PETROGENESIS AND TECTONIC SETTING OF GRANITES OF THE HERMYINGYI-TAUNGPHILA AREA, DAWEI SN-W REGION, SOUTHERN MYANMAR

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Abstract

Hermyingyi-Taungphila area is located in the central granite range of the Dawei Sn-W region. In the study area, the greisen-bordered quartz veins are hosted by a Paleocene granite and Mergui Group. The granite samples have high A/CNK [molecular proportion of Al_2O_3/ ($CaO+Na_2O+K_2O$)] values, ranging from 1.47 to 4.34, which is greater than 1.1 and reveals the S-type. The granite is highly siliceous (SiO_2 = 75-80 wt.%), peraluminous, calc-alkaline, and strongly fractionated. It possesses the enrichment of Cs, Rb, Th, U, K, and La and the depletion of Ba, Sr, and Eu, indicating magma is mainly derived from the lower continental crust. The tetrad REE patterns with strong negative Eu anomalies (Eu/Eu*- 0.01-0.04) and $(La/Sm)_N$ (0.6-0.9) are consistent with the characteristics of a highly fractionated or evolved magmatic-hydrothermal system. Combined with previous geochronological data, the present geochemical data provides that the granites were formed at a collisional setting.

Keywords: Greisen-bordered quartz veins, granite, Hermyingyi, Taungphila, Sn-W mineralization, tetrad REE patterns

Introduction

Sn-W deposits are widely distributed in the Dawei Sn-W region, Tanintharyi Region, Southern Myanmar (Figure. 1b). Hermyingyi, largest primary Sn-W deposit of the Dawei region, is situated at the northern edge of the central range in which the greisen-bordered quartz veins are hosted by the Paleocene granite and Permo-Carboniferous metasediments of Mergui Group. In this research, we studied the geochemistry of Hermyingyi and Taungphila granites to determine their petrogenesis and tectonic setting.

Geological Setting

Regional Geology

There are three granite ranges in the Dawei district: the Coastal Range, Central Range, and Frontier Range (Brown and Heron, 1923) (Figure. 1b). They occur as a part of the Western Granite Province of Southeast Asian Sn-W belt (Figure. 1a) (Cobbing et al., 1992). Most of the Sn-W deposits and prospects are spatially associated with the granites of the Paleocene age (Aung Zaw Myint et al., 2017, 2021; Li et al., 2018) and metasedimentary rocks of the Carboniferous to early Permian Mergui Group. Hermyingyi, Wagone, Bawapin, Pagaye, and Putletto are primary deposits and Heinda is a tin placer deposit, are located in the Central Range (Bender, 1983; Aung Zaw Myint et al., 2021).

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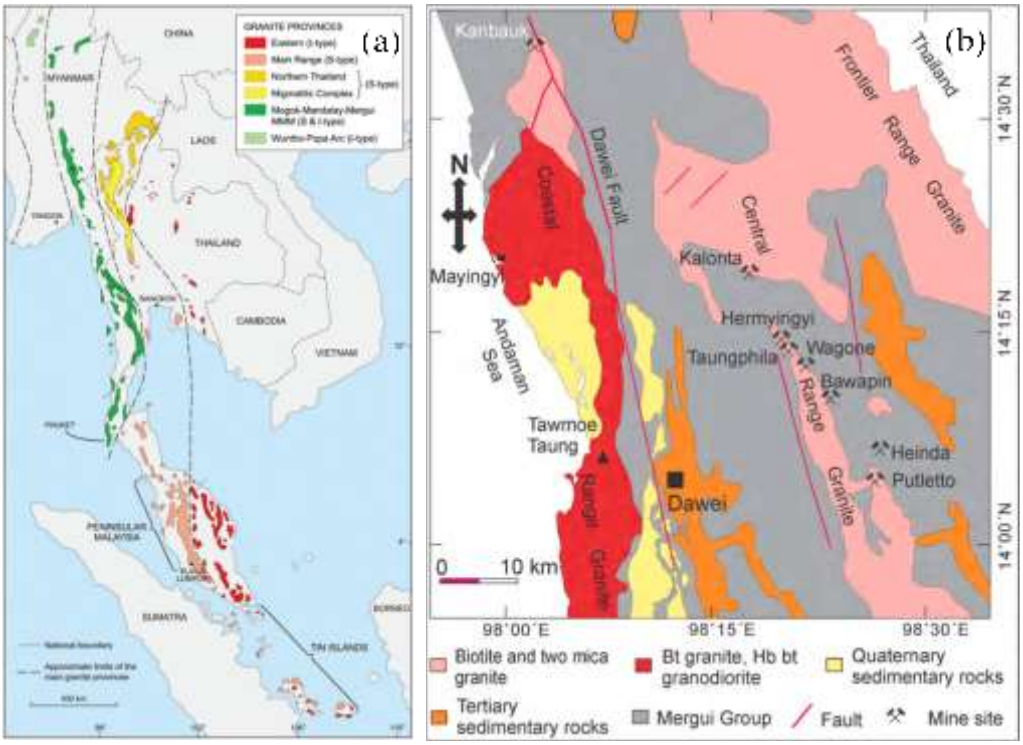

Figure. 1. (a) Southeast Asian Granite Belts (Cobbing et al.,1992, Gardiner et al., 2014) (b) Regional geological map of Dawei Sn-W District (Aung Zaw Myint et al., 2021)

Geology of the Hermyingyi-Taungphila Area

The granites from Hermyingyi and Taungphila area have medium- to coarse-grained and mainly composed of quartz, plagioclase, orthoclase, alkali feldspar (perthite), biotite and muscovite. The biotite and muscovite granites at Hermyingyi and Taungphila have been dated as LA-ICP-MS U-Pb dating of zircon ages of 61.44 ± 0.6 Ma (Li et al., 2018) and 68.8 ± 0.1 Ma (Jiang et al., 2017), respectively. Mergui Group consists of quartzite, greywacke, phyllite, sandy phyllite, and sandy mudstone.

Hermyingyi Sn-W deposit comprises three worksites: namely No (1) adit, West Cave adit, and A1 adit. Gugyi adit and Megyi adit are located in the Taungphila area. The quartz veins trend N-S with vertical inclination (80° to 90°) to the East. Veins have a maximum length of 500 m and thickness ranging from a few centimeters up to 1 m. The veins cut the granite and overlying Mergui Group. Greisenization, the most distinct hydrothermal alteration of the area, represents by an assemblage of quartz-muscovite, indicating the high temperature, post-magmatic alteration of rocks by volatile-rich solutions associated with the cooling of granitic intrusion. Ore veins contain mainly cassiterite and wolframite associated with sulfide minerals of molybdenite, pyrite, arsenopyrite, sphalerite, chalcopyrite, bismuthinite, galena, and covellite.

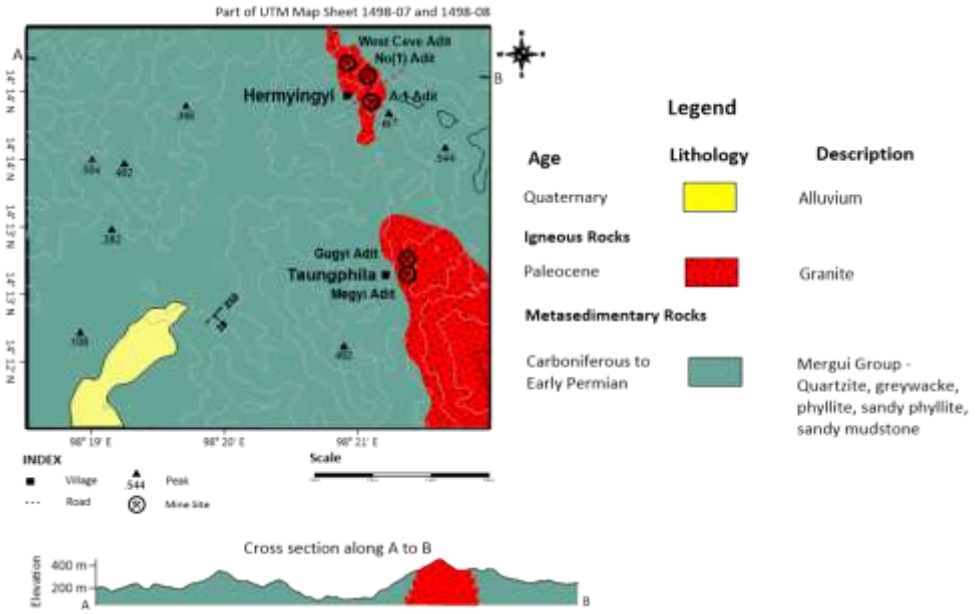

Figure. 2. Geological Map of the Hermyingyi-Taungphila area (Kyaw Swa Win, 2022)

Materials And Methods

Total 15 samples of granite from Hermyingyi and Taungphila area, 9 samples from 3 worksites of Hermyingyi area and 6 samples from 2 worksites of Taungphila area, were analyzed by inductively coupled plasma atomic emission spectroscopy (ICP-AES) for major elements and inductively coupled plasma mass spectrometry (ICP-MS) for trace elements at ALS Testing Services Co. Ltd, Laboratory in Stafford, Queensland, Australia.

Geochemistry

Major and Trace Elements

Geochemical data indicate that the granite samples have a high content of SiO_2 (75.1-80.1 wt. %) associated with Na_2O (0.08-4.02 wt. %), MgO (0.01-0.06 wt. %), Al_2O_3 (11.25-13.8 wt. %), P_2O_5 (0-0.01 wt. %), K_2O (2.79-5.48 wt. %), CaO (0.01-0.67 wt. %), TiO_2 (0.02-0.05 wt. %), MnO (0.07-0.32 wt. %), and Fe_2O_3 (0.88-2.17 wt. %). Loss on ignition (LOI) is very low (0.62-3.39%) that unveiling low volatile contents. The A/CNK [molecular proportion of Al_2O_3/ ($CaO+ Na_2O+K_2O$)] values range from 1.51 to 4.64 and they are greater than 1.1 referring to the peraluminous (Figure. 3a). They plot in the filed of high-K calc-alkaline in the SiO_2–K_2O diagram (Figure. 3b).

They have high content LILE (large ion lithophile elements) of Rb (711-1285 ppm) and moderate concentration HFSE (high field strength elements) of Y (48-200 ppm), U (7.88-25.7), Th (23.5-40.8) with depletion of Hf (4.6-9). They exhibit low Nb/Ta ratios (2.22-4.45), Zr/Hf ratios (11.47-17.92) and high Rb/Sr ratios (66.45-1435.71), Y/Ho ratios (20.6-41.93).

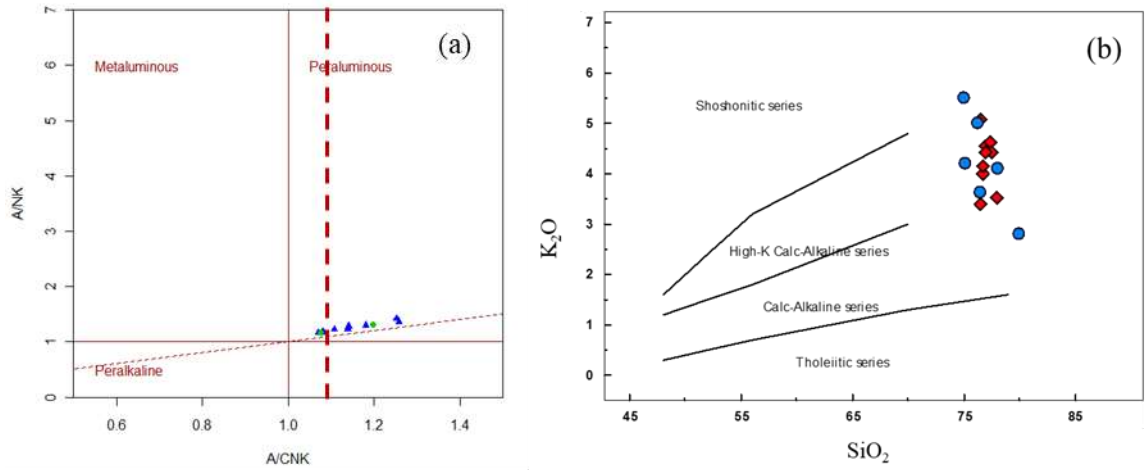

Figure.3.(a) A/NK (molar $Al_2O_3/[Na_2O+ K_2O]$) versus A/CNK (molar $Al_2O_3/ [CaO+Na_2O+ K_2O]$) diagram (Shand, 1943) (b) SiO_2 versus K_2O diagram (Peccerillo and Taylor, 1976) for granite samples in Hermyingyi-Taungphila area

Rare Earth Element (REE) Geochemistry

All granite samples are characterized by the tetrad REE patterns with deep negative Eu anomalies (Eu/Eu* = 0.01 to 0.04) (Figure. 4). The total REE content varies widely, from 91.35 to 176.47 ppm in the Hermyingyi area and 69.08 to 251.27 ppm in the Taungphila area, respectively. The granite samples from Hermyingyi and Taungphila area are similar REE patterns (Figure. 4). In the Hermyingyi-Taungphila area, $(La/Yb)_N$ varies from 0.15 to 0.61 and $(La/Sm)_N$ from 0.6 to 0.99.

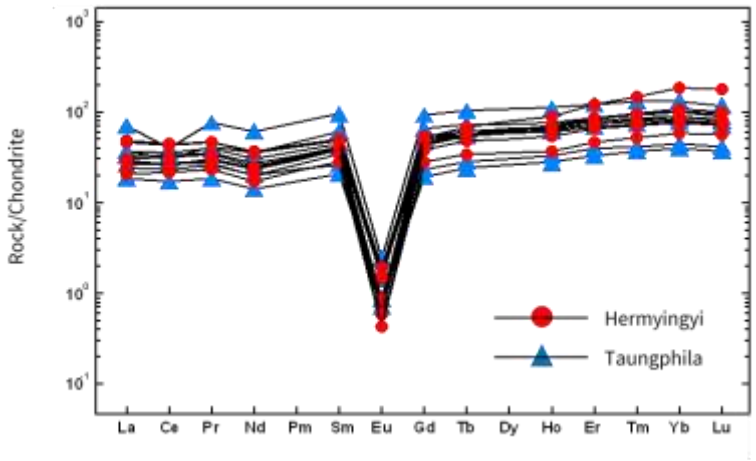

Figure. 4. Chondrite-Normalized REE pattern of the Hermyingyi and Taungphila granites (Sun and McDonough, 1989)

Discussion

Petrogenesis

The REE patterns of the Hermyingyi and Taungphila granites exhibit the tetrad effect and it indicates late magmatic differentiates with strong hydrothermal interactions or deuteric alteration, in highly evolved mineralized granites (Jahn et al., 2001) (Fig. 4). This tetrad effect is accompanied by non-CHARAC (charge-and-radius-controlled) trace element behavior (Fig. 5a). Such behavior occurs typically in highly evolved magmatic systems which may be regarded as

transitional between a pure silicate melt and an aqueous fluid (Bau, 1996). A distinct positive correlation between Nb/Ta and Zr/Hf indicates the geochemical condition during the magmatic to the hydrothermal stage (Figure. 5b).

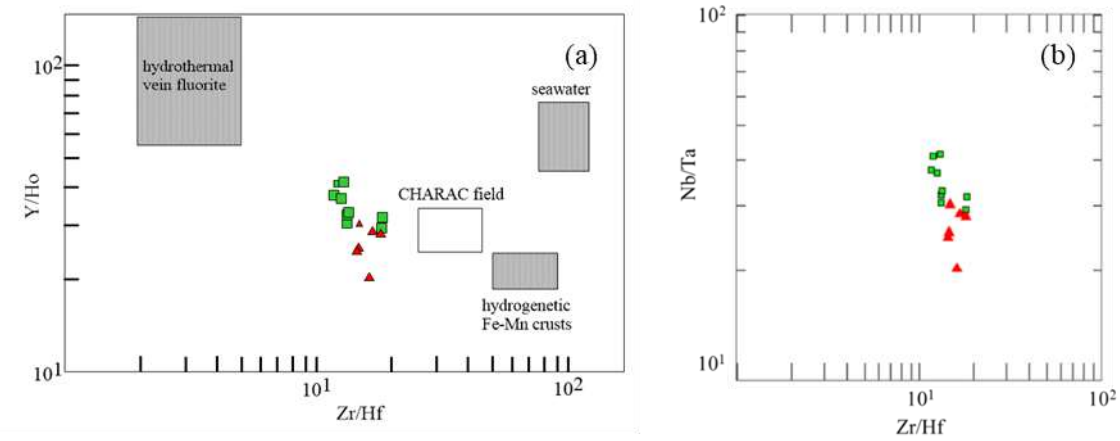

Figure. 5. (a) Y/Ho and Zr/Hf variation diagram of the Hermyingyi-Taungphila granites showing non-CHARAC trace element behavior (Bau, 1996) (b) Zr/Hf and Nb/Ta variation diagram showing the behaviour of HFSEs during magmatic-hydrothermal activity

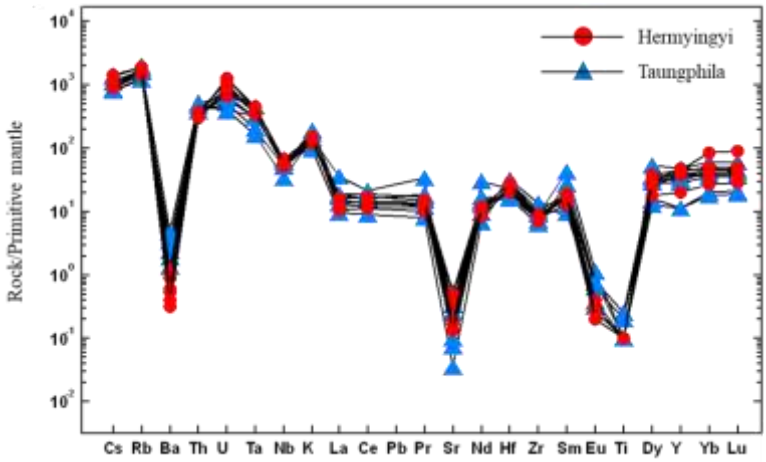

Figure.6. Chondrite-Normalized trace element abundances for Hermyingyi and Taungphila granite (Sun and McDonough, 1989)

The Hermyingyi and Taungphila granites have low ratios of Nb/Ta (2.22-4.45), Zr/Hf (11.47-17.92) and Th/U (1.02-5.03), all of which are consistent with continental crustal derivation (Singh et al., 2017).

Primitive-mantle normalized spider diagram of trace elements (Figure.6) show enrichment of large ion lithophile elements (LILE, e.g., Cs, Rb, Th, U, K, La) and depletion of high field strength elements (HFSE), such as Ba, Sr, and Eu, revealing that the magma is derived from the lower continental crust (Li et al., 2014). Large increases of Rb, Nb, Y, Lu and HREE and decreases of Sr, Ba, Ti, and LREE are associated with higher Si content (Li et al., 2018). All granite samples are presented by the tetrad REE patterns with distinct negative Eu anomalies (Eu/Eu* = 0.01-0.04) (Figure. 4) and low LREE fractionation [$(La/Sm)_N$ = 0.6-0.9] indicate the S-Type granite characteristics (Sha and Chappell, 1999).

Tectonic Setting

The granites from the Hermyingyi-Taungphila area plot syn-collisional granites in the Rb vs. (Y+Nb) and R1-R2 diagram (Figure. 7a & b) and it can be said these granites emplaced at the syn-collisional setting during Paleocene. The tectonic setting of Sn-W mineralization in Myanmar was linked to plate-margin magmatism. Cretaceous to Eocene magmatism in Myanmar developed both proximally in association with a subduction-zone volcanic arc and distally within the back-arc region, showing different granite-type affiliations in N-S-striking magmatic belts (Wang et al., 2014; Gardiner et al., 2015; Jiang et al., 2017).

After the Early Cretaceous collision in West Myanmar and the Sibumasu-Tengchong area (Metcalfe, 2013; Liu et al., 2016), low-angle subduction of the Neo-Tethyan oceanic lithosphere caused the development of an Andean-type magmatic arc with Late Cretaceous- Paleocene (100–50 Ma) felsic magmatism in the Western Granite Province (Mitchell et al., 2012; Jiang et al., 2017; Gardiner et al., 2018; Zhao et al., 2017; Fang et al., 2018; Aung Zaw Myint et al., 2021). Roll-back of the Neo-Tethyan oceanic slab probably plays a key role to produce the crustal derived melts that underwent high degrees of fractional crystallization and subsequent fluid exsolution (Jiang et al., 2017; Li et al., 2018; Mao et al., 2020), which finally formed most of the Sn-W (-Mo) deposits in the Western Granite Province. Late Cretaceous to Paleocene event is characterized by the formation of many large-scale deposits, including Hermyingyi, and medium to small-scale deposits and displays an assemblage of quartz and pegmatite veins, greisens, and skarns (Aung Zaw Myint et al., 2021).

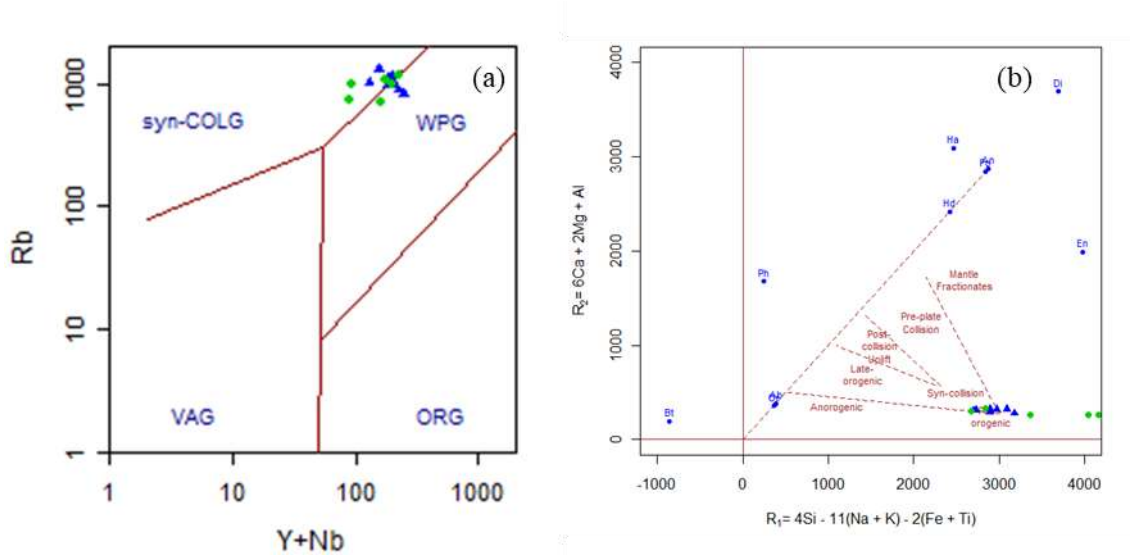

Figure. 7.(a) Rb-(Y+Nb) discrimination diagram (Pearce et al., 1984) (b) R1-R2 diagram (Batchelor & Bowden ,1985) showing the tectonic affinities of Hermyingyi-Taungphila granites

Conclusion

Geochemical signatures of the granites from the Hermyingyi-Taungphila area indicate that the magma is mainly derived from the partial melting of continental crust. The tetrad effect of REE pattern and non-CHARAC trace element behavior indicate Hermyingyi and Taungphila granites are originated from the highly fractionated and highly evolved magmatic systems. The

Hermyingyi-Taungphila granites were emplaced at a syn-collisional setting between Sibumasu and Indian plate during Paleocene.

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