Petrography and Petrochemistry of Rocks in Zingyaik Area, Paung Township, Mon State

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Abstract

The Zingyaik area is located at Paung Township, Mon State. It lies between north latitude16°39′00″ to 16°46′00″ and east longitude 97°23′00″ to 97°300′00″. It is situated at about 22.5km (14miles) the southeastern part of Thaton and 28.9km (18miles) northeastern part of Mawlamyine in Mon State. The area covearage is at about 134.4 square kilometers. The study area is made up of metasedimentary rocks, meta-igneous rock and igneous rocks. Metasedimentary rocks are quartzite and phyllite. Meta-igneous rock is biotite (augen) gneiss. Igneous rocks are foliated biotite granite, (porphyritic) biotite granite and biotite microgranite. Generally, foliation directions of metamorphic rocks of the study area are generally NNW-SSE with average dip amount is between 45° and 75°. Biotite (augen) gneiss formed at the transitional contact with foliated biotite granite. The probable age of metamorphism of metasedimentary rocks is Early Carboniferous to Early Permian. In addition, the age of meta-igneous rocks are probable Early Oligocene.The igneous rocks of the study area belong to acid clan, high K- calc alkaline series, peraluminous nature, Granite field, and S type with magmatic in origin. The S type granitoid rocks may be originated from the crustal source in origin.The liquidus temperature for foliated biotite granite, (porphyritic) biotite granite and biotite microgranite are 680°C, 695°C and 710°C respectively. According to depth-temperature relation diagram, the probable depth of igneous rocks is between 22 and 24km. So, the depth of emplacement may be estimated at the transition between the Mesozone to Catazone. The tectonic environments for the granitoid rocks of the study area fall within Continental Collision Granitoid (CCG) and Continental Arc Granitoid (CAG) field, genetically, the later phase of the subduction related magmatism.

Keywords: Petrography, petrochemistry, Zingyaik Area

I. Introduction

Location of the research area

The study area (above sea level 31.28′) is situated at 22.5km the southeastern part of Thaton town and 28.9km northeastern part of Mawlamyine, Paung Township, Mon State. It is bounded by vertical grids 96-11 and horizontal grids 18-32 of one-inch topographic map sheet nos. 94 $H/_5$, $H/_{6\&2}$, $H/_9$ and $H/_{10}$ of Myanmar Survey Department.(fig.1) Its extent is about 134.4 square kilometer.

Objectives of the project area

Detailed analyzed petrochemical datas are not yet studied in the research area. The present study is the investigated analytical datas of rocks in the study area. Therefore, the main objectives of the project area are as following:

1. To make a fairly detailed geological map of the research area
2. To state the litholgy of various kinds of rocks exposed in the study area
3. To study the petrography of rock units in the research area
4. To express the petrochemistry of rock units in the study area

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5. To determine the economic aspect of the project area

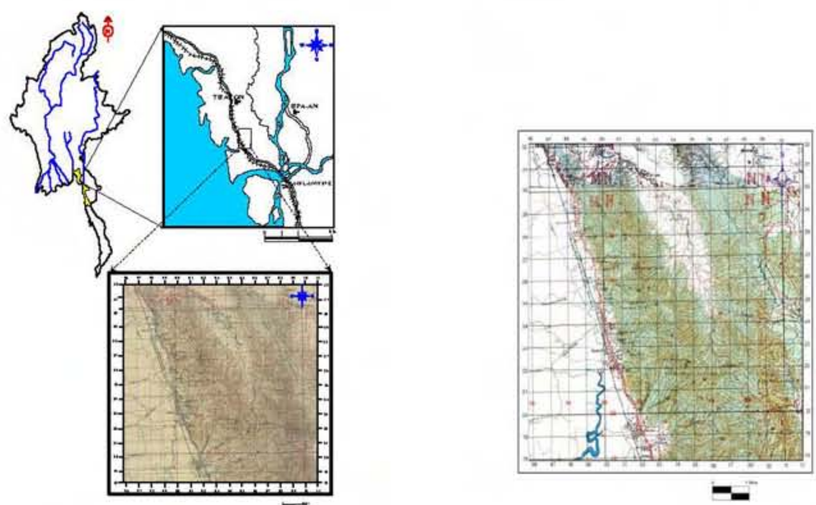
Method of study

Before the field investigation, various literature and previous works were studied. Data and informations from field, were systematically recorded. Field works include (i) collecting of the different representative samples from various rock units, (ii) measuring geological structures and (iii) geological mapping was plotted on the four time enlarged map from one-inch to one mile topographic map. The contacts of litholgy and structural characteristic were interpreted from the landsat satellite, ASTER satellite image and aerial photographs. Landsat satellite and ASTER satellite image were based on GCS-Indian-1954 and Datum: D-Indian-1954.For detailed analysis of the representative rock samples from the study area, about 70 thin sections from different rock units were made and studied under the petrological microscope.

Nature of exposures

The study area is mainly composed of igneous and metamorphic rocks which are metasedimentary and metaigneous rocks. The exposures are generally parallel with the mountain ranges of the study area. Good exposures are commonly present along the sream sections and the peak of mountain ranges. (Porphyritic) biotite granite unit is covered by the eastern and western part of the study area. Microgranite unit cropped out at Myauk Soe chaung. At the peak of Kyauk Pone taung and Pa Htan taung, slightly foliated biotite granite unit is observable. In the western part of the study area, large bodies of biotite gneiss unit is mainly exposed along the Yangon-Mawlamyine Highway.

Phyllite is well exposed at the eastern part of the study area, especially The-Ein village and Kadaik Dam. Quartzite unit is well exposed at the western part of Defence Service. The contact of quartzite and biotite granite unit is clearly observed at Ma Min Sein waterfall. In addition, the contact of biotite granite and phyllite unit is also found at the eastern part of Zingyaik taung. Microgranite dyke intruded into biotite granite and biotite gneiss.



(A) (B)

Figure.1 (A) Location map and (B) topographic map of the study area

II. Regional Geologic Setting

The study area is a part of the Mogok Belt (Searle and Haq,1964) which is extending from Putao in the north through Mogok to Mottama in the south. Regional geological map of the study area and its environs shown in fig.2

The study area lies at the northern part of Martaban Range which is a part of the western tin bearing batholith well known to be Western Tin Belt of South East Asia Tin Province (Mitchell, 1977, Nyan Thin 1984, Thein 1993). Southeast Asia Tin Province extends from the Indonesian islands of Banka continues and Bellitan in the south to Yangon in the north. Igneous Rocks along the Shan Boundary fault and Tenasserim granitoids in the Sino Burma Ranges are recently described by Bender (1983), and igneous rocks of the research area lie along the central granitoid belt. (Khin Zaw, 1990).

Sino-Burma Ranges from part of the landmass of the Indo-Chinese Peninsula. (Yunan, Thailand and Malaysia), which extends to the south in Sundaland (Hutchison, 1973).Sino-Burma Ranges can be subdivided into the East Kachin/ Shan Unit the Karen/Tenasserim Unit, which is separated from the former by the Pan-Lang Fault, and into the West Kachin Unit.Karen-Tenasserim Unit extends from Mandalay via Mawchi to Taungnyo and continues via Tenasserim into Thailand and Malaysia. The study area falls within Karen-Tenasserim Unit and it is located at the north west of Mawlamyine and the south of Thaton. The research area lies within western marginal zone of Shan-Thanintharyi Highland.The Central belt granitoids were formed as a calc-alkaline which magma derived from a source of continental, sialic materials (UN,1996). W-S mineralization is closely and spatially associated with granitoid rocks in this belt.

The research area is covered by low to medium grade metamorphic rocks of Taungnyo Group (Lower Carboniferous), the igneous intrusions (Late Cretaceous to Early Eocene) and alluvial units (Quaternary).The general structural trend of the study area is NNW-SSE in direction.

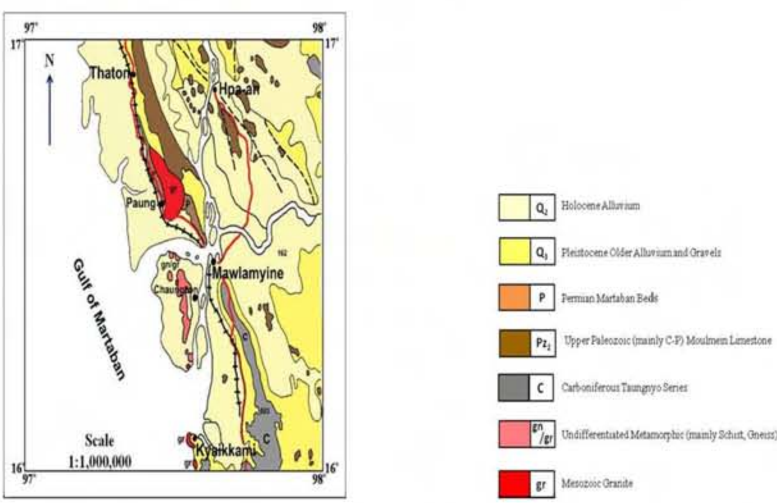


Figure.(2) Regional geological map of the study area

(From Geological Map of Myanmar Survey Department, 1977)

Rock sequence of the study area

-Younger alluvium
-Older alluvium and lateritic soils
} Quaternary

IGNEOUS ROCKS

-Quartz and quartzofeldspathic veins
-Pegmatite and aplite veins
-Leucomicrogranite dyke and microgranite sill
-Biotite microgranite
- Biotite granite
} Probably Late Oligocene

- Foliated biotite granite

METAIGNEOUS ROCK

-Biotite Gneiss — Probably Early Oligocene

METASEDIMENTARY ROCKS

-Phyllite
-Quartzite
} Early Carboniferous to Early Permian

Distribution of rock units

The study area is mainly composed of igneous rocks and low grade metamorphic rocks of Taungnyo Group. Quartzite unit is obviously found at the eastern to southeastern part of the study area. Phyllite unit is exposed at the eastern and northeastern part of the study area.Biotite gneiss unit is exposed at the western, northwestern and southern part of the study area. Igneous rock units are the most widespread unit in the study area. Biotite granite, foliated biotite granite and biotite microgranite are the major igneous rock units of the study area. They are noticeably elongated (linear) bodies. Geological map and cross-section of the project area can be seen in fig.3.

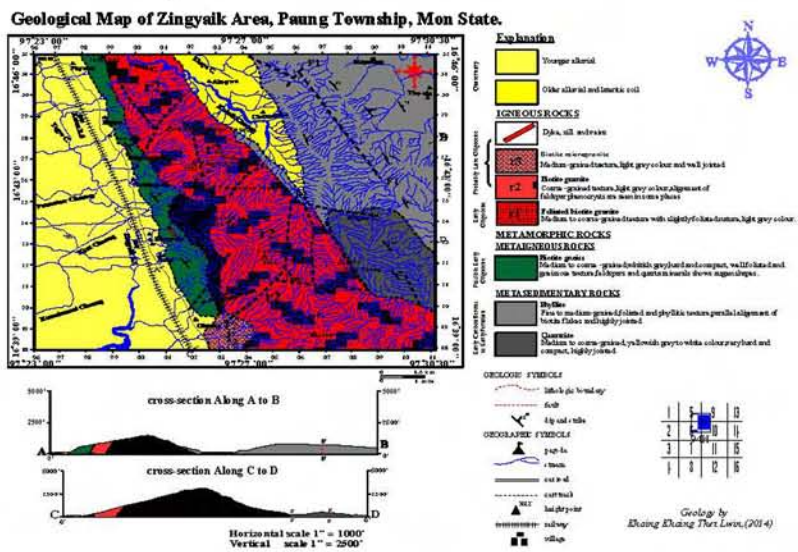


Figure.(3) Geological map and cross-section of the project area

III. Petrography

Petrography of metasedimentary rocks

Quartzite unit is well distributed at the southeastern part of the study area. It is exposed at the western part of the Defense Force as well as eastern part of Dipo taung (figs.4A and B). It is essentially composed of quartz. It is fine to medium-grained, sugary texture. It is well jointed, very hard and compact. At Loc.049264, various quartz veins (bandings) is found, (fig.4C). It is so hard and compact. It is yellowish white colour on fresh surface and pale grey to deep grey colour on visible surface. The contact (sample) of biotite granite and quartzite unit is also found at Ma Min Sein Waterfall,(fig.4D). At the eastern part of Zingyaik taung, a little amount of unmappable metagreywacke are observed.

Quartzite has fine to medium-grained rock with granoblastic texture fig.4E It is mainly composed of quartz with minor amount of biotite, sercite and iron ores. Grain size varies from 0.1 to 0.5 mm. Some quartz grains are elongated, flattened and irregular shaped quartz grains have suture contact boundaries. fig.4F

Phyllite is well exposed at the northeastern part of the study area. It is especially found at the eastern part of Zingyaik range. At Kadaik Dam (Se Daw Oo pagoda), excellent exposures are very distinctive as shown in fig.5A. It has fine to medium-grained. It shows phyllitic texture and soapy feeling character. It is pale yellow colour on fresh surface and yellowish brown on weathered surface. In some places, fresh colour is purple, and reddish purple is weathered colour. At the northeastern part of the study area, U Maung Myint's quarry (old quarry site), stibnite minerals are also found in phyllite. Near the contact of biotite granite and phyllite unit is also found at the eastern part of Zingyaik taung fig.5B. At Kadaik Dam, unmappable slate interclated with phyllite is also found in fig.5C. Microscopically, phyllite is fine to medium-grained. It gives phyllitic texture fig.5D.It is mainly composed of quartz, biotite and minor amount of iron ores. Both biotite and sericite are common constituent minerals. Biotite shows pale brown to dark brown in pleochroism. Quartz grains shows anhedral crystals with wavy extinction. Quartz porphyroblasts are found in the groundmass. Small quartz veins are found along the foliation plane.

Petrography of Meta-igneou Rock

Biotite gneiss units are observed along the northwestern, western and southwestern part of the study area. This unit well cropped out at Zingyaik Waterfall quarry figs.6A and B, Ma Ka Thae quarry, Palette quarry, In Byaung quarry and many other quarries. It is medium to coarse-grained, gneissose texture with augen structures. Its weathered colour is dark grey and fresh colour is whitish grey. It is well jointed. It gives distinctive gneissose texture. It mainly consists of feldspar, quartz, greenish brown mica flakes. Tourmaline minerals are also observed as accessory minerals. Plagioclase feldspars show augen textures. It is medium to coarse-grained, Zoned feldspars megacrysts in biotite gneiss varied from 0.1 inch to 0.6 inch fig.6C. Quartzofeldsaptic vein is found in fig.6D. Microscopically, biotite gneiss shows preferred orientation of minerals (fig.6E) consisting of quartz, plagioclase, biotite (fig.6F), orthoclase, perthite and muscovite. Tourmaline (fig.G), andalusite and silliminite (fig.6H), minerals also occurred as accessory minerals. Opaque minerals are also found.

Petrography of Igneous Rocks

Igneous rocks of the study area are mainly (i) foliated biotite granite, (ii) biotite granite and (iii) biotite microgranite which are mentioned on the geological map are properly identified and named on the basic of modal analyses. They are plotted in the I.U.G.S classification (2001) diagram.fig.7 Minor igneous rock units are leucomicrogranite dyke, microgranite sill, pegmatite, aplite, quartzofeldspatic and quartz veins.

Foliated biotite granite occurs at the southwestern part of the research area. Best exposure cropped out at the top hill of Kyauk Pone Taung (figs. 8A & B) and Pahtan Taung. It is medium to coarse-grained. At the peak of Kyauk Pone taung, mosaic cracks in foliated biotite granite are found in visible suraface, fig.8C. These samples fall in the monzogranite and syenogranite field, fig.7. Microscopically, it is medium to coarse-grained. It shows foliated nature (fig.8D) with quartz, alkali feldspars, plagioclase. Quartz occurs as large to small grains with suture boundaries, fig.8E. It gives wavy extinction. Some quartz occurs as recrystallized minute anhedral aggregates forming around large feldspars. Size varies 0.1 to 0.3 or 0.5 mm. Subhedral to anhedral orthoclase minerals are also found in fig. 8F.

Biotite granite is the most widespread unit in the research area. This unit is well exposed at the peaks of Ka La Ma taung,Yedagun taung and Min Tayatapar taung, figs. 9A to D. Biotite granite is coarse-grained, porphyritic texture, with phenocrysts (megacrysts) of quartz, feldspars. It is mainly composed of quartz, feldspar and biotite. It is light grey colour in fresh surface and pale yellowish colour is weathered surface. Preferred orientations of coarse-grained minerals are found in biotite granite unit at Barr Mae cave at the peak of Ka La Ma taung, fig.9E. These samples fall in the monzogranite and syenogranite field, fig.7. At the eastern part of the study area, phyllite and quartzite unit is also found gradationally contact with this biotite granite. At the peak of Ka La Ma taung, length and width of some feldspar is 1.1×3.2 cm. Alignment of feldspars at that place is 170°-350°. Zoned feldspars are also observed on the visible surface. Sizes of some quartz are 3 inch × 1.5 inch in length. Its length is 2 to 3 inch and width is about 5 inch. Tourmaline occurs as minor amount, fig.9F. Microscopically, biotite granite is coarse-grained, hypidimorphic, granular texture. It is essentially composed of alkalifeldspar, quartz, plagioclase, biotite. Main alkalifeldspar occurs as perthite, orthoclase, microcline.Normal zoned plagioclase and subhedral biotite are seen in Figure 9G and H. Perthite are observed as string perthite, patch perthite, flame perthite. In addition, vein perthite and microperthite are also seen in figs. 9I and J. Apatite, zircon and opaque minerals occurs as accessory mineralsin biotite granite. Figs. 9K and L

Biotite microgranite unit is found at the southern part of the study area, fig.10A. It is well exposed at Myaukso Chaung (Local name - Kyauk Chaw). Good exposure is shown in fig.10B. It has medium-grained, light grey colour on fresh surface and buff to brownish grey colour on weathered colour. Alignment of feldspars are obvious at Loc.N 040192 along Myaukso chaung fig.10C. Various sizes of xenoliths are are clearly observed. In Figure.10D, there is alignment of metasedimentary xenoliths at Kyauk Chaw. Some xenolith has reaction rim fig.10E Some xenoliths are round and some are extended, fig.10F. Striations on the surface of xenoliths can be observed. Microscopically, it is medium-grained, hypidiomorphic granular texture. It is mainly composed of quartz, orthoclase, plagioclase, biotite and muscovite. Orthoclase has euhedral to subhedral forms and some are serisitized, fig.10G and H. Subhedral plagioclase shows polysynthetic twinning and biotite alters to chlorite, figs.10I and J.

Petrography of minor Igneous Rocks

Leucomicrogranite dyke intruded into porphyritic biotite granite at Loc. N 019272, at the left side of the car road from Zingyaik to Min Tayatapar taung, fig.11. Its weathered colour is yellowish white and fresh colour is white. Its trend is 110°-290°.It is medium-grained.Microscopically, it is medium-grained. It contains feldspar quartz, biotite and muscovite.

Microgranite sill intruded into biotite gneiss at the midst of Zingyaik waterfall at Loc. N011226, (Local name- Kyauk Thin Baw waterfall) is well observed in fig.12. It is also found at elevation 122' of Zingyaik waterfall

Pegmatite veins are found at Loc. N 014279 in Min Tayatapar taung (elevation 2069′) intruding biotite granite, fig.13. Its vein trend is 285° -105°. It shows yellowish white colour in weathered surface and fresh colour is grayish white.

Quartzofeldspathic veins are found in biotite gneiss at Zingyaik Waterfall quarry, Loc. **N** 008235, fig.14.

Figure.4 (A) Well exposed nature of quartzite at the eastern part of Dipo taung, Loc. N 085226, Facing 45˚ (B) Sedimentary relic structure in quartzite at the peak of the western part of Defense Service, Loc. N 086253 Facing 160˚ (C) Quartz vein (banding) in quartzite at the southeastern part of the study area, Loc. N 099228, N 16˚41′45.7″ E 97˚30′72″ (D) Contact sample between quartzite and biotite granite from the eastern part of Yedagun taung, (Local name - Ma Min Sein waterfall), N 16˚44′09″ E 97˚30′46″ (E) Granoblastic texture in quartzite, between X.N (F) Suture contact boundaries of anherdral quartz grains in quartzite, between X.N

Figure.5 (A) Excellent exposure of phyllite at the eastern part of Kadaik Dam,Loc.N 050291, Facing 45° (B) Highly jointed nature of phyllite at the northeastern part of Zingyaik Taung (C) Slate intercalated with phyllite, at the eastern part of Zingyaik Taung,Loc. N038277, Facing -20° (D) Phyllitic texture in phyllite, Between X.

Figure 6 (A) well exposed nature of biotite gneiss at Zingyaik waterfall quarry, Loc. N 009236, elevation 60′, (Facing Due East), (B) Zingyaik waterfall quarry in the study area, Loc. N 009236, elevation 60′, (Facing Due East),

Figure 6 (C) Zoned feldspar megacrystal in biotite gneiss at Zingyaik waterfall quarry,Loc.N 009236, elevation 60', (Facing –35˚), (D) Quartzofeldspathic vein in biotite gneiss at Zingyaik waterfall quarry,Loc. N 009236,(Facing –plan view), (E)Preferred orientation of minerals in biotite gneiss at Zingyaik Waterfall quarry, between X. N, (F)Subhedral form biotite in biotite gneiss , between X. N (G) Tourmaline minerals in biotite gneiss, between X.N, (H)Sieve texture of andalusite in biotite gneiss, between X. N

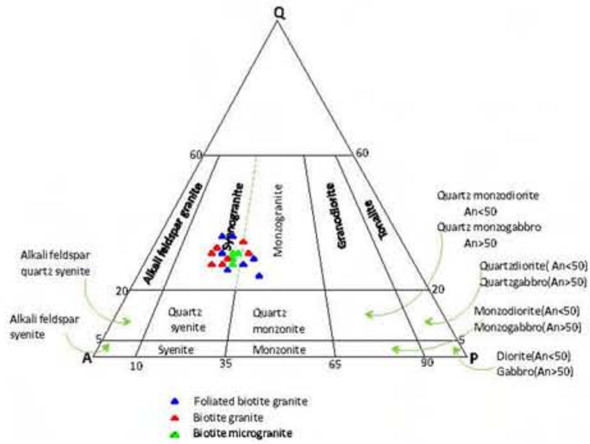


Figure 7 Plotted data of igneous rocks from Zingyaik Area in IUGS classification diagram, Le Maitre, 2001 (based on Streckeisen, 1976).

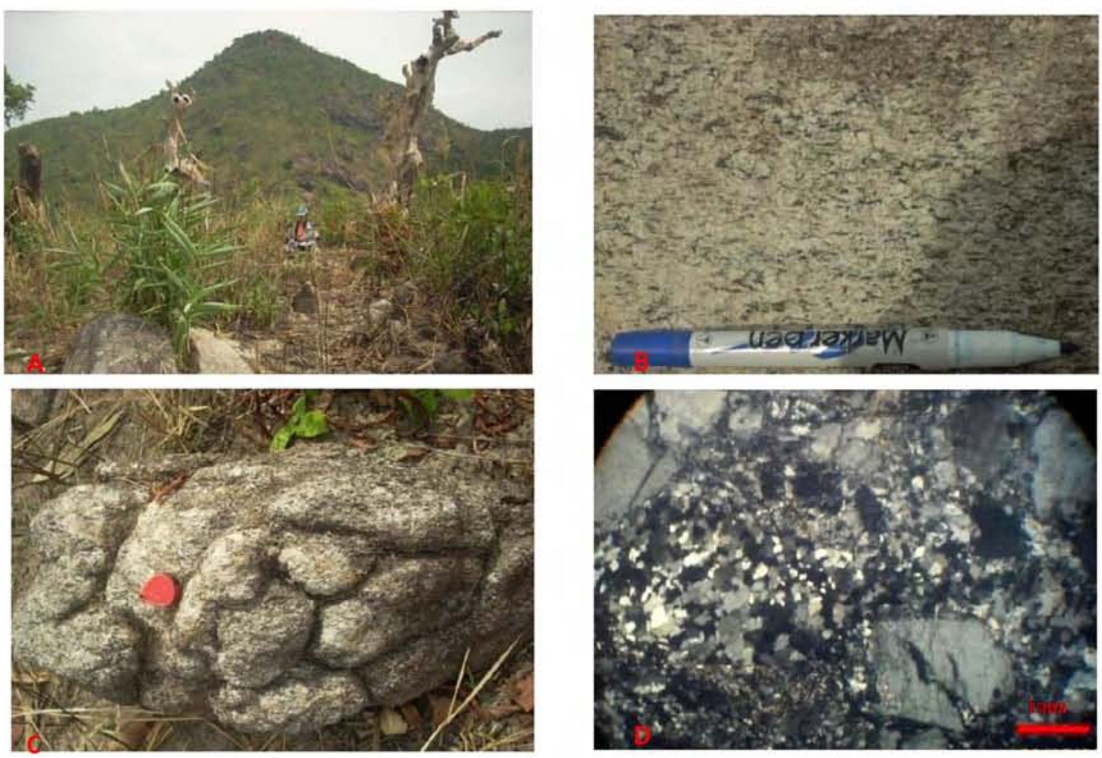


Figure 8 (A) Well exposure of foliated biotite granite at the peak of Kyauk Pone taung, Loc. N 022243, (B) Closer view of mineral alignment or preferred orientation of foliated biotite granite, at the peak of Kyauk Pone taung, Loc. N 022243 (C) Mosaic cracks in foliated biotite granite at the peak of Kyauk Pone taung, Loc. N 022243, Facing- Due East , (D)Foliated nature of mineral grains in foliated biotite granite, between X.N

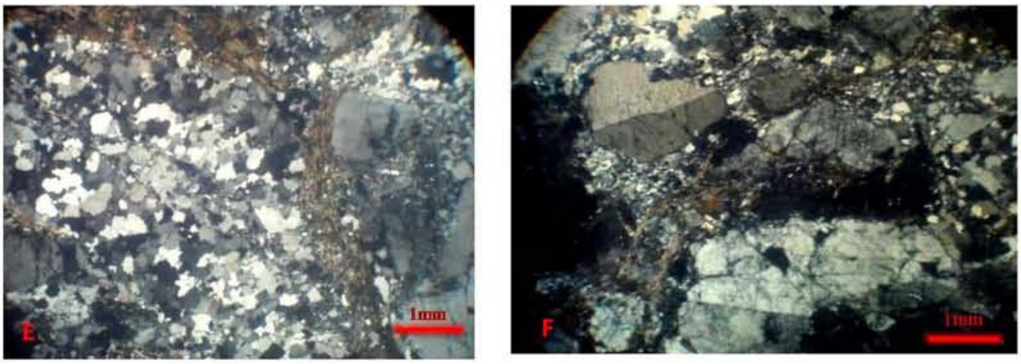


Figure 8 (E) Minute quartz crystal grains in foliated biotite granite, between X.N

(F) Subhedral to anhedral orthoclase minerals in foliated biotite granite, between X.N

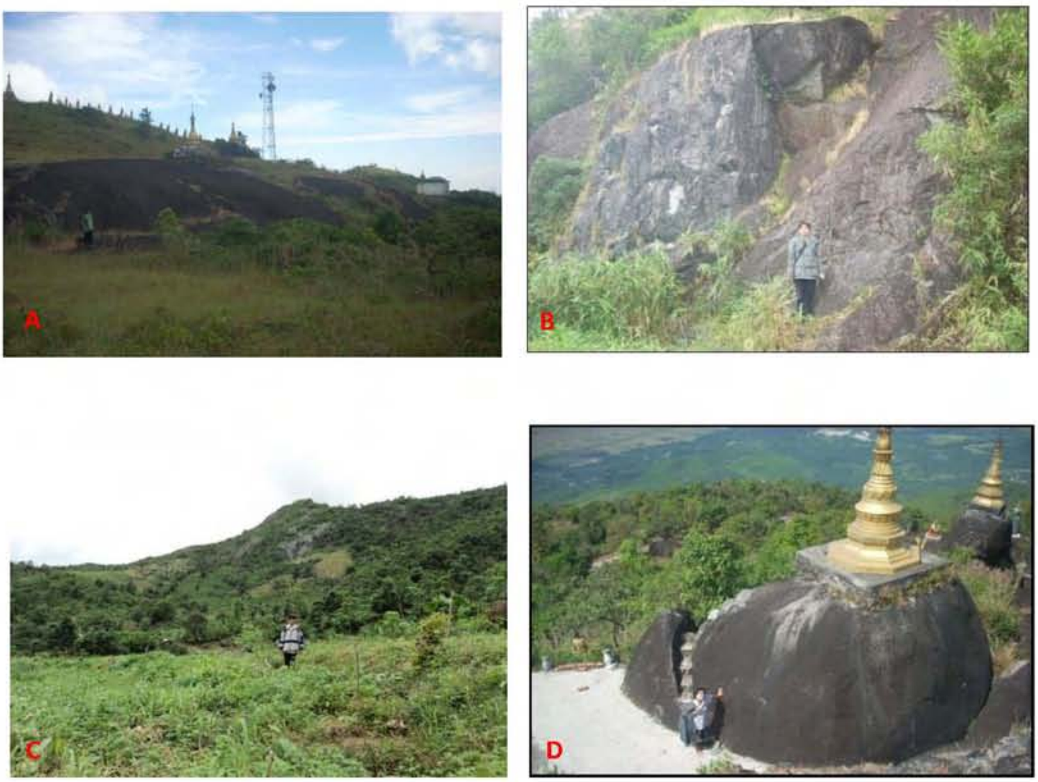


Figure 9 (A) Good exposure of biotite granite, near Telephone Tower at the peak of Kalama taung (3022′) , Loc.N 043225, Facing 120˚, (B) Well exposed unit of biotite granite at the peak of waterfall (Yedagun taung, Local name-Ma Min Sein Waterfall),Loc. N 101281, Facing Due West, (C) Spheroidal weathering in biotite granite at the peak of Min Tayatapar taung,Loc. N012282, (D) Preferred orientation of coarse-grained minerals in biotite granite at Barr Mae caveat the peak of Kalama taung, Loc. N 044222

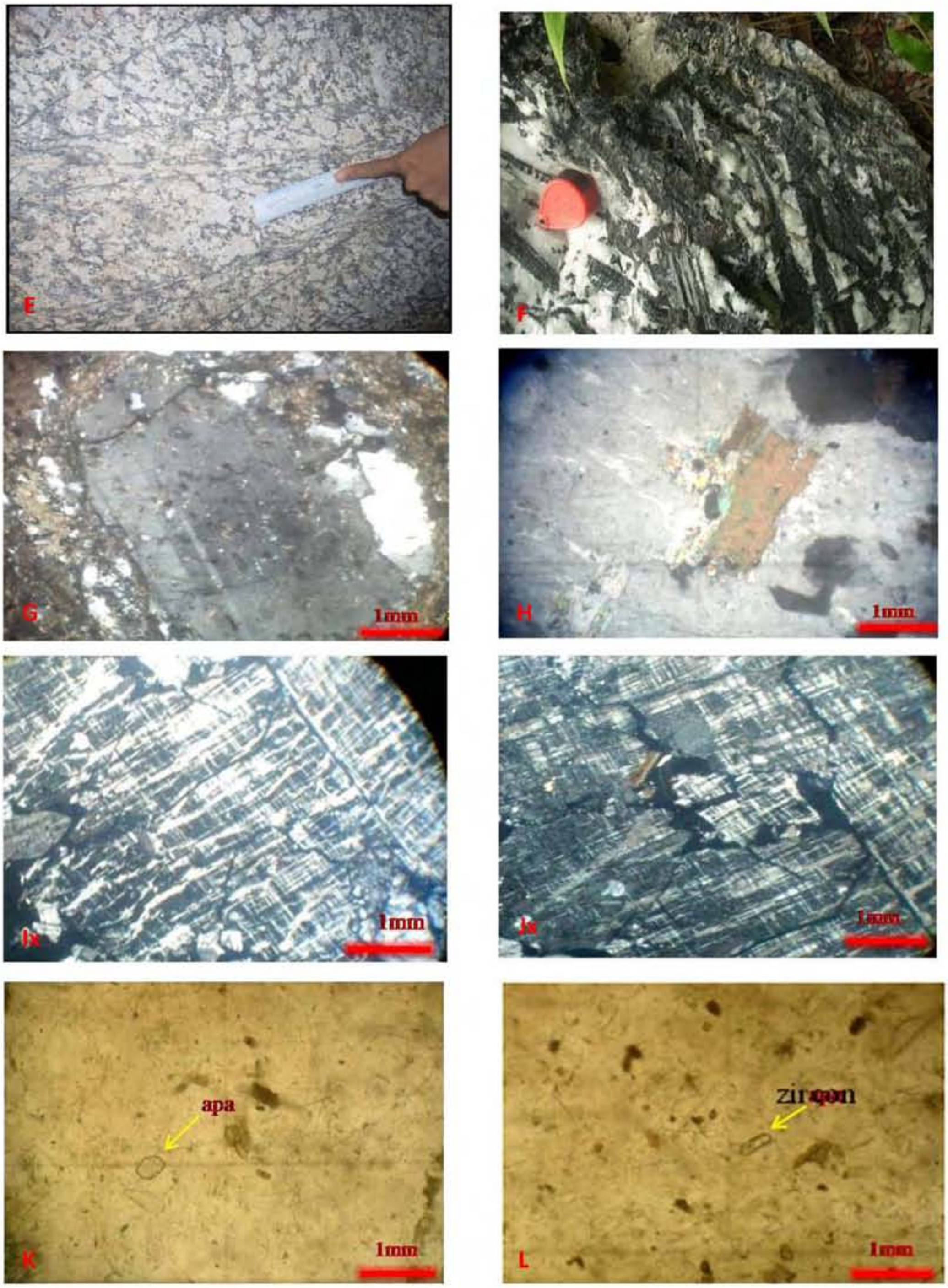


Figure 9 (E) Preferred orientation of coarse-grained minerals in biotite granite at Barr Mae caveat the peak of Kalama taung, Loc. N 044222, (**F**) Pegmatite vein intruded into biotite granite at U Pan Sein's garden, Loc. N 038207, Facing- 345˚ (**G**) Plagioclase showing normal zoning in biotite granite, between X.N (**H**) Subhedral biotite in biotite granite, between X.N (**I**) Vein perthite in biotite granite, between X.N((**J**) Microcline microperthite in biotite granite, between X.N (**K**) Apatite mineral in biotite granite, under PPL (**L**) Zircon mineral in biotite granite, under PPL

Figure 10 (A) Well exposed nature of biotite microgranite at Kyauk Chaw Chaung,Loc. N 038190, Facing 60˚, (B) Best exposure of biotite microgranite at Myaukso Chaung (Local name-Kyauk Chaw Chaung)Loc. N 040192, Facing-100˚., (C) Alignment of feldspars in biotite microgranite at Myaukso chaung (Local name -Kyauk Chaw) Loc. N 038190 ,Facing-60°,(D) Alignment of metasedimentary xenoliths in biotite microgranite at KyaukChaw Chaung, Loc. N 039191, Facing-270˚.Trend is 170˚-350˚, (E) Reaction rim with metasedimentary xenolith in biotite microgranite at Myaukso chaung, Loc.N 038191, (F) Extended metasedimentary xenolith in biotite microgranite at Myaukso chaung (Local name - Kyauk Chaw), Loc. N 039191

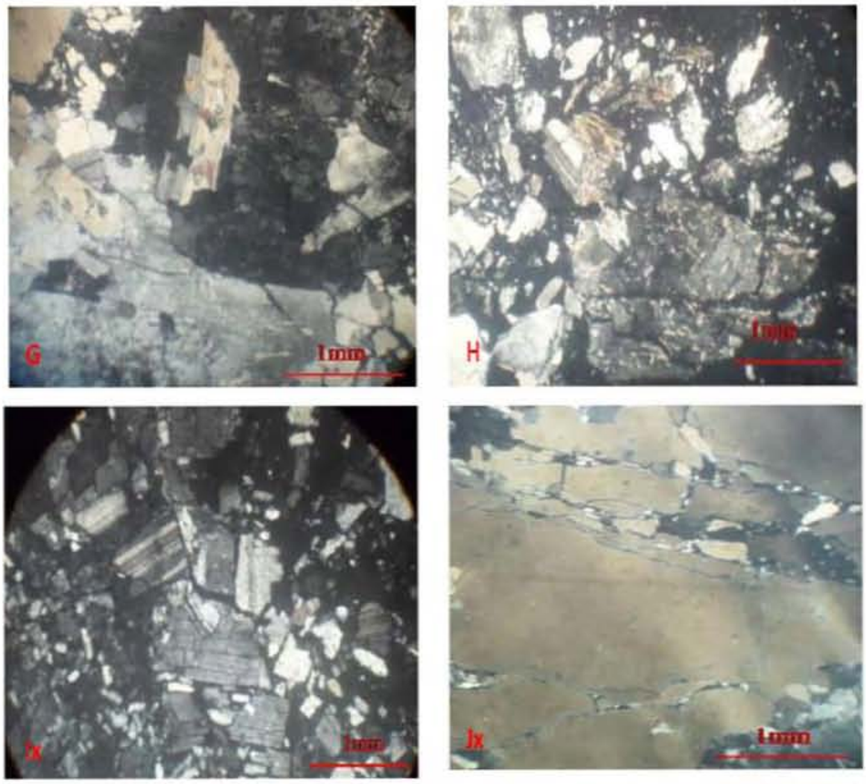


Figure 10 (G) Subhedral orthoclase in biotite microgranite, between X.N, (H)Sericitizationin biotite microgranite, between X.N, (I) Plagioclase showing polysynthetic twinning in biotite microgranite, between X.N, (J) Chlorite along the cleavage of biotite in biotite microgranite between X.N

Figure 11 Intrusion of leucomicrogranite dyke in biotite granite at Loc. N019272, Facing-Due West, Figure 12 Microgranite sill intruded into biotite gneiss at Kyauk Thin Baw water fall (Local name-Zingyaik waterfall), Loc.N 16°41'18.4"- E97°26'12.8", Facing - Due East, Figure 13 Pegmatite vein with tourmaline minerals in biotite granite at Min Tayatapar taung, Loc. N 012280, Facing - Due south, Figure 14 Quartzofeldspathic vein in biotite gneiss at Zingyaik Waterfall quarry, Loc.N 008235, Facing 85°.

The analytical datas of major and trace elements of of the selected igneous rocks the study area shown in Table 1. To interpret the possible tectonic setting of the present Zingyaik area, the tectonic discrimination diagrams of Manniar and Piccoli (1989) were used and shown by using GCD kit 3.00 software.

Chemical characteristics of Igneous Rocks

The granitoid rocks of the Zingyaik area are mainly composed of biotite granite, foliated biotite granite and microgranite. They are generally in acid group. SiO_2 content of all igneous rocks of the study area which varies from 68.85 to 75.80%. Similarly, the content of TiO_2 (0.07-0.54%), Al_2O_3 (12.48-14.41%), MgO (0.28-1.01%), Na_2O (2.33-3.93%), CaO (0.84-2.58%), MnO (0.0.03-0.08), K_2O (4.05-7.04%),FeO (1.11-3.52%) and P_2O_5(0.02-0.13%). CIPW normative corundum ranges up to 2.833 wt%. Total alkali content (Na_2O+ K_2O) varies from 7.07 to 9.44.

According to Harker's variation diagrams, fig.15, major oxides of Al_2O_3, TiO_2, FeO, MnO,, MgO, CaO, K_2O and P_2O_5 (wt%) of the research area are negatively correlated with SiO_2. K_2O is negatively correlated with SiO_2 because the igneous rocks of the research area is highly weathered. Na_2O is positively correlated with the SiO_2.. Harker's variation diagrams, trace elements of Ni, Pb, Co, As, Rb and Y are positively correlated with SiO_2 (fig.16). Trace elements which V, Ba, Sr, Cu, Zn, Ba, Nb, Mo, Zr and Cr are negatively correlated with SiO_2.. H_2O Vs SiO_2 is negatively correlated. The TAS diagram of the igneous rocks of the study area is shown in fig.17. All the igneous rocks of the study area fall in the "Subalkaline" field. . In FeO/MgO Vs SiO_2 (after Mac Donald, 1968) diagram (fig.18), the igneous rocks of the study area fall in the "Calc-alkaline" field. The fig.19, SiO_2 Vs K_2O diagram (after Peccerillo and Taylor, 1976), the igneous rocks of the study area fall in Calc-alkaline to high K Calc-alkaline series. According to Na_2O+ K_2O versus SiO_2 (TAS) diagram, all the granitoid rocks of the study area fall in the "Granite" field (fig.20). In fig.21, Rb-Sr-Ba ternary variation diagram (after EI Bouseilly and EI Sokkary,1975) shows the differentiation trend and compositional group of igneous rocks of the study area. The igneous rocks of the study area are "strongly differentiated granites".In fig.22, (Na-K-Ca) ternary diagram shows biotite granites are fallen in the field of tin-bearing granitoids of New England, (after Juniper and Kleeman, 1979). These biotite granites of Zingyaik area may be tin-bearing granitoids.In addition, ACF diagram fig.23 pointed out that granitoid rocks of the study area belong to the S type field (after Hine et.al 1978). The relatively high quartz content is up to 40.16 wt%.These S type granites can be considered that these granitoid rocks were derived from the quartz rich sedimentary rocks. It may be formed from the supracrustal origin. The liquidus temperature for foliated biotite granite, (porphyritic) biotite granite and biotite microgranite are 680°C, 695°C and 710°C respectively in fig.24. According to depth-temperature relation diagram, the probable depth of igneous rocks is between 22 and 24km in fig.25. Therefore, the depth of emplacement may be estimated at the transition between the Mesozone to Catazone. According to the K_2O(mol) Vs Na2O (mol.) variation diagram (fig.26), biotite granite, foliated biotite granite and biotite microgranite of the research area is regarded as late kinematic granites.

Table 1 Averages and standard deviations of the whole rock major (wt%) and trace elements (ppm) chemical composition of the various igneous rocks of the Zingyaik Area

Major elements' oxides in weight percent (wt%)									
Sample No	KKTL2	KKTL5	KKTL7	KKTL8	KKTL10	KKTL6	KKTL16	KKTL3	KKTL9
SiO_2	75.33	73.28	72.04	75.80	75.66	75.17	71.89	68.85	73.73
TiO_2	0.07	0.17	0.35	0.13	0.11	0.19	0.32	0.54	0.24
$Al2O_3$	12.64	13.11	13.63	12.48	12.56	13.09	14.41	14.21	13.27
FeO	1.06	1.43	2.30	1.35	1.11	1.34	1.88	3.52	1.67
MnO	0.03	0.03	0.05	0.05	0.05	0.04	0.06	0.08	0.04
MgO	0.28	0.55	0.73	0.33	0.37	0.49	0.56	1.01	0.51
CaO	1.13	0.90	0.97	1.14	1.06	0.94	0.84	2.58	1.22
Na_2O	3.93	2.40	2.33	3.25	3.31	2.52	2.36	3.70	2.61
K_2O	4.37	7.04	6.01	4.29	4.38	4.55	5.94	4.05	5.56
P_2O_5	0.02	0.05	0.08	0.03	0.03	0.06	0.09	0.13	0.07
H_2O	1.03	0.91	1.37	1.04	1.24	1.52	1.50	1.21	0.95
S	0.0007	0.0009	0.0042	0.000	0.000	0.0006	0.0004	0.0018	0.0000

Trace elements in parts per million (ppm)

Sample No	KKTL2	KKTL5	KKTL7	KKTL8	KKTL10	KKTL6	KKTL16	KKTL3	KKTL9
V	0	10	18	4	0	6	17	34	17
Cr	0	5	0	0	0	0	0	0	0
Co	6	0	5	13	21	15	17	12	12
Ni	14	4	8	13	12	10	11	9	8
Cu	0	1	2	0	0	1	0	1	0
Zn	0	0	28	4	10	19	35	36	35
Pb	78	62	59	71	40	59	61	39	62
As	28	18	26	27	28	17	27	23	25
Mo	4	8	10	6	5	8	11	14	10
Rb	654	393	420	541	590	477	656	408	459
Sr	14	97	84	31	27	53	53	84	69
Ba	81	408	365	81	122	177	287	197	271
Y	150	27	54	133	114	69	96	78	40
Zr	95	153	223	125	113	115	184	314	166
Nb	47	14	33	50	51	32	57	50	30

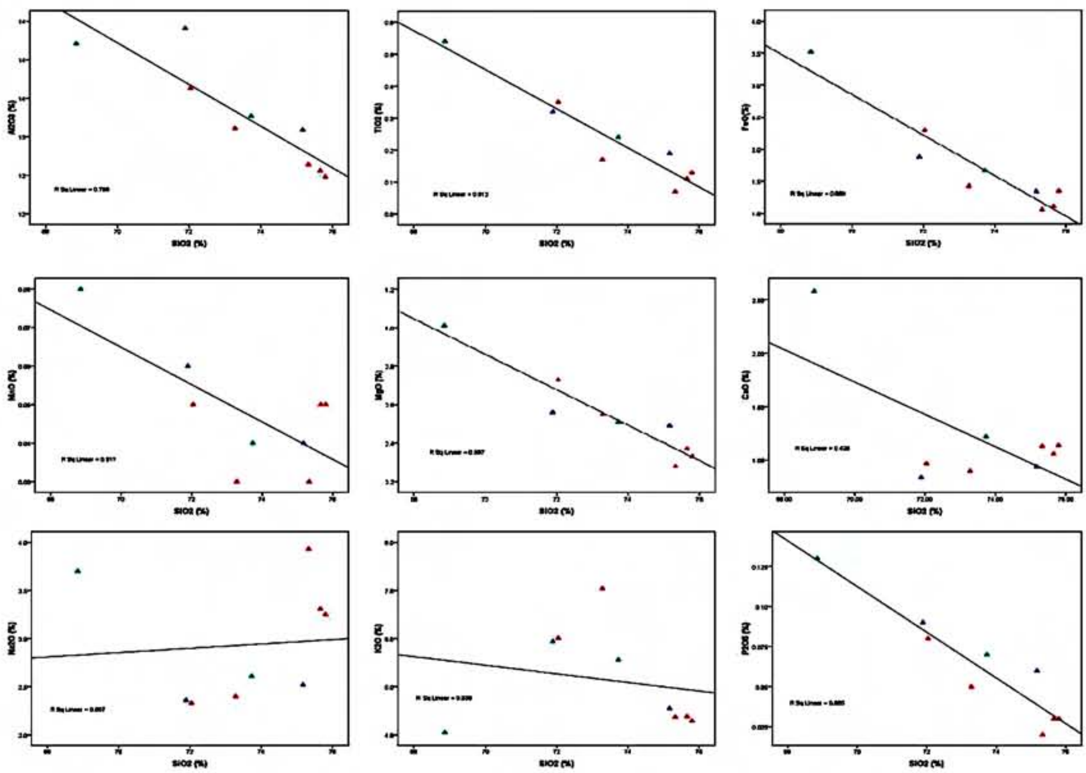


Figure 15 Harker's variation diagrams for SiO_2 Vs major elements of the igneous rocks of the study area

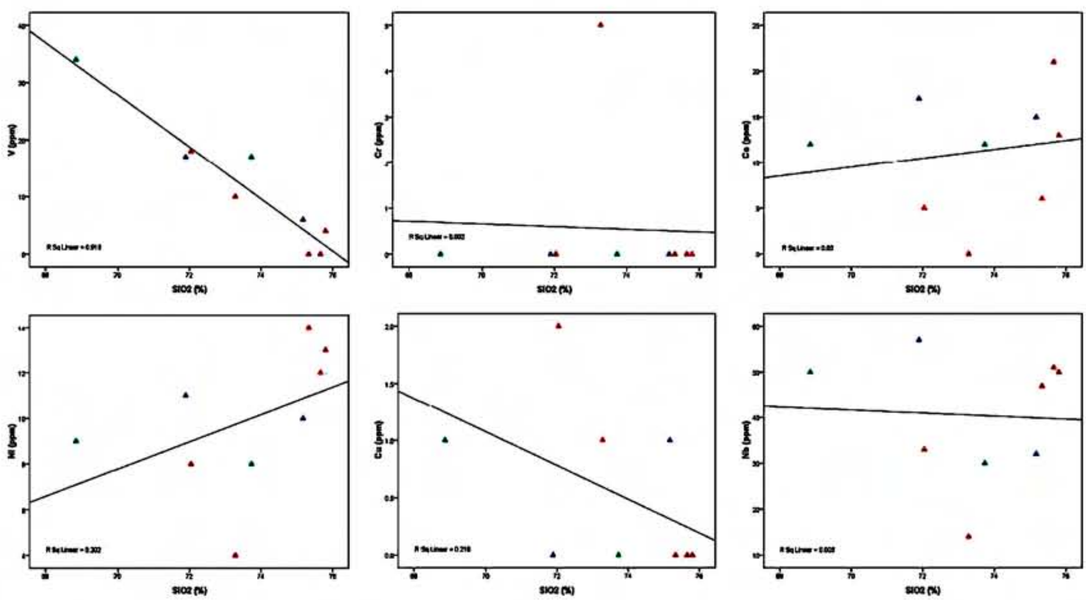


Figure 16 Harker's variation diagrams for SiO_2 Vs trace elements of the igneous rocks of the study area

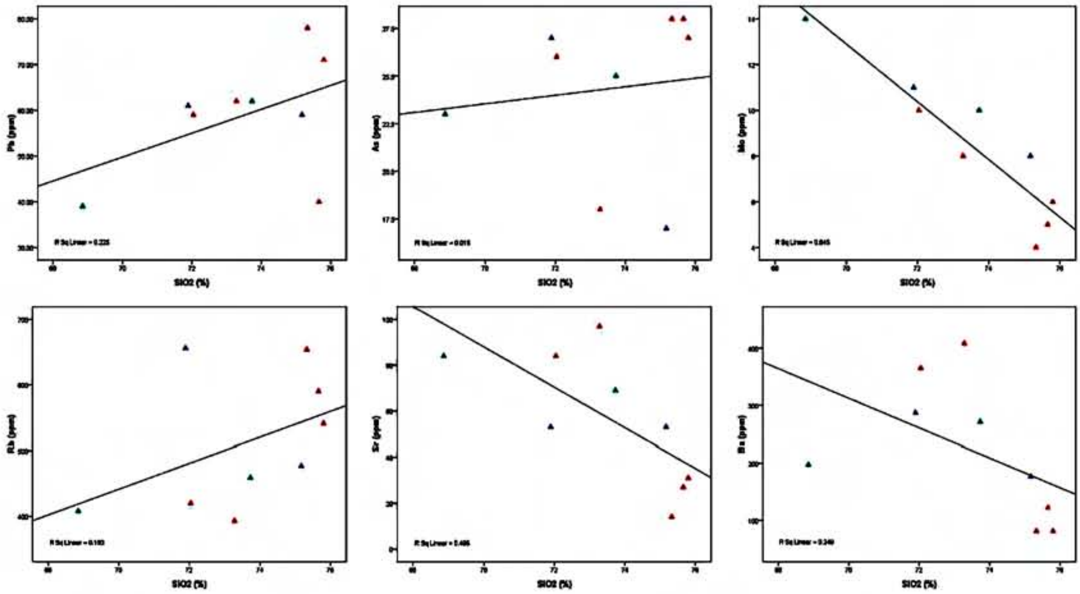
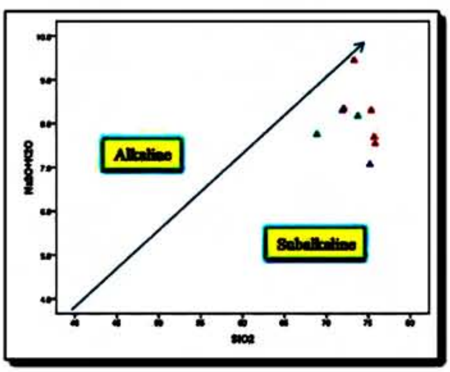


Figure 16 (continued) Harker's variation diagrams for SiO_2 Vs trace elements of the granitic rocks of the study area



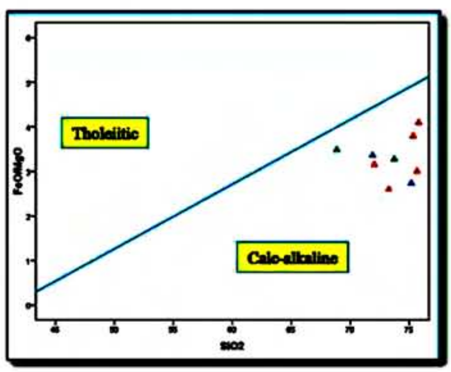
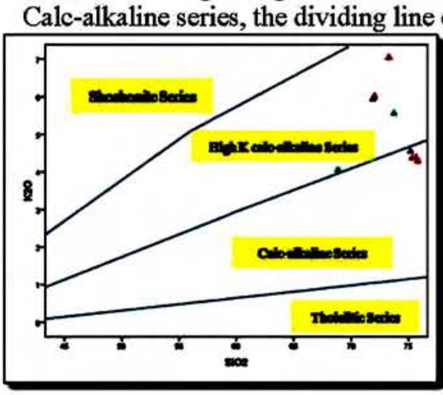


Figure 17 Total alkalis Vs silica diagram distinguishing alkaline and subalkaline series (after Irvine and Bragar, 1971)

Figure. 18 SiO_2 Vs FeO/MgO diagram subdividing the subalkaline magma series to Tholeiitic and Calc-alkaline series, the dividing line chosen by Mac Donald,(1968)



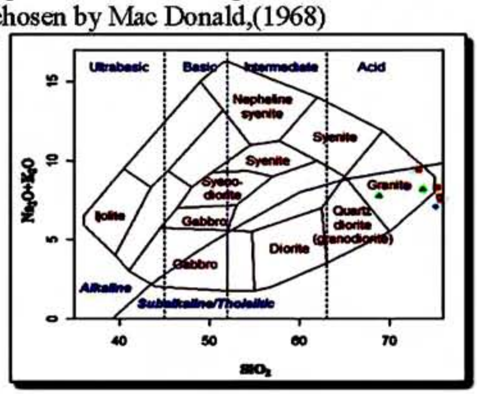
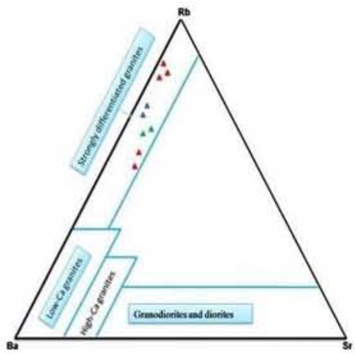
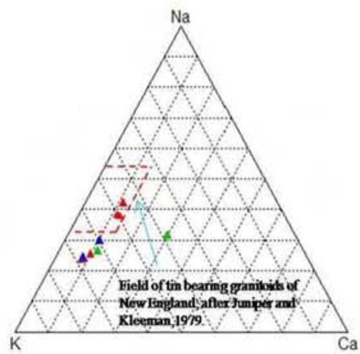
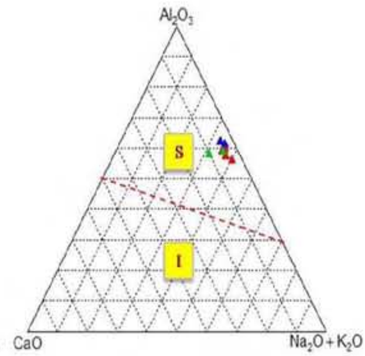


Figure 19 SiO_2(wt%) Vs K_2O (wt%) showing Calc-alkaline to High K calc-alkaline series diagram,the dividing line is chosen by Peccerillo and Taylor, 1976.

Figure. 20 TAS diagram of the granitic rocks of the study area,(Source: Cox et.al (1979)







(21) **(22)** **(23)**

Figure. 21 Rb-Sr-Ba ternary variation diagram of the granitic rocks of the study area, showing the differentiation trend and compositional group of igneous rocks (after El Bouseilly and El Sokkary (1975).

Figure. 22 Na- K- Ca triangular plot showing biotite granites are falling in the field of tin-bearing granitoids of New England,(after Juniper and Kleeman, 1979)

Figure. 23 ACF diagram for granitic rocks of the study area, (After Hyndman,1985) Molar ratios: A-Al_2O_3-Na_2O, C-CaO, F-Fe_2O_3+MgO

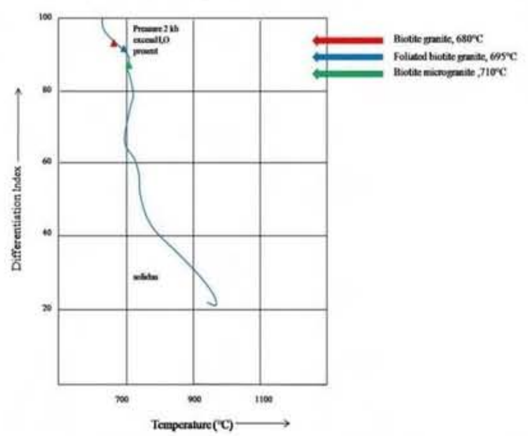
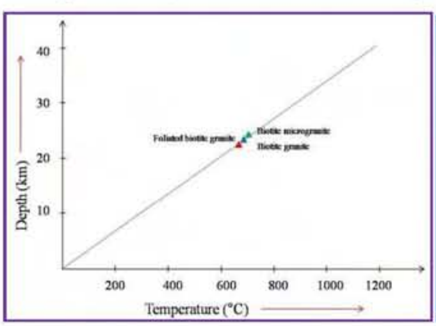
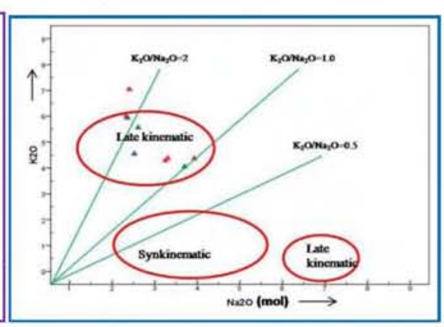


Figure. 24 Temperature-differentiation index diagram for the igneous rocks of the study area, at 2kb water pressure (after Piwinskii and Wyllie, 1970)





(25) (26)

Figure. 25 Schematic Depth-temperature relation diagram for the igneous rocks of the study area, (after Marmo, 1956)

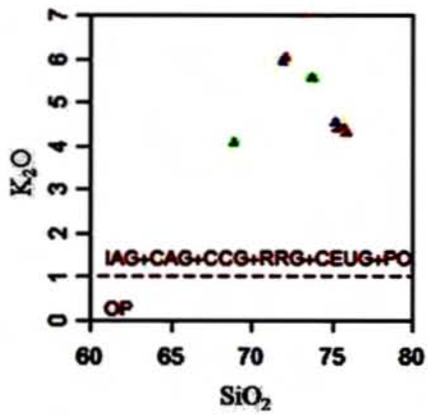
Figure. 26 K_2O mol Vs Na_2O mol variation diagram of the granitoid rocks in the study area showing the late kinematic granites (after Marmo, 1956)

Tectonic discrimination of granitoids (using major elements chemistry)

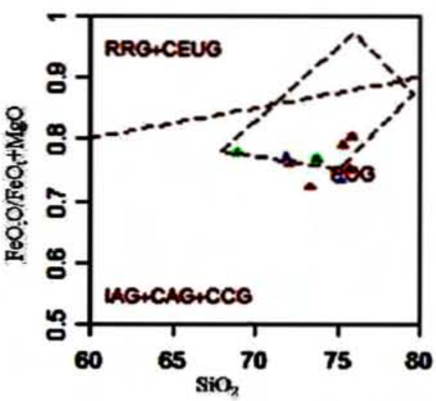
SiO_2 versus K_2O variation diagram divided into the IAG+ CAG+ CCG+ RRG+CEUG and OP. All analyzed granitoid rocks of the Zingyaik area fall in the IAG+ CAG+ CCG+ RRG+ CEUG field, fig.27. SiO_2 versus $FeO_t/(FeO_t+MgO)$ variation diagram shows that these granitoid rocks fall in IAG+ CAG+ CCG and POG field.According to the results of above mention, it could be thought that the granitoid rocks of the research area contained in IAG+CAG+CCG field,fig.28. All granitoid rocks of the project area can be seen in CAG and CCG field in the Shand's Index diagram (fig.29).

Tectonic discrimination of granitoids (using cations)

The tectonic environments of granitoids of the study area were plotted with Batchelor and Bowden (1985)'s R_1-R_2 binary (in millications) diagram, biotite granite, foliated biotite granite and biotite microgranite of Zingyaik area are characterized by syn-collision rocks and be likely in the direction of the Late orogenic zone in fig.30.



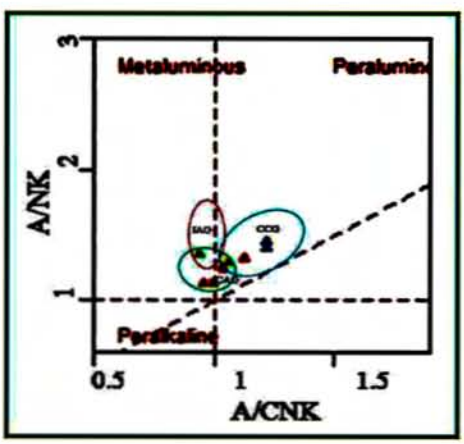
(27)



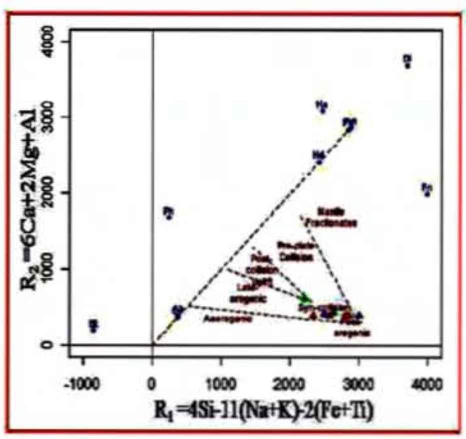
(28)

Figure.27 SiO_2 Vs K_2O diagram for granitoid rocks of the study area, distinction between oceanic plagiogranite and other granitoid rocks from the other environment.

Figure.28 SiO_2 Vs K_2O diagram for granitoid rocks of the study area, distinction between oceanic plagiogranite and other granitoid rocks from the other environment.



(29)



(30)

Figure.29 Shand's Index diagram for granitoid rocks of study area, which fall within the CAG and CCG field

Figure.30 R_1-R_2 binary (in millications) diagram for the ea (After Batchelor and Bowden, 1985)

IV. Conclusions

The research area, Zingyaik, is situated at the southeastern part of the Thaton, Paung Township, Mon State. It lies between latitudes 16°39'00" N to 16° 46'00" N and longitudes 97°23'00" E to 97°30'00" E.

The study area lies within a part of the Mogok Metamorphic Belt (Searle and Haq, 1964). It is situated at the northern part of Martaban Range which is a part of the Western Tin batholith known as Western Tin Belt of Southeast Asia Tin Province. The study area is also a part of Karen-Tenasserim Unit. Zingyaik area belongs to Thaton-Amherst granitoid body, one of the central granitoid belt of Myanmar.

The major rock sequence of the study area are biotite gneiss, quartzite and phyllite are (Lower Carboniferous).Biotite granite (Early Cretaceous), Foliated biotite granite (Qligocene), Microgranite (Late Qligocene), and (leucogranite dyke, microgranite sill, pegmatite &aplite veins, quartz and quartzofeldspathic veins (late Qligocene) and alluvial are Quaternary in age.

On the basis of petrochemical data analyses, the weight percent of silica content of the study area is high, varying from 68.85 to 75.80%. The igneous rocks of the study area belong to Acid clan, high K- calc alkaline series, peraluminous nature , Granite field, and **S** type with magmatic in origin. The S type granitoid rocks may be originated from the crustal source in origin.The liquidus temperature for foliated biotite granite, (porphyritic) biotite granite and biotite microgranite are 680°C, 695°C and 710°C respectively. According to depth-temperature relation diagram, the probable depth of igneous rocks is between 22 and 24km. So, the depth of emplacement may be estimated at the transition between the Mesozone to Catazone. The tectonic environments for the granitoid rocks of the research area fall within Continental Collision Granitoid and Continental Arc Granitoid (CCG and CAG) field, genetically, the later phase of the subduction related magmatism.

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