REPORT
ON
THE COOPERATIVE MINERAL EXPLORATION
IN
THE MAE SARIANG AREA,
THE KINGDOM OF THAILAND

PHASE I

MARCH 1998

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 Project in the Mae Sariang Area 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 December 15, 1997 to February 27, 1998.

The team exchanged views with the officials concerned of the Government of the Kingdom of Thailand and conducted field surveys in the Mae Sariang Area. After the team returned to japan, further studies were made and the prsent report has been prepared.

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

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.

March, 1998

Kimio Fujita
President
Japan International Cooperation Agency

Hiroaki Hiyama
President
Metal Mining Agency of Japan

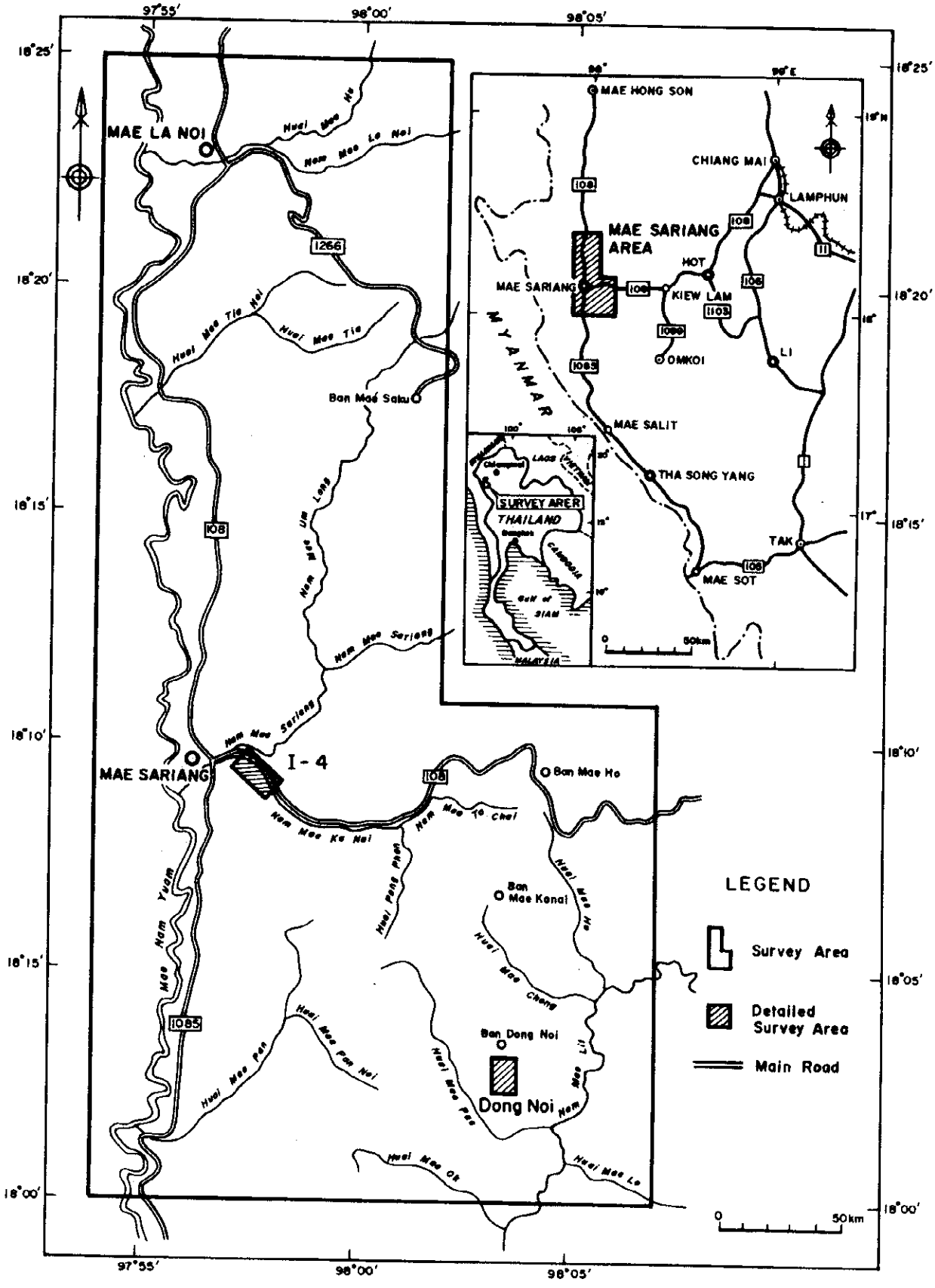

Fig.I-1-1 Location map of the Survey area

Summary

The following conclusion has been reached in consequence of Survey result in this year.

1. Reconnaissance survey of the Mae Sariang Area

The occurrence of various mineralization and the stretch of geochemical anomalies are closely corresponded with carbonate rocks, which are Ordovician and Devonian-Carboniferous limestone formations and thin limestone beds, lenses and alternative beds intercalated in the Permo-Triassic in the Mae Sariang area. This fact indicates that the carbonate rocks in this area had played a great role for the formation of mineralization.

Four promising areas for next phase survey are selected. There are the Mae Kanai area, the Huai Pu to Huai Mae Pan area, the Northeastern of Mae Sariang town area and Huai Hat Ta Ran to Huai Ngu area, where are overlapping the distribution among carbonate rocks, mineral occurrences and Zn-Pb geochemical anomaly.

2. Detailed survey of the Dong Noi area

The mineralization in Don Noi area is considered to be as follows:
ore solution which has gone up along the fault of north-south system bordering between Cambrian sandstone and Ordovician has formed a vein type ore body which mainly consists of galena, barite and pyrite. The remained solution has diffused and replaced along some particular horizons of limestone in the surroundings to form zinc mineralization.

Mineralization seems to have occurred at various horizons in limestone.

3. Detailed survey of the I-4 area

In the I-4 area, geological situation and mineral showings of one side remarkably differ from those of the other side of the NE-SW fault running through the center of the district.

In the northern side of the area, Ordovician limestone formation distributes and geochemical anomalies of Zn and Pb and F are recognized in the limestone. The distribution of anomalies suggests a high possibility that the distribution is controlled by the N-S fracture system. The anomaly levels are lower than those of Don Noi district by one figure. The fact that there is no anomaly of Cd is also different from Don Noi district.

In the southern side of the area, a mineralization zone in which several stockwork vein zones with sulfide minerals are found in the shale from the Permian to Triassic along the river. Geochemical anomalies and low specific resistivity and high chargeability zones distribute in the northwest direction that is the extension direction of the veins. Judging from this correlation, there is a high possibility of existing of vein-type ore bodies under this zone. which are more concentrated than the stockwork veins on the surface.

4. Satellite Image Analysis

In this satellite image analysis, it is suggested that mineral occurrences in Mae Sariang area relate hardly with Granite and Limestone, and with continuous lineaments and density of short or discontinuous lineaments. Therefore, possibility of ore deposit would be high for such area as satisfying the following condition;

1) nearby contacts of Limestone (Ls) and Granite (Gr2),

2) crossing point of continuous lineaments,

3) nearby NNE-SSW lineaments that are considered as tension fracture,

4) high density area of short or discontinuous lineaments

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Part I GENERAL REMARKS

Chapter 1 Introduction

1-1 Background and Objective

In Thailand, as demands for base metals such as copper, lead and zinc have increased due to the industrial development with the rapid advance of economy, the import of these metals is growing quickly; therefore, securing stable supply of domestic mineral resources is their urgent need.

Particularly as for zinc among them, Padeang Industry Company Limited. possesses mines (4.5 million ton of ore reserves: zinc grade 28.9 %; Min. Jour., 1994/4) and is operating the only zinc refinery in Southeast Asia. In recent years, however, with the exhaustion of ore reserves in mines, self-sufficiency in ores to the refinery has decreased and import from foreign countries has increased; consequently, it has been pointed out that the development of new mines is an urgent business.

The Mae Sariang area locates about 180 km in the north from Mae Sod Mine of Padeang Industry Company Limited. and is similar to geological situation of the Mae Sod Mine together with ore showings of lead and zinc. Since it locates on a geological structural extension of a skarn type massive sulfide ore body discovered in the Yang Kiang area through the Cooperative Mineral Exploration Project in 1987, this area is expected to have a high potentiality of lead and zinc deposits.

The purpose of this survey is to find out new deposits by investigating into geological conditions, mineralization, geochemical characteristics and geophysical prospecting in the Mae Sariang area of the Kingdom of Thailand.

1-2 Contents of the Survey

1-2-1 The Survey Area

The Mae Sariang area is, as shown in Figure I-1-1, an area of 760 km^2 covering 14 to 23 km from east to west and 20 to 46 km from north to south.

It locates at about 120 km to the southwest of Chiang Mai City in the north of The Kingdom of Thailand.

Administratively, this area belongs to Amphoe (District) Mae Sariang and Amphoe Mae La Noi of Changwat (Prefecture) Mae Hong Son. It is only 20 km from Mae Nam Sala Win that is the Thai-Myanmar border.

1-2-2 The Outline of Survey

This fiscal year, reconnaissance geological surveys and geochemical survey of stream sediment to evaluate ore deposit potentiality in the whole of Mae Sariang area and the detailed geological and geochemical surveys and geophysical survey in two sub-areas, which are promising area of mineral occurrence, were conducted. These two sub-areas had been selected through the evaluation of mineral potentiality of the southern part of Changwat Mae Hong Son by Department of Mineral Resources, hereinafter referred to as DMR, of the Ministry of Industry, the Kingdom of Thailand and by the Project Finding Survey in the Kingdom of Thailand in Fiscal 1996.

To construct a mineralization model of zinc deposit which has high potentiality of occurrence of ore deposit in this area, existing zinc deposits such as the Mae Sod Mine of Padeang Industry Company Limited and its adjacent Tak Mining Co. Limited were surveyed.

For the reconnaissance geological and geochemical surveys, DMR and Project Finding reports were well studied and then, survey routes and sampling points were selected so that possibilities of existence of ore deposits in the whole area of Mae Sariang could be effectively grasped. For the survey, a topographical map drawn on a scale of 1 to 25,000 which was an enlarged existing map with a scale of 1 to 50,000 was used and the results were summarized on a topographical map drawn on a scale of 1 to 50,000.

At a detailed survey district, to grasp geological feature and alteration conditions as well as ore occurrence, geological and geochemical detailed surveys were carried out to presume the conditions of mineralization. At the same time, through an investigation of a specific resistance structure of a mineralization band and an IP abnormal area by the IP electrical prospecting method, information that would be necessary in selecting survey locations for drilling survey were obtained. For the detail survey, a topographical map with a scale of 1 to 2,500 which was an enlarged existing map drawn on a scale of 1 to 50,000 was used.

Table I-1-1 shows a summary of the contents and the amount survey.

Table I-1-1 Contents and Quantity of Survey

①Contents and amount of the Survey

Item of Work	Quantity
Geological Survey and Geochemical Survey	
Whole area	Survey area 760 km^2 Route length 351.0km
Dong Noi area	Survey area 1.5km^2 Route length 35.0km
I -4 area	Survey area 2.5km^2 Route length 44.0km
Geophysical Survey (IP method)	
Dong Noi area	Length of Survey Line 8.0 km 1.0km×5, 1.5km×2 Number of Station 222points
I -4 area	Length of Survey Line 9.8 km 0.9km×1, 1.0km×2, 1.3km×1 1.6km×1, 2.0km×2 Number of Station 294points

②Laboratory tests

Items	Quantity
Geological Survey and Geochemical prospecting	
A. Thin Sections	12 Sections
B. Polished Sections	12 Sections
C. Fluid Inclusion Analysis Homogenization and Salinity	12 samples
D. Ore Assay (Cu, Pb, Zn, Sb, Ag, Au, Sn, W)	45 samples
E. Geochemical Analysis (Cu, Pb, Zn, Sb, Ag, Au, Sn, W, F, Hg)	2316 samples
F. X-ray Diffraction Analysis	16 samples
G. Stable Isotope Analysis(δ C, δ O)	9 samples
Geophysical Prospecting Measurement of Resistivity and Polarization	33 samples

1-2-3 Personnel of survey mission

Planning and Coordination

Japan

Jiro Osako	Metal Mining Agency of Japan
Toru Nawata	Metal Mining Agency of Japan
Kosuke Takamoto	Metal Mining Agency of Japan
Hiroshi Shibazaki	Metal Mining Agency of Japan
Yoshiharu Kida	Metal Mining Agency of Japan, Bangkok

Thailand

Phisit Dheeradilok	Department of Mineral Resources
Suvit Sampattavenija	Department of Mineral Resources
Phairat Suthakorn	Department of Mineral Resources
Werapun Jantaranipa	Department of Mineral Resources
Boonsong Yokart	Department of Mineral Resources

Field Survey Team

Geological and Geochemical Survey

Japan

Hiroyuki Takahata	Nittetsu Mining Consultants Co., Ltd.
Makoto Miyoshi	Nittetsu Mining Consultants Co., Ltd.
Yasunori Ito	Nittetsu Mining Consultants Co., Ltd.
Norikazu Mikawa	Nittetsu Mining Consultants Co., Ltd.

Thailand

Boonsong Yokart	Department of Mineral Resources
Adoon Wunapeera	Department of Mineral Resources
Phureewat Jenrungrot	Department of Mineral Resources
Wicharn Mungkhun	Department of Mineral Resources

Geophysical Survey

Japan

Hirohisa Horiuchi	Nittetsu Mining Consultants Co., Ltd.
Munemaru Kishimoto	Nittetsu Mining Consultants Co., Ltd.
Mitsuaki Kanahori	Nittetsu Mining Consultants Co., Ltd.

Thailand

Kampanart Lampoonsub	Department of Mineral Resources

1-2-4 Period of the Survey

The first year's field surveys were carried out according to the following schedules.

Geological and Geochemical Surveys:

December 15, 1997 to February 27, 1998 (75 days)

Geophysical Survey:

January 15, 1998 to February 27, 1998 (44 days)

Chapter 2 Geography

2-1 Locations and Access

The Mae Sariang area locates within the range from 97° 54' E to 98° 07' E of Longitude and from 18° N to 18° 25' N of Latitude and about 120 km southwest from Chiang Mai which is the second largest city of Thailand. As shown in Figure I-1-1, the size of the survey area is 760 km^2; it extends about 14 km from east to west in the northern part and about 23 km in the southern part. The length from north to south is from 20 to 46 km.

Administratively, the area belongs to Amphoe Mae La Noi, Amphoe Mae Sariang and King Amphoe Sop Moei of the southern part of Changwat Mae Hong Son which locates at the northwestern border of Thailand.

Through district capital Mae Sariang of Amphoe Mae Sariang locating in southwest of the survey area, Route 108 connecting Chiang Mai with Mae Hong Son is running. Mae Sariang town is 199 km from Chiang Mai and 168 km from Mae Hong Son, almost the middle of these two cities. Transport facilities in general are private cars or buses. In addition to buses, which make eight round trips per day between these two cities, there are buses that make three round trips per midnight between Mae Sariang and Bangkok. It takes about five hours by bus from Mae Sariang to Chiang Mai and about twelve hours from Mae Sariang to Bangkok.

Between Bangkok and Chiang Mai, there are fourteen round-trip flights per day and one trip requires about one hour. From Bangkok, two express trains of the National North Railway runs per day. One trip requires fourteen hours. Moreover, there are many highway bus services.

The above mentioned Route 108 is a completely paved road crossing the southern part of the survey area. From Mae Sariang, it runs through the survey area northwardly along the Nam Mae Yuam. To the south of Mae Sariang, there is paved Route 1086 in the town of Mae Sod in which Mae Sod Mine of Padeang Industry Company Limited. exists. Since within the district, roads for cars, which had connected villages of hilltribes, had been comparatively developed, it was convenient for the survey, but, as most of those roads were

not paved, they became muddy and required much attention for passing during a rainy season.

2-2 Topography

The northwestern part where Mae Sariang area locates belongs to the Thanon Tongchai-Tanasserim Mountains which starts in Yunnan Xing of China and ranges from north to south along the Thai-Myanmar border and reach Malay Peninsula. This part is a mountainous area where high mountains of Thailand including the Thailand's highest peak Doi Inthannon (its height above sea level is 2,595 m).

Mae Sariang Area locates in the West End of this mountainous area and consists of a tectonic basin along Nam Mae Yuam which runs from north to south in the western part of the survey area and a plateau platform in its eastern side. The height above sea level of the basin along Nam Mae Yuam is about 200 to 250 m and mountain streams run directly into Nam Mae Yuam which runs from north to south have developed.

The boundary between this basin and the plateau has formed a sharp cliff. The height above sea level of the plateau surface is from 800 to 1,400 m and there are many comparatively gentle undulations. However, since this plateau is deeply cut by the river system which has developed from north to south, northeast to southwest or northwest to southeast, which is the major geological structure of this area, sharp cliffs are observed from the surface of the plateau to the major rivers.

2-3 Climate and Vegetation

The northern part of Thailand including Mae Sariang area is under influence of a tropical monsoon, but since it locates inland, it has a continental tropical savannah climate which consists of a dry season due to a northeast monsoon and a rainy season due to a southwest monsoon.

The rainy season by a southwest monsoon is in May through October and about 90% of the annual rainfall fall intensively during this period. The dry season by a northeast monsoon is in November through February and there is almost no rainfall in December and January. Temperatures of this season are the lowest of the year. In the morning even in a lowland like Mae Sariang, it is not rare that the temperature becomes below 10° C, In March and April, the monsoon calms down and this period is the hottest season of the year (the hot season) and the temperature reaches as high as 38℃ at maximum.

Table I-2-1, I-2-2 and Figure I-2-1, I-2-2 show statistics of climates of the past three

years.

Table I-2-1 Monthly precipitation in 1995-1997 at the Mae Sariang town

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1995	0.0	0.0	14.5	26.2	92.3	164.0	191.4	286.7	163.5	135.8	38.6	0.0	1113.0
1996	0.0	54.3	4.0	60.9	193.4	358.5	213.2	200.4	216.3	34.7	7.9	0.0	1343.6
1997	0.0	0.0	0.0	58.9	70.5	144.1	138.5	341.0	209.8	88.8	4.0	0.0	1055.6

More than 85 % of Mae Sariang area is a mountainous area which is designated as the National Conservation Region and the Wildlife Preservation Region.

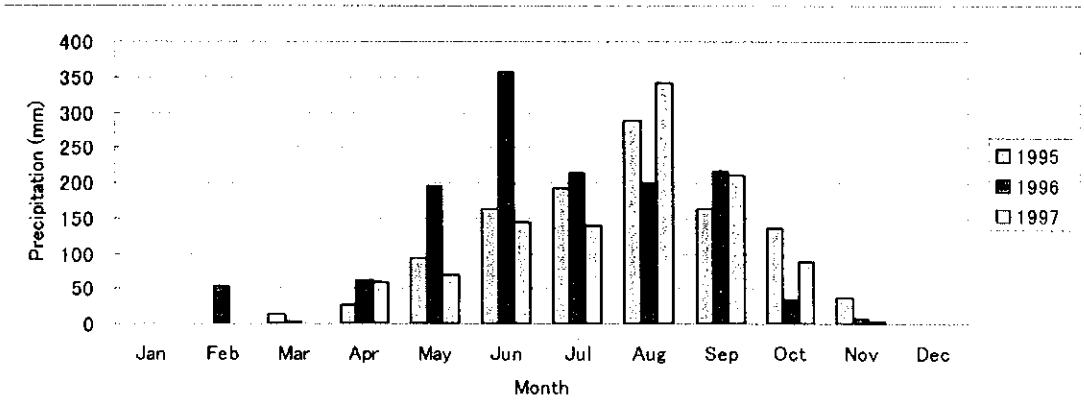


Fig.I-2-1 Monthly precipitation diagram at the Mae Sariang town

Woods are thin deciduous forests consisting of miscellaneous trees together with coniferous trees, teak, shara, red sandalwood. Since many leaves fall during the dry season, can afford an unobstructed view. On the flat part of the mountain summit, villages of hill-tribes are dotted. Around this area, almost no forests have remained because a cash crop is cultivated in accordance with the permanent resident policy and traditional traveling slash-and-burn farming is being carried out.

2-4 General Information

The Mae Sariang area lies across three districts of the southern part of Changwat Mae

Table I-2-2 Monthly average temperature at Mae Sariang town

Max. temp.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1995	32.30	33.57	37.36	39.87	35.20	32.11	30.75	31.38	32.07	32.27	31.47	30.12
1996	31.28	33.29	36.15	36.55	34.05	31.89	31.34	30.94	31.55	32.80	32.31	31.03
1997	30.78	33.18	36.40	36.15	36.39	32.69	30.45	30.23	31.92	33.76	31.86	32.50

Min. temp	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1995	14.40	12.50	18.36	23.01	24.23	23.99	23.40	23.57	23.24	22.63	19.94	14.35
1996	11.55	14.38	17.74	22.52	23.34	23.26	23.06	22.93	23.09	22.38	20.30	15.65
1997	11.54	10.03	17.36	19.77	23.74	23.36	23.15	22.82	22.75	22.49	20.01	17.04

Hong Son such as Mae Sariang, Mae La Noi and Sop Moei. Its major part belongs to Amphoe Mae Sariang.

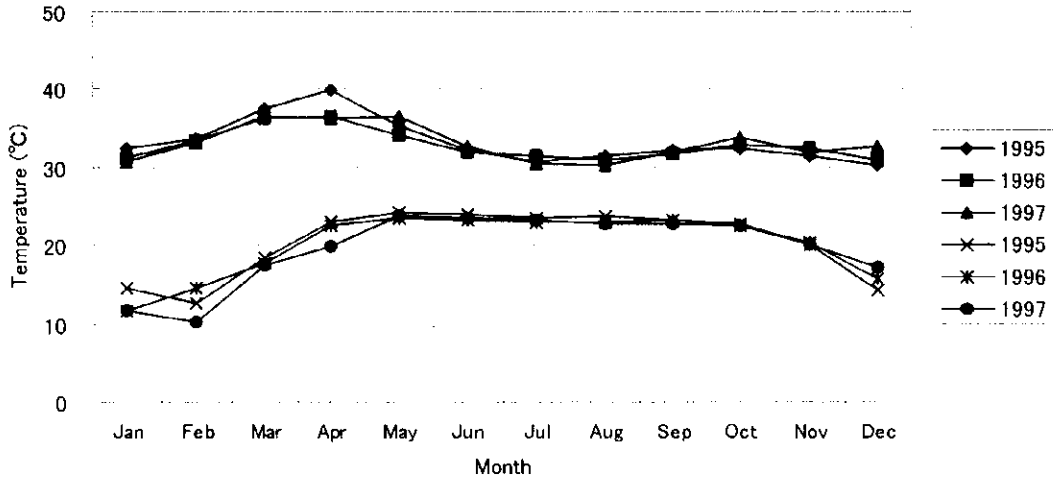


Fig.I-2-2 Monthly average temperature at the Mae Sariang town

Amphoe Mae Sariang is the center of administration and economy of this area. In addition to the administrative government, there are primary, junior high and senior high schools, a hospital, a post and telegraph office and telephone office, an district police sta-

tion, a bank and others.

The population of Amphoe Mae Sariang is 52,204 people (as of the end of June 1997) and the population density is 21 people. 60 % of the people center on the lowland near the Nam Mae Yuam. Since many tribes such as the Karen tribe, the Rawa tribe, the Meo tribe, the Thaiyai tribe and the Thai Lan Na are mixed in addition to the Thai race, their religions, cultures and customs are diversified.

Their main industry is agriculture and stock raising. They cultivate rice and vegetables such as bean, peanut, garlic and cabbage as well as fruits such as longan, tamarind and mango.

Chapter 3 Existing Geological Information

3-1 Previous works

About the geological features and the mineral deposits in the northern part of Thailand near the Laos-Myanmer border, the West Germany Geological Survey Mission investigated systematically early 1970 and drew seven pieces of geological maps on a scale of 1 to 250,000 (Hahn et al., 1986). The report of Mae Sariang area is written in Sheet 4, Chiang Mai of this report.

DMR carried out reconnaissance geochemical detailed survey of promissing area of occurrence of ore deposit in Amphoe Mae Sariang, Amphoe Mae La Noi and Amphoe Khun Yuam as follow-up surveys of the wide area geochemical survey (Jamnongthai, 1985) and geochemical semi-detailed surveys (Jamnongthai, 1986) within Chiang Mai of the geographical map on a scale of 1 to 250,000. They discovered four promising lead-zinc (barite) bearing areas, one promising copper-bearing area and two promising zinc-bearing areas in Amphoe Mae Sariang and two promising lead-zinc (barite) bearing areas in Amphoe Mae La Noi (Jamnongthai, 1988). This survey has been planned on the basis of the above reports.

Between 1984 and 1987, airborne geophysical survey (total magnetic force and radiation) was carried out across Thailand excluding the Thai Peninsula with the assistance of Canada. Result maps with a scale of 1 to 50,000, maps drawn on a scale of 1 to 250,000 and a explanation book about the survey were published. DMR is now developing the data into digital information.

3-2 Geology and Mineral Occurrences in the Survey Area

3-2-1 Geology

The northern part of Thailand is divided, from the west, into four tectonic provinces: the western tectonic province (the border between Thailand and Myanmar), the western major mountain tectonic province (between Mae Sariang and Chiang Mai), from the central plain to the central northern tectonic province and the eastern tectonic province (Khorat Plateau).

The Mae Sariang area is divided two region by N-S fualt along the Mae Nam Yuam. The east region belongs to the western major mountain tectonic province and the west region belongs to the western tectonic province. The western major mountain tectonic province consists of Late pre-Cambrian metamorphic rocks, the Paleozoic to Mesozoic Sedimentary rocks unconformably covering the Pre-Cambrian and Carboniferous and Triassic Granite. The west region is composed with the Paleozoic to Mesozoic carbonate and clastic rocks, and Mesozoic granite.

Geological structure is intensely inferred to the tectonic line dividing the two region. The tectonic line lies in the NW-SE direction in southern area and changes into N-S direction from vicinity of Mae Sariang Town to the north.

3-2-2 Mineral Occurrences

According to "Natural Resources of Changwat Mae Hong Son" (DMR, 1984), mineral resources of Amphoe Mae Sariang, King Amphoe Sop Moei and Amphoe Mae La Noi can be summarized as follows.

(1) Amphoe Mae Sariang and King Amphoe Sop Moei

Amphoe Mae Sariang has not only the largest land in Changwat Mae Hong Son (currently, the southern part is divided into King Amphoe Sop Moei) but also has the biggest income from the mining industry. Major mineral products of the district are tungsten and tin followed by fluorite. In addition, barite, lead and iron have been found in some locations.

Mae Lama Mine owned by Panashito Company Ltd. is only operating mineral deposit which has been known over forty years. This is a mine which was once famous for its largest amount of tungsten exploited in Thailand.

As for the distribution, the ore deposits in the Amphoe Mae Sariang are roughly divided into two areas (See Figure I-3-1.). The northeastern part of the Amphoe Mae Sariang

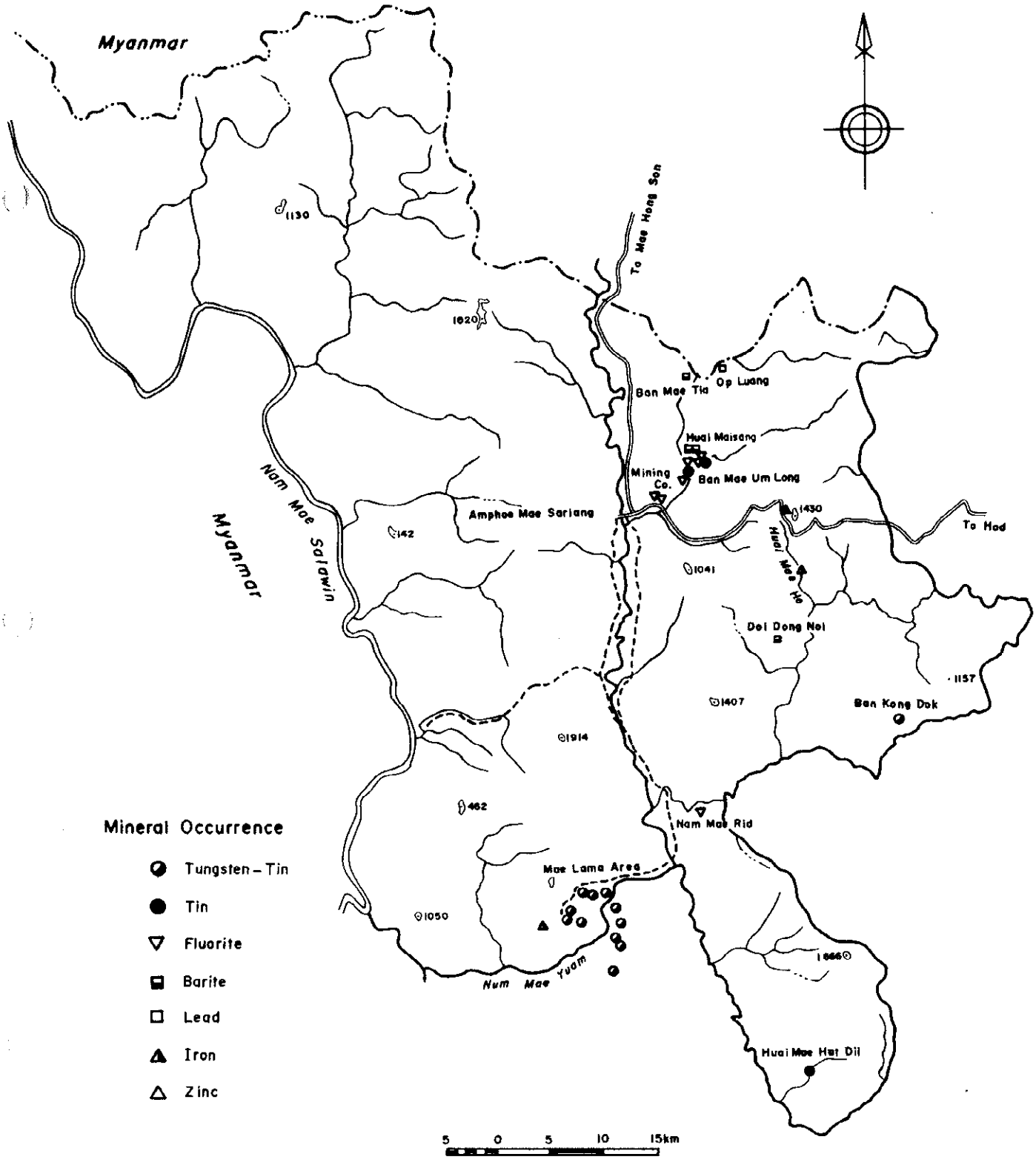


Fig.I-3-1 Mineral occurrence in the Mae Sariang District (DMR,1984)

(east bank area of Nam Mae Yuam) and the south end area of the Amphoe Mae Sariang-which is near the border of Amphoe Tha Song Yang, Changwat Tak. The former excels in fluorite deposits accompanied by ore showings of barite and lead. The latter has tungsten and tin mines. In this district, the overseas geological structure survey "Mae Sariang Area" was carried out in 1983.

From Huai Mae Sariang Noi of the Mae Sariang River to the neighborhood of an exit of a valley adjacent to Mae Sariang urban area, six fluorite ore showings are distributed. Five of them were only discovered but never have been operated yet; however, mining of the fluorite mine owned by Mining Co., Ltd. was already completed. These fluorite ore showing are occurred in the limestone that is adjacent to granite and mixed as in veins or balls. In some parts, veins of the fluorite developed in the shale formation of the lime stone foot wall are also acknowledged. As other fluorite mines owned by Yon Piphad Limited Company, there is one along Nam Mae Rid in the southern part of Amphoe Mae Sariang.

There are three barite mining area claims which are at Huai Mai San near the surroundings where many fluorite occurrences gather in the northeastern part of Amphoe Mae Sariang, at Huai Mae Tia owned by Chiang Mai Transport Company in the northern part of the Amphoe Mae Sariang and the neighborhood of Doi Dong Luang of Ban Dong Luang of the south eastern part of the Amphoe Mae Sariang. In the barite ocurrence of Huai Mai San, veins which are 1 to 5 m wide originate in fine sandstone or alternation of sandstones and shales. Barite occurrence of Doi Dong Luang is about 12 m wide and 150 m long and originate in limestone and is accompanied by lead and copper ore showings.

Lead ore showing exist in Opu Luang which is adjacent to Amphoe Mae La Noi and contain pyrite, copper and malachite. The vein width keeps irregularity varying from 5 to 20 cm and runs from east to west inclining 70° to the north.

In the Mae La Ma region of ore showing of the southern part of Amphoe Mae Sariang, there is limestone, shale, slate and quartzite of the Cambrian and the Ordovician with granite stock (Adamellite) of Triassic Period. In the quartz vein developed at these contacting parts, wolframite, cassiterite and scheelite are occurred. As for Mae La Ma mining area, five mines are distributed on each side of both banks of Nam Mae Yuam. The Mae La Ma mine group on the west bank including Mae La Ma mine mainly contains wolframite and the amounts of cassiterite and scheelite are small. On the other hand, the Huai Luang mine group on the east bank contains more cassiterite than wolframite. The-

re are two directions for the quartz veins: an east-west system and a north-south system of which widths are irregular. Although the quartz veins contain chalcoprite, pyrrhotite, sphalerite, beryl and tourmaline, their amount is too small to commercialize.

In addition to the above mentioned, iron ore showing have been found near Ban Mae Ho. In the hill on the northern side of Route 108 and the valley of Huai Mae Ho which is 3 to 4 km from the southeast of the village, boulders of magnetite and hematite, which are partly limonitized, are dotted. There are limestone and quartzite in the Mae Ho Valley. Because the quality of discovered iron ores is good in spite of the amount to be too small for commercialization, further detailed surveys will be necessary in the future.

(2) Amphoe Mae La Noi

Amphoe Mae La Noi is the newest disrict established in Changwat Mae Hong Son and its area is the smallest.

Amphoe Mae La Noi bears nine ore showings, but the deposits exploited are only two fluorite deposits.

The fluorite deposits locate in Makok Mine of Universal Mining Co., Ltd. along the Nam Mae La Luang in the middle northern part of Amphoe Mae La Noi and in Huai Mae Hu in the east of Mae La Noi urban area.

The fluorite mine in Huai Mae Hu has its origin in a vein structure along faults developed in Ordovician limestone. Operating of this mine started in 1967 and closed in 1975. By 1979, the mining continued on a contract system. The output by 1979 was from 40,000 to 50,000 tons at the lowest estimate. During the period of this year's survey, the mine was under operation as a quarry of limestones.

At a place about 500 m apart from a hot spring near the fluorite mine, boulders of magnetite and hematite are found. They are distributed in the area of 100 m x 50 m which is stretching from north to south along a branch of Huai Mae Hu. These ores are distributed up to about 2 m under the earth surface and the largest diameter is 50 cm.

Zinc occurrences have been found at three places in the basin of Nam Mae Yuam. They exist near the confluence of Huai Mae La Ngiu and the Nam Mae Yuam in the southwestern part of Mae La Noi urban district, Huai Khun Ma of Ban Mae La Luang and Wang Mu Nao of north-central part of Amphoe Mae Sariang. All of them are sphalerite in quartz veins developed in Triassic sandstones. The first mentioned two ore showings are 1 to 3 cm wide and the last one is 10 to 20 cm wide.

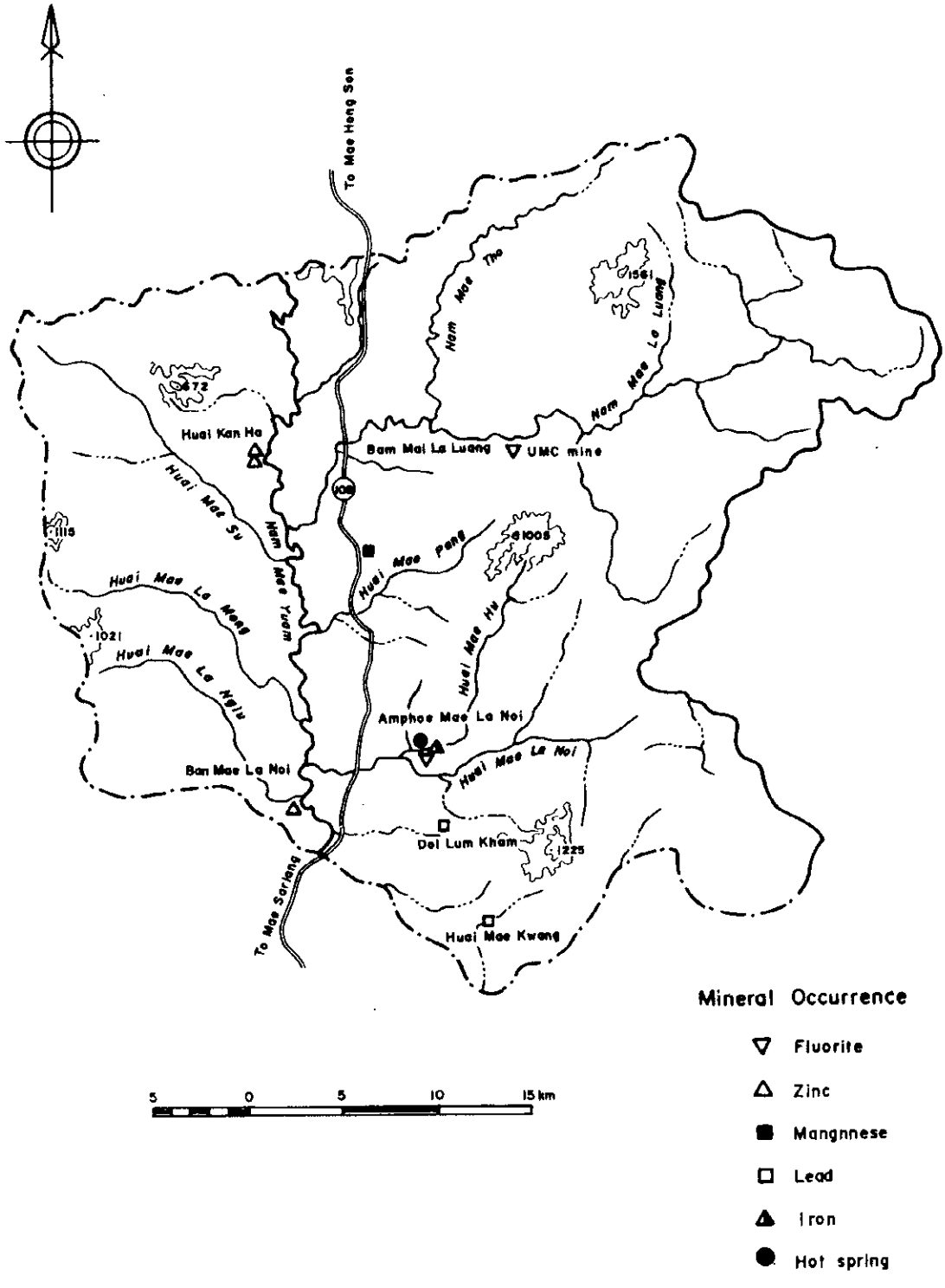


Fig.I-3-2 Mineral occurrence in the Mae La Noi District (DMR,1984)

Lead occurrences exist in Ban Mae Khuwan and Doi Khun Kam of Southern part of Amphoe Mae La Noi. The Mae Khuwan ore showings consists of galena in an about 30 cm wide quartz vein developed in granite. The latter ore showing consists of galena with in a quartz vein and its width is about 6 cm in average, but its length is unknown.

In a small hill on the east of a national road from Mae La Noi to Mae Luang, there is ore showing of manganese. Although massive manganese dioxides are distributed on the earth surface of muddy limestone, no veins have been found.

Chapter 4 Comprehensive Discussion

4-1 Mae Sariang Area

The area in the eastern side of Nam Mae Yuam occupying the most of this survey area belongs to the western major mountain tectonic province. There is composed of sedimentary rocks and granite from the Cambrian age to the Triassic age. The whole geological structure is consistent with the continuous direction of ridges in this area and extends from north to south. Since Triassic granite batholith intrudes the regional center from north to south, this granite divides the Paleozoic formation into the western and the eastern sides. The Paleozoic formation on the west side has a monoclinal structure in a western dip of strike from the north-northwest to south-southeast as a whole. Younger geologic units of sedimentary rocks from Cambrian to Triassic age overlie the unit below from the east to the west. The Paleozoic formation on the eastern side mainly consists of Ordovician sedimentary rocks and Cambrian formation exposes partly.

Thick limestone formations develop in the Ordovician and the Permian. Besides, there are thin alternating beds shale and limestone, limestone lenses and calcareous shale are found in a lower Ordovician formation, the Devonian-Carboniferous formation and in the Triassic formation.

There have been no actually operated metallic mines in this area, but there are many occurrences of galena-barite-quartz veins. Many of them distribute harmoniously with limestone. They are highly correlated particularly to the Ordovician limestone and limestone lenses of the Devonian-Carboniferous age. Most of these showings are indicating the existence of galena-barite-quartz veins. Many such occurrences of veins distribute in the wide area. It continues from the eastern end of I-4 sub-area of the east of Mae Sariang urban area through Huai Pu on the south side, Huai Mae Pan to the river

basin of Huai Mae Pan Noi.

Judging from the geological features, gossan in the peripheral areas of Cahmrat barite mine of the northern part of Mae Sariang area and the surroundings of Ban Huai Ngu and Mae La Noi may indicate also vein–type mineralization. The mineral occurrence extending from the surroundings of Ban Mae Ka Nai in the eastern part of Mae Sariang area through into Don Noi district clearly indicates vein type mineralization such as the galena-barite vein in Don Noi district and along the road on the north of Ban Dong Noi. However, geochemical anomaly of Zn in Don Noi district, massive gossan, skarnized limestone as well as massive magnetite floats occurring in the Ordovician limestone can be stratiform or massive type deposits through metasomatism of limestone.

As for the results of geochemical survey of stream sediment, geochemical anomaly of Zn and Pb are found in the surroundings of the above mentioned zones of mineral showings. According to the results of principal component analysis, it has been judged that the first component with a large factor loading of Zn, Mn, As, Cu, Pb, Ba Sb and F is a factor suggesting mineral showings in Mae Sariang area. In other words, the high score area of the first component seems to have a greater possibility of existing a mineral deposit. The areas of a high score of the first principal component are the eastern part of Mae La Noi extending to the surroundings of Doi Lum Kham, from Huai Hat Ta Lan to Huai Ngu, the northern part of Doi Chang, the surroundings of the junction of Um Mae Sariang Noi, the lower stream of Um Mae Sariang, the area from Huai Hin Lek Fai through Huai Pu into Huai Mae Pan Noi, the upper stream of Nam Mae Ka Nai, the eastern part of Mae Ka Nai and the district from Huai Chang through Don Noi district into the confluence of Nam Mae Rid and Huai Mae Ok. Each of them is occupied by Ordovician limestone, Devonian-Carboniferous and Permian-Triassic shale and calcareous shale with thin limestone layers.

In judging that, areas where distributions of limestone, mineral showings and geochemical anomalies overlap have high potential in occurrence of mineral deposits. The following four areas are with high possibilities of the existence of mineral deposits.

1. Mae Ka Nai Area

This area locates on the eastern side of a mountain ridge extending from Doi Khun Mae Kanai to Ban Mae Ka Nai. It forms a flat plateau and it is occupied by Ordovician formation. The formation, from the base upward, consists of shale-sandstone alternating beds and limestone. Cambrian quartz arenite lie in fault contact along the northern boundary

of the Ordovician formation. Triassic granite is intruding on the west side. The limestone area forms a large karst landform shaped like a boat's bottom. On the ridge surrounding the caved-in area, there are several massive gossan zones and gossan float zones in a 100 meter scale. In the tributary of Huai Mae Ho of the east end of limestone, there are many gossan floats on the boundary of limestone and sedimentary rock. The assay results of these floats show that Zn=1.5 %. Gossan in this area generally contains a high level of zinc, 1,000 to 4,400 ppm. In the branch of the southern side of the limestone, many large magnetite floats of angular shapes (4 m at maximum) distribute. In the upper stream of Nam Mae Ka Nai on the western side, skarnized limestone containing garnet distributes on the border of granite. The geological situation is similar to those of Don Noi district. Judging from mineral occurrence, existing of stratiform or massive sulfide (oxidized) mineral deposits in limestone and/or skarn deposits at the lower part of limestone are highly expected.

2. Huai Pu - Huai Mae Pan Area

This area consists of Devonian-Carboniferous and Permian-Triassic black shale, sandstone and chert with banded limestone and thin layers of limestone. Limestone in general contains calc silicate minerals and often becomes greenish. Many barite-quartz vein floats containing galena, chalcopyrite, sphalerite, pyrite and others are found along the stream as well as at the slope of mountainside. Moreover, small veins (below 30 cm wide) of the same components are also found among shale. Although big limestone bodies do not distribute, geochemical anomaly of zinc and lead are quite high. Therefore, there is a high possibility of existing vein type mineral deposit like the above mentioned or a massive sulfide ore body which has replaced a limestone lens.

3. Northeastern Area of Mae Sariang Town

Ordovician limestone distributes from the I-4 area on the east of Mae Sariang town to the north in this area. The ridge of mountains continues from north to south at 700 to 900 meters above sea level. Along the Nam Mae Sariang on the East Side, the lower Ordovician shale and sandstone distribute and Triassic granite intrudes into these rocks. On the west side it contacts with the Permian limestone by north-south faults. Although there are fluorite deposits in the southern part of the area, there are no ore showing of metallic minerals.

By geochemical survey, Zn anomalies, though their level is not so high, exists everywhere in the stream nearby. The geological situation is similar to those of Don Noi area and Mae Ka Nai area.

It is suggested that it has a possibility of existing zinc occurrence among limestone.

4. Huai Hat Ta Lan - Huai Ngu Area

This area extends from the right bank of Huai Hat Ta Lan on the west of Chamrat Barite Mine to Ban Huai Ngu. The lineament from Huai Hat Ta Lan to Huai Ngu has a high possibility of being a fault in terms of topography. In this area, several streaks of limestone and shale of the Ordovician age which continue from north to south distribute and quartz porphyry dykes are intruding into it.

There are many gossan and barite floats in the tributaries that run into Huai Hat Ta Lan and Huai Ngu from the east side. In the mountains and hills, barite veins without sulfide minerals are scattered. According to the assay results, gossan contains from 1,500 to 5,200 ppm of Zn. Geochemical survey has proven that Pb is showing a higher level than Zn. Anomalies are scattering and no continuous. Judging from the geological situation, a possibility of existing mineralization in veins type is high.

4-2 Dong Noi Area

The Dong Noi area consists of the Cambrian and Ordovician sedimentary rocks. The area is divided into northern and southern parts by a fault in the E-W direction. In the northern part the Ordovician sedimentary rocks and the Cambrian sandstone are distributed while the Cambrian sandstone is not distributed in the southern part. The northern part is divided into east and west by a fault in the north - south direction. The Cambrian outcrops in the eastern side and Ordovician limestone are distributed in the west side, respectively.

The Dong Noi area has a distribution of a galena-barite ore body in the north - south direction around a small hill in the center of the area, magnetite dissemination in the Cambrian sandstone, Gossan floats in the northern part of the area, etc. The galena - barite orebody shows a distribution spreading 100 m x 200 m long north and south including a distribution range of floats, which is assumed to be a mineralized zone predominated by a north - south fault. According to the ore assay results, 3.4 to 14.8 % of Pb, 58 to 146 g/t of Ag were obtained, but the concentrations of other elements are not so high. At test pit No.2 in the 40m east of the outcrop, 970 ppm of Cu and 32.4 g/t of Ag were obtained.

The geochemical survey revealed that a geochemical anomaly of Pb, Ba, Fe, and Mn is distributed in the NNW to SSE directions from the above orebody outcrop. An extension of an anomaly is greater to the northern part. On the other hand, it disappears immediately beyond the east - west fault in the southern part. The first principal component is consid-

ered to be a factor representing this mineralization. A combination of elements Pb, Ba, Sb, and Cu is the same combination of elements in a galena - barite - quartz vein often observed in the Mae Sariang area. It is considered that such a mineralization represents a possibility of an existence of vein-type mineralization zone.

The score distribution of the first principal component shows that the mineralization mainly spreads in the NNW - SSE direction from the orebody outcrop and branches and crosses in the east - west direction along a east - west fracture in the northernmost part. It is thought that this is an orebody formed by an ore solution which caused a mineralization of Pb and Ba along the north - south fault and in part along the east - west derived fault.

A subsurface high chargeability zone at survey points from 700 to 1400 of traverse lines X and Y and survey points from 400 to 600 of traverse lines A and B in the IP exploration results shows that this mineralized zone exists under the ground. An orebody at the outcrop is strongly silicified and exceedingly heterogeneous and the amount of galena remarkably varies. For this reason, chargeability values in a property test, 1.4 to 18.8 mV/sec/V, has a big difference depend on proportion of the ratio of galena in quantity. A chargeability beneath the orebody outcrop in the model simulation is about 20 mV·sec/V, which almost coincides with the highest value among the property test values. On the other hand, a high chargeability zone further north from this indicates a high value of 20 to 32 mV·sec/V. This fact indicates an existence of a mineralized zone accompanies by galena or other sulfide minerals having a grade higher than the outcrop.

It is a possibility that high chargeability zones observed at survey points from 0 to 500 of IP traverse lines C, D, and E below 950 m above sea level and in depths on the south side along traverse lines X and Y may be an orebody. However, since the geological situation shows a coincidence with the distribution of shale of the lower Ordovician system, this is judged as a high chargeability zone formed by shale layer.

The Zn geochemical anomaly is accompanied by Cd, Mg, and Mn anomaly and overlaps the Ordovician limestone area in the southeastern part and that ranging from the southwestern part to the southern part of the area. In the neighborhood coarse grain recrystalline limestone is exposed and no special ore showing is observed with the naked eye. The Mae Sod Mine of Padeang Industry is a zinc deposit which replaced limestone and this deposit is characterized by the fact that it brought about dolomitization and magnesitization in limestone of country rock and it is accompanied by Cd. The Zn geochemical anomaly in the Dong Noi area is similar to the mineralization of this Padeang Mine, which indi-

cates a possibility that a stratiform deposit replacing limestone of the same type will exist. This Zn geochemical anomaly zone exists in limestone so that it does not indicate a remarkably low specific resistance and the chargeability is also very low. According to traverse line E of the IP exploration, it is thought that the distribution of weathered shale at the surface also has an influence upon this anomaly area on the western side. A relatively low specific resistibity area stretches in correspondence with the Zn anomaly area and this probably indicates a mineralized zone.

According to cross sections of the IP traverse lines C, D, and E, an inferred fault is presumed near survey points 500 to 600. There is a strong possibility that a north - south fault in the northern part will continue in the southern part of the area. The appearance of chargeability in cross section differs in both side of this inferred fault. As mentioned above, supposing that a high chargeability zone in the depths on the west side indicates a shale layer, this shale layer is not distributed down to the bottommost depth of the cross section in the eastern part and a limestone layer thickness remarkably differs.

Considering that the Zn geochemical anomaly exists at almost the same altitude, it is thought that the Zn mineralization horizon is differed in the east and west side.

The mineralization in the Dong Noi area is considered as follows:

A mineralizing solution rising along the north-south fault formed a vein type or network orebody mainly composed of galena along the fault.

The mineralizing residual solution containing zinc and cadmium flows a specific horizon in limestone to one side and replaced limestone to form a stratiform ore body.

4-3 I-4 area

The I-4 area can be divided into two blocks, northwestern part and southeastern part, by a fault in the NE - SW direction located in the central part of the area. The northwestern part consists of the Ordovician sedimentary rocks and the southeastern part consists of the Permian to Triassic sedimentary rocks.

The alternating beds of shale and sandstone with limestone lenses are occupied in the lower part. The upper part of the Ordovician sedimentary rocks is limestone in the northwestern part, respectively. The Ordovician rocks show a synclinal structure in the form of a ship bottom plunging on the north side.

The Permian to Triassic sedimentary rocks in the southeastern part consist of an alternating beds of black shale and sandstone intercalating limestone lens es in the lower part

and a platy chert in the upper part. These rocks show a monoclinal structure with a northwest strike inclining toward the southwest.

Although a remarkable sign of mineralization is not observed in the limestone distribution area, small floats of gossan and floats of a quartz vein are found on a slope in the northwestern side of the mountain. There are also a lot of floats of a colorless idiomorphic calcite vein in this neighborhood. The geochemical survey revealed that geochemical anomaly of Zn, Pb, F, Sb, and As are distributed in a wide range in this area. The distribution of these geochemical anomalies seems to be predominated by a north - south system fault or fracture system. Particularly, a chargeability is low in correspondence with this high anomaly zone in the northwestern part of the area having high Zn anomaly like in the Dong Noi area. However, compared to its neighborhood, a relatively low resistivity area is observed. There probably indicate that this is a mineralized zone. The Zn anomaly is 200 to 1,000 ppm, which is lower by one digit than in the Dong Noi area. The characteristic of this area differs from that of the Dong Noi area in that the Zn anomaly is not accompanied by the Cd anomaly. Judging from the fact that this area has cracks and high F anomaly values, there is assumable that this is a halo of mineralization which formed fluorite deposits. In any case, since the distribution of the anomaly can be seen well from the urban area of Mae Sariang and is adjacent to the precincts of a temple, it is difficult to explore this ore deposit. However, since a mineralization like this was discovered in the Ordovician limestone, it is highly possible that other ore deposits exist in the same limestone layer up north from here.

Floats of barite, galena-quartz vein, and quartz vein are distributed here and there in the area covered by the Permian to Triassic sedimentary rocks. In addition, a lot of pyrite disseminations are observed in a chert layer along the national highway at the east end of the area.

Three or four several meter wide stockwork vein zones of galena-arsenopyrite are observed in an outcrop of strongly silicified shale extending over 70 m north and south along the banks of Nam Mae Ka Nai at the east end of the area. The vein stands steeply at N 45 to 50° W in the extension direction. Silicified rocks with pyrite dissemination are distributed on this extension about 100 m downstream.

Both geochemical survey and IP exploration show that geochemical anomaly of Pb, Zn, Cu, Ba, As, Sb, and Sn, low resistivity, and high chargeability zones are distributed in correspondence with its extension direction from this silicified rock outcrop. The geochemi-

cal anomaly zone also shows a stretch in the NW-SE direction that is the same as the direction of the vein observed in the outcrop. Judging from these facts, as shown in the model simulation cross sections of resistivity and chargeability, it is assumed that subsurface network veins are larger in scale than that observed in outcrop and exists as a high grade vein. The Pb and Zn geochemical anomaly zones show the highest value and it is assumed that the center of the orebody is beneath survey points 600 to 700 along traverse line A where a high chargeability zone is distributed under the ground.

Similar geochemical and high chargeability anomaly zones show a directivity parallel to this mineralized zone and are distributed from the ridge on the southwest side from this zone to its west slope. It is thought that a zone equivalent in scale exists. However, unlike the mineralized zone in the eastern part, the lower part of this point shows a high resistivity.

Since there are a lot of similar small vein floats in the Mae Sariang area, it is likely that a vein type mineral showing like this is distributed on a small scale in various places. A possibility was also suggested that the geochemical anomaly in the Huai Pu - Huai Mae Pan areas which are adjacent to the south side of this area and have a similar geological environment is a vein type ore showing similar to this.

4-4 Satellite Image Analysis

As a result of photo-geological analysis using satellite image, it was revealed that geology of the study area consists of Paleozoic (partly Mesozoic) and Granite intruding into them, and that there are three limestone bodies in the Paleozoic. According to the arrangement and bedded structure of the interpreted units, it was assumed that the Paleozoic-Mesozoic has NS strike and dips to west. Granite extending in the ground survey area is Central Granite (Gr2) that might be of composite intrusive or of two or more intrusions of different time.

According to the distribution of continuous lineament, the area might be divided into four blocks. Lineament pattern on the center to north part of the image can be explained by a model; an assumption of a stress field with maximum compression axis in NNE-SSW direction. In this case, N-S lineament would correspond to right-lateral fault, NE-SW lineament to left-lateral fault, and NNE-SSW lineament to tension fracture. It is possible to assume that the central to north part is different to the south part in term of regional stress field or geological structure unit, and that the boundary of them is a tectonic line

that is represented by NE-SW lineaments crossing the image at the center.

Short or discontinuous lineaments tend to concentrate Dong Noi - Mae Kanai area and Mae Sariang river area, and lineament density of them elongates parallel to the NE-SW lineaments crossing the image at the center, while the center of the high lineament density area continues from Dong Noi area to Mae Sariang area with NW-SE direction.

Dong Noi and Mae Kanai mineral occurrences are on the south of the NE-SW lineaments (or tectonic line) crossing the image at the center, while other mineral occurrences are on the north of the lineaments.

Dong Noi and Mae Kanai mineral occurrences are located at the west margin of a Paleozoic Limestone (Ls), on the West of that Granite (Gr2) is extending. Also, these mineral occurrences correspond to high-density area of short or discontinuous lineaments. Dong Noi mineral occurrence extends southward from a crossing point of this high density area and NNE-SSW continuous lineament. Mae Kanai mineral occurrence is located at a crossing point of the NE-SW lineaments (or tectonic line) and NNE-SSW continuous lineament on the North of this high-density area.

Mae Pan river mineral occurrence is lined up on a NNE-SSW lineament in Paleozoic (P4). Since being held between two NE-SW lineaments, this NNE-SSW lineament is interpreted as a tension fracture based on a regional stress field model mentioned above, and existence of vein type deposits agrees with this interpretation. Also, this mineral occurrence corresponds to low density area of short or discontinuous lineaments.

The I-4 mineral occurrence is located near NNE-SSW lineaments among the boundary of Paleozoic (P4), Paleozoic Limestone (Ls) and Granite (Gr2), and corresponds to the west wing of high density area of short or discontinuous lineaments.

Huai Hat Ta Lan mineral occurrence is located in Paleozoic (P3 and P4) and is held between two N-S to NNW-SSW lineaments. This occurrence is lined up in NNW-SSE direction and corresponds to medium density area of short or discontinuous lineaments.

In this satellite image analysis, it is suggested that mineral occurrences in Mae Sariang area relate hardly with Granite and Limestone, and with continuous lineaments and density of short or discontinuous lineaments. Therefore, possibility of ore deposit would be high for such area as satisfying the following condition;

1) nearby contacts of Limestone (Ls) and Granite (Gr2),

2) crossing point of continuous lineaments,

3) nearby NNE-SSW lineaments that are considered as tension fracture,

4) high density area of short or discontinuous lineaments.

Hereafter, it is necessary that making attention to these points.

Chapter 5 Conclusions and Recommendation for the Second Phase Survey

5-1 Conclusions

5-1-1 Mae Sariang Area

The distributions of various minaral occurrences and geochemical anomalies in Mae Sariang Area are closely related to the distribution of carbonate rocks such as limestone and limestone lens, alternating beds of shale and limestone in the Ordovician system, from the Devonian to Carboniferous systems, from the Permian to Triassic systems. It is considered that since carbonate rocks play a great role in the formation of ore mineralization.

In judging that, areas where distributions of limestone, mineral showings and geochemical anomalies overlap have high potential in occurrence of mineral deposits. Four districts of Mae Ka Nai, from Huai Pu to Huai Mae Pan, Northeastern of Mae Sariang town and from Huai Hat Ta Lan to Huai Ngu have been selected as the promising area for next phase. In the areas of Mae Ka Nai and Mae Sariang West Bank, there are possibilities of originating stratiform deposits or skarn type massive sulfide ore deposits through the metasomatism of limestone. In the district extending from Huai Pu to Huai Mae Pan and that from Huai Hat Ta Lan to Huai Ngu, there is a promising potential of vein type sulfide deposits and massive deposits through metasomatism of limestone lenses.

5-1-2 Don Noi Area

The mineralization in Don Noi area is considered to be as follows:
ore solution which has gone up along the fault of north-south system bordering between Cambrian sandstone and Ordovician has formed a vein type ore body which mainly consists of galena, barite and pyrite. The remained solution has diffused and replaced along some particular horizons of limestone in the surroundings to form zinc mineralization.

Vein type ore bodies certainly distribute at the places which correspond to high electric charging area in the north side of the east and west faults. The center is the middle of traverse lines A and B at the depth of 100 to 150 m.

At present, how the occurrences of zinc through metasomatic replacement of limestone are existing cannot be seen clearly with the naked eye. But their features resemble with those of Mae Sod mineral deposit owned by Padeang Industry Inc. Mineralization seems

to have occurred at various horizons in limestone.

5-1-3 I-4 Area

In the I-4 area, geological situation and mineral showings of one side remarkably differ from those of the other side of the NE-SW fault running through the center of the district.

In the northern side of the area, Ordovician limestone formation distributes and geochemical anomalies of Zn and Pb and F are recognized in the limestone. The distribution of anomalies suggests a high possibility that the distribution is controlled by the N-S fracture system. The anomaly levels are lower than those of Don Noi district by one figure. The fact that there is no anomaly of Cd is also different from Don Noi district. Judging from the fact that there are the mineralization of zinc at a certain level in this rock, the geochemical anomaly of zinc in the Ordovician limestone which is continuing from the north side of this limestone is showing a possibility of existing zinc ore body.

In the southern side of the area, a mineralization zone in which several stockwork vein zones with sulfide minerals are found in the shale from the Permian to Triassic along the river. Geochemical anomalies and low specific resistivity and high chargeability zones distribute in the northwest direction that is the extension direction of the veins. Judging from this correlation, there is a high possibility of existing of vein-type ore bodies under this zone which are more concentrated than the stockwork veins on the surface. From the distribution of geochemical anomalies and that of high chargeability, it is recognized that the center of the ore body is somewhere below the measurement point 700 of the traverse line A.

5-1-4 Satellite images analysis

it is suggested that mineral occurrences in Mae Sariang area relate hardly with Granite and Limestone, and with continuous lineaments and density of short or discontinuous lineaments. Therefore, possibility of ore deposit would be high for such area as satisfying the following condition;

1) nearby contacts of Limestone (Ls) and Granite (Gr2),
2) crossing point of continuous lineaments,
3) nearby NNE-SSW lineaments that are considered as tension fracture,
4) high density area of short or discontinuous lineaments

5-2 Recommendations for the Second Phase Survey

The most promising area among those selected on the basis of the preliminary survey

results of Mae Sarian Area is Mae Ka Nai district. In this district, it is necessary to carry out geological detailed surveys, geochemical detailed surveys and IP prospecting to grasp the distribution of mineralization and geological structures to point out locations of existing of mineral deposits.

In the area from Huai Pu to Huai Mae Pan, it is not considered that there is a large scale stratiform mineral deposit, but since geochemical anomalies of zinc and lead are the highest within this area. It is desirable that geological detailed surveys, soil geochemical survey and trench surveys are to be carried out to clarify the existing forms of mineral occurrences

In the northeastern area of Nam Mae Sariang Town in the west bank of Nam Me Sariang, it is necessary to carry out soil geochemical survey along the stream where geochemical anomalies of zinc are found this year to confirm the possibility of zinc occurrence.

In the Don Noi detailed survey area, it is necessary to confirm the scale and the grade of ore body by drilling surveys at the center point of vein type ore body. As for the zone of geochemical anomalies of zinc, it is necessary to clarify existing forms of zinc mineralization and horizons of mineral deposit in limestone by trenching surveys and drilling surveys. It is also necessary to confirm the range of distribution of ore showings by carrying out soil geochemical survey from the southwest side to the west side of the area.

In the I-4 area, it will be useful to carry out a drilling survey at the center of vein type ore body to confirm the occurrence conditions and the grade of ore body. At the same time, it is considered that together with the survey results of the area from Huai Pu to Huai Mae Pan of which geological conditions are similar, clarification of its vein type mineralization will be useful for elucidation of the features of mineralization in Mae Sariang Area.

Part II Detail Description

Chapter 1 Results of Reconnaissance Surveys of Mae Sariang Area

1-1 General Geology

The northern part of Thailand is divided, from the west, into four tectonic provinces: the western tectonic province (the boundary between Thailand and Myanmar), the western major mountain tectonic province (between Mae Sariang and Chiang Mai), from the central plain to the central northern tectonic province and the eastern tectonic province (Khorat Plateau).

Along the Mae Nam Yuam at the western end of the survey area, there is a north-south tectonic line which is the border between the western tectonic province and the western major mountain tectonic province.

The region from Nam Mae Yuam to the eastern side which occupies most part of Mae Sariang area belongs to the western major mountain tectonic province and consists of sedimentary rocks and granite from the Cambrian to the Triassic period. The total geological structure is consistent with the continuous direction of mountains of this area and extends from north to south. Batholith granite of the Triassic period intrudes from north to south in the central part of the area. By this granite, the Palaeozonic formation is divided into the west and the east. The Palaeozonic formation of the west as a whole has a monoclinic structure dipping toward the west; from east to west, beds of sedimentary rocks of the Cambrian period and those of the Permian period (partly those of the Triassic period) pile up in the order of age. The Palaeozoic formation on the east side mainly consists of sedimentary rocks of the Ordovician period and partly exposes sedimentary rocks of the Cambrian period in the understructure.

In these Palaeozonic formations (partly Triassic), ore showings of lead, zinc and copper distribute, but there is no metallic mine which is currently under operation. There are also non-metallic deposits of barite and fluorite. At present, exploitation of some of them is continued.

The region in the west of Nam Mae Yuam belongs to the western tectonic province and the survey area of the region consists of sedimentary rocks after the Triassic period of the Mesozoic Era. No intrusion of igneous rocks is found within the survey area. No ore showings of non-ferrous metals are found in this area either.

Figures II-1-1, II-1-2 and II-1-3 respectively show a geological map, a geological profile and stratigraph of Mae Sariang Area.

1-2 Detailed Geology

1-2-1 Sedimentary Rocks

(1) Cambrian Sedimentary Rocks (CB)

In the northern part of the survey area, from east of Ban Mae La Noi to east of Mae Sari-

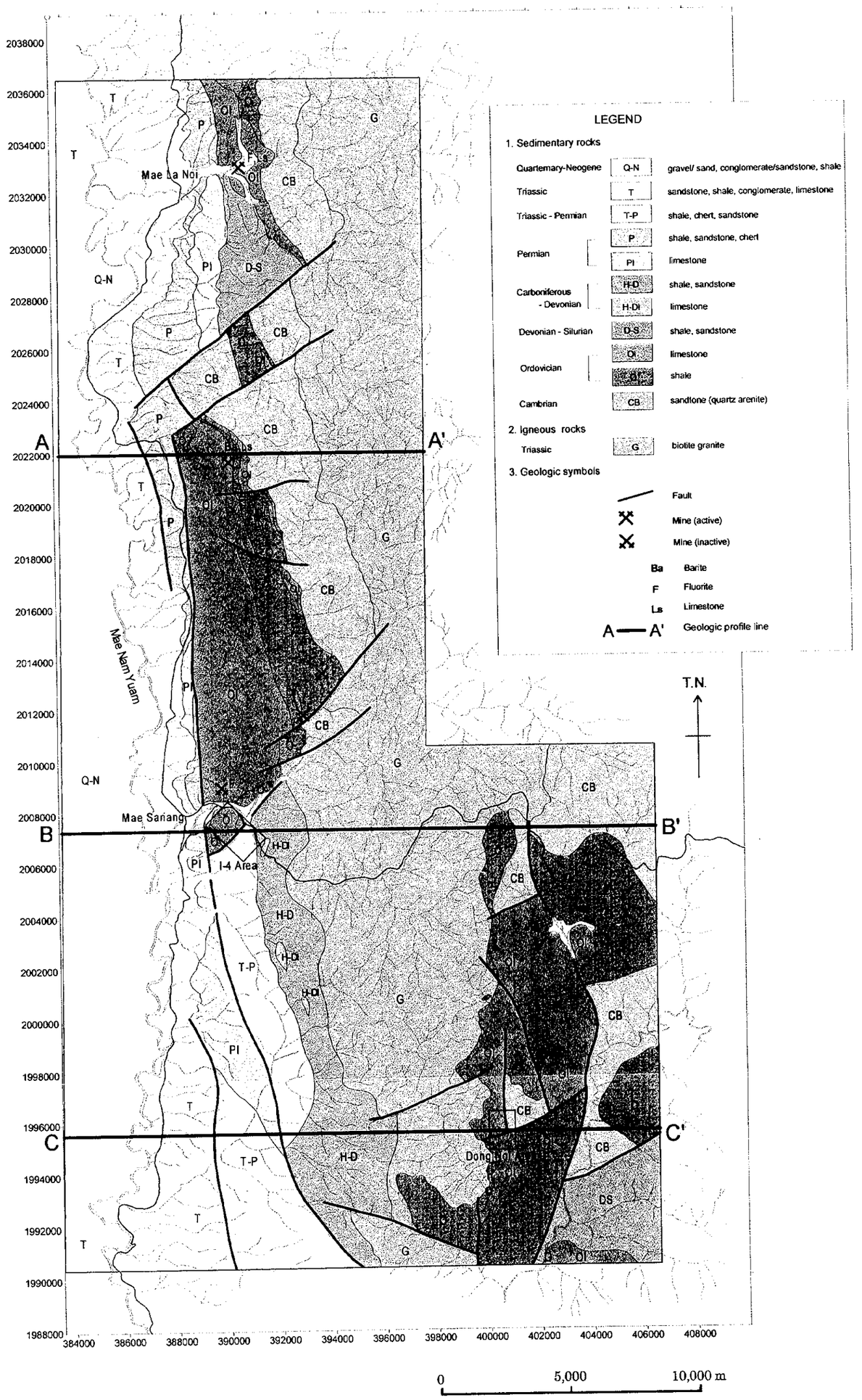


Fig.II-1-1 Geologic map of the Mae Sariang area

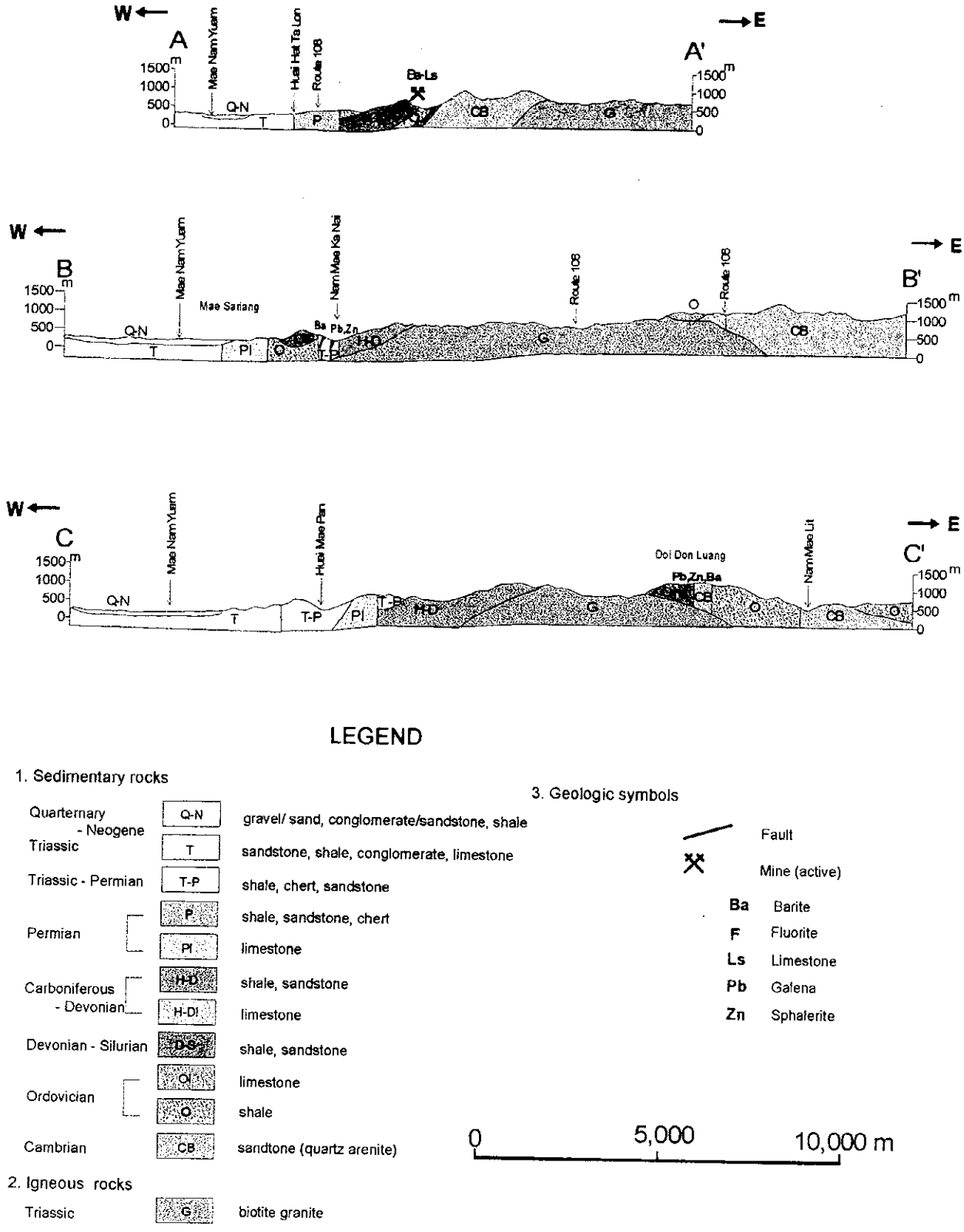


Fig.II-1-2 Geologic profile of the Mae Sariang area

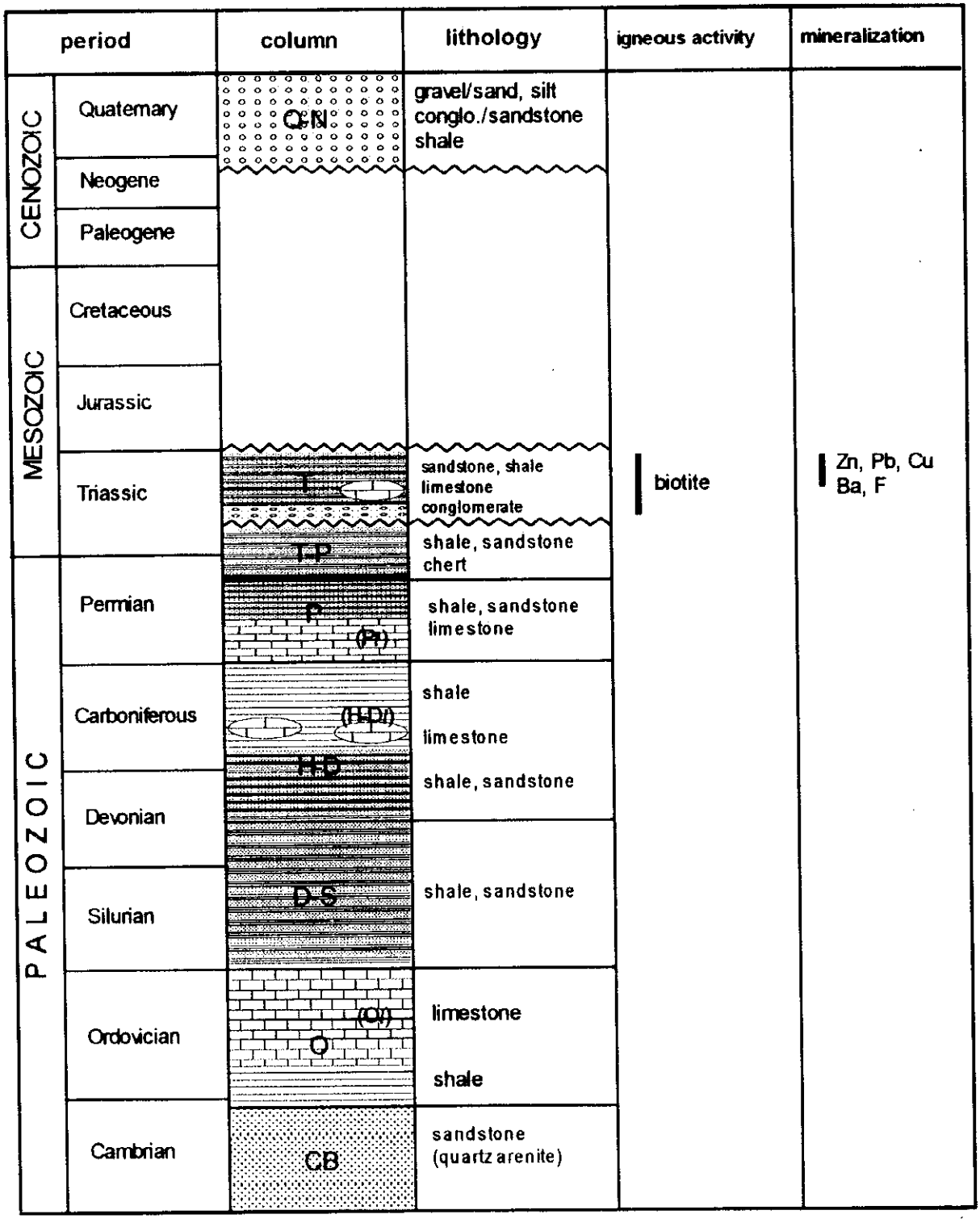


Fig. II-1-3 Schematic geologic column of the Mae Sariang area

ang urban area, these rocks, almost continuously, distribute along the western boundary of Triassic granite. In the southeast of the area, these rocks spread widely beneath the Ordovician sedimentary rocks which distribute on the east side of the granite.

They mainly consist of medium grained massive quartz arenite (orthoquartzite) in pink or whitish brown and partly intercalated sandstone and shale and thin beds of calcareous sandstone and limestone.

In the upper stream of Nam Mae La Noi of the northern part of the survey area, this rock has been metamorphosed into hornfels surrounding granite body and in comparatively pelitic parts, cordierite porphyroblasts are found. Contact Metamorphism occurs near the lead occurrences of Don Noi sub-area and the upper stream of Huai Mae Ho in the southeastern part of the survey area. They have turned green or dark green color due to calcareous silicate minerals; at the same time, in some parts, magnetite dissemination is discovered.

In both of the northern and the southern parts of the survey area, the Ordovician sedimentary rocks conformably overlie this rocks. There is no report of fossils in these rocks.

(2) Ordovician Sedimentary Rocks (O,Ol)

These rocks distribute from the eastern part of Ban Mae La Noi and Huai Hat Ta Lan basin to the area extending to the east of Mae Sariang in the western Palaeozoic formation distribution area. In the eastern Palaeozoic formation distribution area, they widely spread in the area from Ban Mae Kanai to Ban Don Noi in the eastern part of the survey area. The rocks from Ban Mae Kanai to Ban Don Noi have made karst landform on the top of mountains.

At the lower formation, shale and alteration of shale and sandstone is dominant with thin limestone bed. The upper formation is almost composed of banded limestone thinly alternating muddy seams and calcareous seams. This banded limestone generally transits from white to grey massive limestone towards upper part.

The limestone formation exposed from the northwest to the west of the survey area and around Ban Mae Kanai area and Ban Don Noi in the east of the survey has contact aureole by granite and recrystalized into coarse-grain. In addition, it is partly skarnized. Also, outcrops and gigantic boulders in olive color or yellowish green that are rich in calc-silicate mineral rocks are observed. A part of such skarnized rocks are disseminated with magnetite and galena.

The structure of this formation inclines toward the west in the N-S strike from Ban Mae La Noi to the east of Mae Sariang, and in the surroundings of Ban Mae Kanai, it is gently inclining toward the east.

As above mentioned, these seems to conformably overlie the Cambrian sedimentary rocks.

It has been reported that in the limestone exposing from Ban Mae La Noi to the east of Mae Sariang, conodonts from Arenigian to the Llanvirnian periods were found (Hahn et al., 1982).

(3) Silurian to Devonian Sedimentary Rocks (D-S)

These rocks mainly consist of shale and sandstone and spread in the east of Ban Mae La Noi of the north of the survey area and around Ban Huai Wak in the end of southeast of the area.

It is conformable with the Ordovician limestone. However, since Permian limestone overlies this formation near the Mae La Noi, probably, it is unconformity with the upper horizon.

(4) Devonian to Carboniferous Sedimentary Rocks (H-D, H-Dl)

These rocks widely crop out in the south of Mae Sariang town and the southwest of the survey area. Black shale is dominated and accompanied with lenticular limestone and alternating beds of thin bed of chert and limestone.

The lenticular limestone is generally muddy and often shows thin alternating beds of muddy limestone and shale. They are partly affected by silicification and skarnization and are in blue, yellowish green or green in the upper streams of Huai Pu and Huai Mae Pan.

In these rocks, many galena-barite veins are found. The black shale, which are near the granite body, particularly at the upper stream of Huai Mae Pan, are metamorphosed into hornfels over several hundred meters from the contact. At some parts of hornfels, a great amount of mica is formed in clear schistosity.

It is inferred to be conformably covered by overlying Permian to Triassic rocks.

(5) Permian Sedimentary Rocks (P, Pl)

This formation consists of gray shale and massive gray to white limestone. This crops out narrowly from north to south along the east bank of Nam Mae Yuam.

Bivalvia and Fusulinidae from the middle to latter Permian has been reported in the massive limestone of this formation in the south of Mae Sariang. Also in the limestone of the south of Mae La Noi, Cephalopoda from the late Carboniferous to the middle the Permian has been found..

Limestone and shale of this formation in the north side from Mae Sariang town unconformably overlie Ordovician limestone or lie in fault contact with them. In the south of the area, the relationship with this and Permian to Triassic sedimentary rocks is considered to be conformity.

(6) Permian to Triassic Sedimentary Rocks (T-P)

These rocks are traced from Mae Sariang town to the south along the east side of Nam Mae Yuam. The rocks mainly consist of shale, sandstone and alternating beds of shale-sandstone. In Huai Mae Pan, they conformably overlie massive Permian limestone and Conondonts from the middle to late Triassic have been found nearby.

(7) Triassic Sedimentary Rocks (T, Mae Sariang Formation)

Triassic Sedimentary Rocks crop out along the Nam Mae Yuam. They mainly compose of shale and sandstone and partly intercalate thin layer of chert and small limestone lenses. *Daonella cf., Sumatriensis, Daonella aff lommeli* and *Halobia stryriaca* has been reported

from them.

(8) Pliocene to Quaternary Formation (Q-N)

This formation consists of half-consolidated siltstone and conglomerates in addition to unconsolidated gravel formation. Particularly along the Nam Mae Yuam, terraces have developed on which this formation widely is distributed. Along the major rivers within this survey area, Alluvium has developed.

1-2-2 Igneous Rocks

(1) Biotite Granite

The biotite granite is widespread from north to south in the central part of the area. The granite is characterized by a large amount of euhedral phenocryst of potassium feldspar with a longer diameter of several centimeters, 7 cm at maximum, and is medium to coarse-grained holocrystalline granular granite which contains biotite and a small amount of hornblende. In spite of the fact that it is quite widely exposed in the survey area, there is little variety of lithofacies. Although fine-grained facies and aplitic parts are found partly, there is no variation of mineral composition. At both sides of the granite and the sedimentary rocks on boundary, oftenly white-agrillization by cericite, montmorillonite are observed in the width of 3 to 10 m.

This granite has had thermal metamorphic effect on the surrounding sedimentary rocks with which extends often in the width to several hundred meters from the contact. Also subsurface granite bodies or some stocks may exist underbeneath Sedimentary rocks. Because sedimentary rocks, which are more than 1 km far from granite body, underwent thermal metamorphism; a part of Ordovician limestone on the east of Mae Sariang town is marblized, and Cambrian sandstone in the surroundings of Ban Don Noi is metamorphosed into hornfels.

The activity of this granite is considered to be Triassic in age.

(2) Dike rocks

A small number of dikes are observed in the Mae Sariang area. There are only quartz porphyry dikes and dacite dikes at a part of this area.

Outcrops of the quartz porphyry dikes are observed in the northern branches near Ban Huai Ngu of northern part of the survey area, which are about 10 m wide and intruding Ordovician sedimentary rocks. Also along Nam Mae Um Long at 1 km to northeast of Ban Huai Ngu, small quartz-porphyry dike is intruding into Cambrian quartz arenite. They show pale green color and contain round quartz crystals with a diameter of 3 to 4 mm and have been slightly proceeded argillization by kaolinite. Since a small amount of idiomorphic potash feldspar phenocryst is also contained, they are considered to be marginal facies of Triassic granite. In the branch at 1 km to the east from Ban Huai Ngu, a great amount of same quartz porphyry boulders are found.

Dacite dikes crop out in a small stream at 2 km in the north of Ban Mae Ho. It intrudes into biotite granite about 3 to 4 m wide. It is pale green and brown fine-grained rocks containing common hornblende and quartz phenocryst.

1-3 Geological Structure

Within the survey area, the fracture and fault system in the direction of N-S is predominant. Nam Mae Yuam and ridge systems have also developed in this direction. In addition to this system, there is a fault system of NE-SW, which is oblique to N-S fracture. The NE-SW faults particularly develop in Huai Mae Tia Noi and along Nam Mae Sariang. From the north end to the south end of the central survey area, Triassic biotite granite also intruded in relation to lineament of the N-S system.

Each stratum also continues in consistent with N-S direction which is generally a major structural direction. Palaeozoic formation of the west side of the area is dipping toward west while Palaeozoic formation on the east side has been divided into some blocks by secondary NE-SW faults and are almost horizontal to inclining eastward gently.

1-4 Mineral Deposits and Occurrences

There is no metal mine in this area which has been actually operated. But there are occurrences of lead, zinc and copper covering a wide range of this area. Some of non-metallic deposits were once exploited for their barite and fluorite, but now, a barite mine is only in active. Figure II-1-4 is a map showing the locations of mineral occurrence observed by this survey in the Mae Sariang area.

These occurrences have roughly gathered around the following three areas.

1. Area from the Chamrat barite mine to Ban Huai Ngu
2. Area from the eastern part of Mae Sariang town to Huai Mae Pan
3. Area from Ban Mae Ka Nai to Ban Don Noi (Don Noi Area)

1. Area from the Chamrat barite mine to Ban Huai Ngu

In this area, several limestone strata and shale of the Ordovician lie in N-S direction. They are partly intruded by quartz porphyry dikes. The Ordovician continues up to the east of Mae Sariang town.

The development of Chamrat Khongson barite mine started in 1993. A barite vein intruding limestone formation was exploited and limestone aggregate has been produced as its by-product. The barite vein at the lower part of mining face strikes N30°E and dips 30°W with 10 m width. It appears along the limestone bedding. At the upper part of the mine, the vein width is about 3m having a steep dip of over 85° and disconcordant with sedimentary plain of limestone. The extension of the vein is over 500 m. Monthly productions of

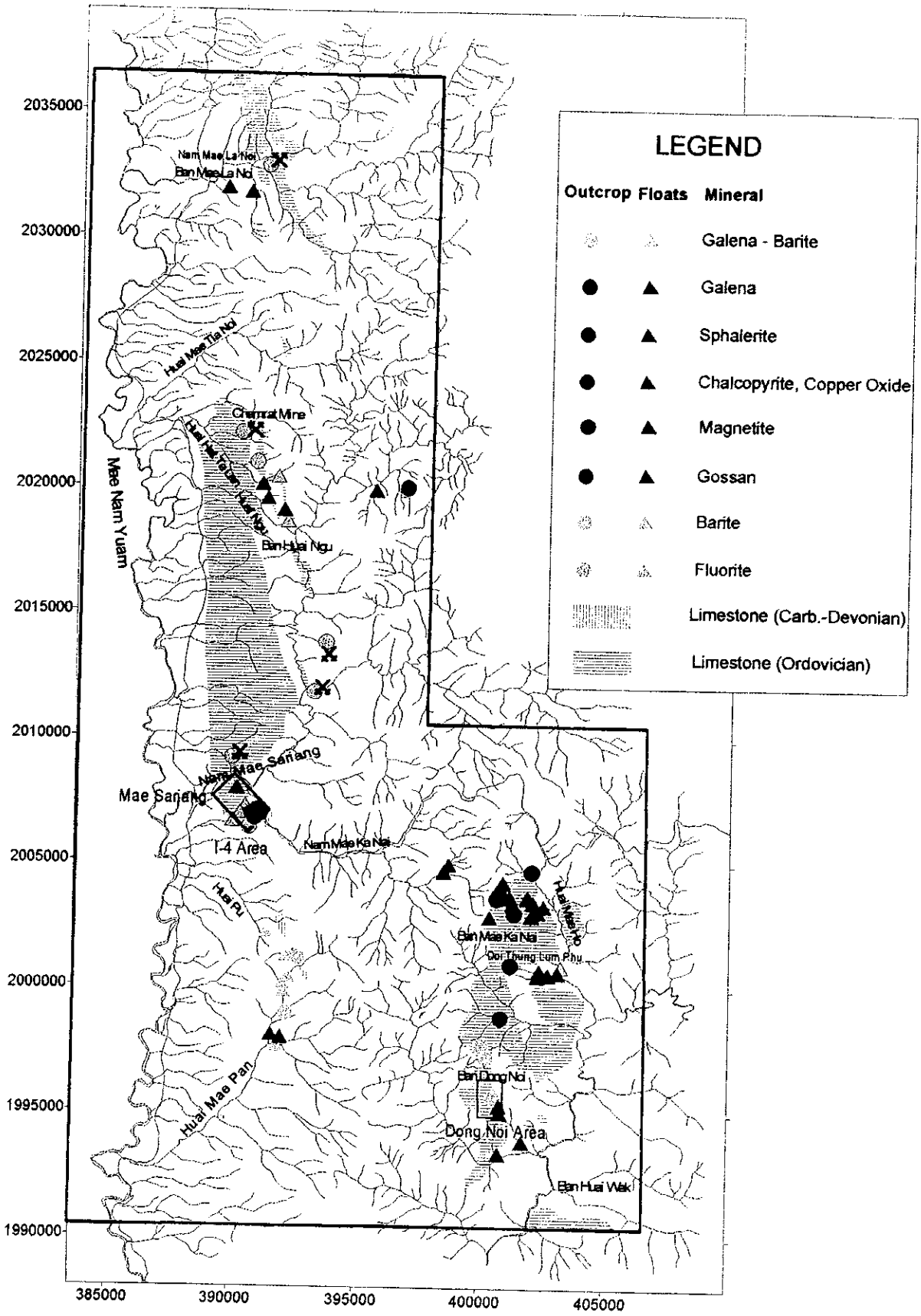


Fig.II-1-4 Mineral occurrences map in the Mae Sariang area

barite are 1,000 to 2,000 tons. It mainly ships as a chemical raw material to Saraburi near Bangkok. Boulders of barite veins scatter from here and there on the southeast side of this mine. These barite veins scarcely contain other minerals and no sulfide minerals. However, assay results of shale boulders (DR010) with fine barite veins collected from a lower stream of waste dam of Chamrat mine shows 5,200 ppm Zn.

At the area covering 5 km from Chamrat Khongson mine to Ban Huai Ngu, barite boulders and gossan floats are found in several branches which run down from the east to Huai Ngu. Assay results of the gossan show 1,500 and 3,800 ppm of Zn (BR-57, DR-031).

2. Area from the eastern part of Mae Sariang town to Huai Mae Pan

This area is covered by the Devonian-Carboniferous formation. In addition to many floats and outcrops of barite and galena veins. As mentioned later, high abnormal value of lead and zinc in stream sediment are concentrated in this area. From the area I-4 through Huai Pu to Huai Mae Pan on the south, outcrops of mineral occurrence are emplaced in the Devonian-Carboniferous formation and the Permian-Triassic formation. The Devonian-Carboniferous formation mainly consists of black shale and alternating beds of black shale and gray sand stone intercalating thin chert and banded limestone layers. Calc-silicate minerals are produced in banded limestone looking greenish at the upper streams of Huai Pu and Huai Mae Pan.. The Permian-Triassic formation consists of shale and chert with small-scaled limestone lenses.

On the northern end of this mineral occurrence, at the riverside of Nam Mae Ka Nai, Nam Mae Sariang tributary, there are three or four network vein zones of galena-arsenopyrite of a few meter width on the shale outcrop which is strongly silicified about 70 m long from north to south. Moreover, on the NW trend from this outcrop, many baritefloats with galena dissemination are found. Since this occurrence belongs to the I-4 sub-area where detailed surveys took place, occurrence will be described in the section 3-4 in detail.

At the upper stream of Nam Mae Pan, galena-barite veins are found at several parts. And great many galena-barite floats as same as those of the veins are continuously distributing from north to south. These rocks are rich also in zinc showing 3,400 ppm (AR-005) and 2,020 ppm (DR-012). A barite-quartz vein containing galena-chalcopyrite-malachyte (AR-006) are also found. According to ore assay, this shows Cu 3.61 % and Pb 3.68 %.

3. Area from Ban Mae Ka Nai to Ban Don Noi

The area from Ban Mae Ka Nai to Ban Don Noi of the south eastern part of the survey area is a place where Ordovician formation is dominant. Beneath limestone and shale of this Ordovician formation, blocks of Cambrian quartz arenite (orthoquartzite) are exposed here and there. Judging from the distribution of limestone of Ordovician age, the Ordovician system of this area is seems to be horizontal to gently inclining toward the east side and covering the Cambrian system. With the Ordovician limestone formation, mineral occurrences

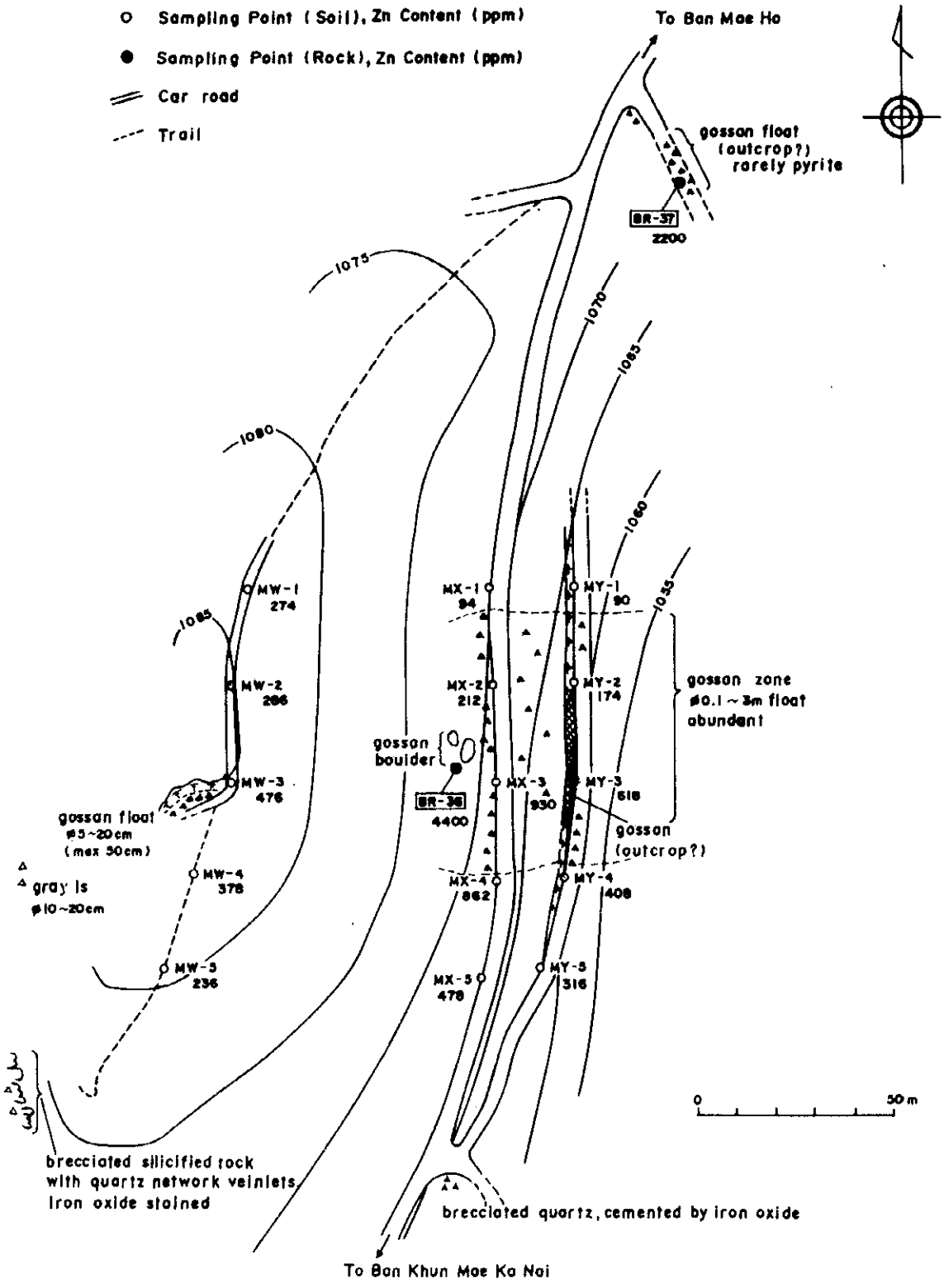


Fig.II-1-5 Gossan occurrences at the north of Ban Mae Kanai

distribute here and there.

In the Ordovician limestone distributing around Ban Mae Ka Nai characterized by karst landform, small gossan zones below 100m width distribute over the ridge surrounding the basin landform in the karst. In addition, a great many gossan floats assumedly derived from the mineralization zone in this limestone are observed at the lower part of the Ordovician limestone in a tributary of Huai Mae Ho of the eastern end of karst. All of this gossan show reddish brown or black brown; some of them have a remaining pyrite in the center.

Particularly on the cutting and the roadbed along the ridge to the north of Ban Mae Ka Nai, gossan zone distributes over the width of 60 m, which must be surely the upper outcrop of mineral deposit. Preliminary geochemical survey was carried out in this part.

This zone locates about 1,200 m north-northeast of Ban Mae Ka Nai. It is on a comparatively gently sloping ridge and almost no rocks are exposed. Therefore, the extent of mineralization zone is not clear, but the dark red gossan zone distributes at least 100 m from east to west and 50 m from north to south (Fig. II-1-5).

Two samples of this zone consisting of mostly hematite and geothite were analyzed (BR-36 and Br-37) and high zinc contents, 2,200 ppm and 4,400 ppm, were respectively detected.

As a preliminary survey, soil geochemical survey in this zone was conducted along 3 survey lines with intervals of 25 m. The analysis results are shown in the appendex. As a result, a level of 200 ppm of Zn is continuously widespread and 930 ppm at maximum in the gossan zone. As for Mn, the value was over 1,000 ppm at maximum.

Judging from the this survey, a mineralized zone of this area still continues in both directions from east to west and in the south.

Among the gossan around Ban Mae Ka Nai, high content of zinc, 1.51 %, was detected at Nam Mae Ho tributary (FR017). By the ore assay (BR-050 and BR-051) of other gossans, 3,400 ppm and 4,200 ppm of Zn were detected, which are generally high. Particularly, BR-50 shows a high lead content of 9,600 ppm.

In the branch to the south of Doi Thung Lum Phu which is the south end of limestone formation near Ban Mae Ka Nai, a great many magnetite(-quartz vein) floats with a diameter of 4 m at maximum distribute. Ordovician shale expose along the stream, and limestone overlies shale near the ridges. In the shale at the lower part, limonite-quartz veins in small scale are found. Since magnetite floats were large in amount and angular in shape, it was estimated that there should be some outcrops comparatively nearby, but none of them were discovered.

In the Cambrian sandstone on the north side of this limestone formation, magnetite dissemination can be seen along Huai Mae Ho. In the greenish sandstone, a great amount of magnetite is disseminated. Similar magnetite dissemination is also found in the Cambrian formation in the Don Noi Area.

On the roadway which is about 1 km to the north from Ban Don Noi, massive galena floats

distribute across the width of about 5 m. This is a small vein intruding through probably Ordovician limestone formation was found when the roadway was improved seven years ago. By an ore assay (AR-001), Pb 58.3 %, Ag 209 g/t and 990 ppm of Zn are detected. On the peripheral ridges, no matter which test pit is exploited, similar galena-barite veins are confirmed. Local people said that in Huai Chang which was a little to the north from here, they had once made bullets for hunting guns out of a galena-quartz vein which distributed in the width of 2 m crossing the stream. However, it was not confirmed by the survey of this time.

In the Don Noi detailed survey area, a large-scale mineralization zone mainly consisting of galena and barite distributes. Details of occurrence in Don Noi will be described in the latter section.

As mineral occurrences in addition to the above, there are many gossan floats in Huai Lum Kham of the east side and in small branch on the west side of Mae La Noi. There are occupied by Devonian- Carboniferous sedimentary rocks and Permian limestone. In Huai Lum Kham, many big gossan boulders with a diameter from 1 to 2 m can be seen at inflection points where geological structure along the stream changes suddenly. As a result of analysis, 1,100 ppm of Zn is contained. On the west side of granite distribution zone contacting with the sedimentary rocks, a great many quartz veins with galena are found. There are many veins particularly in the river basin of Nam Mae Um Long and their width is about 0.5 m and their extension is not known. From ore assay, 530 ppm of Pb and 7.9 to 13.6 g/t of Ag are detected. Near the national highway 108 also, many floats of quartz veins are seen and 463 ppm of Cu and 2,020 ppm of Zn are obtained.

1-5 Geochemical Survey

1-5-1 Sampling and pathfinder Elements

Sampling was carried out together with geological surveys because major objective mineral types were massive ore deposits and/or stratiform deposits which were expected to be originated in limestones. Sampling density was decided with consideration of the limestone distribution shown on the existing geological map and the promising areas selected by Jamnongthai (1988).

In advance to sampling, orientation surveys were carried out at two places near ore showings of Huai Mae Pan to decide the most effective sieve for detection of geochemical anomaly through indicator elements as single variables and correlation among indicator elements.

The number of samples of stream sediment was 851 pieces. The sampling positions were marked on PL-3. Samples were air-dried on sites and then, were shared between Thailand and Japan. Either of them was analyzed.

1-5-2 Orientation Surveys

At two points near the junction of Huai Mae Pan Noi with the midstream of Huai Mae Pan, stream ssdiment were sampled for individual mesh sizes such as 60, 80 and 120, and comparison study was carried out. Chemical analyses were carried out, as same as the orientation survey at Dong Noi District, in the laboratory of DMR Chiang Mai Branch. For certain reasons of analyzing equipment, only three elements of Zn, Pb and Cu were analyzed.

Results of the chemical analyses are shown on Table II-1-1. By the mesh 120, all three elements were most highly sensitive. It was found that the coarser the mesh, the lower the sensitivity. As for zinc, the sensitivity of samples for mesh 120 was 1.25 to 1.5 times as sensitive as that of mesh 60 while as for lead, it became 1.3 to 2.1 times sensitive. For copper, the sensitivity of mesh 60 was the same with that of mesh 80, but comparing with mesh 120, latter was 1.14 to 1.5 times sensitive like other elements.

Table II-1-1 Result of Chemical analysis of stream sediment for orientation survey

Sample No.	Zn	Cu	Pb	Time for sampling(m)
Os1 #60	77	29	128	18
Os1 #80	94	29	140	22
Os1 #120	97	33	172	65
Os2 #60	81	17	112	23
Os2 #80	100	17	228	28
Os2 #120	119	25	232	59

Judging from the results, sampling with mesh 120 could be said to be most effective, but a time required for sampling was more than doubled. The sensitivity difference between the samples of mesh 80 and those of 120 was 1.0 to 2 times; thus, there was no big difference. According to these results, mesh 80 was selected this time.

1-5-3 Analyses of Single Component Data

(1) Statistic Processing

It is known in general that if reliability on analysis accuracy is sufficient, values of geochemical analysis, particularly those of trace components, distribute nearly a log-normal distribution statistically. Accordingly, for analyses of the following values, common logarithm of each analysis value was used. In statistical processing, a half value of a detection limit was used for the analysis values below the limit. As for the analysis values above a detection limit, the limit value was used.

Statistical values of each element are shown on Table II-1-2. Frequency distribution of each element and cumulative frequency curves are shown in Figure II-1-6(1)~(3). Width of class division of the frequency distribution is 1/2 σ.

Correlations among each element are shown in Table II-1-3. In calculating the correlations, Au, Ag and W of which more than 90% of analysis values were below respective detection limit were excluded.

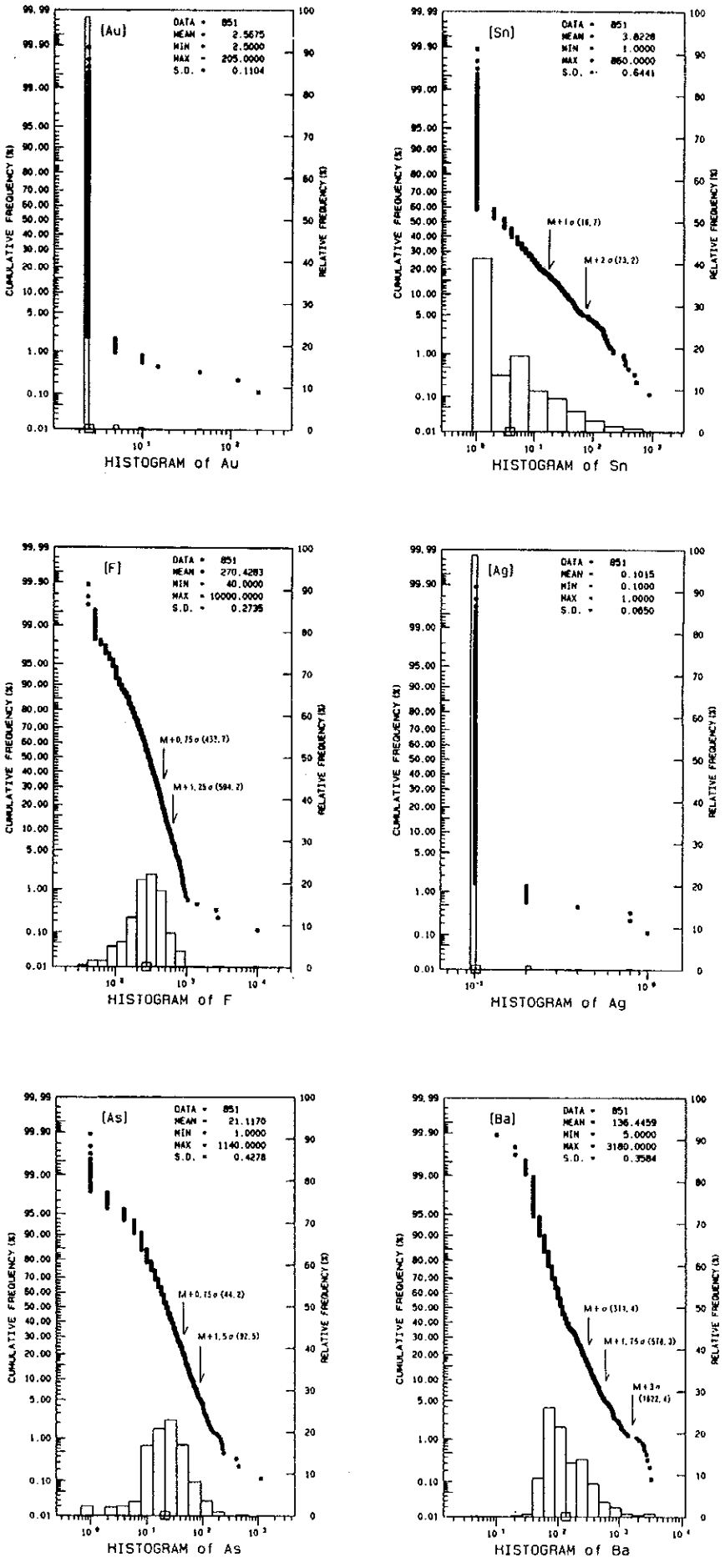


Fig.II-1-6 Relative frequency and cumulative frequency histogram of stream sediments in the Mae Sariang area (1)

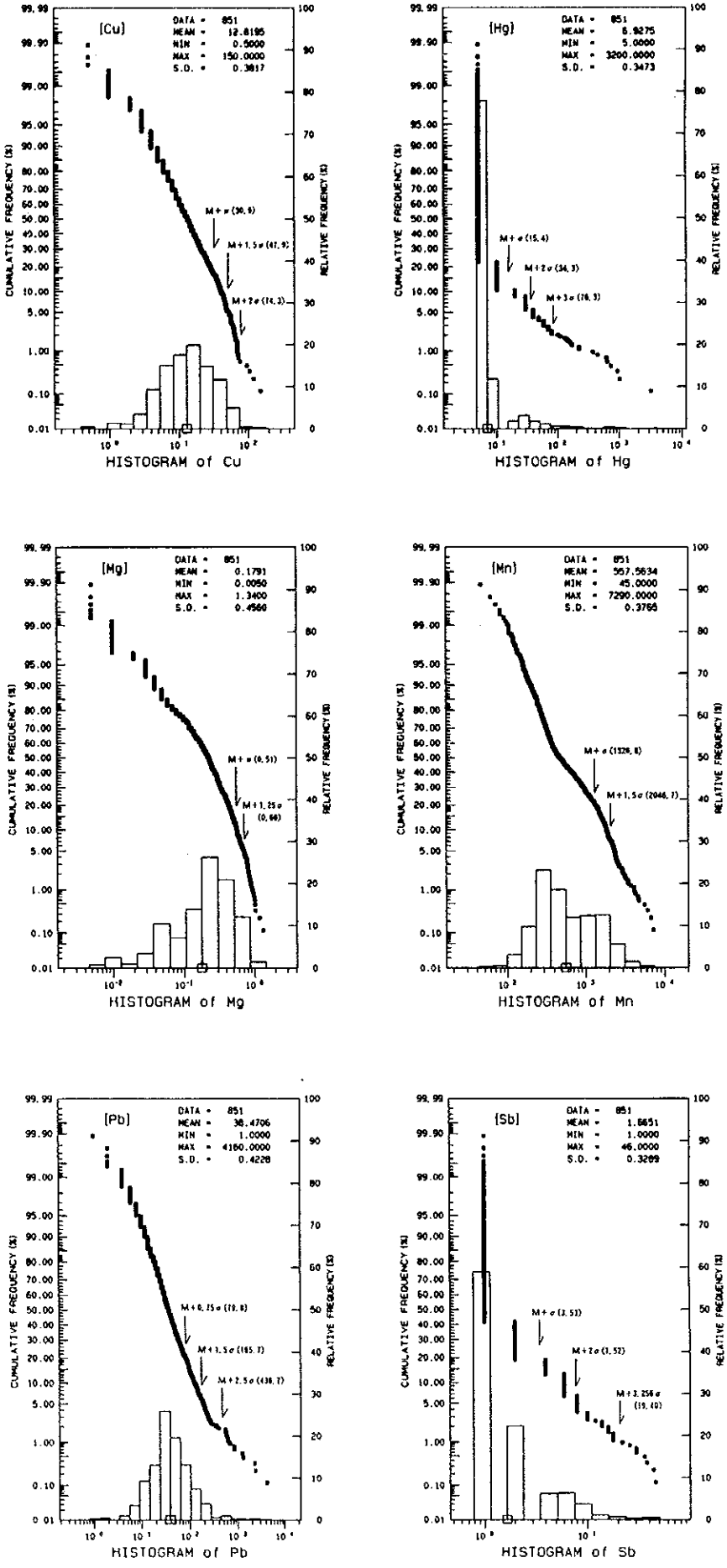


Fig.II-1-6 Relative frequency and cumulative frequency histogram of stream sediments in the Mae Sariang area (2)

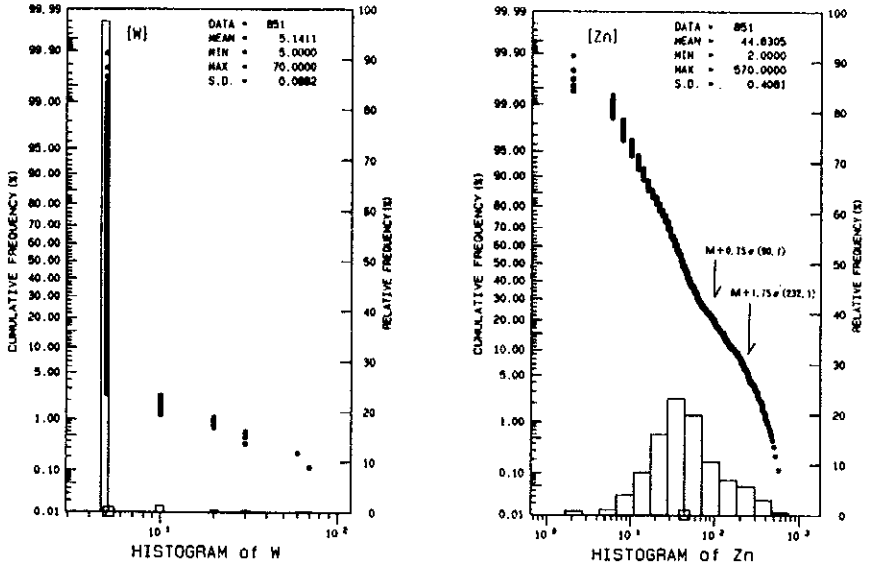


Fig.II-1-6 Relative frequency and cumulative frequency histogram of stream sediments in the Mae Sariang area (3)

Table II-1-2 Geochemical basic statistic quantities of Stream sediment

Element	Unit	Lower Detection Limit	Maximum Value	Minimum Value	Average	Standard Diviation (log)
Au	ppb	5	205	<5	2.57	0.1104
Sn	ppm	2	860	<2	3.88	0.6441
F	ppm	20	>10,000	40	270.43	0.2735
Ag	ppm	0.2	1.0	<0.2	0.10	0.0650
As	ppm	2	1,140	<2	21.11	0.4278
Ba	ppm	10	3,180	<10	136.45	0.3584
Cu	ppm	1	150	<1	12.82	0.3817
Hg	ppb	10	3,200	<10	6.93	0.3473
Mg	%	0.01	1.34	<0.01	0.18	0.4560
Mn	ppm	5	7,290	45	557.56	0.3765
Pb	ppm	2	4,160	<2	38.47	0.4228
Sb	ppm	2	46	<1	1.67	0.3289
W	ppm	10	70	<10	5.14	0.0882
Zn	ppm	2	570	2	44.83	0.4081

Table II-1-3 Geochemical correlation coefficients of stream sediment

	Sn	F	As	Cu	Hg	Mg	Mn	Pb	Sb	Zn	Ba
Sn	1.0000										
F	0.1065	1.0000									
As	0.0168	0.4203	1.0000								
Cu	-0.2054	0.4017	**0.6671**	1.0000							
Hg	-0.1330	0.0610	0.1874	0.1058	1.0000						
Mg	0.3008	**0.618**	0.2355	0.3077	-0.3041	1.0000					
Mn	-0.3459	0.2664	**0.6618**	**0.7271**	0.2810	0.0617	1.0000				
Pb	0.1222	0.3424	**0.5684**	0.4912	0.1961	0.3157	0.4902	1.0000			
Sb	-0.1384	0.1207	**0.5077**	0.4040	0.3844	-0.1151	**0.5374**	0.4520	1.0000		
Zn	-0.0872	**0.568**	**0.6606**	**0.6708**	0.1070	0.4597	**0.6572**	**0.7153**	0.3568	1.0000	
Ba	-0.1696	0.1251	**0.5359**	**0.5507**	0.2606	0.0507	**0.6734**	**0.5020**	0.4452	0.4988	1.0000

Between each element except for Sn and Hg, a positive correlation was recognized. Particularly, the groups, which showed strong positive correlation, were As, Cu, Mn, Pb, Sb, Zn and Ba. The groups of F, As, Cu, Mg, (Pb) and Zn also showed a positive correlation.

The types of mineral showings in Mae Sariang area were mostly barite-quartz veins and fluorite ore deposits accompanied with sulfide minerals such as galena. The groups having a positive correlation of the above showed a possibility to become an index of mineral showings.

(2) Distribution of Geochemical Anomaly

1) Deciding Thresholds

Table II-1-4 Division into geochemical anomaly levels of stream sediment

Element	Unit	Background	High anom-aly1	High anom-aly2	High anom-aly3
Zn	ppm		M+0.75 σ 91	M+1.75 σ 232	
Pb	ppm		M+0.75 σ 80	M+1.5 σ 166	M+2.5 σ 439
Cu	ppm		M+ σ 30.9	M+1.5 σ 47.9	M+2 σ 74.3
Sb	ppm		M+ σ 3.53	M+2 σ 7.52	M+3.25 σ 19.4
Au	ppb		5	10	
Ag	ppm		0.2		
Sn	ppm		M+ σ 16.7	M+2 σ 73.2	
W	ppm		10		
F	ppm		M+0.75 σ 430	M+1.25 σ 594	
Hg	ppb		M+ σ 15.4	M+2 σ 34.3	M+3 σ 76.3
Mn	ppm		M+ σ 1,326	M+1.5 σ 2,047	
Mg	%		M+ σ 0.51	M+1.25 σ 0.66	
Ba	ppm		M+ σ 311	M+1.75 σ 578	M+3 σ 1,622
As	ppm		M+0.75 σ 44.2	M+1.5 σ 92.5	

To decide a threshold which sorts out an anomaly from a background level of geochemical data, various methods have been proposed by Lepeltier (1969), Sinclair (1976) and Govett et al. (1983): a method to use a natural gap of frequency distribution, a method to use broken points of cumulative frequency distribution curves, a method to use average and standard deviation, a method by percentile of frequency distribution and others. In this paper, mainly the combination of an average value and a standard deviation was taken as a criterion. Percentiles of frequency distribution and broken points of cumulative frequency curves were also considered for the decision. Table II-1-4 shows the threshold of each element.

2) Distribution of Anomaly

Distribution of anomaly of each element was shown in Figure II-1-7to 11.

[Zn] The anomalies of Zn were distributed in the granite side on the contact zone of granite with the Cambrian formation along Huai Mae Hu, Nam Mae La Noi and Huai Mae Sakua of

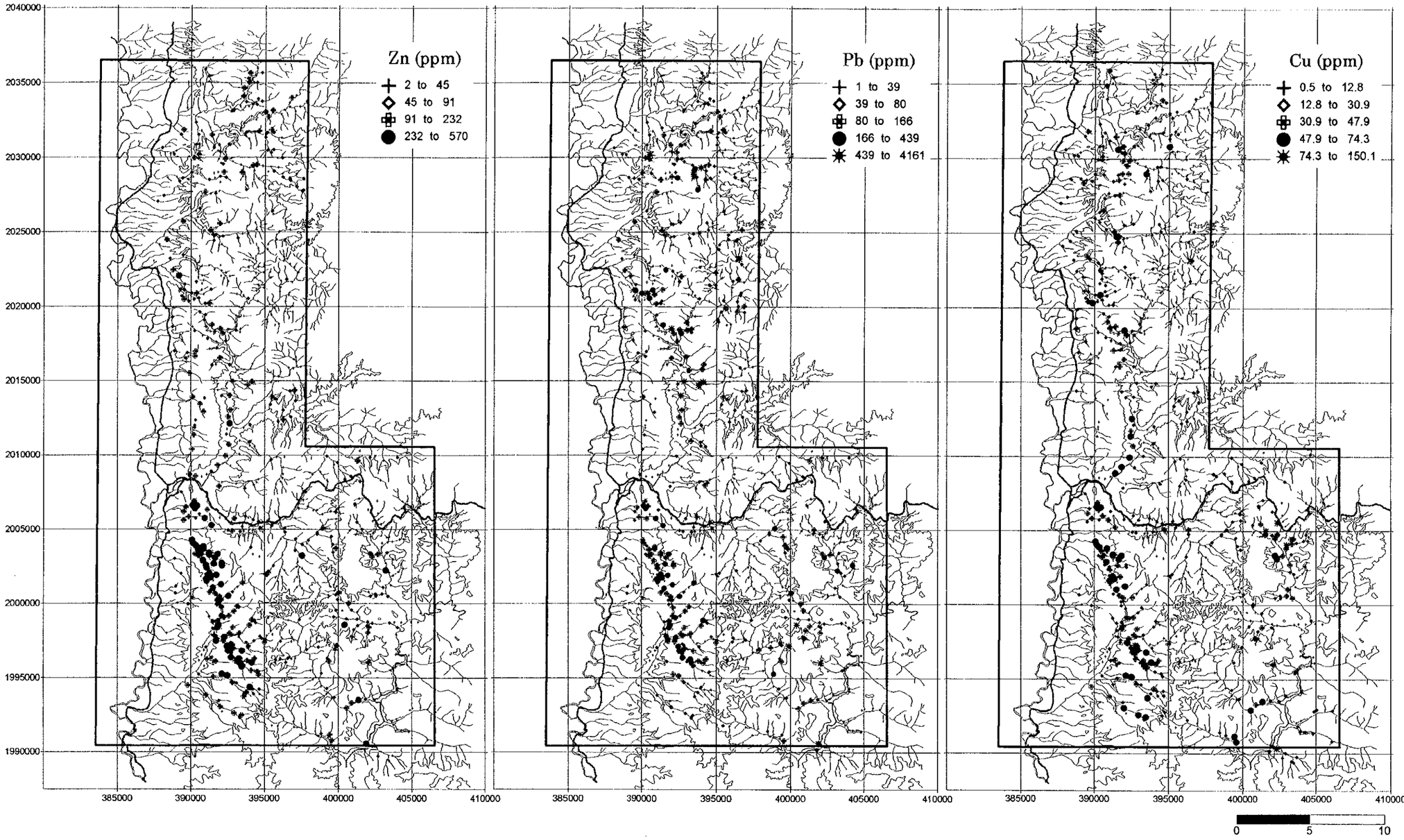


Fig.II-1-7 Geochemical map of Zn, Pb, Cu in Stream Sediment of the Mae Sariang Area

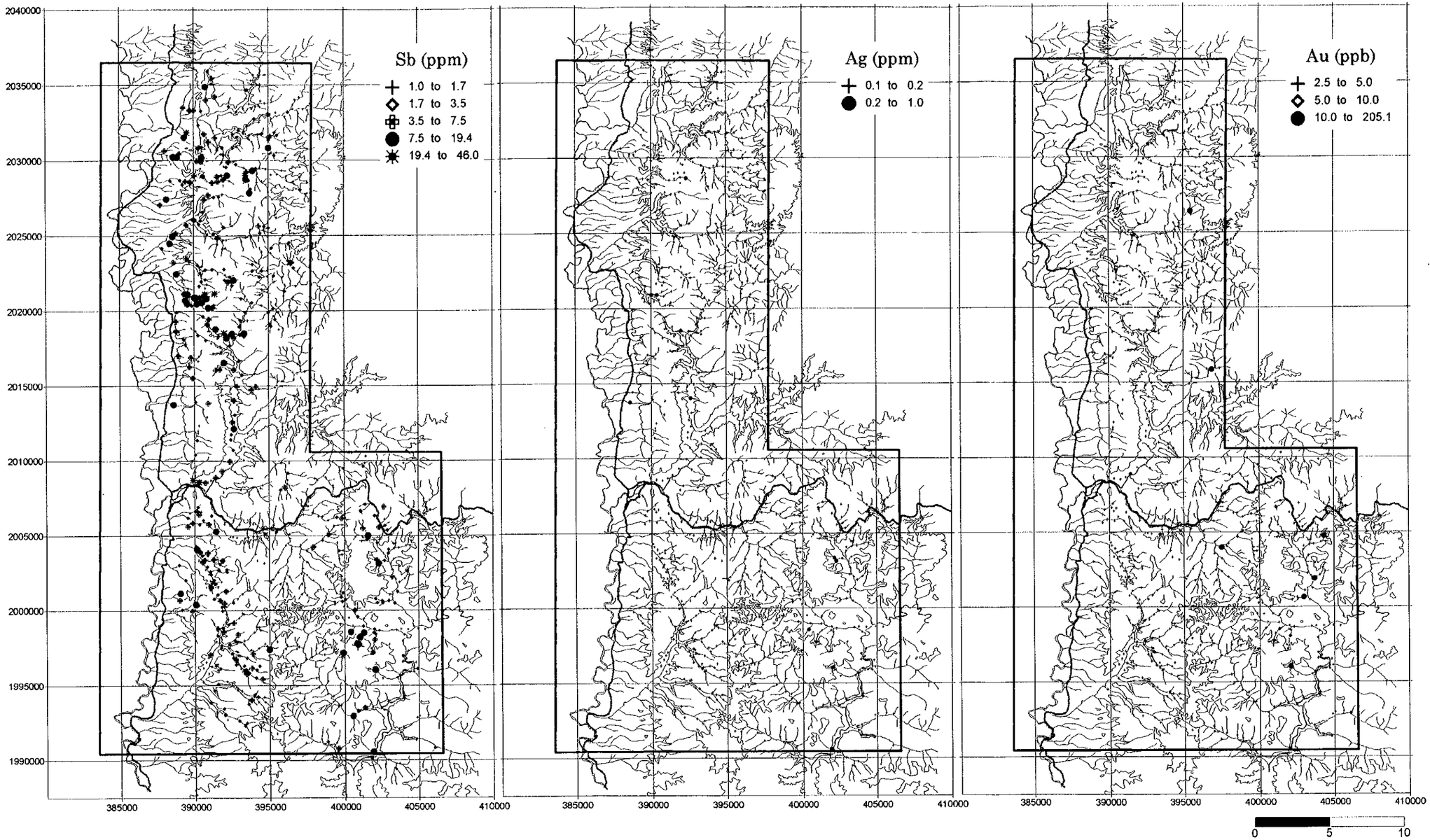


Fig.II-1-8 Geochemical map of Sb, Ag, Au in Stream Sediment of the Mae Sariang Area

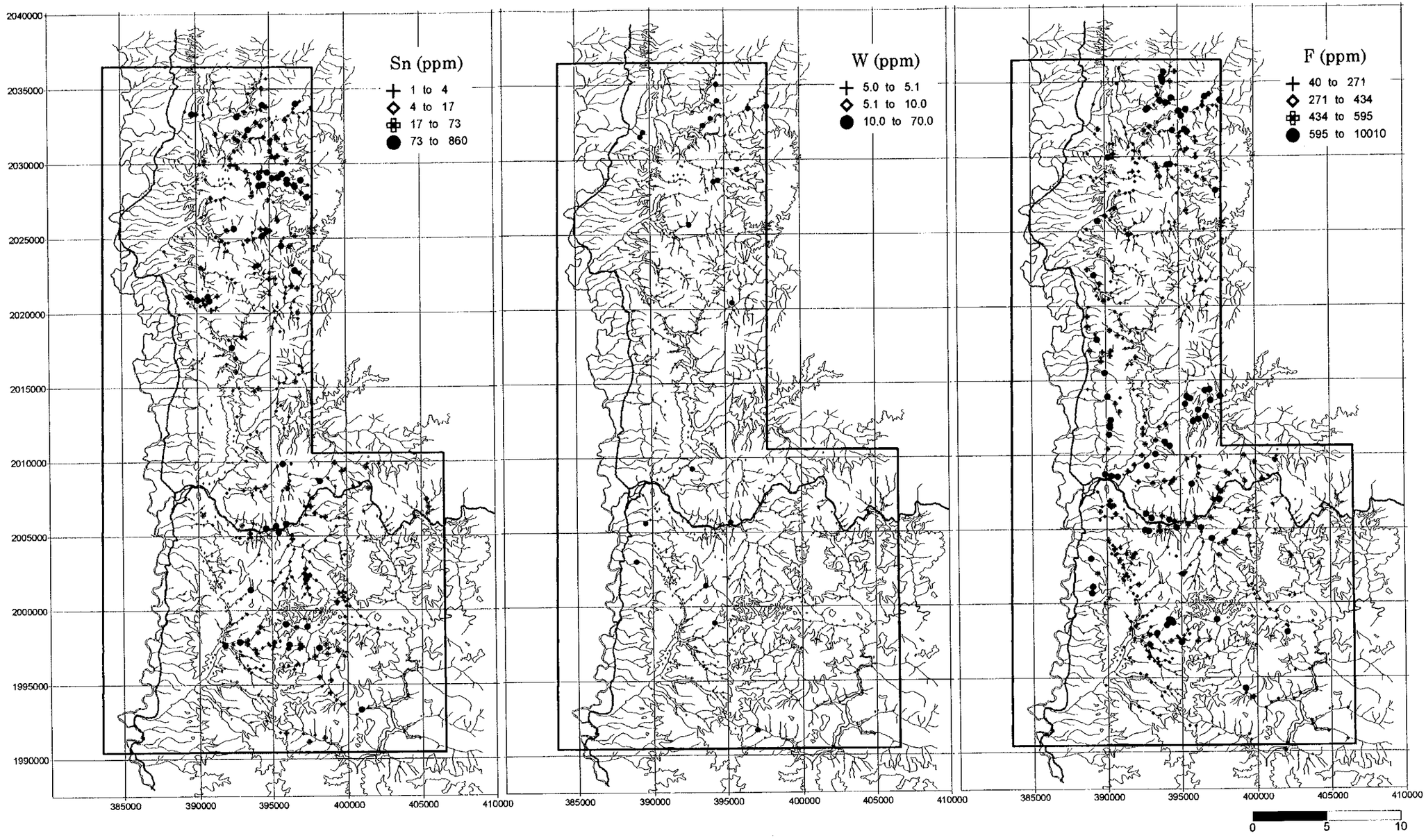


Fig.II-1-9 Geochemical map of Sn, W, F in Stream Sediment of the Mae Sariang Area

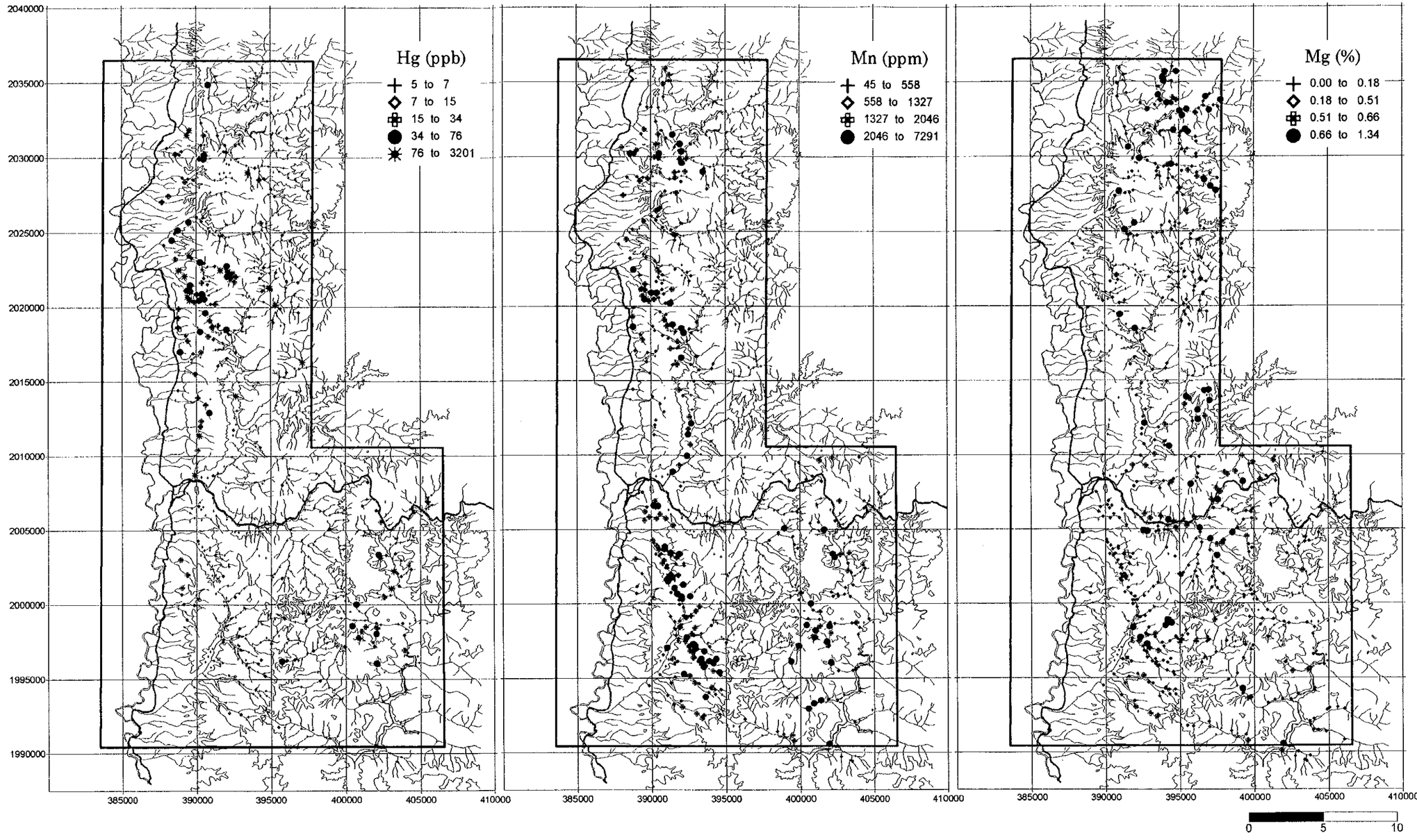
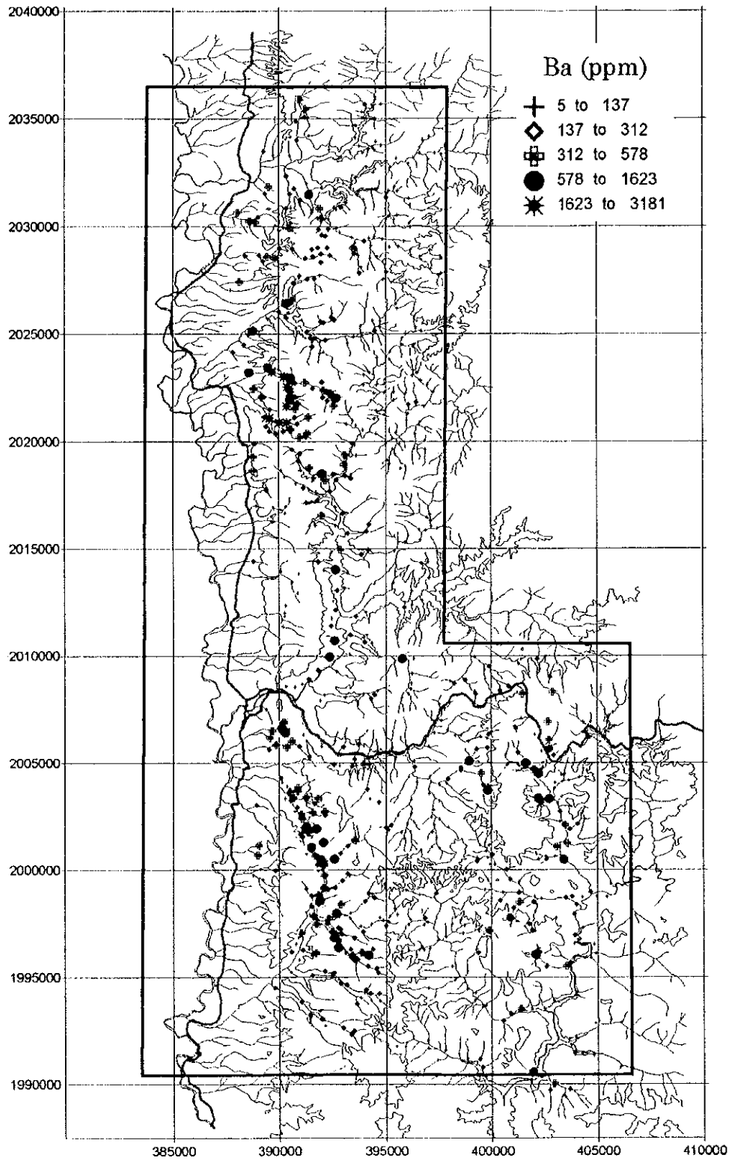


Fig.II-1-10 Geochemical map of Hg, Mn, Mg in Stream Sediment of the Mae Sariang Area



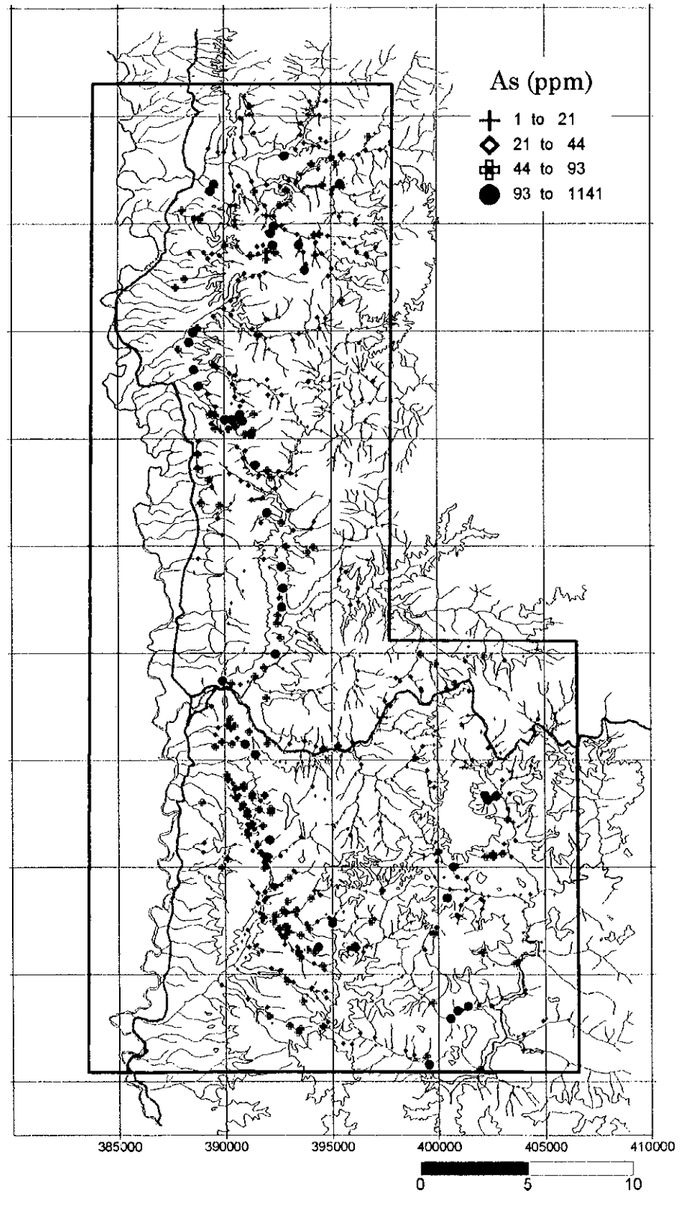


Fig.II-1-11 Geochemical map of Ba, As in Stream Sediment of the Mae Sariang Area

the eastern part of Mae La Noi in the northern part. As for the mid-northern part, quite high anomalies distributed in the Ordovician formation from Huai Hat Ta Lan to Huai Ngu to the west of Chamrat barite mine and in the surrounding areas of Ordovician limestones between Nam Mae Um Long and a national highway. As for the southwestern part, quite high anomalies were distributing over an extremely wide area from the southern side of the I-4 detailed survey area to the east side of Nam Mae Pan (I-3 promising district). Among them, along the upper stream of Huai Hu, high anomalies over 232 ppm were tightly distributed. In this district, the Devonian-Carboniferous and the Permian-Triassic sedimentary rocks were distributing. Thin banded limestone, limestone lemses, calcareous mudstone were interbeded in shale, but no large rocks of limestones were recognized. In the southeast, anomalies were found in the Ban Mae Ka Nai surrounding Ordovician limestone and in the Dong Noi detailed survey area.

[Pb] The distribution of Pb anomalies was quite similar to those of Zn. However, at the distribution area of Zn anomaly of Huai Mae Ho in the northern part of the Survey area, Pb anomalies were not found. At the Huai Mae Sakua, particularly high anomalies were found. These anomalies seemed to correspond to the lead occurrence of Doi Lhun Kam of DMR (1984). From Huai Hat Ta Lan to Huai Ng on the west of Chamrat mine, Pb anomalies were more significant than Zn anomalies and the distribution spreads in the southeastern side. The anomaly distribution in the southwestern part overlapped the Zn anomaly area, but it was not as significant as Zn and there was a tendency that Zn anomaly had become more significant in the south. In the southeastern part of the area, distribution of high anomalies corresponding to those from the lead occurrence on the northern side of the Dong Noi detailed survey area to the lead occurrences of Huai Mae Chang was found.

[Cu] Although Cu anomaly distribution was also similar to those of Zn and Pb, it was not so significant. Most of high anomalies were found at the upper stream of Huai Mae Ho in the southeastern part of the Mae Sariang area.

[Sb] Although Sb anomaly distribution was similar to those of Zn and Pb, anomalies in the Permian limestone were found in the northern part and the southwestern part of the Survey area.

[Ag] 99 % of all the samples were below the detection limit. Even the highest value was 1 ppm and no sample of an anomaly was found.

[Au] Over 98 % of all samples were below the detection limit. Anomalies appeared as isolated spots.

[W] 99 % of all samples were below the detection limit. Even the highest value was 70 ppm and no sample of an anomaly was found.

[F] Most of anomalies of F were consistent with the distribution area of granite, but some were consistent with the distribution of Zn anomalies.

Contents of F in the granite area varied and no anomalies were recognized at the upper

streams of Nam Mae Um Long and of Huai Mae Pe. Anomalies from Mae Sariang urban area to the neighborhood where Nam Mae Sariang and Nam Mae Um Long joined were considered to correspond the fluorite deposits around this area, and they were also consistent with anomalies of Zn. Such a tendency continued from this district to the Huai Pu of the southern side.

[Hg] Most of high anomalies were found in Huai Hat Ta Lan of the mid-northern part of the survey area and the northeastern part. Also high anomalies distribute in Huai Mae Chang and the eastern part of Mae Ka Nai of the south-eastern part of the survey area.

[Mn] Distribution of anomalies of Mn overlapped those of Zn and Pb. It was known that stratified Manganese deposit often originated in the stratiform shale of the Paleozoic age in Thailand. However, the amount of manganese was not always plenty where shale distributed in this area. The distribution of anomalies of Mn was to be effective as an indicative element of mineralization with addition of metallic elements.

[Mg] Anomalies of Mg mostly existed within the distribution of granite. It was considered that this fact showed the distribution of biotite and amphibole derived from granite. Anomalies were also found in Huai Pu and Huai Mae Pan in the southeastern part of the district. Since these overlapped anomalies of Pb and Zn, there was a high possibility of suggesting dolomatization by metallic mineralization.

[Ba] Anomalies of Ba also distributed overlapping those of Zn and Pb. Judging from the fact that many of ore showings of Mae Sariang area were a combination of sulfide minerals-balite-quartz veins, the distribution of anomalies of Ba had a high possibility of indicating the distribution of mineral occurrences in this area. It was natural that many of extremely high anomalies were found in the surroundings of the Chamrat Barite mine of the mid-northern part of the district.

[As] Anomalies of As showed a quite similar distribution with those of the above mentioned elements. Among them, it seemed to be consistent with those of Zn anomalies, but at the part where only anomalies of Zn, F and Hg overlapped, the anomalies of As could not be recognized.

1-5-4 Analyses of Principal Components

For the correlation matrix calculated from logarithm of analysis values of stream sediment, principal components were analyzed. Table II-1-5 shows the results.

Eigen values of up to the third principal components were above 1. Cumulative contribution up to the third principal components was 72 %.

[Z-1] Since the factor loadings of Zn, Mn, As, Cu, Pb, Ba, Sb and F were big, they were considered to correspond to mineral occurrence of these elements. The high score distribution of Z-1 distributed from the east of Mae La Noi to the near to Doi Lun Kam, from Huai Hat Ta Lan to Huai Ngu, the Northward of Doi Chang, neighbor of junction of the Nam Mae Sariang