Development Geology for Thailand into the Year 2000
Chulalongkorn University, Bangkok, Thailand, 13-14 December 1990

GEOLOGY AND ^{40} AR/^{39} AR GEOCHRONOLOGY OF PRANBURI-HUA HIN IGNEOUS-METAMORPHIC COMPLEX, SOUTH-CENTRAL THAILAND : IMPLICATION FOR TECTONIC EVOLUTION

P. CHARUSIRI*, W. PONGSAPICH*
V. DAORERK* and S. VEDCHAKANCHANA*

ABSTRACT

Ten samples of granitoid rocks from the Pranburi-Hua Hin igneous-metamorphic complex have been dated using ^{40}Ar/^{39}Ar total-fusion and step-heating methods. The geochronogical and geological investigations provide the significant tectonic history of the area. According to field evidences, the foliated granitoids and their metamorphic equivalents of amphibolite facies are considered to be of Precambrian or Early Paleozoic. The unfoliated granites were emplaced in the Early Eocene (50-55 Ma) and were inferred to have been contemporaneous with the spatially-related Sn-W deposits. The large-scale, N-trending, dextral, Pranburi-Hua Hin Fault may have taken place prior to Permian and was subsequently overprinted by the Early Oligocene (33-36 Ma) tectono-thermal event. The fault was later reactivated during the Early Miocene (17-20 Ma). Both Early-Oligocene and Early-Miocene displacement events may have been related to the opening of the Gulf of Thailand.

INTRODUCTION

The Hua Hin-Pranburi area, 180-200 km south of Bangkok, is located in Amphoe Cha Am, Changwat Phetchaburi and Amphoe Pranburi, Changwat Prachaub Khirikhan. Physiographically, it is largely a flat terrane, interrupted by low ranges of hills with a N-NNW trend.

Three seasons of detailed geological field-work in the study-area were conducted : from March to April, 1976; from March to April, 1977; and from October to December, 1986. Detailed petrographic descriptions, especially those chosen for age determination, were performed at both mesoscopic and microscopic scales. ^{40}Ar/^{39}Ar datings of mineral samples were carried out at Queen's University

* *Department of Geology, Faculty of Science, Chulalongkorn University, Bangkok 10330, Thailand.*

geochronological laboratory in Kingston, Ontario, Canada, using the method described by Charusiri et al. (1990). X-ray powder diffraction analyses were employed where problematic minerals were encountered.

The purpose of this paper is to describe the geology of the investigated area, and to elucidate the tectonic history of the area using the $^{40}Ar/^{39}Ar$ geochronological results.

DISTRICT GEOLOGY

The geology of the area (Fig. 1) has received attention from several geologists (inter alios: Brown et al., 1951; Dheradilok, 1973; Putthapiban and Suensilpong, 1976; Pongsapich et al., 1983). Particular emphasis has been placed on the occurrence of granitoid and metamorphic rocks.

The oldest lithological unit defined in the area is the low-pressure amphibolite-facies, Pranburi-Hua Hin metamorphic complex (Pongsapich et al., 1983; Dheeradilok, 1985). According to Pongsapich et al. (op. cit.), the metamorphic complex can be subdivided into four sequences: metapelite (including the Hua Hin "gneissic" rocks and mica-sillimanite schist) - the oldest; calc-silicate- and qurtz-feldspathitic marble; quartzite (comprising pure, graphite-bearing, mica-rich, and calc-silicate-rich members); and marble (including pure marble, dolomitic and quartz-rich marble with recrystallized chert nodules)-the youngest. However, uncertainty persists with respect to the age of the metamorphic series. For instance, Brown et al. (1951) classified the "gneissic" granitoid rocks at Amphoe Hua Hin and in areas to the north as "pre-Permian" gneiss. Dheeradilok (1973) assigned the granitoid rocks of the Amphoe Hua Hin and Amphoe Pranburi districts to the Precambrian on the basis of the existence of paragneiss sequences which were considered equivalent to the inferred Precambrian rocks of Tak and Chiang Mai (Campbell, 1973; Dheeradilok, 1985). The Pranburi-Hua Hin metamorphic complex is presumed to be overlain unconformably by Middle to Upper Paleozoic meta-sedimentary rocks. Tertiary felsic dykes are common in the north and cross-cut the granitoid intrusions.

IGNEOUS-METAMORPHIC COMPLEXES

The granitoid rocks exposed in the area can be subdivided into foliated and non-foliated members (Fig. 1), the later occurring less widely and intruding the former. The non-foliated intrusions are small, discrete stocks consisting mainly of medium-grained, biotite-muscovite granite and fine-grained, muscovite ($\pm$ biotite) - tourmaline granite. The foliated granites are further subdivided, on the basis of textural and mineralogical criteria, into the Hub Kapong and Hua Hin gneisses(Pongsapich et al., 1983). The Hub Kapong gneiss occupies the western and southern parts of Amphoe Hub Kapong (see Fig. 1), and consists mainly of a porphyroblastic, biotite $\pm$ muscovite facies grading to a equigranular, biotite-muscovite facies. Its regional foliation is oriented N-to-NE.

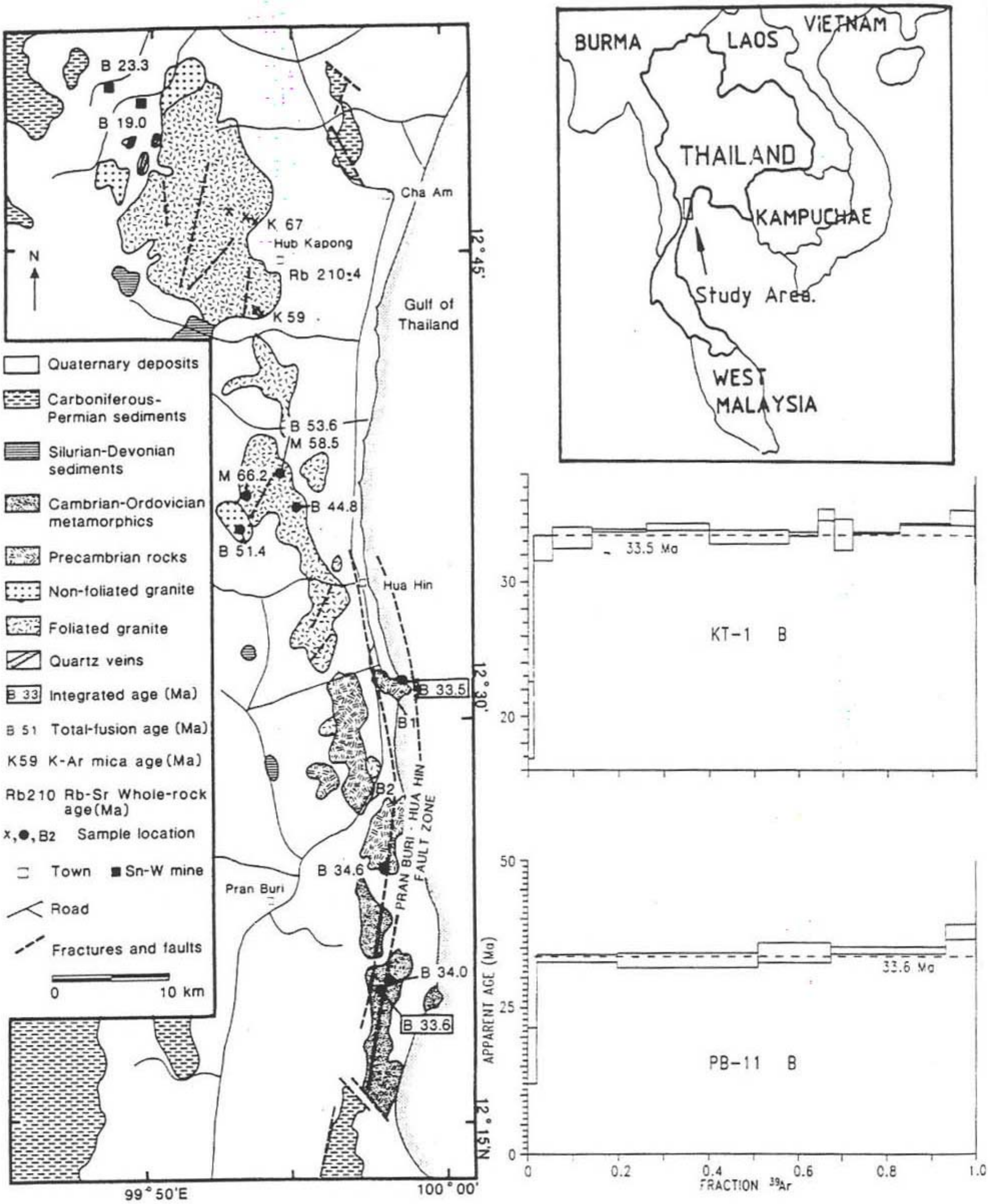

Fig. 1. Geological sketch-map of Hua Hin-Pranburi area, modified after Dheeradilok et al. (1976), Putthapiban and Suensilpong (1978), Pongsapich (1980), and Chonglakmani et al. (1983), and showing locations of $^{40}Ar/^{39}Ar$-dated samples and step-heated age spectra (Charusiri, 1989). X = dated sample locations of Nakhapadungrat et al. (1984); B1, etc. = dated sample locations of Bignell (1972).

The Hua Hin gneiss comprises of the granitoids lying west of Amphoe Hua Hin, and the gneissic rocks of the inferred Precambrian sequence covering a southern part of Amphoe Hua Hin. The regional trend of its foliation is N-to-NNE. Biotite-garnet-sillimanite (± muscovite) and biotite (± muscovite) paragenesis are predominant. Charusiri (1989) assigned the gneissic granitoids on the basis of modal analysis to monzogranites which corresponded to those reported by Putthapiban and Suensilpong (1978).

Pongsapich et al. (1983) also grouped the gneissic rocks of inferred Precambrian and Early Paleozoic age occurring at the NE of Amphoe Pranburi and E of Amphoe Pranburi respectively, as the Pranburi gneiss. The rocks are mostly exposed along the fault zone but their boundaries are not shown in Fig. 1. Field and petrographic investigations indicate that the Pranburi gneiss is in fact a cataclasite (Vedchakarnchana et al., 1976), ranging from protomylonite (Fig. 2 A,B, and E), through mylonite (Fig. 2C), to ultramylonite.

The Pranburi gneiss shows pronounced foliation which is defined by preferred orientation of crushed biotite and deformed quartz and feldspar porphyroblasts. Quartz exhibits both brittle and, more widely, ductile (Fig. 2A) deformation, the latter being due to lateral displacement, and gliding, leading to the formation of quartz lamellar and undulatory extinction of quartz porphyroblasts (see Turner and Weiss, 1963; Bard, 1986). Feldspar exhibits more complex deformation, but usually deforms in a ductile manner, and is characterized by undulatory extinction and undulated twin planes (Fig. 2C). Biotite is both fine- and coarse- grained; the former is invariably parallel to the foliation (Fig 2B), whereas the latter commonly cross-cuts it. Pongsapich et al. (1980) recorded that the Pranburi gneissic and associated schistose rocks show an earlier regional NE-SW foliation which is overprinted by a strong N-S foliation imposed by the Pranburi-Hua Hin fault-zone (see Fig. 1).

The geochemical data of Pongsapich et al. (1980) and Putthapiban and Suensilpong (1978) reveal significantly compositional differences between the Pranburi, Hua Hin and Hub Kapong gneissic rocks. The Hub Kapong and Hua Hin rocks have relatively high potassium contents (e.g., 5.7 wt. % K_2O vs. 3.60% Na_2O). The authors' calculation show that the Hua Hin gneissic rocks display the highest A/CNK values, ranging from 0.93 to 1.68 (av. 1.20), whilst those of the Hub Kapong rocks fall between 1.11 and 1.27 and the Pranburi rocks range from 0.69 to 1.1. Normative corundum is nil for most of the Pranburi facies, but high (up to 6 wt.%) in the other gneissic rocks. From the lithological and geochemical data it can be concluded that the Hua Hin and Hub Kapong gneissic rocks are similar in lithology and geochemistry and represent S-type granitoid suites, the latter being the more differentiated. On the other hand, the Pranburi rocks are of I-type affinity. Similar conclusions were reached by Hutchison (1983).

Most of the xenoliths in the granitoids are of quartzite and calc-silicate rocks. No Upper Paleozoic rock fragments have yet been observed, implying that the granitoids are probably at least as old as Late Paleozoic.

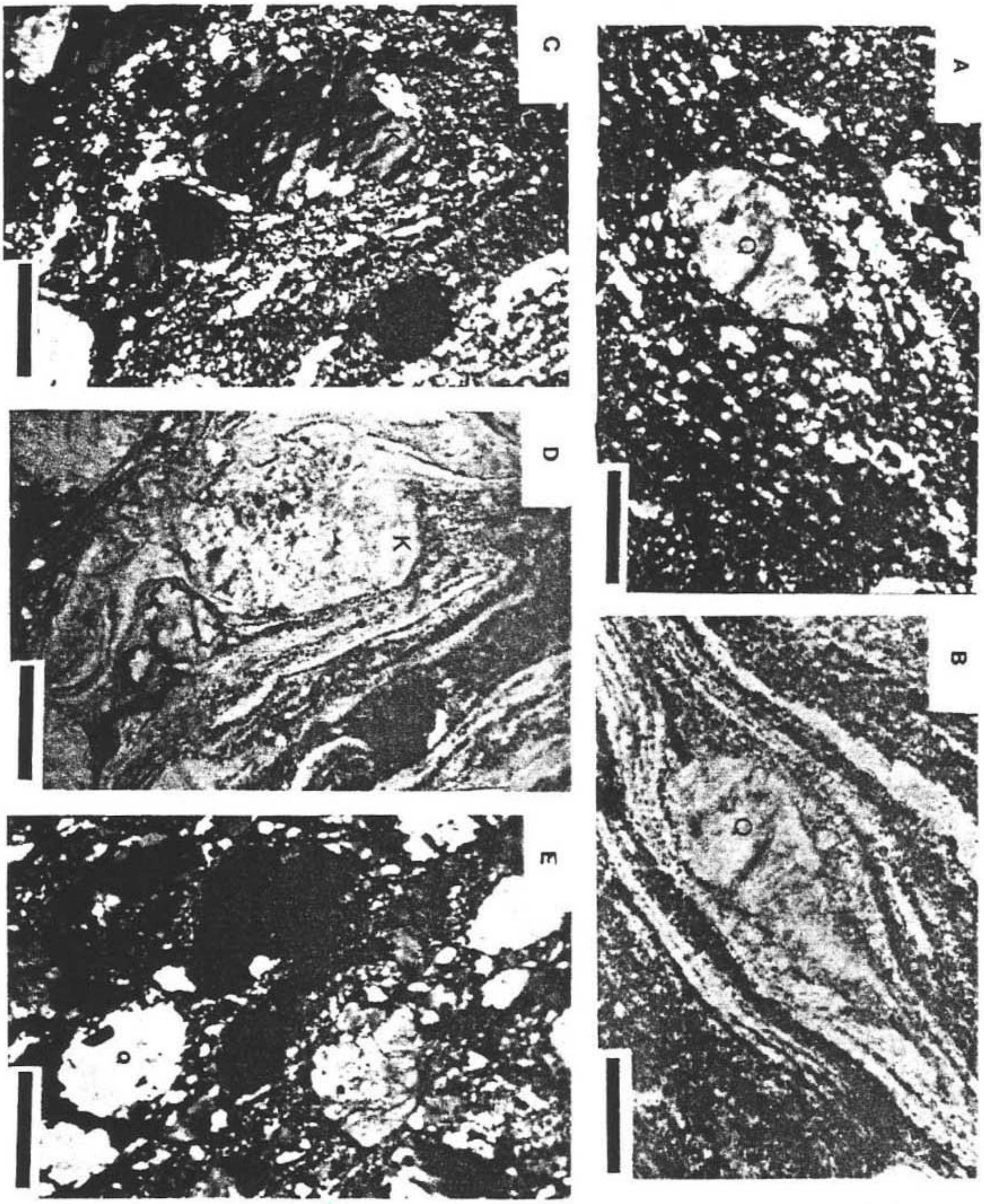

Fig. 2. Photomicrographs of Mylonitic Granitoid Rocks from Hua Hin-Pranburi Area.

A and B. Cataclastic texture showing crushed and stretched quartz porphyroblast (Q) and quartz-filled pressure shadow in protomylonite (sample no.PB - 12:12 km SE of Ammphoe Pranburi. (Scale-bar = 0.5 mm; Fig. A in crossed nicols and Fig. A in crossed nicols and Fig. B in plane-polarized light).

C and D. Microcline (K) and allanite (T) porphyroblasts in mylonite (sample no. PB-48: 11 km ESE of Amphoe Pranburi. (Scale-bar = 0.5 mm. Fig. C in crossed nicols and Fig. D in plane-polarized light).

E. Quartz (Q), plagioclase (P) and microcline (K) porphyroblasts in a matrix rich in biotite and quartz, in protomylonite (sample no. KT-2:3 km N of Amphoe Hua Hin, Changwat Prachaub Khirikhan). (Transmitted light, crossed nicols; scale-bar = 1.5 mm).

PRANBURI-HUA HIN FAULT-ZONE

The major N-trending fault system, referred to herein as the Pranburi-Hua Hin fault-zone, lies very close to the coast (Fig. 1), and extends for at least 50 km and with a width of about 2 km. It was once interpreted as the axis of a metamorphic complex (Dheeradilok et al., 1976). However, it is now widely accepted as representing a large cataclastic zone developed in Precambrian and Lower Paleozoic rocks (Vedchakanchana et al., 1978; Pongsapich et al., 1983; Charusiri, 1989). It should be emphazied herein that faulting does not penetrate into the Ratburi Limestone strata, implying that the fault predated Ratburi Permian rocks.

The sense of movement on the Pranburi-Hua Hia fault-zone is uncertain. However, a mylonite sample (PB-49) located within the major fault, provides some indication of the fault movement. As shown in Fig. 3, quartz phenoblasts have been rotated, giving rise to pressure shadows (see Bard, 1986). Similar, but less prominent, textures may be observed in another mylonite sample,(PB-11). Additional indicator of the sense of movement is the presence of asymmetrical microfolds (Fig. 7). The alignments of micas and deformed quartz-feldspar fragments are usually in the direction of fault movement. Taking the above features into account, it is inferred that the sense of fault movement is right-lateral (or dextral). Because the slabbed surface illustrated in Fig. 3 was originally horizontal, the Pranburi-Hua Hin fault-zone presumably had a transcrurrent component of displacement.

GEOCHRONOLOGY

Previous Geochronological Studies.

Only the Hub Kapong and Pranburi granitoid rocks have been previously dated, by Nakhapadungrat et al. (1984) and Bignell (1972), respectively. Bignell (op. cit.) reported two contrasting ages for Pranburi gneissic granitoids (cataclasites) using Rb-Sr and K-Ar methods. I-type, gneissic granitoids of locality B2 and B1 (Fig. 1) yielded similar recalculated K-Ar biotite ages of 33.4 and 36.9 Ma, respectively. The Rb-Sr whole-rock dates for the same specimens are markedly higher: 397 Ma (at B1) and 566 Ma (at B2), applying an initial Sr isotopic ratio of 0.709. These differing Rb-Sr ages probably indicate an open system of samples since the emplacement of the granitoids. The authors suggest that the discordance in Rb-Sr ages is a result of incomplete isotopic homogenization due to faulting. The old and disturbed apparent ages of granitoids, together with correlations of the metamorphic terrane with those of other regions, have led several authors (inter alios, Dheeradilok et al., 1976; Pongsapich et al., 1983; Dheeradilok, 1985; Charusiri, 1989) to conclude that the gneissic granitoid rocks are of Precambrian age.

The Hub Kapong gneissic granitoid rocks have been dated by Beckinsale et al. (1979) using both K-Ar and Rb-Sr method. The rocks yielded a Rb-Sr whole-rock isochron age of ca. 210 Ma with an initial strontium isotopic ratio of 0.7237. K-Ar dates for the same granitoid rocks are much younger: ranging from 58 to 67.5 Ma. This lead Putthapiban and Suensilpong (1978) to assume that the age of gneissic granitoids exposed in the Hub Kapong and nearby areas to be Early Triassic on the basis of Rb-Sr whole-rock isochron dating. Pongsapich et al. (1980), however, argued that the correlation of the metamorphic and structural history with the Rb-Sr isochron age is less clear than has been proposed.

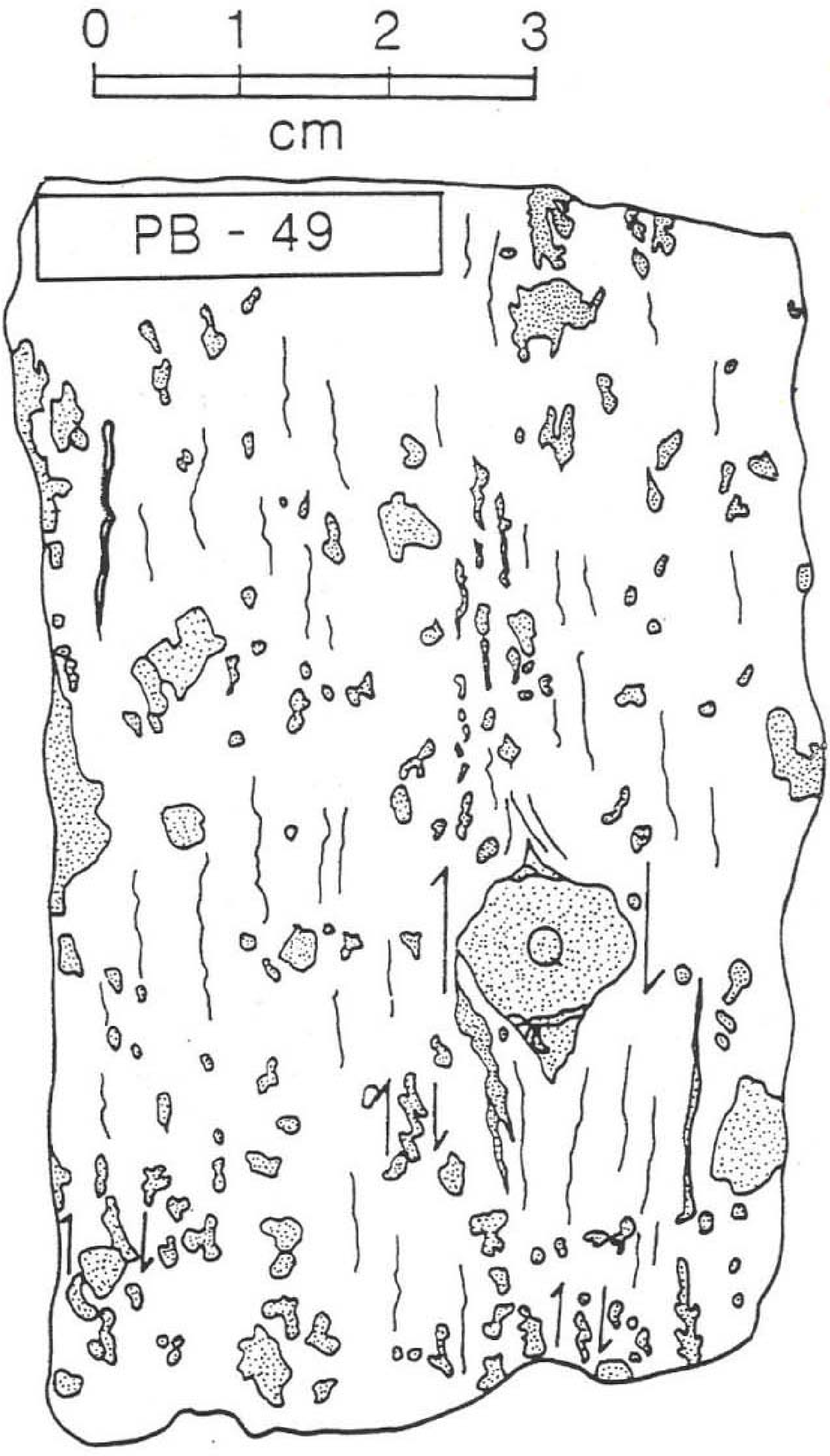

Fig. 3. Sketch of slabbed mylonite sample PB-49 (see Fig. 6.6.2 C) showing grain rotation, asymmetrical folding and dextral movement. The cut surface represents a horizontal outcrop on the foreshore; the foliation is oriented ca. NNE-SSW.

New $^{40}Ar/^{39}Ar$ Age Date

Ten samples of granitoid rocks from the Pranburi-Hua Hin area (see Fig. 1 for locations) have been dated using $^{40}Ar/^{39}Ar$ total-fusion and step-heating methods by Charusiri (1989) and Charusiri et al. (1989, 1990). The analytical data are not presented herein due to limited spaces.

Two white-mica concentrates, consisting of intergrown hydrothermal paragonite and muscovite (Charusiri, 1989), from non-foliated, biotite-muscovite granites (sample no. HUB-1 and -2), collected from tin mines in the northern part of the study area yielded remarkably young total-fusion ages of 19.0 and 23.3 Ma. Coexisting biotite and muscovite from a Hua Hin-type gneissic rock (HUB-3) gave total-fusion ages of 53.6 and 58.5 Ma, respectively. Another sample of the Hua Hin gneiss (HH-1) yielded a biotite total-fusion age of 44.8 Ma. A biotite concentrate separated from a non-foliated, biotite-muscovite granite (HH-2), intruding Hua Hin gneissic rocks, gave a total-fusion age of 51.4 Ma. A muscovite concentrate from a muscovite-tourmaline pegmatite (HUB-4), also cutting Hua Hin gneissic rocks, gave a slightly older total-fusion age of 66.2 Ma.

A biotite from a coarse-grained, protomylonite sample (KT-1) of the Hua Hin "gneiss", within the Pranburi-Hua Hin fault-zone, was dated using the step-heating technique. It yielded an internally-concordant age spectrum with an integrated age of ca. 33.5 Ma. It is of interest that the first step of the Ar release pattern marks apparent age of about 19.7 Ma (Fig. 1).

Four samples of the more intensely cataclased Pranburi gneissic rocks yielded similar biotite $^{40}Ar/^{39}Ar$ ages. Two concentrates from a protomylonite sample, PB-12 (not illustrated herein), and a mylonite sample (no. PB-49: Fig 2C), yielded total-fusion ages of 34.0 and 34.6 Ma, respectively. A biotite concentrate from another protomylonite (no. Pb-11: Fig. 2D) gave an undisturbed age spectrum with an integrated age of ca. 33.6 The age spectrum displays (Fig. 1) a clear plateau with an integrated age of 33 to 34 Ma. Again, the first argon-release step yielded an apparent age of ca. 17 Ma. The minima in the first steps of both age spectra determined for rocks from this area (Fig. 1) are interpreted as indicating argon loss through volume diffusion (Turner, 1968), and record a thermal event at ca. 17-19 Ma.

TECTONIC IMPLICATION : A DISCUSSION

The new $^{40}Ar/^{39}Ar$ dates, together with the previous geochronological data and the geological and geochemical relationships, permit the tectonic and geological history of the Pranburi-Hua Hin area to be interpreted as follows.

Several lines of evidence (see for instance, Pongsapich et al. 1980 and Charusiri, 1989) lead the authors to infer that the I-type, Pranburi-type, cataclastic, gneissic granitoids may have developed their foliation during the early period of metamorphism. The S-type, Hua Hin, gneissic rocks, which are cogenetic with the high-grade schists, probably represent the central zone of the metamorphic complex (Pongsapich et al., 1980) any may have formed at the culmination of metamorphism. The more highly differentated, S-type, Hub Kapong gneissoid granites may have been emplaced contemporaneously with, or later than, the metamorphic culmination. Although the true ages of these gneissic rocks are still uncertain, the authors interpret Pongsapich et al. (1980)'s field and petrological data as indicating that all the granitoid rocks were subject to regional metamorphism during the

Precambrian or, at least, Early Paleozoic. The lack of characteristic Upper Paleozoic xenoliths in the granitoid rocks, and of regional metamorphism of the Permian Ratburi limestone in the south, indicates clearly that all the foliated granitoids are older than Permian. It is possible that the Rb-Sr whole-rock isochron date of Beckinsale et al. (1970) may not represent the age of the granitoid emplacement (see also Pongsapich et al., op. cit.). The first, major period of Pranburi-Hua Hin faulting may have been taken place prior to Permian.

All radiometric data for cataclastic rocks from within the Pranburi-Hua Hin fault-zone, i.e., Bignell's (1972) K-Ar analyses and the $^{40}Ar/^{39}Ar$ dates, show very consistent ages, varying only from 33.5 to 36 Ma. It is considered reasonable, therefore, to infer that the major reactivation of faulting took place in the Early Oligocene, possibly coincident with, or immediately preceding, the initial opening of the Gulf of Thailand, assigned by Bunopas and Vella (1983) to the Oligocene. However, field evidence indicates that the mylonitic foliation of these rocks overprinted the earlier gneissic fabrics.

In addition, the $^{40}Ar/^{39}Ar$ age data for micas from the Hua Hin granitoid rocks reveal ages increasing away from the Pranburi-Hua Hin fault-zone, i.e., ranging from 44.8 Ma about 5 km west of the fault, to 66.2 Ma 10 km further west. A similar situation obtains for the Kub Kapong gneissic rocks (see Nakhapadungrat et al., 1984).

The new geochronological data suggest that the non-foliated, biotite-muscovite granite bodies may have been emplaced in the Eocene, at ca. 51 Ma. However, the ages of similar rocks from the area of the tin-tungsten deposits in the northern and central parts, are much younger, ca. 21 Ma. Although the sparsity of the data must be emphasized, the authors do not consider the mineralization to be of Early Miocene age. The age deduced from the non-foliated granitoid rocks in the central part of the study-area can be regarded as a plausible indication of the timing of granitoid-related mineralization. The development of clay minerals and of paragonite and muscovite after biotite (Charusiri, 1989) might have been caused by renewed hydrothermal alteration postdating Sn-W mineralization. The argillic alteration may also have been associated with the large, barren quartz veins (Fig. 1) which occur along a N-trending, major fracture zone in the area, and may have been coeval with the emplacement of the local Tertiary felsic dykes. This inferred Miocene event, which may be regarded as the youngest to affect the area, may also be recorded by the apparent age minima, at ca. 17-19 Ma, in the two step-heated samples from the Pranburi-Hua Hin fault-zone. The postulated tectono-thermal overprint is tentatively correlated with a stage in the opening of the Gulf of Thailand.

SUMMARY

From the above discussion, it is concluded that the Pranburi, Hua Hin and Hub Kapong foliated granitoid rocks are possibly Precambrian (or Early Paleozoic) in age. The Pranburi-Hua Hin Fault may, firstly, have activated before Permian. Emplacement of the unfoliated granites, which are inferred to have been contemporaneous with the areally-associated tin-tugsten mineralization, occurred in the Early Eocene, at ca. 50-55 Ma. The major transcurrent Pranburi-Hua Hin fault-zone was reactivated during the Early Oligecene, at ca. 33-36 Ma. This and a subsequent tectonothermal event in the Early Miocene, at ca. 17-20 Ma, may have been directly related to the opening of the Gulf of Thailand extensional basin.

ACKNOWLEDGEMENTS

The authors would like to thank Department of Geology, Faculty of Science, Chulalongkorn University for the expenses regarding the preparation of manuscript and the logistical expenses of P.C. during his field-work in the area. P.C. would like to express his sincere gratitutde to Drs. A.H. Clark and E. Farrar for their suggestion. Mr. Veera Uppapong is thanked for preparation of thin section. This paper was typed by Ms. Wanida Muangnoicharoen and some figures were redrawn by Mr. Torkiet Sornphrom, to whom the authors are greatly indebted.

REFERENCES

Beckinsale, R.D., Suensilpong, S., Nakhapadungrat, S., and Walsh, J.N., 1979. Geochronology and geochemistry of granite magmatism in Thailand in relation to plate tectonic model : Journal of the Geological Society of London, V. 136, p. 529-540.

Bignell, J.D., 1972. The Geochronology of the Malayan Granites : Unpublished Ph. D. Thesis, University of Oxford, 154 p.

Brown, G.F., Buravas, S., Javanaphet, J., Jalichandra, N., Johnstone, W.D., Sethaput, V., and Taylor, G.C., 1951. Geologic Reconnaissance of the Mineral Deposits of Thailand : U.S. Geological Survey Bulletin 984, 183 p.

Bunopas, S. and Vella, P., 1983. Tectonic and geologic evolution of Thailand : Proceedings of the Workshop on Stratigraphic Correlation of Thailand and Malaysia, Haad Yai, Thailand, September, 1983, p. 307-322.

Campbell, K.V., 1973. Basement compleses of Thailand : Proceedings of the Conference on the Geology of Thailand, Chiang Mai University, Thailand, Special Publication, no. 1 p. 3-13.

Charusiri, P., 1989. Lithophile Metallogenic Epochs of Thailand : A Geological and Geochronological Investigation : Unpublished Ph.D. Thesis, Queen's University, Kingston, Canada, 819 p.

Charusiri, P., Clark, A.H., and Farrar, E., 1989. Miocene(-Oligocene) Events in Thailand : Evidences from 40 Ar/ 39 Ar and K-Ar Geochronology : Annual Technical Meeting 1989 "Geology and Mineral Resources of Thailand, Indochina and Burma, Chiangmai, Thailand", February 1990, 14 p (in press).

Charusiri, P., Clark, A.H., and Farrar, E., 1990. ^{40}Ar/ ^{39}Ar Geochronology of Some Thai Basalts, Journal of S.E. Asian Earth Sciences (in prep.).

Dheeradilok, P., 1973. The inferred Precambrian rocks and tectonic features of Thailand : Mineral Resosources Gazatte, v. 8, p. 1-18 (in Thai).

Dheeradilok, P., Sukwatananon, P., Boripotkoson, S., Tunsuwan, V. and Lamjuan, A., 1976. Geologic Map of Amphoe Hua Hin, Scale 1 : 250,000, with explanation : Geological Survey Division, Royal Thai Department of Mineral Resources, Bangkok, 2 p.

Charusiri, P., Clark, A.H., and Farrar, E., 1990. ^{40}Ar/^{39}Ar geochronology of Some Thai Basalts, Journal of S.E. Asian Earth Sciences (in prep.).

Dheeradilok, P., 1973. The inferred Precambrian rocks and tectonic features of Thailand : Mineral Resosurces Gazette, v.8, pz. 1-18 (in Thai).

Dheeradilok, P., Sukwatananon, P., Boripotkoson, S., Tunsuwan, V. and Lamjuan, A., 1976. Geologic Map of Amphoe Hua Hin, Scale 1 : 250,000, with explanation : Geological Survey Division, Royal Thai Department of Mineral Resources, Bangkok, 2 p.

Nakhapadungrat, S., Beckinsale, R.D., and Suensilpong, S., 1984. Geochronology and geology of Thai granites : Proceedings of the Conference on Application of Geology and the National Development, Chulalongkorn University, Bangkok, November, 1984. p. 75-93.

Pongsapich, W., Vedchakanchana, S., and Pongprayoon, P., 1980, Petrology of the Pranburi-Hua Hin Metamorphic Complex and Geochemistry of Gneisses in it : Bulletin of the Geological Society of Malaysia, no. 12, p. 55-74.

Pongsapich, W., Pisutha-Arnond, V., and Charusiri, P., 1983. Reviews of felsic plutonic rocks in Thailand : Proceedings of the Workshop on Stratigraphic Correlation of Thailand and Malaysia, Haadyai, Thailand, September, 1983, p. 213-232.

Putthapiban, P. and Suensilpong, S., 1978, The igneous geology of the granitic rocks of the Hub Kapong-Hua Hin area : Journal of the Geologica Society of Thailand, v. 3, p. M1-M22.

Turner, F.J. and Weiss, L.E., 1963. Structural Analysis of Metamorphic Tectonic : McGraw-Hill, New York, 223 p.

Turner, G., 1968. The distribution of potassium and argon in chondrites : in Ahrens, L.H. (ed.), Origin and Distribution of Elements, Pergamon, Oxford, p. 387-398.

Vedchakarnchana, S., Phongprayoon, P., and Pongsapich, W., 1978. Chataclastic rocks and fault zonne in Pranburi area : Report on Scientific Research, Faculty of Science, Chulalongkorn University, v.3, p. 121-131.

♠♠♠