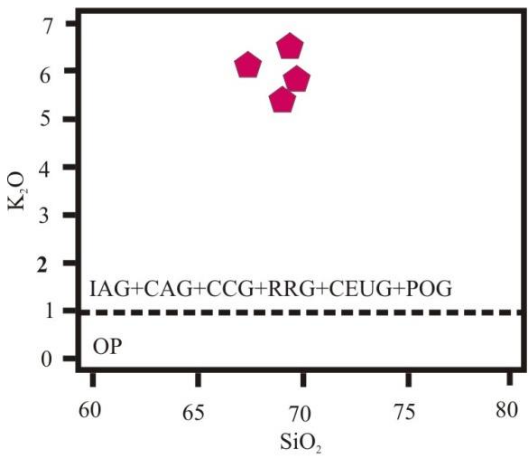

Figure (11). SiO_2 Vs K_2O diagram showing the environment of granitic rocks from the study area (after Maniar and Piccoli, 1989)

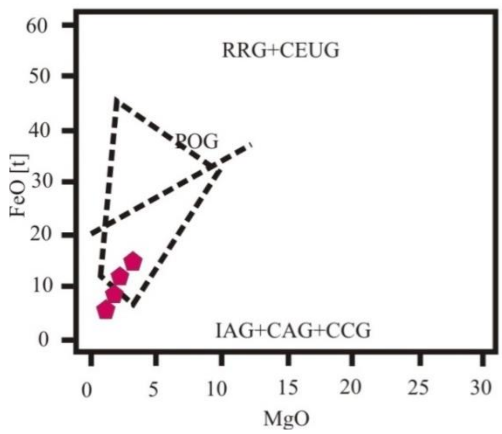

Figure (12). MgO vs FeO[t] diagram showing the environment of granitic rocks from the study area (after Maniar and Piccolo, 1989)

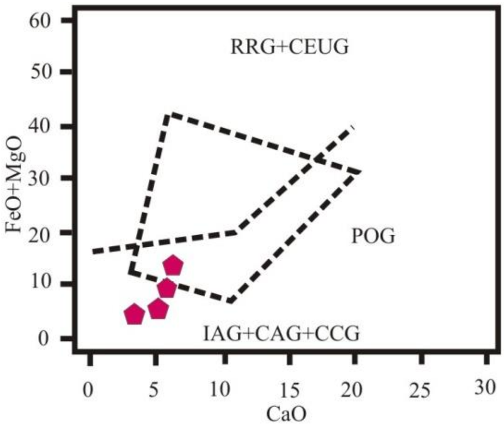

Figure (13). Shan's Index diagram for granitic rocks of study area, which fall within the CAG and CCG field

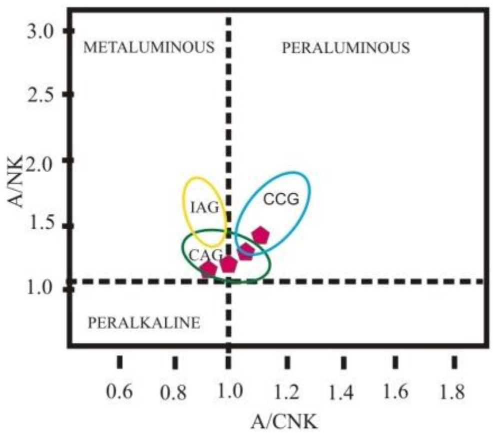

Figure (14). Shan's Index diagram for granitic rocks of study area, which fall within the CAG and CCG field

Summary and Conclusion

The study area is situated in Thandaung Township, Karen State. It is located between Latitudes 19° 13' 30" N to 19° 15' 00"N and longitudes 96° 35' 10" E to 96° 38' 50" E. It lies between horizontal grids 08 to 15 and vertical grids 30 to 34 in one inch topographic map No 94 A/12. The study area occupies within western margin of Shan Scarp. It can be divided into two units viz., the older metasedimentary rocks in the eastern most part and the younger intrusive in the central and western parts. The study area is bounded by the Sagaing strike slip fault in the west and Shan scarp fault in the east.

The study area is mainly composed of metasedimentary rock, igneous rock and metaigneous rocks. Metasedimentary rocks consist of (i) biotite schists intercalated with quartzite, (ii) quartz schists intercalated with phyllite and (iii) phyllite unit. Igneous rocks include biotite granite, porphyritic biotite granite and with minor amount of microgranite dyke, diorite dyke and microdiorite dyke. Metaigneous rock consists of gneissose granite. According to the aerial photo interpretation, two fault systems are recognized in the study area. Zale Chaung Fault (F1) and Thakho Chaung Fault (F2) normal fault are trending NNW-SSE direction.

The representative igneous rock samples (including diorite, microdiorite and biotite granite) were selected for chemical analysis. By the petrochemical analysis, data, the wt% of SiO_2 is high in granite (67.4-69.67) and all the granitic rocks from the study area fall in the calc-alkaline series and peraluminous field. According to tectonic discrimination diagram, the granitic rocks of the study area, fall within the CAG and CCG field. The genetic type in the Leiktho-Naplawkaw area is recognized as S-type according to the mineral and petrochemical characteristics. In Harker's variation diagrams, Al_2O_3, TiO_2, Fe_2O_3, CaO, MgO, MnO, and P_2O_5 are negative correlated with SiO_2 and Na_2O and K_2O are positively correlated with SiO_2.

If the igneous rocks have crystallized at minimum pressure of 2kb, their liquidus temperatures can be estimated from the diagram showing the relationship between differentiation index and temperature at 2kb water pressure. From this diagram, the liquidus temperatures are 705ºC, 710ºC, 720ºC and 920ºC for biotite granite, diorite and microdiorite, respectively.

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