Journal of Asian Earth Sciences 129 (2016) 81–97

Contents lists available at ScienceDirect

Journal of Asian Earth Sciences

journal homepage: www.elsevier.com/locate/jseaes

Full length Article

Petrochemistry and mineral chemistry of Late Permian hornblendite and hornblende gabbro from the Wang Nam Khiao area, Nakhon Ratchasima, Thailand: Indication of Palaeo-Tethyan subduction

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ARTICLE INFO

Article history:
Received 19 February 2016
Received in revised form 5 July 2016
Accepted 9 July 2016
Available online 25 July 2016

Keywords:
Hornblendite
Zircon U-Pb geochronology
Geothermobarometry
PT condition
Arc magmatism
Thailand

ABSTRACT

In the Wang Nam Khiao area, Nakhon Ratchasima, northeastern Thailand, there are various mafic-ultramafic plutons composed of hornblendite, hornblende gabbro and hornblende microgabbro. The rocks are generally dominated by hornblende, plagioclase and clinopyroxene. The mineral chemistry and whole-rock geochemistry of hornblendite, hornblende gabbro and hornblende microgabbro show their similarities, suggesting a close relationship of their magmatic evolution. The flat REE pattern and low HREE concentration indicate fractional crystallization from hydrous magma. The enrichment in LILE (e.g. Ba, K, Sr) and depletion of HFSE (e.g. Nb, Ta, Zr) together with compositions of clinopyroxene and hornblende reflect arc-related subduction. Hornblende-plagioclase geothermometry and Al-in-hornblende geobarometry indicate the PT conditions of crystallization are 5.3–9.8 kbar and 670–1000 °C, 7.6–9.0 kbar and 850–950 °C, and 7.6–8.8 kbar and 750–850 °C for hornblendite, hornblende gabbro and hornblende microgabbro, respectively, at the lower crustal depth (28–31 km). Zircon U-Pb age of hornblende microgabbro dike, that intruded into hornblendite, yields 257 Ma of intrusion age, suggesting the emplacement of the mafic-ultramafic rock in this area is related to Late Permian arc magmatism resulted from subduction of Palaeo-Tethys beneath Indochina Terrane.

1. Introduction

Thailand is composed of two major tectonic terranes; Indochina Terrane in the east and Sibumasu (Sone and Metcalfe, 2008) or Shan-Thai (Charusiri et al., 2002) Terrane in the west (Bunopas, 1981; Sone and Metcalfe, 2008; Charusiri et al., 2002) (Fig. 1a). They are separated by other two terranes including Loei Fold Belt (LFB; Bunopas, 1981) to the east and Sukhothai Terrane (ST; Sone and Metcalfe, 2008) or Sukhothai Fold Belt (Bunopas, 1981) to the west. Loei Fold Belt (LFB) and Sukhothai Terrane (ST) are clearly separated by Nan suture (Bunopas, 1981; Zaw et al., 2014) in the northern part of the country but they are combined together in the central parts where Sukhothai Terrane (ST) disappears, based on geological structure and rock formation (Bunopas, 1981; Sone and Metcalfe, 2008). The Sra Keao Suture is located along the western edge of Loei Fold Belt particularly in the eastern part of the country (Fig. 1a). The history of arc magmatism of both Loei Fold Belt and Sukhothai Terranes are resulted by the collision between Indochina and Sibumasu together with their Palaeo-Tethys (Sone and Metcalfe, 2008; Metcalfe, 2011a, 2011b, 2013) during Late Carboniferous to Late Triassic (Bunopas, 1981; Charusiri, 1989; Charusiri et al., 2002; Barr et al., 1990, 2006; Singharajwarapan and Berry, 2000; Sone and Metcalfe, 2008; Boonsoong et al., 2011; Zaw et al., 2014; Salam et al., 2014; Kamvong et al., 2014; Burrett et al., 2014) which have been reported in the northern (e.g. Nan Suture, Sukhothai, Loei and Phetchabun) and eastern (e.g. Sra Keao Suture) Thailand (Fig. 1a).

Wang Nam Khiao area (WNK), the study area in Nakhon Ratchasima (Fig. 1a) is located in the unclear conjunction of the terranes in the middle of the country, close to the southwestern

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http://dx.doi.org/10.1016/j.jseaes.2016.07.006
1367-9120/

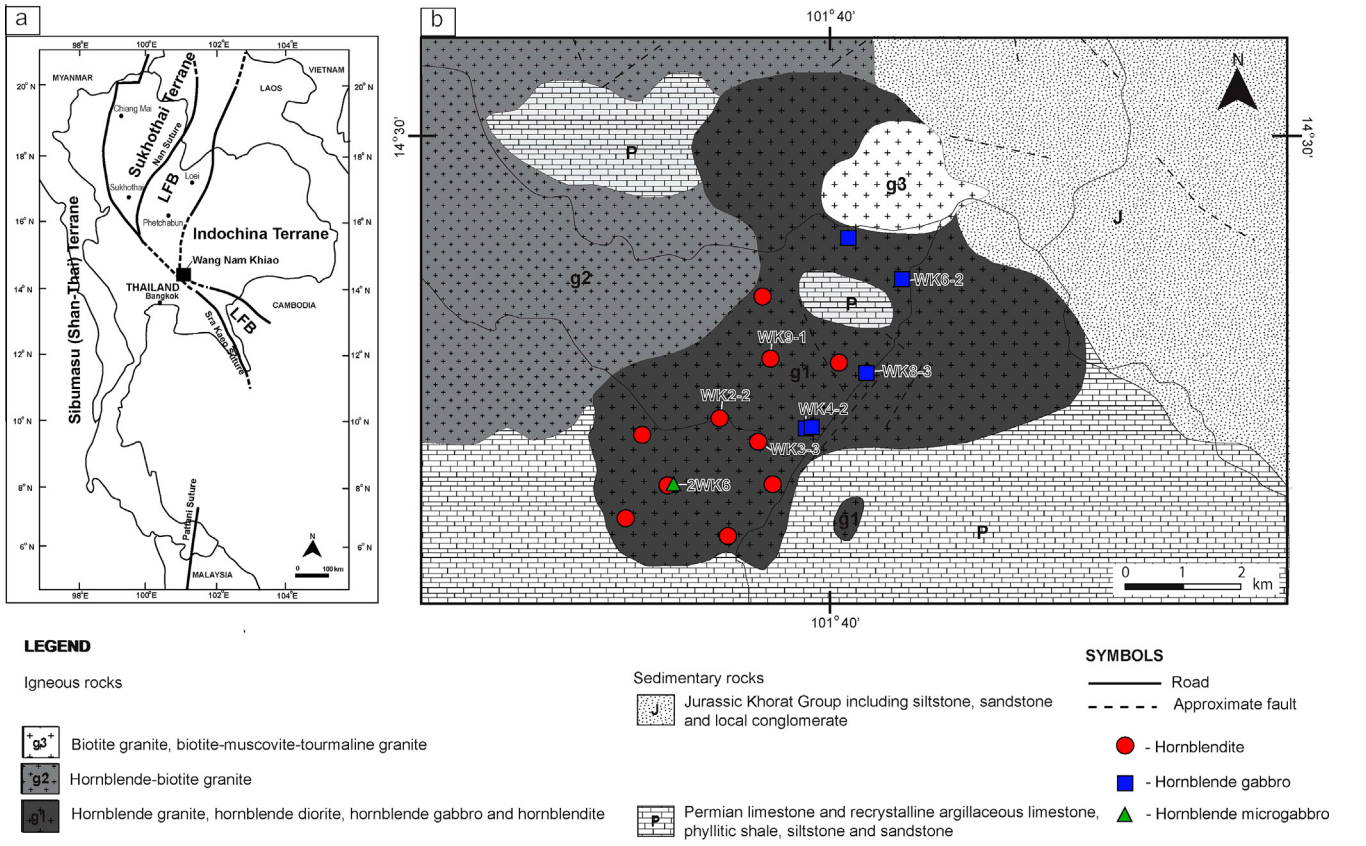

Fig. 1. (a) The simplified map of Thailand showing main tectonic terranes including Indochina Terrane, Sibumasu (Shan-Thai) Terrane, Loei Fold Belt (LFB) and Sukhothai Terrane (ST) (modified after Charusiri et al., 2002; Sone and Metcalfe, 2008; Metcalfe, 2013; Zaw et al., 2014) and the study area. (b) The simplified geological map of Wang Nam Khiao area, Nakhon Ratchasima, the study area (after Putthaphiban et al., 1981, 1989) showing sample locations within the exposures of g1 group.

edge of Khorat Plateau. Several exposures of felsic to mafic-ultramafic plutonic rocks have been reported by some researchers (e.g. Putthaphiban et al., 1981, 1989; Jiratitipat, 2010; Nonsung, 2010; Booncharoen, 2011; Hunyek, 2012), however no detailed study of petrogenesis and geochronology has been done yet. Such magmatic rocks bear significance in understanding the tectonic setting and magmatic event of this region. In this study, we focus on detailed petrological study of mafic-ultramafic rocks (e.g. hornblendite and related hornblende gabbro) in Wang Nam Khiao area, combined with the first U-Pb zircon geochronology of this area. Our new results of petrology, mineral chemistry, geochemistry, and zircon U-Pb geochronology provide the insights into the emplacement age and petrogenesis of the magmatic rocks.

2. Geologic setting

The Wang Nam Khiao area in Nakhon Ratchasima, northeastern Thailand is situated within a major tectonic line that separates the Indochina Terrane and Sibumasu (Shan-Thai) Terrane (Charusiri et al., 2002) (Fig. 1a). The tectonic line has been defined as the Loei Fold Belt (LFB in Fig. 1a: Bunopas, 1981; Zaw et al., 2007, 2014; Kamvong et al., 2014) or Loei-Petchabun Fold Belt (Burrett et al., 2014). This area is also regarded to have a close association with the adjacent Sukhothai Terrane (ST) and Nan - Sra Kaeo suture (Sone and Metcalfe, 2008; Metcalfe, 2011a, 2011b, 2013), therefore the Wang Nam Khiao area corresponds to a junction of several tectonic units.

Previous studies (e.g. Intasopa and Dunn, 1994; Panjasawatwong et al., 2006; Khositanont et al., 2008; Kromkhun et al., 2013; Zaw et al., 2014; Salam et al., 2014; Kamvong et al., 2014) of the LFB and adjacent regions suggest that the LFB is bounded by the Nan Suture and Sra Kaeo Suture to the west (Fig. 1a) that contains widespread mafic exposures dominated by basic volcanic rocks (Intasopa and Dunn, 1994; Panjasawatwong et al., 2006) to felsic volcanic rocks (Khositanont et al., 2008; Boonsoong et al., 2011) with a variety of plutonic rocks (Morley et al., 2011; Zaw et al., 2014; Salam et al., 2014). These volcanic rocks are characterized by tholeiitic to calc-alkaline affinities (Panjasawatwong et al., 2006; Khositanont et al., 2008; Kromkhun et al., 2013; Salam et al., 2014; Kamvong et al., 2014) which usually expose along with I-type granitoids (Zaw et al., 2014; Salam et al., 2014; Kamvong et al., 2014) and S-type granitoids (Sone and Metcalfe, 2008; Morley et al., 2011). These granitoids are also related to the calc-alkaline affinities (Khositanont et al., 2008; Kromkhun et al., 2013; Salam et al., 2014; Kamvong et al., 2014) and they have been grouped into the Triassic Eastern Granite Belt of Thailand (Cobbing et al., 1986, 1992; Nakapadungrat and Putthapiban, 1992; Charusiri et al., 1993; Searle et al., 2012). Several stages of arc-related magmatic events had taken place in the LFB from Early Silurian to Late Cenozoic (Bunopas, 1981; Intasopa and Dunn, 1994; Panjasawatwong et al., 2006; Zaw et al., 2014). For example, three major volcanic events (Devonian to Early Carboniferous, Middle Triassic, and Cenozoic) were reported from the LFB based on Rb-Sr isochron ages by Intasopa and Dunn (1994). Moreover, U-Pb zircon geochronology indicating the Silurian rhyolite (Khositanont et al., 2008; Boonsoong et al., 2011) and the basaltic to rhyolitic rocks of Late Permian/Earliest Triassic to Middle Triassic (Khositanont et al., 2008; Salam et al., 2014; Zaw et al., 2014) were reported, accordingly.