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Original Article

Petrochemistry of granitic rocks in Tha Pai area, Mae Hi sub-district, Pai district, Mae Hong Son province, Northern Thailand

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Abstract

Granitic rocks in the Ban Tha Pai area, Mae Hi sub-district, Pai district, Mae Hong Son province, are located in the western line of the Central Granitic Belt in northern Thailand. These granitic rocks are in N-S orientation and have a Triassic age. Petrographic investigation of the granitic rocks indicates that they are monzogranite with medium to coarse-grained porphyritic texture. Mineral compositions of them mainly consist of quartz, K-feldspar, and plagioclase, with minor biotite and small amounts of muscovite, apatite, zircon, titanite, and opaque minerals. Geochemical investigation of the granitic rocks indicates that they are in sub alkaline series and almost totally of high-K calc-alkaline affinity. Furthermore, the granitic rock samples were S-type granite and peraluminous rock. According to tectonic discrimination diagrams, the granitic rocks might have formed in an orogenic environment.

Keywords: Tha Pai granite, S-type, high K-calc alkaline, orogenic environment

1. Introduction

The Pai district in Mae Hong Son province, northern Thailand, is covered by contrasting granite types. The two contrasting types are I- and S-type granites that are widespread in this granitic belt. The amphibole disappeared in our preliminary petrographic granitic rocks, that were studied differently in prior work on the northern Pai area. Therefore, this study aimed to clarify the granitic types and tectonic setting of emplacement of granitic rocks in the southern Pai district area, using petrochemistry to assess the geologic background of granitic rocks in this region.

Based on the geological environments, lithology and chronogeology, granitic rocks in Thailand and in South-East Asia can be divided into three belts, namely Western, Central, and Eastern Granitic Belts (Charusiri, 1989; Charusiri, Clark, Farrar, Archibald, & Charusiri, 1993; Dunning, Macdonald, & Barr, 1995; Pongsapich, Pisutha-Arnond, & Charusiri, 1983; Qian, Feng, Wang, Zhao, Udchachon, & Wang, 2017; Searle, Whitehouse, Robb, Ghani, Hutchison, Sone, Ng, Roselee, Chung, & Oliver, 2012; Wang, He, Cawood, Srithai, Feng, Fan, Yuzhi, Qian, 2016). The three granitic belts defined across SE Asia are graphically shown in Figure 1.

The Western Granitic Belt (WGB) is in the north-south direction, distributed dominantly in eastern Myanmar with a narrow strip in western Thailand along the Thai-Myanmar border (Mae Lama-Tae Song Yang districts, Thong Pha Phum district, Kanchanaburi province and Prachaub Khirikhan, Ranong, Phang Nga and Phuket provinces). These granitic rocks mainly consist of quartz and microcline with commonly brown biotite and muscovite and relatively rare hornblende. Geochemistry and $^{40}Ar/^{39}Ar$ dating indicate that the WGB was formed by two events including Cretaceous-Tertiary (88-65 Ma) S-type, mineralized, peraluminous granitic plutons and the Paleocene-Eocene (60-55 Ma) S-type, peraluminous and mineralized granitoids (Charusiri *et al.*, 1993). In addition, small areas of unexpected I-type granitoids are locally present (Charusiri, 1989). The new U–Pb dating results from Phuket Island show zircon core ages of 212-214 Ma and a thermal overprint with rims of 85–75 Ma (Searle *et al.*, 2012).

The Central Granitic Belt (CGB) is mainly granitoids in Thailand and occurs as pluton with continuous north-south orientation, underlying almost all of northern-

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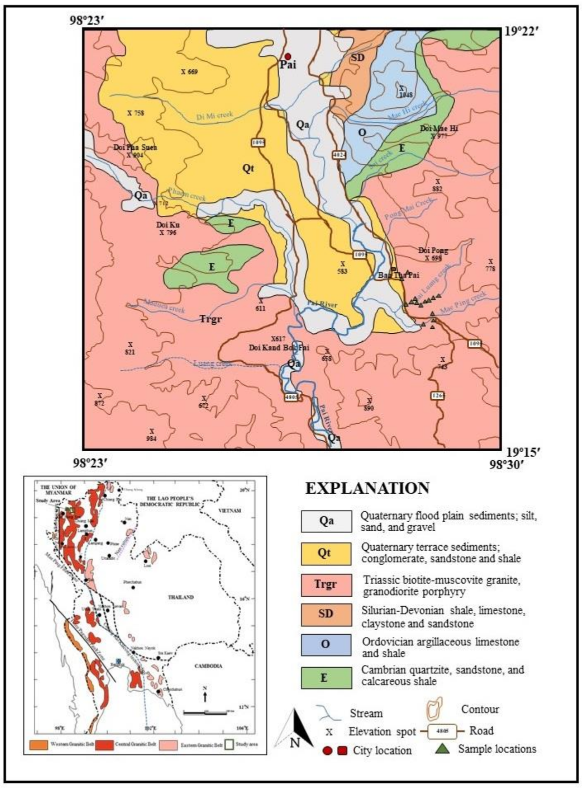

Figure 1. An enlarged map of the study area (see insert) illustrating the distribution of granitic rock in the western line of Central Granitic Belt (modified from Hess & Koch, 1979 and Department of Mineral Resources, 2007) and index map of Thailand showing the distribution of the three granite belts (modified from Charusiri *et al.*, 1993, Morley *et al.*, 2007, Wang *et al.*, 2016, and Qian *et al.*, 2017).

central and peninsular Thailand, the main range of Malaysia and the Bangka, Singkep and Tuju Islands of Indonesia (Charusiri *et al.*, 1993). The CGB within northern Thailand can be divided into two sub-belts, the eastern and the western sub-belts (Charusiri *et al.*, 1993). The eastern sub-belt comprises the Mae Chan pluton in Chiang Rai province, the Fang-Mae Suai and the Wiang Pa Pao-Khuntan batholiths. The western sub-belt is located near the Thai-Burmese border. The southern part of Mae Hong Son province consists largely of composite plutons that are the Mae Sariang complex extending from Pai district through Samoeng, Mae Chaem and Hot districts and Doi Inthanon mountains, Chiang Mai province, to the western part of Tak province. The granitic rocks of this belt are generally coarse-grained, but vary in texture, ranging from abundantly megacrystic to equigranular; and in mineralogy, from biotite-rich to biotite-muscovite-bearing and rarely green hornblende (Charusiri *et al.*, 1993). Although largely granitoids in this belt have S-type affinity, the I-type with magnetite-series granitoids is also found (Doi Mok and Doi Tung, Chiang Rai province). The absolute age of this granitic belt by $^{40}Ar/^{39}Ar$ dating is Late Triassic (220-180 Ma) for northern Thailand to Middle Jurassic, and Late Cretaceous to Middle Tertiary (80-50 Ma) for southern Thailand (Charusiri *et al.*, 1993). The U-Pb dating of zircon from many locations in NW Thailand indicates the age of granitic rocks as Late Triassic-Early Jurassic (200-230 Ma) and late Oligocene (26.8 Ma) (Dunning *et al.*, 1995; Qian, *et al.*, 2017; Wang *et al.*, 2016). Duangkhamsawat and Srichan (2013) and Duangkhamsawat (2015) reported that granitic rocks from the Doi Kio Lom Area, Pai district, Mae Hong Son province are quartz-syenomonzonite, hornblende syenite and alkaline feldspar granite and classified into I-type granite. Tectonic setting interpretation of the Doi Kio Lom igneous rocks is post-collision granite that magmatism events influenced when West Burma collided with Sibumasu in the Late Cretaceous (72-73 Ma). Tukpho and Fanka (2021) report that the granitic rocks in the Dan Chang area, Suphan Buri province are comparable to the S-type granite of the Central Belt Granite of Thailand, resulting from syn-collisional crustal thickening and subsequent post-collision after the closure of the Paleotethyan during the Late Triassic.

The Eastern Granitic Belt (EGB) occurs as small complex plutons or batholiths that extend from southern China through Laos, in eastern Thailand through the edge of Khorat Plateau, eastern Peninsular Malaysia, Billiton Island, Indonesia (Charusiri *et al.*, 1993). The granitic rocks belonging to this belt comprise mainly quartz, K-feldspars, and plagioclase with greenish-brown to green hornblende, biotite, and rarely muscovite. Geochemical studies of EGB (Charusiri, 1989) indicate metaluminous and I-type affinity. The absolute age of this granitic belt by $^{40}Ar/^{39}Ar$ dating is 245 – 210 Ma or Early to Late Triassic (Charusiri *et al.*, 1993). In addition, zircon U-Pb geochronology of the Carboniferous biotite granite, Late Permian hornblende granite and Triassic biotite-hornblende granite yielded intrusion ages of 314.6–284.9 Ma, 253.4 Ma, and 237.8 Ma, respectively (Fanka, Tsunogae, Daorerk, Tsutsumi, Takamura, & Sutthirat, 2018) and granite samples from the Chonburi, Rayong–Bang Lamung and Chanthaburi plutons yielded similar crystallization ages of 222–218 Ma (Qian, *et al.*, 2017). Furthermore, Biotite–K-feldspar granites from Tioman Island off the east coast of Malaysia yield a U–Pb zircon age of 80 Ma (Searle *et al.*, 2012).

2. Geological Background

The Ban Tha Pai village area is located in the southern part of Pai district, Mae Hi sub-district, of Mae Hong Son province (Figure 1) and intrudes by granitic rocks. Geological data of the study area and vicinity, from Hess and Koch (1979) and from the Department of Mineral Resources (2007), indicate that these areas are covered by Cambrian metamorphic and sedimentary rock (E), Ordovician sedimentary rocks (O), Silurian-Devonian sedimentary rock (SD), Triassic igneous rock (Trgr), and Quaternary sediments (Q). Cambrian metamorphic and sedimentary rock are quartzite, sandstone, and calcareous shale. Ordovician sedimentary rocks are composed of argillaceous limestone, dolomitic limestone, and marble interbedded with sandy shale with ammonite, brachiopod and trilobite. Silurian-Devonian sedimentary rocks are phyllite, carbonaceous phyllite, and silicic phyllite. Triassic igneous rocks are biotite-muscovite-tourmaline granite and granodiorite. Quaternary sediments are Quaternary terrace sediments (Qt) and Quaternary flood plain sediments (Qa) including gravel, sand, silt, and clay. The granitic rocks were weathering by an exogenous process that causes outcrops, boulders, and *in situ* float rocks found along streams and creeks, such as Pong Mai, Sai Luang and Mae Ping creeks. The granitic rocks show moderately porphyritic texture with large K-feldspar phenocrysts outstanding. Xenoliths and quartz veins are slightly observed in some localities.

3. Materials and Methods

3.1 Sample collection and selection

Thirteen granitic rocks were collected from the study area, a part of the western line of the Central Granitic Belt, for study of petrography and geochemistry. The collected granitic rocks have been examined under a petrographic microscope for least-altered selection. The least-altered samples generally excluded those with extensive development of mesoscopic domains of secondary minerals such as quartz, resulted from silicification, epidote minerals and chlorite, well-developed foliation or mineral layering, abundant vugs or druses, xenocrysts, and xenoliths and quartz, epidote, or calcite veining and/or patches totaling more than 5 modal%. Then, the least-altered samples were used in an alteration box plot (Large, Gemmell, & Paulick, 2001) to obtain the least-altered samples. Using these criteria, thirteen least-altered granitic rock samples were selected to examination of their petrography, modal analysis, and geochemistry.

3.2 Sample preparation

The least-altered samples were prepared in the form of standard thin sections, stained rock slabs, and fusion discs and pellets for petrographic investigation, modal analysis and whole-rock chemical analysis, respectively. Standard thin sections were made by cutting and polishing rock samples to a thickness of approximately 0.03 mm. The stained rock slabs for modal analysis were made by cutting off the weathering surfaces before making slabs. The slabs were soaked in hydrofluoric acid (HF) and then sodium cobaltinitrite solution ($CoN_6Na_3O_{12}$). The powdered samples for whole-rock chemical analysis were prepared by cutting off the weathering surfaces of the least-altered samples, splitting them into conveniently sized fragments, and crushing them to small chips, using a Rocklabs Hydraulic Splitter/Crusher. The cleaned rock chips were divided by quartering, and approximately 50-80 g of the cleaned chips were then pulverized for a few minutes by a Rocklabs Tungsten-Carbide Ring Mill. All the described procedures were done at the Department of Geological Sciences, Faculty of Science, Chiang Mai University.

3.3 Analytical technique for geochemistry

The powdered samples were chemically analyzed for major oxides, trace elements, and loss on ignition (herein LOI). Chemical analyses of major oxides (SiO_2, TiO_2, Al_2O_3, FeOtotal, MnO, MgO, CaO, Na2O, K_2O and P_2O_5) and some certain trace elements (Ba, Rb, Sr, Y, Zr, Nb, Ni, V, Sc, Cr and Th) were determined using Philips Magix PRO X-ray fluorescence (XRF) spectrometer (wavelength dispersive system). The rock standards were the USGS geochemical reference materials including AGV-2, BCR-2, BHVO-2G, BIR-1a, DTS-2b, DNC-1a, W-2a, GSP-2, QLO-1a, RGM-2 and STM-2. These chemical species were measured from fusion discs prepared with 0.7 g powdered sample, 7 g spectromelt (di-lithium tetraborate; $Li_2B_4O_7$) and 0.375 g lithium bromide (LiBr) for major oxides and from pressed powders prepared with 6 g powdered sample and 0.3 g XRF MULTI-MIX PXR-200 for trace elements. LOI was determined by heating approximately 1 g of powdered samples at 1,000 ºC for 12 hours. All the described procedures were executed at the Department of Geological Sciences, Chiang Mai University.

4. Results and Discussion

4.1 Petrographic investigation

The granitic rocks are grey-white or light grey in the outcrop, and have porphyritic texture in the hand specimens. Modal analysis, performed on the stained rock slabs, revealed that the studied least-altered samples have relative proportions of quartz, K-feldspar and plagioclase as shown in Table 1. Most samples (samples no. TP01, TP02, TP03, TP04, TP05, TP06, TP07, TP09, TP10, TP11, TP13, TP14 and TP15) were classified into monzogranite based on the QAP diagram for plutonic rocks of Streckeisen (1976) (Figure 2).

Table 1. Major oxides, some certain trace elements and modal analysis minerals of the studied least-altered granitic rocks. CIPW normative minerals were calculated, according to the principles of geochemistry.

Sample no.	TP01	TP02	TP03	TP04	TP05	TP06	TP07	TP09	TP10	TP11	TP13	TP14	TP15
Major oxide (wt%)													
SiO_2	72.09	73.46	75.50	72.85	72.91	73.98	71.71	71.08	71.01	74.29	66.07	72.32	74.18
TiO_2	0.39	0.39	0.37	0.38	0.38	0.40	0.38	0.43	0.44	0.37	0.76	0.44	0.34
Al_2O_3	14.02	14.10	13.18	14.76	14.16	13.35	15.15	13.96	15.24	13.92	16.38	14.62	13.74
FeOtotal	2.68	2.51	2.60	2.51	2.78	2.81	2.49	3.02	2.71	2.73	5.24	2.88	2.71
MnO	0.01	0.00	0.03	0.00	0.00	0.03	0.02	0.02	0.01	0.01	0.07	0.00	0.02
MgO	1.92	1.73	1.87	1.75	2.41	1.98	1.81	1.91	1.89	1.97	3.52	2.07	2.21
CaO	0.79	1.49	0.83	0.92	0.91	0.37	1.52	1.17	1.42	0.66	1.52	0.87	0.30
Na_2O	1.85	1.62	1.92	1.63	1.29	2.35	1.72	3.35	1.63	2.15	1.45	1.62	1.50
K_2O	6.00	4.46	3.51	4.97	4.91	4.48	4.93	4.80	5.40	3.65	4.64	4.95	4.76
P_2O_5	0.23	0.24	0.21	0.23	0.26	0.25	0.26	0.25	0.25	0.24	0.35	0.25	0.23
LOI	1.61	1.39	1.59	2.01	2.29	1.92	1.29	1.61	1.26	1.69	1.77	1.92	1.87

Table 1. Continued.

Sample no.	TP01	TP02	TP03	TP04	TP05	TP06	TP07	TP09	TP10	TP11	TP13	TP14	TP15
Original Sum.	99.54	107.08	103.59	99.71	101.21	101.59	103.64	104.86	101.51	103.07	105.42	100.22	102.88
Trace elements (ppm)													
Ba	1200	809	853	973	854	802	1178	943	1239	772	768	960	1034
Rb	311	221	284	242	302	256	284	282	279	195	335	284	283
Sr	166	211	158	218	116	92	205	157	202	128	112	161	131
Y	90.66	72.07	87.00	68.03	81.64	73.79	79.35	82.30	84.45	68.35	99.43	84.89	77.52
Zr	191	195	200	190	190	197	196	212	208	193	282	196	181
Nb	14.37	16.00	14.34	15.13	16.64	18.11	15.82	15.16	13.84	14.29	25.65	16.12	14.96
Ni	39.74	45.58	42.13	41.80	54.66	50.56	39.53	48.12	38.18	36.71	46.02	39.39	42.43
Cr	66.07	83.84	47.52	54.61	127.70	77.66	55.96	61.70	56.08	59.01	116.71	54.91	78.43
V	81.68	83.73	83.00	77.78	82.55	80.34	81.48	83.29	84.06	78.23	130.26	83.17	78.79
Sc	4.70	3.73	7.52	2.96	3.28	2.04	2.74	4.76	5.57	3.71	5.67	1.77	2.39
P	1016	1036	903	1014	1121	1108	1134	1103	1093	1038	1524	1074	994
Ti	2362	2348	2215	2295	2248	2375	2301	2601	2636	2247	4540	2634	2035
Modal analysis													
Quartz (Q)	40.04	59.76	40.83	38.29	34.90	41.11	33.38	37.07	23.12	56.45	26.69	49.95	44.50
Alkali feldspar (A)	23.32	19.51	31.23	28.59	38.59	38.17	29.82	36.75	36.43	24.13	36.78	21.31	19.50
Plagioclase (P)	36.44	20.73	27.94	33.13	26.50	20.72	36.80	26.18	40.45	19.42	36.53	28.74	36.00
CIPW normative													
Quartz	33.80	41.40	46.40	39.84	41.29	39.66	36.95	28.01	35.00	43.67	31.89	39.14	43.34
Anorthite	2.47	5.88	2.80	3.14	2.84	0.23	5.90	4.22	5.47	1.76	5.28	2.74	0.04
Albite	15.65	13.71	16.25	13.79	10.92	19.88	14.55	28.35	13.79	18.19	12.27	13.71	12.69
Orthoclase	36.40	27.01	21.47	30.17	29.74	27.13	30.08	29.16	32.93	22.22	28.07	30.05	29.00
Hypersthene	4.78	4.31	4.66	4.36	6.00	4.93	4.51	4.76	4.71	4.91	8.77	5.16	5.50
Zircon	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.06	0.04	0.03
Apatite	0.53	0.56	0.49	0.53	0.60	0.58	0.60	0.58	0.58	0.56	0.81	0.58	0.53
Chromite	0.01	0.01	0.01	0.01	0.03	0.01	0.01	0.01	0.01	0.01	0.03	0.01	0.01
Ilmenite	0.03	0.01	0.07	0.01	0.00	0.07	0.05	0.05	0.01	0.01	0.15	0.01	0.05
Corundum	3.40	4.33	5.06	5.40	5.55	4.43	4.65	1.56	4.52	5.67	6.92	5.45	5.95
Rutile	0.37	0.38	0.33	0.37	0.38	0.36	0.35	0.40	0.43	0.36	0.68	0.43	0.31
Hematite	2.68	2.51	2.60	2.51	2.78	2.81	2.49	3.02	2.71	2.73	5.24	2.88	2.71

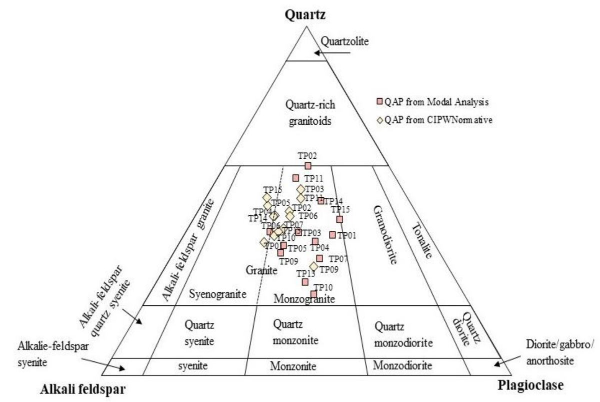

Figure 2. QAP diagram plot by modal analysis and CIPW normative

Petrographic investigation of the rock samples (Figure 3) indicated that monzogranite had a medium to coarse-grained and porphyritic texture. The phenocrysts are K-feldspar that sit in groundmass. Groundmass was composed mainly of quartz, plagioclase and K-feldspar, with minor amounts of biotite, muscovite, apatite, zircon, titanite and opaque minerals. Potassium feldspar phenocrysts and groundmass were orthoclase and microcline and show subhedral outline and perthitic texture. Quartz groundmass showed anhedral crystals, rounded edges, and embayed outlines. Plagioclase groundmass was anhedral to subhedral in outline and showed myrmekitic texture. Biotite was anhedral to subhedral, brown in color and highly altered to chlorite and epidote minerals.

4.2 Whole-rock chemistry

Major oxides and some certain trace elements of the granitic samples are reported in Table 1. The data on major oxides, in terms of weight%, were used to calculate Ishikawa alteration index (AI) (1) and chlorite-carbonate-pyrite index (CCPI) (2), according the equations below. The results show that the studied samples lie well within the limits of least-altered intermediate to felsic rocks of Large *et al.* (2001) diagram, as shown in Figure 4.

$$AI = \frac{100(MgO + K_2O)}{(FeO + K_2O + MgO + Na_2O)} \quad (1)$$

$$CCPI = \frac{100(FeO + MgO)}{(FeO + K_2O + MgO + Na_2O)} \quad (2)$$

The CIPW normative mineralogy calculation was applied to the least-altered intermediate to felsic rocks and used to classify the samples into monzogranite (sample nos. TP02, TP03, TP04, TP06, TP07, TP09, TP10, TP11, TP13 and TP14) and some syenogranite (sample nos. TP01, TP05 and TP15) based on the QAP diagram for plutonic rocks of Streckeisen (1976) (Figure 2). These rock types are in

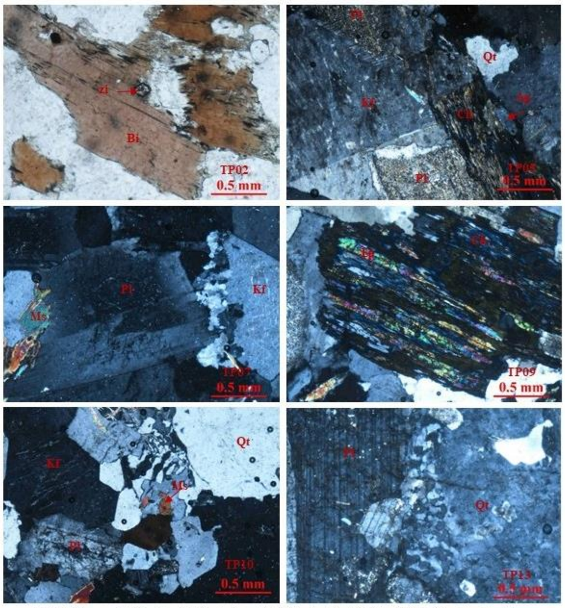

Figure 3. Photomicrographs of monzogranite samples

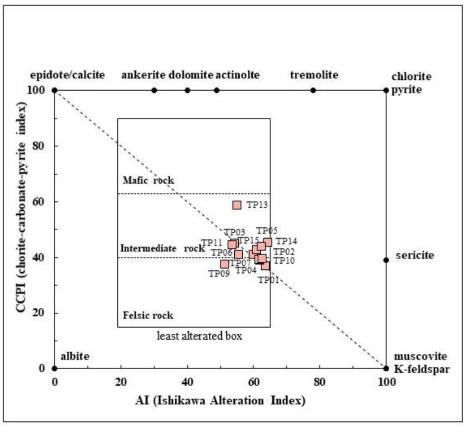

Figure 4. Alteration box plot (Large *et al.*, 2001)

agreement with typification on the basis of modal classification by using quartz, K-feldspar and plagioclase. In addition, the least-altered granitic rocks were chemically classified as monzogranite (sample nos. TP01, TP02, TP03, TP04, TP05, TP06, TP07, TP09, TP10, TP11, TP14 and TP15) and granodiorite (sample no. TP13), based on TAS plot (Figure 5). Moreover, most of the studied rocks appear to be in the fields of subalkaline or tholeiite series (Middlemost, 1994 and Iravine & Baragar, 1971) (Figure 5). These rocks are totally high-K calc-alkaline in affinity on SiO_2-K_2O plot (Figure 6a) and SiO_2-Na_2O-K_2O-CaO plot (Figure 6b). These rocks are calc-alkaline on FeO(total)-Na_2O+K_2O-MgO plot (Figure 7a) and magnesian rocks of Frost and Frost (2008) as shown in Figure 7b. Furthermore, the granitic samples are plotted in the field of S-type granite based on the classification of Chappell and White (1992) (Figure 8a, 8b). The aluminum saturation indices (ASI) plot (Figure 9) of molar ratios A/NK versus A/CNK discriminant diagram after Maniar and Piccoli (1989) and Chappell and White (1974, 2001) clearly indicates

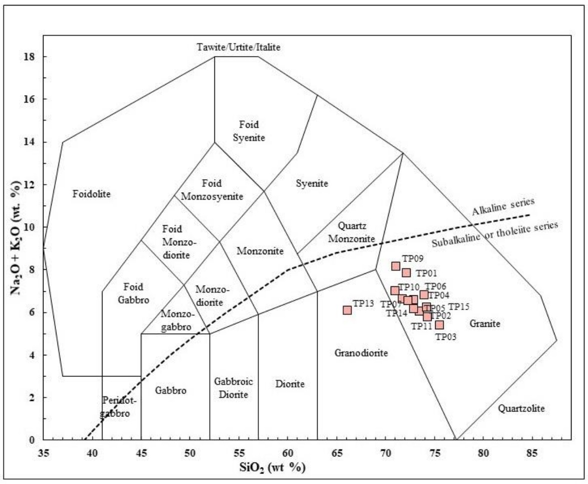

Figure 5. The total alkali versus silica classification diagram after Middlemost (1994) with line boundaries of Iravine and Baragar (1971)

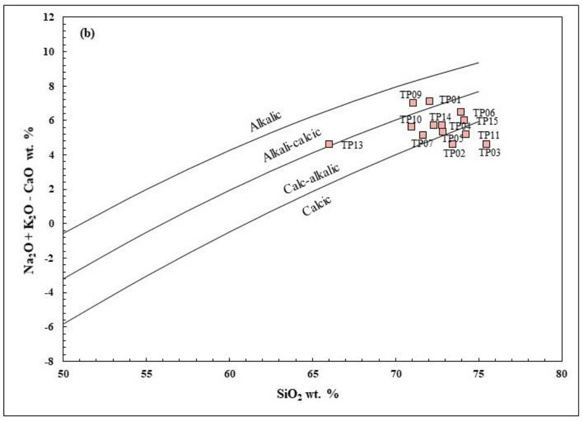

Figure 6. (a) SiO_2 versus K_2O diagram with compositional domains of the different calc-alkaline series (Rickwood, 1989), and (b) SiO_2-Na_2O-K_2O-CaO diagram (Frost *et al.*, 2001)

peraluminous character. In terms of tectonic setting of formation, the granitic samples are in the field of boundary between ocean ridge granite, and within-plate granite and ocean ridge granite from anomalous ridge based on the plot of Y vs Nb (Figure 10a). Moreover, the tectonic setting plot of Rb against Nb+Y diagrams (Figure 10b) after Pearce, Harris, & Tindle (1984) also confirms the within-plate granite.

4.3 Discussion

Many studies (e.g., Charusiri *et al.*, 1993; Qian *et al.*, 2017; Wang *et al.*, 2016) mentioned the Paleotethyan granitic belt in Southeast Asia that can be divided into the I- and S-type CGB and I-type EGB. These granites formed in the post-collisional gravitational collapse setting of the thickened crust in response to the amalgamation of the Indochina with Sibumasu blocks. Although the S-type granite is a major rock in CGB, locally I-type granite was found in the northern Pai district (Duangkhamsawat & Srichan, 2013). The granitic rocks in the southern Pai district are coarse- to medium-grained porphyritic monzogranite with hornblende free that difference from the northern Pai district. The

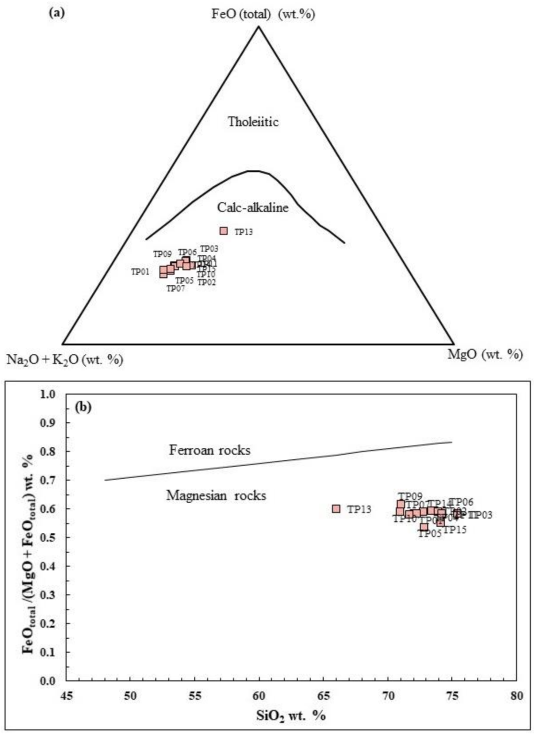

Figure 7. (a) FeO(total) - Na_2O+K_2O - MgO plot (Iravine & Baragar, 1971), and (b) SiO_2-FeO(total)-MgO diagram (Rickwood, 1989)

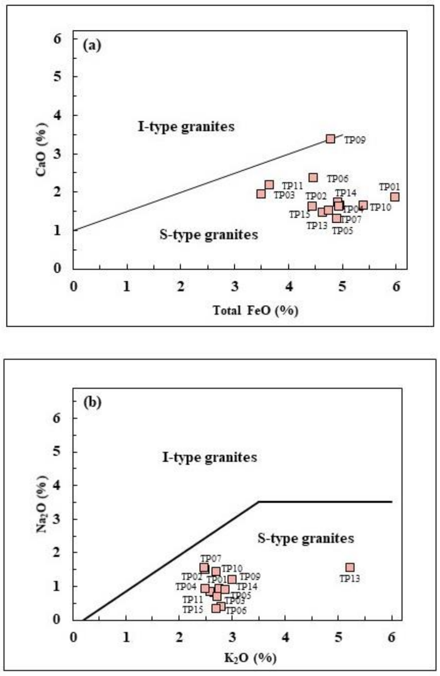

Figure 8. (a) CaO versus total FeO, and (b) Na_2O versus K_2O after Chappell and White (2001)

geochemically signature is high-K calc-alkaline affinity, peraluminous and S-type affinities that relate to a collision. In addition, the Pai granite is similar to the porphyritic granites group I of the massive granites in the Inthanon zone (CGB)

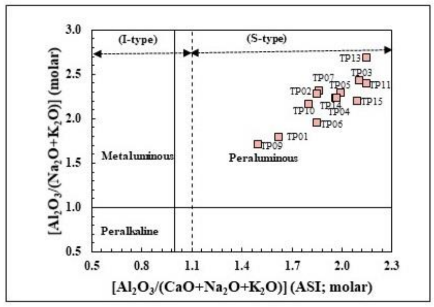

Figure 9. Aluminum saturation indices (ASI) plot of molar ratios A/NK versus A/CNK in a discriminant diagram (Maniar & Piccoli, 1989; Chappell & White, 1974, 2001)

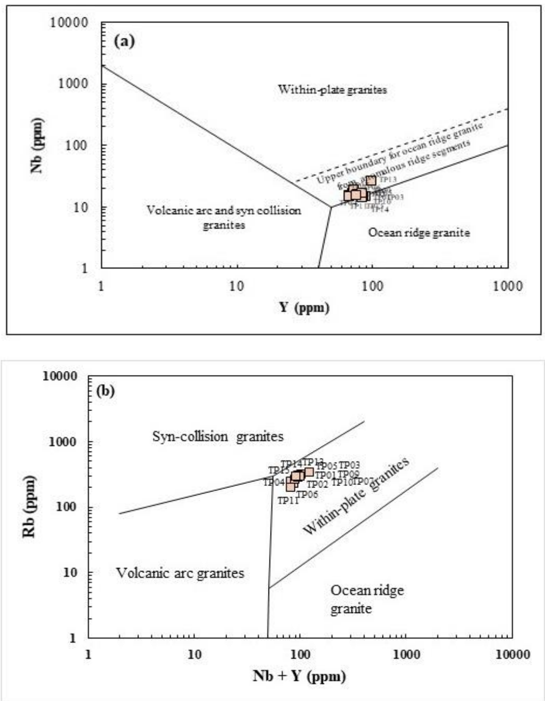

Figure 10. (a) Y versus Nb, and (b) (Nb+Y) versus Rb (Pearce *et al.*, 1984)

that was reported by Wang *et al.* (2016). Furthermore, the massive granite U-Pb zircon dating gave an age of 200-230 Ma (late Triassic). This late Triassic granite originated from a metapelite source hybridized with metavolcanic rocks as Paleozoic supracrustal rocks that were the post-collisional magmatic product.

5. Conclusions

Triassic granitic rocks were sampled from Tha Pai village, Mae Hi sub-district, Pai district, Mae Hong Son province, in Thailand. These rocks are mostly characterized as monzogranite based on modal analyses, normative minerals, and chemical compositions. The rocks show a coarse-grained, porphyritic texture, with abundance of quartz, plagioclase and K-feldspar, along with minor contents of biotite and muscovite. In whole-rock chemistry, these granitic rocks are classified into S-type granitic rocks with high-K calc-alkaline affinity and peraluminous rock. According to tectonic discrimination diagrams, the granitic rocks might have been formed in orogenic environments (continental collision).

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