

Petrography of Mafic Igneous Rocks from the South of Mune District, Vientiane Province, Northwest Lao PDR

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Abstract

Mafic igneous rocks in the south of Mune District, Vientiane Province, northwest of Lao PDR are possibly the northern extension of the central Loei sub-volcanic Belt of Loei Fold Belt, northeastern Thailand. The mafic igneous rocks occurred in association with Late Carboniferous-Early Permian sedimentary rocks and covered an area about 45 square kilometers. The main objective of this study aims to classify the mafic igneous rocks of the south of Mune District by using the petrographic technique. Field relationship and petrographic study indicated that the mafic igneous rocks could be classified as gabbro and gabbroonorite. The gabbro and gabbroonorite are commonly seriated texture, with different amounts of plagioclase, clinopyroxene, orthopyroxene, and opaque minerals phenocrysts or microphenocrysts, and are uncommonly porphyritic textured. The groundmass mainly shows an intergranular texture, with occasionally ophitic-subophitic texture. The groundmass mainly consists of plagioclase, clinopyroxene, orthopyroxene and some opaque minerals. Secondary patches of chlorite/serpentine, quartz, calcite, Fe-Ti oxide, and tiny veins (up to 0.2 mm across) of quartz and calcite are locally present in some samples. The mafic igneous rocks in the south of Mune District are probably occurred as mafic igneous blocks related to ophiolite melange of the Loei Suture.

Keywords: *Petrography, Mafic Igneous Rocks, Loei Fold Belt, NW Laos.*

1 Introduction

The Loei Fold Belt extends from northwestern Laos through Loei and Phetchabun Provinces in northeastern Thailand, to Sra Kaeo in southeastern Thailand and western Cambodia. This belt lies along the western margin of the Indochina Block and is bounded to the west by the Sukhothai Terrane along the Nan Suture, e.g., [1,2]. Many researchers [3-5]

have proposed the volcanic rocks in the Loei Fold Belt, northeastern Thailand were subdivided into eastern, central and western sub-belts.

The central Loei sub-belt is composed mainly of pillow lava, hyaloclastite and pillow breccia. These mafic volcanic rocks are interpreted to be the products of mid-ocean ridge volcanism and have a whole-rock Rb-Sr isochron age of 361 ± 11 Ma (Late Devonian) [6]. [3] reported that the mid-ocean ridge basalt (MORB) exists along with oceanic island-arc mafic lava in the central Loei sub-belt. The arc lavas might have been built on an oceanic basement in major ocean basin or a mature back-arc basin. In addition, [7] studied on geochronology and geochemistry of the volcanic rocks in Pak Lay and Fuang areas, northwestern Laos. They have a zircon U-Pb age dating of 314.6 ± 2.7 , 315.4 ± 3.8 Ma, 330.4 ± 2.2 Ma, 334.9 ± 1.7 Ma, and 349.6 ± 1.7 Ma. Respectively. These ages indicated the information ages of volcanic rocks are Early Carboniferous-Late Carboniferous, not Permian-Early Triassic ages as previously thought and older than the Pak Lay Late Triassic-Jurassic ages (ca. 152-227 Ma), which were acquired by [8]. The Carboniferous zircon ages were first reported in Loei Fold Belt, northwestern Laos and similar to the ages (ca. 310-323 Ma) of volcanic and plutonic rocks from the Phetchabun region in Thailand [2, 9]. Although the previous study of lithofacies, petrogenesis, geochronology and tectonic setting of volcanic rocks are only extensively attended in the Loei Fold Belt, northeastern Thailand, but the igneous rocks in northwestern Laos are lack information and poorly studied. The main objective of this study aims to classify the mafic igneous rocks at the south of Mune District, Vientiane Province, northwest of Lao PDR by using the petrographic technique.

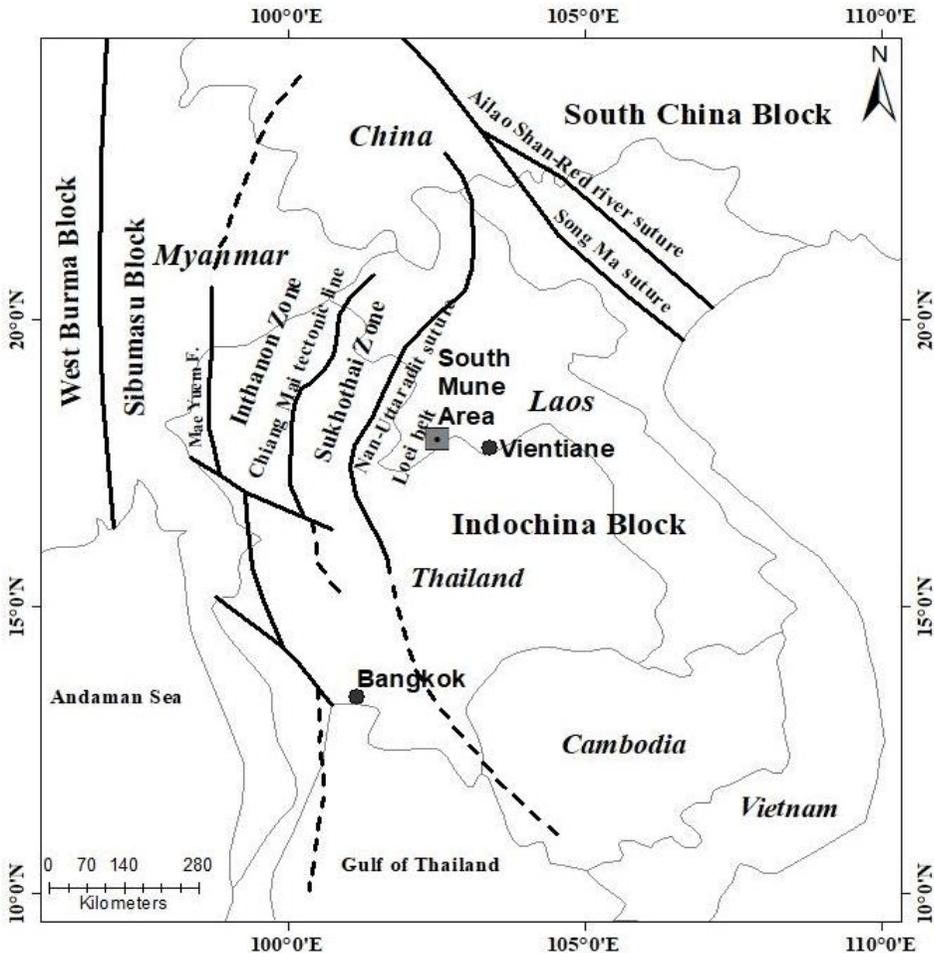


Figure 1 Distribution map of the tectonic zones in the study area (modified from [10])

2 Geological background

Geologic information of the study area and adjacent part has been reported on the 1:1,000,000 geological map of whole Indochina prepared by Department of Geology and Minerals of Vietnam (DGMV) in 1988 and published in 1991. On the geological and mineral resources map of Lao PDR at a scale 1: 1,000,000 was compiled by British Geological Survey and British Mineral Consultants Ltd., (1990, here after called the “BGS Map”) and published in 1991. Furthermore, a revised geological map of NW Laos was compiled by [7] and detailed geological map on 1: 10,000 scales was conducted by senior geologist and staff of Nittetsu Mining Co Ltd., (2017). Accordingly, the study area and vicinity are underlain by sedimentary and igneous rocks that can be separated into four major lithostratigraphic units from older to younger as follows:

The Late Devonian-Early Carboniferous sedimentary rocks comprise light grey to dark grey, thin-bedded to massive shallow shelf sea sequence of muddy limestone [11] (Figure 2). The Late Carboniferous-Early Permian sedimentary rocks including grey to dark greyish black shale. Light grey sandstone, with a cumulative thickness of approximately 500-600 m. Sandstone, siltstone, and shale interbedded, with thickly to very thickly bedded [11] (Figure 2). The Late Carboniferous granitic rocks including fine to medium grained granodiorite and monzogranite [11] (Figure 2). The Permian-Early Triassic acid to intermediate and mafic igneous rocks are mainly composed of basalts, andesites, rhyolites and a small amount of mafic intrusive rocks. The volcanic rocks are characterized by lava flows, pyroclastic, and bedrock out-puts [11]. The mafic intrusive rocks are comprised abundant of green to dark green/blackish, medium to coarse-grained gabbro, with slightly to highly porphyritic texture and generally dominated by plagioclase and clinopyroxene (Figure 2).

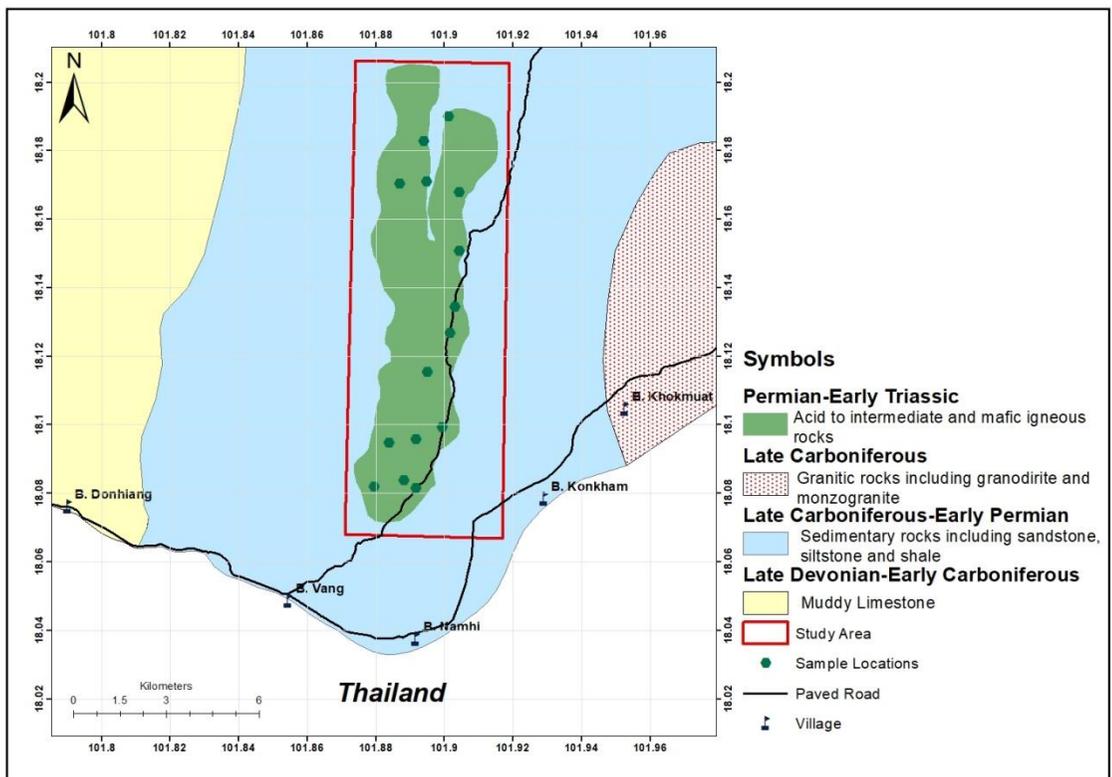


Figure 2 Geological map of the study area. The geology data modified from [11] and [12])

3 Method

The satellite image explanation using the google earth was applied to make a plane for field mapping. Field survey and sample collection were conducted for about two weeks in June 2018. Only fresh and least-altered fifteen samples representative mafic igneous rocks were collected from the exposures on Phu Sarana (PS), Phu PhaNgang (PN), and Phu Phakii (PK) areas (from north to south, respectively.) (Figure 2), south of Mune District, Vientiane Province, NW Lao PDR. Thin- sections were prepared for petrographic analysis using a transmitted light microscope at the Department of Geological Sciences, Faculty of Science, Chiang Mai University, Thailand.

4 Result and Discussion

4.1 Occurrence and relations

The mafic igneous rocks in the south of Mune District, Vientiane Province, NW of Lao PDR exposure cover area about 45 square kilometers as about 3 kilometers wide and about 15 kilometers long (Figure 2). Based on the field work investigation and detailed petrographic classification, these mafic igneous rocks can be classified as gabbro and gabbronorite.



Figure 3 (A, B, C, and D) Photographs of mafic rock exposures in the south of Mune area, Vientiane Province, NW of Lao PDR

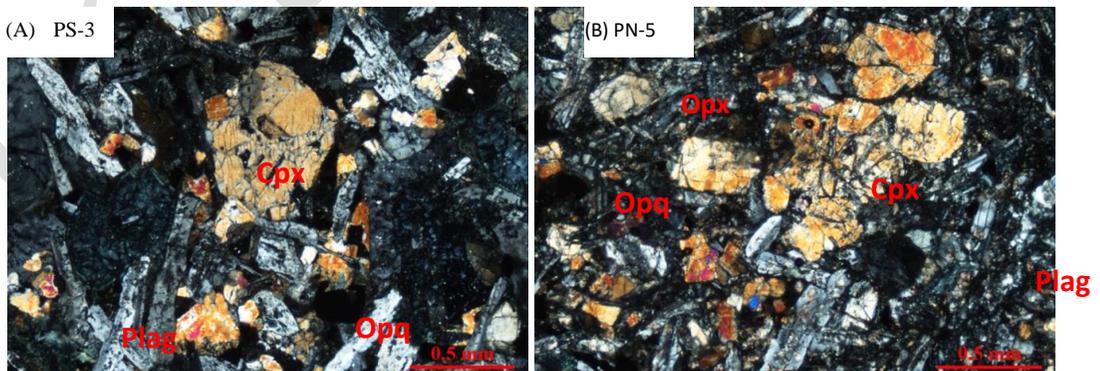
Lithologically, the gabbro and gabbronorite are medium to coarse-grained, green to dark green/blackish coloured massive rock (Figures 3 a, b, c, and d) with yellow to reddish brown weathering surfaces. The mafic rocks in the south of Mune District area occurred as shallow intrusive and associated with the Late Carboniferous-Early Permian sedimentary rocks.

4.2 Petrography

The mafic igneous rocks studied in this area classified as gabbro and gabbronorite based on petrographic study. The details of petrographic characters are explained below.

4.2.1 Gabbro

Gabbro (sample no. PS-2, PS-3, PS-8, PN-5, PN-8, PK-3, and PK-9) were collected from Phu Sarana (PS), Phu PhaNgang (PN), and Phu Phakii (PK) areas (from north to south, respectively). According to petrography and modal analyses, these samples commonly display seriated texture and mainly composed of plagioclase (61.75-69%), with subordinate clinopyroxene (21-27.50%), a small amount of orthopyroxene (4.25-10.5%) and opaque minerals (3.50-7.25%). Secondary patches of chlorite/serpentine, calcite, Fe-Ti oxide, quartz, and tiny veins (size up to 0.5 mm across) of calcite and quartz are locally present in some rock samples. Plagioclase (Plag) crystals are largely subhedral outline (Figures 4a and b) and lath shapes with variable degrees of sericitization and some crystals have An-content in a range 65-70 via an optical method (Michael-Levy method). Clinopyroxene (Cpx) displayed as subhedral to euhedral outlines (0.025 to 2 mm across) (Figures 4a and b) and some crystals show the character of exsolution structure that is made up of lamellae clinopyroxene in orthopyroxene host, corroded outlines, embayment and ophitic/subophitic to plagioclase laths. Orthopyroxene (Opx) crystals are subhedral to anhedral and up to 0.8 mm across. Opaque minerals (Opq) are anhedral to subhedral outlines and irregular shapes.



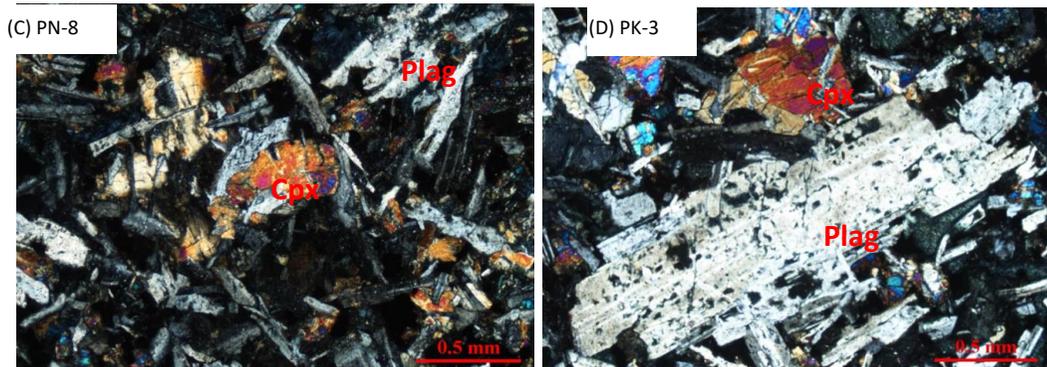
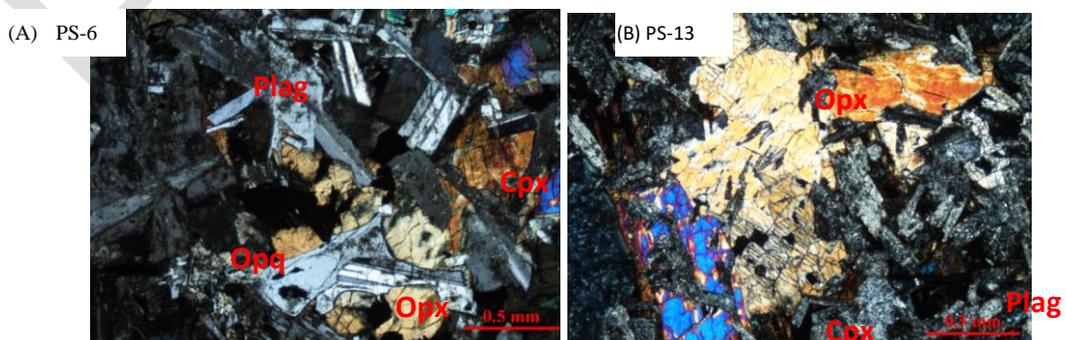


Figure 4 (A, B, C, and D) Microscope photographs for representative gabbro rocks. Plag=plagioclase, Cpx=Clinopyroxene, Opx=Orthopyroxene, Opq=Opaque minerals.

4.2.2 Gabbronorite

Gabbronorite (sample no. PS-6, PS-10, PS-13, PS-14, PN-2, PN-12, PK-4, and PK-6) are seriated texture and some display porphyritic texture (sample number PN-12). They are made up mainly of plagioclase (53.50-64%) with subordinate clinopyroxene (16.75-29%), orthopyroxene (8.50-13.75%), and a small number of opaque minerals (2.25-8.75%). Plagioclase (Plag) crystals are subhedral to anhedral outline (averaged size 0.5 mm across) and some plagioclase grains show corroded outlines, embayment, sieve texture, and inclusions of clinopyroxene, orthopyroxene and opaque minerals in some grains (Figures 5a and b). Clinopyroxene (Cpx) crystals are subhedral to euhedral (averaged size 0.7 mm across) and some crystals show the character of exsolution structure that is made up of lamellae clinopyroxene in orthopyroxene host, ophitic/subophitic to plagioclase laths and intergranular to plagioclase laths (Figures 5a and b). Most of the orthopyroxene (Opx) crystals are subhedral to anhedral and up to 0.8 mm across. Opaque minerals (Opq) are rounded outline and skeleton shapes (averaged size 0.1 mm. across).



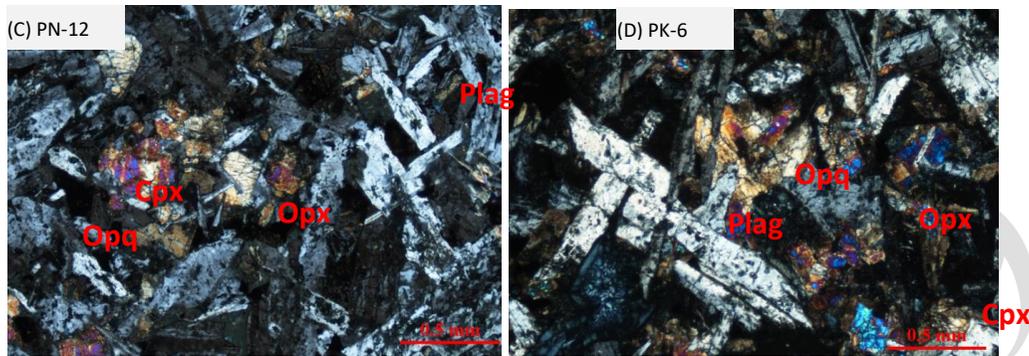


Figure 5 (A, B, C, and D) Microscope photographs for representative gabbronorite rocks. Plag=plagioclase, Cpx=Clinopyroxene, Opx=Orthopyroxene, Opq=Opaque minerals.

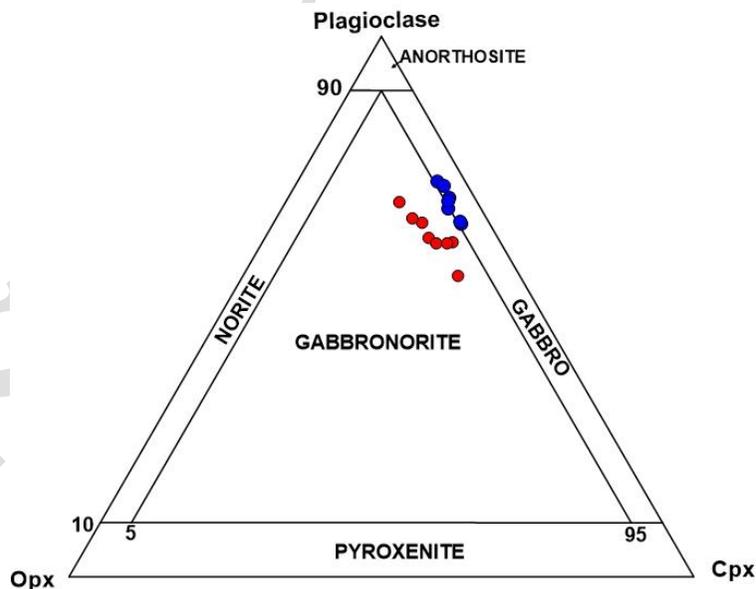


Figure 6 Photograph showing modal classification of gabbroid rocks based on plagioclase (Plag), Clinopyroxene (Cpx) and orthopyroxene (Opx) contents. Blue circle for gabbro rocks and red circle for gabbronorite rocks [13].

4.2.3 Discussion and conclusion

The least-altered mafic igneous rocks discussed in this study were from south of Mune District, Vientiane Province, NW of Lao PDR. The study area is possibly the northern extension of the central Loei volcanic sub-Belt of Loei volcanic Belt, northeast Thailand. This area forms scattered on Phu Sarana, Phu Pha Ngang, and Phu Phakii areas, covering an area of about 45 Km². Fifteen representative of mafic igneous rocks (Figure 2) were petrographically examined and rock name classification. Those rocks were determined into gabbro and gabbro-norite.

Petrographically, seven samples of gabbro area displayed seriated texture and mainly composed of plagioclase, with subordinate clinopyroxene, a small amount of orthopyroxene and opaque minerals. Secondary patches of chlorite/serpentine, calcite, Fe-Ti oxide, quartz, and tiny veins (size up to 0.5 mm across) of calcite and quartz are locally present in some rock samples.

Eight samples of gabbro-norite are also mainly seriated texture and some porphyritic texture. They are made up mainly of plagioclase with subordinate clinopyroxene, orthopyroxene, and a small number of opaque minerals. Plagioclase crystals are subhedral to anhedral outline (averaged size 0.5 mm across) and some plagioclase grains show corroded outlines, embayment, sieve texture, and inclusions of clinopyroxene, orthopyroxene and opaque minerals in some grains. Clinopyroxene crystals are subhedral to euhedral (averaged size 0.7 mm across) and some crystals show the character of exsolution structure that is made up of lamellae clinopyroxene in orthopyroxene host, ophitic/subophitic to plagioclase laths and intergranular to plagioclase laths. Most of the orthopyroxene crystals are subhedral to anhedral and up to 0.8 mm across. Opaque minerals are a rounded outline and skeleton shapes (averaged size 0.1 mm. across).

The gabbro and gabbro-norite from the south of Mune district, Vientiane Province, northwest of Lao PDR in this study are probably occurred in oceanic crust environment and related to the Loei Suture. Geochemistry and Geochronology of the mafic rocks in this area will be studied in the future works for their tectonics and age determination.

5 Acknowledgments

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