REPORT
ON
THE COOPERATIVE MINERAL EXPLORATION
IN
THE CHIANG KHONG, DOI CHONG, RATCHABURI AREA
THE KINGDOM OF THAILAND

CONSOLIDATED REPORT

MARCH 1997

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

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PREFACE

In response to the request of the Government of the Kingdom of Thailand, the Japanese Government decided to conduct a Mineral Exploration in the Chiang Khong - Doi Chong - Ratchaburi Area Project and entrusted the survey to the Japan International Cooperation Agency (JICA) and the Metal Mining Agency of Japan (MMAJ).

The survey was carried out for three years from October 1994 to January 1997 and was brought to completion with the cooperation of the Government of the Kingdom of Thailand, in particular, the Department of Mineral Resources.

This final report summarized the results of Phase I, Phase II and Phase III surveys in the Area.

We hope that this report will serve for the development of the project and contribute to the promotion of friendly relations between Area two countries.

We wish to express our deep appreciation to the officials concerned with the Government of the Kingdom of Thailand for the close cooperation they extended to the team.

February, 1997

Kimio Fujita
President
Japan International Cooperation Agency

Shozaburo Kiyotaki
President
Metal Mining Agency of Japan

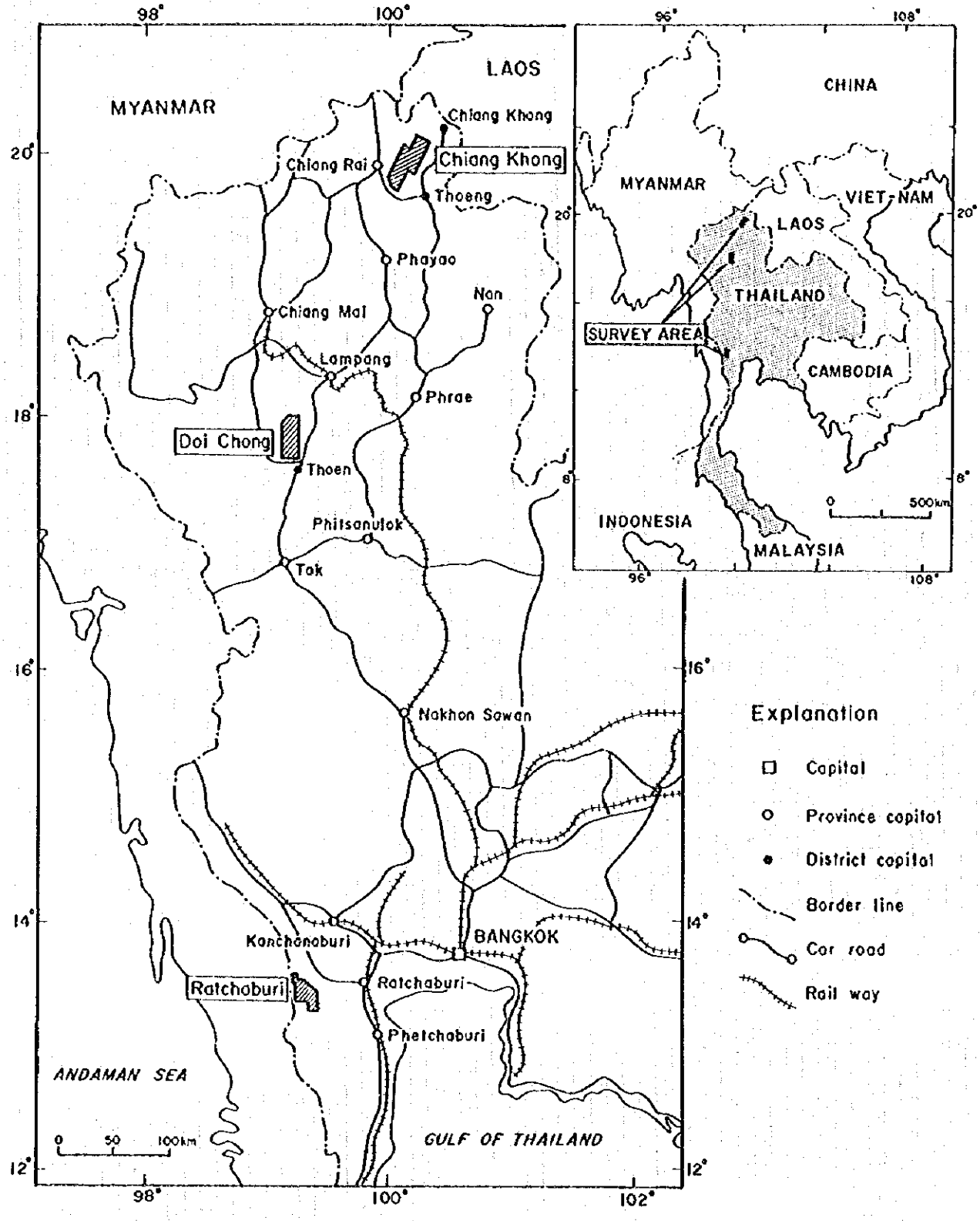

Fig. 1-1 Location Map of Survey Areas(Whole Area)

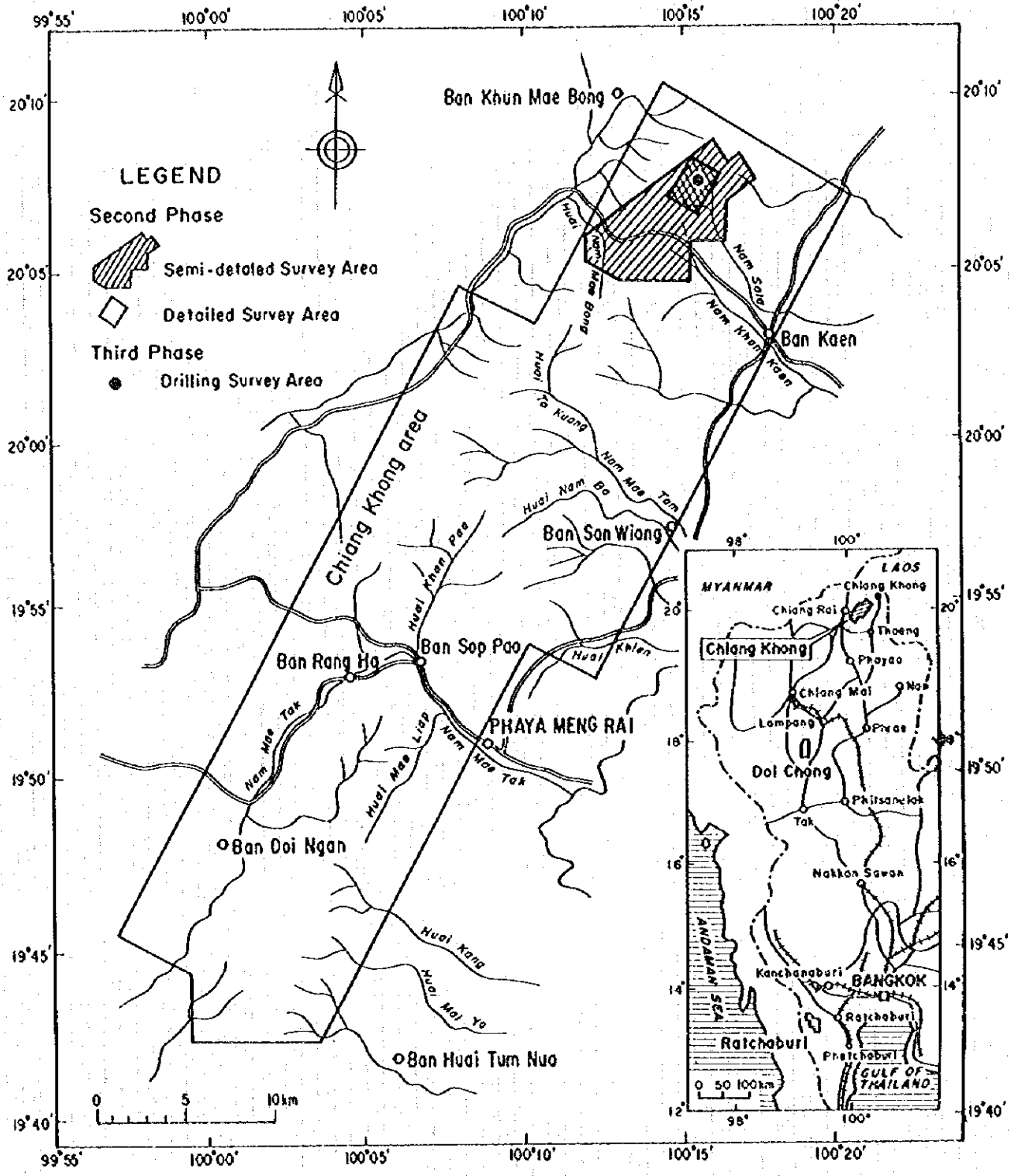

Fig. 1-2 Location Map of Survey Areas(Chiang Khong Area)

SUMMARY

This survey was carried out with the aim of determining the possible existence of deposits of valuable elements such as gold, tin and base metals in the three areas of Chiang Khong, Doi Chong and Ratchaburi in the Kingdom of Thailand. The results of the survey are as follows;

1. Chiang Khong Area

The Chiang Khong Area consists of Permian sedimentary rocks, Permian-Triassic andesitic to rhyolitic volcanic rocks, Triassic-Cretaceous andesites and granites, Jurassic sedimentary rocks, Pliocene silt, and Plio-Pleistocene basalt.

The First Phase Survey resulted in picking out the upper reaches of Huai Nam Sala and Huai Mae Liap regions where gold deposits can be expected, and the Nam Mae Bong and Huai Mai Ya regions where base metal deposits can be expected.

The Second Phase Survey was focused at the Upper Huai Nam Sala Area from the result of the First Phase Survey. As a result, 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 possibility of the existence of subterranean gold deposits.

In the Third Phase Survey, drilling survey was carried out at the high gold potential area that was extracted in the Second Phase Survey. It was clarified that the relation between gold mineralization and the alteration, however, the economical ore deposits to develop at present was not grasped.

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 granites and diorites.

The geologic and geochemical surveys were carried out in the area in the First Phase Survey, then silicified zones and geochemical anomalies were found out. The survey resulted in picking out 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.

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-Cretaceous intrusive granites.

The geologic and geochemical surveys were carried out in the area in the First Phase Survey. The following promising regions were extracted; 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. Granites in the area, however, belong to the S-type and ilmenite series and clearly shows the characteristics of so-called tin granite, and no argillization and /or other alteration is seen in the vicinity of the quartz veins in the host rocks. Moreover, from the results of geochemical prospecting, it is noticeable that the density of individual elements is generally low with the exception of Sn, Ta, Nb, F and W.

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Part I GENERAL REMARKS

CHAPTER 1 INTRODUCTION

1-1 Areas and Objective of Survey

Japanese Government carried out the Cooperative Mineral Resources Exploration which was programmed to be conducted from 1994 in Chiang Khong and Doi Chong Areas in the north of Thailand and Ratchaburi Area in the west (Fig. 1-1).

The Chiang Khong Area is located 20 km east of the city of Chiang Rai in northern Thailand, and covers an area of 700 km^2, approximately 50 km at its longest side and 18 km at its shortest side. Administratively, it belongs to Chiang Rai province.

The Doi Chong Area is located 100 km south of Chiang Mai, Thailand's second largest city, and covers an area of 580 km^2, stretching 40 km north to south and 14.5 km east to west, centering on Mt. Doi Chong. Administratively, the east side of the survey area belongs to Lampang province and the west side to Lamphun province.

The Ratchaburi Area is located 120km southwest of the capital of Bangkok and covers an area of 500 km^2, stretching 35 km north to south and 26 km east to west along the Thai-Myanmar border. Administratively it belongs to Ratchaburi province.

The purpose of this survey is to grasp the existence of primary and secondary deposits of gold, tin, copper, lead and zinc and etc., by examining the geology and geologic structure, extracting geochemical and geophysical anomalies and the results of drilling.

1-2 Method and Contents of Survey

The preliminary surveys consisting of geologic survey and geochemical prospecting for three areas of Chiang Khong, Doi Chong and Ratchaburi were conducted in the First Phase Survey. In the Second Phase Survey the detailed geologic, geochemical and geophysical surveys were carried out at the Upper Huai Nam Sala Area in the northern part of Chiang Khong Area based on the results of the First Phase Survey. Based on the results of the past two years of surveys, drilling survey at the detailed survey zone in the Upper Huai Nam Sala Area were conducted in the Third Phase Survey. The flow chart of the survey process and evaluation process were shown in Fig. 2 and Fig. 3.

The contents of the surveys and the quantities of these works in each year are set forth in the following (Table 1).

1-2-1 The First Phase Survey in 1994

(1) Geologic Survey

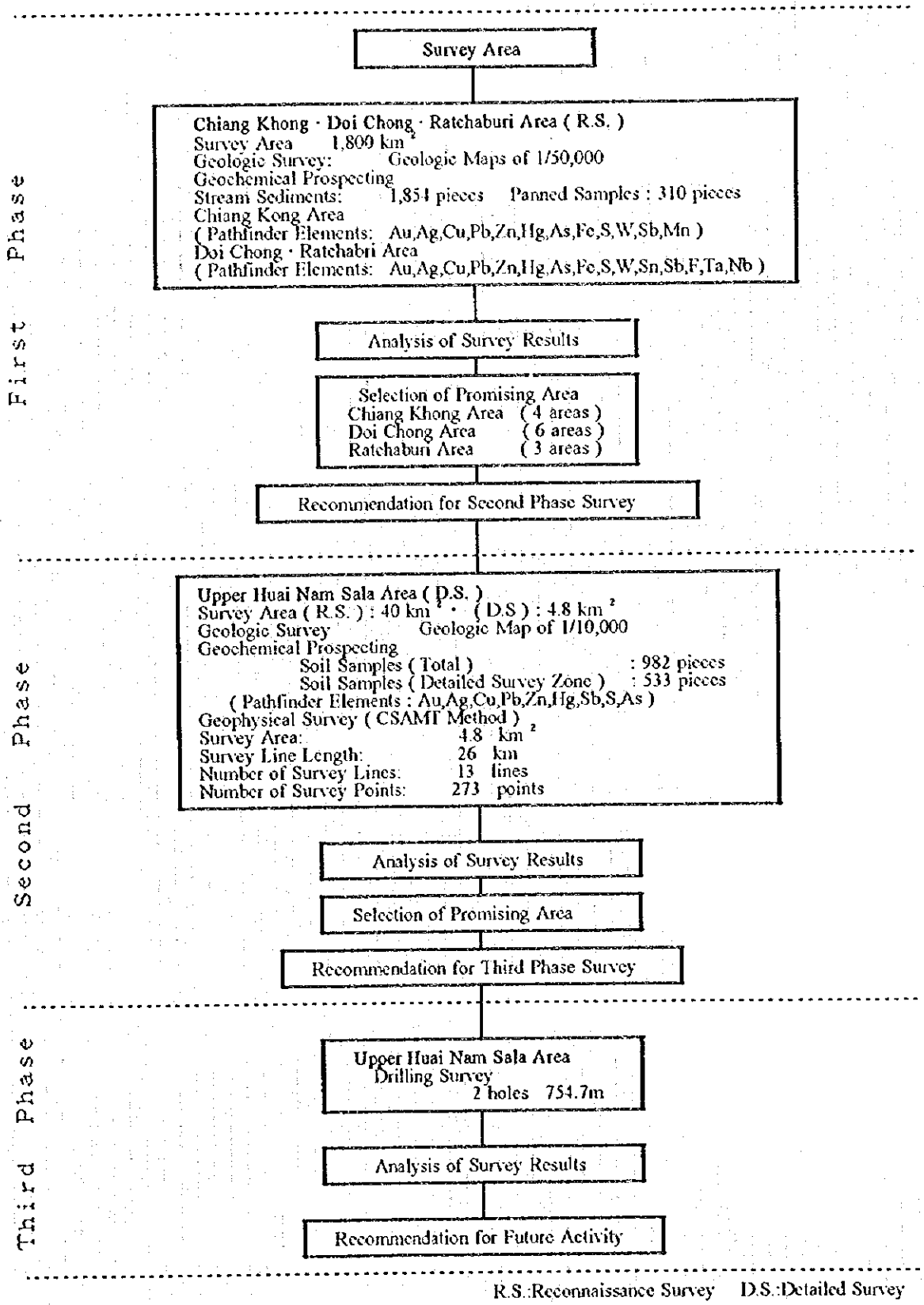

Fig. 2 Flow Chart of Exploration Program

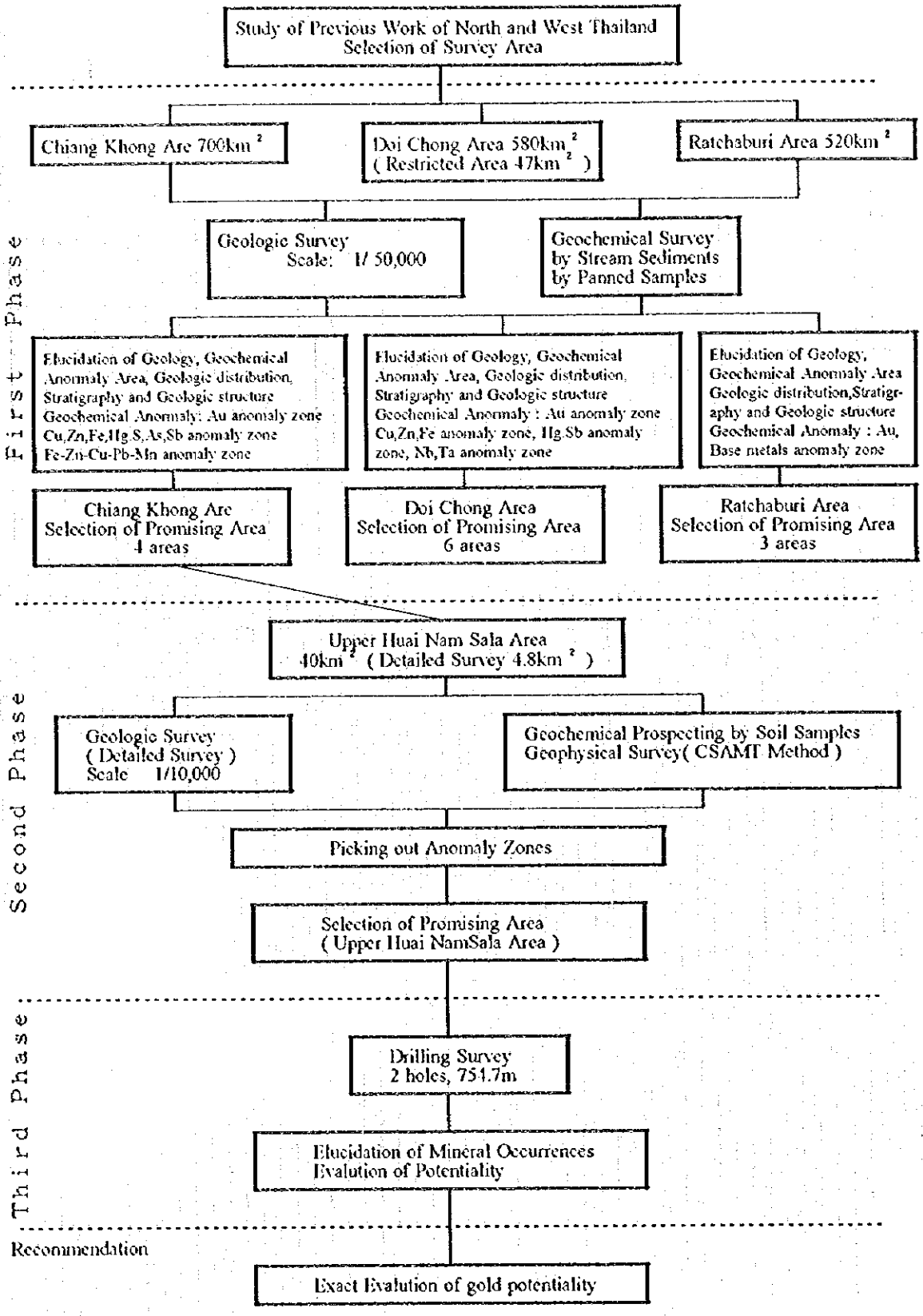

Fig. 3 Flow Chart of Selecting Promising Area

Table 1 Contents of Survey

Item \ Years	Phase I (1994)	Phase II (1995)	Phase III (1996)
Kind of Survey	Geologic Survey Geochemical Prospecting	Detailed Geologic Survey Geochemical Prospecting Geophysical Survey	Drilling Survey
Areas (km^2) and Quantities	Chiang Khong Area : 700km^2 Doi Chong Area : 580km^2 (Restricted area by royal project: 47km^2) Ratchaburi Area : 520km^2 Panned Samples : 310 pieces	Upper reaches of Nam Sala Area(Chiang Khong Area) Geologic Survey : 40km^2 Geophysical Survey : 4.8km^2 (CSAMT Method) Survey Lines Length : 26 km Number of Survey Lines : 13 lines Number of Survey Points : 273 points	Upper reaches of Nam Sala Area(Chiang Khong Area) Drilling Surver 2 holes 754.6 m
Thin section	51	14	6
Polished thin section	41	11	5
X-ray diffraction	25	126	52
K-Ar dating	—	2	—
RES * and FE *	—	24	—
Homogenization temp.	—	—	11
Stream sediments	1854	—	—
Components for analysis	Chiang Khong Area Au,Ag,Cu,Pb,Zn,Hg,As,Fe,S,W,Sb, Mn, Doi Chong and Ratchaburi Area Au,Ag,Cu,Pb,Zn,Hg,As,Fe,S,W,Sb, Sn,F,Ta,Nb,	—	—
Soil samples	—	Total : 982 (D.S.: 533)	—
Components for analysis	—	Au,Ag,Cu,Pb,Zn,Hg,Sb,S,As,	—
Rock samples	35	13	—
Components for analysis	SiO_2,Al_2O_3,CaO,FeO,Fe_2O_3, K_2O,MgO,MnO,Na_2O,P_2O_5, TiO_2,LOI	SiO_2,Al_2O_3,CaO,FeO, Fe_2O_3,K_2O,MgO,MnO, Na_2O,P_2O_5, TiO_2, Cr_2O_3,LOI	—
Ore samples	151	42	43
Components for analysis	Au,Ag,Cu,Pb,Zn,W,Sn,Mn,Ta,Nb,	Au,Ag,Cu,Pb,Zn,	Au,Ag,Cu,Pb,Zn

RES * :Resistivity, FE * :Frequency effect
D.S. : Detailed Survey

For the geologic survey, projects were selected, already existing data examined and surveys conducted along selected river systems in order to discover mineral occurrences and promising zones in the three survey areas, and also to ensure consistency over the whole area. In addition, stream sediments and panning samples were collected for geochemical prospecting.

For the field survey a geologic map, scale 1:10,000, enlarged from an already existing map, scale 1:50,000, was used. The results of the survey were compiled on a geologic map with a scale of 1:50,000.

(2) Geochemical Prospecting

Selecting drainage systems from the whole survey area so that they are of nearly uniform density, a total of 1,854 stream sediment samples and a total of 310 panning samples were collected from the systems and subjected to a chemical analysis. The chemical analysis of the stream sediments was for the 12 pathfinder elements in Chiang Khong Area and the 15 pathfinder elements in Doi Chong and Ratchaburi Areas. The chemical data were statistically processed (Monovariant and Multivariant Analyses), and the geochemical anomaly maps were made. Finally, the promising areas were selected based on the results of the geochemical survey. The results of the survey were compiled on geochemical anomaly map with a scale of 1:100,000.

1-2-2 The Second Phase Survey in 1995

The Upper Huai Nam Sala Area was extracted as a promising region for gold and copper from the result of the First Phase Survey. The Upper Huai Nam Sala Area is located in the northern part of Chiang Khong Area, about 40 km northeast of Chiang Rai. This area has an extent of 40 km^2. The detailed survey zone where geophysical and detailed geochemical prospecting has done is situated in the northern part of the Upper Huai Nam Sala Area and it covers 4.8 km^2 (Fig.1-2).

(1) Geochemical Prospecting

A geochemical prospecting by soil samples was conducted at the Upper Huai Nam Sala Area. From the results of First Phase Survey, nine elements were treated as indicator elements, namely, Au, Ag, Cu, Pb, Zn, Hg, Sb, As and S. The number of soil samples taken was 533 at 50 m intervals on the physical investigation profile lines in the detailed survey zone, plus 449 at roughly 250 m - 300 m intervals along the ridge, a total of 982 samples. The chemical data were statistically processed (Monovariant and Multivariant Analyses), and the geochemical anomaly maps were made. Finally, the promising areas were selected based on the results.

(2) Geophysical Survey

To clarify the relation between resistivity structure and geologic structure, to extract resistivity anomaly zone related to mineralization zone and to collect data for selecting the drilling survey site,

the resistivity survey by Alay type CSAMT(Controlled Source Audio-frequency Magnetio-Telluric) method was carried out after setting up the 13 survey lines with 2 km length (the interval of each line was 200 m) at the Upper Huai Nam Sala Area.

1-2-3 The Third Phase Survey in 1996

The Third Phase Survey was focused at the detailed survey zone in the Upper Huai Nam Sala Area based on the results of the past two years of surveys, and carried out a drilling survey.

(1) Drilling Survey

The survey was undertaken by conducting the exploratory drillings in two holes on two sites totaling 754.60 m. The results were summarized in geologic columns on the scale of 1 to 200.

Based on the results of the survey, the size and grade of mineralization zone and the potential were examined.

In each year's survey microscopic observation, X-ray powder diffraction analysis, measurement of homogenization temperature of fluid inclusions, K-Ar dating, measurement of resistivity and polarization and chemical analyses were carried out to verify the geologic setting and mineralization as shown in Table 1.

1-3 Period and Members of Survey

1-3-1 The First Phase Survey in 1994

(a) Period of the Preliminary Survey: from August 29 to September 8, 1994
Period of the Field Survey: from October 25 to December 25, 1994

(b) Members of the Mission

Planning and Negotiation of Agreement

Japan

Takahisa YAMAMOTO		Metal Mining Agency of Japan
Eigo NOMURA		Ministry of International Trade and Industry
Kazuko MATSUMOTO		Japan International Cooperation Agency
Naoki SATO		Metal Mining Agency of Japan

Thailand

Pricha Attavipach	Director General,	Dept. of Mineral Resources
Boonmai Inthuputi	Director,	Dept. of Mineral Resources
Somsak Potisat	Project Manager,	Dept. of Mineral Resources
Phairat Suthakorn	Project Manager,	Dept. of Mineral Resources
Somechai Sa-gniamsak		Dept. of Mineral Resources

Coordination and Planning

Japan

Katsutaka NAKAMURA Metal Minig Agency of Japan, Bangkok

Thailand

Somsak Potisat	Project Manager,	Dept. of Mineral Resources
Phairat Suthakorn	Project Manager,	Dept. of Mineral Resources
Somechai Sa-gniamsak	Assistant Manager,	Dept. of Mineral Resources

Geologic and Geochemical Survey Team

Japan

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Yasunori ITO	Geologist	
Tetsushi OZAWA	Geologist	
Kenji KIZAKI	Geologist	
Hiroshi IWASAKI	Geologist	

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Ruechai Ngiamphaisan	Field assistant	Dept. of Mineral Resources

Ratchaburi Area

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Karoon Tonthongchai	Geologist	Dept. of Mineral Resources
Teeranai Piyawong	Geologist	Dept. of Mineral Resources
Samart Ratanareng-ampai	Geologist	Dept. of Mineral Resources
Boonchu Panglinput	Field assistant	Dept. of Mineral Resources

1-3-2 The Second Phase Survey in 1995

(a) Period of the Field Survey

Geochemical Prospecting: from October 23 to December 24, 1995 (63 days)
Geophysical Survey : from November 8 to December 24, 1995 (47 days)

(b) Members of the Mission

Planning and Coordination

Japan

Katsutaka NAKAMURA	Metal Minig Agency of Japan, Bangkok
Katsuhisa ONO	Metal Mining Agency of Japan

Thailand

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Phairat Suthakorn	Dept. of Mineral Resources
Somchai Sangiemsak	Dept. of Mineral Resources
Werapun Jantaranipa	Dept. of Mineral Resources
Amnuaychai Thienprasert	Dept. of Mineral Resources
Peerapong Khuenkong	Dept. of Mineral Resources

Geochemical Prospecting Team

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Seiya MORITA	Geologist	Nittetsu Mining Consultants Co.,Ltd
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Karoon Tonthongchai	Geologist	Dept. of Mineral Resources
Teeranai Piyawon	Geologist	Dept. of Mineral Resources

Wicharn Mungkhun	Geologist	Dept. of Mineral Resources
Boonchu Panglinput	Field assistant	Dept. of Mineral Resources
Ruechai Ngiamphaisan	Field assistant	Dept. of Mineral Resources

Geophysical Survey Team

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Hiromi YOSHIMURA	Geophysist	Nittetsu Mining Consultants Co.,Ltd
Yasunori ITO	Geophysist	Nittetsu Mining Consultants Co.,Ltd
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Thailand

Kampanart Lampoonsub	Geophysist	Dept. of Mineral Resources
Desell Suanburi	Geophysist	Dept. of Mineral Resources

1-3-3 The Third Phase Survey in 1996

(a) Period of the Field Survey: from September 30, 1995 to January 18, 1997 (111 days)

(b) Members of the Mission

Planning and Coordination

Japan

Katsutaka NAKAMURA	Metal Minig Agency of Japan, Bangkok	
Yoshiaki IGARASHI	Metal Mining Agency of Japan	

Thailand

Suvit Sampattavenija	Dept. of Mineral Resources
Phairat Suthakorn	Dept. of Mineral Resources
Peerapong Khuenkong	Dept. of Mineral Resources

Drilling Survey

Japan

Dr. Hiroyuki TAKAHATA	Geologist	Nittetsu Mining Consultants Co.,Ltd

Thailand

Phureewat Jenrungroj	Geologist	Dept. of Mineral Resources
Yodying Manoi	Geologist	Dept. of Mineral Resources
Wicharn Mungkhun	Geologist	Dept. of Mineral Resources

CHAPTER 2 GEOLOGIC INFORMATION

2-1 Previous Work

A German geologic survey mission (hereafter referred to as GGM, 1972) have reported systematically on the geology and mineral deposits along the Laos-Myanmar-Thai border in northern Thailand. The Chiang Khong Area is included on Sheet 2 Chiang Rai (scale 1:250,000).

A detailed geologic survey of Amphoe Chiang Khong (geologic map, scale 1:50,000, covering 3 sheets) which includes the northern part of the Chiang Khong Area has been carried out by the Department of Mineral Resources of the Industry Ministry (hereafter referred to as DMR), and a

1:50,000 scale geologic map has been completed but not yet published. Since 1994 DMR has been conducting a prospecting survey for gold in the north of the Chiang Khong Area, but the results of the survey have not yet been collated.

The DMR (1974) Changwat Uttatradit geologic map, scale 1:250,000, includes the Doi Chong Area. The DMR has been conducting surveys around a number of places in the Doi Chong Area and the area to the east where local people had long been mining gold by panning and they have discovered a number of primary gold occurrences (Kumachan 1989, Potisat 1992). The DMR is also assessing the potential of occurrences of magnetite, limonite, etc. in the Doi Chong Area.

The DMR (1982) Changwat Nakhorn Pathom geologic map, scale 1:250,000, includes the Ratchaburi Area. In addition, several reports in Thai have been published outlining tin deposits scattered over the area.

Airborne geophysical surveys of the whole of Thailand, excluding the Thai peninsula, were carried out between 1984 and 1987 and a map showing the findings, scale 1:50,000, a map giving an interpretation, scale 1:250,000, and an explanatory report have been published.

2-2 General Geology

2-2-1 Geology

The Chiang Khong Area was believed to be composed of Permian limestone, Permo-Triassic sedimentary rock, andesite, rhyolite and tuff, Triassic granite and Neogene sedimentary rocks, but from the results of surveys conducted in recent years the Permo-Triassic sedimentary rock has been redefined as Permian, and a part of the volcanic rocks has been redefined as Jurassic to Cretaceous activity. The geologic structure shows a NE-SW direction, and both the continuous direction of the strata and the intrusive direction of the granite conform to this.

The Doi Chong Area is believed to have a basement of Precambrian metamorphic rocks and to consist of Cambro-Silurian meta-sedimentary rocks, Permian sedimentary rocks, Permo-Triassic volcanic rocks, Triassic sedimentary rocks and Cretaceous granites. The geologic structure shows a N-S direction on the west side of Mae Nam Wang, inclining to the east, and on the east side of Mae Nam Wang Permo-Triassic volcanic rocks unconformably overlie Permian sedimentary rocks. The direction in which the volcanic rocks extends differs to that on the west side, showing a NE-SW direction.

The Ratchaburi Area is composed of Cambrian-Ordovician meta-sedimentary rocks, Ordovician limestone, Silurian-Devonian quartzite, Devonian-Carboniferous sandstone, mudstone containing gravel, orthoquartzite, Permian limestone, Triassic-Jurassic sandstone, conglomerate and Jurassic - Cretaceous granite, and they are covered by Neogene-Quaternary terrace and alluvial

sediment. The structure of the metamorphic rocks and sedimentary rocks shows a NW-SE direction, and judging from the rough distribution, the lowest stratum is distributed on the Myanmar border with younger sediments distributed gradually on the east side. Granites have intruded in two zones, on the mountain ridge and on the east side of the area, but the direction in which the rocks extend is controlled by the structural direction of the sedimentary rocks.

2-2-2 Ore Deposits

There are no officially recorded mineral deposits in the Chiang Khong Area. In a survey conducted by questioning local people, it was said that until 5 or 6 years ago about 15 or 16 local people used to excavate placer gold in stream sediments above a waterfall in the middle reaches of Nam Mae Tam in the center of the Chiang Khong Area, but excavation ceased following flooding in the wake of a typhoon. Also, according to a local owner of mining rights, placer gold exists in one place near the granite in the center, and there are prospects of copper in another two places.

There used to be two fluorite mines in the Doi Chong Area, but at the present time both are abandoned. According to DMR information, there is a prospective magnetite region in the mountainside of Doi Chong to the east of the upper reaches of Huai Mae Thot in the center of the survey area, and a prospective limonite area on the east side of the highway in the southeast tip of the area, and small-scale surveys have been conducted in the area in the past. As to occurrence of gold, there are two places in the south of the area where local people used to pan for gold in pits.

About 50 tin mines were worked for a long time in the secondary and primary deposit zones of the Ratchaburi Area, but they were closed about 10 years ago due to the fall in the price of tin and at the present time only two mines producing feldspar remain. The placer tin deposit zone which extends from the south of Kanchanaburi where the Ratchaburi Area is located, through Phchuap Khiri Khan to Chumphon, has long been known to be accompanied by placer gold, and at the height of its prosperity it produced 60 kg of placer gold annually.

CHAPTER 3 SITUATION OF SURVEY AREA

3-1 Location and Accessibility

The three survey areas of Chiang Khong, Doi Chong and Ratchaburi located in the north and west of Thailand, as shown in Fig.1.

The Chiang Khong Area is situated 20 km east of the northernmost city of Chiang Rai at longitude 99° 57' to 100° 20' E and latitude 19° 42' to 20° 10' N. It covers an area of 700 km^2 and is approximately 50 km at its longest side and 18 km at its shortest side. Administratively it belongs to Amphoe Chiang Khong, Amphoe Wiang Chai and Amphoe Phaya Men Rai in the Chiang Rai province. National highway Route 1 runs from the capital of Bangkok to Chiang Rai and it takes about 12 hours to cover the distance of 820 km by car. There are also 4 return flights a day between Chiang Rai airport and Bangkok (flight time: 1 hour 20 minutes) and 2 return flights a day to Chiang Mai (flight time: 40 minutes). Some paved roads run from Chiang Rai to the survey area and takes about one hour. There are paved roads within the survey area and it takes about 30 minutes to reach Chiang Khong at the northern tip of the survey area.

The Doi Chong Area is situated 100 km south of Thailand's second largest city of Chiang Mai, at longitude 99° 07' to 99° 15' E and latitude 17° 37' to 18° 00' N. It covers an area of 580 km^2, extending 40 km north to south and 14.5 km east to west, centering on Mt. Doi Chong. Included in the present survey area is a Royal project protected area in the north (area 47 km^2), making the actual survey area 530 km^2. Administratively the eastern side of the area belongs to Amphoe Soen Ngam, Amphoe Sop Prap and Amphoe Thoen in the Lampang province, and the western side to Amphoe Li in the Lamphun province. National highway Route 1 runs through the eastern side of the survey area, linking Bangkok and Chiang Rai, and it takes 7.5 hours by car to cover the 600 km from Bangkok to Lampang, the provincial capital of Lampang province, 20 km northeast of the survey area. The northern line of the national railway runs to Lampang, linking Bangkok and Chiang Mai, and takes 11 hours from Bangkok. There are also 2 daily flights from Bangkok to Lampang via Phitsanulok. Route 106 branches off from Route 1 at Thoen in the south of the survey area and runs through Li in Lamphun province to Chiang Mai. Local roads linking Li and Lampang run through the northwest of the area.

The Ratchaburi Area is situated 120 km southwest of the capital, Bangkok, at longitude 99° 12' to 99° 26' E and latitude 13° 16' to 13° 35' N. It covers an area of 520 km^2, extending 35 km north to south and 26 km east to west along the Thai-Myanmar border. Administratively, it belongs to Amphoe Suan Phung in the Ratchaburi province. It takes 2 hours (approximately 90 km) from Bangkok to Ratchaburi by Route 4 which runs through southern Thailand or Route 35 which runs along

the coast, and then about another 1 hour to cover the 60 km to the area by local roads. It takes about 1.5 hours by the southern line of the national railway to reach Ratchaburi town.

In addition to paved trunk roads in all three areas, there are also farm roads running along by the large rivers. The latter are not paved and turn to muddy in wet weather Area during the rainy season, making passage by car difficult.

3-2 Environment of Survey Area

3-2-1 Topography

(1) Chiang Khong Area

The Chiang Khong Area is situated in the very north of Thailand near the border with Myanmar and Laos where is so-called "Golden Triangle"and occupies part of the basin between the mountains which has developed in the upper reaches of the Mekong River. The basin forms flat land at an altitude of around 400 m with mountains rising 800 to 900 m in the center. The form of the basin reflects the form of the surrounding mountainous area which reaches altitudes of 1,000 to1,800m, extending NNE-SSW from the Mekong River to the middle of the basin and bending in the southern half to run in a N-S direction. The principal rivers flowing northwards on the west side of the central mountainous region are the Nam Mae Lao and Nam Mae Kok, and on the east the Nam Mae Ing. The survey area covers the central mountainous region located in the north of the sedimentary basin. The mountains extend in a NNE-SSW direction parallel to the structure of the basin. As the mountains in the center of the region are composed of andesite and rhyolite, they have relatively steep gradients and have been deepened by the deep-cut valleys, but the wings of the mountainous region are being steadily eroded and display gently-sloping mountains. The river system that flows parallel to the direction of the mountains and the system that crosses it perpendicularly are well developed and show an overall grid pattern.

(2) Doi Chong Area

The Doi Chong Area is situated in the boundary zone between the mountainous region (the northern half) and the flat land (the southern half) in the north of Thailand. Most of the survey area displays a mountainous topography with altitudes of 500 to 1,200m and steep mountainsides, but flat land with few undulations extends in the northernmost part of the survey area (altitude 350 to 500m) and in the southernmost part (around altitude 200m). The principal mountains are separated into three by tributaries of Mae Nam Wang which flows southwards through the east of the area, and show continuity, inclining from virtually N-S to slightly west. The tributaries of Mae Nam Wang have developed in a NNW-SSE and NW-SE direction and show broad valleys. The valleys which have been developed by the tributaries have developed in the dendritic form.

(3) Ratchaburi Area

The Ratchaburi Area covers part of the Tenasserim mountain range which forms the spine of the Thai peninsula. Overall the mountains continue in a NNW-SSE direction. The survey area is situated on the eastern side of the ridge which forms the Thai-Myanmar border and the altitude gradually falls from west to east. Most of the survey area is mountainous land with altitudes of between 300 and 1,100m, but flat land with few undulations of around 200m extends along the river on the eastern edge of the survey area. The principal river systems are controlled by the direction in which the mountains extend, but the tributaries have two prevalent directions, that of the principal river systems and NE-SW direction.

3-2-2 Climate and Vegetation

Northern Thailand, including the Chiang Khong and Doi Chong Areas, is situated inland and is not greatly affected by monsoons, but it belongs to the tropical savanna climatic zone and is affected by the northeast monsoons in winter. Winter lasts from mid-October to mid-February in the Chiang Khong Area and from November to February in the Doi Chong Area. During this time the weather is dry and the lowest temperature drops below 10° C. March to mid-May is the hottest time of the year (summer) when the monsoons abate and the highest temperature sometimes exceeds 40° C. From mid-May to the end of October is the rainy season which is influenced by the southwest monsoons, and over these six months the rainfall reaches 1,000 to 1,500mm.

The Ratchaburi Area belongs to the tropical monsoon zone and has extremely high rainfall in the rainy season. Summers are rather hot with occasional gales. The length of each season is virtually the same as in the north.

The monthly temperatures and humidity in Lampang city are shown in Table 2 and the monthly rainfall in Lampang city and Amphoe Suan Phung in Ratchaburi Area is shown in Table 3.

In the Chiang Khong Area only a few tropical evergreen rain forests remain on the tops of the mountains, and at the foot of the mountains land is increasingly being cleared and turned into farmland or deciduous forests. The plains and broad alluvial land between the mountains are being cultivated as fields.

Most of the mountainous region in the Doi Chong Area is a forestry conservation zone and dense tropical evergreen rain forests cover most of the mountains. The gently sloping land in the north of the Doi Chong Area is deciduous shrub land, and the lowlands in the south of the region and along the rivers between the mountains are used as fields.

The remains of tin excavations are found in the low, flat land with few undulations in the east of the Ratchaburi Area and in many cases they have turned into ponds, but the land is used as fields

Table 2 Temperature and Humidity at Lampang City

		January	February	March	April	May	June	July	August	September	October	November	December	Average
Maximum (°C)	1988	-	-	-	-	37.7	35.5	35.4	35.2	35.2	34.3	32.0	32.2	34.7
	1989	35.0	37.0	39.0	41.3	39.6	35.7	35.6	34.8	35.5	34.2	33.5	33.2	36.2
	1990	34.8	36.5	38.7	40.5	39.3	36.5	35.5	37.6	34.6	34.6	34.2	33.2	36.3
	1991	33.6	37.2	40.3	42.0	40.2	39.4	37.7	36.6	34.9	34.4	32.8	31.4	36.7
	1992	32.8	35.0	40.7	42.6	41.6	41.1	37.2	35.7	34.7	33.2	32.1	32.2	36.6
Minimum (°C)	1988	12.2	13.5	17.2	16.4	22.1	22.4	22.5	22.5	21.7	18.2	13.7	11.0	18.0
	1989	9.2	12.5	15.9	19.5	20.8	22.8	22.5	21.9	21.7	19.1	14.8	10.0	17.6
	1990	10.0	13.5	13.4	19.7	21.2	21.8	22.7	22.2	21.8	20.4	14.5	10.5	17.6
	1991	12.2	13.2	16.2	19.6	22.6	22.8	23.6	22.7	22.8	19.8	13.7	11.4	18.4
	1992	10.8	10.5	14.1	20.6	22.2	22.7	22.2	22.3	21.4	17.8	11.8	9.6	17.2
Humidity (%)	1988	68.78	61.48	50.61	59.60	74.79	79.42	79.10	81.67	81.99	82.11	77.78	74.46	72.67
	1989	69.12	59.46	58.13	51.03	72.39	77.98	78.29	80.55	83.71	83.98	77.49	72.16	72.02
	1990	67.69	61.30	60.02	57.43	77.19	76.65	73.32	77.44	83.59	81.77	78.25	75.85	72.54
	1991	69.90	59.92	53.20	58.69	63.76	72.96	70.90	82.22	81.29	82.17	76.16	73.57	70.41
	1992	71.07	59.59	54.34	51.33	54.41	70.10	77.66	79.10	82.29	82.96	75.40	71.94	69.18

Table 3 Monthly Rainfall at Lampang City and Suan Phun Town

	January	February	March	April	May	June	July	August	September	October	November	December	Total
Lampang City													
1988	0.0	12.1	0.0	19.9	118.3	253.0	150.2	243.3	113.4	137.7	41.4	0.0	1089.3
1989	1.4	0.0	27.6	15.4	254.2	107.0	166.3	225.6	171.9	121.2	0.0	0.0	1096.8
1990	0.0	5.9	63.2	46.5	203.7	121.8	95.2	205.4	231.6	104.0	78.8	0.0	1158.1
1991	0.0	0.0	10.5	57.6	48.8	66.3	58.5	293.5	68.1	73.8	11.2	4.6	713.1
1992	12.0	41.2	0.0	3.5	21.0	118.6	291.3	162.2	406.9	117.0	0.0	101.8	1275.5
1993	0.0	0.0	40.6	48.3	115.4	58.1	61.9	125.2	285.9	86.7	0.7	0.0	822.8
Ratchaburi area													
1991	0.0	4.3	70.9	136.6	150.3	70.6	125.2	109.8	115.9	272.7	9.8	47.5	1113.6
1992	0.0	36.0	0.0	31.3	114.6	101.5	198.4	50.3	140.8	361.5	2.6	0.0	1039.0
1993	0.0	0.0	87.5	96.7	189.3	43.2	86.7	98.3	259.6	475.8	0.0	0.0	1337.1
1994	0.0	0.0	134.3	15.9	290.1	106.0	178.6	154.3	116.2	119.6	-	-	1115.0

unit: mm

or orchards for growing pineapples and other fruit. The mountainous region is covered with sparse woods of tropical deciduous trees.

3-2-3 General Information

The Chiang Rai province in which the Chiang Khong Area is situated covers an area of 11,678,000 km^2 and consists of 12 districts, 4 sub-districts, 102 regions, 1,302 villages and 1 autonomous city. The survey area extends over the 3 districts of Chiang Khong, Phaya Men Rai and Chiang Chai.

The population of the Chiang Rai province is around 1,060,000, 75% of whom live in villages. The main industries of the Chiang Rai province are agriculture, commerce and service industries with only a small percentage accounted for by manufacturing. The main agricultural produce is rice, corn for animal feed, tobacco and fruit.

The Lampang province in which the Doi Chong Area is situated covers an area of 12,533,961 km^2 and consists of 13 districts, 99 regions, 761 villages and 1 autonomous city. The population stood at 776,251 at the end of December 1992, with 124,519 peoples in Amphoe Thoen which includes the Doi Chong Area, Amphoe Soem Ngam and Amphoe So Prap. The main industry of Lampang province is agriculture, and produce includes rice, corn for animal feed, peanuts, soy beans, barley, garlic and fruit. In the mining industry, ornamental rocks such as kaolinite, marble and granite, and lignite, etc. are mined.

The Ratchaburi Area is situated in the Suan Phung district of Ratchaburi province. Amphoe Suan Phung is a new district, raised to the status of district in 1983. It has an area of 2,145 km^2 and a population of 41,464 as of the end of September 1992 and consists of 7 regions and 61 villages. The main industry is agriculture, centering on dry field crops of pineapples, tapioca, sugar cane, etc. There used to be many tin mines, but today there are only a few feldspar mines.

CHAPTER 4 CONCLUSION AND RECOMMENDATION

4-1 Conclusion

The survey was carried out with the aim of determining the possible existence of deposits of valuable elements such as gold, tin and base metals, by obtaining a comprehensive understanding of the relationship between the geology and geologic structure, and mineralization and geochemical characteristics of the three areas of Chiang Khong, Doi Chong and Ratchaburi.

4-1-1 Chiang Khong Area

The Chiang Khong Area consists of Permian sedimentary rocks such as sandstone, mudstone, conglomerate and limestone, Permo-Triassic andesitic to rhyolitic lava, tuff and tuff breccia, Triassic to Cretaceous andesite lava and granites, 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 3 km wide by 12 km 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 Permo-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 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.

For the Second Phase Survey, a prospecting area with an area of 40 km^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 prospecting 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 4.8 km^2 considered particularly prospecting a geophysical survey, detailed soil geochemical prospecting and geologic surveys were carried out. As a result, 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. 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.

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 trend 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 network 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.

4-1-2 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 in the First Phase Survey.

4-1-3 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-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 to 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 concentrated in the Mae Nam Phachi basin where there are many old deposits, and anomaly zones are distributed in the old deposit and background granite zones. On the other hand, in many cases no anomaly zones are seen in either the granite zones 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 in the First Phase Survey.

4-2 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 region 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.