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NEW ^{40}Ar/^{39}Ar GEOCHRONOLOGY AND CHARACTERISTICS OF SOME CENOZOIC BASALTS IN THAILAND

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Abstract

Occurrences of Cenozoic basalts are reported in several parts of Thailand except the south. ^{40}Ar/^{39}Ar age-dating technique was applied to date some basalt samples in Thailand, those are Bo Ploi basalt in the west, Mae Tha basalt in the northern, Wichian Buri and Lam Narai basalts in the central, and Khao Wua, and Nong Bon basalts in the eastern. ^{40}Ar/^{39}Ar ages of these basalts can be divided into 6 major episodes, as 22-24 Ma (Late Oligocene) episode, 18-20 Ma (Early Miocene) episode, 8-14 Ma (Middle to Late Miocene) episode, 4-5.3 Ma (Early Pliocene), 1.6-3.6 Ma (Late Pliocene) episode, and less than 1.6 Ma (Quaternary) episode.

1. Khao Wua basalt is located in Khao Ploi Waen range in Chanthaburi province. It is characterised by black to dark grey, fine-grained basalt with megacrysts of clinopyroxene and spinel. ^{40}Ar/^{39}Ar age of 3.0±0.19 Ma was obtained from this basalt.

2. Nong Bon basalt is identified as dark grey to black, fine-grained porphyritic basalt. Olivine phenocrysts and augite microphenocrysts occur in groundmass of clinopyroxene, opaques, and glass. Age of 2.38±0.16 Ma was obtained from 40Ar/39Ar method.

3. Wichian Buri basalt is black fine-grained, porphyritic or diabasic texture. It locally contains lherzolite xenoliths. Occurrences of gem-quality sapphire can be found nearby the boundary of this basalt. ^{40}Ar/^{39}Ar age determination yielded 9.08±0.29 Ma (Intasopa, 1993), 8.82±0.09 Ma, and 11.03±0.03 Ma.

4. Lam Narai basalt occurs as dark grey or greenish grey fine-grained with vesicular texture and phenocrysts of plagioclase, clinopyroxene and olivine. ^{40}Ar/^{39}Ar ages of 18.1±0.7 Ma and 24.1±1.0 Ma were reported (Intasopa, 1993) from this area.

5. Bo Ploi basalt, the major source of sapphire in Thailand, is generally fine-grained with clinopyroxene and microlites scattered throughout a glassy groundmass and megacrysts of olivine,

INTRODUCTION

Exposures of basalts in Thailand spasmodically distribute in the north, western, central, and eastern parts of the country (Figure 1). These basalts can be subdivided into 2 major groups based on occurrence of gems (mainly corundum) as corundum-bearing, and corundum-barren basalts (Vichit, 1992). They can be geochemically subdivided to be basanitoids and hawaiite basalts (Barr and Macdonald, 1978). According to Jungyusuk and Khositanont (1992), gem-quality corundum is expected to be typically associated with basanitoid basalts. Previous geochronological data indicate that most basalts in Thailand were conclusively assigned to be Late Cenozoic in age, but some are of Permo-Triassic (see Intasopa, 1993). Their ages were obtained from fission-track, paleomagnetic, and K/Ar age dating methods. Localities of samples dated, their ages, and dating methods are complied in Table 1. This paper presents the new $^{40}Ar/^{39}Ar$ ages and some cha-racteristics of basalts in 6 areas, including Mae Tha in the north, Bo Ploi in the east, Lam Narai, and Wichian Buri in the north central, and Khao Wua, and Nong Bon in the east. The details of geochronological data and some characteristics of individual basalts are present below.

GEOLOGIC CHARACTERISTICS

1. KHAO WUA BASALT

It is generally found as flat plains, and small hills of volcanic landforms. This basaltic area is a dominant source of sapphire. The exposed area (25 km) is located in Khao Ploi Wean range in the North and covers some parts of Amphoe Tha Mai, Changwat Chanthaburi, eastern Thailand. Khao Wua basalt frequently shows erosional surface. It is characterised by black to dark grey, fine-grained rocks with megacrysts of clinopyroxene and spinel. It also covers mainly Quaternary deposits, and partial Carboniferous rocks and Triassic granite (Figure 2). Vesicular basalts are always found, and scoriaceous materials are observed in some places of this area. It often contains lherzolite xenoliths and comprises plagioclase, clinopyroxene, and olivine, as major constituent. Basalt in Khao Ploi Waen can be geochemically characterised by high alkali and low silica contents (Barr and Macdonald, 1981).

2. NONG BON BASALT

This basalt exposes in a terrane occupied by Triassic rocks (Figure 3). It is located in Amphoe Bo Rai, Changwat Trat, eastern Thailand. The rock is classified as nephelinite (Barr and Macdonald, 1978). This basaltic area (up to 20 km2) is the major source of ruby. This basalt always shows flow layers. Gemstones were mined in alluvial, colluvial, and residual soils of basalts. Recently, mines are working into weathered basaltic source rock. Megacrysts including clinopyroxene, garnet, spinel, ilmenite, and magnetite, can be commonly found in this area. Nong Bon basalt is identified as dark grey to black, fine-grained, porphyritic basalt. Phenocrysts commonly comprise olivine and clinopyroxene. Groundmass is composed largely of clinopyroxene, nepheline, and opaques. This basalt is geochemically identified as basanitoid (Barr and Macdonald, 1981).

3. WICHIAN BURI BASALT

The basalt covers approximately 300 km 2 in Amphoe Wichian Buri, Changwat Phetchabun, central Thailand. It widely exposes in Permian rocks, Tertiary sedimentary rocks, and Quaternary deposits (Figure 4). It frequently occurs as greyish black to black, very fine-grained, porphyritic rock. Volcanic plugs can be delineated in the field. This basalt was partially developed as columnar jointing. Lherzolite xenoliths are frequently distributed in basalts. The other xenoliths, as gneiss and gabbro, can be seen in this basalt. Gem-quality sapphire can be encountered close to the boundary of this basalt. Megacrysts of euhedral black spinel are often present. Plagioclase frequently occurs as laths of oligoclase. Diabase dike intruded this basaltic flow in many locations. This basalt can be geochemically classified as alkali basalts, including alkali olivine basalt, hawaiite, nepheline hawaiite, and basanite (Vichit and others, 1988).

4. LAM NARAI BASALT

This basalt (700 km) exposes widely in Amphoe Chai Badan and Amphoe Si Thep, Changwat Lop Buri, central Thailand. This basalt is located within Lam Narai Volcanic Field (Jungyusuk and Khositanont, 1992). The basalt is relatively older than Lam Narai basalt. The basalt is characterised by dark grey or greenish grey, dense to vesicular, fine-grained and porphyritic texture. Groundmass invariably shows flow textures. Phenocrysts of lath-

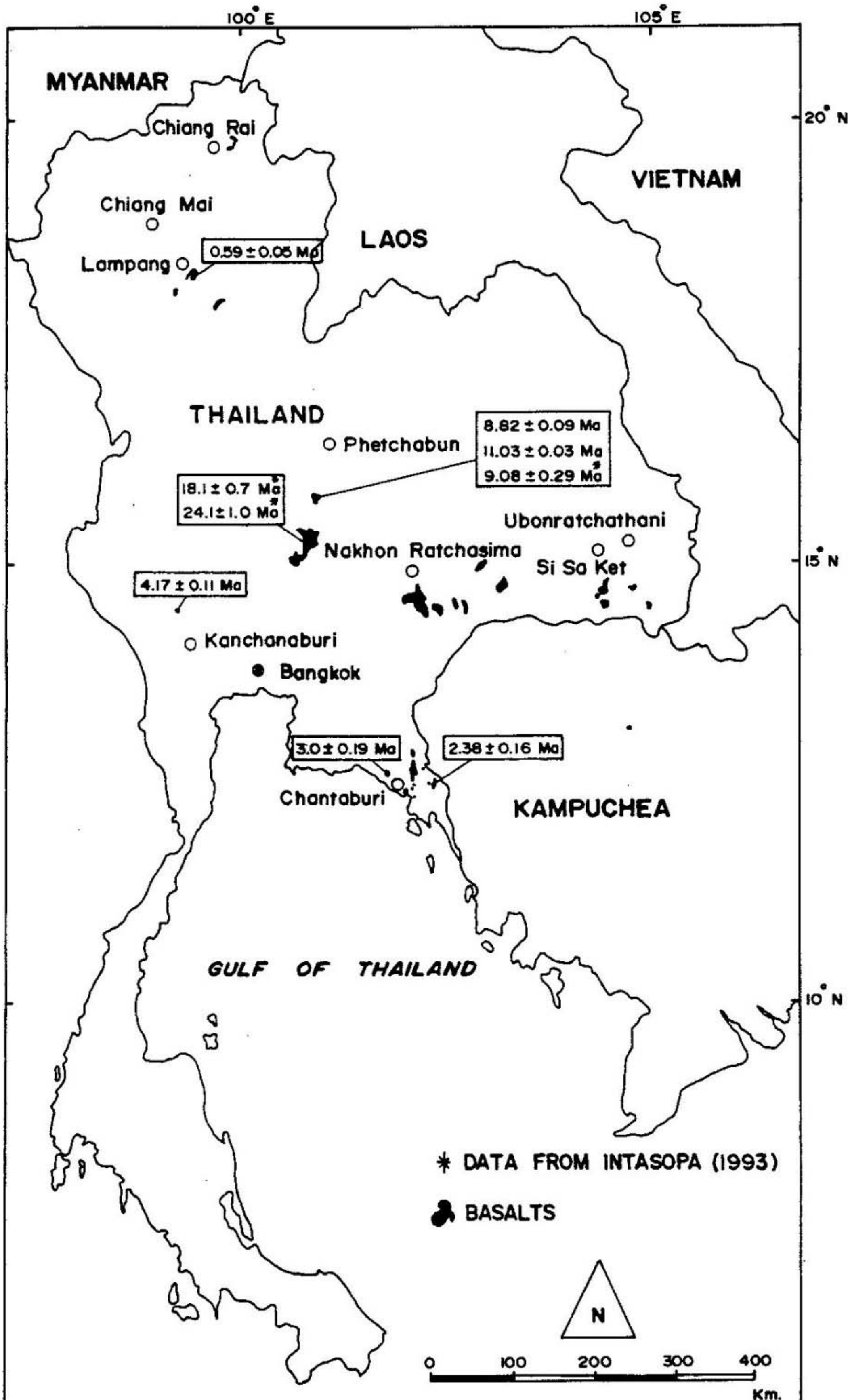


Figure 1 Map showing the distribution of Cenozoic basalts and some $^{40}Ar/^{39}Ar$ ages.

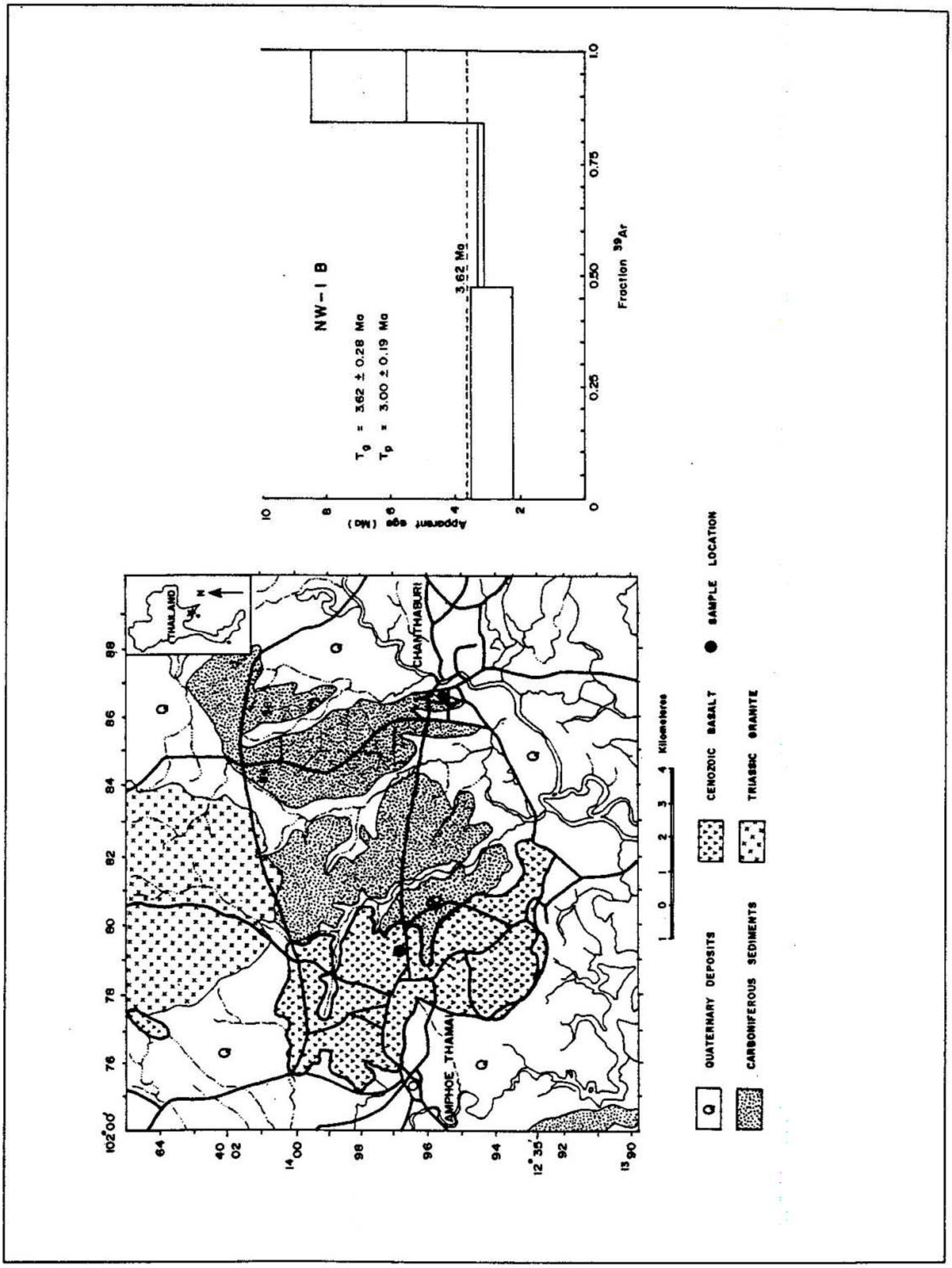


Figure 2 Geological sketch-map of Khao Wau area, modified after Vichit (1992). Map shows the location of $^{40}Ar/^{39}Ar$-dated sample (NW-1) and step-heating age spectra.

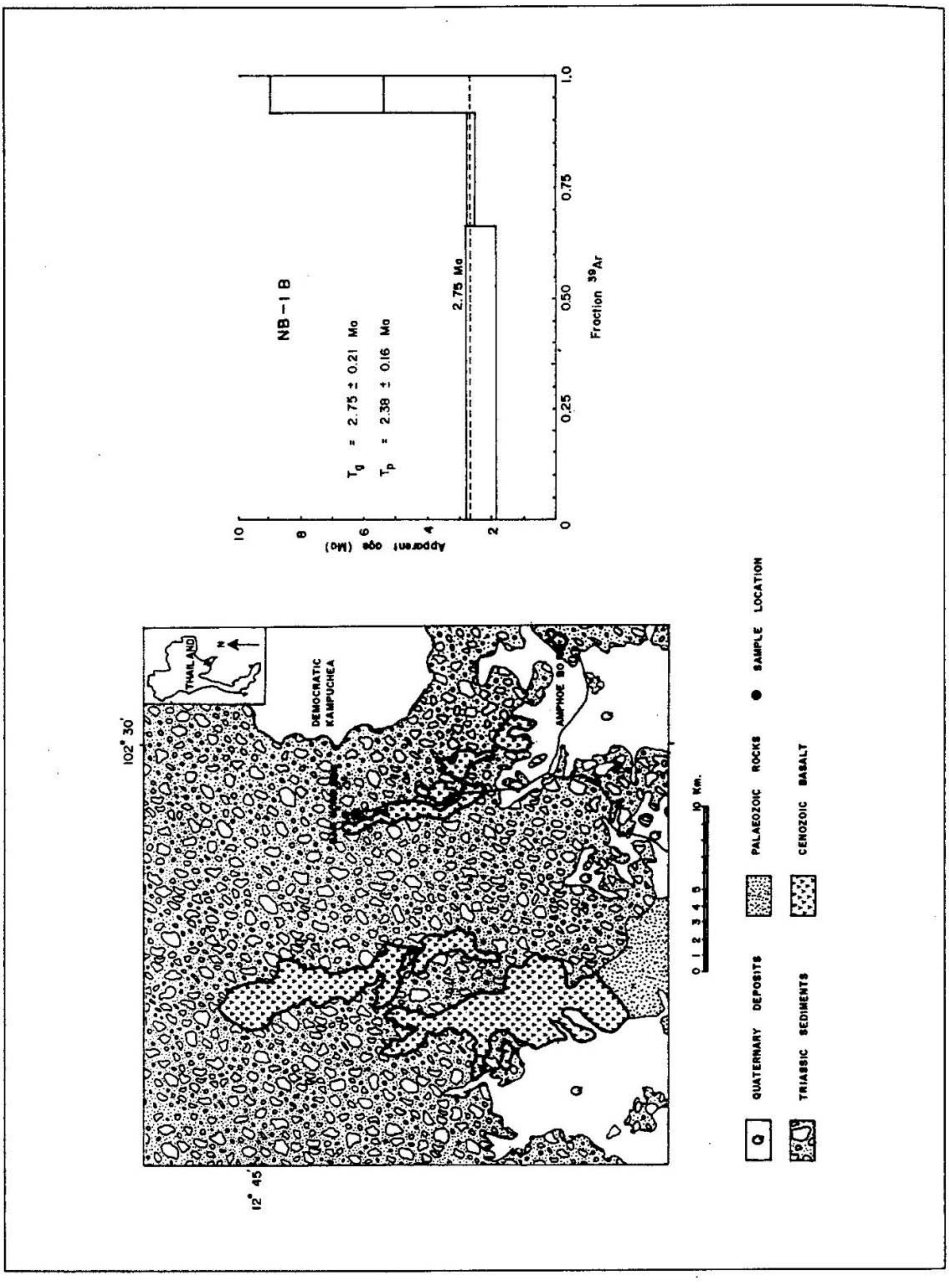
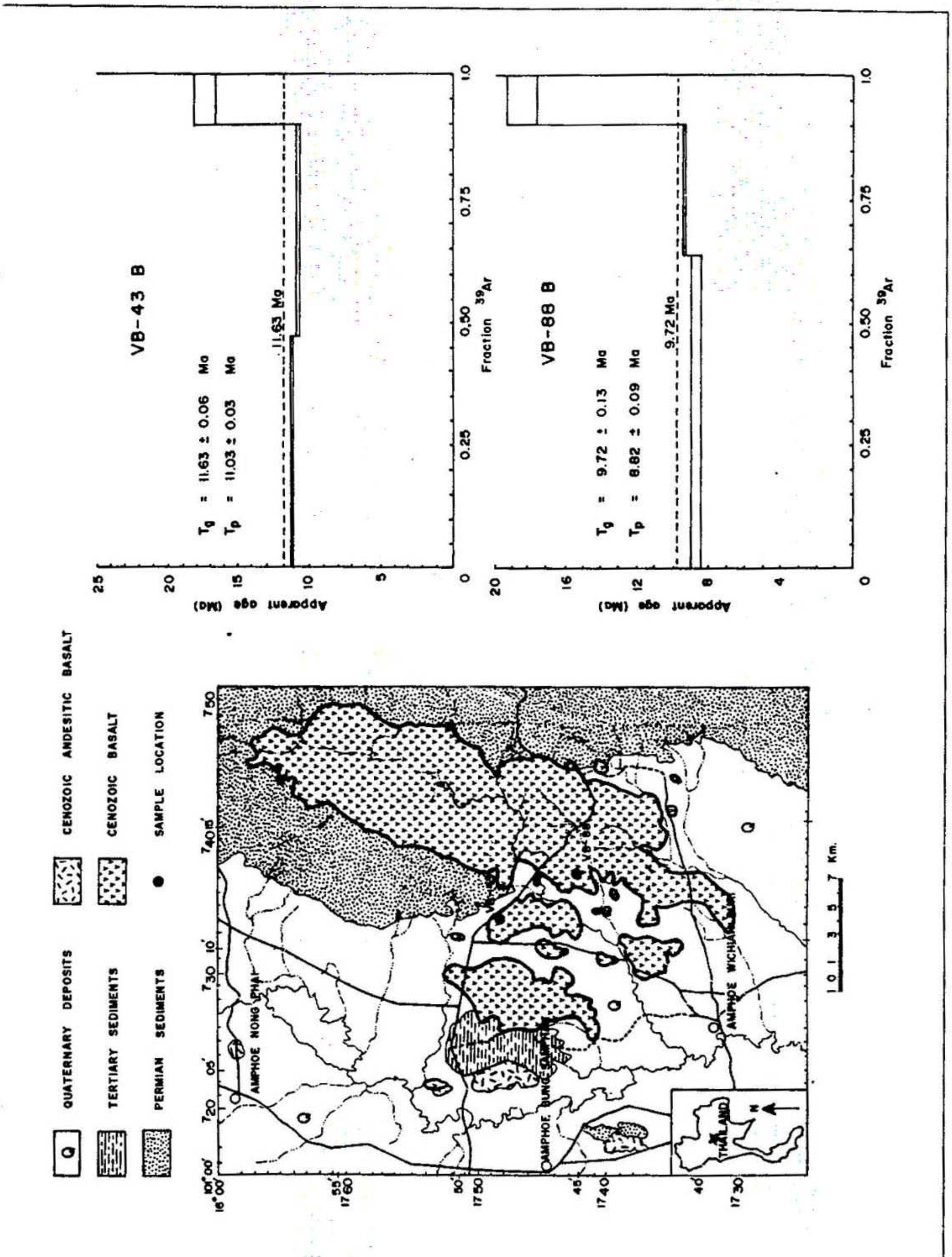


Figure 3 Geological sketch-map of Nong Bon area, modified after Tansathien and others (1985). Map shows the location of $^{40}Ar/^{39}Ar$-dated sample (NB-1) and step-heating age spectra.



ure 4 Geological sketch - map of Wichianburi area, modified after Vichit and others (1988). Map shows the locations of r/^{39}Ar - dated samples (VB-88 and VB-43) and step-heating age spectra.

shaped plagioclase, round-shaped olivine, and short prismatic clinopyroxene are also present in this basalt. Plagioclase range is typically within labradorite, with minority in bytownite. Clinopyroxene is typically augite. Vesicles are often filled with silica minerals as opal, agate, and chalcedony (Sonpirom, 1993). Basalt shows a small range in silica content, but large variation in total alkali content. It is geochemically classified as transitional basalt, tholeiitic basalt, and alkali basalt (Intasopa, 1993).

5. BO PLOI BASALT

The basalt occupies an aerial extent of 0.5 km2 in Amphoe Bo Ploi, Changwat Kanchanaburi, western Thailand. Bo Ploi basalt represents the major source of blue sapphire in Thailand. The basalt extrudes Silurian-Devonian quartzite (Figure 5). It generally occurs as dark, dense, fine-grained to aphanitic rock. Lherzolite nodules and megacrysts of clinopyroxene, black spinel, sanidine, and olivine, are generally present in the basalt. Its texture includes fine-grained, aphanitic and porphyritic. The rock comprises plagioclase, clinopyroxene, olivine, sanidine, and opaques. Plagioclase is in the range of andesine composition. Chemical composition shows that Bo Phloi basalt yields high K_2O content and low total Fe (Yaemniyom, 1982). It was geochemically grouped as nepheline hawaiite by Barr and Macdonald (1981).

6. MAE THA BASALT

The area is located in Amphoe Mae Tha, Changwat Lampang, northern Thailand. This basalt extrudes Permian limestone, Permo-Triassic volcanic rocks, Triassic and Tertiary sedimentary rocks, Quaternary unconsolidated deposits (Figure 6). Volcanic landforms, such as vents, cones, and flows, are present in this basaltic area. Volcanic vents of this basalt can be found in Pha Kog Hin Foo and Pha Kog Jam Pa Daed. Basalt always shows vesicular and massive textures. Lherzolite nodules and phenocrysts of olivine, sanidine and spinel are encountered nearby the volcanic vents. Amygdules of calcite are invariably present. Aa lava flows are also recognised in this basalt. Plagioclase, pyroxene, olivine, and opaques are major constituents. Plagioclase ranges form andesine to labradorite in composition. Glass generally fills in void, showing intersertal texture. Geochemically, this basalt has high SiO_2 and K_2O contents, and low total Fe content (Vichit and others, 1978). This basalt is classified as basanite and hawaiite (Barr and Macdonald, 1981).

ANALYTICAL METHODS OF GEOCHRONOLOGY

Five samples of Thai basalts used for 40Ar/39Ar incremental step-wise heating analysis, were irradiated in the McMaster University (Hamilton, Ontario, Canada) reactor, which has been found suitable for this purpose by other workers (see Berker and York, 1979, Archibald and other, 1983). Samples were then loaded into an aluminum sample holder, designed to fit into the irradiation capsules used at the McMaster University. Samples were arranged in the canister coaxially, one wafer-like packet on top of another. The flux monitors were uniformly distributed in the can since the neutron flux was able to vary considerably over short distances in a nuclear reactor. The samples were irradiated for one hour and the canister received high neutron flux. The sample package was allowed to cool to allow for the decay of short-lived radioactive nucleides. After cooling, the samples were unloaded in a lead-lined box while wearing a high-efficiency particle respirator.

After irradiation, the samples were removed from the aluminium sample holder, and were analysed at the Queen's University Geochronlab (Kingston, Ontario, Canada). Laboratory procedures used in this study followed those outlined by Gerasim off (1989) and Charusiri (1989). The samples were loaded into niobium-molybdenum crucibles and, following an 18 h bake-out, were incrementally heated in 1 h steps, with the temperature monitoring using an optical pyrometer. Ar gas was extracted and purified by conventional procedures. Corrections for Ca- and K-derived interfering isotopes were made, using correction factors determined by Bottomley and York (1976). The ages and uncertainties were calculated using equations given by Dalrymple and others (1981).

The J values for flux monitors and the 40Ar/39Ar ages for the samples were calculated using expression given by Dalrymple and Lamphere (1971) and Dalrymple and others (1981). The interpolated J values for the irradiated basalt samples ranged from 2.75×10^{-3} to 3.2×10^{-3} with an uncertainty of less than 0.5 %. The large difference among J values for a given irradiation indicated that the flux gradients were much greater than those reported by other workers using the McMaster reactor (see also Archibald and others, 1983). The quoted errors represent the analytical uncertainty at 2σ level. These errors are valid for a comparison of the age of different steps for the same sample. Only 3 conse-

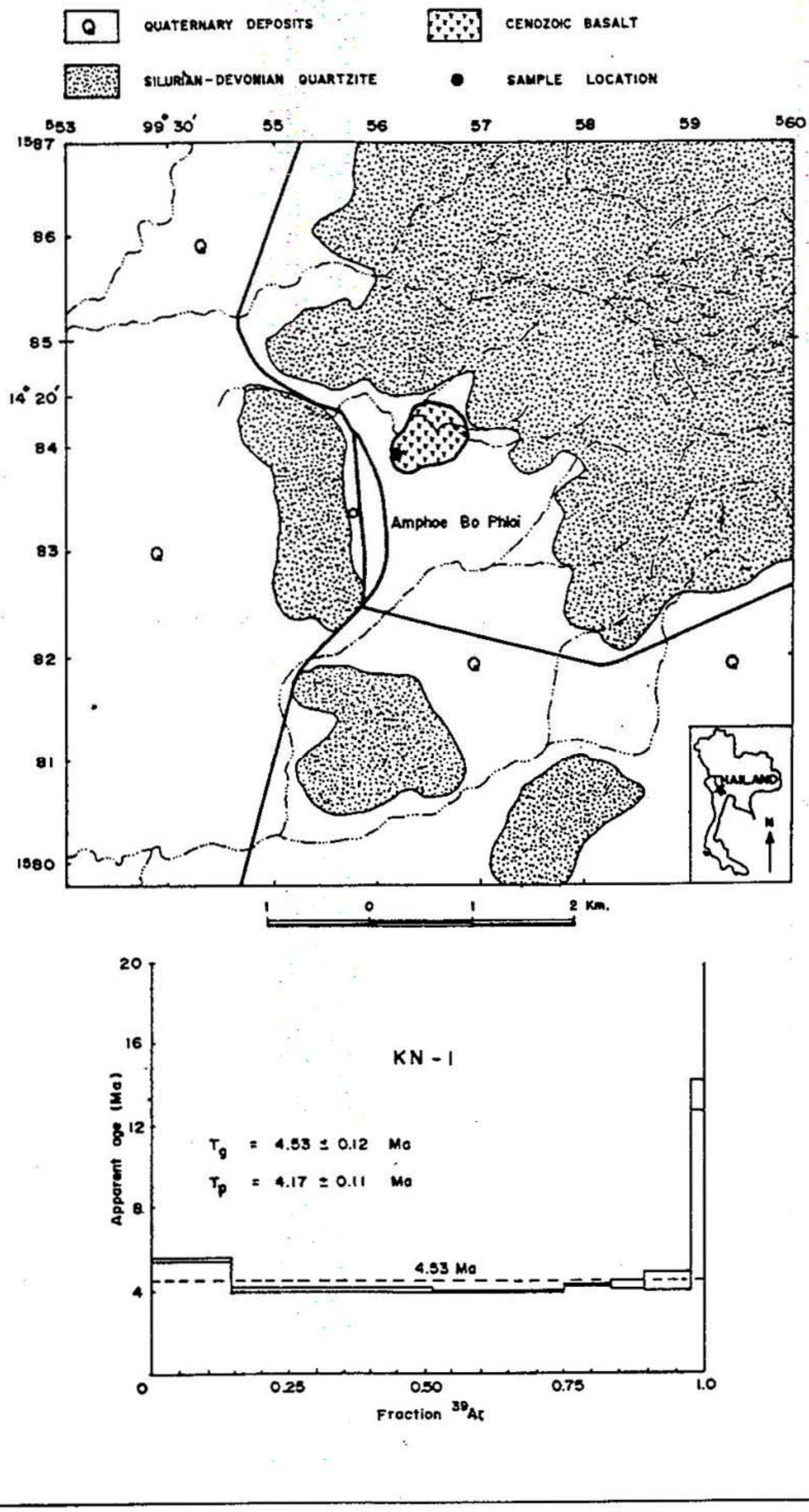


Figure 5 Geological sketch - map of Bo Ploi area, modified after Bunopas and Bunjitadulya (1975). Map shows the location of $^{40}Ar/^{39}Ar$ -dated sample (KN-1) and step-heating age spectra.

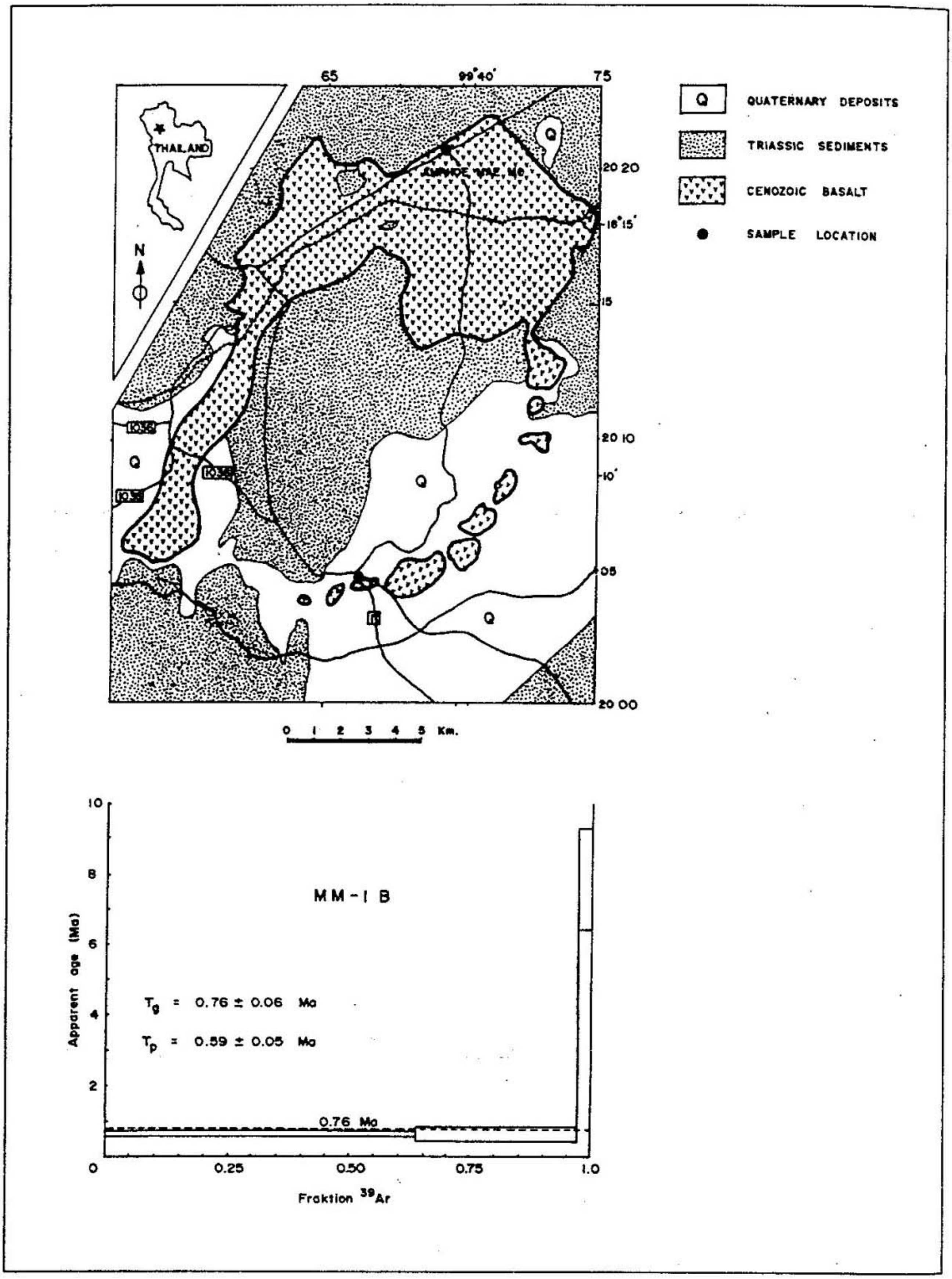


Figure 6 Geological sketch - map of Mae Tha area, modified after Chualaowanich (1992). Map shows the location of $^{40}Ar/^{39}Ar$-dated sample (MM-1) and step-heating age spectra.

cutive steps; i.e. at 700, 900 and 1,150°C were chosen for this study due to the small amount of ^{39}Ar volume. Only one sample from Kanchanaburi was done in 7 steps. The criteria used for determining plateau age were those of Fleck and others (1977). The total gas age (tg) or integrated age represents a weighted average age based on the total amount of ^{39}Ar in each increment. The plateau age (tp) is the mean of the apparent ages considered to be concordant, represented by a flat pattern on a plot of the $^{40}Ar/^{39}Ar$ dates for each step against the cumulative proportion of the released argon.

GEOCHRONOLOGICAL RESULTS

1. NW - 1

The whole-rock specimen is a basalt from Changwat Chanthaburi (Figure 2). The sample was incrementally heated in 3 steps from 700 to 1050°C (temperature of fusion). The age spectrum shown in Figure 2 represents a fairly concordant release spectrum. The step 1 and 2, comprising approximately 85 % of the total gas released, yield a plateau age (tp) of about 3.00±0.19 Ma. However, the third step (about 15 % of the volume 39Ar) gave the very high apparent age (7.01±0.74 Ma). This is interpreted to represent the date contaminated principally by atmospheric Ar. The total-gas age (t_g) is 3.62± 0.28 Ma. Therefore, the geological age for this sample is inferred to be 3.03±0.025 Ma (Early Pliocene).

2. NB - 1

The whole-rock basalt is from Changwat Trat (Figure 3). The age spectrum illustrated in Figure 3 displays an internally concordant age profile. The first two steps yield well-defined plateaux for more than 90% of the total-age Ar released during heating. However, the last step (about 8%) shows relatively high apparent age (ca 7.16±0.90 Ma), which is probably due to atmospheric contamination. The total-gas age (t_g) is calculated to be 2.75±0.21 Ma whereas the plateau age (t_p) is approximately 2.38±0.16 Ma. The latter is considered to represent the more reliable geological age, that is Early to Late Pliocene.

3. VB - 88 and VB - 43

The basalt whole-rock samples are from Changwat Phetchabun (Figure 4). The age spectra of these two samples are depicted in Fig 4. For VB-88, the first two steps show a reliable plateau age with the apparent age of 8.59±0.13 Ma and 9.38±0.17 Ma. Approximately 90% volume of the ^{39}Ar were released after the second step. The last step (10% of ^{39}Ar) yields a very high date of 18.45±0.42 Ma, representing instrumental Ar contamination. Therefore, the integrated age (t_g = 9.72±0.13 Ma) is herein interpreted not represent the "real-good" age. The computed plateau age is 8.82±0.09 Ma and is regarded as the geologically meaningful age. The second sample, VB-43, yields a nearly identical age spectrum. The spectrum is characterised by a well- defined plateau age with the approximate 91% of the total argon release. The last step yields a higher apparent -age of about 17.26±0.33 Ma . This, in turn, gives rise to the higher integrated age of about 11.63±0.06 Ma. However, the plateau age is calculated to be 11.03±0.03 Ma and represents the very reliable 'true' age of Middle Miocene.

4. KN-1

The whole-rock basalt sample from Kanchanaburi was heated in 7 steps from 500 to 1200°C (fusion). The age spectrum illustrated in Figure 5 is a perfectly concordant ^{39}Ar release spectrum. Without regarding the first and the last steps. The heating steps 2 to 6, comprising more than 83.43% of the total ^{39}Ar released, yield a well-defined plateau age of approximately 4.17±0.11 Ma. The integrated or total-gas age (t_g) is 4.53±0.12 Ma. In this regard, it is interpreted that the 4.17±0.11 Ma represents the "true" extrusion age of this basalt.

5. MM-1

The MM-1 basalt is collected from the Mae Moh district of the Lampang province (Figure 5). The age spectrum of this sample is illustrated in Figure 5. The first two steps yield the well-defined plateau age with the total ^{39}Ar release of approxi-mately 97.5 %. The calculated plateau age is about 0.59±0.05 Ma. The last step (1,150 °C, which com-prises the total gas release of 2.5%, yields the very high apparent age of 7.85±0.7 Ma. The resultant integrated age (t_g) is computed to be 0.76±0.06 Ma which is slightly higher than the plateau age. Therefore, the geological age is more likely to be 0.59±0.05 Ma (Pleistocene).

DISCUSSION

The current $^{40}Ar/^{39}Ar$ geochronological data together with the previous $^{40}Ar/^{39}Ar$ and K/Ar age information on Thai basalts, suggest that distinct episodes of volcanism which may have been related to and caused by modifying patterns of tectonic regimes. The Cenozoic volcanic activities in Thailand have been inferred to be episodic rather than continuos and have involved at least 6 events. The geologic time scale used herein is based upon that of Palmer (1983).

CHRONOLOGY OF VOLCANISM

(1) 22-24 Ma Episode (Late Oligocene)

The probable oldest Cenozoic basaltic rocks were in Lop Buri area. The 40Ar/39Ar age data of weakly alkali basalts from this area indicate that the rocks were emplaced during Late Oligocene to Early Miocene (24 Ma). The rhyolite from southern Chao Phraya plain was dated at Early Miocene (22.5 Ma, Hooper, 1969). These age data correspond to the displacement event of the Ailao Shan/Red River metamorphic belt along the sinistral Red-River Fault which occurred at appoximately 23 Ma (K-Ar age) (Tapponnier and others, 1990). Rapid extension of the Lopburi area, therefore, may have occurred in the Oligocene epoch and closed in the Early Miocene. Extension of Mergui basin may have closed also during Early Miocene (Polachan, 1988). However, no gem-bearing basalt of the Epoch were encountered.

(2) 18-20 Ma Episode (Early Miocene)

The Lop Buri area still acted as the locus of the volcanism. The second episode of volcanic activity (alkali-basaltic-andesitic-rhyolitic series), as dated by Intasopa (1993) using $^{40}Ar/^{39}Ar$ method, was Early Miocene (18-20Ma). Again no gem-bearing volcanism has been reported yet.

(3) 8-14 Ma Episode (Middle to Late Miocene)

The third episode of basaltic activity occurred during Miocene. Even though no basaltic rocks of Middle Miocene were encountered, the 13.6 Ma rhyolitic volcanic rock was determined by Intasopa (1993) using $^{40}Ar/^{39}Ar$ dating technique. The emplacement of basaltic volcanics occurred later about 5-11 Ma. Alkali basalts and rhyolite from Lop Buri area yield respectively the age of 11.3 Ma (K-Ar, Barr and Macdonald, 1982) and 9.1 Ma ($^{40}Ar/^{39}Ar$, Intasopa, 1993). It is interpreted that the rhyolite-associated basalts have not given rise to gem generation.

Table 1 Age determination of basalts in Thailand, modified after Jungyusuk and Khositanont (1992).

Localities	Age(Ma)			Paleomag.
	Fiss. Track	K/Ar	Ar/Ar (tp)	
Ban Chang Khian		1.69±1.25[A]		
Chiang Khong		1.05±0.81[A]		
Mae Tha		0.8±0.3[E]	0.59±0.05[F]	0.69-0.95[A]
		0.6±0.2[E]		
Denchai		5.64±0.28[A]		
Lam Narai		11.29±0.64[A]	18.1±0.7[D]	
			24.1±1.0[D]	
Wichianburi			9.08±0.29[D]	
			8.82±0.09[F]	
			11.03±0.03[F]	
Bo Ploi		3.14±0.17[A]	4.17±0.11[F]	
Khao Kradong	2.57±0.2[C]	0.92±0.3[A]		
Phu Fai		3.28±0.48[A]		
E. Chantaburi				
Khao Ploi Waen		0.44±0.11[A]		
Khao Wua			3.0±0.19[F]	
Nong Bon		1.31±0.17[A]	2.38±0.16[F]	
Ko Kut		8.5±1.0[B]		

References:

A Barr and Macdonald (1981)
B Bignell and Snelling (1977)
C Carbonel and others (1972)
D Intasopa (1993)
E Sasada and others (1987)
F This study

The locus of Neogene volcanism appears to :tend northwards along the Late Paleozoic suture one. Wichian Buri basalts in the Phetchabun area ere emplaced late at approximately 8-11 Ma (40Ar/ 9Ar method, this paper). These alkali basalts were roved to be temporally associated with gems. This asaltic volcanism can be regarded as the first pisode of gem bearing basalt in Thailand. In ddition, basalt from the Phitsanulok basin was ated at 10.3 Ma using K-Ar method (Knox and Vakefield, 1983). Such event may have taken into ccount the generation of Ko Kra Ridge which may xtend northward from the eastern Gulf of Thailand o this tectonic-related volcanic belt. The occurrence of Ko Kra ridge can be regarded as the indication of he rapid uplift of this volcanic belt. Similar age (i.e. 11 Ma) is interpreted by Charusiri and others (1991) o represent the reactivation of the NNE-trending Pran Buri - Hua Hin Fault. This major event, therefore, marks the regional and rapid tectonic uplift and the cessation of the main extensional phase. It is quite probable that once the culmination of extension was reached, the first episode of gem-bearing basalt commenced. Voluminous supply of terrigenous sediments in the Gulf of Thailand and the Phitsanulok Basin, which also indicate rapid up-lift, were also reported to have occurred during Middle to Late Miocene (Polachan, 1988).

(4) 4-5.3 Ma Episode (Early Pliocene)

This episode of basaltic volcanism took place during 5.3 to 4 Ma (Early Miocene). This event was evident from dated basalts at Chanthaburi-Trat and Kanchanaburi areas ($^{40}Ar/^{39}Ar$ method, this paper). This event is also gemrelated and characterised by the emplacement of basanitoid basalt.

(5) 1.6-3.6 Ma Episode (Late Pliocene)

The fifth episode of Cenozoic basalt is during 1.6 to 3.6 Ma. These basalts occurred at Chiang Rai and Trat. They are inferred to be also gem-related. The volcanic activity is characterised by the appearance of tholeiite and basanitoid. This episode represents the last episode of gem-bearing basalts. Sutthirat (1992) found, based upon geochemical constituents, that gem-bearing gabbroid hypabyssal rock at Phu Fai is probably contaminated by crustal materials.

(6) Less than 1.6 Ma Episode (Quaternary Episode)

The youngest episode of basalt volcanism in Thailand occurred in 1.6 Ma. The basalts are mainly basanitoid and hawaiite. They are found in Lampang (Mae Tha, this paper) and Buri Rum (e.g. Khao Phanom Rung, see Plathong, 1994) areas. However, several lines of evidences suggest that they are not regarded as gem-bearing basalts.

TECTONIC SETTING OF THAI CONTINENTAL BASALTS

It is imperative that the Cenozoic activity in Southern Asia be often cited as being a consequence of continental collision between the Indo-Australian Plate and the southern margin of the Eurasian continent (McCabe and others, 1988; Tapponnier and others, 1982 and 1988). The most likely time for initial contact between those two plates remains controversial at present. Even though several workers (e.g. Dewey and Burk, 1973; Sahni and Kumar, 1974; Molnar and Tapponnier, 1975; Tapponnier and others, 1982; Dewey and others, 1988 and 1989) propose the Eocene epoch for the initial collision, Klootwijk and others (1992) argued, based upon paleomagnetic data, that the initial contact was probably established during K-T boundary (65 Ma). As the collision of India with South Asia proceeded, the Southeast Asia continental plate was moved southeastward along the NW-trending, sinistral fault zones of the Red River in southern China and Vietnam, and the Mae Ping and the Three-Pagoda Faults in Central Thailand. The continental collision of these two plates resulted in crustal shortening and thickening, clockwise rotation of SE Asia, and NE- and NW-trending strike-slip movement with associated development of Cenozoic basins. (see McCabe and others, 1988; Polachan, 1988; Charusiri and others, 1991, The collision-involved thickening by imbrication of the upper crust and the lower crust-upper mantle is proposed by Hirn (1988).

It is quite likely that the ancient fault zones (such as Nan-Uttaradit, Mae Ping, Three Pagodas) which welded stable lithospheric blocks, may have continued to develop as a zone of a crustal weakness (Salun and other, 1974). The differential stresses within the amalgamated continental plate may have caused thinning and fracturing of the lithospheric plate. The thinning of the lithosphere is characterised by the presence of anomalously high heat flow (see Spohn and Schubert, 1982).

Long and arcuate volcanic belt in Central Thailand (Loei-Lop Buri-Trat) which was regarded to have occurred since Middle to Late Paleozoic (see Bunopas, 1981; Intasopa, 1993) can possibly act as a large zone of crustal weakness in Thailand. This zone is susceptible to be reactivated by major strike-slip

Table 2 ^{40}Ar/^{39}Ar analytical data for dated samples.

NW-1 J=2.98E-0.3

Age (Ma)	Error (Ma)	Vol^{39}Ar (cc10^{-6})	Temp (C)	Fract^{n} ^{39}Ar (%)	Cum ^{39}Ar (%)
700	2.850	0.320	0.03811	48.147	48.147
900	3.200	0.021	0.02873	36.297	84.444
1150	7.010	0.740	0.1231	15.556	100.000

Tg = 3.62±0.28 Ma Tp = 3.0±0.19 Ma

NB-1 J=3.20E-0.3

Age (Ma)	Error (Ma)	Vol^{39}Ar (cc10^{-6})	Temp (C)	Fract^{n} ^{39}Ar (%)	Cum ^{39}Ar (%)
700	2.300	0.210	0.04668	66.748	66.743
900	2.580	0.159	0.01783	25.498	92.246
1150	7.164	0.902	5.42E-0.3	7.7540	100.000

Tg = 2.75±0.21 Ma Tp = 2.38±0.16 Ma

VB-88 J=2.90E-0.3

Age (Ma)	Error (Ma)	Vol^{39}Ar (cc10^{-6})	Temp (C)	Fract^{n} ^{39}Ar (%)	Cum ^{39}Ar (%)
700	8.597	0.134	0.04719	64.224	64.224
900	9.375	0.017	0.01946	26.480	90.705
1150	18.455	0.416	6.83E-0.3	9.295	100.000

Tg = 9.72±0.13 Ma Tp = 8.82±0.09 Ma

VB-43 J=2.95E-0.3

Age (Ma)	Error (Ma)	Vol^{39}Ar (cc10^{-6})	Temp (C)	Fract^{n} ^{39}Ar (%)	Cum ^{39}Ar (%)
700	11.226	0.031	0.02519	47.303	47.303
900	10.818	0.036	0.02295	43.108	90.411
1150	17.255	0.335	511E-0.3	9.580	100.000

Tg = 11.63±0.06 Ma Tp = 11.03±0.03 Ma

movement and accompanying extensional and vertical tectonism as Indian-South Asia continental collision proceeds. It is inferred that while the Western Burma-Shan-Thai continental collision have occurred in the west during Eocene (Charusiri, 1989), the readjustment of the eastern margin of the Shan-Thai block may have developed, and hence the thinning of the crustal lithosphere may have triggered. Intasopa (1993) suggested based upon isotope data, that in response to the 56 Ma rhyolite in the Lop Buri area may have emplaced as a consequence of high-heat flows generated by emplacement of high-temperature basaltic magma into the crust and causing the crustal partial melting.

Thinning of the lithosphere plate may have induced asthenospheric diapirism (or uprising mantle) and partial melting (Wilson, 1989). According to Thienprasert and Raksaskulwong (1984) and Barr and others (1981), unusually high heat flows were also reported at several places in Thailand.

It is believed herein that these processes may have involved in subsequent development of the continental rift zone (or aulacogen) along the weakness zone.

Table 2 (cont.)

MM-1

Age (Ma)	Error (Ma)	Vol^{39}Ar (cc10^{-6})	Temp (C)	Fract^{n} ^{39}Ar (%)	Cum ^{39}Ar (%)
700	0.5838	0.028	0.10948	63.508	63.508
900	0.6052	0.089	0.05885	34.138	97.647
1150	7.8520	0.702	4.06E-0.3	2.353	100.000

Tg = 0.76±0.06 Ma   Tp = 0.59±0.05 Ma

KN-1 J = 3.5325

Age (Ma)	Error (Ma)	Vol^{39}Ar (cc10^{-6})	Temp (C)	Fract^{n} ^{39}Ar (%)	Cum ^{39}Ar (%)
500	5.443	0.058	0.07784	14.066	14.066
600	4.011	0.054	0.20424	36.908	50.974
700	4.000	0.040	0.13330	24.088	75.062
800	4.303	0.066	0.4315	7.797	82.859
900	4.312	0.161	0.03523	6.366	89.225
1050	4.498	0.417	0.04581	8.278	97.497
1200	13.518	0.749	0.01381	2.499	99.996

Tg = 4.5±0.12 Ma   Tp = 4.17±0.11 Ma

CONCLUSION

Previous geochronological information and this $^{40}Ar/^{39}Ar$ geochronological data of Late Cenozoic basalts in Thailand suggest that major Cenozoic basaltic eruptions in Thailand are divided into 6 periods, as 22-24 Ma, 18-20 Ma, 8-14 Ma, 4-5.3 Ma, 1.6-3.6 Ma, and younger than 1.6 Ma. The Cenozoic basalts of Thailand can be divided into 2 major groups based on occurrence of gems (mainly corundum), as corundum-bearing and corundum-barren basalts (Vichit, 1992). The current geochronological data of basalts in gem deposits in Thailand indicated that three episodes of basaltic volcanism in Thailand are recognised to be gem-related; i.e. 8-11 Ma, 4-5.3 Ma, and 1.6-3.6 Ma. The last episode is regarded to be the most typical. Geochemical and petrological date support that the gem-bearing basalts are frequently basanitoids. Field evidence suggests that they are unlikely to be associated spatially with silicic volcanic. Based upon the tectonic aspect, the continental basalts in Thailand and mainland SE Asia are generated as a result of continental rifting after the Tertiary continental collision of Indian and South Asia blocks.

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