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PETROGENESIS AND GEOCHEMISTRY OF GRANITIC ROCKS IN ZAW PHO KYIN MINE, DAWEI TOWNSHIP, TANINTHARYI REGION

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Abstract

The present research area was conducted at Zaw Pho Kyin Mine situating about 70.84 km east of Dawei, Tanintharyi Region. The total area coverage is about 32 km^2. Two major rock units, the metasedimentary rocks of Mergui Group and biotite granite are widely exposed. Granite is well exposed in the central part of the study area. Granite is highly weathered at Zaw Pho Kyin prospect in which the wolframite bearing quartz veins are intruded. The texture of the biotite granite in the Dawei district varies from coarse to medium-grained, consists of quartz, microcline, partly sericitized, plagioclase, biotite and minor muscovite. Geochemically, granitic rocks show high - K calc-alkaline series and are predominantly peraluminous. In Harker's variation diagram, Al_2O_3, TiO_2, FeO, CaO, Na_2O, K_2O and MnO are negatively correlated with SiO_2 whereas MgO and P_2O_5 are positively correlated with SiO_2. Plots of Harker's variation diagrams, selected trace elements of W, Sn, Mo, Ba, Rb, Y, Ni and Zn are negatively correlated with SiO_2 and Zr is positively correlated with SiO_2. Standard CIPW normative corundum ranges from 1.826 to 6.809 and A/CNK ratio is > 1.1, indicated S-type granite and peraluminous granite from Zaw Pho Kyin mine area.

Keywords: *S-type granite; paraluminous; Zaw Pho Kyin Mine, Dawei Township*

Introduction

Myanmar is located at the south of the East Himalayan Syntaxis. The major topographic and tectonic features of Myanmar are generally NNW-SSE direction. As a result of the study of plate tectonic evolution, the geotectonic provinces of Myanmar, from east to west are divided into four main provinces, such as the Eastern Highlands Province (EHP) or Sino-Burma Ranges**,** the Central Myanmar Belt (CMB) or Inner-Burma Ranges**,** the Western Ranges (WR) or Indo-Burma Ranges**,** the Rakhine Costal Belt (RCB) or Arakan Coastal Area (Win Swe *et.al*, 2012). Tanintharyi Ranges are composed various deformation and weakly metamorphosed clastic sedimentary rocks that referred to as the Mergui Group in Late Carboniferous to Early Permain. The Mergui Group of rocks is exposed along the Tanintharyi Region, including both the mainland and Myeik Archipelago (Win Swe,1975 and 1976). The region is part of the tin-tungstern metallogenic province. This province is about 1500 km (932 miles) long, which extend from Yunan in the north to Malaysia and Indonisia in the sourth. This tin- tungstern belt passes through the Shan-Tanintharyi Region. This belt is a middle segment of a great tin-tungstern province of SE-Asia. The tin-tungsten deposits constitute one of the most important minerals resource of Myanmar. The study area is located southern part of tin-tungsten belt in Myanmar. The tin-tungsten mineralization is spatially related to granitic intrusion. Dawei is famous for its Sn-W deposits and occurrences situating in the Eastern Highland Province (EHP). The EHP is composed Kachin State from the north, Shan plateau in the middle and Tanintharyi ranges together with Myeik Archipelago to the south. The oldest rocks in Myanmar are exposed only in EHP. The regional geology of the Tanintharyi area, Dawei Township, according to the regional geological map of Dawei area (Aung Zaw Myint, 2016), two main rock types occurred metasedimentary rock of Mergui Group and granitic rocks. Mergui Group is the oldest rock unit in this area. It is widely distributed in the Dawei area. The main purpose of the present study was to know the origin of

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granitic rock in Zaw Pho Kyin mine area, Dawei Township, Taninthayi Region (Figure 1). The objectives were to construct seveal discrimination and variation diagrams, to distinguish the rocks types, to identify their geochemical characters and to constrain the tectonic setting of the granitic magmatism.

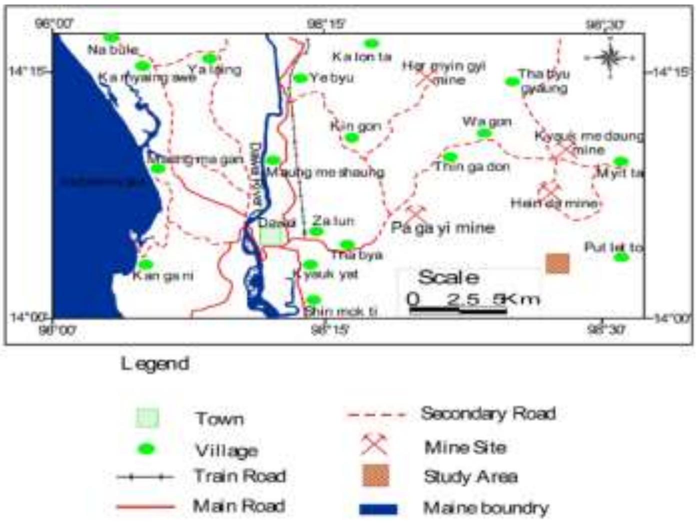

Figure 1. Location map of the study area

Materials and Methods

Study area and study period

Dawei is located 639.17 km southeast from Yangon. The study area is situated about 70.84 km east from Dawei city (Figure 1). The study area is between Latitudes 14°03´00´´-14°05´00´´N and Longitude 98°25´45´´- 98°29´45´´ E in one-inch topographic map of 95-J/8. It is situated between vertical grid No.380 to 460 and horizontal grid No. 530 to 570 in UTM map of 1498/08. It covers length about 8 km in East-West direction and width about 4 km in North-South direction. The total area coverage is about 32 km^2.This paper presents mineralization as well as ore mineralogy, wall rock alteration, and geochemical characteristics of tungsten-tin mineralization.

The present research area was conducted at Zaw Pho Kyin Mine situating about 70.84 km east of Dawei Township, Tanintharyi Region. Two major rock units, the metasedimentary rocks of Mergui Group and biotite granite are widely exprosed in the research area. They are Mergui Group (pebbely mudstone and metagraywacke) and granitic rocks (biotite granite and greisenized granite) are exposed in the research area. The Mergui Group is widely distributed around the Putletto area and the oldest unit in the study area. Generally, they trend NNW-SSE direction and dipping to the east. The mainly prominent rocks are bluish grey color and highly jointed metagraywacke. In the study area, the plutonic (intrusive) igneous rocks can be divided into two types. They are Biotite granite and greisenized granite. This granite is well exposed in the central part of the study area and it hosts tin-tungsten mineralized quartz vein. Geological map of the study area is shown in Fig (2). The study was lasted in 2018.

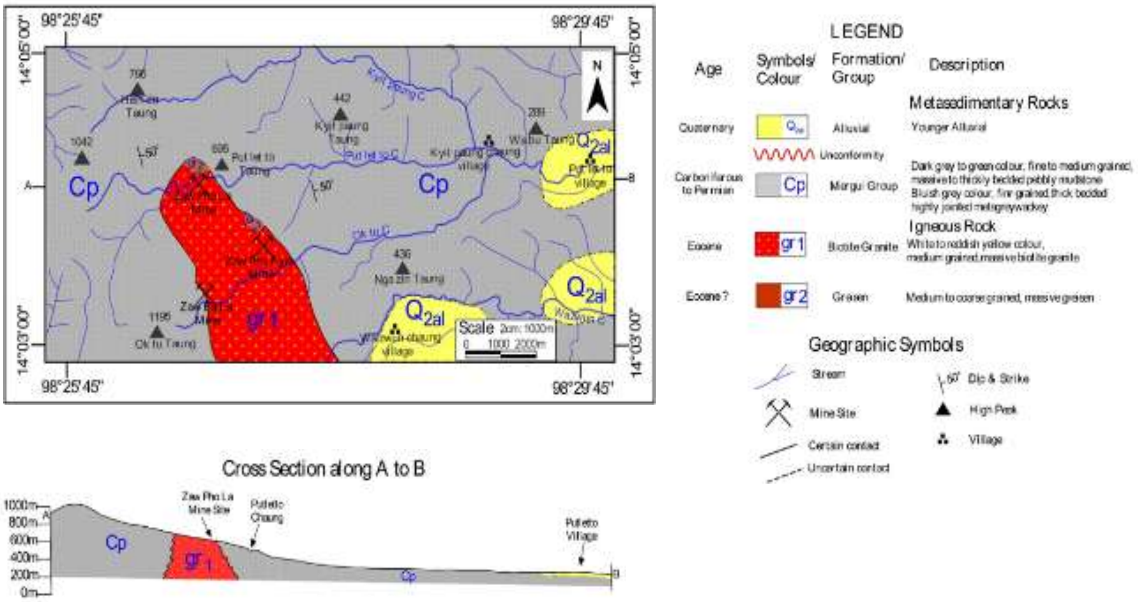

Figure 2. Geological Map and Cross-Section of the Study area

Study of petrographical analysis

Thin-sections of the rock samples were prepared for detail petrographic studies using transmitted light polarizing microscope. These samples were described megascopically and microscopically with representative hand specimen photographs and photomicrographs.

The representative igneous rock samples including 7 biotite granites and 2 greisen from the study area were selected for analysis. The major oxide and trace elements abundance were determined by X-ray fluorescence spectrometry. All igneous rock samples from the study area were analyzed at Economic Geology Laboratory, Department of Earth Resources Engineering, Kyushu University.

Results

Petrogenesis of granitic rocks

Granite is well exposed in the central part of the study area. Granite is highly weathered at Zaw Pho Kyin prospect in the study area. The wolframite bearing quartz vein intrudes the granite of the study area. The texture of the biotite granite in the Dawei district varies from coarse to medium-grained. In study area, biotite granites are coarse-grained, hypidiomorphic granular texture. It is essentially composed of quartz, plagioclase, alkali feldspar (orthoclase, microcline, perthite and albite), biotite and minor amount of muscovite (Figure 3a &b)

Quartz grains are elongate, euhedral to subhedral. Plagioclase occurs as subhedral grains with polysynthetic twins and normal zoning some are altered to saussuritization (Figure 4a)

Alkali feldspar consists of perthite, microcline and orthoclase. The most common alkali feldspar is orthoclase that has subhedral form and simple contact twin. Untwined orthoclase is more common than twinned orthoclase. Simple contact twin of orthoclase crystal in microcline (Figure 4d). Some orthoclase is altered to sericite and zircon inclusion in orthoclase (Figure 4b). Sericitization is well developed in orthoclase (Figure 4c). Microcline exhibits cross hatched twinning (Figure 4d). Microcline intergrowth with sodic plagioclase from microcline perthite (Figure 5a). Perthitic texture is fromed by the intergrowth of alkali feldspar and albite. Perthitic textures indicate that the feldspars are formed at high temperature and cooled slowly, result in unmixing as the solvus curve.

Biotite occurs as subhedral flakes form and it shows yellowish brown to dark brown. Biotite is observed as inertial the orthoclase feldspar and edge of orthoclase crystal (Figure 5b). In some biotite is altered to chlorite along the cleavage plane, (Figure 5c) and it sometime associated with muscovite, (Figure 5d).

Figure (3) a. Photograph showing nature of exposure and close up view of biotite granite at Zaw Pho Kyin Prospect, b. Photograph showing nature of exposure and megascopic view of greisen at Zaw Pho Kyin Prospect

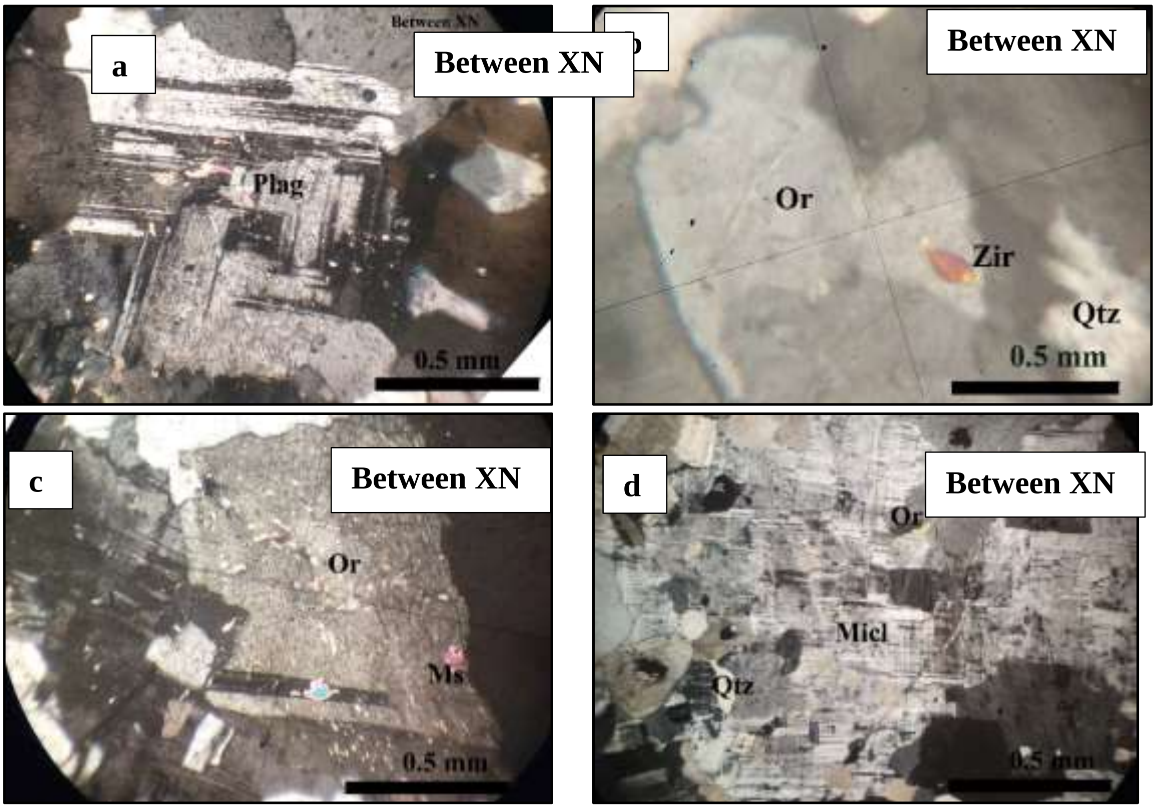

Figure (4) a. Photomicrograph showing normal zoning plagioclase in biotite granite (Between X.N, 10X), b. Photomicrograph showing zircon inclusion in orthoclase crystal in biotite granite (Between X.N, 10X), c. Photomicrograph showing secritization in orthoclase crystal (Between X.N, 10X), d. Photomicrograph showing simple contact twin of orthoclase in microcline at biotite granite (Between X.N, 10X)

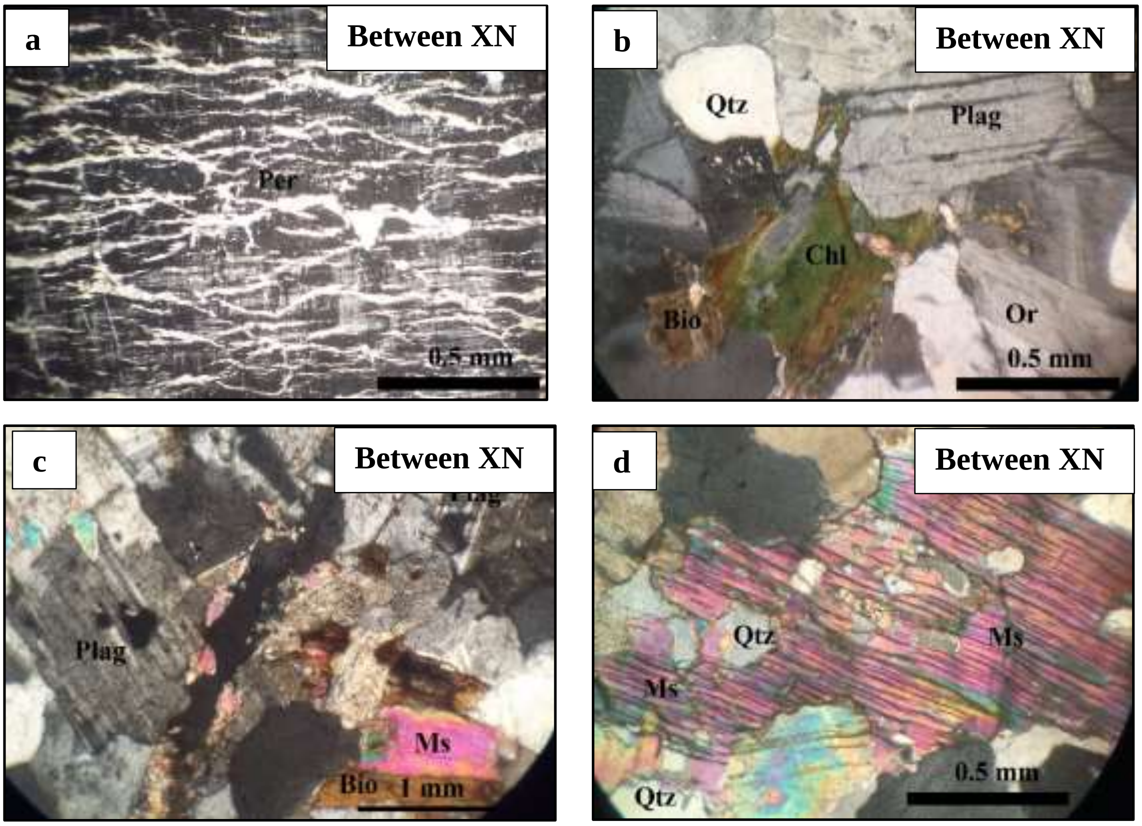

Figure (5) a. Photomicrograph showing string perthite in biotite granite (Between X.N, 10X) b. Photomicrograph showing chloritization along the biotite cleavage planes in biotite granite (Between X.N, 10X & 4X), c. Photomicrograph showing the biotite (Bio) associated with muscovite in biotite granite (Between X.N, 10X), d. Photomicrograph showing quartz grain observe as muscovite (Ms) flakes in greisen (Between X.N, 10X)

Geochemical characteristics of granitic rocks

Major elements oxide

The granitic rocks of the study area are biotite granites and greisen. The concentration of major element oxides of biotite granite rocks from the study area include SiO_2, Al_2O_3, FeO, MgO, CaO, K_2O, Na_2O, TiO_2 and P_2O_5 are presented in table (1). The SiO_2 contents range between 75.641 and 78.058 wt.% corresponding to a felsic composition. The contents of Al_2O_3(11.534-13.17wt.%), K_2O (3.942-4.631wt.%) and Na_2O (0.386-2.836wt.%) respectively. Total alkali contents (Na_2O + K_2O) ranges from 4.328 to 7.467 wt%. MnO and P_2O_5 concentrations are less than 0.5 wt%.

The concentration of major element oxides of greisen rock from the study area include SiO_2, Al_2O_3, FeO, MgO, CaO, K_2O, Na_2O, TiO_2 and P_2O_5 are presented in table (1). The SiO_2 contents range between 75.441 and 83.423 wt.% corresponding to felsic composition. The contents of Al_2O_3 (8.647- 12.538 wt.%), K_2O (2.924-4.279wt.%) and Na_2O (0.357-0.398wt.%) respectively. Total alkali contents (K_2O+Na_2O) ranges from 3.281 to 4.677 wt%. MnO and P_2O_5 concentrations are less than 0.5 wt%.

Table 1. Concentration of major (in wt.%) and trace elements (in ppm) by XRF for the Granite and Greisen sample in study area

Sample No	zpl-1/16	zpl-5/19	zpl-6/19	zpk-3/20	zpk-5/20	zpk-8/20	zpk-11/20	zpl&zpk-5/21	zpl-6/21
Major elements (wt%)									
SiO_2	76.33	77.908	78.058	83.423	75.641	75.649	76.108	75.672	75.441
TiO_2	0.019	0.018	0.013	0.029	0.034	0.03	0.068	0.029	0.019
Al_2O_3	12.897	12.201	12.181	8.647	11.534	13.17	12.701	13.136	12.538
FeO	1.138	0.977	0.821	2.229	3.969	1.299	1.412	1.287	3.373
MnO	0.153	0.074	0.044	0.167	0.271	0.101	0.081	0.106	0.37
MgO	0.297	0.288	0.285	0.311	0.289	0.304	0.346	0.303	0.295
CaO	0.542	0.29	0.302	0.049	0.045	0.655	0.622	0.76	0.817
Na_2O	2.597	2.812	2.836	0.357	0.386	2.755	2.414	2.802	0.398
K_2O	5.309	4.631	4.49	2.924	3.947	4.749	5.306	4.56	4.279
P_2O_5	0	0.009	0.015	0.005	0	0	0.005	0	0
Total	99.862	99.878	99.885	99.871	98.856	99.872	99.857	99.875	99.66
Trace elements (ppm)									
S	**0.0046**	**0.0075**	**0.0064**	**0.0081**	**0.9578**	**0.0074**	**0.0067**	**0.0057**	**0.0811**
Cl	5	1	2	2	1	4	4	1	1
V	0	0	0	1	1	9	0	6	0
Cr	19	23	21	28	26	22	17	22	24
Co	10	34	9	0	15	26	20	8	15
Ni	42	38	37	38	35	39	35	38	43
Cu	6	3	6	8	303	3	1	3	324
Zn	8	27	19	59	0	20	41	18	516
Pb	89	88	75	0	472	44	65	36	83
Hg	0	0	0	0	0	0	0	0	0
As	17	15	13	11	0	11	16	14	0
Sb	15	17	14	23	25	19	20	24	28
Sn	29	23	24	143	244	51	43	53	295
Bi	0	0	0	0	0.013	0	0	0	0.007
Mo	12	12	12	14	34	16	18	16	10
W	53	45	33	25	281	37	15	34	70
Rb	687	694	676	848	1239	741	775	703	1330
Sr	8	6	5	0	0	0	25	0	0
Ba	172	162	126	106	133	106	233	100	158
Y	229	173	174	202	227	199	187	205	324
Zr	75	78	75	95	87	92	109	94	73
Th	27	21	22	38	88	38	29	41	57
U	18	19	13	9	0	18	19	10	18

Harker diagrams are used for some major elements relative to SiO_2. Most of the major elements are negatively correlated with SiO_2 whereas the exception of the P_2O_5 contents which are slightly positively correlated (Figure. 6). Classification of the rock with SiO_2 & (K_2O + Na_2O) geochemical rock classification diagram of Middlemost (1994) for plutonic rocks shows that they plot in the granite field (Figure.7).

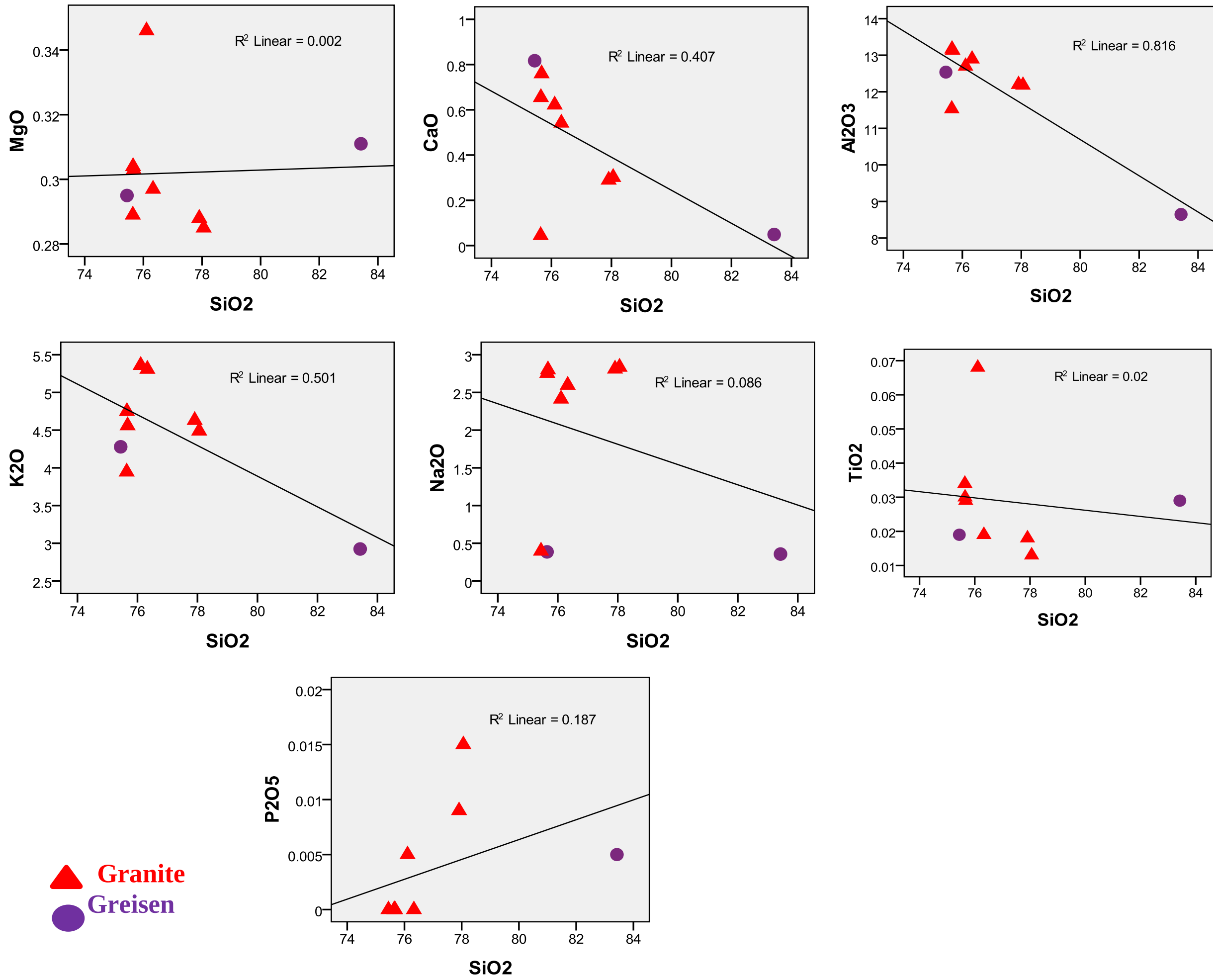

Figure 6. Harker's variation diagrams showing the correlation between major oxide (wt%) and SiO_2 (wt%) of the granitic rocks from the study area

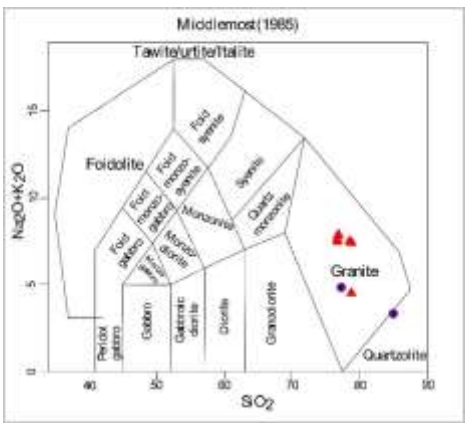

Figure 7. TAS diagram of Middlemost (1985) showing the granitic rock of the study area.

All granitic samples from the study area fall in the high-potassium calc-alkaline series in the K_2O and SiO_2 diagram after Peccarillo and Taylor (1976) Figure 8. The alumina saturation index (ASI) defined by molecular ratio Al_2O_3 / (Na_2O + K_2O + CaO) is greater than one in all the granitic samples ranging from 1.18 to 1.22 implying that the granitic rocks are peraluminous and S-type (Shand, 1943) Figure. 9.

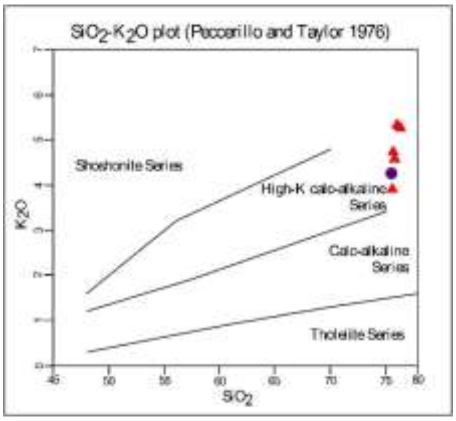

Figure 8. K_2O Vs SiO_2 plot for the granitic rocks of the study area are fitted as in the high-K cala- alkaline Series (after Peccerillo & Taylor, 1976)

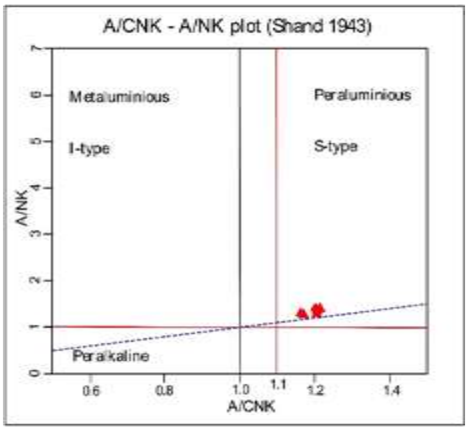

Figure 9. Alumina saturation index diagram of Shand (1943)

Trace elements

Trace elements concentration of the granitic rocks from the study area are listed in table (1) which shows the concentration of large ion lithophile elements (LILE) such as Rb (676-1330 ppm), Sr (0-25 ppm) and Ba (100-233 ppm). The ternary diagram Rb-Ba-Sr is applied for classification of genetic types of plutonic rocks (EL Bouseily and EL Sokkary, 1975) Figure.10. Trace elements discrimination (Y+Nb) and Rb diagrams (Pearce et al., 1984) indicates that the granitic rocks of study area fall in the WPG setting (Figure. 11).

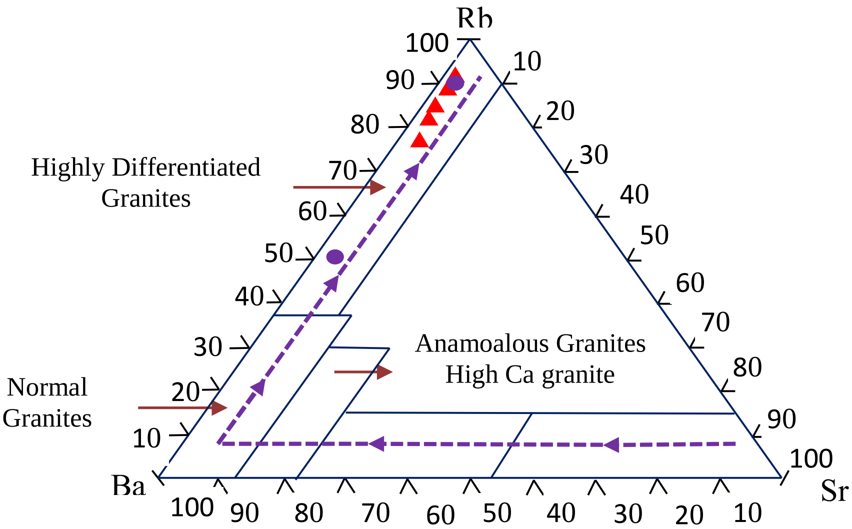

Figure 10. The different fields of the ternary relation Rb-Ba-Sr on some investigated granitic rocks. Arrow indicates differentiation trend. (after EL Bouseily and EL Sokkary, 1975)

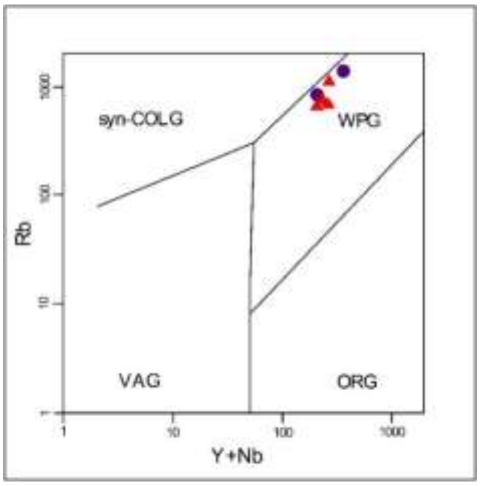

Figure 11. Y+Nb Vs Rb diagram showing the tectonic setting of granitic rocks (after Pearce et al, 1984)

Discussions

In the study area, P_2O_5 of biotite granite is slightly increased with SiO_2 contents. It reveals a highly fractionated S-type granitic magma. The Rb-Ba-Sr relationship also exhibits that highly differentiated granite. The granitic rocks of the study is characterized as highly fractionated, peraluminous, and exhibiting a tectonic signature of WPG setting, which confirms that they were formed on the continent relation to the subduction of an oceanic plate beneath the continent. Yang *et al.* (2018) stated that the strongly peraluminous S-type granite formed from the partial melting of peraluminous clastic sediments are common in the continental collisional zones, even during the Neoarchean time.

According to the previous literatures stated that the content of P_2O_5 in highly fractionated S-type granites is high compared to I-type granites (Chappel and White, 1992; Champion and Bultitude, 2013). In the present result recorded that the granitic rocks of the study area is characterized by the A/CNK [molar Al_2O_3/ ($CaO+Na_2O+K_2O$)] value ranging from 1.18 to 1.22. The SiO_2 is negatively correlated with Na_2O, MgO, TiO_2, Al_2O_3, K_2O and CaO except for P_2O_5.

Conclusion

The granites within the WGP of the Southeast Asia are mostly S-type and I-type granites which are related to collision following the westward subduction of the West Myanmar Terrane beneath Sibumasu during the Cretaceous to Tertiary. Tin-tungsten mineralization in the Central Granitoid Belt of Myanmar occurs dominantly as near-vertical and parallel, greisen bordered, quartz vein-type deposits at the cusps of small granitoid plutons or along the granitoid metasedimentary rocks contact or exclusively in the adjacent metasedimentary country rocks. The granitic rocks of the Zaw Pho Kyin tin-tungsten deposit are mainly composed of quartz, feldspar (plagioclase, orthoclase, and microcline), and mica (muscovite and biotite). They are strongly peraluminous and highly fractionated S-type granites formed in a WPG setting. Thus, S-type granites of Zaw Pho Kyin Mine area were produced through partial melting of the metasedimentary rocks and parental magma may have been derived from a crustal source.

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