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PETROCHEMISTRY AND TECTONIC IMPLICATION OF HIGH K-CALC-ALKALINE SERIES, PERALUMINOUS S-TYPE GRANITOIDS OF KYAING TONG, SHAN STATE (EAST), MYANMAR

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Abstract

The study area is situated about 8 km north of Kyaing Tong. It covers a part of UTM map sheet No.2199/11. Areal coverage is about 130 square kilometers. Regionally, the study area comprises the Eastern High Lands Province, located in the western part of the Shan-Thai Block. The present area lies within the Eastern Granitoid belt of Myanmar, comprise in mostlyigneous units in the area. Representative samples from the study area were used to analyze the geochemical study of the granitoid rocks. Although Kyaing Tong batholith mainly consists of biotite granite, porphyritic biotite granite, foliated granite, hornblende granite, granodiorite and leucogranite, this study will focus on geochemistry and tectonic setting of Kyaing Tong S-type granite. A total of 7 representative samples have been selected and analysed for this study. The whole rock major oxides and trace element compositions were analyzed by XRF (X-ray fluorescence) spectrometer using standard calibration method at Economic Geology Lab., Department of Earth Resources Engineering, Kyushu University, Japan. Fresh rock specimens of about 0.5-1kg were crushed for XRF sample preparation method. Major oxides analysis was carried out on fusion discs and trace elements were pressed powered pills. Aims of this research which are: to study geochemical characteristics and to interpret the tectonic setting of the study area, tectonic discrimination diagrams were illustrated by using PetroGraph 2Beta software and GCD kits software. All analyzed samples fall in in acid group, recognized in subalkaline/tholeiitic series. Kyaing Tong granitoid rocks are the high abundance of Cr, Rb Ba, S, Zr and Sr. Based on the geochemical data, most granitoid rocks belong to the peraluminous field. Kyaing Tong S-type Granitoids of subduction related rocks due to the collision effects of Sibumasu and Indochina Block during Late Triassic closure of paleotethys, later Indosinian orogeny event.

Keywords: *Kyaing Tong Area, S-Type Granitoids, geochemical study, tectonic setting*

Introduction

Kyaing Tong is comprised in Eastern Granitoid Belt of Myanmar. The study area is located in Eastern most part of Myanmar, which is bounded by North Latitudes 21º 23΄ 47″ to 21º 28΄15″ and East Longitudes 99º 34΄45″ and 99º 42΄35″. It is bordered nearby Northern Thailand, Lao and Southwestern Yunan. The location map of the study area is shown in (Figure 1).

Regional Geologic Setting

The study area in the easternmost province of Myanmar, comprising high lands and plateaus, east of the Sagaing fault, referred to as the Eastern High Lands Province (EHP) covers the entire eastern half of the country. Regional geologic setting around the study area is shown in (Figure 2) and geological map of the study area is shown in (Figure 3).

The present area lies within the Eastern Granitoid belt of Myanmar (Khin Zaw, 1990). The eastern belt granitoids are characterized by medium to coarse porphyritic textures and country rocks of regionally metamorphosed, turbiditic sediments of Chaung Magyi Group (Upper Precambrian). This eastern granitoid belt lies immediately to the north of mostly Triassic

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granitoids in northern Thailand, and the Sn-W bearing, mesozonal, Permo-Triassic, Main Range granitoids in the western part of the Malay Peninsula.

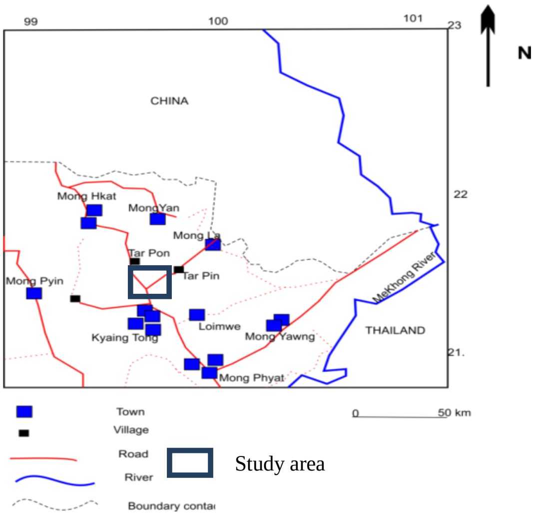


Figure 1 Location map of the study area.

Method of Study

Field methods and laboratory methods have been carried out for the present work. Modern analytical methods such as XRD and XRF were used to get geochemical data for this research work. The major and trace elements data were illustrated in variation diagrams, ternary diagrams, binary diagrams and triangular plots by using Petro Graph 2Beta software and GCD kits 4.1 software. Thornton and Tuttle Index (TTID or D.I, Differentiation Index) were calculated from standard CIPW norms which can be used as an indicator of bulk composition. To interpret the tectonic setting of the study area, tectonic discrimination diagrams were illustrated by using PetroGraph 2Beta software and GCD kits software.

Petrography

Leucogranite

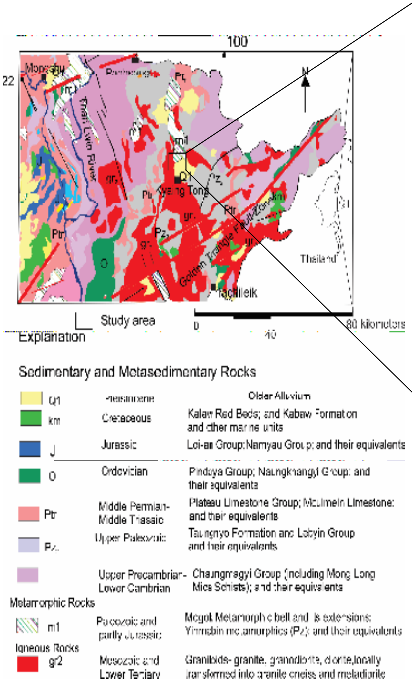
Leucogranite in the area shows distinct kaolinization developed on most outcrops(see Figure 4 a). It develops in highly weathered zone near metamorphic terrane. Petrographically, it shows holocrystalline, hypidiomorphic granular texture (Figure 4 b). It is characterized by sub equal proportions of quartz, alkali feldspar and plagioclase with a few amounts of muscovite. Accessory minerals are apatite, zircon and sphene. The main alkali feldspars are perthitic orthoclase, microperthite and orthoclase which shows Carlsbad twin. It contains about 40 % by volume of rock.

Granodiorite

Granodiorite is poorly exposed in the study area. It is observed at the northeastern part and core of the area with nearly north-south trend.In some exposures, it is also exposed in the form of boulder due to the exfoliation weathering of very large different joint sets (Figure 5 a). Microscopically, granodiorite shows holocrystalline, medium-grained hypidiomorphic granular texture (Figure 5 b). It is mainly composed of feldspar, quartz andbiotite. Feldspars make up the greater part of granite, a pothshand soda-bearing feldspar in equal amount. Accessory minerals are apatite, zircon and sphene.

Biotite Granite

Biotite granite is one of the major intrusive igneous rocks of the study area (Figure 6 a & b). Exfoliation nature is occasionally found in this unit. The occurrences of xenoliths size are 0.5 inch to 5 inches wide and 1.0 inch to 11 inches long. Petrographically, Biotite granite shows holocrystalline, coarse-grained hypidiomorphic granular texture (Figure 6 c & d). Biotite is significantly present compared to other granites of the study area, comprising about 10 percent of the total volume of the constituent minerals. Apatite, sphene, chromite, zircon and magnetite occur as accessory minerals as inclusions in biotite flakes.



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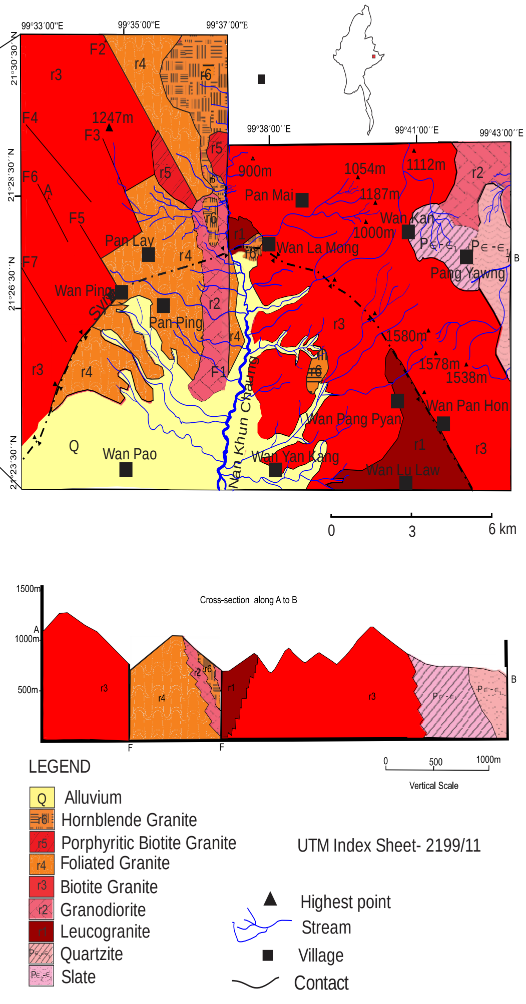

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(**Source:** Myanmar Geoscience Society (2014)).

Figure 2 Regional geological map of the Kyaing Tong area, Eastern Granitoid Belt of Myanmar

Figure 3 Geological map of the study area (Khine ZarWai, 2018).

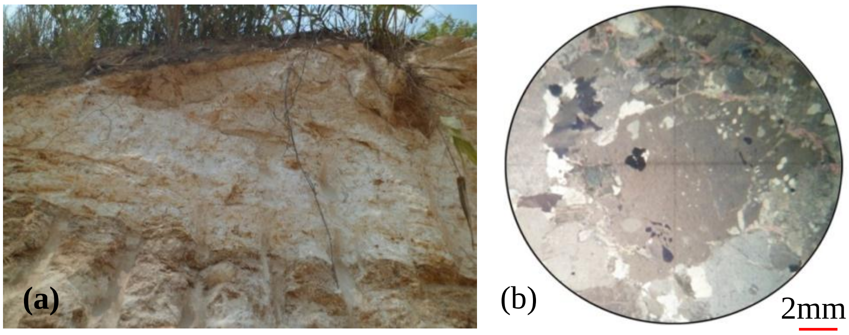


Figure 4 (a) Massive outcrop nature but highly weathered of leucograntie.
(b) Holocrystalline texture in leucogranite, under XN.

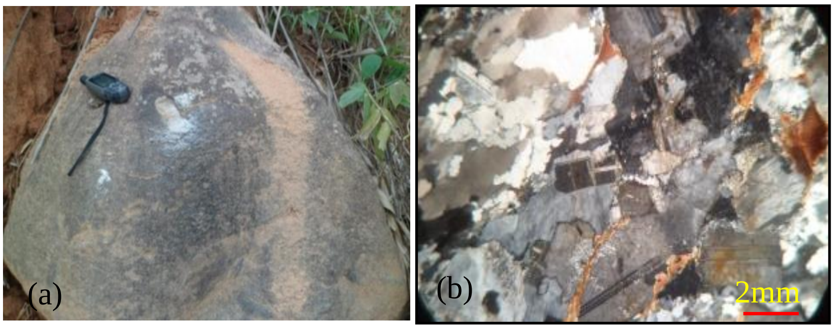


Figure 5 (a) Outcrop of granodiorite boulder (Loc 21˚ 27́ 30" N & 99˚ 37́ 00"E). (b) Medium-grained, holocrystalline, hypidiomorphic granular texture of under X.N view of granodiorite.

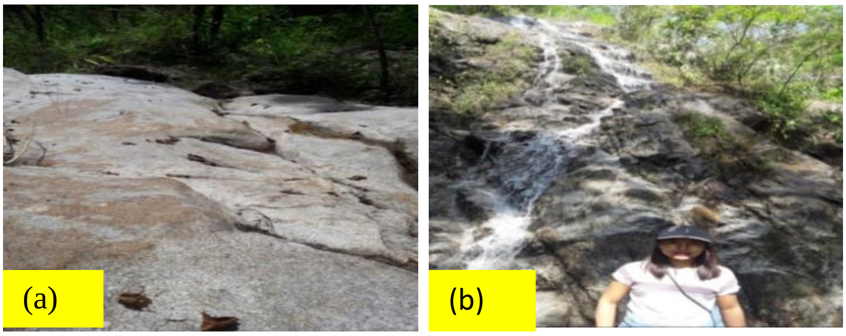


Figure 6 (a) Highly exfoliated character of biotite granite outcrop (Loc.21º 27′ 07.54″ N & 99º 36′ 54.31″ E) (b)Very massive outcrop of biotite granite (Loc.21º 27′ 15.562″ N & 99º 37′ 43.293″ E).

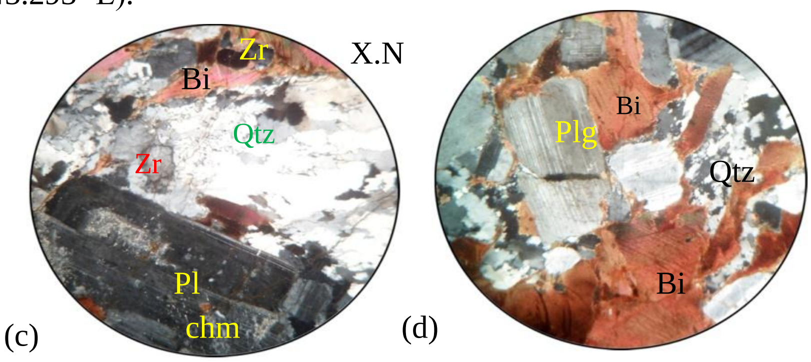


Figure 6 (c) Photomicrograph showing sericitization, zoning and simple twin in euhedral large orthoclase, under XN.(d) Automorph plagioclase surrounded by recrystallization of biotite, under XN.

Petrochemistry

Geochemical Characteristics of Granitoid Rocks

Major oxides and trace elements compositions of 7 representative samples from the study area have been selected and analyzed. The major oxide and trace element compositions of the representative granitoid rocks from the study area are shown in (Table (1) & (2)).Standard CIPW norms and CIPW norm with biotite and hornblende are calculated following to the rules of Hutchison (1975) by using the aid of computer (Table 3).

SiO_2 contents of biotite granite samples are in the range (65.83- 70.69%), granodiorite(66.80- 68.22%) and leucogranite(73.23-74.73%)respectively. Al_2O_3contents are (13.6%-15.25%) in biotite granite, (15.11%-15.46%) in granodiorite and (13.8%-14.06%) in leucogranite. K_2O contents are (3.64%-3.95%) in biotite granite, (2.99%-3.96%) in granodiorite and (4.01%-6.31%) in leucogranite. CaO contents are (1.92%-3.06%) inbiotite granite, (0.61%-2.57%) in granodiorite and (0.31%-0.52%) in leucograniteeach other. A/CNK (molecular Al_2O_3/ (CaO+Na_2O+ K_2O) content in all analyzed samples show >1.1values.According to Chappell & White (2001), I-type and S-type of granitoid rocks are distinguished by the 1.1 limited values based on molecular Al_2O_3/ (CaO+Na_2O+ K_2O) content.CIPW normative corundum content in all granitoid rocks show >1%.

Differentiation Index (D.I) of granitoid rocks in the study area varies from 73.8 to 92.7. CIPW norms with hypersthenes contents range from 2.50 % to13.10%. Magnetite contents (0.52-2.54%), ilmenite contents (0.04-1.69%)and zircon content (0.03-0.06%)are noted. Total alkali content (Na_2O+ K_2O) ranges from 4.48% to 7.71% while (Na_2O+ K_2O+CaO)contents are (6.68%-9.27%) and (Al_2O_3+Na_2O+ K_2O) contents are (19.32%-21.72%). Kyaing Tong granitoid rocks show high abundance of Cr, Rb,Sr,Ba, Sand Zr.

According to White (1979),the two types of granite come from source rocks of fundamentally different origin, one formed by deposition on the crust, S-type (Sedimentary or Supracrustal source) and the other by accretion beneath the crust, I-type (Igneous or Infracrustal source). Based on the geochemical data, the weight percent of alumina is higher in all granitoids (13.6-15.46 wt %), indicating that all analyzed granitoid rocks in the study area belong to the peraluminous field and some to metaluminous field.

In AFM diagrams (after Irvine and Barragar, 1971) (Figure 7), all granitoid samples fall in calc-alkaline field. According to K_2O Vs SiO_2 diagram by Peccerillo and Taylor (1976), most granitoid samples fall in high- K calc-alkaline series and one leucogranite sample falls in shoshonite series (Figure 8). Na_2O-Al_2O_3-K_2O diagram (Figure 9) shows all granitoid rocks of the study area fall in the metaluminous+peraluminous field clan with more potassic feldspar than sodic proportions.

Table 1 Major oxide weight (%) compositions of the S-type granitoid rocks from the study area.

Sample NO.	KZW-8	KZW-19	KZW-3	KZW-12	KZW-18	S-1	K-2
SiO_2	66.80	68.22	74.73	73.23	65.83	68.7	70.69
TiO_2	0.88	0.79	0.02	0.23	0.89	0.83	0.47
Al_2O_3	15.11	15.46	14.06	13.8	13.96	13.6	15.25
Fe_2O_3	6.02	5.23	1.19	2.01	5.54	4.87	2.35
MnO	0.09	0.08	0.31	0.02	0.09	0.07	0.03
MgO	3.76	3.24	0.36	0.76	3.51	2.47	1.27
CaO	2.57	0.61	0.52	0.31	3.06	1.92	2.81
Na_2O	1.49	2.11	3.65	1.4	1.81	1.77	3.07
K_2O	2.99	3.96	4.01	6.31	3.64	3.95	3.39
P_2O_5	0.29	0.29	0.06	0.2	0.31	0.19	0.13
Total	100.00	99.99	98.91	98.27	98.64	98.4	99.46

In A/Nk (molecular Al_2O_3/ (Na_2O+K_2O) versus A/CNK (molecular Al_2O_3/ (CaO+Na_2O +K_2O)) diagram by Shand(1943), all granitoid samples fall in peraluminous field (Figure10). Various plots are used to distinguish the genetic type of granitoids rocks of the study area. All variation diagrams indicate that S-type signature.

S-type granites are always oversaturated in Al, or peraluminous, and that is the case also for the more felsic I-type granites. Chappell and White (1974) recognized this in drawing their boundary between the I- and S-types, with a limiting value for the Aluminium Saturation Index (ASI:Zen 1986) of 1.1, or 1% normative corundum with respect to the above geochemical signatures. The magmatic differentiation trend of S-type granitoid rocks of the study area are in accordance with of molecular (A/CNK) Vs SiO_2 diagram (Figure 11).

Table 2 Trace elements (ppm) compositions of the S-type granitoid rocks from the study area.

Sample NO.	KZW-8	KZW-19	KZW-3	KZW-12	KZW-18	S-1	K-2
As	0	4	0	0	3	2	0
Ba	1501	783	28	488	918	913	1536
Co	43	25	53	34	30	38	38
Cr	122	103	0	0	110	70	5
Cu	24	2	2	2	19	26	5
Mo	8	8	0	7	11	8	16
Nb	18	18	26	17	17	17	7
Ni	37	47	7	11	31	39	10
Pb	38	33	29	56	32	43	62
Rb	152	255	352	414	218	208	111
S	181	180	98	559	491	1837	343
Sr	305	142	10	34	203	143	1089
V	142	113	5	10	122	123	44
Y	33	40	35	36	47	35	16
Zn	75	69	0	15	65	68	44
Zr	312	268	24	125	306	293	225

Table 3 Standard CIPW norms and CIPW norm with biotite and hornblende weight (%) compositions of the S-type granitoid rocks from the study area.

Sample No.	KZW-8	KZW-19	KZW-3	KZW-12	KZW-18	S-1	K-2
Quartz	32.58	32.59	35.92	38.83	28.28	34.32	30.72
Orthoclase	18.37	23.52	23.70	37.65	15.32	24.07	21.27
Albite	12.19	17.52	30.89	11.85	13.21	14.98	25.98
Anorthite	10.63	1.20	2.19	0.23	22.24	8.34	13.44
Corundum	5.02	6.97	2.91	4.52	2.07	3.22	1.38
Hypersthene	13.10	11.37	2.50	3.26	12.36	8.88	4.51
Magnetite	2.54	2.23	0.52	0.87	2.41	2.07	1.03
Ilmenite	1.61	1.46	0.04	0.44	1.69	1.58	0.89
Apatite	0.65	0.65	0.14	-	0.72	0.44	0.30
Zircon	0.60	0.06	-	0.03	0.06	0.06	0.04
Chromite	0.03	0.03	-	-	0.03	0.01	-
Pyrite	0.04	0.04	0.02	0.13	0.11	0.38	0.06
D.I	73.8	74.8	92.7	88.6	79.0	81.7	91.4
Total	96.82	97.64	98.84	98.27	98.49	98.34	99.62

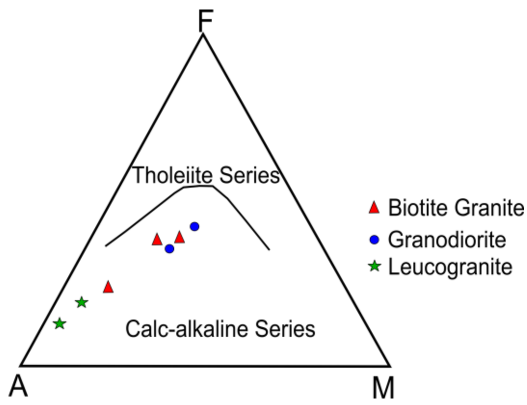


Figure 7 AFM diagram (after Irvine and Barragar, 1971) shows the Calc-alkaline magma series of granitoids of Kyaing Tong.

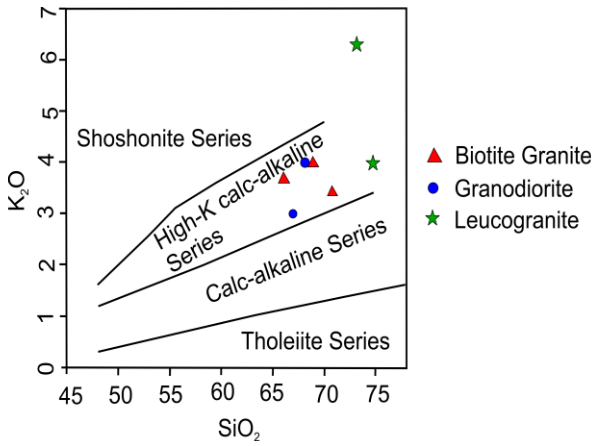
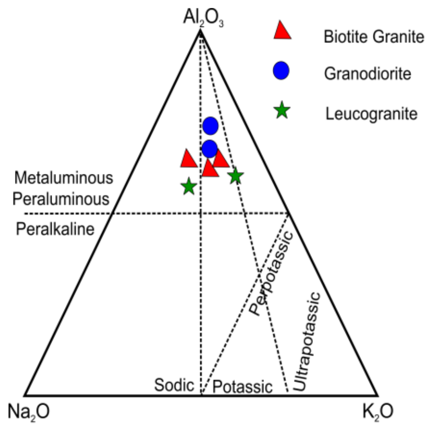


Figure 8 K_2O Vs SiO_2 diagram by Peccerillo and Taylor (1976) shows most granitoid samples fall in high- K calc-alkaline series and one leucogranite sample falls in shoshonite series.



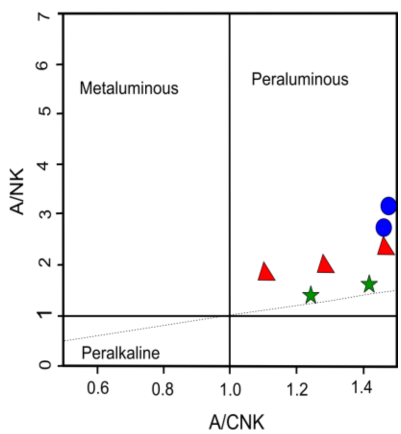


Figure 9 Na_2O-Al_2O_3-K_2O diagram shows all granitoid rocks of the study area fall in the metaluminous+peraluminous field

Figure 10 A/Nk versus A/CNK diagram by Shand (1943) shows all granitoid samples fall in peraluminous field.

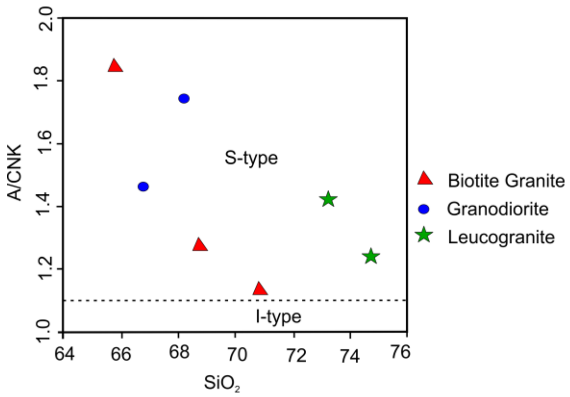


Figure 11 Molecular (A/CNK) Vs SiO_2 diagram shows S-type granitoid rocks of the study area.

Geotectonic Setting of Granitoids

When trace element data plotted by (Pearce et al, 1984), one biotite granite sample falls in VAG + syn-COLG setting and the others are WPG setting (Figure 12 a & b).

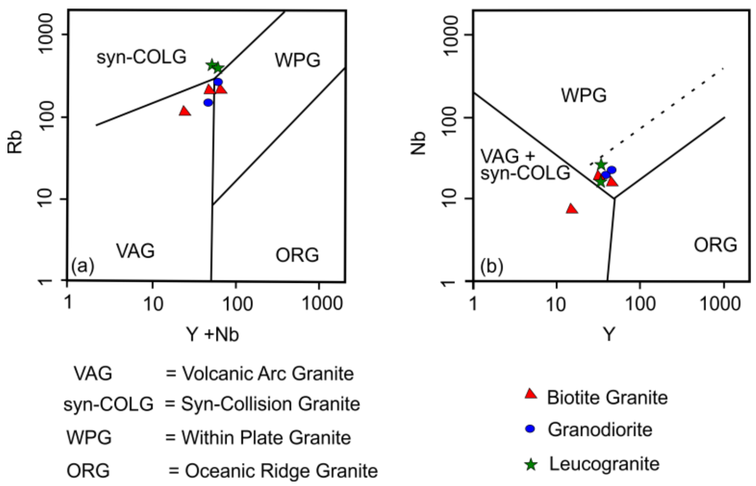


Figure 12 (a) (Y+ Nb) vsRb diagram and (b) Y vsNb diagram show tectonic setting of granitoids rocks of the study area. (after Pearce et al, 1984)

Regional Tectonic Setting

Plate tectonic interpretations of geological events within the Burmese region have been made by many workers in recent years (Mitchell, 1973, 1977, 1979, 1981, Mitchell and Garson 1972, 1976, Goossens 1978, Curray *et al.* 1979, 1982, Hla Maung 1987, Win Swe 1981a, b, Maung Thein 1983, Bender 1983, Khin Zaw 1986, 1987a, 1989). Kyaing Tong granitoidbatholith is the most important part of eastern granitoids belt of Myanmar (Khin Zaw, 1990). Eastern granitoid belt of Myanmar lies in important mineralized granitoid province in the Southeast Asian region. It is geographically considered as a part of the Shan-Thai Block, tectonically defined as a part of Sibumasu Block, especially considered as a northern continuation of Inthanon Zone of central granitoid belt of Thailand.

Eastern Granitoid Belt of Myanmar

KhinZaw (1990) reported that there are three granitoid belts of Burma which are namely Eastern Granitoid Belt, Central Granitoid Belt and Western Granitoid Belt from east to west (Figure 13 (a)).Mitchell (1977) suggested the Eastern Granitoid Belt of Myanmar as being the result of continental collision and similar to the Malay Peninsula Granitoids. Bender (1983) commented on large granite complexes found east of the Salween River. He presumed a Early Triassic age on these based on their apparent correlation with the granites in the Fang District in northern Thailand as dated by Von Braun et al. (1976), and now inferred to be a part of the Main Range Province. More recently, the Department of Geological Survey and Exploration of Myanmar (DGSE) has undertaken mapping within the Eastern Shan State, and they have assigned a Mesozoic age to the Tachileik granite (MyintKo et al., 2007; U Nyunt Htay, Personal communication). Than Htun et al. (2014) reported a Late Triassic age from a biotite granite within the Mong Ton – Mong Hsat tin district, on the Myanmar - Thailand border.

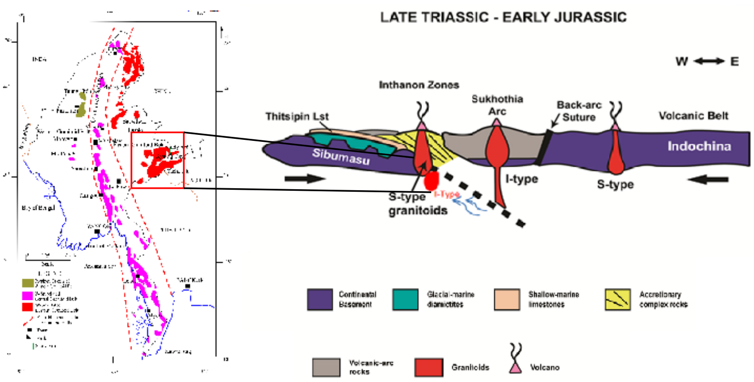
Kyaing Tong Granitoids

Kyaing Tong granitoid batholiths (including the present study area) appear to intrude the preexisting Chaung Magyi sediments. During the final collisional consolidation of these terranes, Late Triassic to Early Jurassic collisional tin-bearing Main Range granitoids were formed in Southeast Asia. However, the study area is mainly concerned with the subduction zone related to the Inthanon Zone, especially Central granitoid belt of Thailand.

Possible Tectonic Setting

Sibumasublock was eastward dipping underneath the Indochina Block forming the subduction zone during Late Triassic which might induce the intrusion of the Kyaing Tong Granitoids. S-type granitoids are believed to be derived from the partial melting of continental crust at the edge of Sibumasu (WPG, within Plate) due to the evidences: magmatic differentiation in Rb,Ba and Sr correlation. Kyaing Tong Basin is considered as the back-arc basin type behind the subduction suture. Southern portion of the study area entirely belongs to the northern marginal segment of Kyaing Tong Basin. It took place in Late Indonisian orogeny event, the closure of Palaeo-Tethys time. Possible tectonic setting of Kyaing Tong ganitoids is shown in (Figure 13(b)).

Possible Tectonic Setting of Eastern Granitoid Belt of Myanmar



(a) (b)

Figure 13 (a) Granitoid Belt of Myanmar (Eastern, Central &Western) (KhinZaw, 1990).(b) Possible tectonic setting of Kyaing Tong granitoids(Modified after Metcalfe et al., 2011).

Conclusion

The granitoid rocks in the study area are mostly in peraluminous field. It indicates that the distinct crustal sources and high peraluminousity of the granites also prefer more pelitic sediments may contribute in the magma. Main body of eastern granitoid belt of Myanmar, the Kyaing Tong granitoids also has the same kind of geological characteristics of the Taung Peng Granites and Central granitoid belt of Thailand. Moreover, these entirely differ from Tak Batholiths of Eastern granitoid belt of Thailand. It is tectonically defined as a part of Sibumasu Block, especially considered as a northern continuation of Inthanon Zone of Central Thailand.

According to the geochemical signatures of trace elements data interpretations, Kyaing Tong granitoids is very complicated marked by syn-collision, volcanic arc granites and within plate granite. These are closely similar to the Inthanon Zone of Central Granitoid Belt of Thailand. Granitoid rocks of the study area (S-type) originated as a result of partial melting of thick continental crust. It may have been directly related to the collision of Shan-Thai (Sibumasu Block) and Indochina block. These produced voluminous S-type granitoids occurring as highly mountain chains generally as a NW-SE trending. Emplacements of granitoids are formed when collision related granites were generated late in the Triassic, the collision was already completed. The Sibumasu Block may have been continued eastward dipping subduction beneath Indochina block and that consequently the margin of Sibumasu Blockoverthrust the margin of Indochina causing the subduction zone.

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