CHAPTER 2 DOI CHONG AREA

2-1 Geology

2-1-1 General Geology

The geology of the Doi Chong Area is made up, from below, of Silurian-Devonian-Carboniferous Mae Tha Group and Donchai Group, Permian Ratburi Group Kiu Lom Formation (P1), Pha Huat Formation (P2) and Huai Thak Formation (P3), Permo-Triassic Volcanic Formation (PTR), Triassic Lampang Group Hong Hoi Formation (TR) and Triassic intrusive granite (Gr) and diorite (Di), etc.

The survey area can be broadly classified geologically into three regions: a steep mountainous region which accounts for the main part of the survey area, gently-sloping hilly terrain distributed in the north, and flat land seen in the southernmost part. Of these three regions, the hilly region in the north is thought to correspond to Hong Hoi Formation of the Triassic Lampang Group, and the flat land at the southern tip to the alluvium. According to the geologic map, scale 1:250,000, (DMR, 1985), Silurian-Devonian strata are widely distributed in the mountainous region which forms the main part of the survey area. However, judging from the fact that Middle Permian fossils have been discovered in the limestone in the survey area, and from the characteristics of the rock facies, for this survey Permian system is taken to be widely distributed in these zones, and distribution of Silurian-Devonian-Carboniferous strata is limited to the southwest of the survey area which has undergone relatively strong metamorphism and deformation. Also, distribution of Permo-Triassic volcanic rock is limited to the southeastern tip of the survey area.

There are many relatively small-scale granite and diorite bodies. The largest has a size of around 2 x 8 km and is found in the mountainous region between Huai Mae Thot and Huai Mae Tia. It has been confirmed that sedimentary rock around the granite has frequently undergone contact metamorphism, showing that the granite is intrusive. It is assumed that the intrusive direction of the granite is N-S or NW-SE, and this harmonizes with the geologic structure of the surrounding sedimentary rock and the direction of the faults. The age of the granite in the survey area is not clear, but judging from the fact that the granite intruded into Permo-Triassic strata and that the granite in the environs of the survey area has been reported to have an age of 205 to 236Ma by Rb-Sr radiometric dating, it is thought to belong to the Later Triassic. The order of intrusion of the granite and diorite is, however, not clear.

The geologic map and schematic geologic column of the Doi Chong area are shown in Figs. 29 and 30.

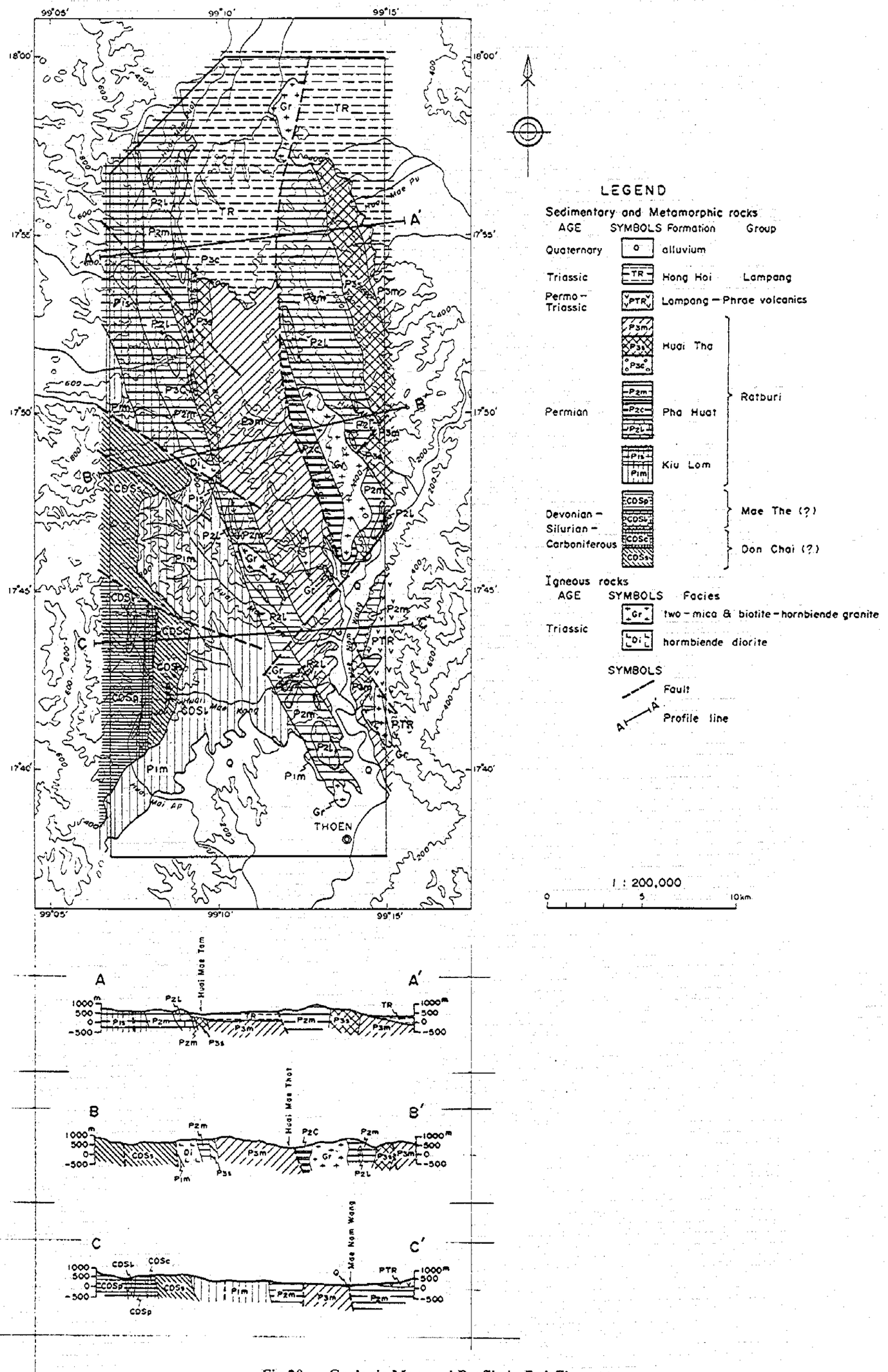


Fig.29 Geologic Map and Profile in Doi Chong Area

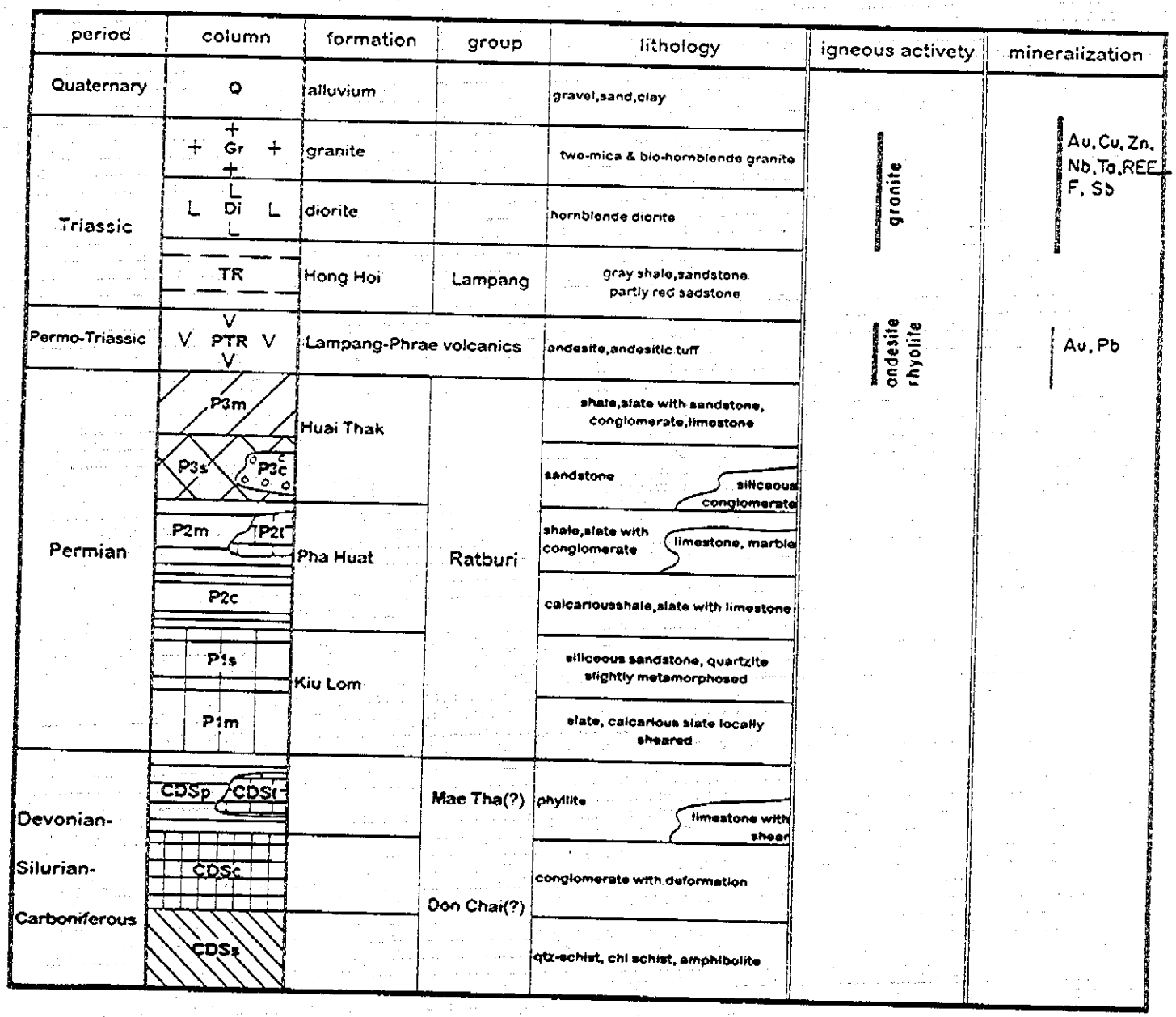


Fig.30 Schematic Geologic Column in Doi Chong Area

2-1-2 Detailed Geology

(1) Silurian-Devonian-Carboniferous rocks (CDS)

The Silurian-Devonian-Carboniferous in the survey area is composed of crystalline schist (CDSs) such as quartz-mica schist, quartzite and chlorite-schist, conglomerate (CDSc) which has undergone deformation, phyllite (CDSp) and limestone (CDSl). From the characteristics of the rock facies, it can be correlated to Carboniferous Mae Tha group or Siluro-Devonian Donchai Group. This stratum is distributed on the west of the Permian and is thought to have a discordant relationship, or in some part s a fault relationship, with the Permian.

Two types of crystalline schist (CDSs) are mainly seen, siliceous schist and basic schist. The former includes quartz-mica schist, quartz schist, etc. and is intercalated with seams of pelitic schist, limestone, meta-conglomerate and chlorite-schist. The basic schist includes chlorite-schist, amphibole, etc. and the primary rock is taken to be basic tuff or massive basic lava, etc. It displays a pale green to green color and sometimes contains pyrite.

The conglomerate (CDSc) includes gravels of limestone and quartz with a diameter of around 5 to 15cm. It has undergone complete deformation, mica has formed on the matrix and a schistose plane has developed.

The phyllite (CDSp) shows a grayish-white to white color and is accompanied by muscovite, etc. A planar structure has developed and peels off easily like leaves. On rare occasions it is intercalated with extremely fine sandstone and limestone.

The limestone (CDSl) is distributed as small rock bodies in the phyllite or quartz-mica schist. It displays a white to grayish-white color and is crystalline. It has undergone complete deformation, and some has a weak planar structure and some shows a gravely form. The limestone distributed in this stratum is characterized by having undergone deformation and by a total lack of Fusulinidae, and this distinguishes it from Permian limestone.

(2) Permian Ratburi Group

Ratburi Group can be generally classified into Kiu Lom Formation (P1), Pha Huat Formation (P2) and Huai Thak Formation (P3). Kiu Lom Formation consists mainly of mudstone, shale and sandstone and is characterized by having undergone shearing deformation. Pha Huat Formation is accompanied by many limestone bodies and is composed of shale, calcareous shale. Huai That Formation consists of shale and sandstone with limestone seams.

The rock facies of Ratburi Group in the survey area are mainly composed of shale, slate, sandstone, conglomerate, calcareous shale and limestone, etc. These rock facies have gradually changed, making classification into the strata mentioned above difficult, but the limestone bodies and shale surrounding them, distributed almost continuously arranged in zones from the southeast

tip to the northwest tip of the survey area, correlate to Pha Huat Formation. Also, the shale stratum distributed to the west of the Pha Huat Formation, which is accompanied by a sandstone layer and phyllite and has undergone weak metamorphism, is thought to correlate to Kiu Lom Formation, and the stratum distributed to the east, which consists mainly of shale, is thought to correlate to Huai Thak Formation.

(3) Lampang-Phrae Volcanic Formation (PTR)

This formation is widely distributed in the mountainous region on the left bank of Mae Nam Wang, but only slight distribution is seen at the southeast tip of the survey area. It is thought to have unconformably covered the lower Permian system. The rock facies are andesite, pale green to greenish gray tuff, tuffceous shale, etc. Intrusive bodies of granite are seen in this formation and andesite around the granite has undergone slight thermal metamorphism.

(4) Hong Hoi Formation (TR)

This formation is widely distributed in the north of the survey area and has formed gently-sloping basins and hilly regions. The rock facies consists of sandstone, shale and alternation of sandstone and shale and sandstone is dominant. It has a generally unconformable relationship with the underlying Permian, but is thought to have been bordered by a reverse fault running N-S in the Huai Mae Haet basin. Both the bedding plane and the cleavage plane run NNE-SSW, show a high-angle western dip and resemble the geologic structure of the Silurian-Devonian-Carboniferous and Permian. The sandstone is medium to coarse grained and generally shows a gray to grayish-white color, but red to dark brown is also seen. In many cases it has undergone heavy weathering and is rather soft. The shale displays a gray to pale gray color. Some shows a fold structure on a NW-SE axis. Granitic intrusives are seen in this formation, but no thermal effects of the rocks surrounding the granites is evident.

(5) Intrusive rocks

Nine intrusive bodies of varying size are seen in the survey area. Only one of these is dioritic, but most of the intrusives are granite.

Granite (Gr): The intrusive direction of the granite is mainly N-S or NW-SE and is thought to have been controlled by the surrounding geologic structure or the direction of the fault. The intruded horizon is Permian, Permo-Triassic or Triassic and it has caused contact metamorphism of the Permian and Permo-Triassic.

The rock facies are biotite granite, biotite-muscovite granite, muscovite granite, muscovite granite porphyry, etc. They are generally leucocratic. The fine grain leucocratic rock containing hardly any colored minerals is also seen, especially in the periphery of their bodies. The susceptibility of the granites is low, showing a value of 0.04 to 0.06 x 10^{-3} S.I. unit, and they are

thought to belong to the ilmenite series.

Diorite (Di): Diorite is distributed in the uppermost reaches of Huai Mae Toen. It is composed of diorite containing amphibole and pyroxene, and quartz-diorite, and in many parts it has undergone cataclastic action. In addition to a wide-ranging silicified zone that has formed in the environs of the rock bodies, the rock bodies themselves have undergone dissemination of molybdenite, pentlandite, etc.

(6) Alluvial deposits (Q)

This is distributed in the Mae Nam Wang basin and on the flat land in the south of the survey area. It is composed of unconsolidated gravel and sand.

2-1-3 Geologic Structure

There are assumed to be faults running NW-SE, N-S and NE-SW in the survey area. The direction of the bedding and cleavage planes of the strata in the vicinity of the NE-SW fault along Mae Nam Wang and the NW-SE fault in the upper reaches of Huai Mae Toen inclines to the direction of the fault. It is assumed that in the case of the other faults too, taking the fault as the boundary, the geology is not continuous. In particular, the faults along the Huai Mae Thot running NNW-SSE to N-S are assumed to be relatively large-scale reverse faults.

The geologic structure of the Silurian-Devonian-Carboniferous and Permian runs in a NNW-SSE direction and the upper stratum overlaps facing northeast on the whole. Permo-Triassic volcanic rocks and Triassic system are also distributed covering them unconformably. According to the fault along Huai Mae Thot, it is, however, thought that the eastern side of the fault has risen relatively, and with the fault as the boundary, the subordinate Permian layer is exposed.

Schistosity and cleavage planes of varying degrees are seen in most of the sedimentary rocks in the survey area, and on the whole the planar structure runs NNW-SSE to N-S. It is known that the environs of the survey area underwent wide-ranging deformation in Carboniferous time and there is marked development of schistose planes, phyllitization, conglomerate deformation in the Silurian-Devonian-Carboniferous. The planar structure that is seen in the Permian and Triassic is well developed in the vicinity of the faults, and in addition it has also developed around the granite bodies, accompanied by hornfelsization.

2-1-4 Geochemical characteristics of igneous rock

Whole rock analysis of 14 samples taken in the Doi Chong area was carried out.

As can be seen in Figs. 31 and 32, with the exception of one sample of diorite and one of granite porphyry, the range is narrow with SiO_2=65 to 75%. The behavior of the individual

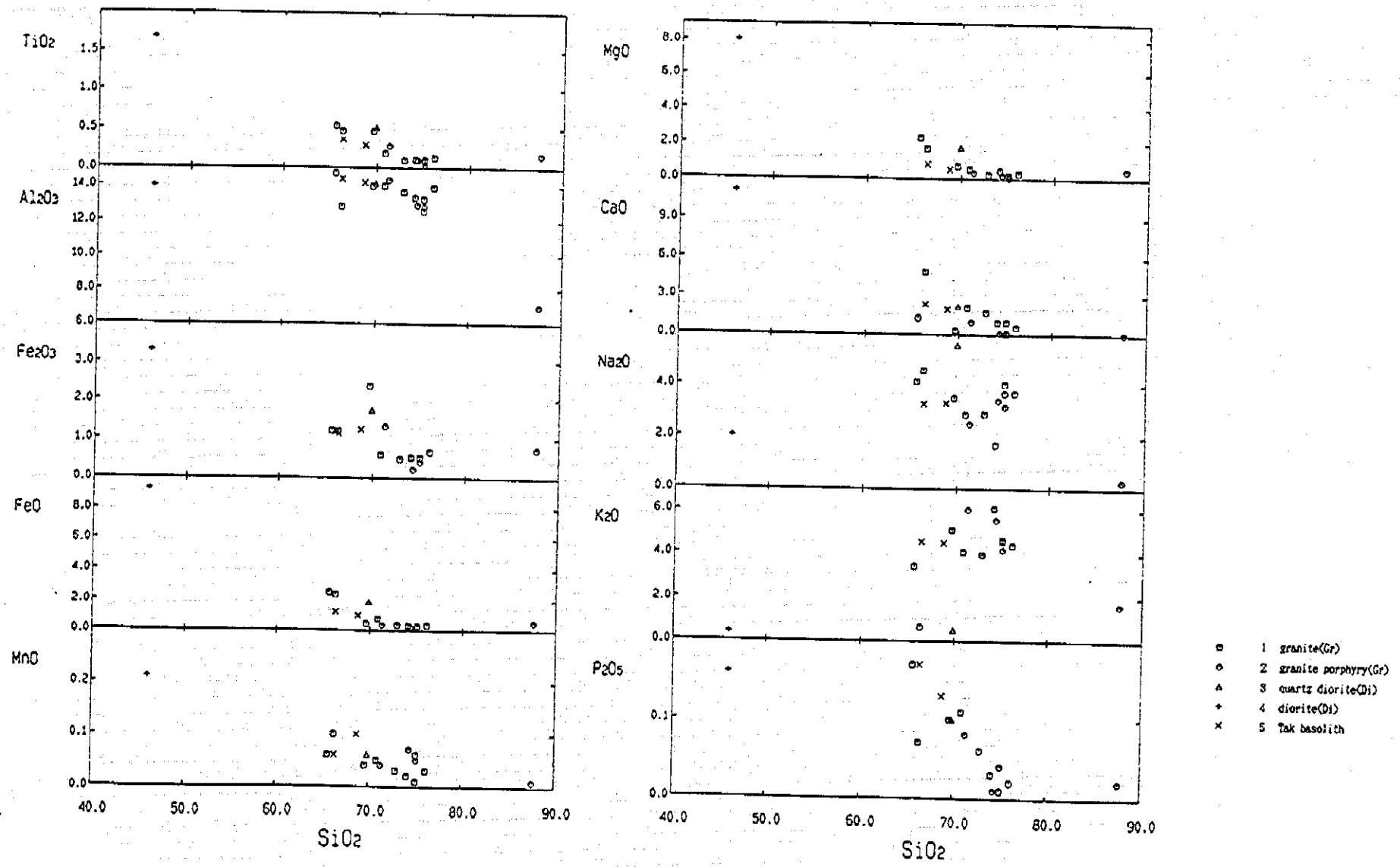
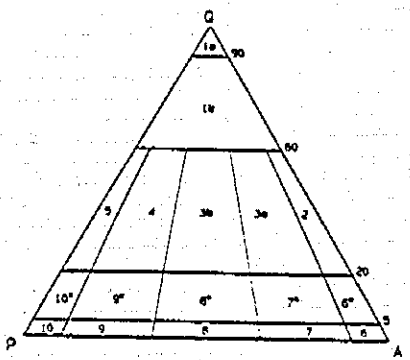


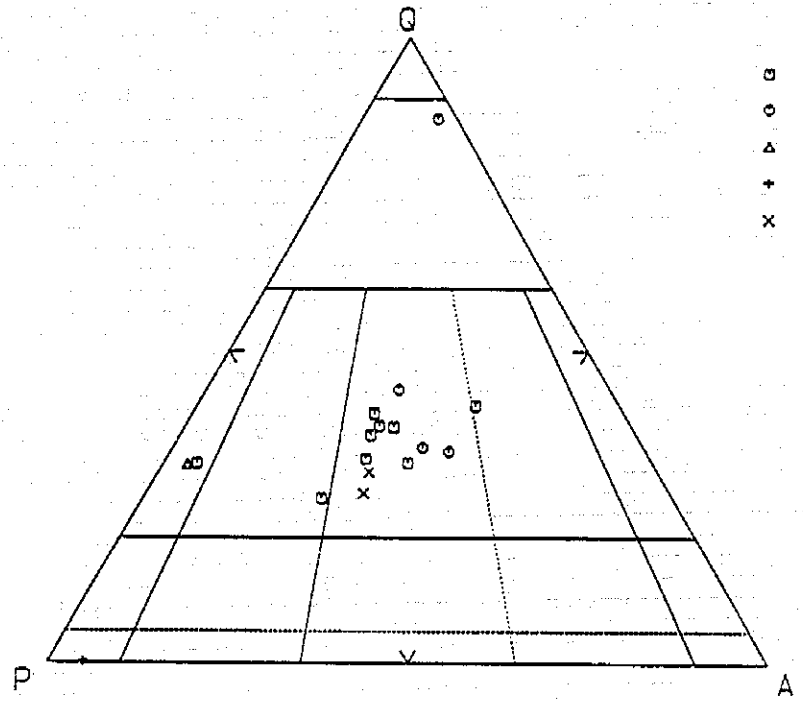
Fig.31 Harker Diagram of Igneous Rocks in Doi Chong Area



Classification of granitic rocks
(IUGS, 1973)

Q—quartz ; A—alkali feldspar (including microcline, orthoclase, sanidine, anorthoclase, and perthites (including their plagioclase components), and plagioclase An=0-5) ; P—plagioclase other than An=0-5; F—feldspathoids (leucite and pseudoleucite, nepheline, sodalite, nosean, hauyne, cancrinite, analcime, etc.

1a, quartzolite (silexite) ; 1b, quartz-rich granitoids ; 2, alkali-feldspar granite ; 3, granite ; 4, granodiorite ; 5, tonalite ; 6*, quartz alkali-feldspar syenite ; 7*, quartz syenite ; 8*, quartz monzonite ; 9*, quartz monzodiorite/quartz monzogabbro ; 10*, quartz diorite/quartz gabbro/quartz anorthosite ; 6, alkali-feldspar syenite ; 7, syenite ; 8, monzonite ; 9, monzodiorite/monzogabbro ; 10, diorite/gabbro/anorthosite



1 granite(Gr)
2 granite porphyry(Gr)
3 quartz diorite(Di)
4 diorite(Di)
5 Tak basolith

Fig.32 Normative Q-P-A Diagram in Doi Chong Area

elements is similar, but the 2 samples of Tak batholith come within the category of basic rocks even in the granite of the Doi Chong Area, and it is observed that the behavior of TiO_2, MgO, Na_2O, etc. is rather different to that of the granite of the Doi Chong Area. Judging from the fact that diorite and quartz diorite form the continuous bodies, they are thought to have derived from one magma, but considering the behavior of MgO, Na_2O, K_2O and P_2O_5, it is clear that their differentiation trend is different to that of granite. This suggests that the original granitic magma and original dioritic magma were clearly different.

In the ACF diagram in Fig.33, the granite porphyry is classified for the most part as S-type, but the granite and diorite are plotted as both S-type and I-type.

In the MFA diagram in Fig.34, the differentiation route of granite in this area conforms well to that of island arc calc-alkali rock series.

2-1-5 Mineral Deposits and Occurrences

A map showing the location of mineral occurrences in the Doi Chong Area is shown in Fig.35.

There used to be 2 fluorite mines in the Doi Chong area. One is situated about 1km north of Ban Mae Toen and is massive ore lying in Permian phyllite, accompanied by argillized zones between the host rocks. The deposit extended for a length of 150m, a depth of 10 to 20m and a vein width of 5 to 20m with ore reserves of 30,000t. Work began on the road way in 1968, but was abandoned following loss of life when the tunnel collapsed around 1987. The other mine is situated in the hilly region 200m east of Wat Mae Keang in Ban Mae Keang. Prospecting was carried out by a Japanese company in 1975, but later the operating rights passed to a Chinese company and it was developed by open cut mining. There are many points concerning the scale of the deposits, etc. that are not clear, but like the deposits at Mae Toen, there was massive ore inside phyllite that bended in a shape along the fault and the bended parts were massive bonanza. At the present time, mining remains extend over an area 100m wide by 300m long.

Old gold mining are distributed in two places, one east of Ban Na Ban Rai and the other on the west side of Wat Tham Suk Kasem Sawan, 2.5km further north. The former is a well-rounded float of quartz veins lying in the flat laterite soil, and there are pits and mounds of excavated ground in the range of 50 x 60m. The highest result obtained in geochemical prospecting of the soil is 477ppb and the gold content is not very high. The latter is a hilly region with a relative height of 20m or less, formed by mica schist and two-mica granite, and enormous quartz vein rocks are scattered over a wide area on the ground surface. After mining the black and gray quartz vein developing mainly in the granite and crushing it with a stamp mill, only the visible golds were collected by panning. Today, the mine is disused because the high-grade quartz veins have been exhausted. Host

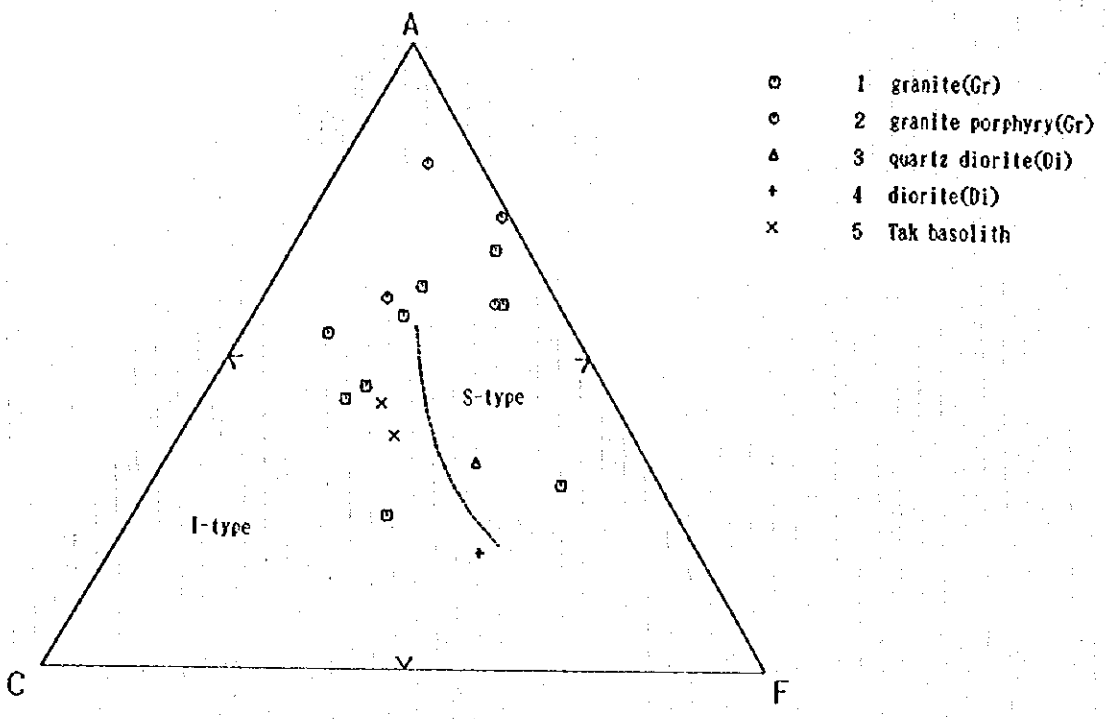


Fig.33 ACF Diagram of Igneous Rocks in Doi Chong Area

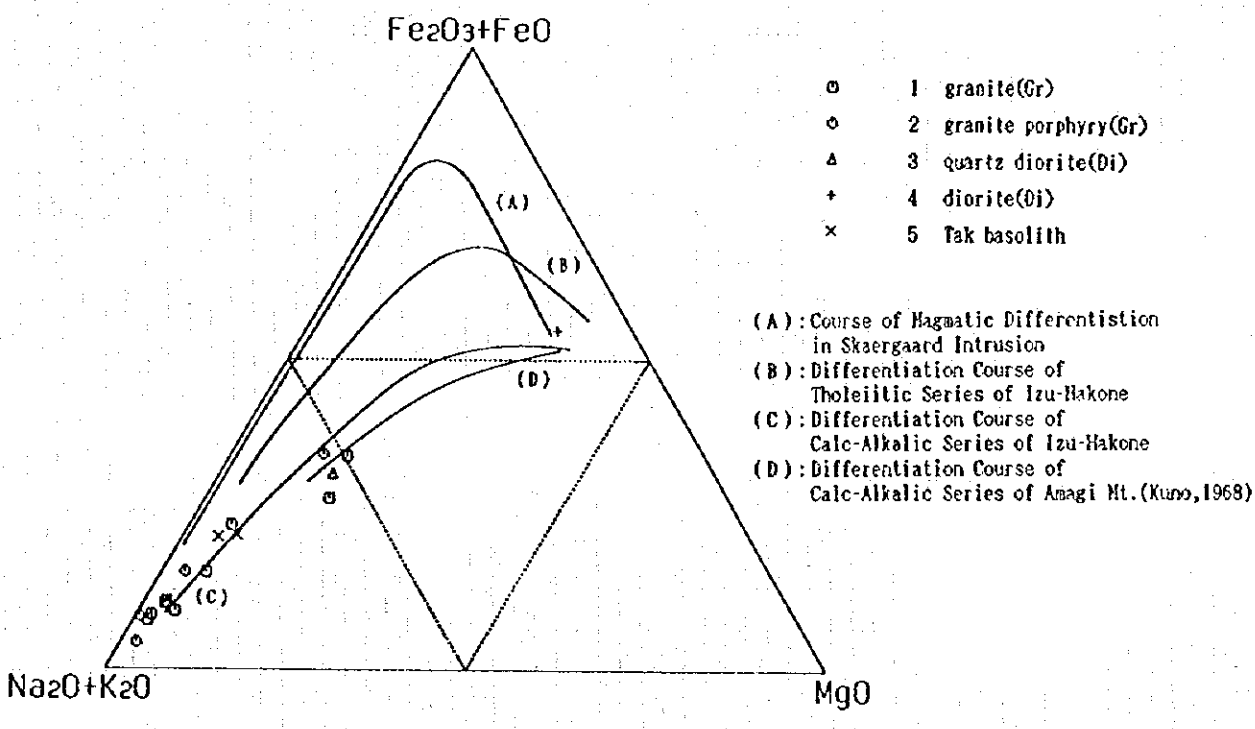


Fig.34 MFA Diagram of Igneous Rocks in Doi Chong Area

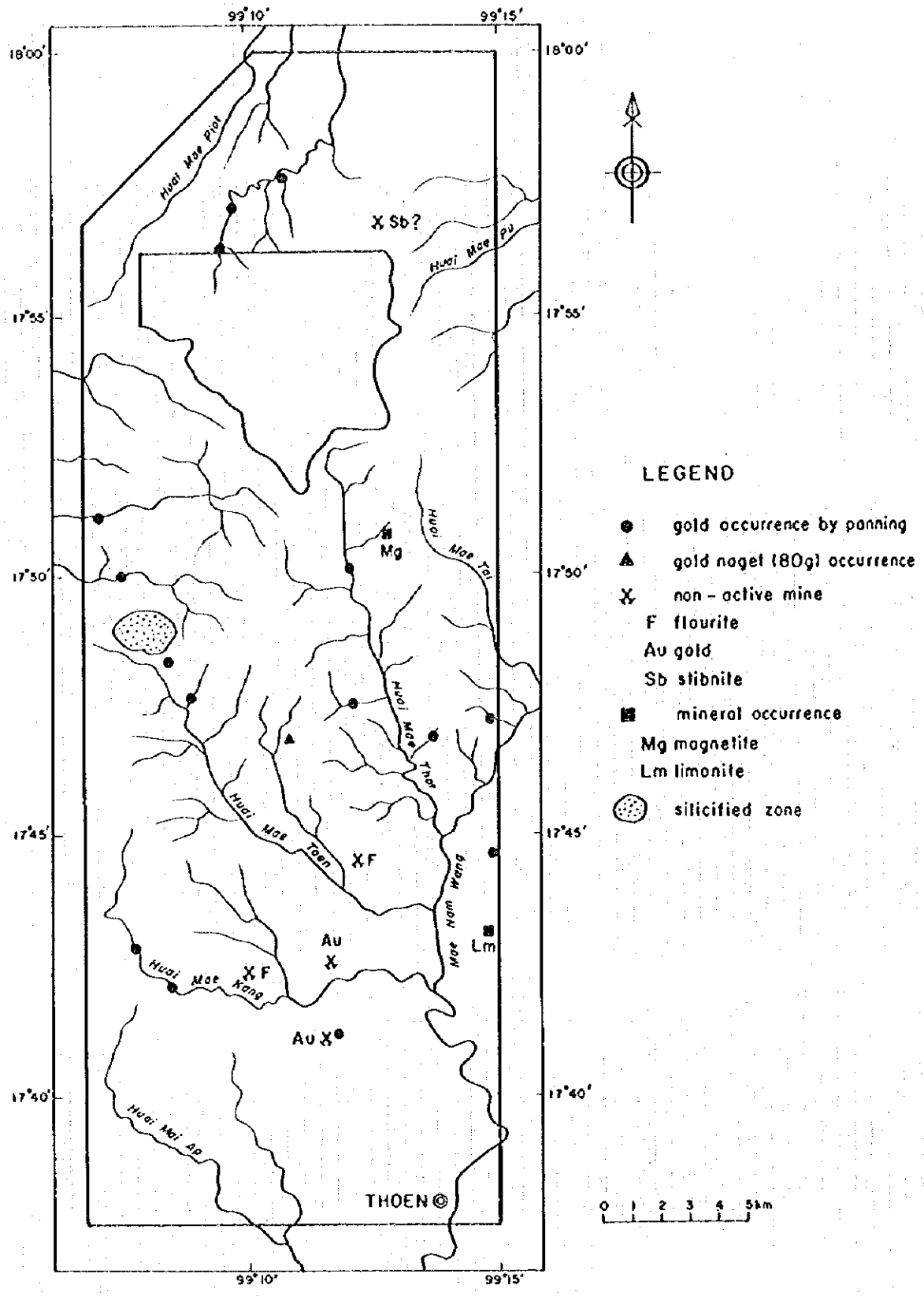


Fig.35 Location Map of Mineral Occurrence in Doi Chong Area

rock granite and quartz veins from the pit were analyzed, but they gave the same results of less than 0.03g/t Au.

In addition, there is known to be magnetite occurrence on the side of Doi Chong on the left bank of the upper reaches of Huai Mae Thot, and limonite occurrence in Huai Hia in the southeast of the region. A careful investigation was carried out within the DMR's narrow range, but it did not lead to development.

According to information obtained from local residents, there used to be antimony deposits near the granite in Huai Mae Haet.

No other mineral occurrence were observed during the field survey, but it was confirmed that there are veins of aplite several meters wide scattered in the Doi Chong Area, accompanied by small-scale silicification nearby. Moreover, large-scale silicified zones are distributed near the diorite in the upper reaches of Huai Mae Toen.

2-2 Geochemical Prospecting

2-2-1 Methodology

Sampling was conducted in the Doi Chong Area in the same way as in the Chiang Khong Area and 623 samples were taken.

S-type granite is known to exist in the Doi Chong Area, and from the fact that occurrence of tin, niobium and tantalum was anticipated, 15 elements were taken as pathfinder elements: Au, Ag, Cu, Pb, Zn, Hg, As, Fe, S, W, Sn, Sb, F, Ta, and Nb. The statistics were processed using the same logarithm values as for the Chiang Khong Area.

2-2-2 Results of the Geochemical Prospecting

The comprehensive map of the Doi Chong area was shown in Fig. 36.

Gold anomaly zones are seen in Huai Mae Pu and Huai Wua Sam Tue in the northeast, and Huai Mae Haet and Huai Mae Tam in the center of the northern region. Gold flakes were confirmed by panning in the vicinity of the anomaly zone in the center of the northern region. Gold anomaly zones in the middle reaches of Huai Mae Toen are distributed in the vicinity of small granite bodies. The anomaly zone in the middle reaches of Huai Mae Thot is situated on the other side of the ridge. It corresponds to the place where local residents discovered an 80g gold nugget. As for the anomaly zones north of Ban Na Ban Rai, there are anomaly zones in the vicinity of where the local people mined for gold, but the extent of gold occurrence is extremely small and is thought to originate in small granite bodies. The anomaly zones in Huai Mae Kaeng in the southwest of the area are distributed in the metamorphic rock distribution zones, and no

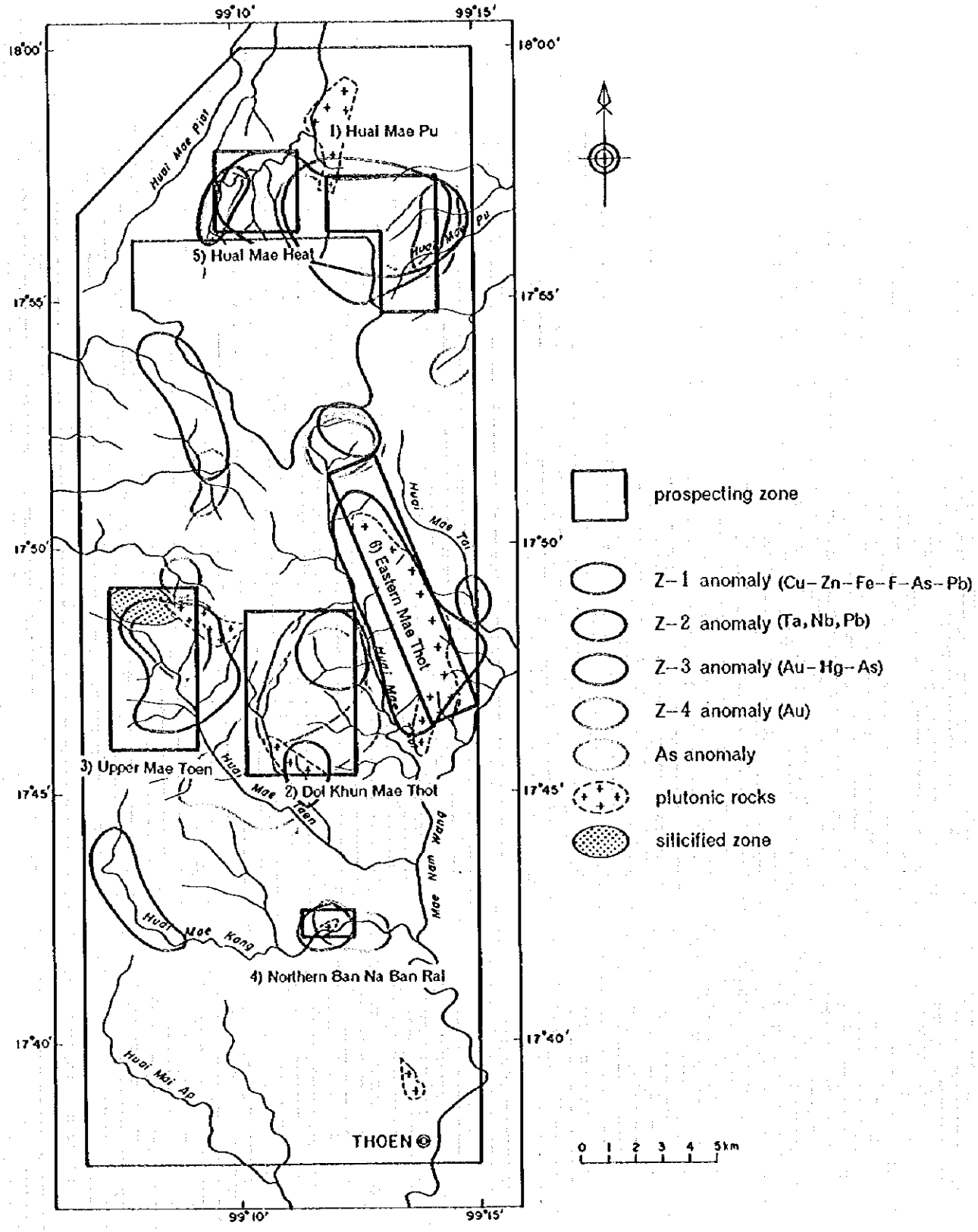


Fig.36 Interpretation Map of Doi Chong Area

mineralized zones such as might be connected with the anomaly zones are particularly seen.

Principal components analysis of 11 of the components, excluding Ag, S, W and Sn for which over 90% of the samples show detection limit values or below, was carried out of the correlation matrices obtained from logarithm values of geochemical analytical values.

First component(Z-1): The factor loadings of Zn, Fe, Cu, F, As and Pb are high, suggesting mineralization of base metals. High score zones are distributed over a wide area, from Huai Mae Tam to Huai Mae Pu in the north of the area, and in the upper reaches of Huai Mae Toen. In addition, high scores are also distributed in Huai Mae Thot, the upper reaches of Huai Mae Kaeng, and in Huai Mae Tid in the east of the area. As the high score zones in Huai Mae Thot and the upper reaches of Huai Mae Kaeng originate in the anomaly zones of As and Fe, no occurrence of base metals can be expected.

Second component(Z-2): The factor loadings of Ta, Nb and Pb are high. It is possible that Pb which coexists with Ta and Nb may be lead from disintegrated uranium, and it is likely that they are accompanied by rare earth elements. This component is thought to show the existence of rare metal and rare earth elements related to granite. The high score zones are concentrated in the vicinity of granite bodies, and high scores are concentrated in particular over a wide area in the vicinity of the granite body on the left bank of Huai Mae Thot. High scores are also distributed on the right bank in the upper reaches of Huai Mae Toen, though covering a small area, and the existence of subsurface granite is assumed.

Third component(Z-3): The factor loadings of Hg, Au and Sb are high, suggesting mineralization of epithermal gold-containing quartz veins and their halos. High score zones are seen in Huai Mae Tam in the north and from Huai Mae Haet to Huai Mae Pu, along the fault running NW-SE in the upper reaches of Huai Mae Bon in the northwest, in the uppermost reaches of Huai Mae Thot, from Huai Krathin to Huai Pun Yang on the right bank of Huai Mae Thot, in the middle reaches of Huai Mae Kaeng, north of Ban Na Ban Rai.

Fourth component(Z-4): Au has a high factor loading by itself and Hg which is closely connected with gold has a negative factor loading. Rather than indicating mineralization of gold, this component is thought to indicate high density distribution of gold (distribution of placer gold) in stream sediment. High scores are seen near where placer gold was confirmed by panning and further upstream.

2-3 Considerations

The geology of the Doi Chong Area is composed, from below, of Silurian-Devonian-Carboniferous Mae Tha Group and Donchai Group, Permian Ratburi Group Kiu Lom Formation,

Pha Huat Formation and Huai Thak Formation, Permo-Triassic Volcanic Formation, Triassic Lampang Group Hong Hoi Formation and Triassic intrusive granite and diorite.

Most of the granites and diorites are relatively small-scale. The largest-scale rock bodies are around 2 x 8m on the left bank of Huai Mae Thot and they are seen in the mountainous region between Huai Mae Thot and Huai Mae Tia. It has been confirmed that the sedimentary rocks around the granite have often undergone contact metamorphism, showing that the granite is intrusive rock. It is assumed that the granites intruded in a N-S or SW-NE direction, harmonizing with the geologic structure of sedimentary rock in the vicinity and with the direction of the fault. The age of the granite in the survey area is not clear, but judging from the fact that the granite bodies intruded into the Permian and Triassic strata and that an age of 205 to 236Ma by Rb-Sr radiometric dating has been reported for granite bodies in the environs of the survey area, they are thought to belong to Late Triassic time.

Schistosity or cleavage planes of varying degrees are seen in the sedimentary rocks in most of the survey area, and the planar structure on the whole runs NNW-SSE to N-S. It is known that the environs of the Doi Chong Area underwent widespread deformation in Carboniferous time, and the Silurian-Devonian-Carboniferous show marked development of schistose planes, phyllitization, conglomerate deformation, etc. Moreover, in addition to development of planar structures seen in the Permian and Triassic in the vicinity of the fault, development is accompanied by hornfelsization in the vicinity of the granite bodies.

Sedimentary rocks and metamorphic rocks older than the Permian are prevalent in the Doi Chong Area. Its consolidation is high. Mineralization and alteration is considered difficult to occur in it. In fact, no argillization and other alteration has been observed. However, quartz veins have developed accompanied by small-scale silicified zones in the environs of granite bodies and small veins of aplite. Also, large-scale silicified zones are distributed around the diorite in the upper reaches of Huai Mae Toen.

According to the results of geochemical prospecting, a high score zone for the first component (Z-1) which indicates mineralization of base metals is seen running E-W from Huai Mae Tam to Huai Mae Pu in the north. This high score zone can be divided into the region between Huai Mae Tam and Huai Mae Haet where mineralization of base metals can be expected, and the region between Huai Mae Haet and Huai Mae Pu, overlapping the high score zone of the third component (Z-3), where medium to epithermal poly-metal vein deposits can be anticipated. The high score zone which covers a wide area in the upper reaches of Huai Mae Toen is distributed around diorite. The high score zones in the north are accompanied by anomaly zones for gold, but there are no anomaly zones for mercury or arsenic and the deposits are thought to be high temperature contact

replacement deposits. There are also high values for mercury and arsenic in the south, and hydrothermal vein deposits can be expected. Judging from the fact that anomaly zones of niobium, tantalum and fluorine are also distributed in the region to the south, the existence of subsurface granite is presumed. Judging from the distribution of anomaly zones for individual elements, the high score zone in Huai Mae Tid in the east of the region indicates promising high temperature type base metal deposits. The second component (Z-2) suggests the existence of rare metal and rare earth deposits of niobium and tantalum, and especially in the environs of granite bodies on the left bank of Huai Mae Thot, there is a strong possibility of the existence of primary and placer deposits. The third component is thought to show the existence of hydrothermal gold deposits, and in addition to the region between Huai Mae Haet and Huai Mae Pu which overlaps the Z-1 high score zone, high scores are also distributed in promising mineral regions in the upper reaches of Huai Mae Kaeng in the southwest, the upper reaches of Huai Mae Bon in the northwest, the uppermost reaches of Huai Mae Thot, from Huai Krathing on the left bank of Huai Mae Thot to Huai Pun Yang, and north of Ban Na Ban Rai. Taken together with the fourth component which shows the existence of gold, the high score areas in the upper reaches of Huai Mae Bon and in Huai Mae Kaeng give strong indications of mercury and are likely to indicate the overburden of deposits. As for the high score zone from Huai Krathing to Huai Pun Yang, judging from the distribution of individual element anomaly zones for Z-4 and fluorine which is thought to be a halo for prospective gold deposits, the promising mineral zone extends as far as Huai Mae Toen, centering on Doi Khun Mae Thot. The region north of Ban Na Ban Rai has actually been excavated and there is scope for prospecting. Mineralization in the Doi Chong Area is thought to be mainly connected with Triassic plutonic rocks.

From the above, the following regions have been selected as promising mineral deposit regions in the Doi Chong Area: the Huai Mae Pu region where vein type deposits of gold and base metals can be expected, the Huai Mae Haet region and the upper reaches of Huai Mae Toen where there is a high possibility of the existence of base metal deposits, the Doi Khun Mae Thot mountainous region and the region north of Ban Na Ban Rai where hydrothermal gold deposits can be expected, and the region east of Huai Mae Thot where rare metal and rare earth deposits can be expected.

CHAPTER 3 RATCHABURI AREA

3-1 Geology

3-1-1 General Geology

The Ratchaburi Area is composed of Ordovician Thung Song Group, Silurian-Devonian Kanchanaburi Group (SD), Huai Phu Ron Formation (Ch) and Kao Phra Formation (Ck) of the Devonian-Carboniferous Kaeng Kranchan Group, and granites that have intruded into in Jurassic-Cretaceous age. Thick stream sediments have accumulated along each river and were once excavated as secondary tin deposits.

The geologic map and schematic geologic column of the Ratchaburi Area are shown in Figs.37 and 38.

3-1-2 Detailed Geology

(1) Ordovician Thung Song Group (Ot)

The Thung Song Group is distributed in granite roof pendant form in Huai Takua Pit Thong, north of the Ratchaburi Area. The rock facies mainly consist of slate with seams of calcareous mudstone and limestone. Overall it has undergone intense thermal metamorphism due to the granite.

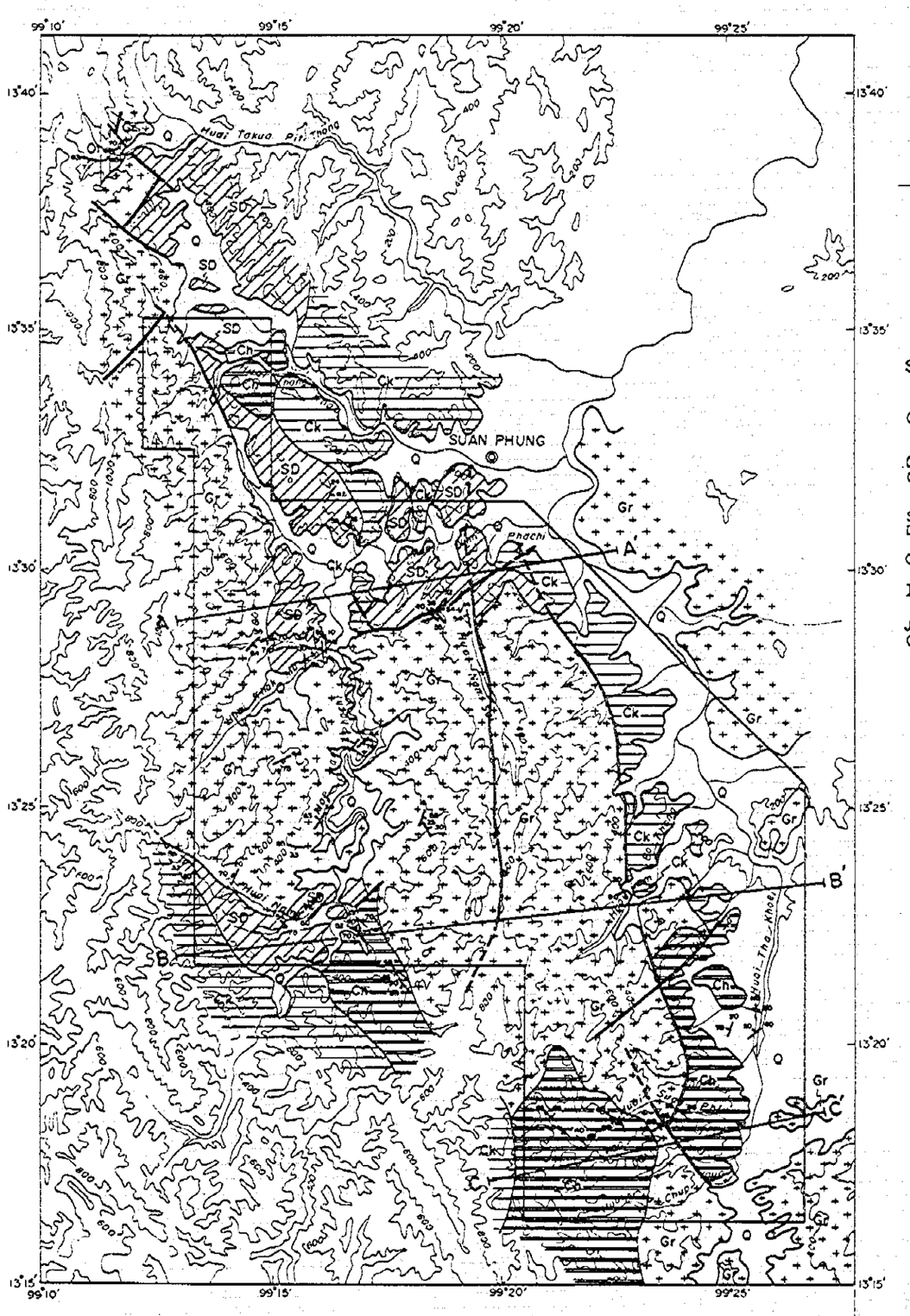
(2) Silurian-Devonian Kanchanaburi Group (SD)

The Kanchanaburi Group is distributed in Huai Nam Nak in the upper reaches of Mae Nam Phachi, in the basin of Huai Bo Khlung, a tributary of Mae Nam Phachi in the northwest of the area, and in the region south of Amphoe Suan Phung where the district office is located. It is composed of alternation of quartzite, phyllite and mica schist. The schistose structure is well developed on the whole. Especially in the contact zone with granite, the schistose structure is clear and the schist has a granoblastic texture.

(3) Devonian-Carboniferous Kaeng Krachan Group

The Kaeng Krachan Group consists of the Huai Phu Ron Formation (Ch) which is composed of quartzite and slate, and the Kao Phra Formation (Ck) which is characterized by mudstone containing gravels.

Huai Phu Ron Formation (Ch): The Huai Phu Ron Formation is distributed in the basin of Huai A Na in the upper reaches of Mae Nam Phachi at the southwestern tip of the area, in Huai Khang Khao in the north of the area, and in the upper reaches of Huai Tha Khoei in the southwest of the area. It is composed of massive dark gray quartzite, dark gray or black slate, calcareous shale, hornfels and spot schist which shows preferred orientation. Compared with the Kanchanaburi



LEGEND

Sedimentary rocks

AGE	SYMBOLS	Formation	Group
Quaternary	Q	alluvium, terrace, debris	
Devonian – Carboniferous	Ck	KHAO PHRA	KAENG KRACHAN
	Ch	HUAI PHURON	KAENG KRACHAN
Silurian – Devonian	SD		KANCHANABURI
Ordovician	Ot		THUNG SONG

Igneous rocks

AGE	SYMBOLS	Facies
Jurassic – Cretaceous	Gr	two-mica granite with pegmatite quartz vein

SYMBOLS

- Fault
- Strike and dip of bedding
- Strike and dip of slaty clvage
- Strike and dip of joint plane
- Strike and dip of quartz vein
- A — A' Profile line

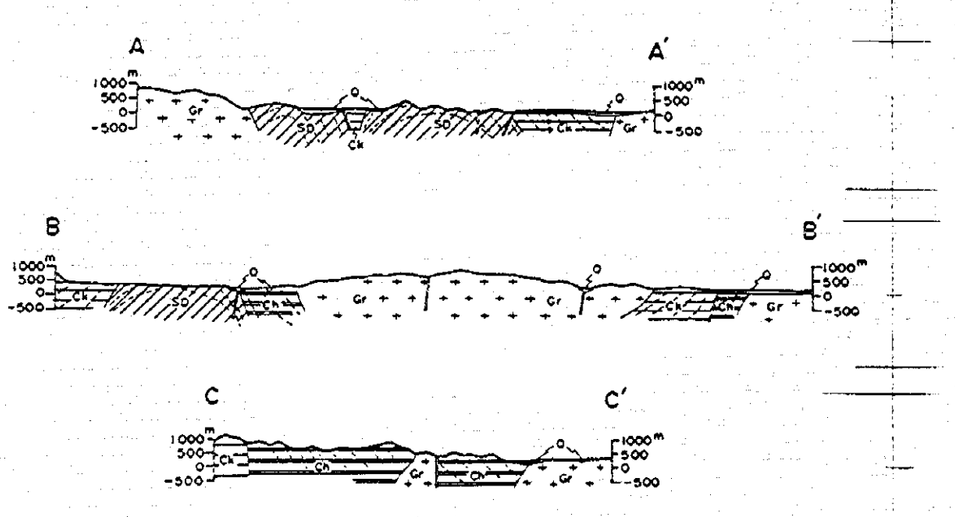


Fig.37 Geologic Map and Profile in Ratchaburi Area

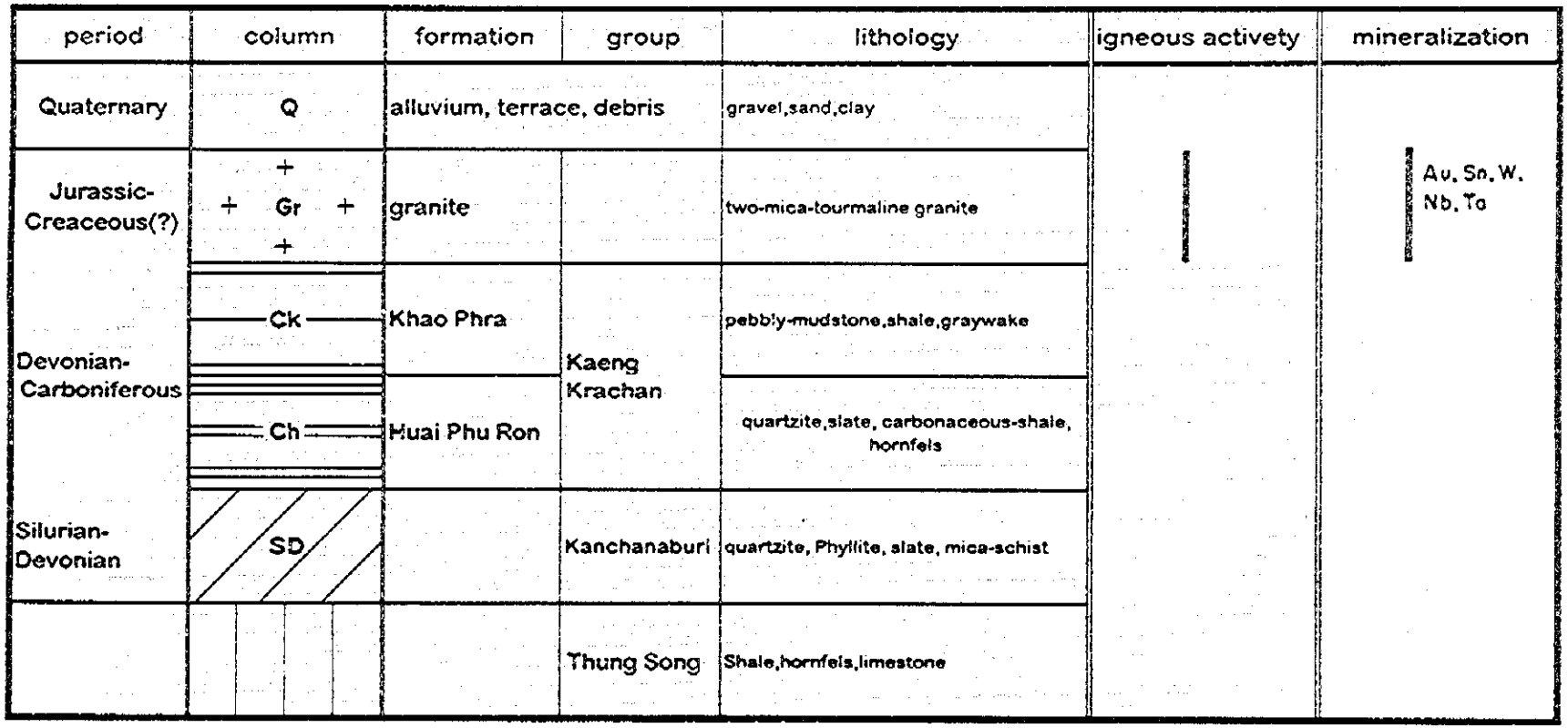


Fig.38 Schematic Geologic Column in Ratchaburi Area

Group, the schistose structure is weak, but a weak schistose structure is observed in various places.

Kao Phra Formation (Ck): The Kao Phra Formation is distributed along the outer edge of the granite on the east side of the survey area. The Kao Phra Formation is composed of mudstone which contains gravel of varying diameters, shale which is characterized by sandstone and shows slaty cleavage and shell-shaped fractures, graywacke sandstone and calcareous sandy shale, etc. The mudstone which contains gravel and the sandstone are mainly massive, but slumping structure and cross lamina are seen.

(4) Jurassic-Cretaceous Granite (Gr)

Granite distribution extends over the greater part of the area. It is divided into two bodies, one on either side of the alluvial lowlands of Huai Tha Khoei, but no difference in rock facies is seen.

Phenocrysts of potassic feldspar are seen in some parts in the medium to coarse two-mica (-tourmaline) granite. Hardly any rock facies changes are seen, but pegmatite, aplite and quartz veins are found scattered around the granite bodies.

(5) Quaternary sediment (Q)

Quaternary sediments have developed in the vicinity of where Huai A Na and Huai Nam Nak converge in the upper reaches of Mae Nam Phachi in the southwestern tip of the area, where Huai Bo Khlung, a tributary of Mae Nam Phachi, and Mae Nam Phachi converge in the northwest of the area, and in the Huai Tha Khoei basin in the east of the area. They consist of unconsolidated gravel, clay, silt, etc. and the stratum is around 8 to 20m in thick (Suthakorn & Udomporwirat, 1991).

3-1-3 Geologic Structure

The sedimentary rock structure is distributed in fragments on account of intrusion of granite, but the schistosity and sedimentary structures display a NW-SE direction and new strata tend to overlap on both sides of the Silurian-Devonian anticline structure.

The granite is part of a massive batholith that intruded along the Thai-Myanmar border and the intrusive direction of the batholith conforms on the whole to the structure of the sedimentary rock. Lineaments running NE-NW to NNE-SSW are clearly seen in the granite area.

3-1-4 Geochemical Characteristics of Granite

Geochemical analysis of 12 samples from the Ratchaburi Area was conducted.

Based on Fig.39, the results obtained from the granite and granite porphyry are in the extremely narrow range of SiO_2=70 to 75% and no major difference is seen for any of the other elements. The range is narrow, but a reduction of TiO_2, Fe_2O_3, FeO, MgO, CaO and K_2O accompanying differentiation is seen as well as a tendency for increased MnO and Na_2O.

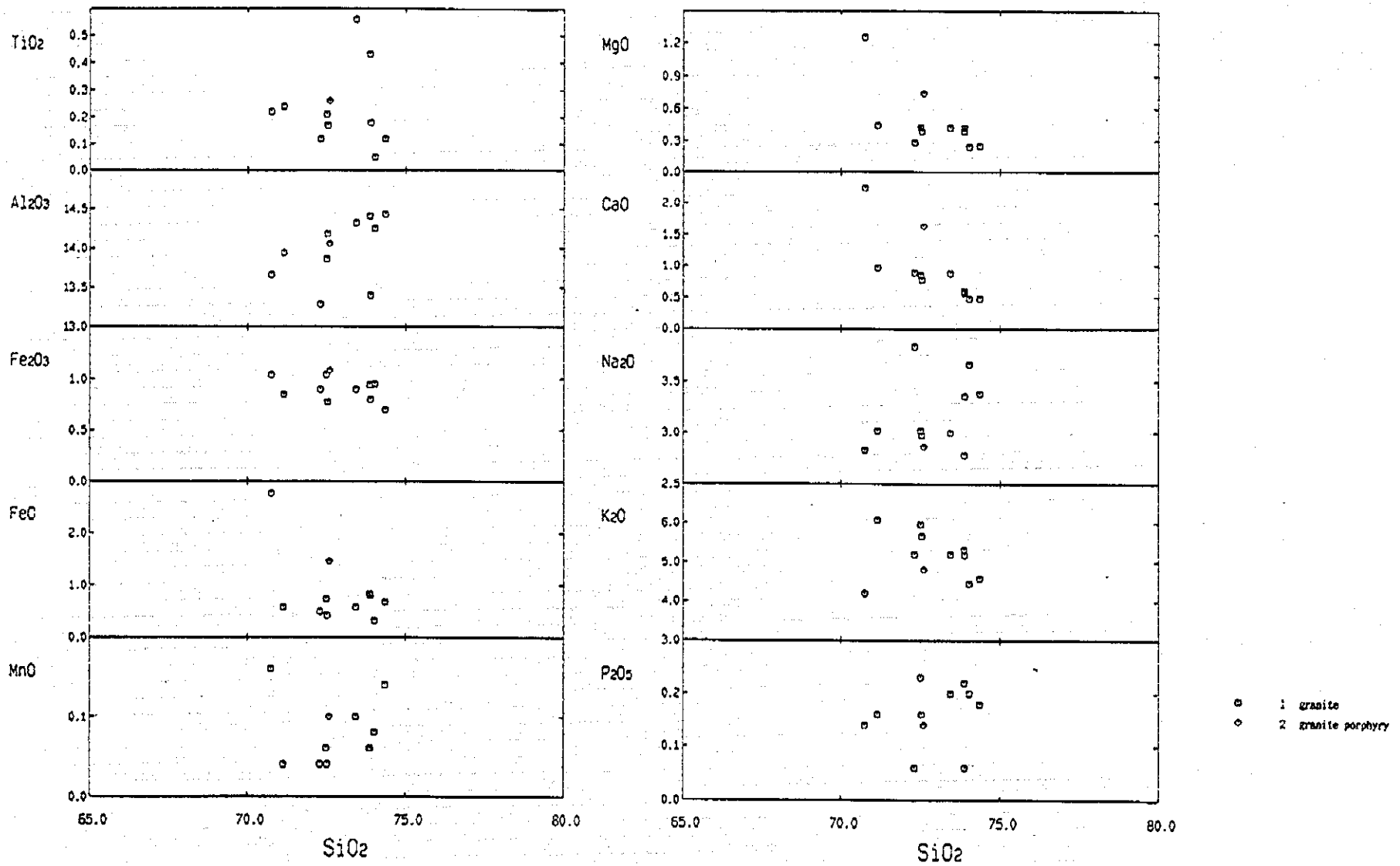
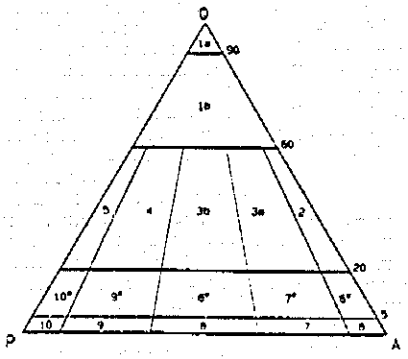


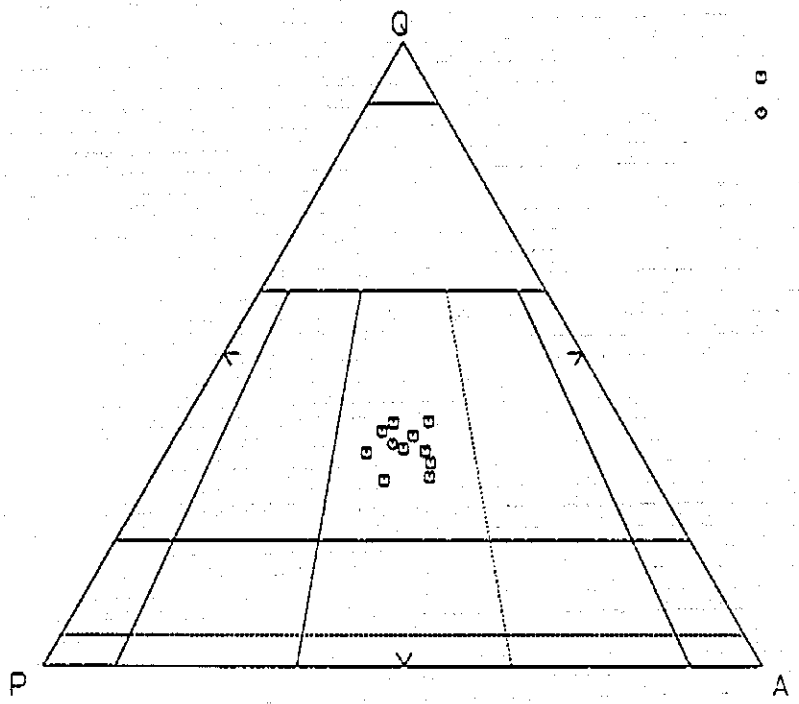
Fig.39 Harker Diagram of Igneous Rocks in Ratchaburi Area



Classification of granitic rocks
(IUGS, 1973)

Q—quartz ; A—alkali feldspar (including microcline, orthoclase, sanidine, anorthoclase, and perthites (including their plagioclase components), and plagioclase An=0-5) ; P—plagioclase other than An=0-5; F—feldspathoids (leucite and pseudoleucite, nepheline, sodalite, nosean, hauyne, cancrinite, analcime, etc.

1a. quartzolite (silexite) ; 1b, quartz-rich granitoids ; 2, alkali-feldspar granite ; 3, granite ; 4, granodiorite ; 5, tonalite ; 6* quartz alkali-feldspar syenite ; 7* quartz syenite ; 8* quartz monzonite ; 9* quartz monzodiorite/quartz monzogabbro ; 10* quartz diorite/quartz gabbro/quartz anorthosite ; 6, alkali-feldspar syenite ; 7, syenite ; 8, monzonite ; 9, monzodiorite/monzogabbro ; 10, diorite/gabbro/anorthosite



1 granite
2 granite porphyry

Fig.40 Normative Q-P-A Diagram in Ratchaburi Area

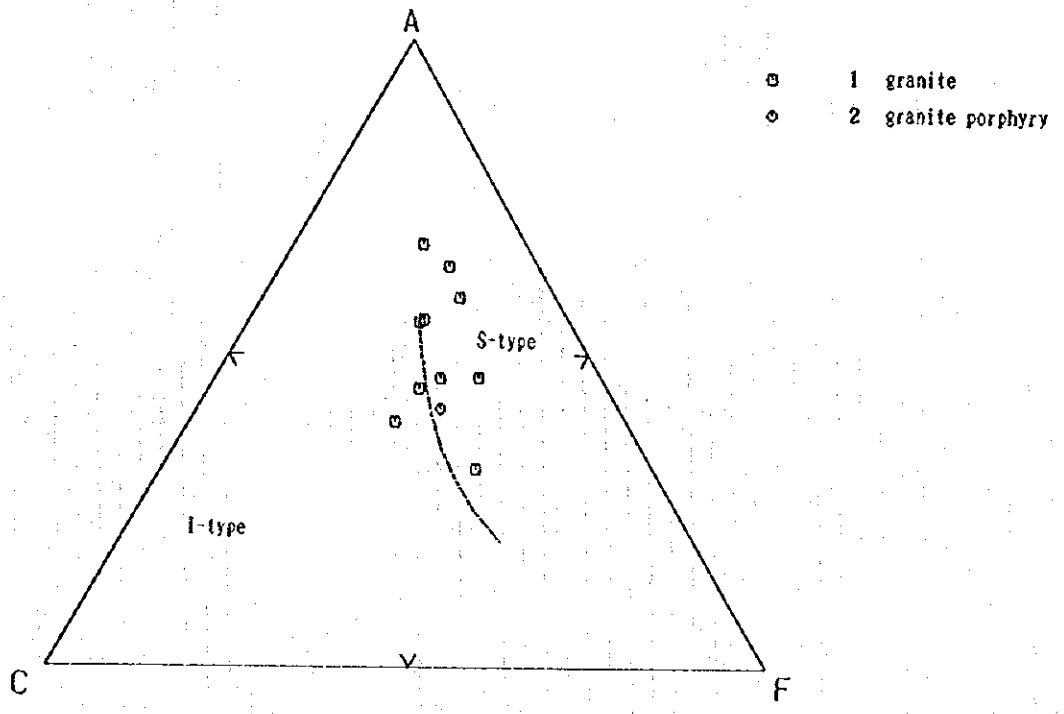


Fig.41 ACF Diagram of Igneous Rocks in Ratchaburi Area

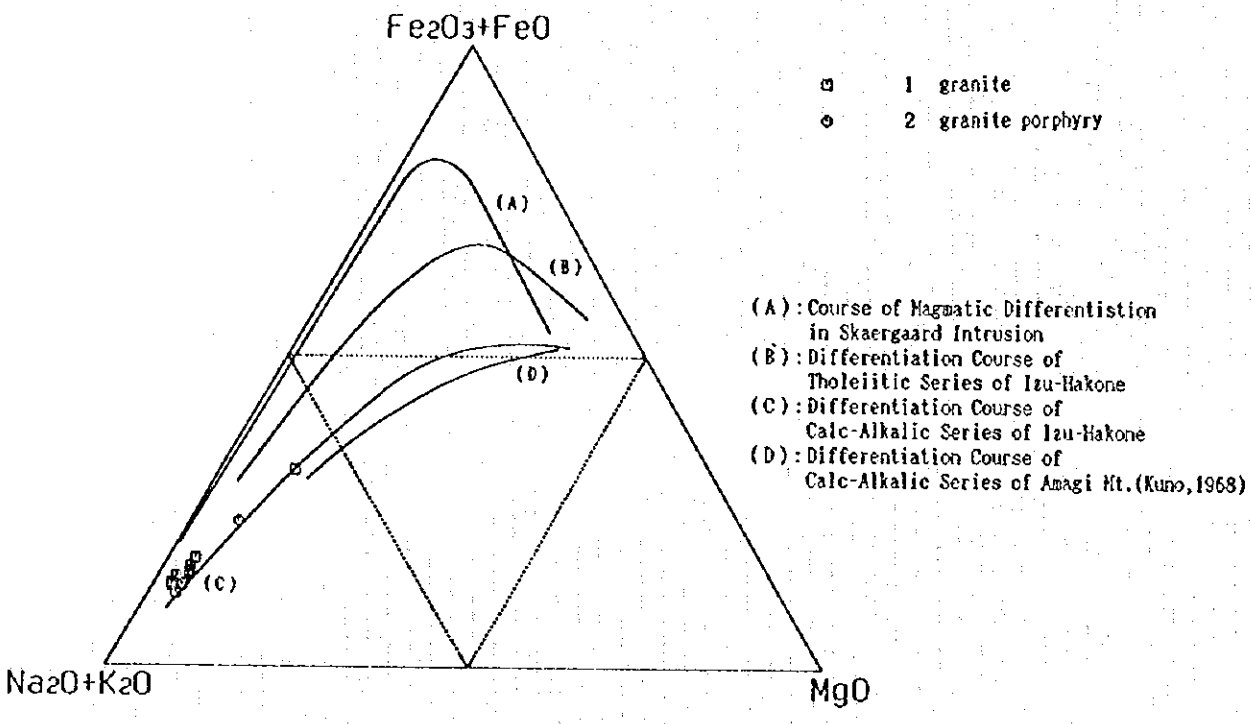


Fig.42 MFA Diagram of Igneous Rocks in Ratchaburi Area

In the QPA diagram in Fig.40, all the granites are classified into "granite" in a narrow sense. Furthermore, in the ACF diagram(Fig.41), although some of the samples are plotted as I-type, but they are generally classified as S-type. In the MFA diagram(Fig.42), the differentiation trend of the granite conforms closely to that of island arc calc-alkali rock series.

3-1-5 Mineral Deposits and Occurrences

The location of mineral occurrences in the Ratchaburi Area is shown in Fig.43.

Tin was long excavated in the Ratchaburi Area and in addition to secondary placer deposits, there were primary tin deposits with pegmatite, greisen, etc. In the late 1980s deposits were found in about 40 places. Today all the mines have closed and pegmatite feldspar is mined in only one place.

As for the tin mining zone along the Thai-Myanmar border region which includes the Ratchaburi Area, there is not only a clear concentration of high values for tin, but the region was also well known for gold.

Mineralization of tin and gold in the Ratchaburi Area is limited to the boundaries between granite and meta-sedimentary rock. Tin occurs pegmatite and greisen which develop in and around the granite bodies, and within quartz veins in the granite and sedimentary rock, but the origin of gold is still not clear.

In this survey, no clear quartz veins were found in the granite, but quartz veins of between about several to less than 20cm are prolific in the sedimentary rocks around the granite. No hydrothermal alteration is present around the quartz veins.

3-2 Geochemical Prospecting

3-2-1 Methodology

Sampling was carried out in the Ratchaburi Area in the same way as in the previous two areas. 530 samples were taken. However, as old secondary tin mines are distributed in many places along the main river in the area and there were fears of geochemical pollution, as far as possible samples were collected away from the remains of secondary deposits.

The Ratchaburi area has long been a tin deposit region and deposits of tin accompanied by unexplored niobium, tantalum and tungsten, can also be expected. 15 elements were taken as pathfinder elements: Au, Ag, Cu, Pb, Zn, Hg, As, Fe, S, W, Sn, Sb, F, Ta and Nb. The statistics were processed using the same logarithm values as for the Chiang Khong and Doi Chong Areas.

3-2-2 Results of the Geochemical Prospecting

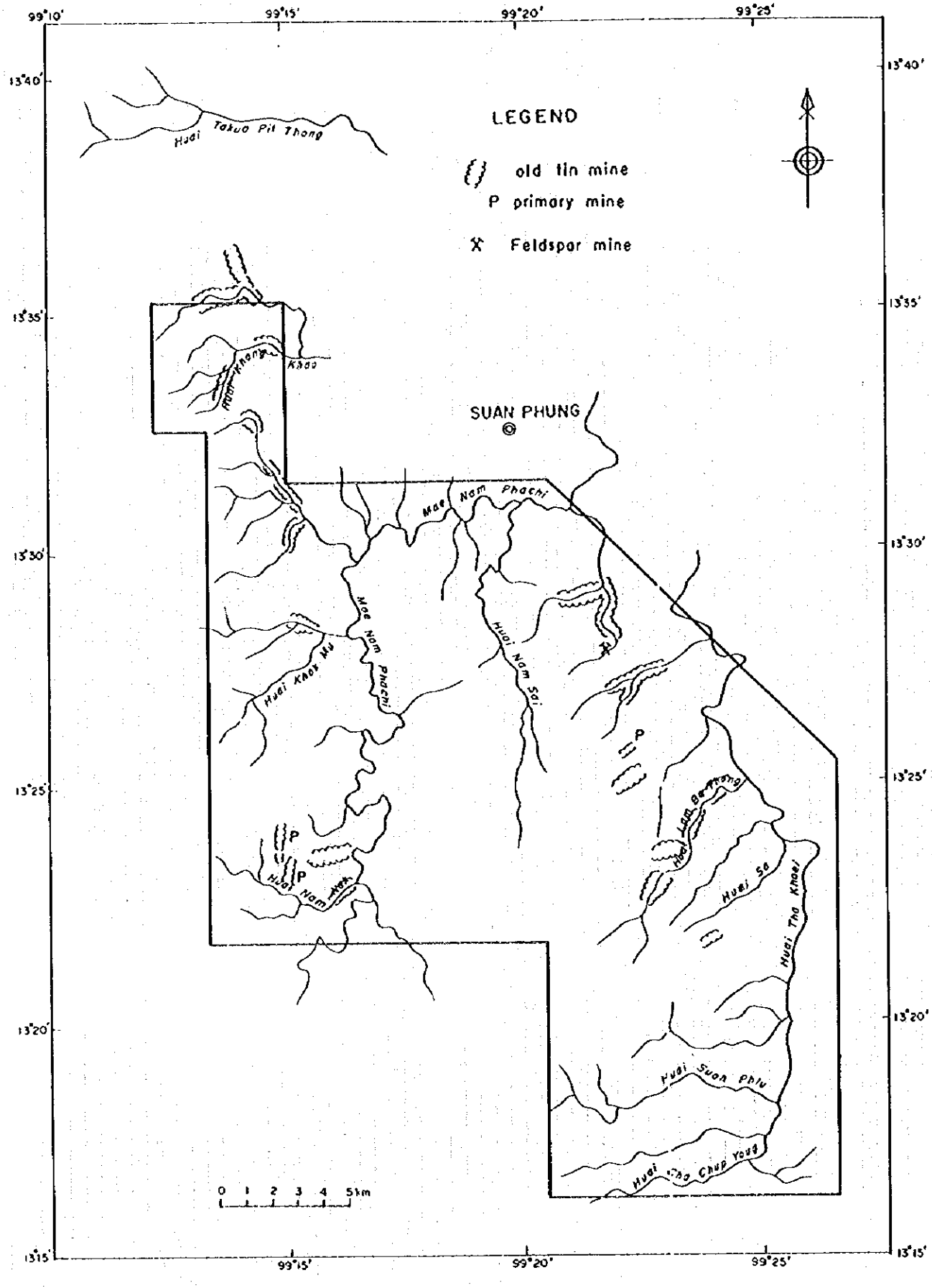


Fig.43 Location Map of Mineral Occurrence in Ratchaburi Area

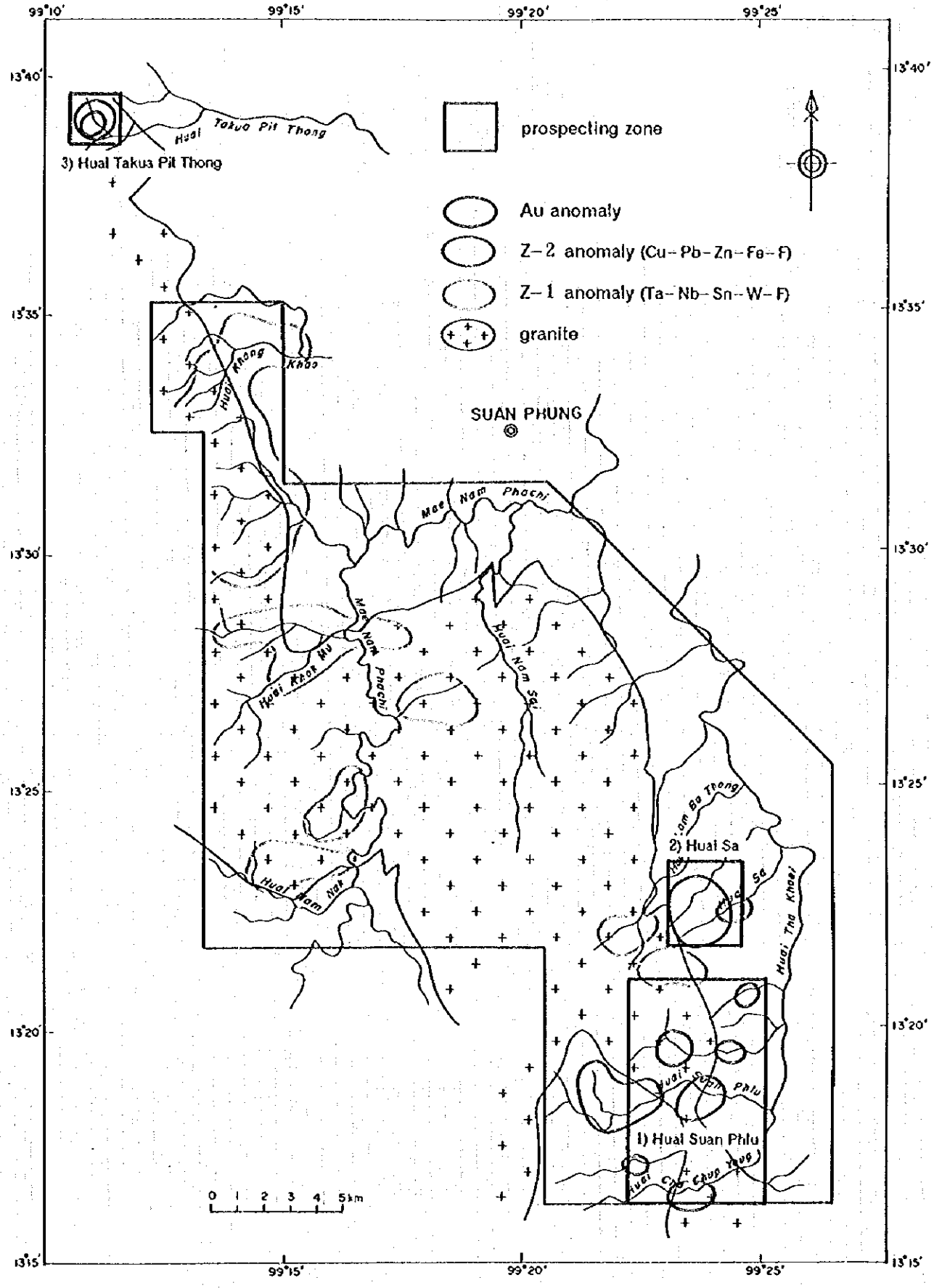


Fig.44 Interpretation Map of Ratchaburi Area

The comprehensive map of the Ratchaburi Area was shown in Fig.44.

Au anomaly zones are found scattered particularly in the west and a large group of anomaly values is seen in the southeast of the area. An anomaly value of 106 and148ppb was obtained in the boundary zone between sedimentary rock and granite in Huai Cha Chup Yong in the southernmost part of the area. And 98ppb was obtained in the stream further north.

Analysis was carried out of the correlation series obtained from the logarithm values of the geochemical analytical values for 13 principal components, excluding As and Sb for which over 90% of the samples showed detection limit values or below.

First component(Z-1): The factor loadings for Sn, Ta, Nb, F and W are high, and the negative factor loadings for Fe, As, Cu and S are high. This component suggests distribution of Sn, Nb, Ta and F derived from granite in stream sediments and the existence of primary deposits. The high score zones are widely distributed in the old deposit zones in the west, with few deposit zones in the east. Low score zones overlap sedimentary rock zones.

Second component(Z-2): Whereas the factor loadings for Au, Ta and S are low, positive factor loadings are shown for all the elements, suggesting a high density distribution range of pathfinder elements with the exception of Au. High score zones are distributed particularly in the stream east of Ban Bo Wi, in the boundary zones between granite and sedimentary rock in the upper reaches of Mae Nam Phachi, in Huai Sa in the southeast of the area, Huai Suan Phlu and Huai Takua Pit Thong in the north.

3-3 Considerations

The Ratchaburi Area is composed of Ordovician Thung Song Group, Silurian-Devonian Kanchananburi Group, Devonian-Carboniferous Kaeng Krachan Group Huai Phu Ron Formation, Kao Phra Formation and granite which has intruded into the Jurassic to Cretaceous. Thick stream sediments have accumulated along each stream and secondary tin deposits used to be mined at one time.

The structure of the sedimentary rocks shows fragmented distribution on account of the intrusions of granite, but the schistosity and sedimentary structures display a NW-SE direction and there is a tendency for new strata to overlap on both sides of the Silurian-Devonian background structure.

The intrusive directions of the granite on the whole conform to the structure of the sedimentary rock. Lineaments running NE-SW to NNE-SSE are clearly seen in the granite zones. The granites in this area belong to S-type and the ilmenite series. It clearly shows the characteristics of tin granite.

Sedimentary rocks in contact with granite are turned to semi-schist or schist, and in many cases quartz veins develop along the schistosity. However, no argillization and / or other alteration is seen around the quartz veins.

From the results of geochemical prospecting, it is noticeable that the density of individual elements is low overall, with the exception of Sn, Ta, Nb, F and W. The anomaly zones of Sn, Ta, Nb, F and W are concentrated in the Mae Nam Phachi basin where there are many old deposits, and anomaly zones are distributed in the old deposits and background granite zones. On the other hand, in many cases no anomaly zones are seen in the granite zones and old mining site in the Huai Tha Khoei basin. It suggests that the erosion level of granite body is different at Mae Nam Phachi and at Huai Tha Khoei. It is likely that at Mae Nam Phachi shallow facies of granite that can still supply tin, niobium and tantalum in the stream has been exposed, and at Huai Tha Khoei regions deeper facies which contains tin-tungsten minerals not so much has been exposed. As for the north and south of the Huai Tha Khoei basin, it is assumed that there is less erosion the south where there are large distributions of sedimentary rock. The anomaly zones conform to already known deposits and there is little possibility of the existence of new deposits.

The anomaly zones for gold and base metals are concentrated in the roof pendant Thung Song Group at Huai Takua Pit Thong in the north of the area, and in the contact zone between sedimentary rock and granite in the south of the area. As mentioned earlier, the quartz veins are well developed in these areas, but there are few alteration zones and the existence of contact metasomatic-type deposits and / or stockwork-type quartz vein deposits lying near granite can be expected.

Mineralization in the Ratchaburi Area includes deposits related to the Jurassic to Cretaceous granite, pneumatolytic to katathermal deposits of tin, tungsten, niobium and tantalum, contact replacement deposits observed at Huai Takua Pit Thong, and stockwork-type quartz vein deposits in the southeast of the area.

Promising regions are the Huai Takua Pit Thong region where gold and base metals can be expected, and the Huai Sa and Huai Suan Phlu regions where stockwork-type gold deposits can be expected.

PART Ⅲ CONCLUSION AND RECOMMENDATION

CHAPTER 1 CONCLUSION

1-1 The First Phase Survey

In the first year of the survey, geologic surveys and geochemical prospecting were carried out with the aim of selecting promising regions from 3 areas extending over 1800 km^2 in the Kingdom of Thailand: Chiang Khong and Doi Chong areas in the north and Ratchaburi area in the west. The following conclusions were reached.

1-1-1 Chiang Khong Area

The Chiang Khong Area consists of Permian sedimentary rocks such as sandstone, mudstone, conglomerate and limestone, Permo-Triassic andesitic-rhyolitic lava, tuff and tuff breccia, Triassic to Cretaceous andesite lava and granite Jurassic red siltstone and sandstone, Pliocene silt, and Plio-Pleistocene basalt. Four ages of igneous activity are known, Permian-Triassic andesite and rhyolite, Triassic granite, Jurassic andesite and Pliocene-Holocene basalt.

In the vicinity of the upper reaches of Huai Nam Sala in the north of the Chiang Khong Area, a white argillized alteration zone 3km wide by 12km long accompanied by limonite-quartz veins is seen along the fault zone running NE-SW which is accompanied by activity of Jurassic andesite. Gold and base metal geochemical anomaly zones are distributed along the fault and alteration zones, and hydrothermal deposits can be expected.

Prospects of mineral occurrence in the south of the area are not very clear, but strong argillized alteration and quartz veins are seen in part of the Permian-Triassic tuff distributed in the southeast of the area, and quartz veins have also developed in the Permian slate. Geochemical anomaly zones of base metals are seen in the same region. Hornfelsization and small-scale skarnization are apparent in the vicinity of granite, but are accompanied by only slight dissemination of pyrite, pyrrhotite and chalcopyrite.

Regions with potential mineral deposits in the Chiang Khong Area are the upper reaches of Nam Sala and Huai Mae Liap region where gold deposits can be expected, and the Nam Mae Bong and Huai Mai Ya regions where base metal deposits can be expected.

1-1-2 Doi Chong Area

The geology of the Doi Chong Area is composed, from below, of Silurian-Devonian-Carboniferous Mae Tha Group and Donchai Group, Permian Ratchaburi Group Kiu Lom Formation, Pha Huat Formation and Huai Thak Formation, Permian-Triassic Volcanic rocks, Triassic Lampang Group Hong Hoi Formation and Triassic intrusive granite and diorite.

Quartz veins accompanied by small-scale silicified zones have developed in the vicinity of granite and aplite seams. And large-scale silicified zones are distributed in the vicinity of diorite in the upper reaches of Huai Mae Toen.

Geochemical anomaly zones are distributed in the vicinity of granite and diorite and in the vicinity of veins of aplite, etc. In addition to expected contact metasomatic-type and hydrothermal vein-type deposits, deposits of niobium and tantalum accompanied with rare earth elements can be expected in the vicinity of the largest granite bodies.

Regions with potential mineral deposits in the Doi Chong Area are the Huai Mae Pu region where gold and base metal deposits can be expected, the Huai Mae Haet region and upper reaches of the Huai Mae Toen where there is a high possibility of base metal deposits, the Doi Khun Mae Thot region and the northern part of Ban Na Ban Rai where hydrothermal gold deposits can be expected, and the eastern part of Huai Mae Thot where rare earth deposits can be expected.

1-1-3 Ratchaburi Area

The Ratchaburi Area is composed of Ordovician Thung Song Group, Silurian-Devonian Kanchanaburi Group, Devonian-Carboniferous Kaeng Krachan Group Huai Phu Ron Formation, Kao Phra Formation and Jurassic to Cretaceous intrusive granite. Thick stream sediments have accumulated along each of the rivers and were once mined as secondary tin deposits.

In many cases the sedimentary rocks in contact with the granite have become semi-schist or schist, and quartz veins have developed along the schistosity. However, no argillization and / or other alteration is seen in the vicinity of the quartz veins.

Granite in the area belongs to the S-type, ilmenite series and clearly shows the characteristics of so-called tin granite.

One notable feature of the results of geochemical prospecting was the overall low density of single elements, with the exception of Sn, Ta, Nb, F and W.

Anomaly zones for Sn, Ta, Nb, F and W are concentrated in the Mae Nam Phachi basin where there are many old deposits, and anomaly zones are distributed in the old deposit areas and background granite zones. On the other hand, in many cases no anomaly zones are seen in either the granite zones or old deposit remains in the Huai Tha Khoei where there are many old deposits. The distribution of the anomaly zones conforms to that of previously known deposits and the possibility of discovering new deposits is slight.

The anomaly zones for gold and base metals are concentrated in the contact zone of sedimentary rock and granite in the northernmost part of the area and in the southeast.

Mineralization in the Ratchaburi Area includes deposits related to Jurassic to Cretaceous

intrusive granite, pneumatolytic to katathermal deposits yielding tin, tungsten, niobium and tantalum, contact metasomatic deposits observed at Huai Takua Pit Thong, and stockwork-type quartz vein deposits in the south of the area.

Promising regions are the Huai Takua Pit Thong region where gold and base metals can be expected, and the Huai Sa and Huai Suan Phlu regions where stockwork-type gold deposits can be expected.

1-2 The Second Phase Survey

For the Second Phase Survey, a prospecting area with an area of 40km^2 and high potential of the presence of gold and copper deposits in the Upper Huai Nam Sala Area of Chiang Khong district was chosen, based on the result of the geochemical survey carried out in the First Phase Survey. A semi-detailed survey involving a soil geochemical prospecting and geologic survey were carried out, and for an area of 4.8km^2 considered particularly prospecting a physical survey, detailed soil geochemical and geologic surveys were carried out.

In the eastern half of the detailed survey zone, the distribution of geochemical anomalies, suggesting the existence of gold mineralization, and corresponding to that the distribution of low resistivity zones and high resistivity zones, were clarified and it became clear that there is a strong possibility of the existence of subterranean gold deposits.

The Upper Huai Nam Sala Area is composed of Permian sedimentary rocks, the basement of this area, Permo-Triassic rhyolitic volcanic rocks, Permo-Triassic andesitic rocks, Jurassic to Cretaceous intrusive rock and Quaternary riverbed deposit. Permian basement rocks are distributed in western part of the detailed survey zone.

Within the survey area two fault systems, running N-S and NE-SW, were observed. The alteration zones and mineral occurrences are developed in Permo-Triassic tuff which is the main host rock, and are regulated by those fault systems.

In the eastern half of the detailed survey zone, the geochemical anomalies of Au, As, Sb, Hg which suggest gold mineralization continue in a N-S and NE-SW direction corresponding to the direction of the faults.

These geochemical anomalies are distributed from the border area between the high resistivity zones on western side of the detailed survey zone and low resistivity zones on eastern side of the detailed survey zone(resistivity discontinuous line) to low resistivity zone which are extracted by the geophysical survey. The geochemical anomalies of the combination of Au, As, Sb is located in the eastern side of resistivity discontinuous line, and the surface part has low resistivity, but high resistivity zone thought to be a silicified zone occurs at a comparatively shallow depth underground.

The geochemical anomaly zones with a combination of Hg and As, on the other hand, lie almost just above the resistivity discontinuous line, and low resistivity zones and relatively high resistivity zones continue down deep.

In the results of the ore assay analysis of quartz veins and silicified rock accompanying the alteration zones, the only values showing a high gold content were 5.6g/t and 1.0g/t, obtained from quartz veins accompanying a strong silicification zone that spreads out on the eastern side of the detailed survey zone, but in the anomaly zones of Hg and As, there is a brecciated limonite/quartz vein with a high Hg and As content the same as the quartz vein of highest Au content. Since the production temperature of quartz veins in the surface area estimated from the homogenization temperature of fluid inclusion in the quartz, is around 150℃, and it may be surmised that boiling took place, it is expected that a promising gold mineralization is present below the surface in this area.

1-3 The Third Phase Survey

In the third year of the survey, 2 holes were drilled in places where gold mineralization was anticipated in the deep zone, and mineralization of a maximum 0.34g/t of gold were obtained.

There is a fault on a N-S direction bordered by Permian sedimentary rock and Permian-Triassic volcanic rock in the survey area, and a reverse fault has been formed where the volcanic rock distributed on the east side has subsided in relation to the west side.

From the results of the present survey, it is clear that the Permian-Triassic volcanic rock along the fault has intruded into the sedimentary rock as dikes, and the dikes and surrounding sedimentary rock have undergone quartz - chlorite - sericite - ankerite - calcite alteration to such an extent that distinction of the original rock is no longer possible, along the dikes and the old fault which is thought to control the dikes, and it was confirmed that this is where large-scale hydrothermal activity took place. Accompanying this alteration, extensive pyrite dissemination was alternately formed in net-like and vein-like form, but the prospect of useful metals such as Au, Ag, Cu, Pb and Zn is extremely small.

However, in places where pyrophyllite is confirmed in the alteration, anomaly values of Au, Ag, Pb and Zn are detected.

With regard to the nature of the alteration, the whole alteration area has undergone uniform alternation, and no proof was obtained that mineralization had occurred where hydrothermal solution repeatedly circulated along the cracks and formed veins in the vicinity of where drilling survey was conducted.

From this it can be seen that hydrothermal activity accompanied by gold mineralization exists in the vicinity of the two drilling holes in the present survey, but judging from the analyzed values,

the condition of the alteration and the state of development of the veins, there is little possibility of the existence of mineralized zones that could be linked to mining development in this area.

CHAPTER 2 RECOMMENDATION FOR FUTURE ACTIVITY

As a result of the drilling survey, hydrothermal activity accompanied by mineralization of gold and silver has at least been confirmed, and the possibility has been raised of the center of the mineralization being somewhere in this alteration zone.

Judging from the chemical properties of the rock, the alteration and the results of the geochemical survey, it is likely that calc-alkalic hornblende andesite and rhyolite that was active at the end of the period caused gold mineralization in the Permian-Triassic volcanic rock, and there is thought to be scope for prospecting where they are distributed at the eastern tip of the Huai Nam Sala area that extends south from east of the survey positions in the third year of the survey.

In future it will be necessary to reexamine the alteration zones and geochemical anomaly zones in the vicinity of the detailed survey base line in shallow places that appeared promising in the second year of the survey, and in the area further east where rhyolite is distributed, and to confirm whether there is any prospect of gold at a lower level.

Finally, gold mineralization accompanying large-scale hydrothermal alteration zones, such as that found in the present survey, has not been known in Thailand until now. It is possible that this is a special place, but the Lampang-Phrae volcanic belt extend as far as Laos and several places in the same parallel geological belt have not been adequately surveyed yet. Due consideration must be given to this type of deposit too when pursuing future prospecting.

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