Geological and Petrological Aspects of Banbwegon Granites of the Banbwegon-Paung Area, Paung Township, Mon State

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Abstract

The Banbwegon-Paung area, a middle part of the Moattama Range is situated at about 14 km north-west of Moattama, Mon State. The area is principally composed of granitic rocks. Porphyritic biotite granite is the most abundant rock type in the area. The distinctive features of these granites are the presence of large feldspar phenocrystes. Porphyritic botite granite is gradually transformed to foliated porphyritic biotite granite and then to granite gneiss. These granite rocks are strongly peraluminous, belonging to Calc-Alkaline suite, fall in the S-type granite . There are two faults in the area, one is trending nearly N-S and the other is trending NE-SW.

Key words: Granites, Banbwegon-Paung, phenocrystes, peraluminous, S-type

Introduction

The Banbwegon-Paung area is situated about 14 km northwest of Mottama of Mon state. It lies between latitude 16º 35'30" N to 16º 38'30" N and longitudes 97º26'30" E to 97º 31'50"E. The area coverage is about 44.8 square kilometers (Fig. 1)

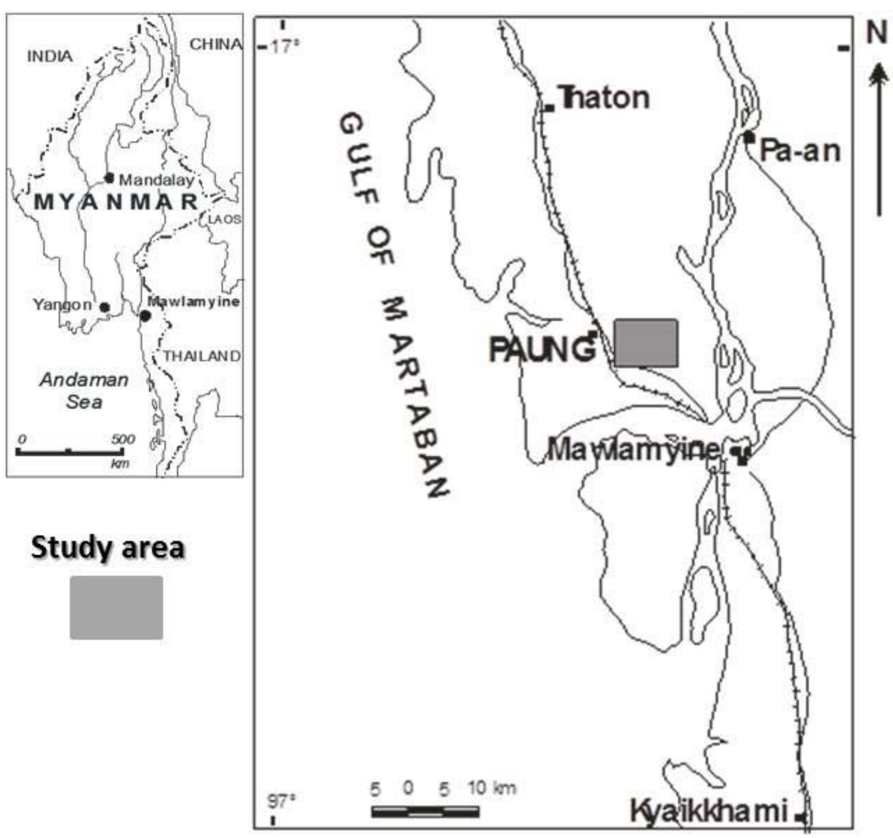

Figure (1). Location map of the study area.

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Paung Township is about 280 km away southeast from Yangon. Therefore it is accessible to reach the area directly by car or by train the whole year around.Banbwegon and other villages in the vicinity of the area are accessible from Paung Township by car and on foot as well.

Regional Geology

Regional Geologic Setting

The Banbwegon-Paung area is situated in the western part of Bilin plain as well as in the northern part of Tanintharyi granite belt. This area is actually a part of the western tin-bearing batholiths known as Western Tin Belt of Southeast Asia Tin Province (Mitchell, 1977; MaungThein, 1983; Nyan Thin, 1984). This Western Granite Belt of Southeast Asia is associated with eastward subduction of Indian Plate (Pitcher, 1982; Maung Thein, 1986).

Igneous rocks along the Shan Boundary Fault system and Tenassrim granitoids in the Sino-Burma Ranges are recently described by Bender (1983) to lie along the central granitoid belt and emplaced during continent-arc collision at the early state of westward migrating, east dipping subduction zone during the Upper Mesozoic and Lower Ecocene (KhinZaw, 1990). Regionally undifferentiated metamorphic rocks, metasedimentary rocks, upper Paleozoic sedimentary rocks are predominately exposed in the surrounding regions. However the granitic intrusive rocks are very well cropped out in the Banbwegon-Paung area and volcanic (mainly Basic) are found as small patches in northwestern part. Taungnyo Group (Carboniferous) is mainly made up of metasedimentary and sedimentary rocks and it is widely distributed in the northern and eastern parts of the study area. The Moulmein Limestone and Martaban Beds (mainly Carboniferous-Permian) are commonly found in the northern part which are trending NW-SE or nearly N-S directions. Undifferentiated metarmorphic rocks (mainly schist and gneiss) are distributed in the south of the study area and northwestern part of Thaton area.

The Banbwegon-Paung area is situated in the southern part of Martaban Range, which is a part of the western tin-bearing batholiths known as Western Tin Belt of Southeast Asia Tin Province (Mitchell, 1977; Nyan Thin, 1984), MaungThein, 1993). MaungThein (1986) regarded the Central Granitoid Belt of Myanmar as being developed in the tectonic setting of subduction related magmatic arc. It also lies within a part of the Mogok Belt (Searle and Ha, 1964) which is extending from Putao in the north through Mogok to Moattama in the south.

Table (1). Rock sequence of Banbwegon-Paung area

Alluvium	- Quaternary
Igneous rocks	
Porphyritic muscovite biotite microgranite	Possible Late Oligocene
Porphyritic biotite granite	
Foliated porphyritic biotite granite	
Metaigneous rock	
Granite gneiss	Prossible Early Oligocene

Petrology

The study area is mainly made up of igneous rocks and metaigneous rocks. The igneous rocks are predominantly exposed (Fig. 2)

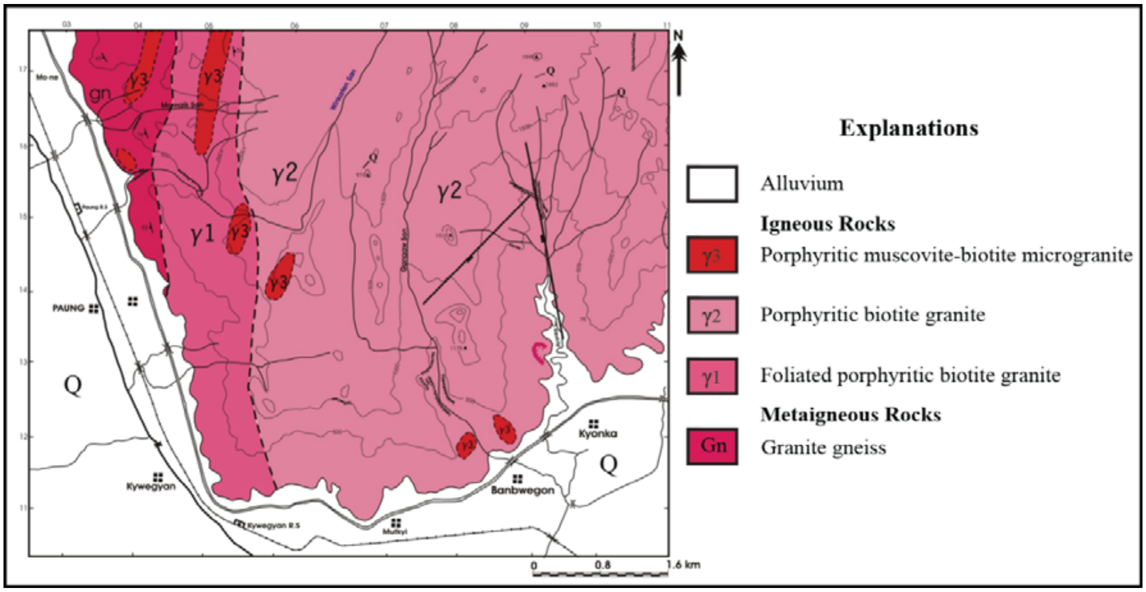


Figure (2). Geological map of the Banbwegon-Paung area.

Metaigneous rocks

Granite Gneiss

Megascopic study

This unit is observed at the westernmost part of the study area especially near Paung Town, Dawezu and Mo-ne Villages. This unit is separated from the foliated porphyritic biotite granite by a gradational contact in the eastern margin of this unit. They are quite hard and compact. Biotite and mafic minerals occurs as the foliations around augen-like quartzofeldsparthic minerals. The trend of foliations is generally NNW-SSE. Feldspar porphyroblasts are 1 to 2 cm in length and 0.5 cm to 1 cm in width (Fig. 3).

Figure (3). Augen texture on the grey colour weathered surface of granite gneiss at Mo-ne.

Microscopic study

It is medium to coarse-grained and mainly composed of quartz, alkali feldspar, plagioclase, biotite and minute flakes of muscovite. Zircon, sphene and magnetite are occurred as accessory minerals. Alkali feldspars occur as poprphyroblasts surrounded by fine-grained recrystallized quartz and biotite flakes. Sericitization is also noticed along the cleavage planes of alkali feldspar. Minute grains of recrystallized quartz and infiltrating into cracks and interspace between the grains and shown gneissose texture (Fig. 4a)

Plagioclase are closely spaced twinned, An percentage is about 8-17 (Albite-Oligoclase range), Biotite occurs as elongated flakes aligned between feldspar porphyroblasts. Some are bent and some are altered to chlorite (Fig. 4b)

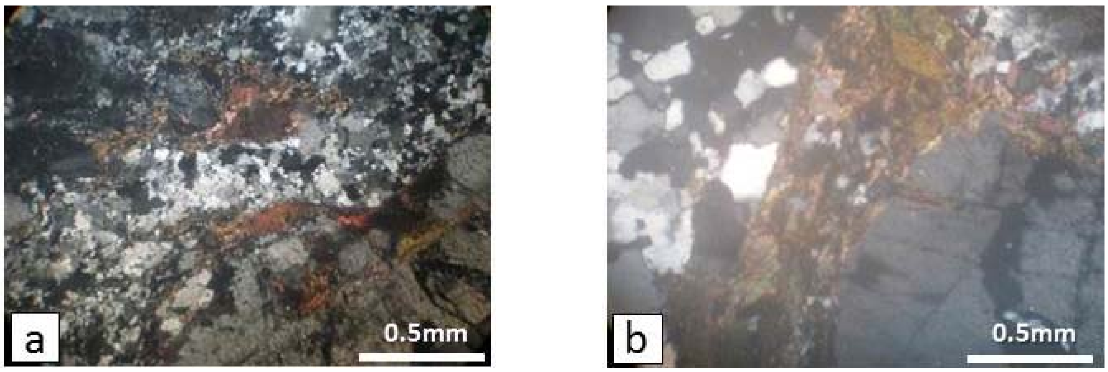


Figure (4). (a) gneissose texture and (b) showing bent biotite in granite gneiss (under XN).

Igneous Rocks

Foliated porphyritic biotite granite

Megascopic study

The foliated porphyritic biotite granite gradationally changes into granite gneiss in the west, well observed near Kyawegyan village. It is coarse-grained showing porphyritic texture and slightly foliated (Fig. 5a & b). The foliated porphyritic biotite granite gradationally contacts with the granite gneiss.

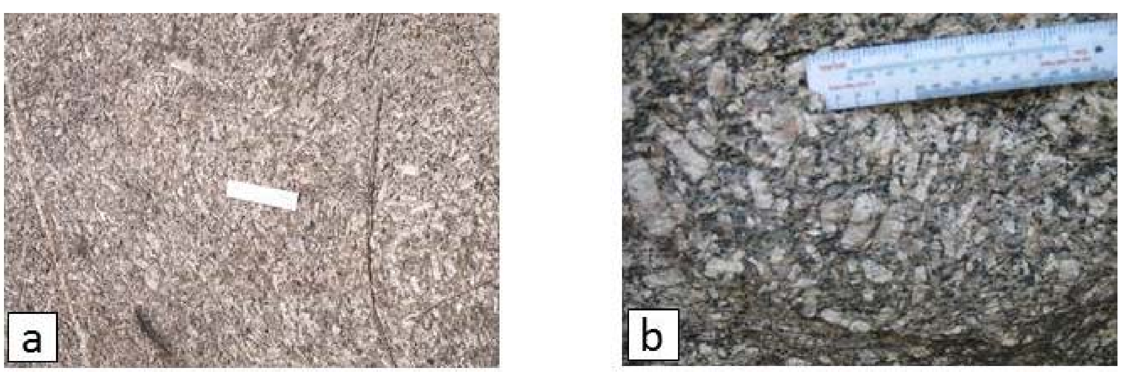


Figure (5). (a) the slightly foliation of feldspar phenocrysts in foliated prophyritic biotite granite (Loc:N. 087135, facing 170º). (b) Foliated feldspar phenocrysts in foliated porphyritic biotite granite (Loc:N. 051262, near Kywegyan, facing 260º

Microscopic study

It is mainly composed of the alkali feldspar, quartz, plagioclase and biotite. Accessory minerals are muscovite, apatite, sphene, zircon and magnetite Fig. 5 (c & d). Alkali feldspars are represented by orthoclase, perthitic orthoclase, microcline and microcline microperthite. Perthites are string, flame, vein, braid and patch perthites. Myrmekitic texture is also common (Fig. 6a). Quartz is found as a single large crystals and recrystallized minute grains of anhedral habit forming around large lobate crystals of feldspars.

In plagioclase feldspar, normal zoning is observed. Biotite show favorable alignment and are surrounding large grains of feldspar and quartz. Minute flakes of muscovite occur as interstitial minerals (Fig. 6b).

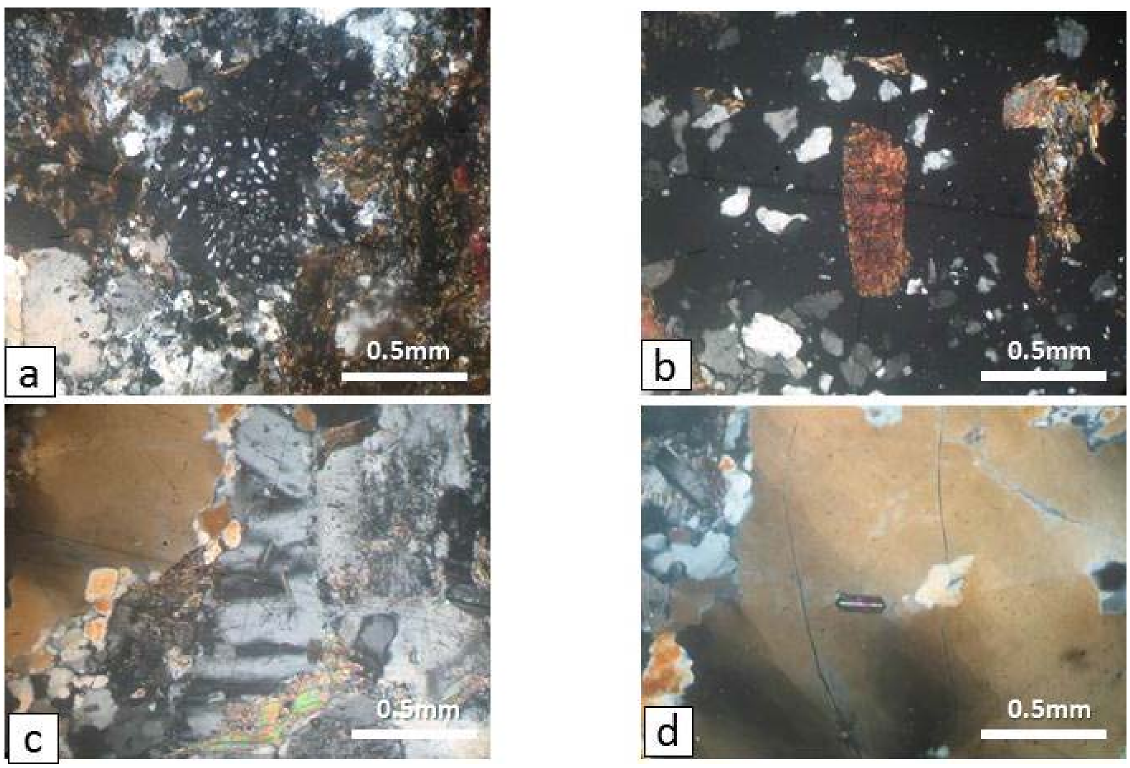


Figure (6). (a) Myrmekitic texture (b) Minute flacks of muscovite (c) apatite inclusion (d) zircon inclusion.

Porphyritic biotite granite

Megascopic study

This unit is found in the western part of the study area. Dark grey colour is noted on the weathered surface and light grey is in the fresh samples. Porphyritic biotite granite exhibits coarse-grained, porphyritic teture with megaphenocrysts of feldspar. Zoned feature of plagioclase can be seen with the unaided eye (Fig. 7).

Microscopic study

It mainly composed of alkali feldspar, quartz, plagioclase and biotite. Apatite, zircon and opaque minerals are accessories (Fig 8a & b). Alkali feldspar occur as perthitic orthoclase, microcline, and microcline microperthite. Perthites are mainly string perthite, vein perthite, microcline microperthite, patch perthite, braid perthite and film perthite (Fig. 9a & b).

Quartz is observed as anhedral grains and interstitial grains. Plagioclase commonly occurs as subhedral to euhedral. The composition of the plagioclase ranges from An 10-15. Some biotite grains are bent and some are altered to chlorite.

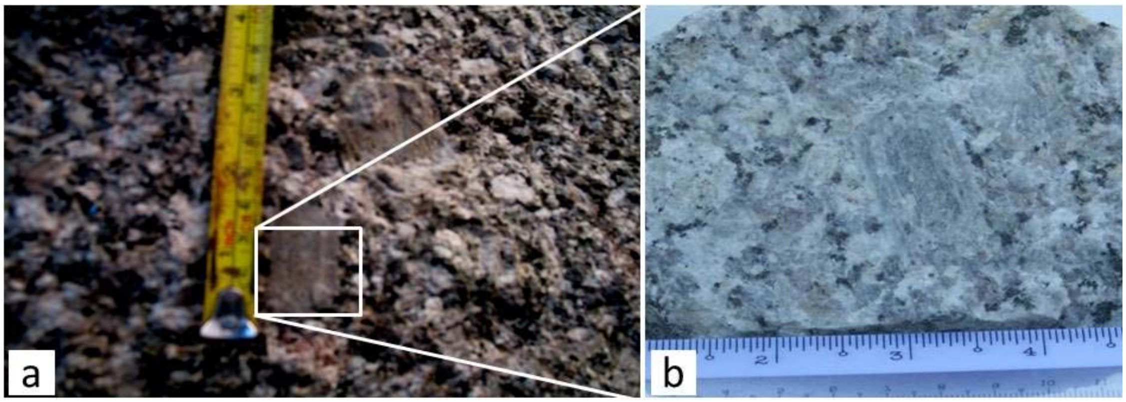


Figure (7). Normal zoning of plagioclase in porphitic biotite granite at Kyoka and Nwalabo range. (a) outcrop view, (b) closeup view of (a).

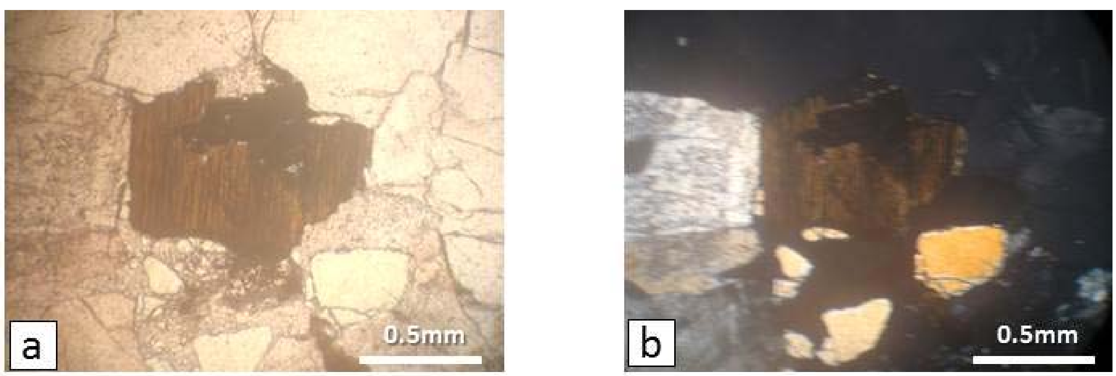


Figure (8). Quartz,feldspar and biotite in the porphyritic biotite granite. (a) Under PPl. (b)XN

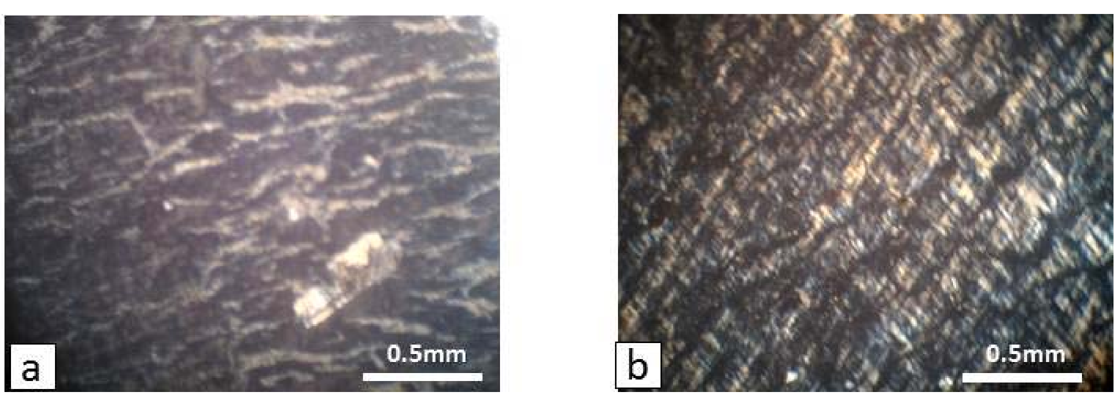


Figure (9). (a) Patch pertite (b)microcline microperthite in porphitic biotite granite.

Porphyritic muscovite-biotite microgranite

Megascopic study

Porphyritic muscovite-biotite microgranite is intruded into porphyritic biotite granite, foliated porphyritic biotite granite and granite gneiss. It is medium-grained, hard and compact with porphyritic texture.

Microscopic study

It is medium-grained has a hypidiomorphic granular texture and is mainly composed of orthoclase, microcline, quartz, plagioclase, biotite, and muscovite (Fig. 10a & b). Six sided zircon crystals are found as accessory minerals.

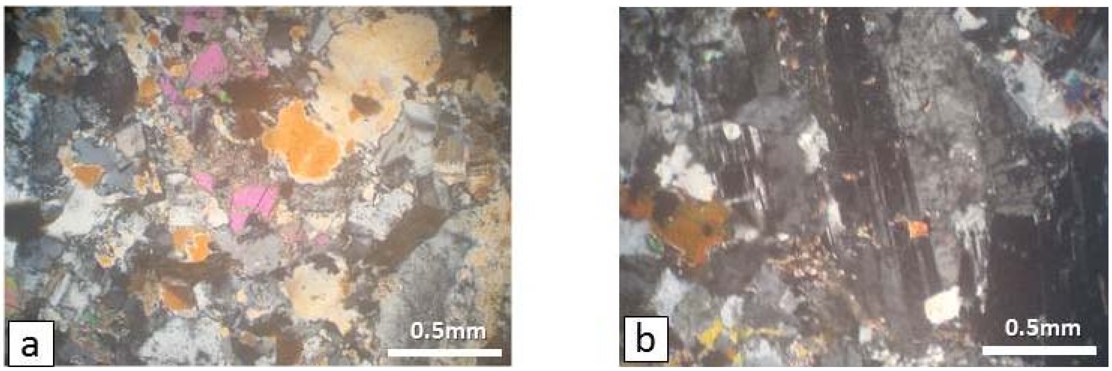


Figure (10). (a) Quartz,feldspar ,muscovite and biotite (b) Plagioclase phenocryst in porphyritic muscovite biotite microgranite.

Table (2). Modal composition of the Porphyritic biotite granite (in volume percent)

Sample No.	**1**	**E4**	**B4**	**B2**	**B3**	**7**	**C3**	**C8**	**6**	**C4**	**C5**	**2**	**4**	**9**	**A1**
Grid location	(091129)	(053180)	(077145)	(103167)	(077158)	(091131)	(074121)	(045157)	(091129)	(073122)	(062149)	(191130)	(103168)	(088124)	(086123)
Total counts	1116	760	1047	1130	1027	1104	1020	906	886	860	1000	936	1126	860	1320
Alkalifeldspar	46.53	55.26	47.47	49.56	37.95	44.57	45.49	45.25	36.16	44.19	40.00	31.20	43.10	44.19	36.50
Quartz	35.85	21.05	23.69	26.55	34.99	28.08	35.69	30.13	29.38	25.58	36.00	38.46	29.00	34.88	30.10
Plagioclase	10.22	12.63	13.57	12.39	18.95	18.11	10.98	12.14	18.08	18.60	14.00	23.50	15.50	11.63	27.50
Biotite	7.39	10.53	13.37	10.62	7.29	8.15	7.84	8.61	15.82	11.62	10.00	6.41	12.20	8.72	5.80
Muscovite	-	-	0.48	-	0.87	-	-	1.21	-	-	-	0.21	-	0.58	-
Sphene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Apatite	-	-	-	-	-	-	-	-	-	-	-	0.21	-	-	0.05
Zircon	-	-	-	-	-	-	-	-	0.56	-	-	-	0.18	-	0.01
Opaques	0.11	0.63	1.43	0.88	-	1.09	-	-	-	-	-	-	-	-	-
Total	100.10	100.10	100.01	100.00	100.05	100.00	100.00	97.34	100.00	99.99	100.00	99.99	99.98	100.00	99.96

Table (3). Modal composition of the Porphyritic biotite granite (in volume percent)

Sample No.	**1**	**E4**	**B4**	**B2**	**B3**	**7**	**C3**	**C8**	**6**	**C4**	**C5**	**2**	**4**	**9**	**A1**
Grid location	(091129)	(053180)	(077145)	(103167)	(077158)	(091131)	(074121)	(045157)	(091129)	(073122)	(062149)	(191130)	(103168)	(088124)	(086123)
Total counts	1116	760	1047	1130	1027	1104	1020	906	886	860	1000	936	1126	860	1320
Alkalifeldspar	46.53	55.26	47.47	49.56	37.95	44.57	45.49	45.25	36.16	44.19	40.00	31.20	43.10	44.19	36.50
Quartz	35.85	21.05	23.69	26.55	34.99	28.08	35.69	30.13	29.38	25.58	36.00	38.46	29.00	34.88	30.10
Plagioclase	10.22	12.63	13.57	12.39	18.95	18.11	10.98	12.14	18.08	18.60	14.00	23.50	15.50	11.63	27.50
Biotite	7.39	10.53	13.37	10.62	7.29	8.15	7.84	8.61	15.82	11.62	10.00	6.41	12.20	8.72	5.80
Muscovite	-	-	0.48	-	0.87	-	-	1.21	-	-	-	0.21	-	0.58	-
Sphene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Apatite	-	-	-	-	-	-	-	-	-	-	-	0.21	-	-	0.05
Zircon	-	-	-	-	-	-	-	-	0.56	-	-	-	0.18	-	0.01
Opaques	0.11	0.63	1.43	0.88	-	1.09	-	-	-	-	-	-	-	-	-
Total	100.10	100.10	100.01	100.00	100.05	100.00	100.00	97.34	100.00	99.99	100.00	99.99	99.98	100.00	99.96

Table (4). Modal composition of the porphyritic muscovite-biotite-microgranite (in vol%)

Sample No.	**C7**	**E3**
Grid location	(054160)	(043174)
Total counts	2058	1015
Alkalifeldspar	44.83	49.78
Quartz	27.21	22.17
Plagioclase	16.52	17.24
Biotite	10.69	10.84
Muscovite	0.24	-
Sphene	-	-
Apatite	-	-
Zircon	0.5	-
Opaques	-	-
Total	99.99	100.03

According to IUGS classification diagram the granitic rocks are fall within granite by using table (2, 3 & 4) (Fig. 11)

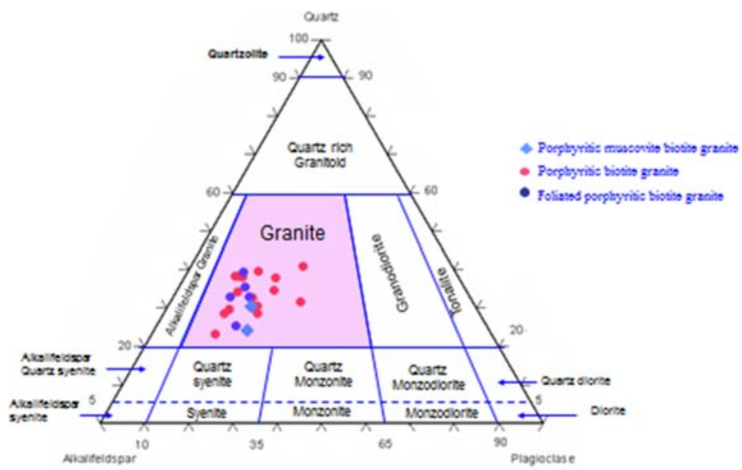


Figure (11). Plot data of the igneous rocks on the IUGS classification diagram of Le-Maitre (1989).

Petrochemistry

For geochemical study, the major oxides composition (wt %) and trace elements (ppm) of ten granite samples are recorded by XRF analysis. The major oxide (wt %) and trace elements of ten granite rock samples by XRF analysis are shown in Table (5).

Table (5). Chemical compositions in porphyritic biotite granite determined by XRF analysis

Sample No.	M1 (091131)	M2 (092129)	M3 (103168)	M4 (089131)	M5 (122156)	M6 (099131)	M7 (003167)	M8 (160125)	M9 (063135)	M10 (077158)
SiO_2	73.94	82.04	74.66	85.06	82.66	86.6	72.92	72.43	70.74	79.75
TiO_2	0.45	0.50	0.3	0.51	0.55	0.53	0.59	0.6	0.53	0.62
AL_2O_3	8.61	9.21	6.51	6.46	8.57	0.76	9.72	10.37	9.02	9.63
FeO	3.21	3.72	2.64	2.22	3.29	2.76	3.01	3.8	3.1	4.35
Fe_2O_3	0.36	0.41	0.29	0.25	0.36	0.31	0.33	0.42	0.34	0.48
MnO	0.24	0.07	0.13	0.15	0.06	0.06	0.3	0.31	0.5	0.04
MgO	1.41	1.23	1.29	1.12	1.12	1.06	2	1.92	1.7	1.61
CaO	9.19	0.43	12.62	5.04	0.49	0.45	7.74	6.82	11.44	0.68
Na_2O	1.35	0.26	1.02	0.99	1.28	1.03	1.59	1.47	1.39	1.38
K_2O	1.88	1.83	1.5	1.34	1.86	1.07	2.11	2.18	1.96	2.05
P_2O_5	0.22	0.08	0.08	0.07	0.09	0.07	0.12	0.11	0.11	0.09

Table (6). Standard CIPW norms of the granites in the Banbwegon area,

Sample No.	M 1	M 2	M 3	M 4	M 5	M 6	M 7	M 8	M 9	M 10
Grid location	(091131)	(092129)	(102168)	(089131)	(122156)	(099131)	(103167)	(060125)	(063135)	(077158)
Quartz	29.77	49.99	33.23	52.41	50.80	62.07	25.26	25.87	22.60	43.55
Orthoclase	15.07	14.83	12.05	10.64	15.13	8.75	16.89	17.49	15.66	16.60
Albite	21.07	19.80	15.99	15.32	20.31	16.33	24.69	22.84	21.58	21.66
Anorthite	7.62	1.78	5.43	6.10	2.07	1.96	8.05	10.84	8.21	3.02
Corundum	-	3.18	-	-	2.24	2.52	-	-	-	2.49
Diopside	18.92	-	16.56	12.59	-	-	22.71	18.91	21.31	-
Apatite	0.43	0.17	0.17	0.14	0.17	0.16	0.24	0.21	0.21	0.17
Hypersthene	-	9.13	-	-	8.14	7.39	-	2.58	-	11.15
Ilmenite	0.61	0.68	0.42	0.68	0.76	0.72	0.8	0.82	0.72	0.86
Sphene	-	-	-	-	-	-	-	-	-	-
Magnetite	0.38	0.43	0.3	0.25	0.38	0.33	0.35	0.44	0.35	0.51
Wollastonite	6.15	-	15.84	0.87	-	-	0.99	-	9.56	-
Olivine	-	-	-	-	-	-	-	-	-	-
Spinel	-	-	-	-	-	-	-	-	-	-
Total	100.02	99.99	99.99	100.00	100.00	100.00	99.99	100.00	100.00	100.01

Table (7). Standard CIPW norms with hornblende and biotite in the Banbwegon area.

Sample No.	M 1	M 2	M 3	M 4	M 5	M 6	M 7	M 8	M 9	M 10
Grid location	(091131)	(092129)	(102168)	(089131)	(122156)	(099131)	(103167)	(060125)	(063135)	(077158)
Quartz	34.78	54.97	37.62	55.93	55.31	66.03	31.37	32.33	28.12	49.74
Orthoclase	7.36	7.39	5.30	5.06	8.45	2.88	7.51	7.59	6.94	7.44
Albite	20.95	19.68	15.93	15.22	20.17	16.22	24.52	22.67	21.44	21.49
Anorthite	7.58	0.52	5.42	6.06	0.68	0.62	8.02	10.76	8.15	1.44
Corundum	-	3.62	-	-	2.73	3	-	-	-	3.04
Biotite	11.96	11.67	10.66	8.55	10.61	9.23	14.22	15.21	12.62	16.25
Hornblende	-	-	-	-	-	-	-	-	-	-
Apatite	0.42	0.17	0.17	0.14	0.17	0.16	0.24	0.21	0.21	0.17
Hypersthene	-	-	-	-	-	-	-	-	-	-
Ilmenite	0.6	0.68	0.42	0.68	0.75	0.72	0.79	0.81	0.72	0.85
Sphene	0.78	0.88	0.54	0.88	0.98	0.95	1.02	1.05	0.93	1.1
Magnetite	0.38	0.43	0.3	0.25	0.38	0.33	0.35	0.43	0.35	0.5
Wollastonite	15.2	-	23.86	7.25	-	-	11.97	8.95	19.94	-
Olivine	-	-	-	-	-	-	-	-	-	-
Spinel	-	-	-	-	-	-	-	-	-	-
Total	100.01	100.01	100.02	100.02	100.03	100.02	100.01	100.01	100.22	100.02

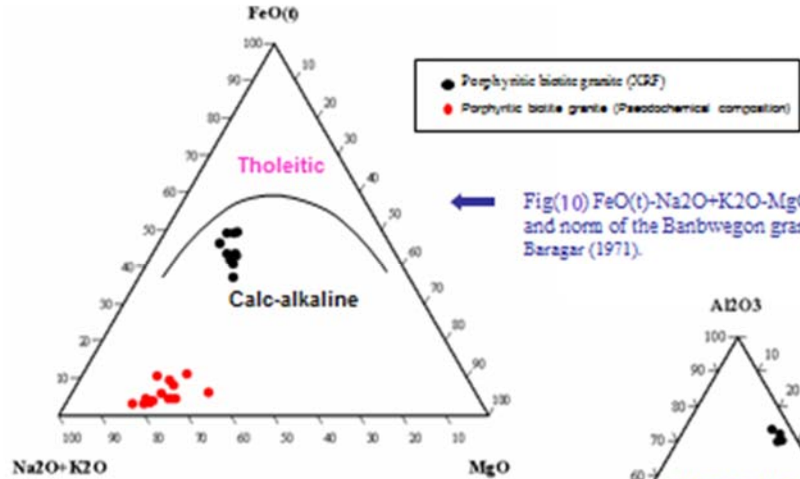
Chemical Analysis from the Mode

Detail petrochemical studies were made by means of weight percent oxide methods in some diagrams. Comparison of chemical composition (wt %) by XRF are listed in table CIPW norm standard and with biotite and hornblende are listed in Table (6 & 7)

According to the result on the AFM diagram, the rocks of the study area display strong enrichment in Na_2O+K_2O and they fall within the Calc-alkaline suite (Fig. 10)

Molecular Al_2O_3 percent is greater than Na_2O+K_2O+CaO. It indicated that the rocks of the study area strong peraluminous in character of Al_2O_3-Na_2O+K_2O+CaO diagram (Fig.12)

K_2O versus Na_2O plot of these rocks clearly fall in the S-type granite field of (White and Chappell, 1983) (Fig.13)



Fig(10) FeO(t)-Na2O+K2O-MgO plot for the pseudonorm and norm of the Banbwegon granite. (Diagram from Irvine and Baragar (1971).

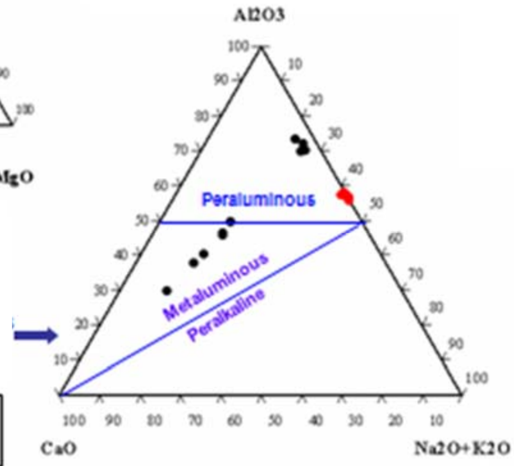
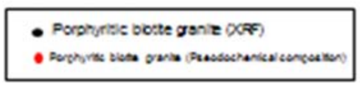


Figure (12). Al_2O_3-Na_2O+K_2O+CaO Plots of the granites in the Banbwegon area (According to Hydnman, 1985)



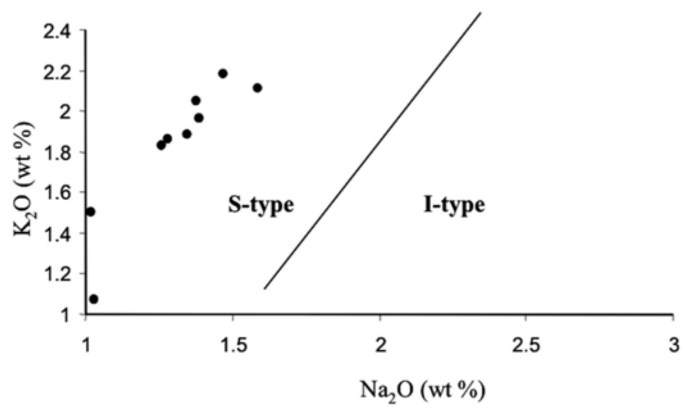


Figure (13). Na_2O vs K_2O variation diagram for Banbwegon-Paung area using the diagram of Chappell and White (1983).

Petrogenesis of Granite

Suggested origin of granite

The origin of the granite rocks is suggested as magmatic in origin of the present area, according the following characteristics:

1. SiO_2 content is rather high.
2. Perthite, orthoclase and microcline are fairly common.
3. The dominant mafic minerals are biotite flakes and devoid of hornblende

4. Presence of myrmekitic texture formed by the reaction during the late stage magmatic crystallization.
5. The presence of the K-feldspar and zonal plagioclase phenocrysts.
6. The absence of migmatites.

Genetic type of the granite rocks

The granitic rocks of the present area are regarded as S-type based on the following field evidence, petrographical and petrochemical analyses such as:

1. SiO2 content is high (68.07 to 83.46 wt %)
2. Most variation diagrams are irregular
3. Hornblende is absent, biotite is common
4. Muscovite are present
5. According to SiO_2-FeO+MgO+CaO-Na_2O+K_2O+Al_2O_3 diagram, the plot of these granites indicate that they are tin mineralized granite rocks.
6. Mol Al_2O_3/ (Na_2O+K_2O+CaO) ratio of greater than 1.1%.
7. Another distinctive chemical property determined by Chappell and White is the normative corundum in S-type granites, being greater than 1% CIPW corundum.
8. Plotting on Na_2O Vs K_2O diagram of White and Chappel (1983), show that these granitic rocks fall in S-type region.

Possible age of granite

The radiometric dating of the granite samples which are collected fromThaton and Kyaikhto by the GIAC (1999) are described as follow:

Kyaikhto area porphyritic granite	- Mg. 96.21	
(K-Ar method)	(Bio.31 ± 0.9 Ma)	
Kyaikhto Isotropic granite	- My. 96.213	
(K-Ar method)	Bio = 32.2 ± 0.9 Ma	Q+F 30.5 ± 0.9 Ma
Thaton area Isotropic granite	-My 96.222	
(K-Ar method)	Bio. 29.2 ± 0.7 Ma	
Thaton area Isoltropic granite	- My. 96.217	
(Ar-AR method)	Bio. 25.9 ± 0.5 Ma	

The Rb-(Y+Nb) diagram for tectonic setting of granites (Pearce et. al., 1984) indicates the Banbwegon granites fall within the Post-Collision Granite.

These evidences for relative age and radiometric dating of the granitic rocks of the adjacent area are used to assign the age of the igneous rocks of the study area. Therefore, it is regarded that granitic rocks of the study area were intruded during Late Oligocene.

Summary and conclusions

The Banbwe –Paung area igneous rocks is principally composed of granitic rocks. The granitic rocks are foliated porphyritic biotite granite, porphyritic biotite granite, porphyritic muscovite biotite granite. Due to regional metamorphism affected on these granitic rocks, granite gneiss are gradationally formed at the western part the granitic rocks.

Petrologically, the origin of the granite rocks are suggested as magmatic origin according to perthite, orthoclase, and microcline are fairly common and absence of migmatites.

Petrochemically, these granites are strongly peralluminious , S type granite and Calc-Alkaline granite.TheRb-(Y+Nb) diagram for discriminating the tectonic setting indicates these granites fall within the Post Collision Granite.

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