REPORT

ON

THE COOPERATIVE MINERAL EXPLORATION

IN

THE CHIANG KHONG, DOI CHONG, RATCHABURI AREA,

THE KINGDOM OF THAILAND

PHASE I

MARCH, 1995

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 to survey to the Japan International Cooperation Agency (JICA) and the Metal Mining Agency of Japan (MMAJ).

The JICA and MMAJ sent to the Kingdom of Thailand a survey team headed by Dr. Hiroyuki Takahata from October 25 to December 25, 1994.

The team exchanged views with the officials concerned of the Government of the Kingdom of Thailand and conducted field surveys in the Chiang Khong, Doi Chong, Ratchaburi areas. After the team returned to Japan, further studies were made and the present report has been prepared.

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

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

February, 1995

Kimio Fujita
President
Japan International Cooperation Agency

Takashi Ishikawa
President
Metal Mining Agency of Japan

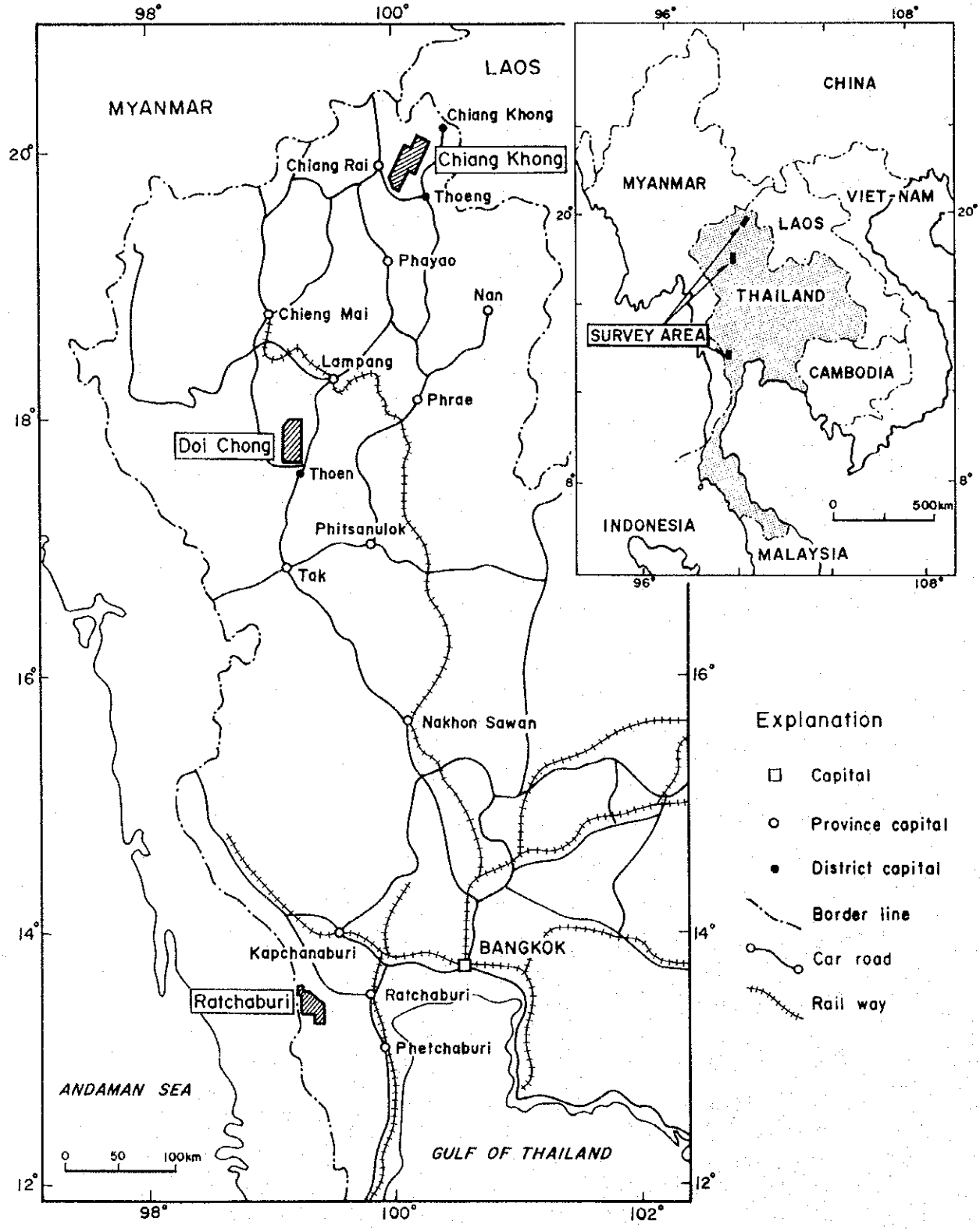

Fig. 1 Location map of the Survey areas

SUMMARY

The survey was carried out with the aim of determining the possible existence of deposits of valuable elements such as gold, tin, base metals and antimony, 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 Chon and Ratchaburi.

1. Chiang Khong Area

The Chiang Khong area consists of Permian sedimentary rock such as sandstone, mudstone, conglomerate and limestone, Permo-Triassic andesitic-rhyolitic lava, tuff and tuff breccia, Triassic granite, Jurassic andesite, 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 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.

2. Doi Chong Area

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

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 rock in contact with the granite has 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 this 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-Cretaceous intrusive granite, pneumatolytic to katahermal 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.

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Part I GENERAL REMARKS

CHAPTER 1 INTRODUCTION

1-1 Backgound and Objective

The existence of gold in Thailand has long been known and the amount of gold produced in the past is apparent in the gold statues of Buddha found throughout the country and in individual gold ownership. Many placer gold-producing districts are known in various parts of the country and local people used to pan for gold in the classical manner during the dry season. And in western and southern Thailand gold was collected from drift sand deposits as a by-product of tin.

In recent years there has been a steady increase in the amount of gold consumed in Thailand, but the supply of gold is mostly dependent on foreign imports. For this reason, the Department of Mineral Resources of Thailand is promoting the discovery of primary deposits and the reassessment of secondary deposits in the area in the vicinity of previously known occurrences of gold.

Under these circumstances, the Government of the Thailand requested the Japanese government to conducted to a cooperative mineral exploration project for gold and base metals deposits in three areas in the north and west of Thailand.

In response to this request, the Japanese government dispatched a preliminary survey mission to Thailand and on September 2, 1994 an Scope of Works was signed between the International Cooperation Agency (JICA) and Metal Mining Agency of Japan (MMAJ), and the Thailand representatative, the Department of Mineral Resources (DMR), the Ministry of Industry.

On the basis of this agreement, it was decided to conduct a cooperative mineral resource exploitation survey extending over three years, starting in 1994, in the Chiang Khong and Doi Chong areas in the north of Thailand and the Ratchaburi area in the west.

The purpose of the survey is to grasp the possibility and amount of useful elemental deposits, such as gold, tin, base metals and antimony, by obtaining a comprehensive grasp of the relationship between the geology and geologic structures of the survey areas, and mineralization, geochemical characteristics and geophysical prospecting.

1-2 Contents of the Survey

1-2-1 Survey area and purpose of survey

The survey area is divided into 2 zones in the north of Thailand and 1 in the west, namely Chiang Khong and Doi Chong in the north and Ratchaburi in the west.

The Chiang Khong area is located 20km 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 18km at its shortest side. Administratively, it belongs to Chiang Rai province.

The Doi Chong area is located 100km 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, center-

ing 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 year's survey is to grasp the existence of primary and secondary deposits of gold and deposits of tin, copper, lead, zinc and antimony, by examining the geology and geologic structure and extracting geochemical anomalies.

1-2-2 Contents of the survey

The survey for this year is a preliminary survey of all three areas, involving a geologic survey, geochemical prospecting and associated laboratory tests.

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 and geochemical anomaly map with a scale of 1:100,000. The contents and quantities of the survey are shown in Table 1.

Table 1 Contents of Survey

Contents	Item	Quantity
Geological and Geochemical Surveys	Coverage	1,800 km^2
	Survey Route Length	720 km
	Stream Sediments	1,854 pieces
	Panned Sample	310 pieces
Laboratory Works	Rock Thin Section	51 pieces
	Ore Polished Thin Section	41 pieces
	X-ray Diffration	25 pieces
Chemical Analysis	Stream Sediments	
	Chiang Khong Area	698 pieces
	Au,Ag,Cu,Pb,Zn,Hg,As,Fe,S,W,Sb,Mn	
	Doi Chong Area	623 pieces
	Ratchaburi Area	530 pieces
	Au,Ag,Cu,Pb,Zn,Hg,As,Fe,S,W,Sn,SbF,Ta,Nb	
	Rock Samples	35 pieces
	Ore Assay	151 pieces

1-3 Schedule and Personnel

1-3-1 Planning and negotiation

In order to conduct a preliminary investigation, negotiate the agreement and hold meetings to plan the survey for the first year, an investigation commission was dispatched according to the schedule below.

(a) Schedule for preliminary investigation and agreement negotiations

Period: from August 29, 1994 to September 8, 1994

(b) Members

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 Minig 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

1-3-2 Field survey team

(a) Period of survey

The field survey for the first year was carried out from October 25, 1994 to December 25, 1994.

(b) Members

Japan

Coordination and Planning

Katsutaka NAKAMURA	Metal Minig Agency of Japan, Bangkok

Geological and Geochemical Survey Team

Hiroyuki TAKAHATA	Geologist
Yasunori ITO	Geologist
Tetsushi Ozawa	Geologist
Kenji KIZAKI	Geologist
Hiroshi IWASAKI	Geologist

Thailand

Coordination and Planning

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

Geological and Geochemical Survey Team
Chiang Khong and Doi Chong Area

Chamlong Pintawong	Geologist,	Dept. of Mineral Resources
Phureewat Jenrungrot	Geologist	Dept. of Mineral Resources
Adoon Wunapeera	Geologist	Dept. of Mineral Resources
Jitisak Prommanee	Geologist	Dept. of Mineral Resources
Anuchit Vichitchalermpong	Geologist	Dept. of Mineral Resources
Ruechai Ngiamphaisan	Field assistant	Dept. of Mineral Resources
Ratchaburi Area		
Peerapong Khuenkong	Geologist	Dept. of Mineral Resources
Patchara Jariyawat	Geologist	Dept. of Mineral Resources
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

CHAPTER 2 GEOGRAPHY

2-1 Location and Access

The three survey areas of Chiang Khong, Doi Chong and Ratchaburi are 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 approxisimetly 50 km at its longest side and 18km 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). A paved road runs from Chiang Rai to the survey area and takes about 30 minutes. There are paved roads within the survey area and it takes about 2 hours to reach Chiang Khong at the northern tip of the survey area.

The Doi Chong area is situated 100km 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 or during the rainy season, making passage by car difficult.

2-2 Topography

2-2-1 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 900m 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.

2-2-2 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.

2-2-3 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.

2-3 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 or orchards for growing pineapples and other fruit. The mountainous region is covered with sparse woods of tropical deciduous trees.

2-4 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.

Table 2 Temperature and humidity at the 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	41.8	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	18.4	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	50.81	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	58.89	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 the 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	27.8	15.4	254.2	107.0	166.3	225.6	171.9	127.2	0.0	0.0	1096.8
1990	0.0	5.9	63.2	48.5	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	86.3	58.5	293.5	68.1	73.8	11.2	4.8	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

CHAPTER 3 EXISTING GEOLOGICAL INFORMATION

3-1 Previous Works

A German geological survey team (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 survey 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 survey 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 survey 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.

3-2 Geology and Ore Deposits in the Survey Areas

3-2-1 Outline of 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 rock, 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 rock has been redefined as Jurassic 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 rock and to consist of Cambro-Silurian meta-sedimentary rock, Permian sedimentary rock, Permo-Triassic volcanic rock, Triassic sedimentary rock and Cretaceous granite. 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 rock unconformably overlies Permian sedimentary rock. The direction in which the volcanic rock extends differs to that on the west side, showing a NE-SW direction.

The Ratchaburi area is composed of Cambrian-Ordovician meta-sedimentary rock, 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-Quartenary terrace and alluvial sediment.

The structure of the metamorphic rock and sedimentary rock shows a NW-SE direction, and judging from the rough distribution, the lowest stratum is distributed on the Myanmar border with younger sediment distributed gradually on the east side. Granite has 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 rock.

3-2-2 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 for 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 scondary 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 60kg of placer gold annually.

CHAPTER 4 COMPREHENSIVE DISCUSSION

4-1 Chiang Khong Area

The Chiang Khong area is composed of Permian sedimentary rock such as sandstone, mudstone,conglomerate and limestone, Permo-Triassic andesitic and rhyolitic lava, tuff and tuff breccia, Triassic granite, Jurassic andesite lava, red siltstone and sandstone of the Jurassic, Pliocene siltstone, and Plio-Pleistocene basalt.

Four periods of igneous activity are known: andesite and rhyolite in the Permo-Triassic, granite in the Triassic, andesite in the Jurrssic and basalt in Plio-Pleistocene age.

The geologic structure shows the formation of a mountainous region extending NE-SW overall, and there is an evident tendency for the distribution of stratum to continue virtually in harmony with this direction. The strikes and dips of Permian sedimentary rocks show steep dip and a large syncline structure, with the center of moutainous range as its axis.

Permo-Triassic volcanic rock is accompanied by tuffs and covers the Permian system with unconformity. It shows elongated parallel to thefault zones running NE-SW. Permo-Triassic tuff, accompanied by dome-shaped andesite and rhyolite, is prevalent in the northeast of the Chiang Khong area, and it shows a monoclinal structure on the east side in this region.

In addition to the faults and lineaments of the Chiang Khong area which have developed in a NE-SW direction along the synclinal axis of sedimentary rock of the Permian, there is marked faults which run obliequely in an ENE-WSW direction. These faults and lineaments are well developed in the north than in the center of the Chiang Khong area. Distribution of Jurassic andesite and alteration zones in the north is controlled by these fault systems.

There are no mines with a productive record in the Chiang Khong area. According to information from a local owner of mining rights, there are two occurrence for copper and one for gold. The gold occurrence is located on the boundary with sedimentary rock at the southernmost part of the central granite body. The owner once discovered gold flake with 5 to 6 milieters in diameter by panning. A geochemical data of Au=16ppb was obtained from a stream sediment. One of copper occurrence is locted on the west of Ban Bo Seang. There is a white sandstone of Permian age. Seams of green copper are evident in the massive sandstone and a grade of Cu=1.57% was obtained from the sample.

Tuffceous rocks in the Chiang Khong area have undrgone marked white argillization, but it is mostly thought to have been kaolinnized duc to tropical weathering. Nevertheless, a white argillized alteration zone acoompanying limonite-quartz vein is senn on the mountain pass of the highway which traverses the northern part of the Chiang Khong area. Gold flake was discovered by panning in two places in rivers along the alteration zone. It is likely that this alteration zone is connected with gold mineralization. The alteration zone covers 3km wide by 12km long along the

fault zone which runs in a NE-SW direction.

There are no very clear mineral occurrence in the south of the area, but intense argillized alteration and quartz vein are seen inaprts of Permo-Triassic tuff in southeast of the area, and quartz veins have developed in Permian slate.

From the results of geochemical prospenting, the high score zone of the third component (Z-3) which shows Au-Hg-S minaralization and its halo, extends over a wide area, overlapping with the argillized zone along the faults around the upper reaches of Nam Sala in the north. The Au anomaly in Nam Sala ranges from 30 to 770ppb. In the south, high score zones for Z-3 are also widely distributed in Huai Mae Liap, southwest of Phaya Men Rai.

The high score zone of first component which indicates base metals mineralization is distributed in harmony with the alteration zone and faults in the north. It surrounds the high score zone for Z-3 in the upper reaches of Huai Sala. With the exception of high score zones involving Fe anomaly, the potential area of Cu and Zn mineralization is limited to the area from Huai Thung Lo to Huai Kong Kean tributary in the southwest of alteration zone. In the southeast of the area, A high score zone is observed on the east side of the granite body.

These mineralizations occur with Permo-Triassic volcanic rocks and in parts, Permian sedimentary rocks. It is likely that in the north, mineralization occuered due to the activity of Triassic andesite, in the south in connection with Triassic granite.

Judging from the above, the promising regions of mineral deposits in the Chiang Khong area are the upper reaches of Huai Sala and Huai Mae Liap regions for gold deposits, and Nam Mae Bong and Huai Mai ya regions for base metal deposits.

4-2 Doi Chong Area

The geology of the Doi Chong area is composed, from below, of Carbono-Siluro-Devonian 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, etc.

Much of the granite and diorite is relatively small-scale. The largest-scale rock bodies are around 2 x 8m. It has been confirmed that the sedimentary rock around the granite has often undergone contact metamorphism, showing that the granite is intrusive rock. It is assumed that the granite 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 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.

In the geologic structure of the Doi Chong area there are assumed to be faults running NW-SE,

Kanchananburi Group, Devonian-Carboniferous Kaeng Krachan Group Huai Phu Ron Formation, Kao Phra Formation and granite which has intruded into the Jurassic-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 rock shows fragmented distribution on account of the intrusion 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 direction of the granite on the whole conforms to the structure of the sedimentary rock. Lineaments running NE-SW to NNE-SSE are clearly seen in the granite zones.

Several old tin (-tungsten) placer and primary deposit exist, from the boundary zones between granite and sedimentary rock to the alluvial basins of the streams in the Ratchaburi area, but they are no longer worked today. Only one deposit presently being worked produces feldspar in pegmatite.

Sedimentary rock in contact with granite is 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.

The granite in this area is S-type and belongs to the ilmenite series. It shows the characteristics of tin granite clearly.

From the results of geochemical prospecting, it is noticeable that the density of individual elements is low overall, with the exception of tin, tantalium, niobium, flourine and tungsten.

The anomaly zones of tin, tantalium, niobium, flourine and tungsten are concentrated in the Mae Nam Phachi basin where there are many old deposits, and anomaly zones are distributed in the old deposits and backland 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.

N-S and NW-SE. The direction of the bedding and cleavage planes of the strata in the vicinity of the fault running NE-SW along the Mae Nam Wang and the fault runing NW-SE in the upper reaches of the Nam Mae Toen inclines toward the direction of the fault. In particular, the faults running NNW-SSE to N-S along the Huai Mae Thot are assumed to be relatively large-scale reverse faults.

The Carbono-Siluro-Devonian and Permian geologic structure on the whole runs in a NNW-SSE direction and the upper strata overlap in a northeasterly direction. In addition, Permo-Triassic volcanic rock and Triassic system are distributed, covering them unconformably. However, judging by the fault along the Huai Mae Thot, the east side of the fault is thought to have risen relatively, and the subordinate Permian layer is exposed on the east of the fault.

Schistosity or cleavage planes of varying degrees are seen in the sedimentary rock 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 Carbono-Siluro-Devonian show marked development of schistose planes, phyllitization, conglomerate deformation, etc. Morcover, 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.

There used to be fluorite mines in Ban Mae Kaeng and Ban Mae Toen in the Doi Chong area, and gold excavation pits to the east and north of Ban Na Ban Rai. Also, according to information from DMR, there were small-scale occurrences of magnetite and limonite, one in Huai Mae Thot and one in the southeast of the area, and according to information from local residents, there used to be antimony deposits in Huai Mae Haet in the north.

Sedimentary rock and metamorphic rock 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 multi-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. Also, there are 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.

4-3 Ratchaburi Area

The Ratchaburi area is composed of Ordovician Thung Song Group, Silurian-Devonian

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-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

CHAPTER 5 CONCLUSION AND RECOMMENDATION

5-1 Conclusion

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.

5-1-1 Chiang Khong Area

(1) The Chiang Khong area is composed of Permian sedimentary rock including sandstone, mudstone, conglomerate and limestone, Permo-Triassic andesitic and rhyolitic lava, tuff and tuff breccia, Triassic granite, Jurassic andesite, Jurassic red siltstone and sandstone, Pliocene siltstone, Plio-Pleistocene basalt.

(2) The overall survey area consists of a mountainous region extending NE-SW, and a tendency is seen for the distribution of the various strata to continue virtually in harmony with this direction. The lowest level Permian stratum shows a synclinal structure with its axis in the center of the mountainous region. Permo-Triassic volcanic rock accompanied by tuff covers the Permian system unconformably and is distributed in two parallel zones running NE-SW. It is likely that andesite was active along fractures running in this direction.

The faults or lineaments in the Chiang Khong area have developed in a NE-SW direction along the synclinal axis of Permian sedimentary rock, and there are noticeable faults crossing them obliquely in an ENE-WSW direction. The lineaments are more developed in the north than in the center of the Chiang Khong area. Distribution of Jurassic andesite and alteration zones in the north is controlled by these fault systems.

(3) From mutual examination of the results of the geologic surveys and geochemical prospecting, the following promising regions were selected.

1) Upper reaches of Nam Sala (20 km^2)

The fault systems running NE-SW and ENE-WSW and accompanied by activity of Jurassic andesite have developed conspicuously. White alteration zones accompanied by limonite-quartz veins extend along the fault systems. Au-Hg(-Ag-Pb) geochemical anomaly zones are distributed accompanying the alteration zones and epithermal vein deposits containing gold can be expected.

2) Nam Mae Bong region (20 km^2)

This region covers the southwest part of the upper reaches of Nam Sala and the southwest part of the fault and alteration zones extending from Nam Sala. Fe-Zn-Cu-Pb-Mn geochemical anomaly zones are distributed in the region and vein deposits of base metals can be expected. Gold anomaly zones are also distributed further to the southwest.

3) Upper reaches of Huai Mae Liap (10 km^2)

There are few outcrops and the geological condition is not clear in many places, but most of the region is composed of Permian slate and not many alterations are seen. In addition to Au-Hg-As-Sb, there are distributions of Cu and S geochemical anomaly zones.

4) Huai Mai Ya region (12 km^2)

This region is composed of Permian sedimentary rock and Permo-Triassic andesite and tuff. The tuff has altered intensely and Cu, Zn, Fe, Hg, S, As and Sb geochemical anomaly zones accompanied by quartz veins are seen, with Au anomaly zones in some parts. Vein deposits of base metals containing gold can be expected.

5-1-2 Doi Chong Area

(1) The geology of the Doi Chong area is composed, from below, of Carbono-Siluro-Devonian Mae Tha Group and Donchai Group, Kiu Lom Formation, Pha Huat Formation and Huai Thak Formation of the Permian Ratburi Group, Permo-Triassic volcanic Formation, Triassic Lampang Group Hong Hoi Formation and Triassic intrusive granite and diorite.

(2) There are assumed to be faults running NW-SE, N-S and NW-SE in the survey area. In particular, the faults running NNW-SSE `N-S along Huai Mae Thot are assumed to be relatively large-scale reverse faults.

The Carbono-Siluro-Devonian and Permian geologic structure on the whole runs NNW-SSE and the upper strata overlie towards the NE. Also, Permo-Triassic volcanic rock and Triassic system are distributed, covering them unconformably.

However, judging by the fault along Huai Mae Thot, the east side of the fault is thought to have risen in relation to the west and the lower Permian stratums is exposed, with the fault as the boundary.

The intrusive direction of the granite also conforms to the direction of the fault.

(3) From mutual examination of the results of the geologic surveys and geochemical prospecting, the following promising regions have been selected.

1) Huai Mae Pu region (14 km^2)

Geochemical anomaly zones for base metals and Au, Sb and Hg are seen over an extremely wide area extending from Huai Mae Pu to Huai Mae Haet in the west. Geologically, the Permian sandstone layer is prevalent, but according to local people, there was once an antimony mine. Polymetallic hydrothermal vein deposits can be expected.

2) Doi Khun Mae Thot region (24 km^2)

Many seams of granite and aplite have intruded into the Permian sandstone and mudstone along the schistose structure. There are also many quartz seams and silicified zones have developed in some parts.

Geochemical anomaly zones for Au and the parent elements of Hg and Sb are distributed running E-W along the sides of Doi Khun Mae Thot and As geochemical anomaly zones are distributed continuously to the south of these anomaly zones.

Also, geochemical anomaly zones for base metals are distributed at the foot of the mountain. Hydrothermal Au vein deposits and mineralization of base metals below them can be expected.

3) Region of upper reaches of Huai Mae Toen (18 km^2)

Geochemical anomaly zones for base metals (Cu, Zn and Fe) are distributed overlapping distribution of diorite in the upper reaches of Huai Mae Toen, silicified zones that have developed in the vicinity, and subsurface granite (diorite) to the south. An anomaly zone for the single element of gold (2,180ppm) is distributed overlapping these zones. Chalcopyrite is disseminated in the diorite, though in small quantities. Metasomatic and hydrothermal deposits of base metals can be expected.

4) Northern region of Ban Na Ban Rai (2 km^2)

Small granite bodies have intruded into the Permian semi-schist in the area where local people excavated gold. Au and Hg geochemical anomaly zones are distributed here. It is already known for mineral occurrences at the surface, but more detailed assessment is required in deeper part.

5) Mae Haet region (9 km^2)

As there are hardly any outcrops in the flat lands between Huai Mae Haet and Huai Mae Tam, the geological condition is not clear. Anomaly zones of base metals (Fe, Cu and Zn) and Hg and Sb are distributed here and hydrothermal base metal deposits can be expected.

6) Eastern region of Huai Mae Thot (20 km^2)

Geochemical anomaly zones for niobium and tantalum are extremely strong in the vicinity of granite zones to the east of Huai Mae Thot. In addition to niobium and tantalum, other rare earth element deposits can also be expected.

5-1-3 Ratchaburi Area

(1) 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 granite that has intruded into the Jurassic-Cretaceous.

(2) On account of the intrusion of granite, the sedimentary rock structure shows fragmental distribution, but the schistosity and sedimentary structures run in a NW-SE direction and there is a tendency for new strata to overlie on both sides of the Silurian-Devonian anticlinal structure.

The granite bodies are part of a giant batholith which has intruded along the Thai-Myanmar border, and the intrusive direction of the batholith on the whole conforms to the structure of the sedimentary rock. Lineaments running NE-SW`NNE-SS W are conspicuous in the granite distribution zone.

(3) From mutual examination of the results of the geologic surveys and geochemical prospecting, the following promising regions have been selected.

1) Huai Suan Phlu region (34 km^2)

2) Huai Sa region (9 km^2)

Both region are located in the contact zone between granite and Devonian-Carboniferous sedimentary rock and narrow quartz veins have developed in the sedimentary rock. In addition to the anomaly zone just for gold, the region also shows an anomaly zone for base metals. The two anomaly zones overlap in few places and the gold anomaly zone tends to be distributed in the vicinity of the base metal anomaly zone. Judging from the fact that hardly any alteration zones are seen, mineralization of stockwork-type quartz veins that have developed near the granite bodies can be expected.

3) Huai Takua Pit Thong region (4 km^2)

Slate, calcareous mudstone and limestone are found in the granite and have undergone thermal metamorphism. Ploymetallic contact metasomatic deposits can be expected.

5-2 Recommendation for the Second Phase Survey

The following surveys are recommended of the promising regions mentioned previously.

5-2-1 Chiang Khong Area

With regard to the upper reaches of Huai Sala in 1) and the Nam Mae Bong region in 2), in addition to conducting geochemical prospecting of the soil at random points using the ridges and streams (at intervals of about 50m) and detailed geologic investigation, electrical prospecting by specific resistance or the IP method should be carried out to narrow down the more promising zones.

With regard to the upper reaches of Huai Mae Liap in 3) and the Huai Mai Ya region in 4), considering that the type of mineral deposits is not clear, detailed geologic investigation and detailed geochemical prospecting of the stream sediments should be conducted to narrow down the promising zones and clarify the mineralization situation.

5-2-2 Doi Chong Area

With regard to the Huai Mae Pu region in 1) and the upper reaches of Huai Mae Toen in 3), as the whole range of mineral occurrence has not always been grasped, detailed geologic surveys and detailed geochemical investigation of stream sediments should be carried out to clarify the scale of mineral occurrence and narrow down the promising regions.

With regard to the Doi Khun Mae Thot region in 2), detailed geochemical investigation of the soil using the streams and ridges and detailed geologic surveys should be carried out to narrow down the more promising regions.

With regard to the northern part of Ban Na Ban Rai in 4), in addition to carrying out detailed geochemical prospecting of the soil by grid method to specify the location of promising quartz veins, the continuity of the quartz veins to deep parts should be grasped by electrical prospecting, etc. Where necessary, pits should be dug to confirm the grade and existence of quartz veins.

With regard to the Huai Mae Haet region in 5), exposure is poor and the mineralization pattern is not clear. Considering that the topography is flat, the promising regions should be narrowed down by geochemical prospecting of the soil and detailed geologic surveys and the mineralization pattern clarified.

With regard to the region east of Huai Mae Thot in 6), as the mineral occurrences are outside the mineral types under this survey, the pathfinder elements should be changed and detailed geochemical prospecting carried out. Reassessment is necessary.

5-2-3 Ratchaburi Area

It may be possible to clarify the origins of placer gold not previously specified. For this reason, detailed geologic surveys and detailed geochemical prospecting of stream sediments should be carried out to clarify the existence of quartz veins and mineral occurrence.

PART II DETAIL DESCRIPTION

CHAPTER 1 CHIANG KHONG AREA

1-1 General Geology

The Chiang Khong area is composed of Permian sedimentary rock such as sandstone (PRs), mudstone (PRm),conglomerate (PRc) and limestone (PRl), Permo-Triassic andesitic and rhyolitic lava (PTa, PTr), tuff (PTt) and tuff breccia (PTb), Triassic granite (Gr), Jurassic andesite lava (ms2), red siltstone and sandstone (ms3) of the Jurassic, Pliocene siltstone (ng), and Plio-Pleistocene basalt (Ba). The overall geologic structure conforms to the continuous direction of the mountain ridge in the Chiang Khong area and shows extension in a NE-SW direction.

This area has not yet been surveyed for mineral deposits for DMR, and as for mining, there is only a distribution of sedimentary manganese deposits in alluvium in the southeast of the Chiang Khong area..

The geologic map and schematic geological column of the Chiang Khong area are shown in Figs. 2 and 3.

1-2 Detailed Geology

1-2-1 The Permian sedimentary rock series (PR)

The Permian sedimentary rock consists of sandstone, conglomerate, mudstone and limestone, and in some parts they form alternate strata. They are widely distributed along the northern boundary of the Chiang Khong area and southwards from the central region.

Mudstone (PRm), which is the most widely distributed, is mainly made up of black slate and sandy mudstone in the north. Slate is also found in the south where granite is distributed, but in many cases it is mica schist. Also, on the west side of the southern granite body, the mudstone contains lens-shaped limestone. Though outside the area, brachiopods from the Permian period have been confirmed in the same stratum (Hahn et al., 1982).

Grey-colored, medium to coarse sandstone (PRs) prevails in the north, but fine or medium tuffceous sandstone which shows a white colour is prevalent in the southern half. Sandstone in the south has a high tuffceous silt content and clastic grains are composed of quartz, feldspar, etc.

Conglomerate (PRc) is mainly dark-grey pebbly conglomerate of relatively good roundness.

In addition to the limestone (PRl) which is distributed as stacks in the plains in the southwest of the area, small-scale lens-shaped limestone bodies are also found scattered in the mudstone area in the south. Fusulinidae has been confirmed in this limestone and has been correlated from the uppermost Carboniferous to the lower Permian. (Hahn et al.,1982).

1-2-2 Permo-Triassic Volcanic rock series(PT)

Volcanic rock of the Permo-Triassic is composed of andesite (PTa), rhyolite (PTr), andesitic and rhyolitic tuff (PTt), and andesitic tuff breccia (PTb). This volcanic rock series are part of the upper Permian-lower Triassic volcanic rock zone of Bunopas (1992). With the Chiang Khong area and Doi Yao mountain ridge to the east marking the northern tip,it continues southwards in an S-shape,

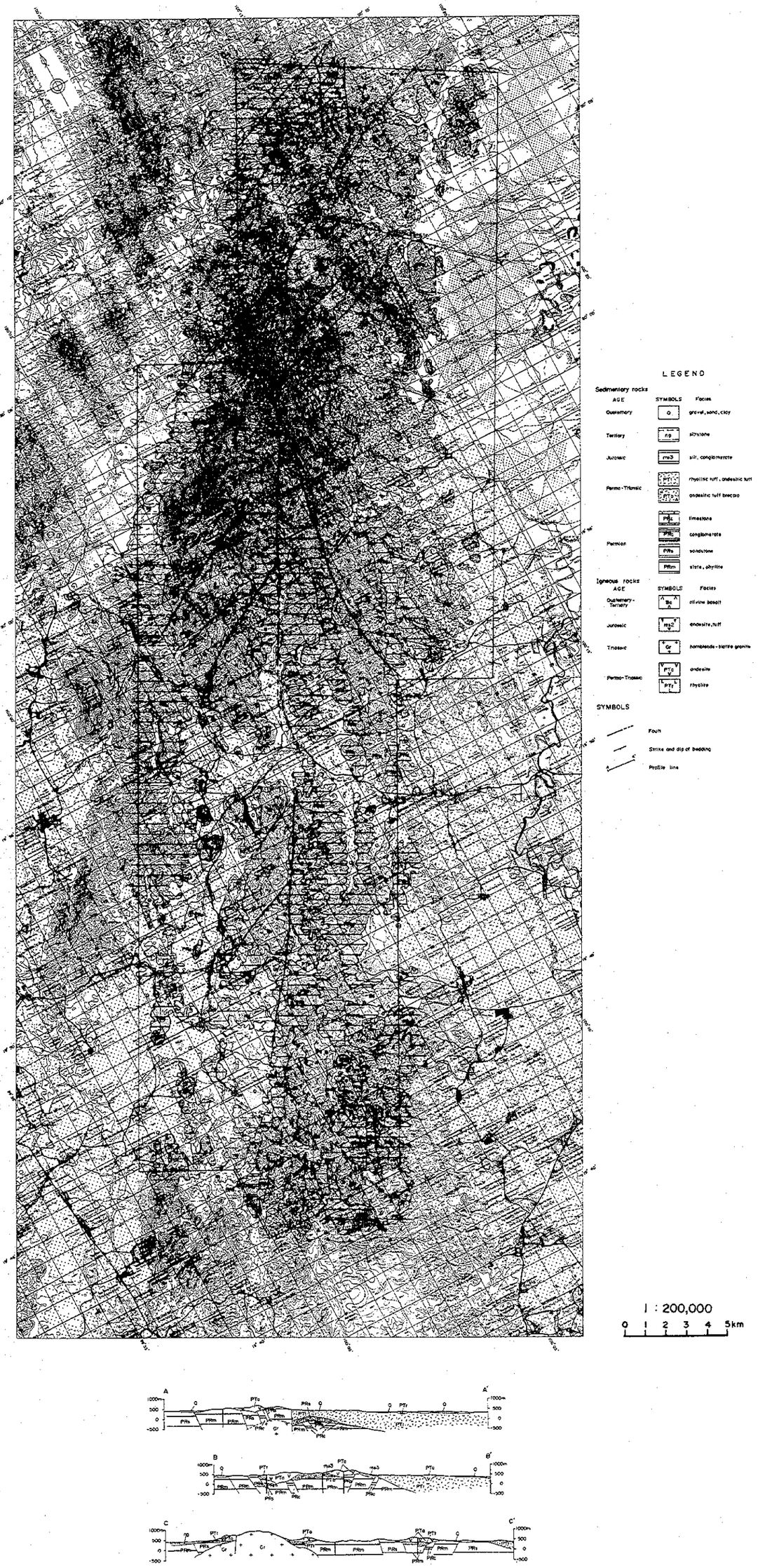


Fig. 2 Geologic Map in Chiang Khong area

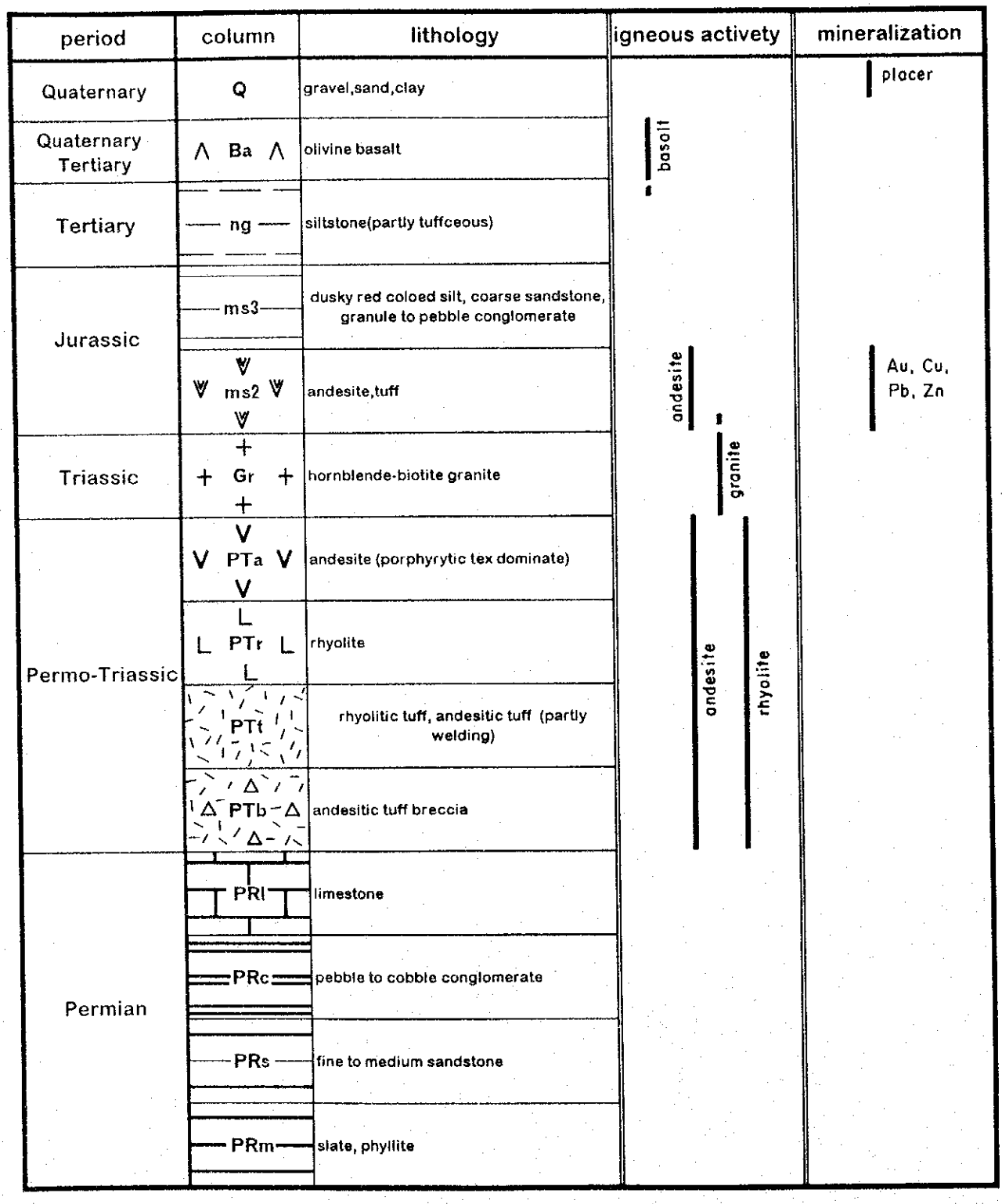


Fig. 3 Schematic geologic column in Chiang Khong area

through Ngao and Phrae to the east side of the Doi Chong area.

This volcanic rock is prevalent in the northern part of the Chiang Khong area, but with little in the south. In the north, distribution differs on the east and west sides of the fault that divides the area in two. On the eastern side of the fault, tuff is predominant and lava cones of andesite and rhyolite are scattered here and there, but no distribution is seen on the western side. Andesite lavas continues in two parallel belts, on the western side of the fault and immediately to the east of the fault, and is accompanied by tuff breccia in some parts. Andesite lavas accompanied by tuff are found scattered in the south.

Andesite (PTa) is massive lava which shows a dark red or dark green colour, and in some parts is characterized by a content of idiomorphic platy plagioclase phenocrysts. It is two-pyroxene andesite with intersertal texture and it has undergone intense alteration of chlorite, sericite and calcite. Overall, there are many andesites which show a dark green colour and they are propylititic.

Rhyolite (PTr) is a vitritic rock which contains two-pyroxene. Spherulitic, perlitic textures are seen. Like andesite, it has undergone intense alteration of chlorite and sericite.

Tuff (PTt) is composed of fine rhyolitic tuff, andesitic sandy tuff, lapilli tuff and welded tuff. As for tuff distributed on the east side of the fault, bedding has developed in many parts. It shows a NE-SW strike and dips gently on the east side. At the dam site in the middle reaches of the Nam So to the west of Ban So, andesitic welded tuff of a dark brown color is distributed below green fine rhyolitic tuff. Similar rocks are also found in the Nam Mae Pao tributary in the central western part of the area.. The tuff has undergone chlorite alteration, but is weaker than andesite. Nevertheless, outcrops that have undergone intense hydrothermal alteration of kaolinite, sericite, etc. are widely distributed along the national highway on the west side of Ban Kaeng in the north of the area.

Andesitic tuff breccia (PTb) is distributed in Huai Ta Khuan in the upper reaches of Nam Mae Tam. It is breccia tuff which shows a grey color. The gravel is subanguler to subrounded and the amount is small. Chloritization is marked in gravel andesite, but alteration of the matrix is not very strong.

1-2-3 Triassic granite (Gr)

Biotite-hornblende granite of Triassic age is distributed in three rock bodies from the center to the south of the area. The granite is medium to coarse-grained granite which contains biotite and hornblende and it shows holicrystalline and equigranular texture. Chloritization of biotite and amphibole and sericitization of plagioclase are seen, but overall it is fresh.

The susceptibility of the granite by a handy susceptibility gauge shows 6.0～7.7 x 10^{-3} S.I. unit, 7.4 ～9.6 x 10^{-3} S.I. unit, and 10.0～12.5 x 10^{-3} S.I. unit, and it can be classified into magnetite series.

It is observed that the granite in each place causes thermal metamorphism of the surrounding sedimentary rocks, but the width is only around 50 to 60 metres.

1-2-4 Jurassic andesite (ms2)

In addition to andesite which shows distribution in lava cones of about 1km diameter in the north

of the area, there is also andesite which shows distribution in dikes, cutting across andesite of the Permo-Triassic. Megascopically it is non-phenocrytic andesite and alteration is not very strong.

1-2-5 Jurassic sedimentary rocks (ms3)

Thier are narrowly distributed in the center of the area.. It has developed by discordantly covering conglomerate, sandstone, andesite and tuff of the Permian. The rockfacies is siltstone, coarse sandstone, granule conglomerate which show such colors as dark red, brick color and reddish purple, and the dip is a gentle dip of less than 20°. Judging from these occurrences, it is assumed to be continetal sediments.

1-2-6 Pliocene sedimentary rock (ng)

This is distributed on the boundary between the mountainous region and the plains south of the center in the west of the area. It is composed of half-consolidated siltstone, tuff sandstone.

1-2-7 Plio-Pleistocene basalt (Ba)

In the southern area basalt is distributed covering the sedimentary rock and granite. In addition to covering the mountain ridge in the form of a cap rock, there are places where distribution gently descends to the plains. It corresponds to the Chiang Rai basalt of Jungyusuk & Sirinawin (1983) and shows an overall age of 1.69 ± 1.25Ma by K-Ar age dating. The basalt is porous rock which assumes colors from pale grey to black. It shows intergranuler texture and contains microphenocrysts of olivine, pyroxene and plagioclase. Smectite and chlorite are seen in small quantities, but are extremely new.

1-3 Geologic Structure

The survey area as a whole forms a mountainous region extending NE-SW and a tendency is seen for the distribution of each stratum to continue virtually in harmony with this direction. The strikes and dips of Permian sedimentary rocks show NE-SW strike with SE dip in the central southern half of the Chiang Khong area, and NE/SW - N/S strike with W dip on the east side of the central region. It is assumed to show a large syncline structure.

Permo-Triassic volcanic rock is accompanied by tuff and covers the Permian system with unconformity. It shows distribution in two parallel zones running NE-SW. It is likely that these andesites were active along fractures running in the same direction. Permo-Triassic tuff, accompanied by dome-shaped andesite and rhyolite, is prevalent in the northeast of the Chiang Khong area, and it shows a monoclinal structure on the east side in this region.

In addition to the faults and lineaments of the Chiang Khong area which have developed in a NE-SW direction along the synclinal axes of sedimentary rock of the Permian, it is noted that there are lineaments which run obliquely to them in an ENE-WSW direction. These faults and lineaments are more developed in the north and center than in the south of the Chiang Khong area. Distribution of Jurassic andesite and alteration zones in the north is controlled by these fault systems.

Granites intrude virtually into the axis of the synclinal structure, and the major axis direction of the rock body conforms to the NE-SW direction of the area, but the line linking the centers of the three rock bodies runs obliquely to this direction, showing a NNE-SSW direction, and distribution is in

echelon.

Whereas the granite is exposed in the southern half of the area, no distribution of granite is evident at the northern tip. It is known that small granite bodies have intruded to the north of the Chiang Khong area and the existence of granite bodies is assumed below the northern tip of the area. It is assumed from this that the N-S geologic structure of the Chiang Khong area shows that the southern half rose considerably and plunged to the north which was pared away.

1-4 Geochemical Characteristics of Igneous Rocks

Geochemical analysis was carried out on 12 samples from the Chiang Khong area.. The analytical values and norm component values are given at the end of the volume. The samples were 2 Plio-Pleistocene basalt samples, 6 andesite samples of the Permo-Triassic and 3 granite samples. One sample was eliminated as it was arkosic sandstone. Granite, andesite and rhyolite from the preliminary survey are given as reference values. In Fig. 4, basalt has lower alkali and P_2O_5 than andesite and appears to have been formed at a clearly different structural site. The most basic andesite is rockfacies andesite which contains porphyritic plagioclase and it is widely different in composition from other andesites. Excluding the fact that trivalent iron, alkali, etc. have moved greatly due to the alteration of andesite, etc., the values of andesite and granite from the Triassic period show extremely similar chemical composition values, and judging from the time of formation, it is thought possible that they derived from the same magma. In Fig. 5 the granite is classified granite in sensu strito. And in Fig. 6, judging from its susceptibility, I-type belongs to the magnetite series. In the MFA diagram in Fig. 7, whereas granite, andesite and rhyolite conform well to the differentiation series of the island arc calc-alkali series, basalt has a tendency to be fairly rich in iron following differentiation and it shows a differentiation course similar to that of the tholeiite series. In the variation diagrams too, the possibility that the two were formed in different places was pointed out, but the results in this figure suggest that the andesite and granite magma originated in response to compression zone and the basalt magma was formed under tension condition.

Many sapphires and other precious stones are found in the environs of Pliocene basalt in Thailand and it is thought that they originated in the excess alumina of the basalt, but no normative corundum showing excess alumina is evident in the basalt in this area.

1-5 Mineral Deposits and Occurrences

As stated earlier, there are no metal mines with a production record in the Chiang Khong area. Fig. 8 shows a map giving the location of prospective mineral regions in the area.

According to the only information obtained during the field survey, placer gold in riverbed deposits in the middle reaches of the Nam Mae Tam was mined by about 10 local peples for about 5 years from around 10 years ago, but the details are not clear.

Furthermore, according to information from a local owner of mining rights, there are two prospective regions for copper and one for gold. The gold region lies on the boundary with sedimentary

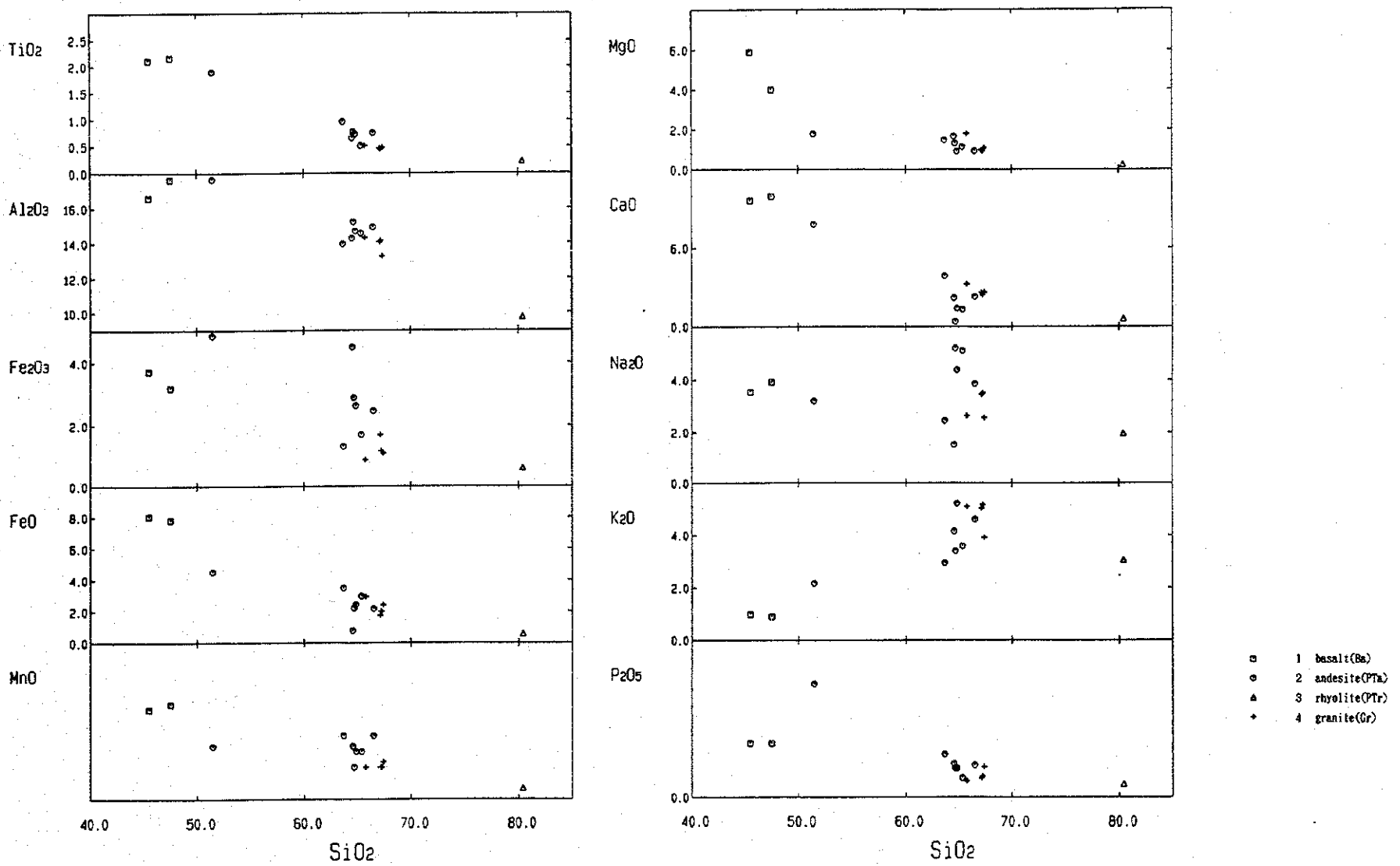
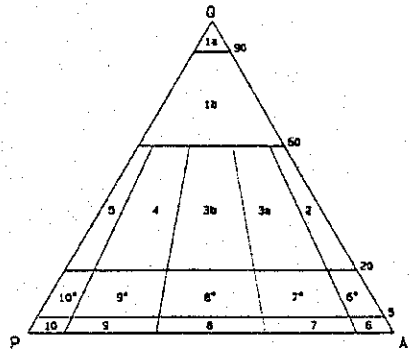


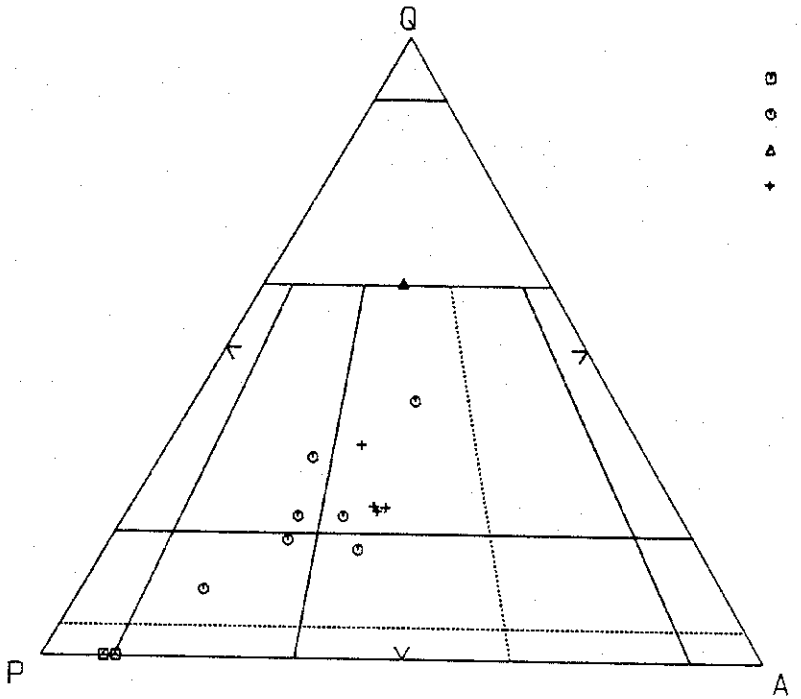
Fig. 4 Variation diagrams of igneous rocks in Chiang Khong area



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, noselh, 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 basalt(Ba)
2 andesite(PTa)
3 rhyolite(PTr)
4 granite(Gr)

Fig. 5 Normative Q-P-A diagram in Chiang Khong area

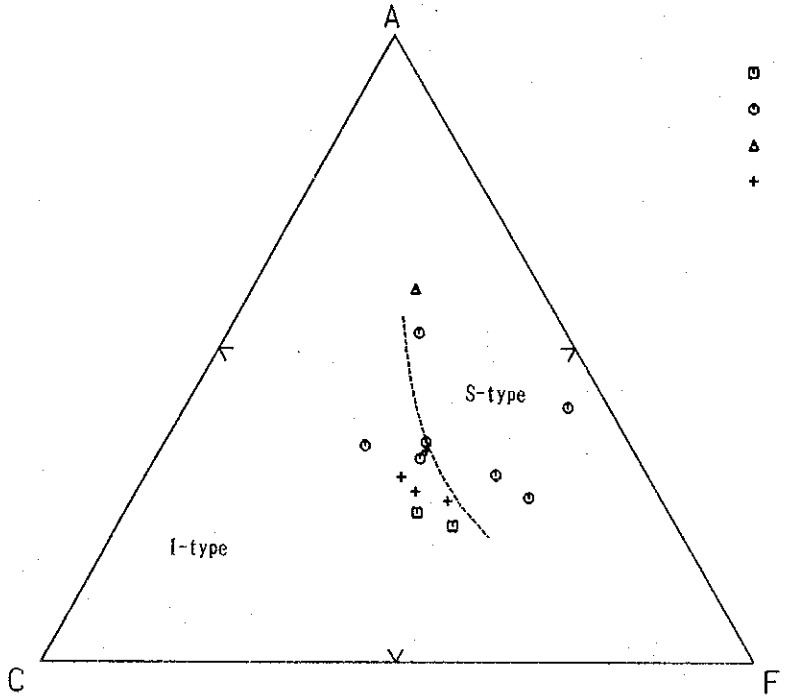


Fig. 6 ACF diagram in Chiang Khong area

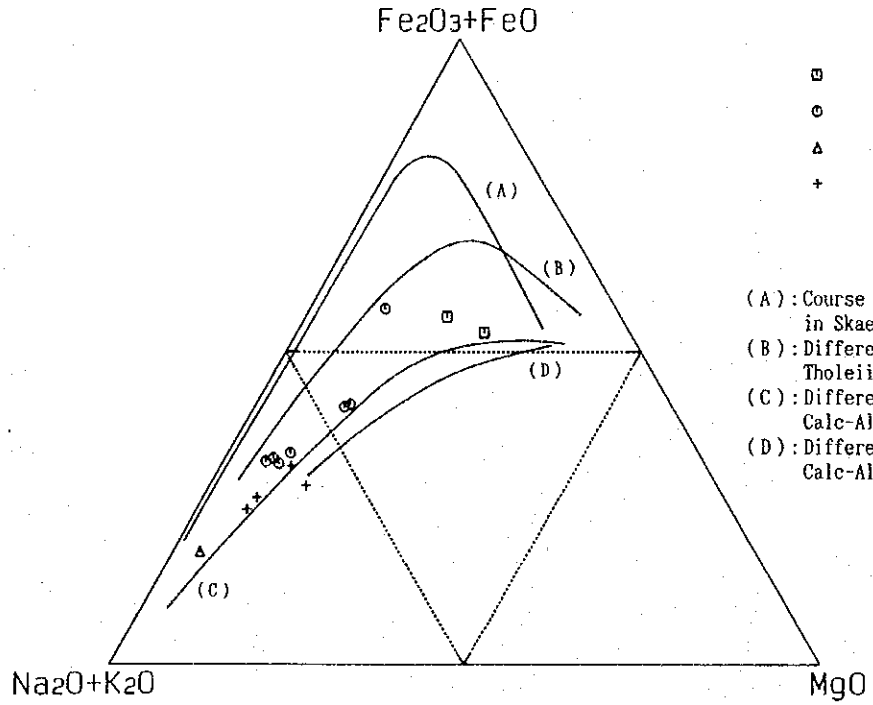


Fig. 7 MFA diagram in Chiang Khong area

rock at the southernmost part of the granite body in the middle of Huai Hom Hae, and the owner of the mining rights once discovered gold flake with 5 to 6 millimeters in diameter by panning there. In this survey we were unable to find any gold by panning, but a result of Au=16ppb was obtained from a stream sediment sample. In addition to ascertaining contact between granite and mica schist originating in the sedimentary rock, contact with andesite is also apparent. Andesite is skarnized and pyrrhotite, chalcopyrite, magnetite, etc. are disseminated. A small-scale silicified zone and skarn zone are evident in the sedimentary rock further up the same river and minute particles of chalcopyrite and pyrite are disseminated.

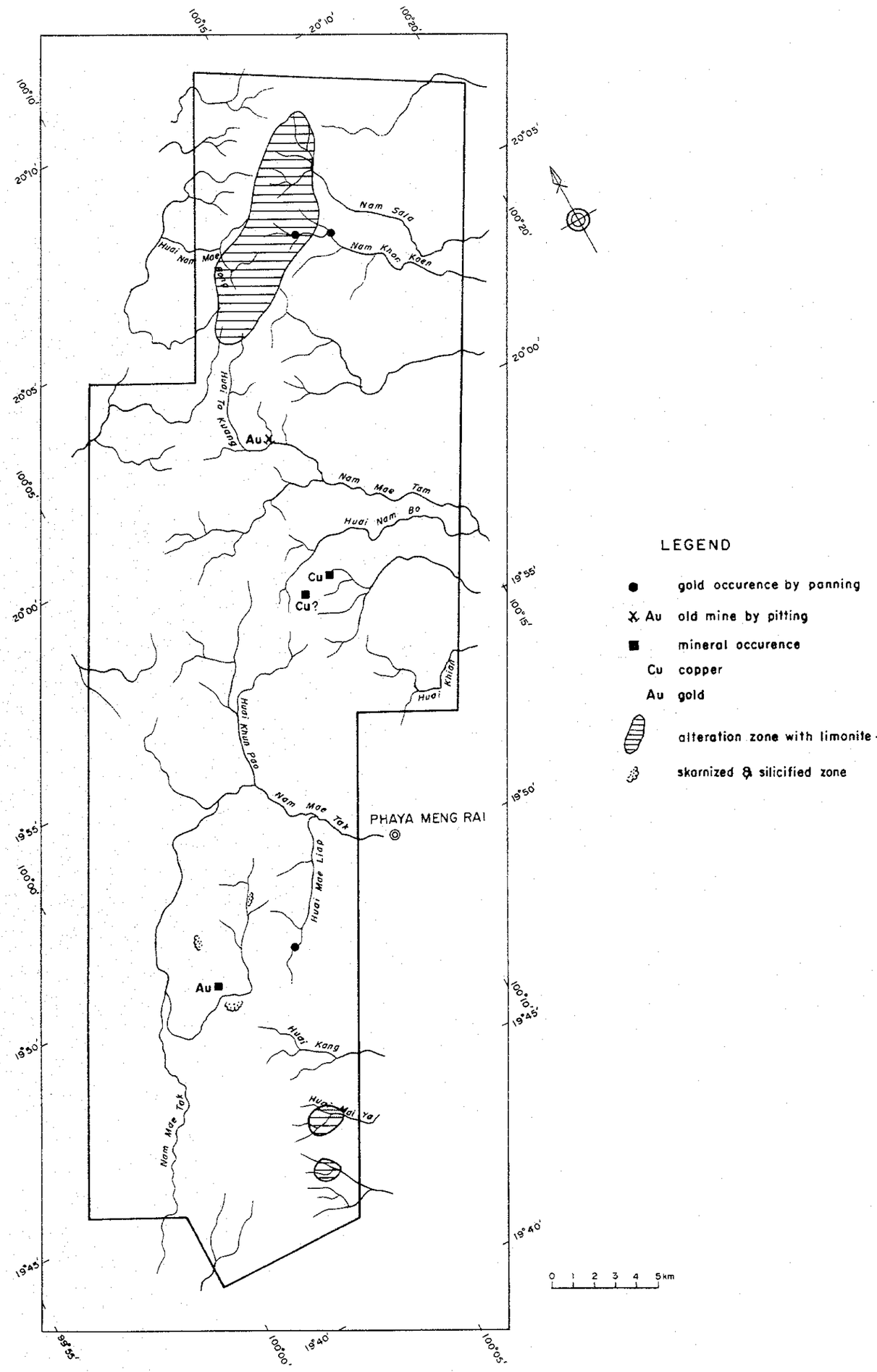
One of the prospective copper regions is distributed on the Doi Ngaem mountain ridge west of Ban Bo Seang. The geology is a Permian white sandstone stratum and seams of green copper can be seen in this massive sandstone. It was prospected 15 or 16 years ago. Ore assay result is Cu= 1.58%.

The other prospective copper region could not be confirmed due to the lack of a guide because it was the busy farming season and because the underbrush was too thick at the end of the rainy season. The region is said to be located on the Doi Nang Puk mountain ridge which is composed of andesite, west of the first prospective copper region. It consists of massive rocks about 2 meters in diameter and the surface is covered with covelline and green copper.

Tuffceous rocks in the Chiang Khong area have undergone marked white argillization, but it is mostly thought to have been kaolinized due to tropical weathering. Nevertheless, white argillized alteration zones accompanied by limonite-quartz veins are evident in a number of places by the side of the highway which traverses the north of the Chiang Khong area. Gold flakes were found by panning in two places in the river along this alteration zone and there is a strong possibility that it is an alteration zone related to the mineralization of gold. The alteration zone covers an area 3km wide by 12km long along the fault zone that runs NE-SW.

Fig. 9 and Fig. 10 are sketches of two places in the alteration zone along the highway. Fig. 9 shows outcrops in the alteration zone on the crest of the highway, and Permian sedimentary rocks are distributed with unconformity on the north side and tuff ofthe Permian-Triassic system on the south side. A fracture system running N65°E-60°～ 75°N has developed and it is accompanied by brown iron ore-quartz veins. Sedimentary rock of the Permian system is hard and there are few altered parts, but in the near-discordant tuffceous sandstone, it has undergone dissemination of pyrite, and silicification, sericitization and kaolinization. The tuff on the west side has completely altered and a mixing layer of quartz-halloysite-smectite/illite has formed. Cutting across this alteration in the extension on the west side of the outcrop, newer alterations of natural sulphur, pyrite and marcasite overlap. In an analysis of the quartz vein, a result of Au=0.03g/t was obtained.

Fig. 10 shows an outcrop of tuff of the Permian-Triassic system at a point about 1km east of the pass. A network limonite-quartz vein 10～40cm wide has developed and the surroundings have been replaced by white clay. The limonite-quartz vein shows a reddish-brown color and is silicic and brittle. Narrow quartz veins are apparent in the center of the each vein. Alteration beside the vein is characterized by quartz, chlorite and montmorillonite. A weak altered area has developed in stratified



LEGEND

- ● gold occurence by panning
- ✕ Au old mine by pitting
- ■ mineral occurence
- Cu copper
- Au gold
- alteration zone with limonite – quartz vein
- skarnized & silicified zone

Fig. 8 Location map of mineral occurrence in Chiang Khong area

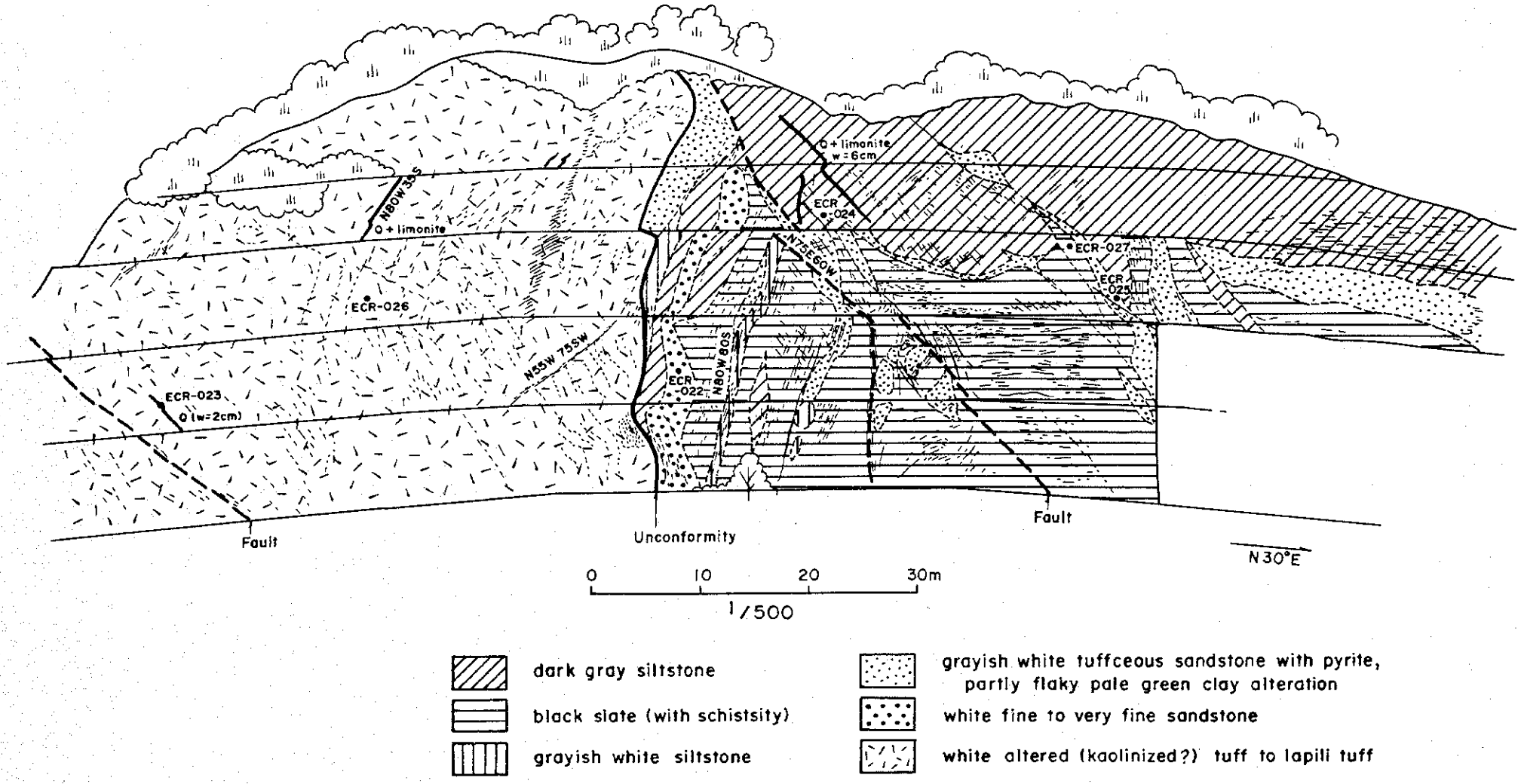


Fig. 9 Sketch of alteration zone (1) in northern Chiang Khong area

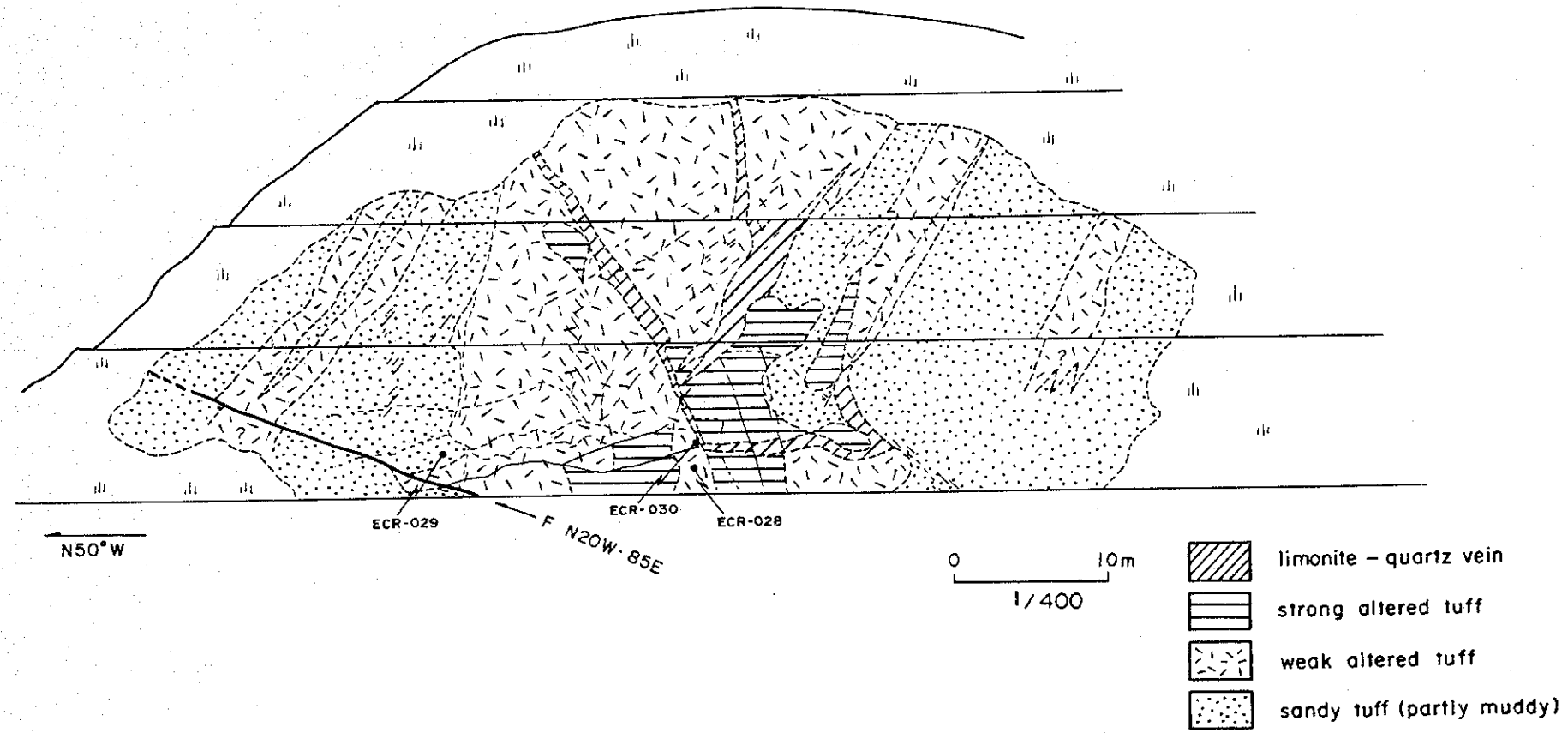


Fig.10 Sketch of alteration zone (2) in northern Chiang Khong area