National Conference on "Geologic Resources of Thailand: Potential for Future Development"
17-24 November, 1992, Department of Mineral Resources, Bangkok, Thailand.

AIRBORNE RADIOMETRIC DATA INTERPRETATION AS AN AID TO GRANITIC TERRAIN MAPPING: A CASE STUDY FOR HUA HIN - PRAN BURI AREA, SOUTH CENTRAL THAILAND

Jarin Tulyatid.

Mineral Resources Development Project, Department of Mineral Resources, Rama VI Rd., Bangkok 10400, Thailand.

ABSTRACT:

The Hua Hin - Pran Buri area is located in the south-central Thailand. The study-area is covered by foliated gneissic granite and non-foliated granite. The latter is believed to be associated with tin-tungsten mineralization of the area. Airborne radiometric data of the study-area were processed and studied. The results clearly show that different phases of granitoid rocks can be distinguished according to the radiometric data. Specific airborne radiometric data criteria over the mineralized-related non-foliated granite can also be set up. The study, therefore, presents a possible way to differentiate not only among granitic rocks of different phases but also between mineralized- and non-mineralized ones.

INTRODUCTION

A regional airborne radiometric survey has been recognized as a very effective way at subdividing felsic igneous and metamorphic rocks in poorly mapped shield areas (Chatterjee and Muec-ke, 1982; Corey, 1987; Ford and O'Reilly,1985; Galbraith and Saunders, 1983; and Slaney, 1985). It highlights those rock types characterized by unusual amounts or proportions of radio elements such as peralkaline, carbonatite, and ultrabasic complexes. The method is also successful in distinguishing Sn-W mineralized granitoids (Webster, 1984; Yeates et al., 1982). The method is then applied to the granitic terrane in the Hua Hin - Pran Buri area in order to distinguish different types and phases of granites.

Geographical and geological setting

The Hua Hin - Pran Buri Area is located in south-central Thailand (Figure 1), approximately 170 to 230 km SSW of Bangkok, between latitudes 12° 15' N and 12° 51' N and longitudes 99° 45' E and 100° 01' E. It extends along Thanon Phetch Khasem (HWY. no. 4) in the area of Amphoe Tha Yang and Amphoe Cha-am, Changwat Phetchaburi; and Amphoe Hua Hin and Amphoe Pran Buri, Changwat Prachuab Khiri Khan. Topography is mainly flat, but approxi-mately 30 - 35% of the area comprises ranges of low, NNW-trending, hills under-lain by gneissic granitoid and metamorphic rocks.

The Present Study

This study is part of the current activities of the Airborne Geophysical Data Interpretation Section (AGDIS), Mineral Resources Development Project(MRDP), Royal Thai Department of Mineral Resources (DMR). The study is carried out in order to document airborne radiometric data in response to different granitic plutons of Thailand. The study will also be useful, as a case study, in distinguishing between mineralized- and non-mineralized-granites.

Field work was previously carried out by the writer between mid-April and the end of May, 1989, as part of his study on tectonothermal history of the area(Tulyatid, 1991).

In the present work, the radiometric maps and data of the study-area are re-compiled using a GEOSOFT software to produce maps (1:250,000 scale) of the area representing radiometric content, which are: total count (TC); potassium (K); uranium (eU); thorium (eTh) eU/K, eU/eTh, and eTh/K ratios; shaded TC; and ternary map. Aeromagnetic data were also considered for subsurface information.

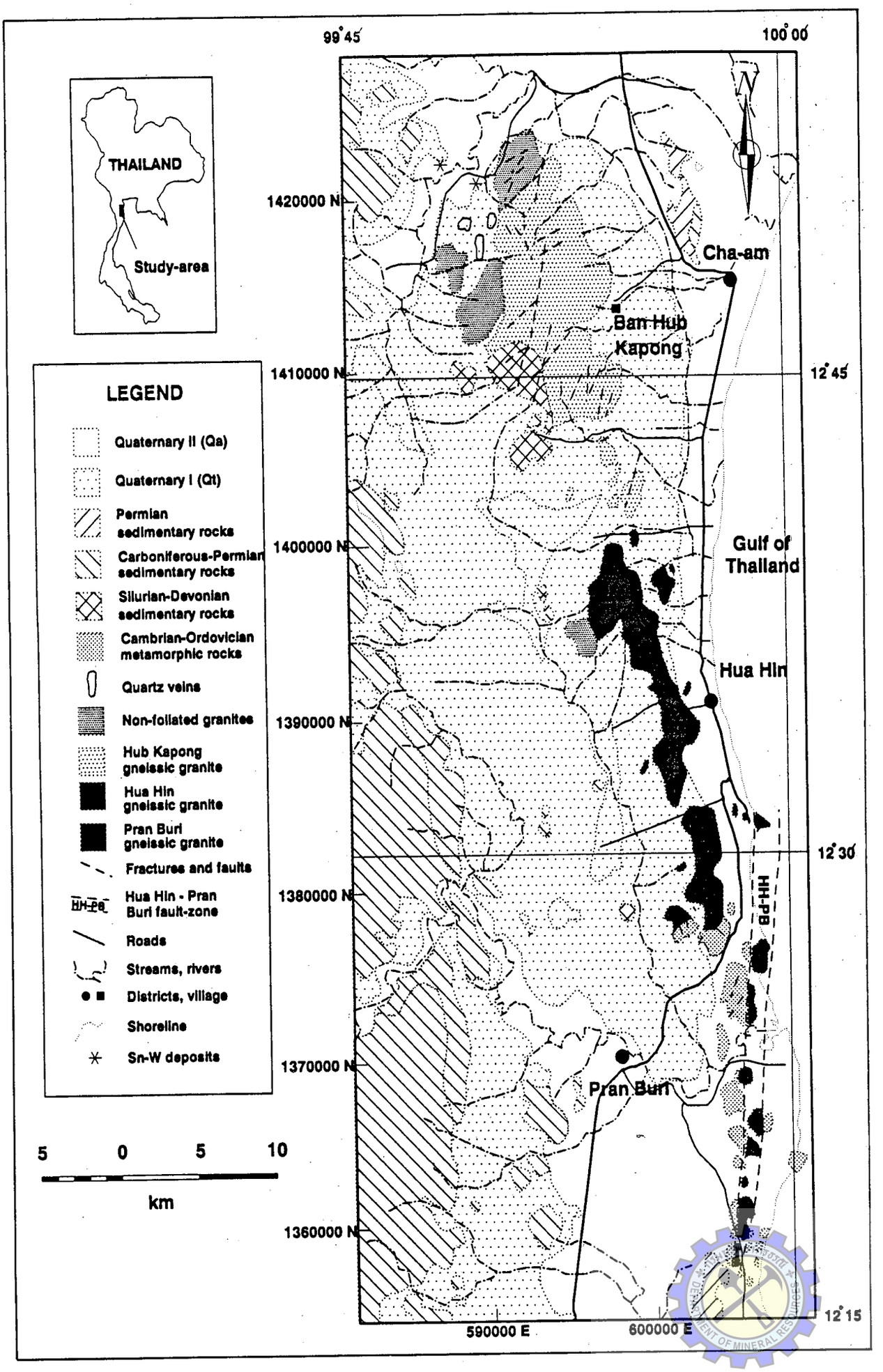

Figure 1 Geological sketch-map of the Hua Hin- Pran Buri area.

GEOLOGY OF THE STUDY-AREA

Geology of the study-area (Figure 1) and its surroundings has been the subject of several studies (Brown et al,1951; Campbell, 1973; Dheeradilok, 1973; Dheeradilok et al, 1976; Workman, 1975) .However, intensive study did not begin until the late 1970's, when senior students of the Department of Geology, Chulalongkorn University, mapped the area indetail (Chanasitt, 1977; Charusiri, 1977; Gunnaleka, 1977; Harnpittanapanich, 1977;Permtong, 1977; Pornrattanapitak, 1977; Sasipoka, 1977; Tem-Udom, 1977; Tipthon-sub, 1977). Putthapiban and Suensilpong(1978) and Pongsapich et al., (1980) documented the geology and geochemistry of the granitic rocks of the Hub Kapong area. Charusiri (1989), as part of a study of the timing of intrusion and lithophile-metal mineralization in Thailand, investigated the $^{40}Ar/^{39}Ar$ geochronology of deformed granites in Hua Hin - Pran Buriarea and related the ages obtained to the tectonism in the region. Most recently, Tulyatid (1991) studied the tectonothermal history using the $^{40}Ar/^{39}Ar$ geochronological method.

The study-area, referred to as the Pran Buri - Hua Hin metamorphic complex(Pongsapich et al., 1980), consists of a group of regionally metamorphosed and granitoid rocks. The complex is overlain by slightly metamorphosed sedimentary rocks of Silurian to Permian age. Widely different ages have been assigned to the complex, e.g., Middle Triassic (Putthapi-ban and Suensilpong, 1978) and Precambrian or Early Paleozoic(Charusiri, 1989).

The granitoid rocks can be divided into two groups, foliated and unfoliated. Three groups of foliated granite have been studied: the Hub Kapong, Hua Hin and PranBuri Gneissic Granites (Figure 1). In most outcrops, these rocks are coarse-grained, porphyro elastic, biotite gneissic granite and medium-grained, equigranular to coarse-grained biotite gneissic granite. The Pran Buri Gneissic Granite is a cataclasite within the Hua Hin - Pran Buri fault-zone, with a steeply dipping foliation. It is more deformed than the Hua Hin and Hub Kapong Gneissic Granites. The K-feldspar megacrysts in Hub Kapong and Hua Hin Gneissic Granites and the garnets in the Hua Hin Gneissic Granite are of porphyroclastic origin (Tulyatid,1991). On the basis of geochemical data (Putthapiban and Suensilpong, 1978; Pong-sapich et al., 1980), it is suggested that the Hua Hin and Hub Kapong Gneissic Granites are S-type, whereas the Pran Buri Gneissic Granite is of I-type affinity. The non-foliated granite is exposed mainly in the western part of the granite plutons. It usually forms small, discrete stocks. Putthapiban and Suensilpong (1978) recognized three groups: medium-grained biotite-muscovite granite; muscovite granite; and tourmaline granite.

The meta-sedimentary rocks of the region have been subjected to high-grade metamorphism and penetrative deformation. These rocks are grouped as Cambrian-Ordovician metasedimentary rocks located to the southeast of the study-area.

The Kaeng Krachan Group of Carboniferous-Permian age crops out approximately 10 km west of the granite plutons, which is subdivided into the Khao Phra and Khao Chao Formations by Dheeradilok et al.(1982). The former comprises mudstone, shale, sandstone and limestone. The latter includes quartzite, shale and sandstone.

The Permian Ratburi Group occurs in the northernmost and southernmost part of the study-area and comprises both massive and well-bedded limestone (Kobayashi,1973).

Unconsolidated Quaternary sediments have been divided into higher terrace and alluvial deposits (Dheeradilok et al,1982). The higher terrace comprises: colluvial deposits; piedmont deposits; talus; and gravel beds. The alluvial deposits comprises: beach sand and ridge; silt, clay mud and swamp or marsh area. These two units are referred to as Quaternary I (Qt) and Quaternary II (Qa) in figure 1, respectively.

The N-S-trending Hua Hin - Pran Buri fault-zone, a major right-lateral cataclastic zone, possibly represents a system of branch fractures generated by the flanking Ranong - Khlong Marui and Three-Pagoda fault-zones. On the basis of 40Ar/39Ar total-fusion and step-heatingmica-ages (Charusiri, 1989; Tulyatid,1991), it is suggested that fault movement occurred in the Early Oligocene, probably coinciding with, or immediately preceding, the opening of the Gulf of Thailand.

A number of mineral deposits that occurs is associated with the non-foliated granites in the northwestern corner of the study-area. These are usually quartz occurrence within the plutons. Tin and tungsten are also found in sediments located to thewest of the northernmost part at the margin of the Hub Kapong Pluton (Figure1). There are no current operation for these Sn-W mines. The development of clay minerals and muscovite after biotite might have been caused by renewed hydrothermal alteration. Charusiri (1989) suggests tin-tungsten mineralization occurred in theEarly Eocene, at ca. 50-55 Ma. New evidence suggests the timing of mineralization

to be occurred during 70-80Ma. (Tulyatid, 1991).

THE AIRBORNE GEOPHYSICAL SURVEY

The study-area is part of the C1C area of the regional airborne radiometric survey conducted during 1985 and 1987 by Kenting Earth Sciences International Ltd.(KESIL). The survey was conducted with two rotary-wing aircrafts at approximate speeds of 45 m/sec with a nominal terrain clearance of 120 m. Traverses were flown in east-west direction with 1 km interval. Radiometric data were acquired with gamma-ray spectrometers equipped with twelve 102'102'406 mm3 NaI(Tl) detectors (volume 50.3 litres) analyzing energies in the range from 0 to 3 MeV into 256 channels. Potassium was measured directly from the gama-ray photons emitted by 40K, whereas uranium and thorium were measured indirectly from gamma-ray photons emitted by daughter products in their decay series, 214Bi and 208Tl, respectively.

Window count rates were corrected for dead time, cosmic radiation, back-ground radiation, spectral scattering, deviations from 120 m terrain clearance and for ambient temperature and pressure changes. Counts were converted to ground surface concentration units assuming an infinite flat homogeneous source.

The survey also included aeromagnetic survey employing GEOMETRICSG813 proton precession magnetometer.

AIRBORNE RADIOMETRIC DATA

Airborne radiometric data of the study-area are shown in Figure 2a to 2h for each elements and ratios. Ternary maps, which is useful for geological mapping, is presented in Figure 3a and 3b. These maps, in contour form, were then overlain on geologic map as shown in Figure 4a to 4g.

The study-area shows normal back-ground radiometric activity associated with the underlying geology. There are low and high radioactivities. The latter occurs over a N-S trending granitic terrane and metamorphic rocks, whereas the former covers the area of sedimentary and meta-sedimentary rocks of Silurian-Devonian, Carboniferous and Permian limestones. The radioactivity of variousrock types is summarized in Table 1.

The radioactivity over the north-easternmost part of Hub Kapong Pluton shows a number of divisions (Figure 2, 3and 4). The Hua Hin Gneissic Granite, located in the central part of the area, exhibits the highest radioactivity whereas the Pran Buri Gneissic Granite shows the lowest value among these foliated granites. The non-foliated granite, located to the western rim of the Hua Hin Pluton, is also recognized by its low activity (Table 1). Two Quaternary deposites, Qa and Qt, show approximately the same level of radioactivity.

INTERPRETATION

As mentioned above, the study emphasizes on differentiating various phases of granitic rocks of the study area. The interpretation, is therefore, considered only those of high radio-activity area where granites are present.

On the basis of radiometric maps reproduced, the study-area can be divided into 30 divisions (Figure 5, Table 2). Division no. 1 (western portion), 7, 11, 12, 13, 18, 19 and 21 cover various phases of the Hub Kapong Gneissic Granites. Division no. 22, 23, 25, 26 and 27 cover the area of the Hua Hin Gneissic Granites. Division no. 2, 4, 5, 6, 8, 10 and 24 indicate the non-foliated granite. Division no. 28 and 29 indicate the metasedimentary rocks, and division no. 30 located along the N-S trending Hua Hin -Pran fault-zone is Pran Buri Gneissic Granite. Division no. 1, 3, 9, 14, 15, 16, 17, and 20, covering the higher terrace area (Qt), may indicate either the washover of the source rocks or the very thin overburden over the granitic rocks. A comparison of TC, K, U and Th ranges among radio-geological units (Table 2) are displayed in Figure 6a to 6d.

The boundary of these divisions generally cover larger areas than the mapped area. The evidence is supported by field observations, e.g. the high terrace area in the geologic map (Figure 1) located to the west of the Hua Hin Pluton is in fact a granite outcrops.

In the Hub Kapong Pluton, various divisions may indicate different phases of granite intrusions. This may caused by the existing of various grain sizes and textures of the Hub Kapong Gneissic Granite. In addition, the intrusion of later non-foliated granite and the hydrothermal alteration play parts in these variations.

Additional information can be acquired from ratio maps, including eU/K, eU/eTh, and eTh/K. In general, the high values in eU/K and eTh/K ratio maps are considered meaningless as it enhances the areas of low K concentration, e.g., Quaternary sediments located W of the granite plutons.

Contour interval plays an important role in

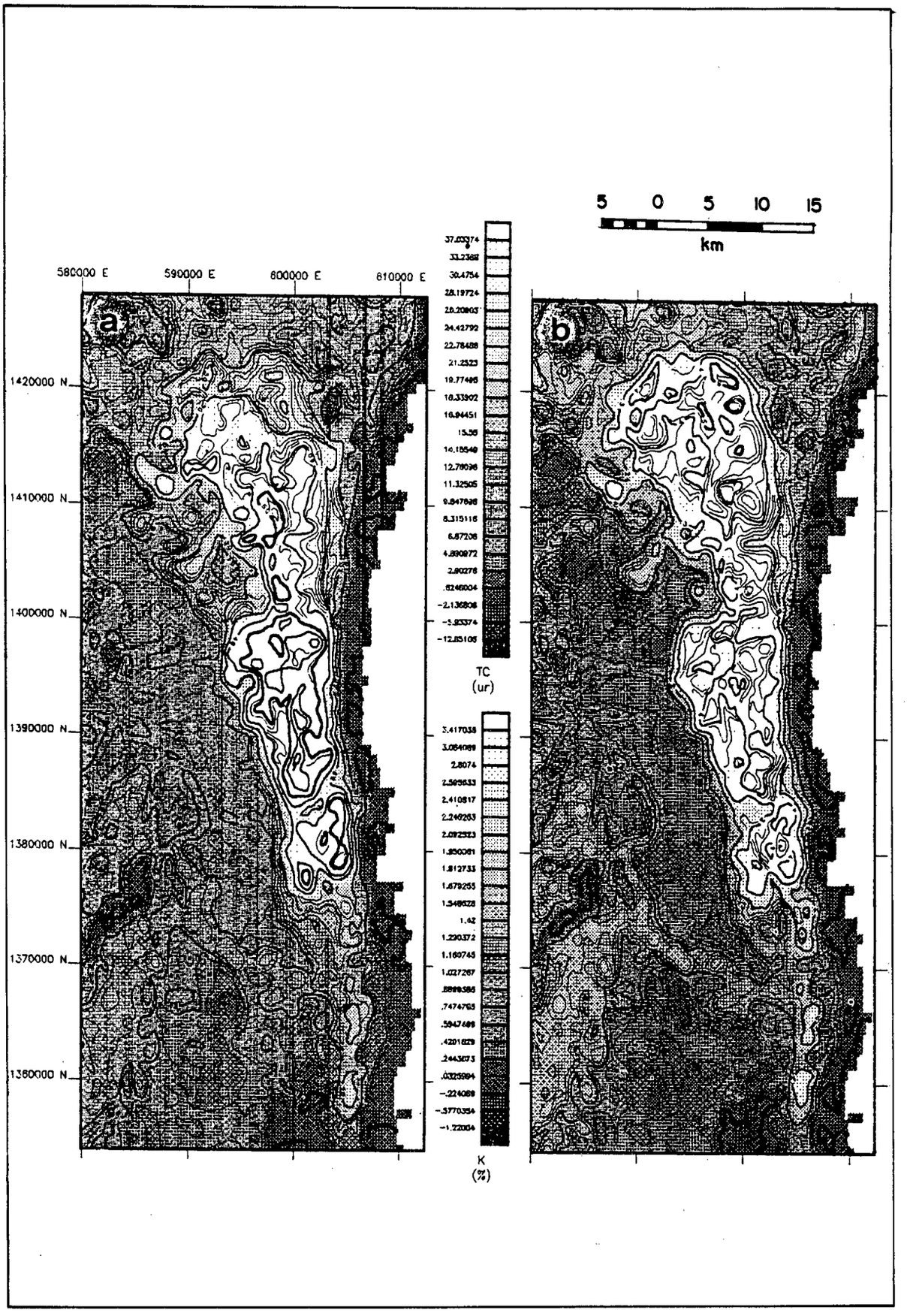

Figure 2

a) **Total count contour with grey-tone plot of the study-area. Dark areas represent low content. The granitic terrane yields the highest radio element content.**

b) **Potassium contour with grey-tone plot of the study-area. The highest K content is located to the northernmost part of the Hub Kapong pluton. It also clearly shows trends of stream deposits with low to moderate radio-content, e.g., sediments along the Pran Buri River located in the middle of the lower part of the plot.**

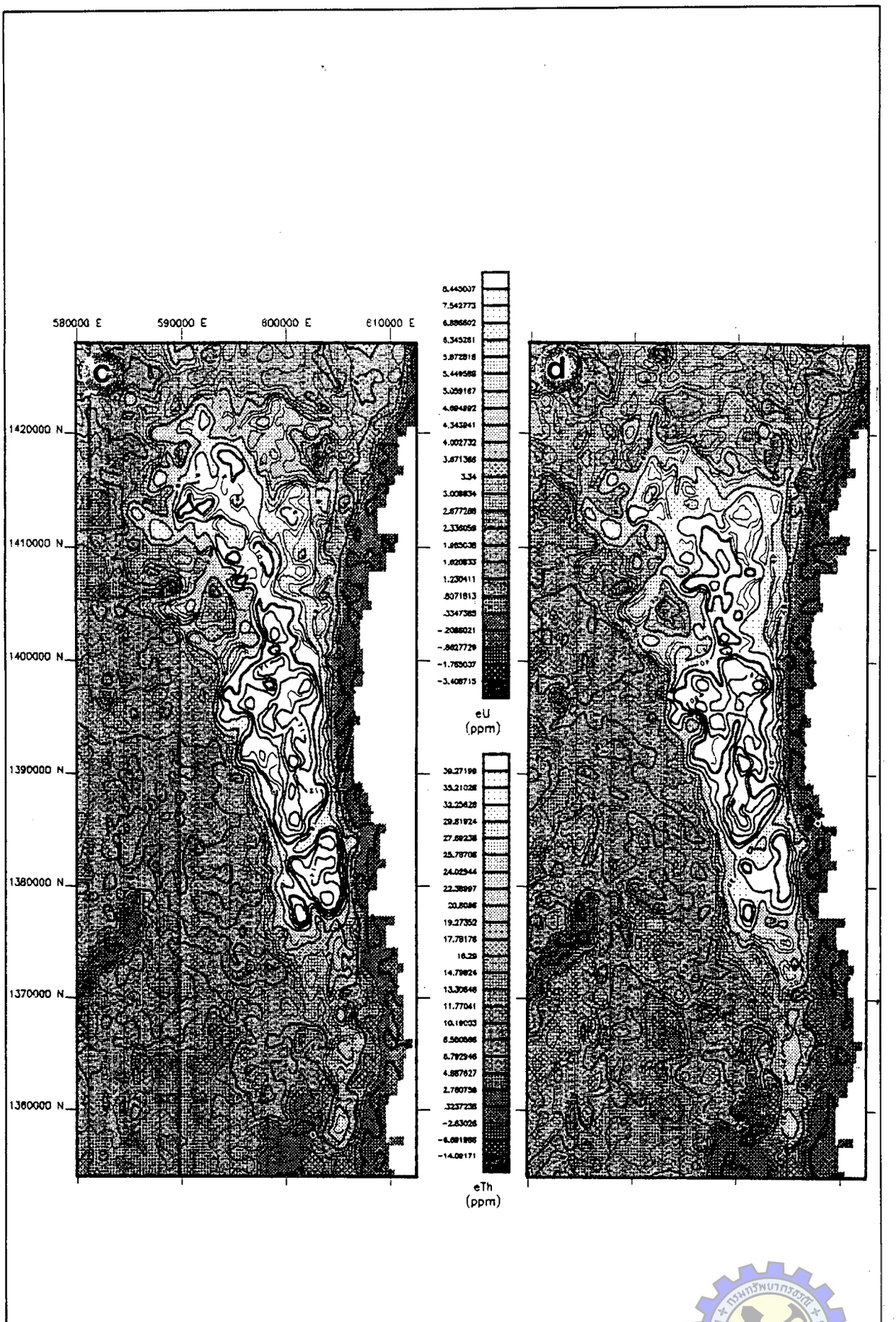

Figure 2 (contd.)

c) Equivalent Uranium contour with grey - tone plot of the study-area. The Hua Hin Gneissic Granite yields the highest U content.

d) Equivalent Thorium contour with grey-tone plot of the study-area. The Hua Hin Gneissic Granite shows the highest Th content.

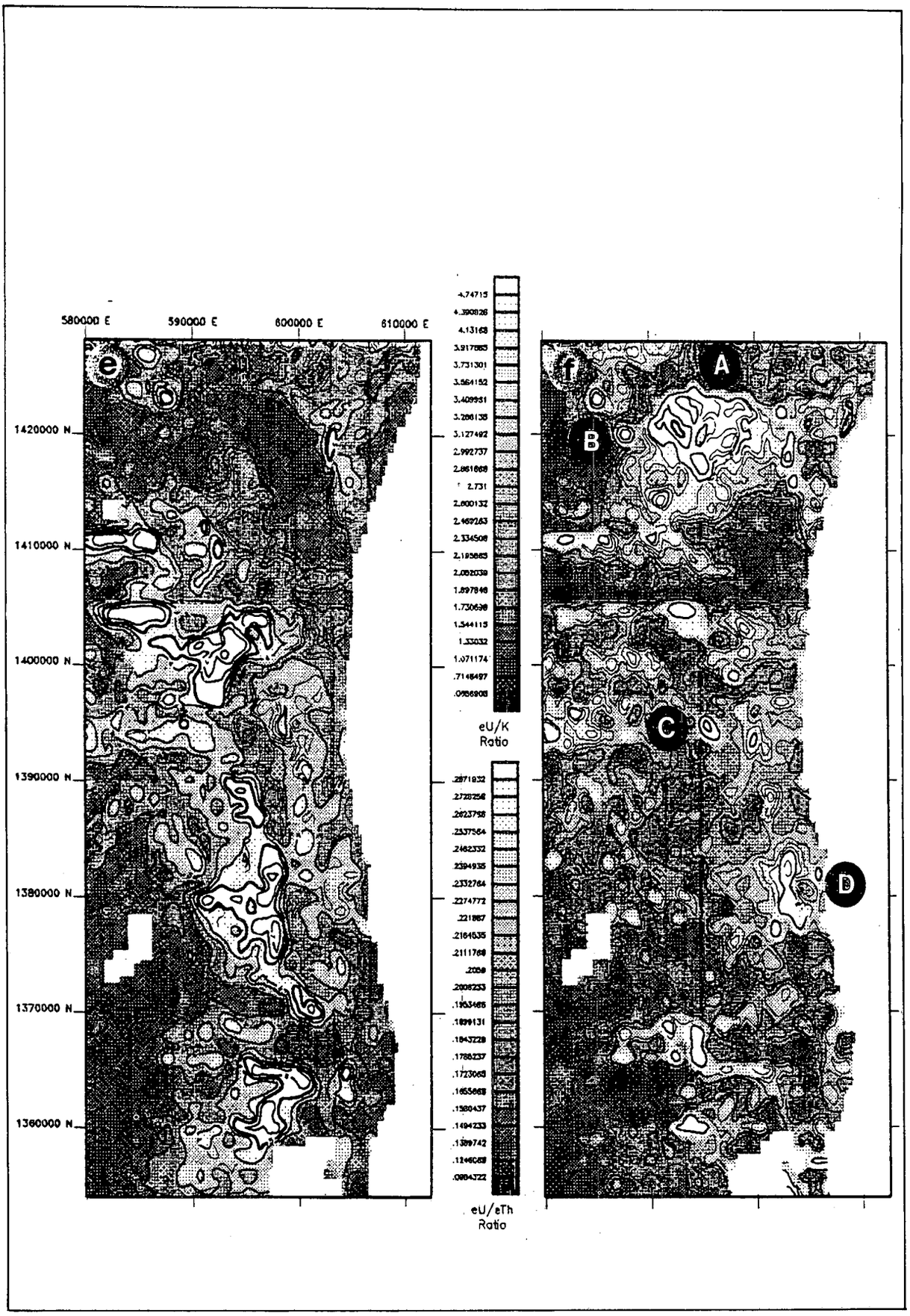

Figure 2 (contd.)

e) EU/K ratio contour with grey-tone plot of the study-area. The plot, in this case, is considered meaningless as the exaggeration result of the high-value area located in the Quaternary II west of the granitic pluton caused by very low K low eU content.

f) EU/eTh ratio contour with grey-tone plot of the study-area. The highest value is located at the northernmost part of the Hub Kapong Pluton (A), which are nonfoliated, leuco-granite. Two moderately high values (B) are located to the northwesternmost part: one at the centre of the plot (C), the other, probably part of the Hua Hin Pluton (D) located close to the shoreline, indicating the existence of the non-foliated granite.

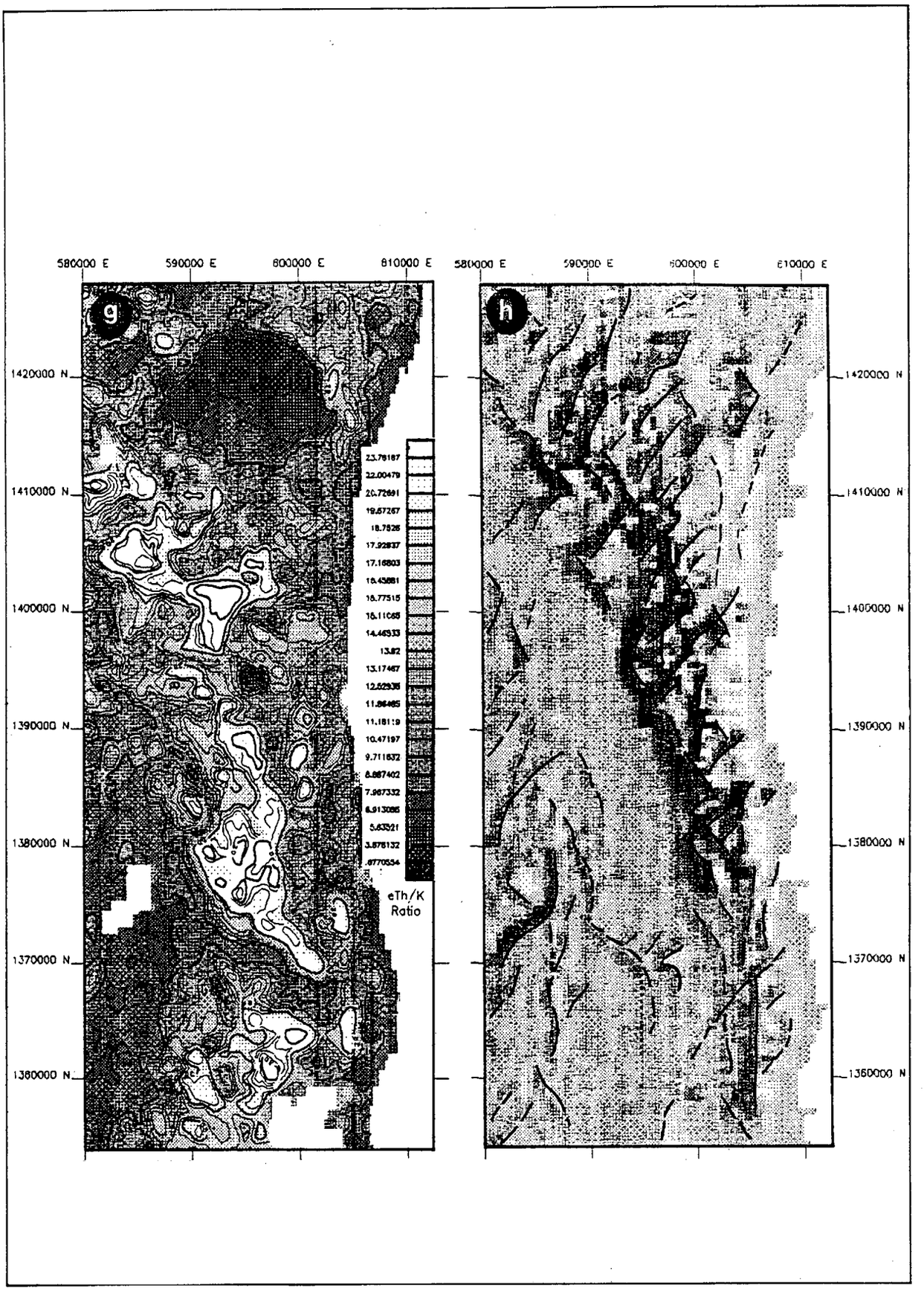

Figure 2 (contd.)

g) ETh/K ratio contour with grey-tone plot of the study-area. The low value is located to the northernmost part of the Hua Hin Pluton indicating the non-foliated granite. Another low value area also indicates non-foliated granite located to the west of the Hua Hin Pluton, in the middle of the plot. The high ratio values located in the Qt are considered meaningless as previously mentioned.

h) Image of total count plot of the study-area with a NE and SE sun illumination angles (45° and 135° declination and 45° inclination). Most of the lineament- show NW and NE directions. A large N-S trending located to the southeastern part of the plot may indicate the existence of the Hua Hin - Pran Buri fault-zone.

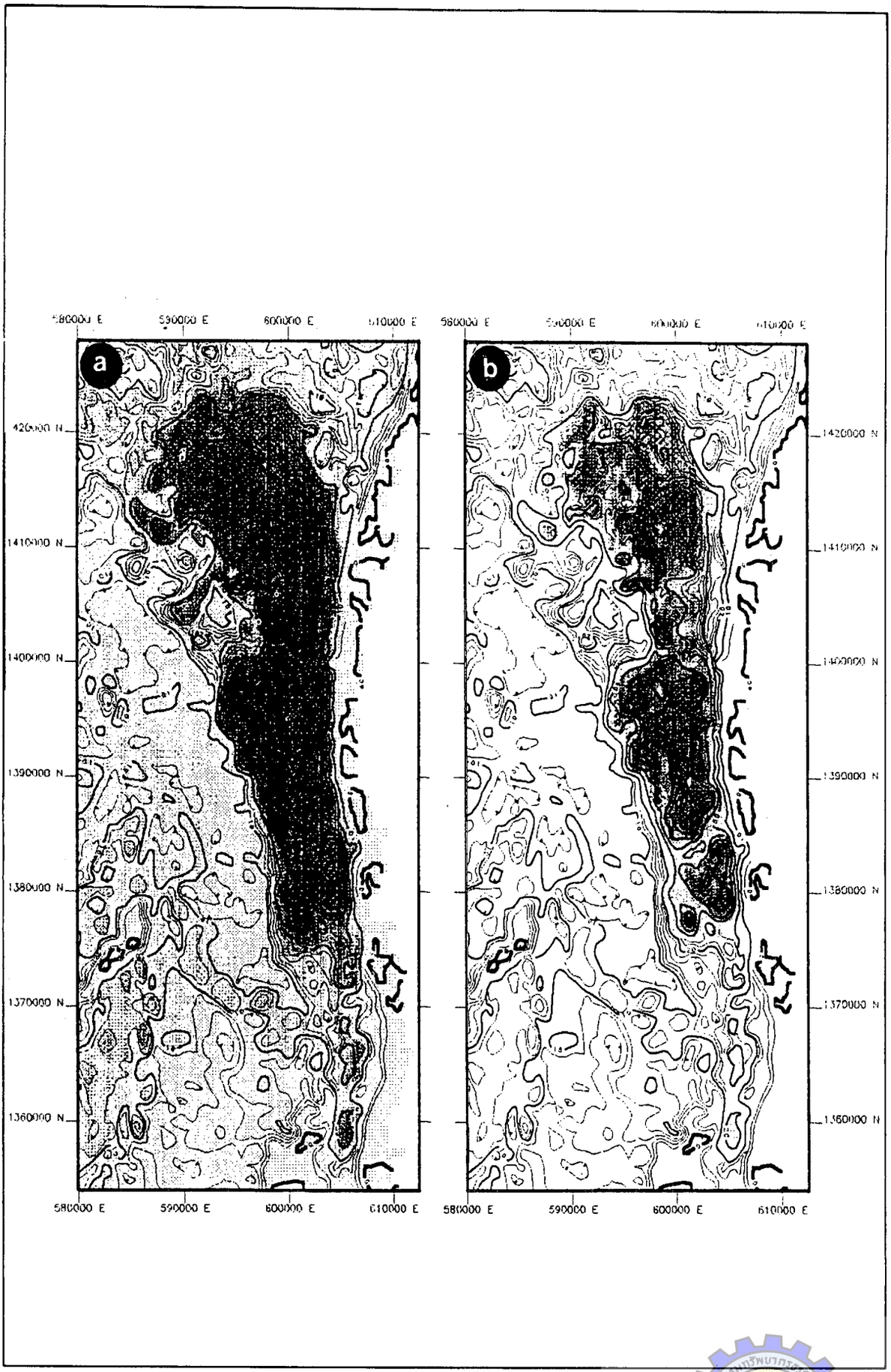

Figure 3

a) Ternary maps of the study-area: K = red; U = yellow; and Th = blue. Dark areas indicate high radioactive content.

b) Ternary maps of the study-area enhancing within the granitic terrane, i.e., K = 2.0-5.5 %; eU = 4.0 - 21.0 ppm; and eTh = 20 - 100 ppm. It clearly shows that the granitic rocks of the area can be easily distinguished.

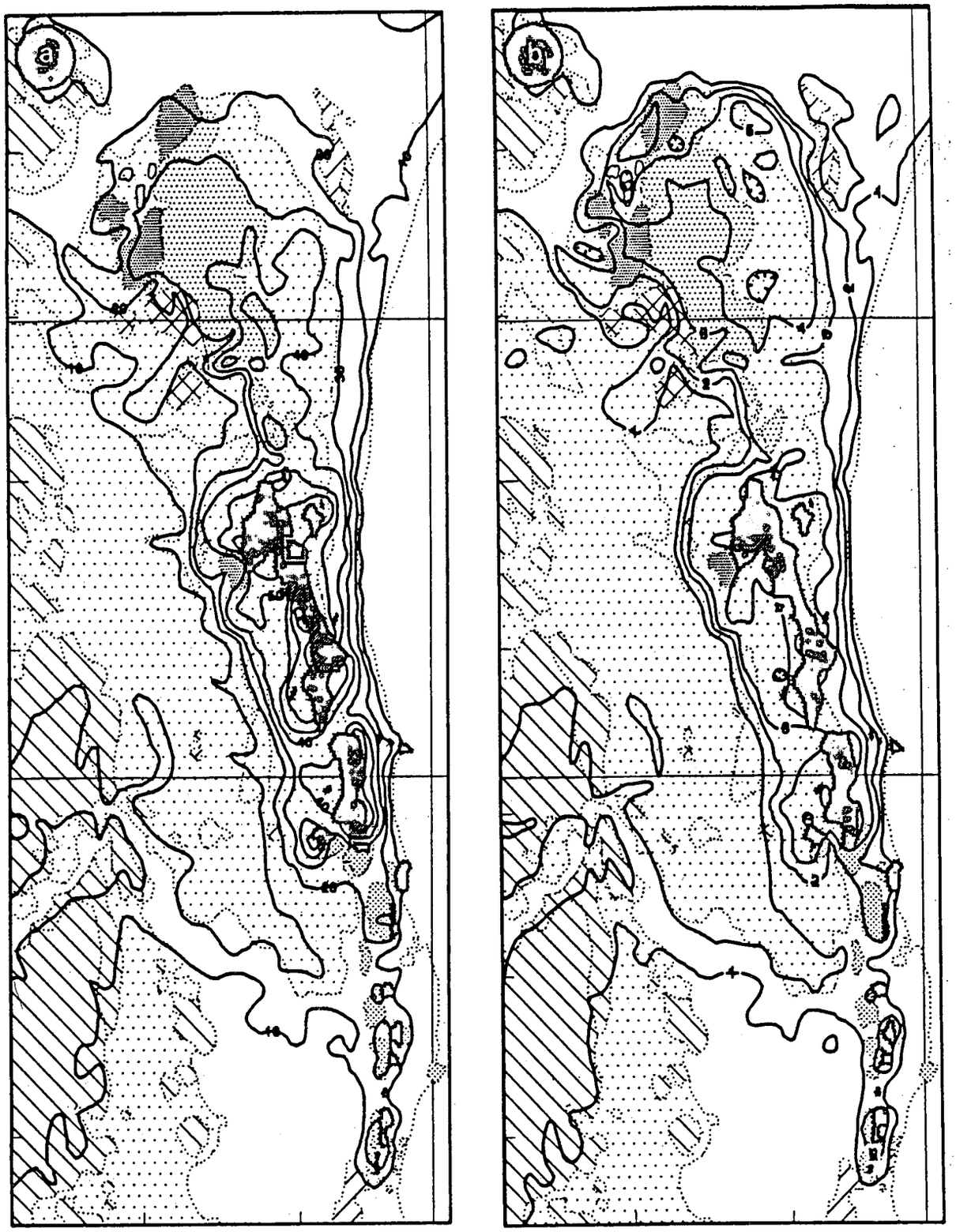

Figure 4 a-g

a) and b) Simplified contours of TC and K of the Hua Hin - Pran Buri area, respectively. The contours overlay the geological sketched-map. Contour interval of: 10 ur and 1 %; and the minimum contour of 10 ur and 1 %; are presented for TC and K, respectively. It is obvious that the geological boundaries, especially those of the granitic rocks, on the geologic map, cover smaller area than those indicated by radiometric contours. Potassium conform nicely along the mylonitic rocks located in the Hua Hin - Pran Buri fault-zone.

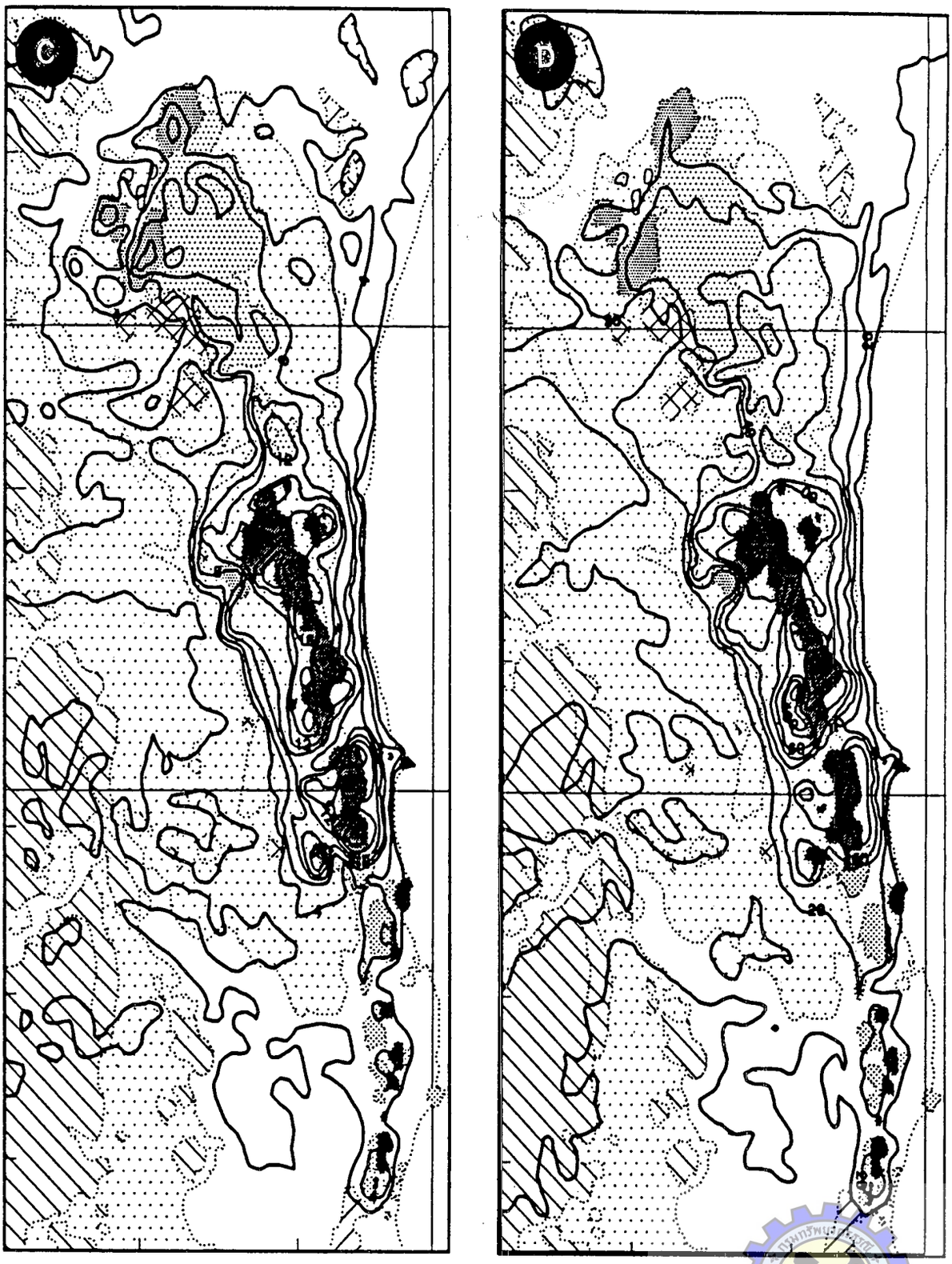

Figure 4 (contd.)

c) and d) Simplified contours of eU and eTh of the study-area, respectively. Contour intervals of 2 ppm and 10 ppm; and the minimum contours of 2 ppm and 10 ppm are presented, respectively.

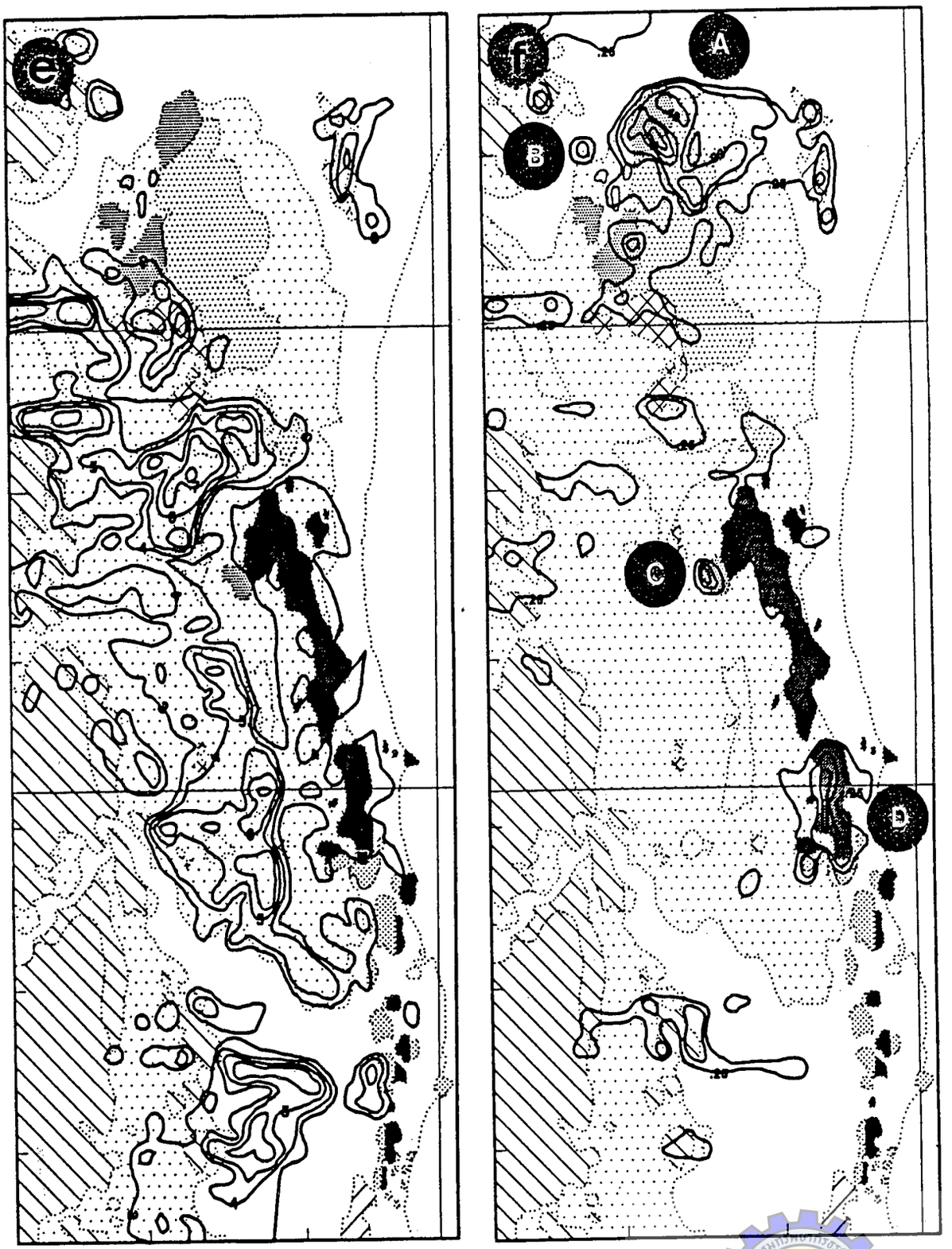

Figure 4 (contd.)

e) and f) Simplified contours of eU/K and eU/Th ratios of the study-area, respectively (see discussion in Figure 2e and 2f). Contour intervals of 1 and 0.05; with the minimum contours of 3 and 0.25 are presented, respectively.

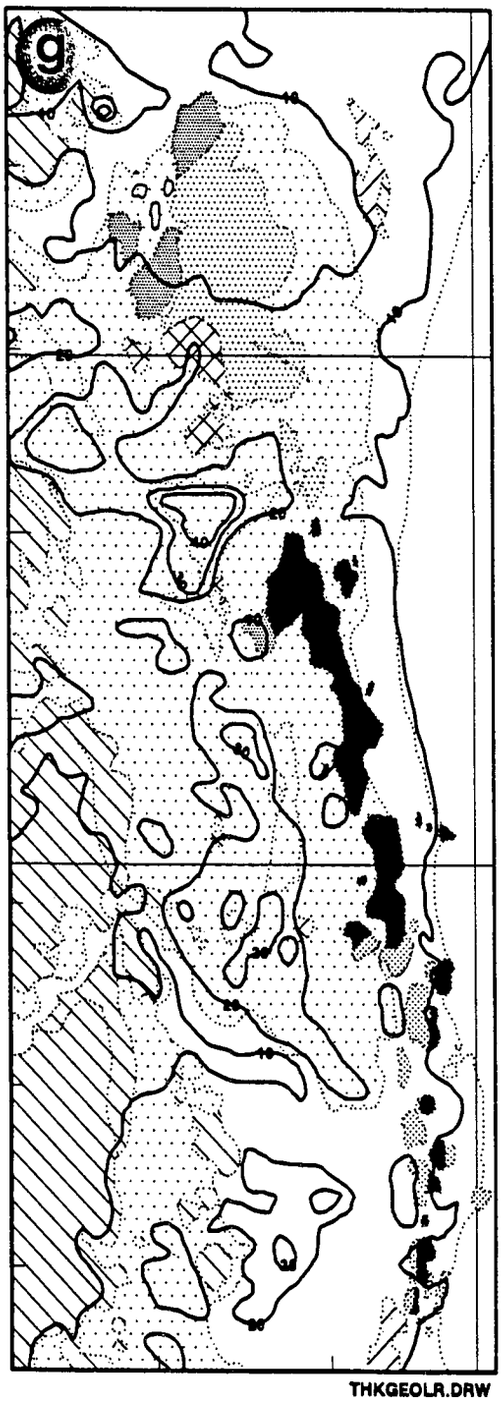

Figure 4 (contd.)

g) Simplified contours of eTh/K ratio of the study-area. Contour interval of 10 with the minimum contour of 10 are presented.

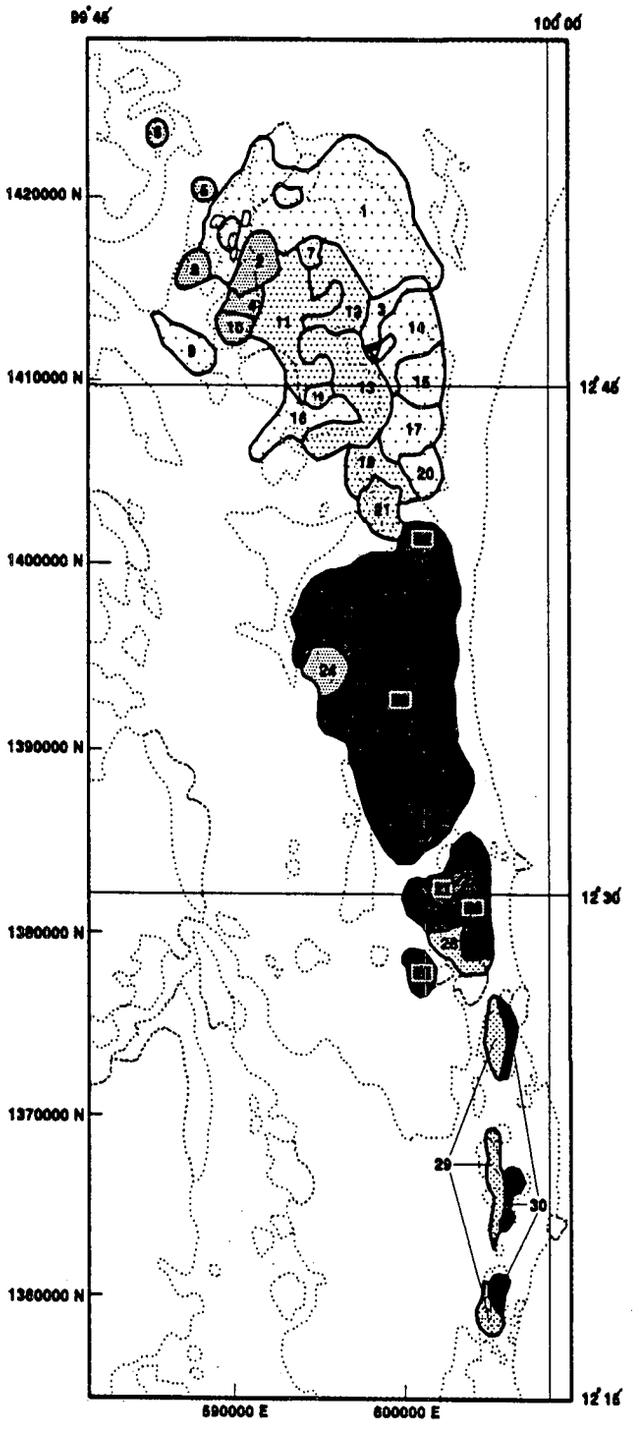

Figure 5

Radiometric interpretation sketch-map of the study-area. A number of 30 divisions are delineated. Equivalent geologic units are presented by the same filled patterns shown in Figure 1.

Table 1 Radioelement contents of Hub Kapong, Hua Hin and Pran Buri Gneissic Granites and surrounding rocks.

Rock unit	Total count (ur)	Potassium (%)	Equiv. Uaranium (ppm)	Equiv. Thorium (ppm)
Hub Kapong Gneissic Granite	20.0 - 60.0	2.0 - 5.2	3.0 - 9.0	20.0 - 62.0
Hua Hin Gneissic Granite	10.0 - 70.0	1.0 - 4.6	3.0 - 16.0	20.0 - 90.0
Pran Buri Gneissic Granite	5.0 - 25.0	0.6 - 2.4	0.5 - 5.0	6.0 - 26.0
Non-foliated granite	10.0 - 50.0	1.0 - 4.0	2.0 - 11.0	10.0- 30.0
Khao Sa Woe Rat Fm. (Silurian-Devonian)	8.0 - 15.0	0.6 - 0.8	2.0 - 4.0	10.0 - 15.0
Kaeng Krachan Group (Carboniferous)	7.0 - 15.0	0.6 - 2.2	0.5 - 3.0	0.0 - 22.0
Ratburi Limestones (Permian)	2.0 - 6.0	0.6 - 0.8	0.2 - 0.6	2.0 - 6.0
Quaternary I (Qt)	6.0 - 45.0	0.5 - 5.2	2.0 - 8.0	10.0 - 50.0
Quaternary II (Qa)	0.0 - 15.0	0.0 - 2.0	0.0 - 4.0	0.0 - 30.0
Background	10.0	1.0 - 1.6	1.0 - 1.5	10.0 - 12.0

recognizing the non-foliated granites in eU/eTh ratio map. The division is unrecognizable in the printed map by KESIL using the contour interval of 0.1. The small, isolated anomalies (division no. 5, 6 and 24, Figure 5) of 0.25 to 0.35, in an average value of approximately 0.2, indicate the presence of non-foliated granite (marked A-D, Figure 2f; and Figure 4f). The high value of eU/eTh portion (marked D, Figure 2f; Figure 4f) located to the west of the southern part of the Hua Hin Pluton may indicate the latest intrusion or tectonic activity as it oriented in N-S direction parallel to the major Hua Hin - Pran Buri fault-zone.

The low values of eTh/K ratio occur in the northernmost part of the Hub Kapong Pluton. The high values of K, U and the eU/eTh occur approximately at the same location (Figure 2.g and 4.g). This particular signature has been recognized as late-stage leucocratic granites, which often exhibit Sn and/or W with the possibility of economic mineralization (Darnley and Ford, 1991). Therefore, this non-foliated granite is believed to be the source for Sn and W deposits in the study-area.

Metamorphic rocks associated with the mylonitic rocks yield a little higher radioactivity level than the mylonite. The evidence is supported by the presence of mica in the metamorphic rocks. However, variations may be found by using similar technique in enhancing the level of the granite plutons.

AEROMAGNETIC INTERPRETATION

Aeromagnetic data were also studied. Interpretation of the study-area is diffi-cult because of cultural effects along the roads and the railroad, which aligned in the N-S direction along the coastline.

The magnetic response on the study-area is characterized by three main division groups (Figure 7a and 7b). A weak response covers the Silurian-Carboniferous meta-sedimentary and clastic sedimentary rocks and Permian limestone. A flat response covers most of Quaternary deposits. Finally, several distinct anomalies are aligned along a N-S-trending outcrops of granite and the metamorphic complex. The latter extend northward onto Sheet ND 47-11 and southward to a large outcrop of Permian limestone. A large anomaly located to the west of the Hua Hin Pluton (Figure 7), may indicate either the existence of the underlying intrusion or the granite cutting in the middle by an E-W striking fault (KESIL, 1989).

DISCUSSION AND CONCLUSION

The airborne radiometric data interpretation of the study-area results in a success record as the method aids in geological mapping, especially in the granitic terrane. From this study, it is clearly shown that additional information can be achieved by reprocessing, representing and interpreting of the airborne radiometric data, specifically on the granitic

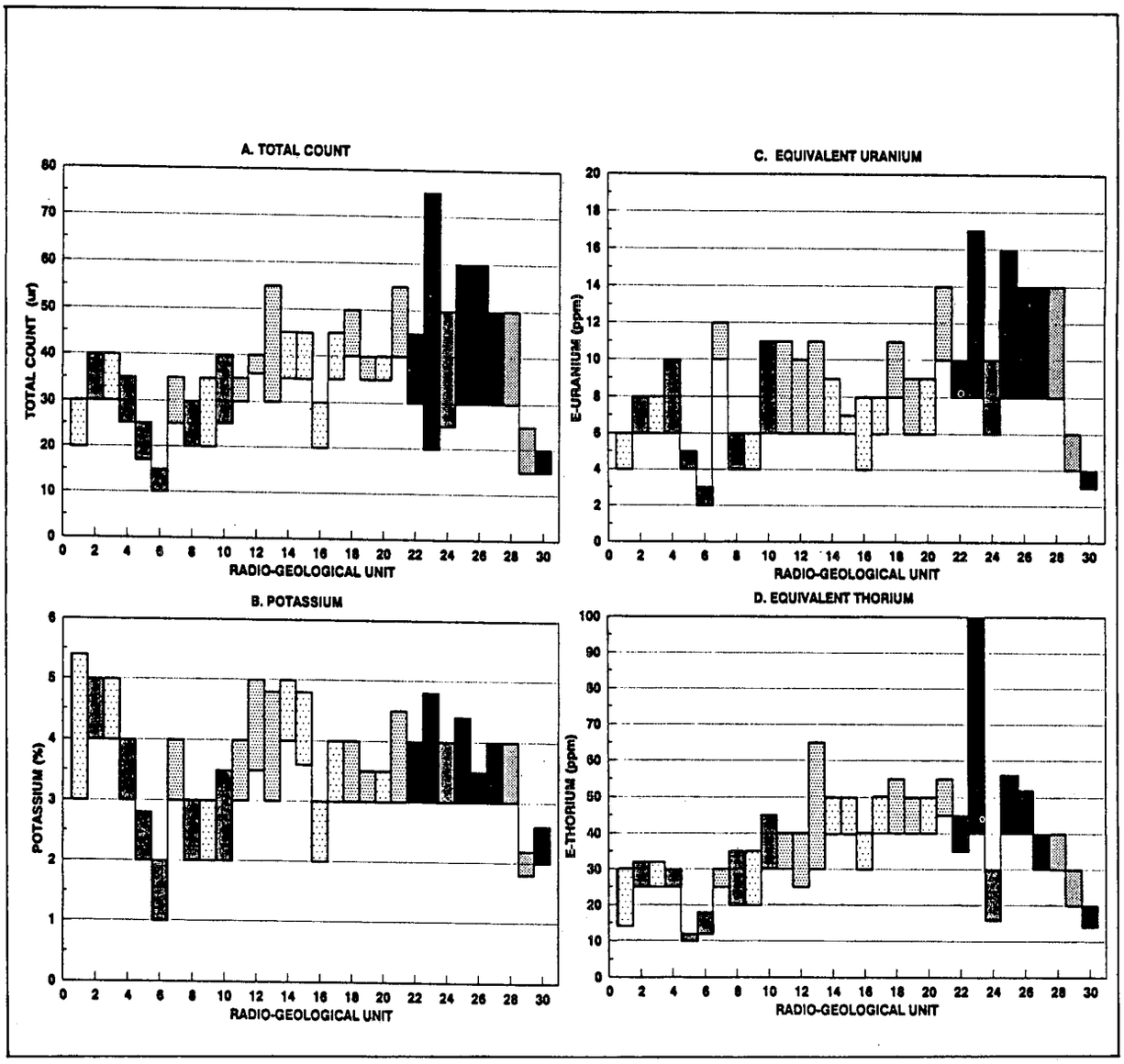

Figure 6 a - 6d A comparison of radioactive ranges among 30 radio-divisions (Table 2 and Figure 5) in TC, K, U, and Th, respectively. Filled patterns are corresponded with geologic units in Figure 1 and Figure 5.

terrane.

It is possible to use radiometric survey data as an efficient tools in distinguishing not only different rock types but also different phases of granitoid or other felsic rocks. These rocks of different phases have to exhibit minor difference in its chemical composition. Later event such as alteration is also important as it changes the chemical composition of the original rocks. The method makes use of variation in K, U, and Th contents. Ratios among these elements are also necessary in many cases as discussed below.

The Hua Hin - Pran Buri fault-zon located to the southeastern most part of the area is fairly detected by means of airborne radiometric survey. It is obvious that these mylonitic rocks show low radiometric content. Although interrupted by cultural noise, aeromagnetic data still support the existing of the fault-zone by a number of small anomalies aligned along the N-S-trending fault-zone. This is another application of the method in geological mapping.

The data may indicate the area that had been effected by hydrothermal alteration. The major product from this type of alteration is high-K-content clay mineral. The area yields a high K level, low to moderate content of U and Th, very low eTh/K ratio, and possibly moderate to high eU/eTh ratio (Table 2). In this study, the hydrothermal alteration is believed to occur associated with the latest intrusion of the leuco-granitic rocks located in the northernmost part of the Hub Kapong pluton. It is, therefore, possible to set up criteria in order to locate high potential area for mineral exploration.

Table 2 **Interpreted maximum-range radioelement content of the study-area.**

DIVISION	TC	K	eU	eTh	eU/eTh	Geological Unit
1	20-30	3.0-5.4	4.0-6.0	14-3	0.25-.55	Non-foliated Gr (W) and Qt (E)
2 and 3	30-40	4.0-5.0	6.0-8.0	25-32	<.25	Non-foliated Gr/Qt
4	25-35	3.0-4.0	6.0-10	25-30	.25-.40	Non-foliated Gr
5	17-25	2.0-2.8	4.0-5.0	10-12	.25-.35	Non-foliated Gr
6	10-15	1.0-2.0	2.0-3.0	12-18	.25-.35	Non-foliated Gr
7	25-35	3.0-4.0	10-12	25-30	<.25	Hub Kapong Gr
8 and 9	20-35	2.0-3.0	4.0-6.0	20-35	<.25	NFGr/Qt
10	25-40	2.0-3.5	6.0-11	30-45	<.25	Non-foliated Gr
11	30-35	3.0-4.0	6.0-11	40-40	<.25	Hub Kapong Gr
12	35-40	3.5-5.0	6.0-10	25-40	<.25	Hub Kapong Gr
13	30-55	3.0-4.8	6.0-11	30-65	<.25	Hub Kapong Gr
14	35-45	4.0-5.0	6.0-9.0	40-50	<.25	Quaternary (Qt)
15	35-45	3.6-4.8	6.0-7.0	40-50	<.25	Quaternary (Qt)
16	20-30	2.0-3.0	4.0-8.0	30-40	<.25	Hub Kapong Gr
17	35-45	3.0-4.0	6.0-8.0	40-50	<.25	Quaternary (Qt)
18	40-50	3.0-4.0	8.0-11	40-55	<.25	Hub Kapong Gr
19 and 20	35-40	3.0-3.5	6.0-9.0	40-50	<.25	Hub Kapong GrQt
21	40-55	3.0-4.5	10-14	45-55	<.25	Hub Kapong Gr
22	30-45	3.0-4.0	8.0-10	35-45	.25-.40	Hua Hin Gr
23	20-75	3.0-4.8	8.0-17	40-100	.20-.35	Hua Hin Gr
24	25-50	3.0-4.0	6.0-10	16-30	.25-.45	Non-foliated Gr
25	30-60	3.0-4.4	8.0-16	40-56	.25-.	35Hua Hin Gr
26	30-60	3.0-3.5	8.0-14	40-52	.25-.35	Hua Hin Gr
27 and 28	30-50	3.0-4.0	8.0-14	30-40	.30-.40	Hua Hin Gr / meta-sed.rks.
29	15-25	1.8-2.2	4.0-6.0	20-30	<.25	Meta-sed. rks.
30	15-20	2.0-2.6	3.0-4.0	14-20	<.25	Pran Buri Gr

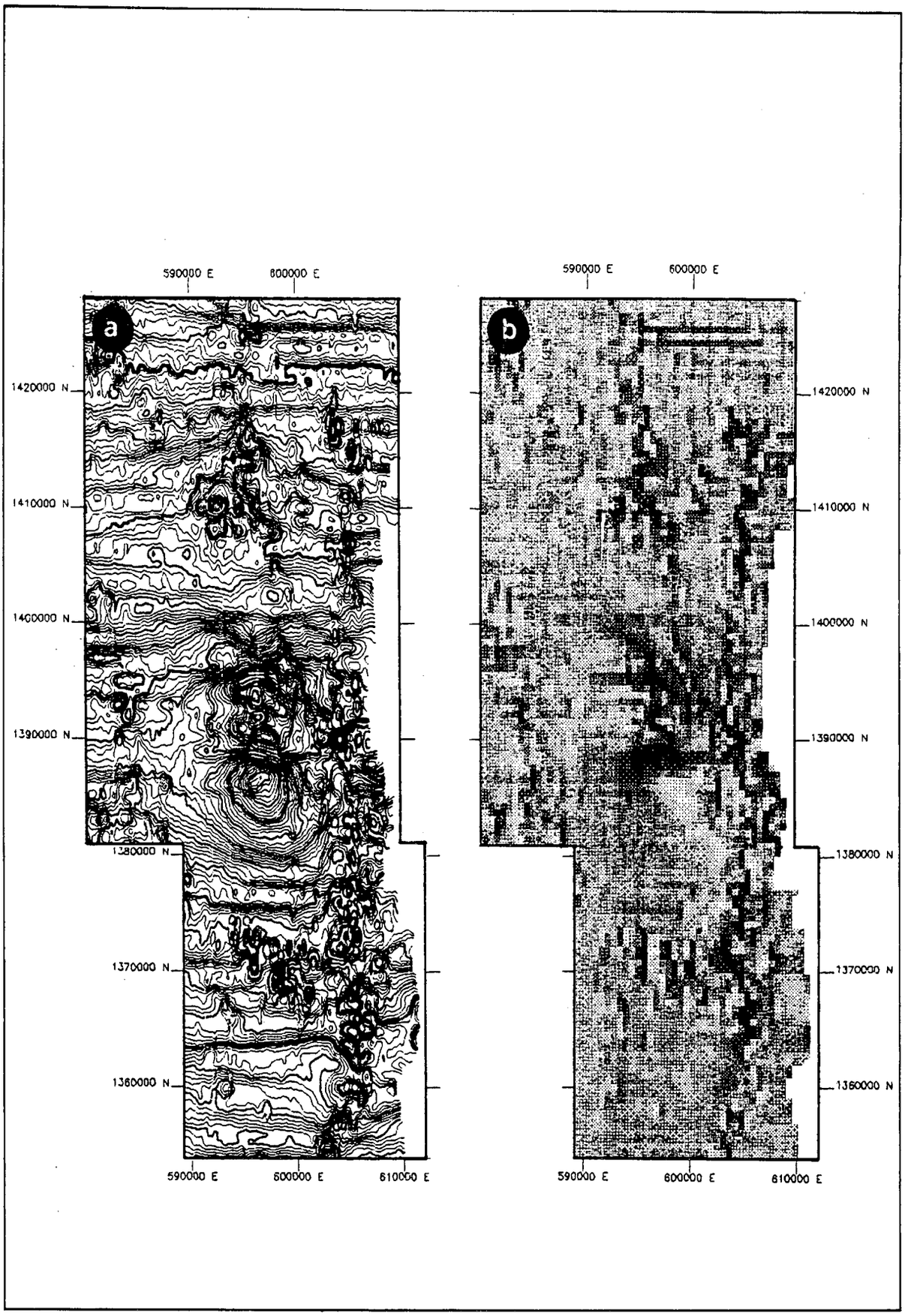

Figure 7

a) **Aeromagnetic contours of the Hua Hin - Pran Buri area. A large anomaly located at the centre of the map may indicate the E-W trending fault or the existence of intrusive body. A N-S lineament located to the southeastern part of the area may indicate the Hua Hin - Pran Buri fault-zone. The data also reflect cultural noise from non-geologic sources such as towns and railroad located to the east of the area.**

b) **Image of aeromagnetic plot of the study-area with NE and SE sun illumination angles (45° and 135° declination and 45° inclination). Similar information from figure 7a may be obtained.**

ACKNOWLEDGEMENT

The writer would like to thank Khun Satien Sukontapongpow, Chief of AGDIS, for his supports and valuable advices. Thanks are extended to Khun Pichai Otarawanna, AGDIS, for preparing some of the illustrations in this article. The invaluable help from Khun Tana Kiattiwongchai in the use of the software program for geophysical data compilation is greatly appreciated.

REFERENCES

Bristow, Q., 1983. *Airborne Gamma-ray Spectrometry in Uranium Exploration, Principles and Current Practice;* International Journal of Applied Radiation and Isotopes, v. 34, No. 1, pp. 199-229.

Brown, G. F., Burovas, 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, V. 984, 183p.

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

Chanasitt, M., 1977. *Geology of Hua Hin Area: area no. 4.* Unpublished undergraduate field study report, Department of Geology, Faculty of Science, Chulalongkorn University, Bangkok, Thailand, March 29 - April 27, 45 p.

Charbonneau, B. W., Richardson, K. A., and Grasty, R . L . , 1973. *Airborne Gamma-ray Spectrometry as an Aid to Geological Mapping Township 155*, Elliot Lake Area, Ontario; Geological Survey of Canada, Paper 73-1, Part B. pp. 39-47.

Charusiri, P. 1977. *Geology of the Hua Hin Area: area no. 2.* Unpublished undergraduate field study report, Department of Geology, Faculty of Science, Chulalongkorn University, Bangkok, Thailand, March 29 - April 27, 42 p.

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

Chatterjee, A. K., and Muecke, G. K., 1982. *Geochemistry and the Distribution of Uranium and Thorium in the Granitic Rocks of to South Mountain Batholith, Nova Scotia:* Some Genetic and Exploration Implications; pp. 11-17 in Uranium in Granites, edited by Maurice, Geological Survey of Canada, Paper 81-23, 173 p.

Corey, M. C., 1987. *A Re-interpretation of U-Th Ratios in the New Ross Area:* **Evidence for a Zoned Pluton;** p. 105-109 in Nova Scotia Department of Mines and Energy, Mines and Minerals Branch, Report of Activities, Part A, Report 87-5, 252 p.

Dheeradilok, P., 1973. *The inferred Precambrian rocks and tectonic features of Thailand:* Mineral Resources Gazette (Bangkok), V. 8, p. 1-18 (in Thai).

Dheeradilok, P., Suensilpong, P., Boripotkosum, S., Tansuwan, 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, Thailand, 1 p.

Ford, K. L., and O'Reilly, G. A., 1985. *Airborne Gamma-ray Spectrometric Surveys as an Indicator of Granophile Element Specialization and Associated Mineral Deposits in the Granitic Rocks of the Meguma Zone of Nova Scotia, Canada: pp. 113-133;* in High Heat Production (HHP) Granites, Hydrothermal Circulation and Ore Genesis,The Institution of Mining and Metallurgy, London,England, 593 p.

Galbraith, J.H., and Saunders, D.F., 1983. *Rock Classification by Characteriscs of Aerial Gamma-ray Measurements;* Journal of Geochemical Exploration, V. 18, pp. 49-73.

Gunnaleka, S., 1977. *Geology of the Hua Hin Area: area no. 1.* Unpublished undergraduate field study report, Department of Geology, Faculty of Science, Chulolongkorn University, angkok, Thailand, March 29 - April 27, 52 p.

Harnpattanapanich, T., 1977. *Geology of the Hua Hin Area: area no. 1. Unpublished undergraduate field study report, Department of Geology, Faculty of Science,* Chulalongkorn University, angkok, thailand, March 29 - April 27,52 p

Kenting Earth Sciences International Ltd., 1989. *Interpretation Report for Airborne Geophysical Survey of the Mineral Resources Development Project,* Department of Mineral Resources, Thailand. V. XXXIV, Mapsheet ND47 - 15, 19 p.

Kobayashi, T., 1973. *The Early and Middle Paleozoic history of the Burmese-Malayan geosyncline:* Geology and Paleontology of SE Asia, V. 11, p. 93 - 108.

Permtong, P., 1977. *Geology of Hua Hin Area: area no. 5: Unpublished undergraduate field study report, Department of Geology, Faculty of cience,* Chulalongkorn University, Bangkok, thailand, March 29 - April 27,52p.

Pongsapich, W. Vedchakanchana, S. and Pongprayoon, P., 1980. *Petrology of the Pranburi - Hua Hin metamorphic complex and geochemistry of Gneisses in it:* Geological Society of Malaysia Bulletin, V. 12, pp. 55 - 74.

Pornrattanapitak, P., 1977. *Geology of Hua Hin Area: area no. 3:* Unpublished undergraduate field study report, Department of Geology, Faculty of Science, Chulalongkorn University, Bangkok, Thailand, March 29 - April 27, 52p.

Putthapiban, P. and Suesilpong, S., 1978. *The igneous geology of the granitic rocks of the Hub Kapong -Hua Hin area: Journal of the Geological Society of Thailand,* V. 3, pp. M1- M22.

Sasipoka, B., 1977. *Geological Report of Amphoe Pranburi: area no. 7:* Unpublished undergraduate field study report, Department of Geology, Faculty of Science, Chulalongkorn University, Bangkok, Thailand, March 29 - April 27, 52p.

Slaney, V. R., 1985. *Lansat MSS and Airborne Geophysical Data Combined for Mapping Granite in Southwest Nova Scotia; 11th International Symposium on Machine Processing of Remotely Sensed Data,* Purdue University, Indiana, June 25-27.

Tem-Udom, L., 1977. *Geology of Hua Hin Area: area no. 6:* Unpublished undergraduate field study report, Department of Geology, Faculty of Science, Chulalongkorn University, Bangkok, Thailand, March 29 - April 27, 52 p.

Tipdhonsub, C., 1977. *Geology of Pranburi - Thung Plai Ngam: area no. 8:* Unpublished undergraduate field study report, Department of Geology, Faculty of Science, Chulalongkorn University, Bangkok, Thailand, March 29 - April 27, 52 p.

Tulyatid, J., 1991. *40Ar/39Ar Geochronological Study of Deformed Meta-granitoid Rocks adjacent to the Hua Hin - Pran Buri Fault System:* Unpublished M.Sc. Thesis, Queen's University, Kingston, Ontario, Canada, 351 p.

Webster, S. S., 1984. *Comments on the Use of Gamma- ray Spectrometry for Tin Prospecting.* Exploration Geophysics, V. 15, pp. 61-63.

Workman, D. R., 1975. *Tectonic evolution of Indochina:* Journal of the Geological Society of Thailand, v. 1, pp. 3-19.

Yeastes, A. N., Wyatt, B. W., and Tucker, D. H., 1982. *Application of Gamma-ray Spectrometry to Prospecting for Tin and Tungsten Granites, Particularly Within the Lachlan Fold Belt, New South Wales.* Economic Geology, V. 77, pp. 1725-1738.