Yadanabon University Research Journal, 2019, Vol-10, No.1

Petrographic Characters of the Granitic Rocks in the Momeik-Myitson Area, Northern Shan State: Criteria for Depth of Emplacement

Naing Lin*

Abstract

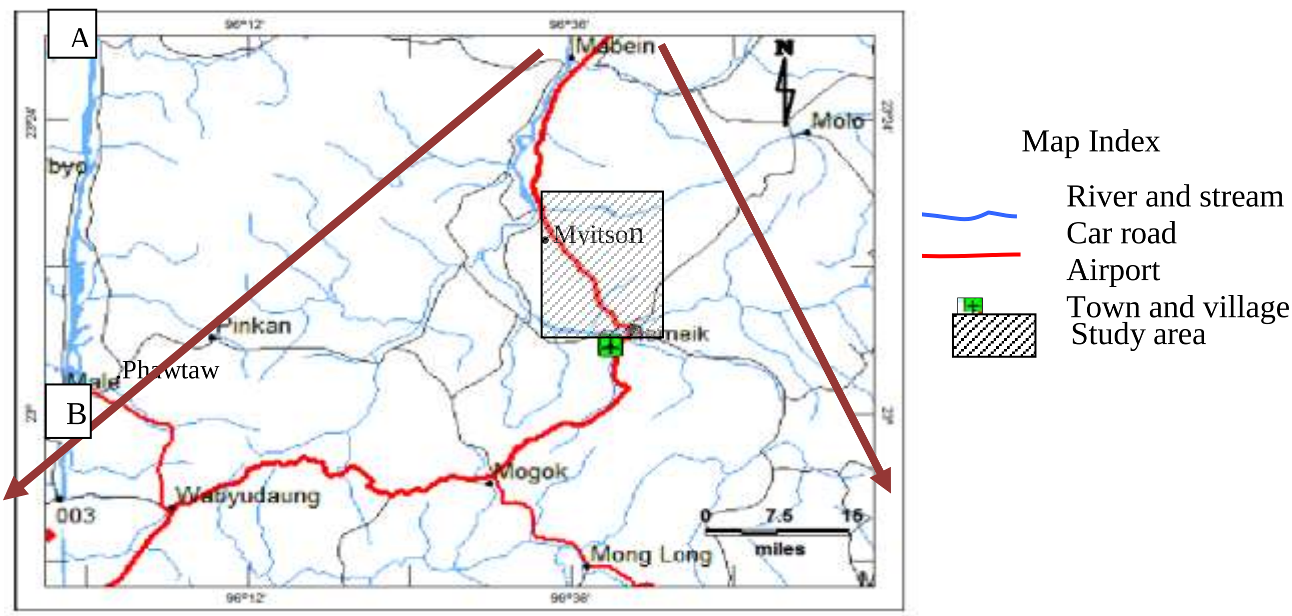
The research area is situated within the northern adjacent part of the Momeik Town. It is constituted chiefly of metamorphic (metapelite, metacarbonate and metaigneous) and associated igneous rocks. The present work deals to describe the petrographic characters of granitic rocks and to investigate the depth of emplacement of granitic rocks based on not only geochemical data but also field observations. From the microscopic examination, the cooling temperature of the granitic rocks generally decreases from south to north. Based on geochemical data, the liquidus temperatures for the granitic rocks are 630 ^{o}C for biotite microgranite, 620 ^{o}C for leucogranite and 610 ^{o}C for tourmaline granite. The depth of crystallization of the granitic rocks of the study area interpreted from the schematic depth-temperature relation diagram might be assumed 21 km for tourmaline granite, 22 km for leucogranite and 23 km for biotite microgranite. Based on field criteria, the granitic rocks of the Momeik-Myitson area might have emplaced either in the upper level of mesozone or lower level of epizone.

Keywords: *petrography, geochemical data, emplacement, Momeik, metapelite, metacarbonate, mineral assemblage, petrography*

Introduction

The study area, the northern continuation of Mogok Metamorphic Belt, is situated within the northern adjacent part of the Momeik Town. The area is bounded by latitude 23°9' N to 23°19'N and longitude 96°32' to 96°43'E in one inch to one mile scale topographic maps of 93-A/11 and 93-A/12. It covers approximately about 285 square kilometer with 18 km in length and 16 kilometer in width of rugged and mountainous terrains (Fig.1-A).

The Mogok Metamorphic Belt included in the study area is mainly composed of metamorphic (metapelite, metacarbonate and metaigneous) and associated igneous rocks. The main objectives of this work are to describe the petrography and to interpret the depth of emplacement of the granitic rocks on the basis of petrochemical evidences and detailed field observation.



* Lecturer, Dr., Department of Geology, Yadanabon University

Yadanabon University Research Journal, 2019, Vol-10, No.1

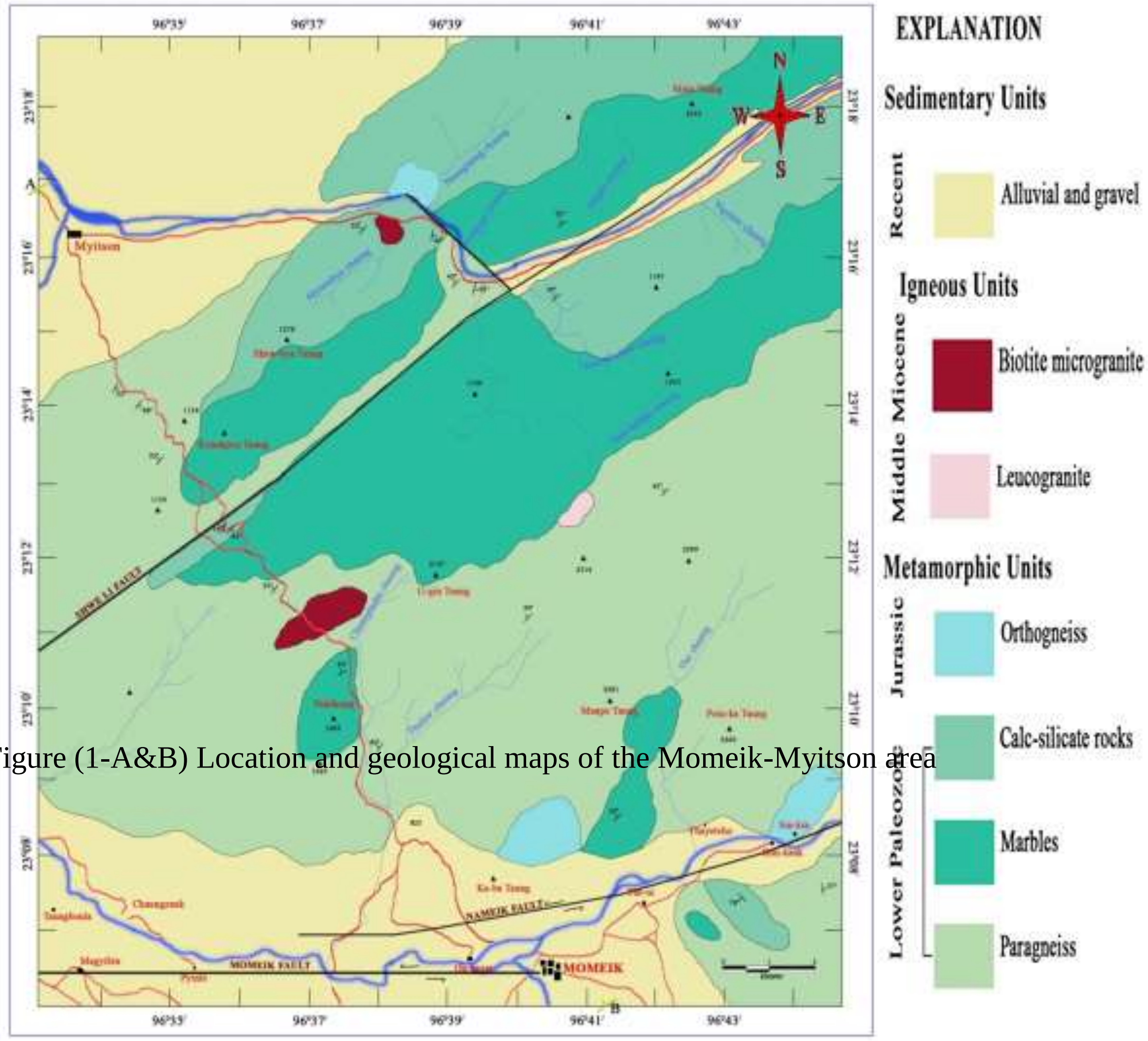
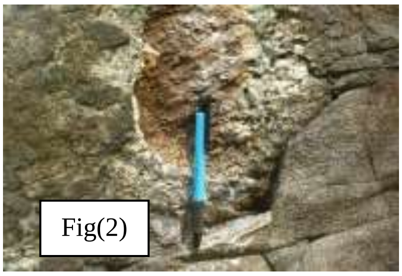


Figure (1-A&B) Location and geological maps of the Momeik-Myitson area

Distribution of the Petrographic units

The most abundant metamorphic rocks occupied in this area are : metapelites (garnet-biotite gneiss, biotite gneiss, silliminite schist and biotite schist); metacarbonate units (forsterite-graphite marble, phlogopite marble, diopside marble, white marble and diopside calc-silicate rock); metaigneous rocks (Orthogneiss). The exposed igneous rocks in the study area are the younger intrusives which are mainly granitic in composition including tourmaline granite, leucogranite and biotite microgranite. Toumaline granite occurs as sporadic unmappable exposures in the vicinity of Sin-Kin village at the southern part of the area (Fig-2). Leucogranite is well exposed at the central part (Fig-3). Biotite microgranite is well cropped out at the central and the northern part of the study area (Fig-4).

Yadanabon University Research Journal, 2019, Vol-10, No.1



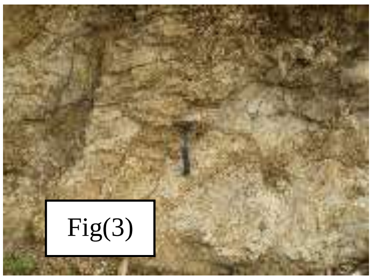


Fig. (2) Tourmaline granite intruded into silliminite schist near Sin-Kin village
Fig. (3) Highly weathered and jointed leucogranite exposed beside the Momeik-Myitson car-road.
Fig. (4) Exfoliated spheroidal blocks of biotite-mrcrogranite on the left side of Momeik-Molo car-road west of U-gin Taung

Depending upon the available field relationship, structural and stratigraphic evidences, the rock sequence arranged in decending order in age is shown in Table (1) and their distributions are shown in geological map of the study area in Figure (1-B).

Table (1) Rock sequence of the Momeik-Myitson area

	Lithologic Units		**Age**
	Sedimentary Unit		
	Alluvium and gravely soil		Recent
	Igneous Unit		
Metagranitoid	Leucogranite		
	Biotite microgranite		Miocene
	Toumaline granite	unconformity	
	Metamorphic Unit		
Metapsammite and metapelite	Biotite Gneiss		Late Jurassic-Early Cretaceous
	Skarn rock		
	Quartzite		
	Biotite Schist		
	Silliminite Schist		
Metacarbonate	White Marble		
	Diopside Marble		
	Diopside calc-silicate rocks		Early Paleozoic
	Phlogopite Marble		
	Forsterite-graphite Marble		
Paragneiss	Biotite gneiss		
	Garnet-biotite gneiss		

Petrography

For petrographic study, more than twenty thin-sections were cut from various representative rock samples collected from the investigated area and ten representative fresh rock samples which lack alteration were carefully selected for the petrochemical analysis.

Based on the constituent mineral assemblages, the granitic rocks in the investigated area are tourmaline granite, leucogranite and biotite microgranite.

Petrography of toumaline granite

Microscopically, **toumaline granite** is essentially composed of quartz, orthoclase (commonly perthite), plagioclase and tourmaline. A small amounts of hornblende, apatite, magnetite and zircon are also present. In this slide, myrmekitic texture in which worm-like quartz grains are present along the marginal zone of quartz and feldspar (Fig.5), and patchy zoning of plagioclase are observed. Zoned plagioclase enclosed within the perthitic orthoclase indicates that the plagioclase was earlier crystallized than the perthitic orthoclase (Fig.6).

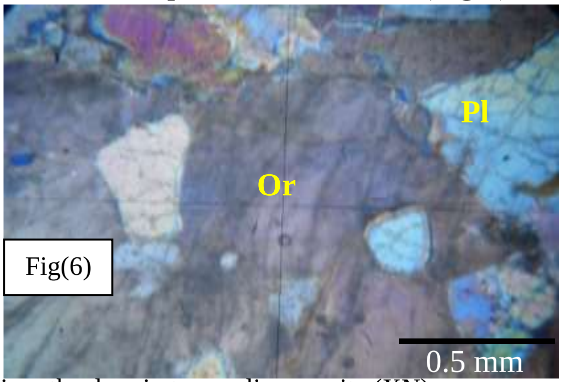
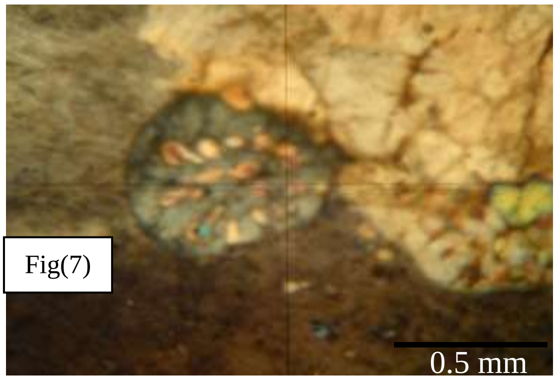


Fig. (5) Myrmekitic texture along the margin of perthitic orthoclase in tourmaline granite.(XN)
Fig. (6) The zoned plagioclase enclosed within the perthitic orthoclase in tourmaline granite.(XN)

Petrography of leucogranite

Under the petrological microscope, this rock consists principally of felsic constituents - quartz, orthoclase, microperthite and plagioclase. Mafic constituents of magnetite and apatite are rare but observed in minor amounts. In this slide, The intergrowth of quartz with plagioclase may be seen as myrmekitic texture (Fig.7) and perthitic orthoclase in the structure of patch type is also found (Fig.8). Alling (1932) suggested that the string type forms at highest temperature, and the film, vein, and patch types form at successively lowed temperature (see, reference to Wahlastrom, 1950, in Thet Tun, 2009). Therefore, the cooling temperatures of the granites generally decrease from south to north.



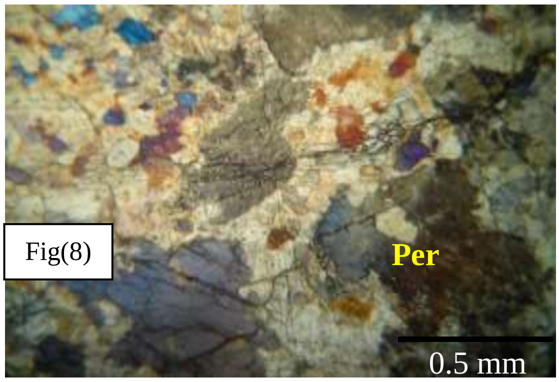
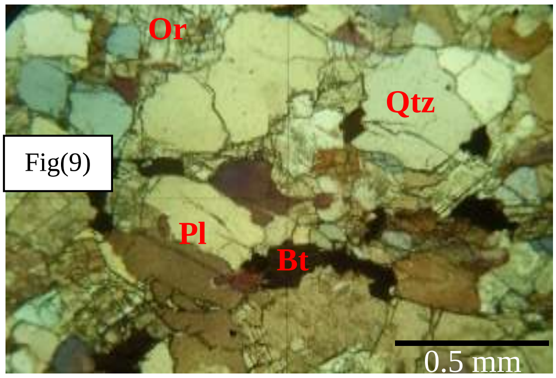


Fig. (7) Myrmekitic texture of quartz and feldspar intergrowth in the leucogranite. (XN)
Fig. (8) Patch perthite in the porphyritic leucogranite. (XN)

Petrography of biotite microgranite

In this section, biotite microgranite is essentially composed of quartz, orthoclase, plagioclase, biotite and hornblende. Magnetite, apatite and zircon are the accessory minerals. The texture is medium-grained and hypidiomorpic granular in general (Fig.9). In some places, numerous inclusions of anhedral quartz grains, euhedral biotite flakes, zircon, apatite and magnetite show poikilitic texture (Fig.10).



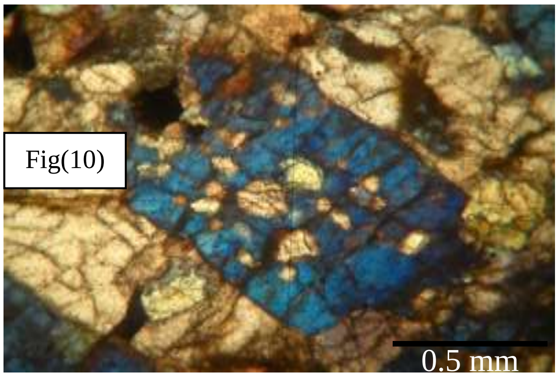


Fig. (9) Photograph showing hypidiomorphic granular texture in biotite microgranite. (XN)
Fig. (10) Quartz inclusions in feldspar grain showing poikilitic texture in biotite microgranite. (XN)

Depth of emplacement of the granitic rocks

The interpretation on the depth of emplacement of the granitic rocks is based on the field relationship and geochemical data. To analyze the petrochemical characters of igneous rocks, ten representative fresh rock samples which lack alteration and veining as much as possible were carefully selected. The results of geochemical analysis are presented in Tables 1, 2 and 3.These data were evaluated and plotted in the variation diagrams and triangular diagrams to interpret the interrelationship between conditions of crystallization and depth-temperature relation.

Petrochemical Criteria

When geochemical data are plotted on the ternary diagrams of normative Qtz-Or-Ab and Qtz-Or-An, almost all the points of granitic rocks lie within the ternary minimum of 2 kb and 10 kb, but two points of biotite microgranite lies at the 5 kb curve (Fig.11). Assuming $P_{H2O} = P_{total}$, the minimum P_{H2O} allowed by the scattered points are 2 kb and 5 kb respectively. In addition to the normative Qtz-Or-An diagram (Fig.12), almost all of the granitic rocks lie between the ternary minimum of 1 kb and 5 kb.

Rock Type	biotite microgranites								
Sample	NI-1	NI-2	NI-3	NI-4	NI-5	NI-6	NI-7	NI-8	NI-9
SiO_2	71.82	72.6	70.66	71.23	71.11	74.24	71.73	70.87	70.98
TiO_2	0.5	0.44	0.45	0.47	0.14	0.06	0.43	0.12	0.21
Al_2O_3	15.51	15.19	15.27	16.04	16.23	16.15	15.54	16.56	15.22
FeO	1.62	1.24	0.21	0.22	1.26	0.44	1.67	1.25	3.15
MnO	0.08	0.06	0.05	0.07	0.08	0.01	0.04	0.01	0.07
MgO	0.23	0.08	0.21	0.42	0.26	0.08	0.41	0.18	0.25
CaO	3.05	2.84	1.78	3	2.07	0.74	2.21	0.92	1.57
Na_2O	0.45	1.21	2.74	3.75	3.97	2.63	3.47	3.46	2.54
K_2O	4.96	5.29	7.8	4.57	4.21	5.54	3.57	6.3	4.7
P_2O_5	0.19	0.21	0.13	0.22	0.1	0.01	0.08	0.07	0.12
Sum	98.41	99.16	99.32	99.99	99.43	99.9	99.15	99.74	98.81

Rock Type	Leucogranites			tourmaline granites	
Sample	NI-10	NI-11	NI-12	NI-13	NI-14
SiO_2	76.27	73.27	74.15	74.46	73.36
TiO_2	0.12	0.07	0.1	0.12	0.11
Al_2O_3	14.05	14.21	13.39	15.85	14.98
FeO	1.67	0.71	1.39	2.14	1.93
MnO	0.04	0.02	0.04	0.1	0.07
MgO	0.12	0.02	0.03	0.24	0.25
CaO	0.98	1.07	1.06	0.95	0.79
Na_2O	2.58	2.67	2.83	0.04	3.01
K_2O	6.29	6.34	6.26	6.02	5.4
P_2O_5	0.22	0.15	0.19	0.03	0.02
Sum	102.34	98.53	99.44	99.95	99.92

Yadanabon University Research Journal, 2019, Vol-10, No.1

CIPW Norm or Wt % Norm

Quartz	31.62	40.16	21.61	25.5	27.52	36.1	33.04	24.87	36.45
Orthoclase	29.21	31.49	46.4	27	25.01	32.77	21.27	37.32	27.57
Albite	19.9	10.41	21.34	31.72	33.78	22.27	29.61	29.35	21.34
Anorthite	13.84	12.93	6.37	13.43	9.67	3.61	10.53	4.11	6.95
Corundum	1.16	2.86	0	0	1.62	4.51	2.15	2.55	3.36
Diopside	0	0	0	0	0	0	0	0	0
Hypersthene	2.86	0.58	0.1	1.64	0.65	0.19	1.03	0.44	0.61
Ilmenite	0.94	0.62	0.59	0.61	0.17	0	0.08	0.02	0.14
Hematite	0	0	0	0	1.26	0.44	1.68	1.25	3.12
Apatite	0.44	0.5	0.31	0.52	0.23	0.02	0.19	0.16	0.28
Titanite	0	0	0	0	0	0	0	0	0
Rutile	0	0.11	0	0.14	0.05	0.06	0.38	0.01	0.13
Sum	99.97	99.66	98.72	99.56	99.96	99.97	99.96	100.06	99.95
DI	81.63	84.72	91.36	84.23	91.50	92.12	87.66	90.12	89.94

Table-1. Major- and minor-element analyses and norms of the biotite microgranite of the study area.

CIPW Norm or Wt % Norm

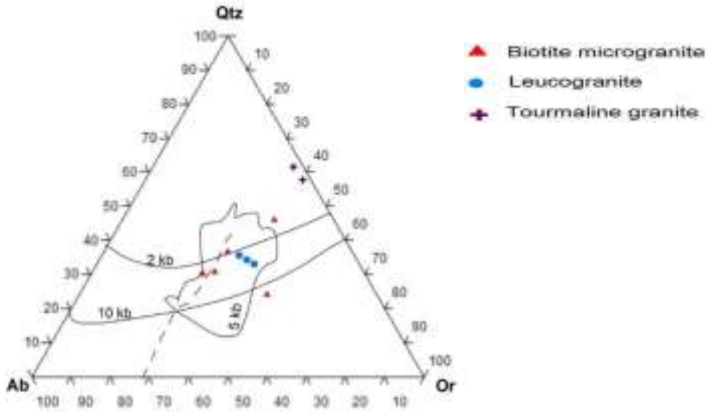
Quartz	30.56	32.04	32.13	48.9	53.67
Orthoclase	38.62	38.02	37.19	35.59	31.93
Albite	22.68	22.92	24.07	0.33	0.08
Anorthite	3.55	4.38	4.03	4.51	3.79
Corundum	1.81	1.3	0.48	7.61	7.75
Diopside	0	0	0	0	0
Hypersthene	0.31	0.05	0.07	0.59	0.62
Ilmenite	0.08	0.04	0.08	0.21	0.15
Hematite	1.73	0.72	1.39	2.14	1.93
Apatite	0.54	0.36	0.45	0.07	0.04
Titanite	0	0	0	0	0
Rutile	0.07	0.04	0.05	0	0.03
Sum	99.95	99.88	99.94	99.95	99.97
DI	93.68	94.38	93.89	92.45	93.42

Table-2. Major- and minor-element analyses and norms of the leucogranite and tourmaline granite of the study area.

Rock Type	Biotite microgranites				Leucogranites			Tourmaline granites	
Sample No.	NI-1	NI-2	NI-3	NI-4	NI-10	NI-11	NI-12	NI-13	NI-14
Locality	N 23°11' E 96°37'	N 23°11' E 96°38'	N 23°11' E 96°36'	N 23°16' E 96°38'	N 23°12' E 96°41'	N 23°12' E 96°40'	N 23°11' E 96°40'	N 23°09' E 96°43'	N 23°09' E 96°42'
Rb	9.07	92.30	164.39	95.21	118.69	115.34	140.66	323.92	288.21
Cs	1.80	27.10	5.86	6.43	22.58	5.57	5.54	5.73	19.61
Ba	153.64	1226.44	1060.89	1532.51	464.63	244.10	465.95	73.44	75.91
Sr	68.06	587.80	193.68	663.60	73.66	50.12	99.32	36.51	33.85
Ga	2.54	21.60	26.85	26.88	20.26	24.68	20.80	29.69	30.09
Tl	0.27	2.60	3.08	2.73	2.45	2.23	2.63	3.44	2.82
Ta	0.40	5.21	3.78	3.55	2.63	2.16	3.57	5.10	2.63
Nb	0.42	2.37	12.18	4.04	5.81	2.09	4.93	6.10	7.03
Hf	1.57	13.19	18.78	17.38	10.58	11.43	9.70	7.45	1.20
Zr	13.01	114.15	212.14	139.27	39.21	54.31	18.80	52.95	70.90
Y	1.86	10.43	25.97	15.13	8.51	11.01	8.87	60.96	66.50
Th	1.32	8.40	32.13	10.30	5.93	5.30	1.66	37.58	37.08
U	0.30	0.72	0.58	0.64	1.41	2.92	1.66	5.88	8.59
La	5.40	2.89	38.44	30.10	2.58	2.78	2.77	2.86	2.68
Ce	9.63	2.89	120.32	3.21	2.58	41.00	2.77	2.86	2.68
Yb	-	-	-	-	-	-	-	2.86	2.68
V	0.07	11.24	0.73	0.81	29.81	25.11	15.60	32.13	24.45
Cu	0.83	6.48	7.73	9.51	11.34	9.13	9.85	8.93	11.26
Pb	5.19	5.07	65.38	52.90	52.83	58.01	52.00	66.44	59.99
Zn	6.41	56.72	370.75	76.95	12.33	10.19	14.59	43.21	40.58
Bi	0.35	2.60	2.20	2.89	2.71	24.82	3.46	3.15	3.09
Cd	0.29	2.89	2.93	3.21	2.58	2.78	2.77	2.86	2.68
Sn	0.46	1.86	4.12	5.04	0.20	7.62	3.00	9.91	16.29
W	0.15	1.49	1.51	1.65	1.33	1.43	1.42	1.47	1.38
Mo	0.04	1.44	1.46	1.60	1.03	0.55	0.13	1.14	0.53
Ag	0.29	2.89	2.93	3.21	2.58	2.78	2.77	2.86	2.68
Ge	0.07	0.72	0.73	0.80	1.41	1.39	1.66	1.00	0.67
As	0.09	1.20	0.83	0.73	1.17	0.79	1.05	1.24	1.06
Se	0.14	1.30	1.61	1.44	1.41	1.67	1.38	1.86	1.34
Sb	0.34	5.67	4.52	3.75	1.94	4.93	2.08	1.51	1.82

Table-3. Trace element analyses (in ppm) of the plutonic rocks of the study area

If the crystallization of the igneous rocks of the study area were assumed at minimum pressure of 2 kb, their liquidus temperature could have been cogitated from the diagram that shows the relationship between differentiation index and temperature at 2 kb water pressure (Fig.13). From this diagram, the liquidus temperatures are 630 ^{o}C for biotite microgranite, 620 ^{o}C for leucogranite and 610 ^{o}C for tourmaline granite. Assuming that they were emplaced at P_{H2O} of 10 kb, the temperature of crystallization of these rocks would become considerably lower. The depth of crystallization of the granitic rocks of the study area interpreted from the schematic depth-temperature relation diagram might be assumed 21km for tourmaline granite, 22 km for leucogranite and 23 km for biotite microgranite (Fig.14).



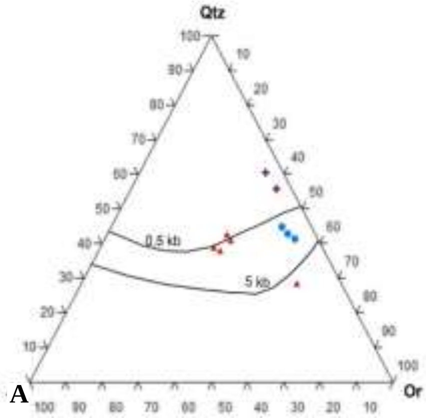
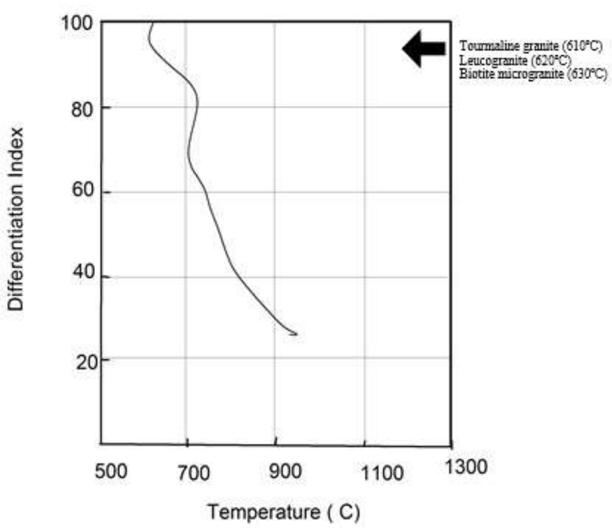


Fig. (11) Normative Qtz-Ab-Or-H_2O diagram for the granitic rocks of the study area showing H_2O saturated liquidus field boundaries and isobaric temperature. (after Tuttle and Bowen, 1985).

Fig. (12) Normative Qtz-An-Or diagram for the granitic rocks of the study area showing the boundaries curves and minima at 0.5 to 5kb. (after Tuttle and Bowen, 1985).



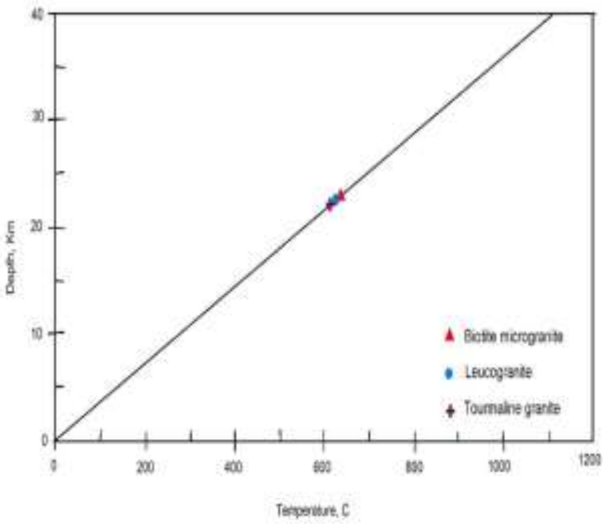


Fig. (13) Temperature-differentiation index diagram at P_{H2O}= 2kb for the granitic rocks of the study area. (after Piwinskii and Wyllie, 1970).

Fig. (14) Schematic depth-temperature relation diagram showing the position of the granitic rocks of the study area. (after Marmo, 1958).

Field Criteria

Depending on the classification by Hyndaman (1978) and Winter (2001), the depth of emplacement of igneous rocks in the study area has been determined.

The characteristics of the epizonal emplacement of granitic rocks are suggested as follows:

(1) Presence of grossularite-bearing skarn zones.
(2) The blocky nature of the biotite microgranite and the invaded rocks.
(3) The widespread medium-grained texture of the biotite microgranite.
(4) The rarity of microcline in granitic rocks.

The above mentioned features seem to agree with those of epizonal emplacement. On the other hand, mesozonal characters are seen as follows:

(1) Miarolitic cavities are absent in all granitic rocks.
(2) No graditional contact between country rocks and intrusions.
(3) Mostly discordant structural relations to the country rocks.
(4) The country rocks are observed that intrusive temperature is greater than 450 ^{o}C and belong to amphibolites facies.
(5) Absence of chilled border zone.

The granitic bodies of the study area show partly epizonal characters and partly mesozonal characters. So, it might be concluded that they might have emplaced either in the upper level of mesozone or in the lower level of epizone.

Conclusion

The research area is mainly composed of metamorphic (metapelite, metacarbonate and metaigneous) and associated igneous rocks. The present work deals to describe the petrographic characters of granitic rocks to determine the rock types and to investigate the depth of emplacement of granitic rocks for the study area. Based on microscopic examination, geochemical data and field evidences, the depth of emplacement for the granitic rocks of the study area could be considered either in the upper level of mesozone or lower level of epizone.

Acknowledges

I express my gratitude to Rector Dr Maung Maung Naing and Pro-rectors Dr Si Si Khin and Dr Tin Moe Thu Zar, Yadanabon University, for providing necessary resources. I also wish to express many thanks to Professor Dr Htay Wing, Head of Geology Department, Yadanabon University for his kind permission to carry out this work and his constructive comment and suggestions.

Reference

Best, M.G., 1986. *Igneous and Metamorphic Petrology.* CBS publisher and Distributors, New Delhi, India. 620p.

Chappell, B. W. and White, A. J. R., 1974. Two contrasting granite types. Pacific Geol., v. 8, p-173-174.

El-Sayed, M., Mohamed, F. H., Furnes, H. and Kanisawa, S., 2002. Geochemistry and Petrogenesis of the Neoproterozoic Granitoids in the Central Eastern Desert, Egypt. Chem. Erde 62 (2002), p.317-346.

Hutchison, C.S., 1975. The Norm, its Variations, their Calculation and Relationships. *Sch. Min. Pet., Mitt.,* 55, p. 243-256.

Hyndman, D. W., 1985. Petrology of igneous and metamorphic rocks. New York, McGraw Hill. 2nd edt., 786p.

Irvine, T. N. and W. R. A. Barager, 1971. A guide to the chemical classification of the common volcanic rocks. *Can. Jour. Earth Sci.,* v.8, p. 523-548.

Maniar, P. D., and Piccoli, P. M., 1989. Tectonic discrimination of granitoids. Geol. Soc. Am. Bull., v. 101, p-635-643.

Marmo, A., 1956. On the emplacement of granites. Amer. Jour. of Sci., v. 254, p-479-492.

Thet Tun, 2009. Petrology and Petrogenesis of the Granitoid Rocks exposed along the Shan Boundary Fault System between Belin-Kyaukse and Yamethin Areas, Mandalay Division. (unpublished) PhD Thesis, University of Mandalay.

Turner. F. J. and Verhoogen, j., 1960. Igneous and Metamorphic Petrology. 2nd ed., McGraw Hill, New York.

Tuttle, O. F., and N. L. Bowen 1958. Origin of granite in the light of experimental studies in the system $NaAlSi_3O_8$-SiO_2-H_2O. Geol. Soc. America Mem. 74. P. 153

Wahlstron, E.E., 1950, *Introduction to Theoretical Igneous Petrology*. John Wiley & sons Inc.

Winter, J.D., 2010. *An Introduction to Ignous and Metamorphic Petrology*.2nd ed. Prentice Hall, New Jersey. 702p.