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

PHASE III

MARCH 2000

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

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

PHASE III

MARCH 2000

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

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 January 10, 2000 to March 18, 2000.

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 present report has been prepared.

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

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

March, 2000

Kimio Fujita
President
Japan International Cooperation Agency

Naohiro Tashiro
President
Metal Mining Agency of Japan

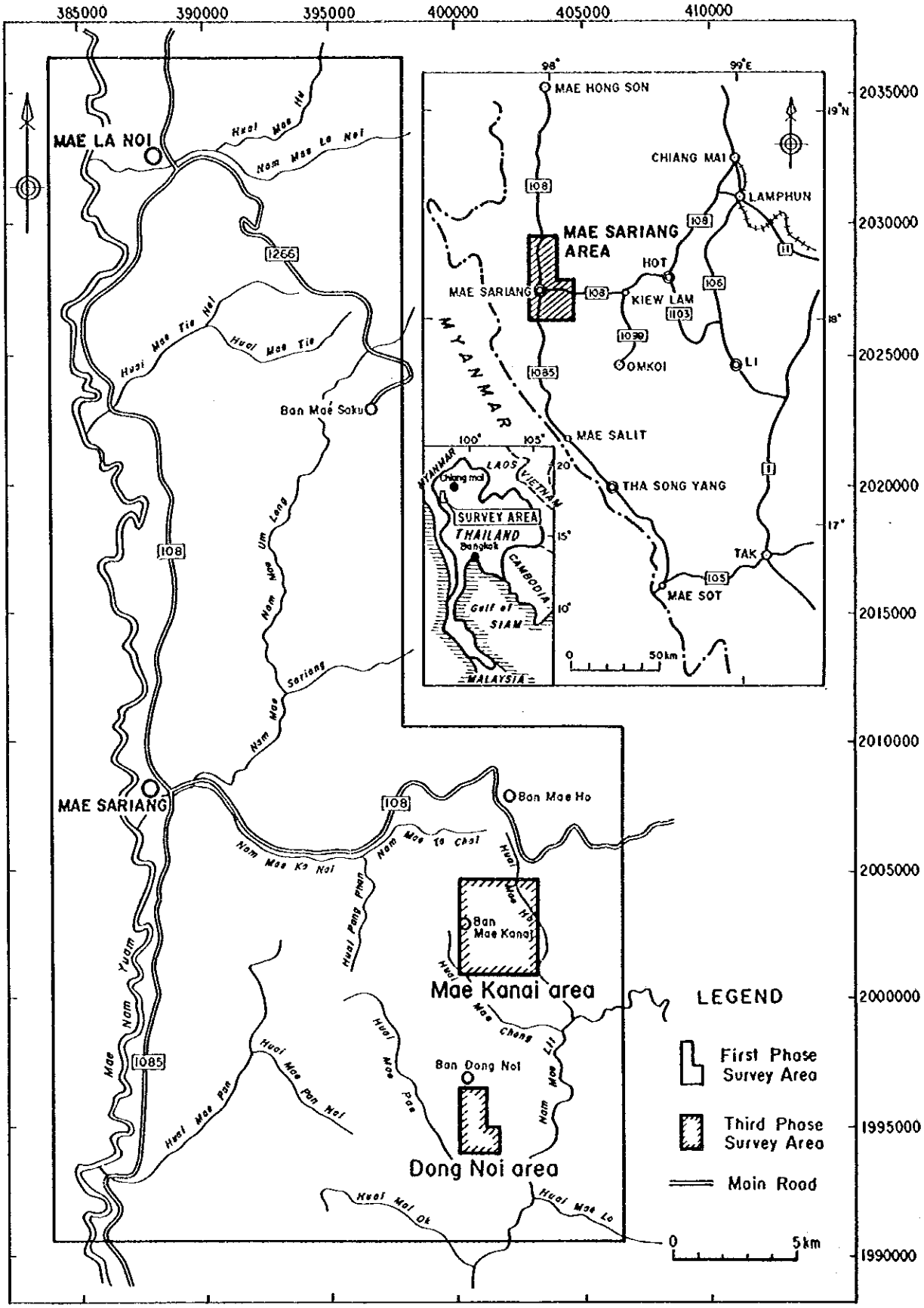

Fig. I -1-1 Location map of the survey area

Summary

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

1. Dong Noi Area

In the area with geochemical anomalies in zinc and lead values extending in the western half of Dong Noi area where limestone was distributed, hydrothermal ore solution in temperature of 140-250℃ and with high salinity rose up through joints in limestone and bedding place of fissures, formed silicificated zone on a certain horizon in relatively upper layers, caused occurrence of wide-ranged dolomitization and zinc/lead mineralization right above it, and at the same time formed quartz vein which changed joint systems and a specific horizon, precipitating galena and sphalerite.The quartz vein in dolomitized zone was in width of 80 cm and its grade values were 7.86%Zn and 2.82%Pb. The sample extracted from 20 m section including this quartz vein also showed high values of 1.60%Zn and 1.43%Pb, and existence of zinc body was expected. However, since the structure to form quartz vein changes open joints and the part along bedding of a certain specific horizon, it is necessary to explain more in detail rock faces and the geological structure to estimate the position of its existence.

As a result of our investigation into MJTM-6 Hole excavated in a spare part of the district with IP anomalies, it was further clarified that the district with high IP anomalies might represent a mineralized zone of copper and lead overlapped with skarn zone. The depth of around 64 m in MJTM-6 Hole where occurrence of chalcopyrite was observed was almost in conformity with the depth of the upper limit to the anomaly zone (16 m V-sec/V or more) revealed through IP exploration. The depth of 140 m or lower where mineral showing including pyrite dissemination was intensified in general was in conformity with the district where IP anomalies (20 m V-sec/V or more) were observed. The district with IP anomalies (16 m V-sec/V or more) extended in a range of 100 m in diameter and 800 m in the total length. Based on the results of MJTM-5 Hole and MJTM-6 Hole, in view of the tendency of copper concentration to increase in a lower layer, i.e. the part where it was in contact with granite, ore bodies might possibly exist near the face which was in touch with granite. However, since copper showing in skarn zone is apt to be unevenly distributed, it is considered difficult to decide the exact position of such ore shoots.

2. Mae Kanai Area

Resulting from our investigation on MJTM-7 Hole and past drilling survey conducted by DMR, we found that the district with high IP anomalies corresponds to the mineralized zone including the silicificated zone along the fracture continuing in the NE-SW direction and accompanied predominant pyrite dissemination and chalcopyrite showing. The chalcopyrite was the most prevailing in the depth of around 129 m, but its grade was low. We may point out that this mineralized zone might represent the passage of ore solution having formed the gossan zone where was distributed on the western side of the ridge.

The gossan zone with high zinc content in the Mae Kanai area had been considered to extend in a vertical direction. However, through our drilling survey of this time, we confirmed that the gossan zone was distributed in thickness of a little more than 10 m and almost along the land surface and that remarkable mineral showing scarcely existed in its lower layers. The gossan zone was distributed between argillized mudstone or sandstone, and the gossan zone was originally a massive sulfide mineral abundant with pyrite and accompanying sphalerite, we presume that pyrite may have been oxidized and changed to limonite and sphalerite may have flown out through weathering.

The sedimentary rocks near the gossan zone were strongly influenced by argillization of talc-sericite-chlorite-smectite especially on the side of lower wall. Further, we observed that silicified zone in the form of hydrothermal breccia accompanying white argillization and quartz vein

had been developed on the upper wall of the gossan zone.

The gossan zones occur almost on the same level, in the district surrounded by MJTM-8 Hole, MJTM-9 Hole and DMR's MK-3 Hole, it is quite possible that the horizon of the gossan may be beneath the land surface and that the gossan zone may have been hidden under it. Moreover, we presume that IP anomalies may be distributed at the east end of profile lines E and D for geophysical exploration on a slope inclined to east right under the land surface and that massive sulfide minerals may exist under the land surface.

Contents

Part I General Remarks

Part II Detail Description

Figures

Tables

Appendices

Attached Plate

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 Conclusion and Recommendation of the Second Phase Survey

1-2-1 Conclusion

1. Dong Noi area

On the result of the trenching and drilling survey, it is made clear that the geochemical soil anomaly of Zn, Cd, Pb and Mn does not indicate the strata-bound or massive ore deposit embedded into limestone. Nevertheless the galena-sphalerite dissemination related to dolomitization and the galena-sphalerite dissemination of fissures or shear zone in limestone located to the upper part of the skarn-type mineralization. The fluid inclusion examination revealed the existence of a high salinity ore fluid which needed to form a strata-bound or massive ore deposits, but it is inferred that this year's field did not have the geologic condition such as a large porous and/or fructured carbonate body to precipitate a large amount of ore minerals. The same mineral indication widely occurs in the northwestern part of the area, where detailed exploration has not been completed.

The soil geochemical anomaly of Cu, Pb and A is derived from the skarn-type mineralization adjacent a buried granite body. This anomaly extends northward from Dong Noi lead occurrence along a north striking fault. It can be interpreted that the skarn-type Cu, Pb and Ag mineralization intersected by the drill holes MJTM-3 and MJTM-5 is consistent with the north-south ex-

tending high chargeability zone with 100 m in diameter and more than 800 m in length obtained by the last year's IP survey. The ore assays of drill core samples range from 0.05 to 1.30 % Cu, from 1.4 to 46.4 g/t Ag, and from 0.02 to 12% Pb. Farther drillings and ore assays are necessary to confirm the reserve and grade of an ore deposit.

The outcrops of gossans were found on the ridge in the southern part of the Dong Noi area for the first time by this phase detailed geologic survey, and the geochemical soil sampling and the IP geophysical survey was carried out around the gossan zone. The gossan channel samples contain ranging from 600 to 800 ppm Cu. Though the values of all pathfinder elements in soil samples could not be obtained high values compared with those in the northern part of the area, the soil samples contain rather high copper content more than 100 ppm and a weak gold anomaly ranging from 30 to 40 ppb on the gossan zone. The IP survey is detected a low resistivity and high chargeability anomaly deeper than 800 meters above sea level, that is 200 m underground. The result of the geochemical survey and the IP survey may lead the existence of the vein-type or stockwork-type ore deposit under the gossan zone.

2. Mae Kanai area

The Mae Kanai area is underlain by the Paleozoic sedimentary rocks. Triassic granite is distributed on the west side of the sedimentary rocks. The sedimentary rocks mainly consist of Ordovician shale, sandstone and limestone, but Silurian-Devonian sanstone is south and north, in fault contact with Ordovician rocks. Shale and sandstone unit are dominant in the Ordovician on the surface, but it is inferred that limestone is widely distributed under the shale and sandstone unit.

More than seven gossan zones with several hundreds meters in diameter occur on the Ordovician shale and sandstone. These gossans contain highly concentrated zinc. Especially high zinc content is obtained from the samples of the gossan zone south of Ban Sam Lung. They normally range from 0.7 to 0.8 %, and the maximum value is 1.54 % from 5 m channel sample. The gossans of other zones commonly contain high Zinc content ranging from 0.2 to 0.3 %.

The ordinary geochemical survey and the MMI geochemical survey are revealed the anomalies around gossan zones. The following anomaly areas are delineated on the result of the geochemical survey.

1) The area around the points ranging from 200 to 500 of Line B and Line C

2) The gossan zone southeast of Ban Sam Lung

3) The area from the F-1000 on a gossan zone to Line E

4) The periphery area around the points ranging from 800 to 900 of Line D

As the result of 2-D analysis of the IP survey, the resistivity discontinuity is found along the north striking fault from Line A to Line C, and the low resistivity distributes at the east part of this discontinuity. The chargeability shows highest value near B-500 station, and the center of the high chargeability is shifting to C-300 station. Therefore the most significant area based on the result of the geophysical survey is an area around B-500 station, where the resistivity shows low value and the chargeability shows high value. It is interpreted that this IP anomaly is accompanied by a fault-related mineralization because it is situated at a peripheryof the fault zone

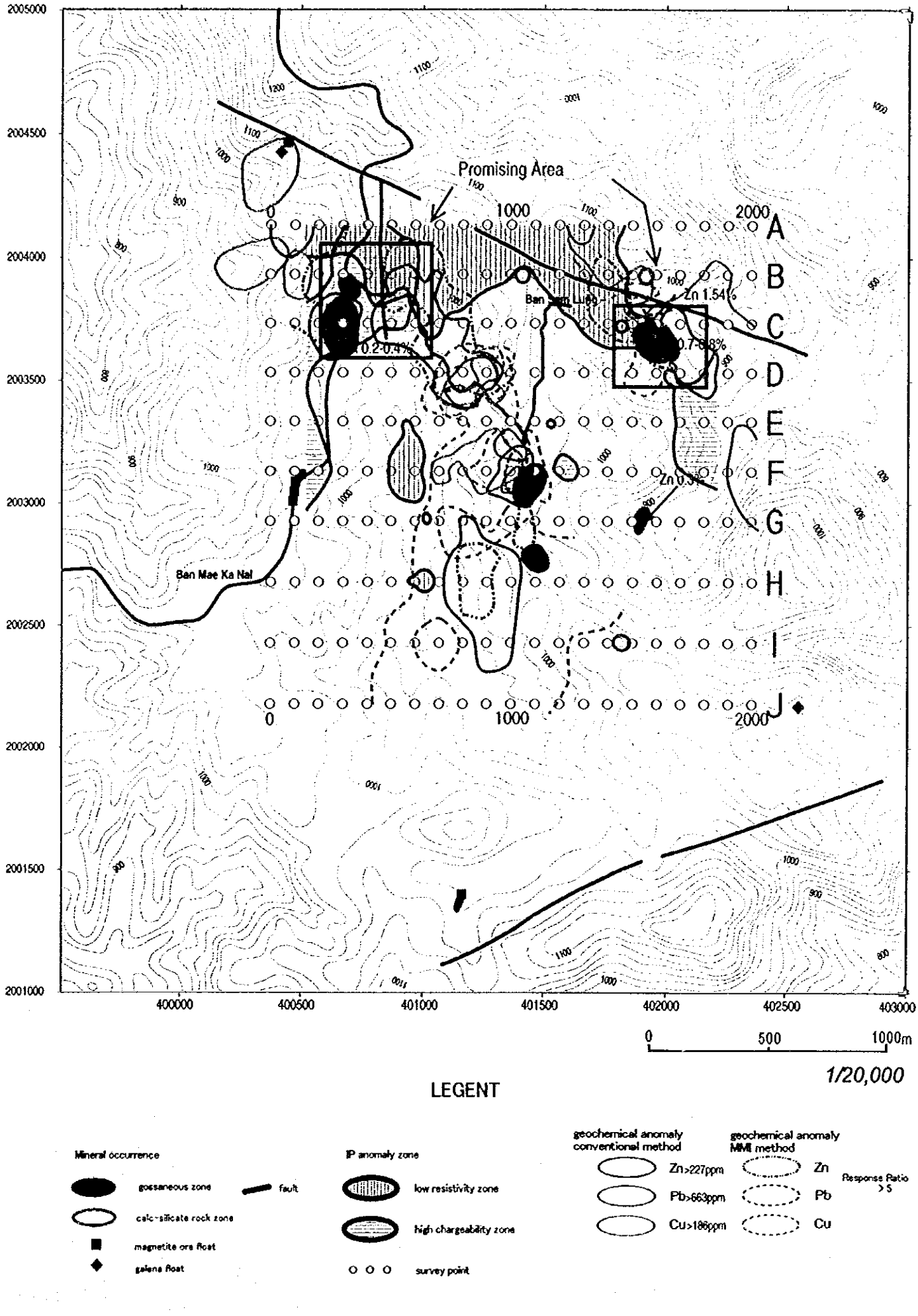

Fig.I-1-2 Interpretation map of the Mae Kanai area

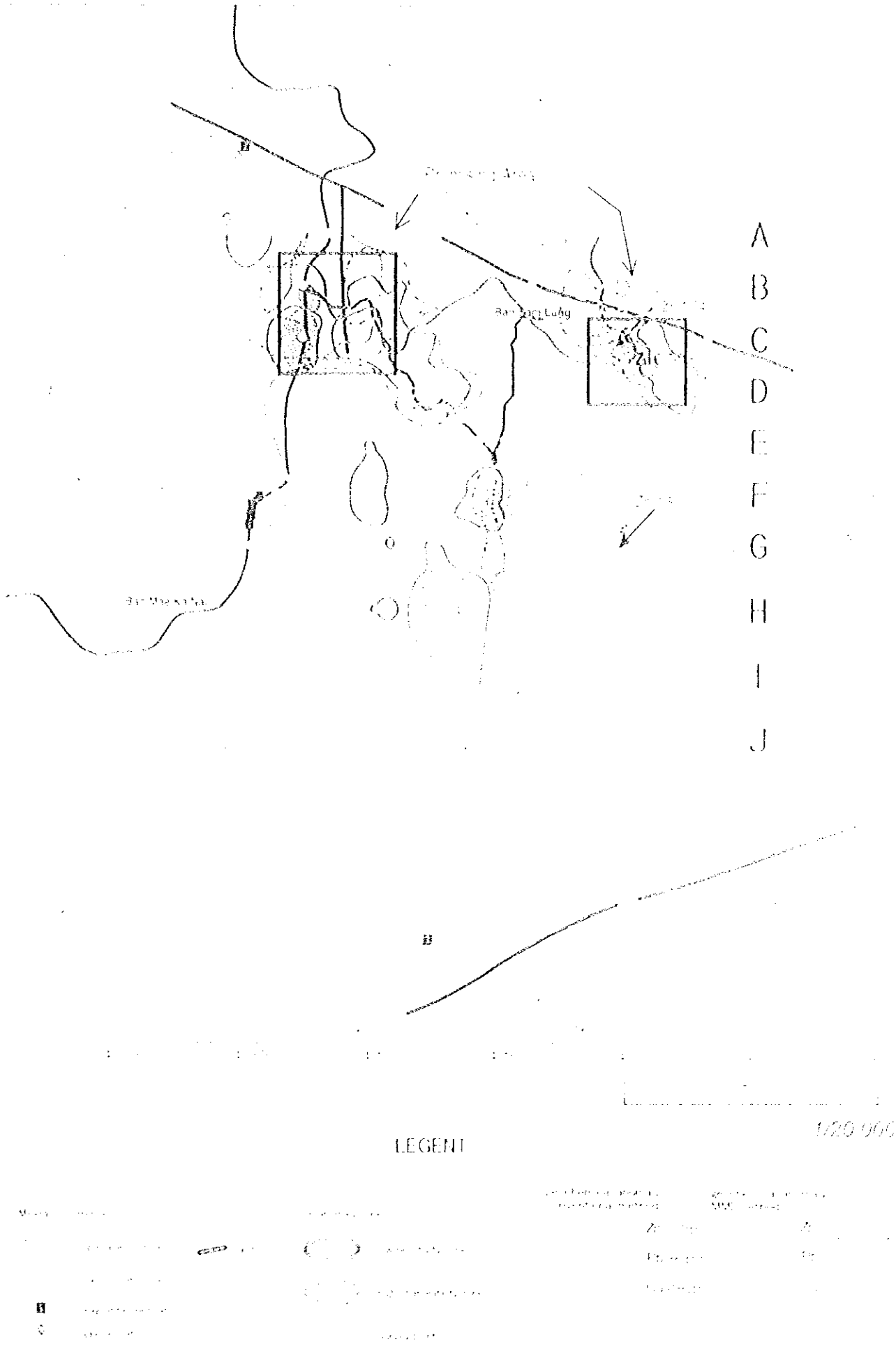

Fig.I-1-2 Interpretation map of the Mae Kanai area

and very near from the gossan zone.

A wide low-resistivity zone along a fault extends from B-1000 station to C-1600 station, and a high-chargeability zone extends from D-1800 station to F-1800 station. A gossan zone occurs zone near C-1600 station between these two IP anomalies. The low resistivity zone, the gossan zone and the high chargeability zone continue to the direction of the fault. Therefore it may be also accompanied by a fault-related mineralization.

The promising areas led by the geochemical survey and the geophysical survey are as follows.

1) The area from a gossan zone to a fault, ranging from 300 to 600 stations of Line B and Line C. It overlaps with zinc anomaly, low-resistivity and IP high-chargeability zone.

2) The gossan zone and the high-chargeability zone east of Ban Sam Lung. Gossan contains high zinc content, and the zone overlaps with geochemical copper-lead-zinc MMI anomaly area. Here is also found a low-resistivity zone.

The characteristic of geochemistry and geophysical anomaly suggests that the fault-related mineralizations are expected in these areas.

3. I-4 Area and Southern I-4 Area

The Southern I-4 area is mainly underlain by the Devonian-Carboniferous sedimentary rocks.

The western part of the area is cut by a north striking fault, and the Permian limestone crops out on the west side of the fault. The Devonian-Carboniferous rocks are complexly folded on outcrops, but the fold as a whole is a series of northeast trending syncline and anticline.

The floats with galena-barite veinlets are occasionally found in places in Huai Pu valley. The chemical composition of a galena-barite sample shows 615 ppm Pb and 140 ppm Zn. Some small quartz stockworks zones less than 10 meters wide in brecciated and silicified shale occur in the upper stream of Huai Pu valley, and the maximum value obtained by chemical analysis is 188 ppm Cu, 341 ppm Pb and 560 ppm Zn.

Two soil geochemical sampling lines were arranges on the ridges in Huai Pu valley. Some high values of Pb, Zn and Ba in soil are detected on black shale. These values are almost the same level as those in regional stream sediments geochemical samples of last year's survey.

The result of the geological survey and the geochemical survey indicate that the anomaly detected by regional stream sediments geochemical survey origins from barite-galena veinlets in black shale and/or quartz stockworks accompanied by brecciated and silicified shale. Only confined and low-grade samples floats of barite-galena veinlets have been found in the field survey, and quartz stockworks are very small scale. There is no discovery other type mineralization in the area. Therefore there is a little possibility that an economic minable deposit exists in the Southern I-4 area.

The drill hole MJTM-4 in the I-4 area could encounter the mineralization extending from Nam Mae Kanai occurrence. The mineralized quartz veinlets at the depth ranging from 20 to 30 m is corresponded to an extension of sulfide disseminating quartz veinlets with 12 m wide in the northernmost of the Nam Mae Kanai occurrence. The estimated width of mineralized zone from MJTM-4 to the occurrence ranges from 4 to 12 m, and the distance is about 100 m. It is inferred

that the mineralization extends to the southeast side and to the deeper part. The estimated grade ranges from 19.8 to 135 g/t Ag, 310 to 1,000 ppm Cu, 0.89 to 8.15 % Pb, and more than 0.1 % Zn based on the chemical analysis of core samples, but all length of mineralized core is not analyzed.

Other two mineralized zones are observed at the 81 m depth and the depth ranging from 105 to 120m. The former zone is corresponded to the pyrite-galena disseminated silicified rock on Nam Mar Kanai occurrence by its similar characteristic of mineralization. Usually the grade is not high as a whole, but this zone frequently contains highly mineralized parts; for example 0.37 % Pb and 1.22 % Zn by 30 cm core sample.

1-2-2 Recommendation for the Third Phase Survey

1. Dong Noi Area

1) Further drilling survey is necessary at the high chargeability zone in the central part of the Dong Noi area to make clear the detailed mineralization style and the extension of mineralization, and to confirm the reserve and grade.

2) Trenching is recommendable in the northwestern part of the area, where the zinc and lead geochemical anomaly overlaps with dolomitized limestone to confirm the existence of a promising host rocks for ore deposit.

3) The drilling survey is necessary at a low-resistivity and high chargeability target beneath the gossan zone in the southern part of the area to clarify the existing forms of mineralization.

2. Mae Kanai Area

The drilling survey is necessary at the area ranges from 300 station to 600 station of Line B and Line C and the gossan area southeast of Ban Sam Lung, extracted as the most promising areas, to clarify the type, scale and grade of its mineralization and the geologic structure.

3. I-4 Area

Further drilling is necessary to confirm the lateral extension and the depth of vein-type mineralization extending from Nam Mae Kanai occurrence.

The distributions of various mineral 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.

1-3 Contents of the Third Phase Survey

1-3-1 Survey area

The Mae Sariang area is located in the northwestern part of Thailand. The area is 760km^2, 17 to 24km in east and west, 30km in north and south.

The Myanmer's border is located about 50km to the west.

Chiang Mai city, Second city of Thailand, is about 150km to northeast of the area.

It is about one hour flight from Bangkok to Chiang Mai. Chiang Mai to Mae Sariang is three hours by car.

Mae Sariang town, Center of Mae Sariang District, is located in the valley along Yuam river. This valley is 200 to 250m in altitude. The east half of the survey area is 500 to 1000m highland.

In this phase, geological, geochemical and geophysical survey and drilling survey will be conducted in four promising areas which were picked out through survey results in last phase. There are Dong Noi area, Mae Kanai area, I-4 area and southern I-4 area shown in Fig. I-3-1.

1-3-2 Objective of Survey

The survey of this year is the first phase of the Cooperative Exploration in the Mae Sariang Area of the Kingdom of Thailand. The objectives of the second phase survey are to discover new promising area of ore deposit through the understanding of the metallic mineralization and the geology of the area and to evaluate the potential by detailed geological and geochemical survey ,geophysical survey and drilling survey.

1-3-3 Methods of Survey

Mineral occurrence survey and drilling survey were performed in the Dong Noi area and Mae Kanai area where were selected for the promising areas through second phase.

1. Mineral occurrence survey

Mineral occurrence survey was done at northwestern part of Dong Noi area for checking a cause of high geochemical anomaly.

Rock tip samples and ore samples were collected along survey lines with detailed geological survey.

Infer the location of the potential area for base metal deposit through geological structure and the distribution of alteration zone and geochemical anomalies.

2. Drilling Survey

The objective of drilling survey is to explore and to assess the mineral potential of base metals in the Dong Noi area and Mae kanai area

In the Dong Noi area, one vertical drill hole with 187.50m length was operated at the north extension of MJTM-3 and MJTM-5 in IP anomaly area where was considered copper and lead mineralization zone.

In the Mae Kanai area, three vertical holes and a inclined hole with 892.90m in total length were drilled for purpose to reveal the potential of base metals mineralization.

Contents of these surveys are shown in Table I-1.

Table I-1 Contents and quantity of survey

①Contents and amount of the Survey

Item of Work		Quantity		
Mineral Occurrence Survey Dong Noi area		Route length		1.64km
Drilling Survey				
Area Name	Hole Number	Inclination	Direction	Length
Dong Noi Area	MJTM-6	-90°		187.50m
Mae Kanai Area	MJTM-7	-90°		270.00m
	MJTM-8	-60°	N151° E	222.90m
	NJTM-9	-90°		200.00m
	MJTM-10	-90°		200.00m
Total Length				1,080.40m

②Laboratory tests

Items	Quantity
Mineral Occurrence Survey	
A. Rock Geochemical Analysis	61 samples
B. Fluid Inclusion Analysis Homogenization and Salinity	2 samples
C. X-ray Diffraction Analysis	1 sample
Drilling Survey	
A. Thin Sections	5 Sections
B. Polished Sections	3 Sections
C. Fluid Inclusion Analysis Homogenization and Salinity	7 samples
D. Ore Assay (Cu, Pb, Zn, Sb, Ag, Au)	61 samples
E. X-ray Diffraction Analysis	16 samples

1-3-4 Personnel of survey mission

Planning and Coordination

Japan

Tadashi Ito	Metal Mining Agency of Japan
Noboru Fujii	Metal Mining Agency of Japan
Hiroshi Shibasaki	Metal Mining Agency of Japan
Takeshi Moriya	Metal Mining Agency of Japan, Bangkok
Yoshiharu Kida	Metal Mining Agency of Japan, Bangkok

Thailand

Somsak Potisat	Department of Mineral Resources
Satien Sukontapongpow	Department of Mineral Resources
Peerapong Khuenkong	Department of Mineral Resources
Adoon Wunapeera	Department of Mineral Resources

Field Survey Team

Drilling Survey

Japan

Hiroyuki Takahata	Nittetsu Mining Consultants Co., Ltd.
Yoshihiko Ichii	Nittetsu Mining Consultants Co., Ltd.

Thailand

Adoon Wunapeera	Department of Mineral Resources
Wicharn Mungkhun	Department of Mineral Resources

1-3-5 Period of the Survey

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

Drilling Survey: January 20, 2000 to March 18, 2000 (69 days)

(including mineral occurrence survey in the northwestern part of the Dong Noi area)

Chapter 2 Geography

2-1 Location 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, 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. Tem-

peratures 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.

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

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 hilltribes 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.

Chapter 3 Existing Geological Information

3-1 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 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.

3-2-1 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). The northeastern part of the Amphoe Mae Sariang (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 occurrence 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. There 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 con-

tain 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.

3-2-2 Amphoe Mae La Noi

Amphoe Mae La Noi is the newest district 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.

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 Dong Noi area

Taking into consideration the results of mineral occurrence surveys and drilling survey, we reached the following conclusion:

In the area with geochemical anomalies in zinc and lead values extending in the western half of Dong Noi area where limestone was distributed, hydrothermal ore solution in temperature of 140-250℃ and with high salinity rose up through joints in limestone and bedding place of fissures, formed silicificated zone on a certain horizon in relatively upper layers, caused occurrence of wide-ranged dolomitization and zinc/lead mineralization right above it, and at the same time formed quartz vein which changed joint systems and a specific horizon, precipitating galena and sphalerite.

The quartz vein in dolomitized zone was in width of 80 cm and its grade values were 7.86%Zn and 2.82%Pb. The sample extracted from 20 m section including this quartz vein also showed high values of 1.60%Zn and 1.43%Pb, and existence of zinc body was expected. However, since the structure to form quartz vein changes open joints and the part along bedding of a certain specific horizon, it is necessary to explain more in detail rock faces and the geological structure to estimate the position of its existence.

As a result of our investigation into MJTM-6 Hole excavated in a spare part of the district with IP anomalies, it was further clarified that the district with high IP anomalies might represent a mineralized zone of copper and lead overlapped with skarn. The depth of around 64 m in MJTM-6 Hole where occurrence of chalcopyrite was observed was almost in conformity with the depth of the upper limit to the anomaly zone (16 m V-sec/V or more) revealed through IP exploration. The depth of 140 m or lower where mineral showing including pyrite dissemination was intensified in general was in conformity with the district where IP anomalies (20 m V-sec/V or more) were observed. The district with IP anomalies (16 m V-sec/V or more) extended in a range of 100 m in diameter and 800 m in the total length. Based on the results of MJTM-5 Hole and MJTM-6 Hole, in view of the tendency of copper concentration to increase in a lower layer, i.e. the part where it was in contact with granite, ore shoots might possibly exist near the face which was in touch with granite. However, since copper showing in skarn zone is apt to be unevenly distributed, it is considered difficult to decide the exact position of such ore shoots.

4-2 Mae Kanai area

Resulting from our investigation on MJTM-7 Hole and past drilling survey conducted by DMR, we found that the district with high IP anomalies corresponds to the mineralized zone including the silicificated zone along the fracture continuing in the NE-SW direction and accompanied predominant pyrite dissemination and chalcopyrite showing. The chalcopyrite was the most

prevailing in the depth of around 129 m, but its grade was low. We may point out that this mineralized zone might represent the passage of ore solution having formed the gossan zone where was distributed on the western side of the ridge.

Based on the result of our investigation conducted in the second year, the gossan zone with high zinc content in the Mae Kanai area had been considered to extend in a vertical direction. However, through our drilling survey of this time, we confirmed that the gossan zone was distributed in thickness of a little more than 10 m and almost along the land surface and that remarkable mineral showing scarcely existed in its lower layers. The gossan body was distributed between argillized mudstone or sandstone. Although the gossan zone was originally a massive sulfide mineral abundant with pyrite and accompanying sphalerite, we presume that pyrite may have been oxidized and changed to limonite and sphalerite may have flown out through weathering.

The sedimentary rocks near the gossan zone were strongly influenced by argillization of talc-sericite-chlorite-smectite especially on the side of lower wall. Further, we observed that silicificated zone in the form of hydrothermal breccia accompanying white argillization and quartz vein had been developed on the upper wall of the gossan zone.

The present gossan zone is distributed only along the ridge and on a slow eastern slope of the land surface of the Mae Kanai area. Taking into consideration the fact that the bedding face was a slow slope inclined to east as well as our drilling results, the gossan zone is considered to have been formed a few to fifteen meters away from the border between the limestone and general sedimentary rocks toward the side of sedimentary rocks or on the border in some part, and at present its upper face is almost in conformity with the land surface. In view of the fact that gossan zones occur almost on the same level, in the district surrounded by MJTM-8 Hole, MJTM-9 Hole and DMR's MK-3 Hole, it is quite possible that the horizon of the gossan may be beneath the land surface and that the gossan zone may have been hidden under it. Moreover, we presume that IP anomalies may be distributed at the east end of profile lines E and D for geophysical exploration on a slope inclined to east right under the land surface and that massive sulfide minerals may exist under the land surface.

Chapter 5: Conclusions and Recommendations for the Future

5-1 Conclusion

5-1-1 Dong Noi area

Taking into consideration the results of mineral occurrence surveys and drilling survey, we reached the following conclusion:

In the area with geochemical anomalies in zinc and lead values extending in the western half of Dong Noi area where limestone was distributed, hydrothermal ore solution in temperature of 140-250℃ and with high salinity rose up through joints in limestone and bedding place of fis-

sures, formed silicificated zone on a certain horizon in relatively upper layers, caused occurrence of wide-ranged dolomitization and zinc/lead mineralization right above it, and at the same time formed quartz vein which changed joint systems and a specific horizon, precipitating galena and sphalerite.

The quartz vein in dolomitized zone was in width of 80 cm and its grade values were 7.86%Zn and 2.82%Pb. The sample extracted from 20 m section including this quartz vein also showed high values of 1.60%Zn and 1.43%Pb, and existence of zinc body was expected. However, since the structure to form quartz vein changes open joints and the part along bedding of a certain specific horizon, it is necessary to explain more in detail rock faces and the geological structure to estimate the position of its existence.

As a result of our investigation into MJTM-6 Hole excavated in a spare part of the district with IP anomalies, it was further clarified that the district with high IP anomalies might represent a mineralized zone of copper and lead overlapped with skarn. The depth of around 64 m in MJTM-6 Hole where occurrence of chalcopyrite was observed was almost in conformity with the depth of the upper limit to the anomaly zone (16 m V-sec/V or more) revealed through IP exploration. The depth of 140 m or lower where mineral showing including pyrite dissemination was intensified in general was in conformity with the district where IP anomalies (20 m V-sec/V or more) were observed. The district with IP anomalies (16 m V-sec/V or more) extended in a range of 100 m in diameter and 800 m in the total length. Based on the results of MJTM-5 Hole and MJTM-6 Hole, in view of the tendency of copper concentration to increase in a lower layer, i.e. the part where it was in contact with granite, ore shoots might possibly exist near the face which was in touch with granite. However, since copper showing in skarn zone is apt to be unevenly distributed, it is considered difficult to decide the exact position of such ore shoots.

5-1-2 Mae Kanai area

Resulting from our investigation on MJTM-7 Hole and past boring survey conducted by DMR, we found that the district with high IP anomalies corresponds to the mineralized zone including the silicificated zone along the fracture continuing in the NE-SW direction and accompanied predominant pyrite dissemination and chalcopyrite showing. The chalcopyrite was the most prevailing in the depth of around 129 m, but its grade was low. We may point out that this mineralized zone might represent the passage of ore solution having formed the gossan zone where was distributed on the western side of the ridge.

Based on the result of our investigation conducted in the second year, the gossan zone with high zinc content in the Mae Kanai area had been considered to extend in a vertical direction. However, through our boring survey of this time, we confirmed that the gossan zone was distributed in thickness of a little more than 10 m and almost along the land surface and that remarkable mineral showing scarcely existed in its lower layers. This zone was distributed between argillized mudstone or sandstone. Although the gossan zone was originally a massive sulfide mineral abundant with pyrite and accompanying sphalerite, we presume that pyrite may have

been oxidized and changed to limonite and sphalerite may have flown out through weathering.

The sedimentary rocks near the gossan zone were strongly influenced by argillization of talc-sericite-chlorite-smectite especially on the side of lower wall. Further, we observed that silicificated zone in the form of hydrothermal breccia accompanying white argillization and quartz vein had been developed on the upper wall of the gossan zone.

The present gossan zone is distributed only along the ridge and on a slow eastern slope of the land surface of the Mae Kanai area. Taking into consideration the fact that the bedding face was a slow slope inclined to east as well as our boring results, the gossan zone is considered to have been formed a few to fifteen meters away from the border between the limestone and general sedimentary rocks toward the side of sedimentary rocks or on the border in some part, and at present its upper face is almost in conformity with the land surface. In view of the fact that gossan zones occur almost on the same level, in the district surrounded by MJTM-8 Hole, MJTM-9 Hole and DMR's MK-3 Hole, it is quite possible that the horizon of the gossan may be beneath the land surface and that the gossan zone may have been hidden under it. Moreover, we presume that IP anomalies may be distributed at the east end of profile lines E and D for geophysical exploration on a slope inclined to east right under the land surface and that massive sulfide minerals may exist under the land surface.

5-2 Recommendations for the future

5-2-1 Dong Noi area

It is indeed possible that zinc bodies may exist in the limestone in the northwestern part of the Mae Kanai area. However, in estimating the position of such existence, careful attention should be paid to the result of detailed surveys on the geological structures and degrees of dolomitization concerned.

We note that the area with IP anomalies - especially the part with anomalies of 16 m V-sec/V or more – located in the central part of the Dong Noi area actually accompanies copper mineralization. Resulting from the drilling surveys conducted three times by now, although no adequate grade or reserve of the deposit has been discovered to be considered as object of an operation, we think there still remains some room for further investigations.

5-2-2 Mae Kanai area

Further investigations should be made on the eastern part of the district where existence of subsurface gossan and massive sulfide ores is quite possible.