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

## PHASE II

MARCH 1999



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 October 18, 1998 to February 6, 1999.

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, 1999

Kimio Fujita
President
Japan International Cooperation Agency

Hiroaki Hiyama
President
Metal Mining Agency of Japan

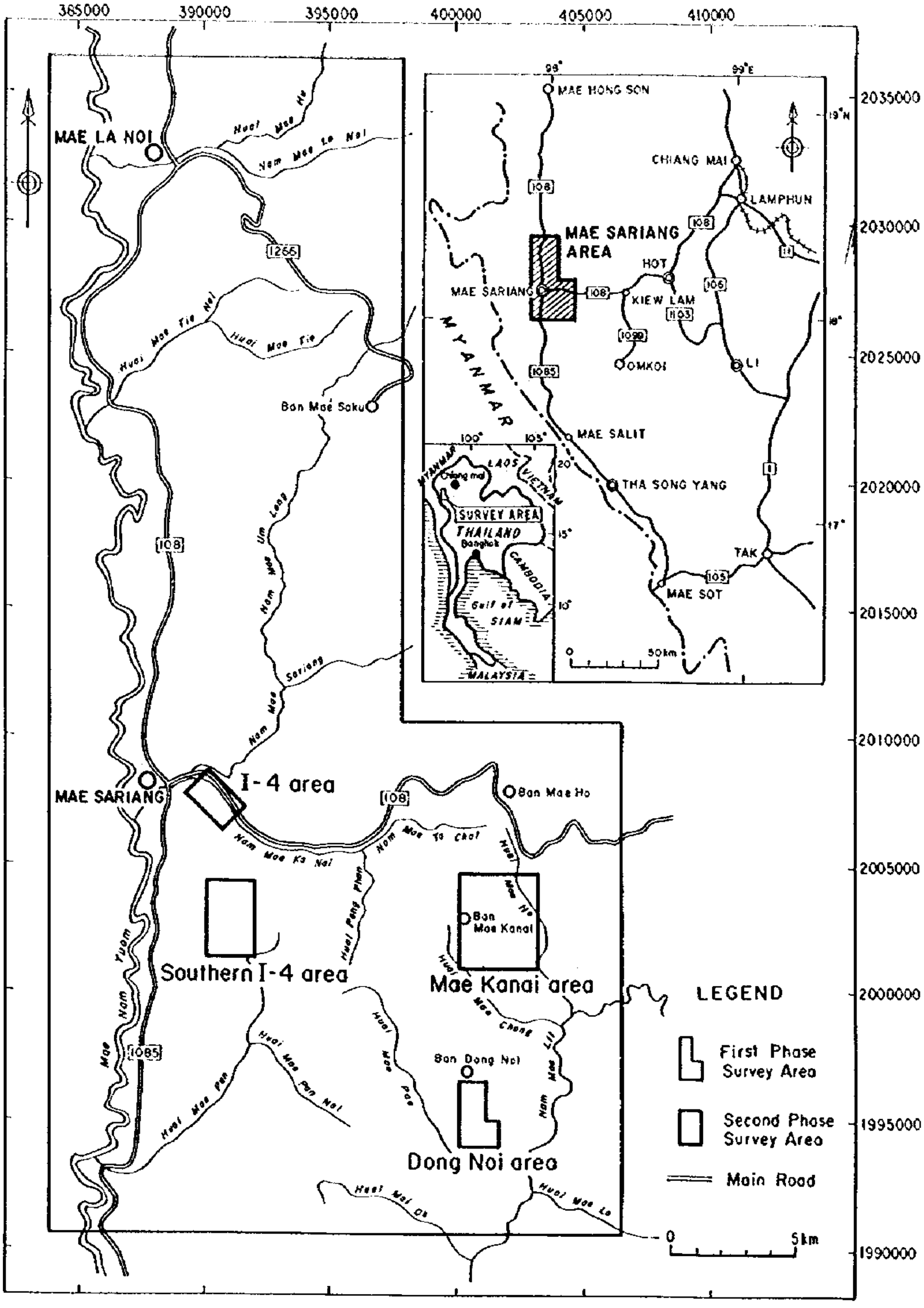


Fig. I-1-1 Location map of the survey area

# Summary

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

**1. 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, but 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.

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 extending 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.

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**

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

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 periphery of the fault zone 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 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.

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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 Conclusion and Recommendation of the First Phase Survey

### 1-2-1 Conclusion

1. Mae Sariang Area

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.

## 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.

## 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.

## 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

### 1-2-2 Recommendation 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.

## 1-3 Contents of the Second 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

1. Geological and Geochemical Prospecting

1)Main Objective

Clarify the relationship between the geological structure and mineralization, and especially clarify the characteristics of each alteration.

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

2)Areas and Accuracy of Survey

Detailed geological and geochemical survey will be performed in Dong Noi area and Mae Kanai area and I southern I-4 area. Geophysical survey by IP method will be performed in the Mae Kanai area. Drilling Survey is planed in Dong Noi and I-4 area.

3)Field Survey

A) Common Items

a)Topographic base map will be prepared from the existing 1:50,000 topographic map.

b)The survey route will be determined after studying existing report.

c)Aerial and satellites photographs will be used.

d)Location of survey point will be certified using GPS system. For the survey of mineralized zone and/or important outcrops, simply topographic survey will also be carried out.

e)Observation features will be described as concretely as possible on route map. At important outcrops, sketches of 1:100 to 1:200 scales will be made and color photographs will be taken.

f) The result of field survey will be compiled on 1:50,000 scale map in the whole area and on 1:2,500 scale map in detailed survey areas.

g) In trenching Survey, as a general rule, width of trench is more than 1.5 meter and it will be dug the ground until bed rocks. After finishing survey, trenches will be filled up.

B) Dong Noi Area

a) Interval of soil sampling is 25 meters.

b) Sampling depth is generally 1 meter in B horizon.

c) Description of sample will be done at sampling

C) Mae Kanai area

a) Soil and MMI sampling will be performed using on Geophysical survey line.

b) Sampling depth is generally 1 meter in B horizon

c) Interval of soil sampling is 50 meters.

4)Sampling and Laboratory works

a)Rocks with present geologic units, which clarify geologic relationships and other important material will be sampled with care.

b)Microscopic observation will be carried out on samples representing geologic units and also on those with different lithology. X-ray diffractometry will be carried out whenever necessary.

c) Regarding ore and mineralized rock samples, chemical analysis and polished section observation will be made.

d)Specimens of all samples studied in the laboratory will be retained. The specimens will be cut to 6cm×4cm×2cm size leaving one fractured surface for hard rock, and similar volume of soft rock samples will be preserved in plastic bag.

e)The number of samples to be studied in the laboratory is shown in Table I-3-1.

5)Processing of analyzed value

Geochemical data will be stored in a floppy disk in the format specified by MMAJ.

2. Geophysical survey (IP survey)

1)Objective

The objective of IP survey is to clarify resistivity structure and IP anomalies concerning to mineralization zone and its corresponding alteration area in Dong Noi sub-area and I-4 sub-area.

2)Field Survey

a)Setting survey lines and stations

Survey line and stations will be measured by open traverse measuring method. If possible, these can be measured by GPS system.

Table I-3-1 shows the total length of survey lines and the number of stations. Setting lines and station shows in Figs. II-1-6-6 and II-2-6-3.

b)Measurement

Table I-3-1 shows the number of stations

The electrode configuration for IP survey will be Dipole-Dipole arrangement.

The electrode spacing will be 100m at a level.

The electrode separation to be measured will be from N=1 to N=4.

The time domain IP method will be applied.

If needs for change in electrode spacing and separation arise during the survey, reasons will be submitted to MMAJ supervisor and instructions will be sought.

c)Laboratory test

Typical rock and ore samples will be collected in the survey area and their resistivity will be measured in a laboratory in the same way in the field. Table I-3-1 shows the number of measuring samples.

d)Processing of measured data

Measured data will be stored in a floppy disk in the format specified by MMAJ.

## 3. Drilling Survey

1) Objective

The objective of drilling survey is to explore and to assess the mineral potential of base metals in the Dong Noi area and I-4 area

2) Method of Survey

Contents of this survey are shown in Table I-3-1.

250m, 350m and 200m holes in vertical will be carried out in Dong Noi area. 250m holes with 70 degrees inclining in I-4 area.

## Table I-3-1 Contents and quantity of survey

①Contents and amount of the Survey

| Item of Work | Quantity | |
|---|---|---|
| Geological Survey and Geochemical Survey | | |
| Mae Kanai area | Survey area | 8.0km$^2$ |
| | Route length | 51.4km |
| Dong Noi area | Survey area | 2.5km$^2$ |
| | Route length | 23.5km |
| I-4 area | Survey area | 3.75km$^2$ |
| | Route length | 30.3km |
| Trenching Survey | | 200.0m |
| Geophysical Survey (IP method) | | |
| Mae Kanai area | Length of Survey Line | 20.0km |
| | Number of Station | 660points |
| Dong Noi area | Length of Survey Line | 1.0km |
| | Number of Station | 26points |

Drilling Survey

| Area Name | Hole Number | Inclination | Direction | Length |
|---|---|---|---|---|
| Dong Noi Area | MJTM-1 | -90° | | 250.0m |
| | MJTM-2 | -90° | | 345.0m |
| | MJTM-3 | -90° | | 145.0m |
| | NJTM-5 | -90° | | 100.0m |
| I-4 Area | MJTM-4 | -70° | N180° | 210.0m |
| Total Length | | | | 1,050.0m |

②Laboratory tests

| Items | Quantity |
|---|---|
| Geological Survey and Geochemical prospecting | |
| A. Thin Sections | 12 Sections |
| B. Polished Sections | 11 Sections |
| C. Fluid Inclusion Analysis Homogenization and Salinity | 6 samples |
| D. Ore Assay (Cu, Pb, Zn, Sb, Ag, Au) | 45 samples |
| E. X-ray Diffraction Analysis | 16 samples |
| F. Stable Isotope Analysis( δC, δO) | 5 samples |
| G. Soil Geochemical Analysis | 1,055 samples |
| H. MMI Geochemical Analysis | 281 samples |
| Geophysical Prospecting | |
| Measurement of Resistivity and Polarization | 38 samples |
| Geological Survey and Geochemical prospecting | |
| A. Thin Sections | 2 Sections |
| B. Polished Sections | 31 Sections |
| C. Fluid Inclusion Analysis Homogenization and Salinity | 10 samples |
| D. Ore Assay (Cu, Pb, Zn, Sb, Ag, Au) | 46 samples |
| E. X-ray Diffraction Analysis | 16 samples |
| F. Stable Isotope Analysis( δC, δO) | 5 samples |

### 1-2-3 Personnel of survey mission

Planning and Coordination

**Japan**

| | |
|---|---|
| Tadashi Ito | Metal Mining Agency of Japan |
| Takafumi Tsujimoto | Metal Mining Agency of Japan |
| Noboru Fujii | Metal Mining Agency of Japan |
| Hiroshi Shibasaki | Metal Mining Agency of Japan |
| Yoshiharu Kida | Metal Mining Agency of Japan, Bangkok |

**Thailand**

| | |
|---|---|
| Nopadon Mantajit | Department of Mineral Resources |
| Somsak Potisat | 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 and Drilling Survey

**Japan**

| | |
|---|---|
| Hiroyuki Takahata | Nittetsu Mining Consultants Co., Ltd. |
| Makoto Miyoshi | Nittetsu Mining Consultants Co., Ltd. |
| Yasunori Ito | Nittetsu Mining Consultants Co., Ltd. |
| Kosei Takayama | 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**

| | |
|---|---|
| Toshio Kasagi | Nittetsu Mining Consultants Co., Ltd. |
| Munemaru Kishimoto | Nittetsu Mining Consultants Co., Ltd. |
| Tateyuki Negi | Nittetsu Mining Consultants Co., Ltd. |

**Thailand**

| | |
|---|---|
| Suebsak Sologosoon | Department of Mineral Resources |
| 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: | October 29, 1998 to December 28, 1998 (61 days) |
| Geophysical Survey: | November 9, 1998 to December 26, 1998 (48 days) |
| Drilling Survey: | October 18, 1998 to February 6, 1999 (112 days) |

# 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-1-1, 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.

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 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.

### 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

The detailed geological and geochemical survey, and the drilling survey was programed for the Phase II exploration in the Dong Noi area.

The geochemical survey was confined zinc and lead anomaly zones extending to the outside of the Phase I area. Four drill holes made clear the mineralized zones and the geologic structure underneath of the Dong Noi area.

Two main zinc geochemical anomaly zones are delineated in the Dong Noi area. The one is in the western part in the Dong Noi area that overlaps with a strong dolomitized limestone area. The other is in a southeastern limestone body where the drill hole MJTM-2 and Trench No. 2 were carried out.

In the former west zinc anomaly zone, limestone is recrystallized, and intercalated shale beds have been subjected to pelitic hornfels metamorphism. But skarnization is not observed.

In the southern part of the west anomaly, the drill hole MJTM-1 and Trench No.1 were carried out. A small amount of galena dissemination in dolomitic limestone and a float with galena-barite veinlets are found in Trench No. 1. Sphalerite is not observed in the trench, nor in the drill hole MJTM-1, even in the trench samples containing 1,800 ppm Zn. Though the high zinc content in soil, that is generally more than 1,000 ppm Zn, has not been clear yet, it can be stated that the existence of a massive zinc ore deposit is questionable in the southern part of the west anomaly based on the result of drilling and trenching survey. The northern part of the west anomaly also shows a high geochemical zinc anomaly and limestone has been affected dolomitization, but no further work has been carried out. Therefore this northern part still remains the potential for an ore deposit.

In the latter southeastern zinc anomaly, it can be interpreted that the high concentration of zinc in soil is derived from disseminations of sphalerite in the matrix of some brecciated and shear parts of dolomite layers, that are observed at the upper portion of drill hole MJTM-2. This sphalerite dissemination is also associated with galena, chalcopyrite and pyrrhotite. The dolomite in MJTM-2 is generally compact and hard, though it contains a large amount of argillaceous laminas. Perhaps porous or fractured rocks may need to trap ore solution and then to form a massive ore deposit, but brecciated and shear parts in dolomite are commonly very small-scale and porous carbonate rocks do not occur in MJTM-2. It appears that a massive zinc ore deposit may not exist in the southeastern part of the Dong Noi area.

The Pb moderate anomaly overlaps with the west zinc anomaly. This Pb anomaly can be explained by above-mentioned occurrence of galena-barite veinlets in the dolomitized limestone.

Other two Pb geochemical anomalies are detected; the area in the periphery of the drill hole MJTM-2 and Trench No. 2, and the area extending northward from the Dong Noi lead occurrence along a north-south striking fault and southeastward of the Dong Noi occurrence.

The Pb anomaly of the periphery of MJTM-2 is interpreted the same as the southeastern Zn anomaly that derived from dissemination in the brecciated and shear parts of dolomite layers.

The Pb anomaly centering the Dong Noi lead occurrence overlaps with the high Cu geochemical anomaly. It can be interpreted that the high concentration of lead and copper in soil is derived from the skarn-type Pb-Cu-Ag mineralization, that are observed at MJTM-5 and MJTM-3 drill holes.

The depth of skarn-type mineralization intersected by drill holes are quite consistent with the distribution of IP anomaly by Phase 1 geophysical survey. The intensity of IP has a close relation to the copper grade of the drill core. This IP anomaly is a columnar shape plunging gently north with 100 m in diameter and more than 800 m in length, and the roughly estimated potential is 20 million tons of mineralized rocks. In this year, only two holes have been drilled in the IP anomaly. Further drilling work needs to confirm ore reserve and grade in the whole IP anomaly.

Though the similar argillaceous limestone crops out in the western, central and southwestern parts of the Dong Noi area, the facies of limestone under the ground are very different with each other according to the drilling survey. The drill core of the western limestone shows only weakly skarnization though the limestone adjoins a granite batholith, whereas the drill core of the central and eastern limestone has been strongly skarnized from a shallow part to the bottom. It is inferred that a granite body intruded to the shallow depth along the north-south striking fault and this intrusion has caused the skarnization related to magnetite, chalcopyrite and galena mineralization in the central and western part of the Dong Noi area. Actually the drill hole MJTM-3 encountered a granite body at 123 meters depth to the bottom. The high salinity ore fluid may have been further brought and/or passed from the skarnized rocks to out side haloes, where sulfide minerals such as galena-sphalerite deposited in the brecciated or schistosed texture of dolomite. While the western dolomitized limestone may have also been suffered by sphalerite-galena mineralization, but the grade of the mineralization may have been weak and only have formed a high Zn-Pb geochemical anomaly zone.

The northwestern limestone has undergone by the strong dolomitization but no skarnization, and overlaps with a high geochemical anomaly. Therefore the possibility of the existence of a massive ore deposit depends on the occurrence of porous and fractured host rocks. Further survey needs to make clear the characteristic of the limestone and fracture pattern in the northwestern limestone area.

Another mineralization as a gossan zone was confirmed 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 on this gossan zone. The gossan channel samples contain ranging from 600 to 800 ppm Cu. The result of the geochemical survey shows a rather high copper content more than 100 ppm, and a weak gold anomaly ranging from 30 to 40 ppb on the gossan zone, and that anomaly does not have a halo. Other elements anomalies are not detected in the area. The IP geophysical survey is detected a low resistivity and high chargeability anomaly deeper than 800 meters above sea level. It is inferred that a mineralized zone might continue to the zone underneath the gossan zone, because gossan zone is commonly formed at the extremity of ore solution pass from an ore deposit. The result of the geochemical survey and the IP survey may lead the occurrence of the vein-type or stockwork-type ore deposit under the gossan zone, that is a unique mineralization in the Dong Noi area.

## 4-2 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 sandstone is south and north, in fault contact with Ordovician rocks.

Shale and sandstone units are dominant in Ordovician rocks on the surface, but it is inferred that limestone is widely distributed under the shale and sandstone units.

More than seven gossan zones with several hundreds meters in diameter occur on the Ordovician shale and sandstone unit. They commonly contain high concentration of zinc. The gossan zone southeast of Ban Sam Lung is obtained high zinc content ranging from 0.7 to 0.8 % Zn, and maximum 1.54 % Zn. The gossan samples collected from other gossan zones are also shown high zinc content ranging from 0.2 to 0.4 % Zn on average.

Both geochemical anomaly of conventional method and MMI method are distributed around gossan zones.

A gossan zone on the southeastern of Ban Sam Lung with high content of zinc is accompanied with Zn, Cu, Pb geochemical anomaly by MMI method. A mineralized zone ought to exist under ground.

The west side of Line A, Line B and Line C is also potential area for the fault-related mineralization because several gossan zones with 0.3% Zn occur and zinc anomaly values run parallel with a fault.

Only two areas combined anomalies of conventional and MMI technique are observed at the area from the F-1000 on a gossan zone to Line E and the periphery area around the points ranging from 800 to 900 of Line D.

Four following anomaly areas are selected 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

The apparent resistivity of this area shows from 35 to 5186Ω·m, and the chargeability shows a maximum of 53mV·sec/V. As for the distribution of apparent resistivity, it shows different distribution from Line A to C, from Line D to J. The distribution of apparent resistivity from Line D to J show same pattern, and the resistivity structure extends N-S direction. The low apparent resistivity distributes N-S direction, which center is station 600, and this distribution is coincident with that of alluvium in geologic map. Both sides of alluvium, shale·sandstone distributes, and the apparent resistivity shows relatively high value. The low apparent resistivity distributes widely from Line A to C. As for the chargeability, the high value part distributes widely around station 500 of Line B. Also, the chargeability shows relatively high value at the east end of Line E.

The low apparent resistivity at N=1 distributes widely at Line A and B in the north part of survey area. This low apparent resistivity extends from station 1000 of Line B to station 1600 of Line C along the fault. The mineral occurrence of gossan is located near station 1600 of Line C. Also, the apparent resistivity shows low value from station 500 of line A to station 500 of Line C along the N-S fault. The low apparent resistivity from station 500 to station 600 of Line F is located in the alluvium, and it is supposed that there is no relation to mineralized zone.

The high chargeability zone is divided into two parts. One part is around the gossan and the N-S fault near station 300 of Line A and Line B. This high chargeability part extends to station 300 of Lime F. The mineral occurrence of magnetite is located near station 100 of Line F and this anomaly is related to this mineral occurrence, but it is located out of the survey area, then the details are obscure. The other part is from station 1800 of Line D to station 1800 of Line F, and the gossan is located around the high chargeability part, but this part is not coincident with the mineral occurrence. This high chargeability part is smaller as the depth increase. There are several small anomaly parts, but there are not coincident with the mineral occurrence.

As the result of 2-D analysis, the resistivity discontinuity is seen along the N-S fault from Line A to Line C, the low resistivity distributes at the east part of this discontinuity. The chargeability shows highest value near the station 500 of Line B, and the center of the high chargeability is shifting to the west compared with that of Line B.

As the results of these data, it is supposed that the promising part is around station 500 of Line B. In this part, the resistivity shows low value and the chargeability shows high value. Also, this part is around the fault and near the mineral occurrence, then this anomaly is related to the mineralized zone.

The promising areas led by the geochemical survey and the geophysical survey for further survey are shown 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.

## 4-3 I-4 Area and Southern I-4 Area

The Southern I-4 area is mainly underlain by Devonian-Carboniferous sedimentary rocks. Permian limestone is in a north striking fault contact with Devonian-Carbonifeous formation in the western part of the area.

The Devonian-Carbonifeous formation mainly consists of black shale with fine alternation and graded beds of shale and sandstone, but contains thick chert beds and the beds alternation of limestone and chert. Black shale rarely contains several ten centimeters dolomite lenses. The rocks in the southwestern part have been subjected to the contact metamorphism by a granite batholith intruding to the east of the area. Black shale has been metamorphosed to micaceous schistose pelitic hornfels, and the calcareous part of the alternating rock contains a large amount of calc-silicate minerals. Pelitic biotite hornfels also occurs in places in Huai Pu valley.

The Permian limestone is composed of gray to white massive limestone, and contains a small amount of the laminated argillaceous limestone.

The Devonian-Carbonifeous rocks are cut by several northeast striking faults. They are observed complexly folded in the field, but the fold as a whole is a series of northeast trending syncline and anticline. A north-south striking fault divides into the Devonian-Carboniferous rocks and Permian rocks.

Some floats with galena-barite veinlets are found in places in Huai Pu valley, but no outcrop has been confirmed. The chemical composition of a galena-barite sample shows 615 ppm Pb and 140 ppm Zn. These values are rather lower than those of the samples collected in Nam Mae Pan neighboring south on Huai Pu.

Some small quartz stockworks zones less than 10 meters wide in brecciated and silicified shale occur in the upper stream of Huai Pu valley. One of the samples shows 188 ppm Cu, 341 ppm Pb, and 560 ppm Zn, but other samples contain very low content of copper, lead and zinc.

Two soil geochemical sampling lines traversing a general geologic trend were arranged on two 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.

This means that the anomaly detected by regional stream sediments geochemical survey on Phase 1 survey origins from barite-galena veinlets in black shale and/or quartz stockworks accompanied by brecciated and silicified shale. The broad geochemical anomaly of stream sediments may indicate that these vein-type mineralizations are common in the Southern I-4 area. But only confined and low-grade floats mineralized by galena-barite 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 zone at the depth ranging from 20 to 30 m is almost vertical and about 4 m wide. It is inferred from a plane projection that the mineralized zone is an extension of veinlets with 12 m wide in the northernmost of Nam Mae Kanai occurrence. This vein continues horizontally about 250 m on the assumption that the vein continues to the slope 150 m northwest of the drilling site, where floats of galena-barite-quartz vein occur and its grade was 16.8 % Pb. 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 analized.

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 the surface, that is 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.

Judging from the geology of MJTM-4 and its surrounding area, the mineralization of the Nam Mae Kanai occurrence extends to the N50 ° W direction and is accompanied by silicification and smectite argillic halo. The alteration zone is about 100 m wide and 300 m long.

An alternation bed of carbonate rock and chert occurs at the depth ranging from 140 to 170 m in MJTM-4, but no mineralization is observed. Therefore it appears that the zinc and lead mineralization replacing a carbonate rock may not exist in the I-4 area.

Another area overlapping with the geochemical anomaly, low-resistivity and high-chargeability zone is detected to the west of Mae Ka Nai occurrence. The area has also high potential because of the same characteristic with the occurrence. Further exploration needs to confirm the mineralized rocks at this area.

# Chapter 5 Conclusions and Recommendation for the Third Phase Survey

## 5-1 Conclusions

### 5-1-1 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, but 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 extending 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.

### 5-1-2 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 sansstone 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 1.51 % 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 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.

## 5-1-3 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.

## 5-2 Recommendation for the Third Phase Survey

### 5-2-1 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

### 5-2-2 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.

### 5-2-3 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.

# Part II Detail Description

# Chapter 1 Dong Noi Area

## 1-1 Outline of Geology

The Dong Noi area is underlain by the Cambrian and the Ordovician sedimentary rocks. Triassic granite is distributed in the western part of the area as a large-scale batholith.

The Cambrian formation consists of sandstone. The Ordovician formation consists of shale and sandstone, and impure limestone. The rocks have been often metamorphosed to hornfels and calc-silicate rocks. The limestone is occasionally recrystallized and dolomitized.

The Dong Noi mineral occurrence, that consists of dissemination and stockworks of galena-barite-quartz, is situated in the central part of the area. A gossan zone is found in the southern part of the area.

Fig II-1-1-1 and Fig II-1-1-2 show a geologic map and profiles of the Dong Noi area.

## 1-2 Detail Description of Geology

### 1-2-1 Sedimentary rocks

**1. Cambrian sedimentary rocks (CB)**

The Cambrian sedimentary rocks widely expose around Doi Dong Luang. The formation mainly consists of green or dark green, hard and compact medium- to coarse-grained siliceous sandstone. The sandstone has been extensively metamorphosed and skarnized, and is accompanied by calc-silicate minerals as garnet porphyloblasts. A dissemination of pyrite is widely observed in sandstone at a precipitous cliff on the South of the Doi Dong Luang.

**2. Ordovician sedimentary rocks (Ol, Os)**

The Ordovician sedimentary rocks mainly consist of impure limestone (Ol) and shale (Os).

The impure limestone contains a large amount of thin argillaceous layers or schlierens. The limestone with abundant argillaceous layers is phyllitic, and locally grades into phyllitic shale. The limestone is recrystallized in the southwestern and the western parts of the area. The limestone of the western part has strongly undergone dolomitization, and is accompanied with vein-form or pool of white crystalline dolomite. The intensely dolomitized limestone also contains a large amount of veinlets of quartz and calcite, and dark brown carbonate material consisting carbonate mineral and its stained secondary iron mineral.

The shale mainly consists of phyllitic black shale, with occasional gray to dark green sandstone beds in the western part of the area. The shale has been often metamorphosed, and is accompanied with cordierite porphyloblasts in the southern part of the area.

### 2-2-2 Granitic rocks (G)

The Triassic biotite granite is widespread in the western part of the area. The granite is characterized by a large amount of euhedral phenocrysts of potassium feldspar. The aplitic fine-grained biotite granite is distributed near the boundary between biotite granite and sedimentary

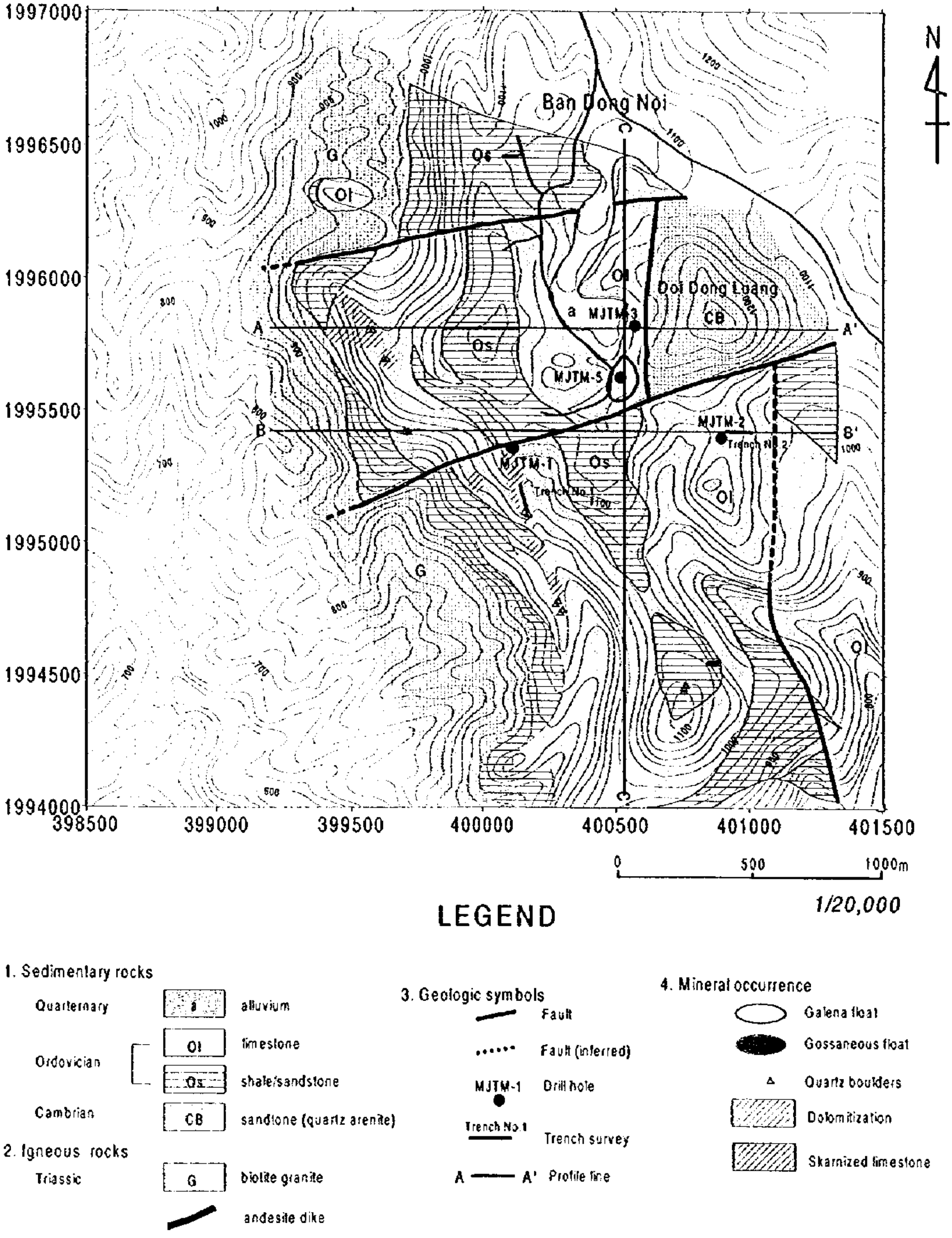


Fig. II-1-1-1 Geologic map of the Dong Noi Area

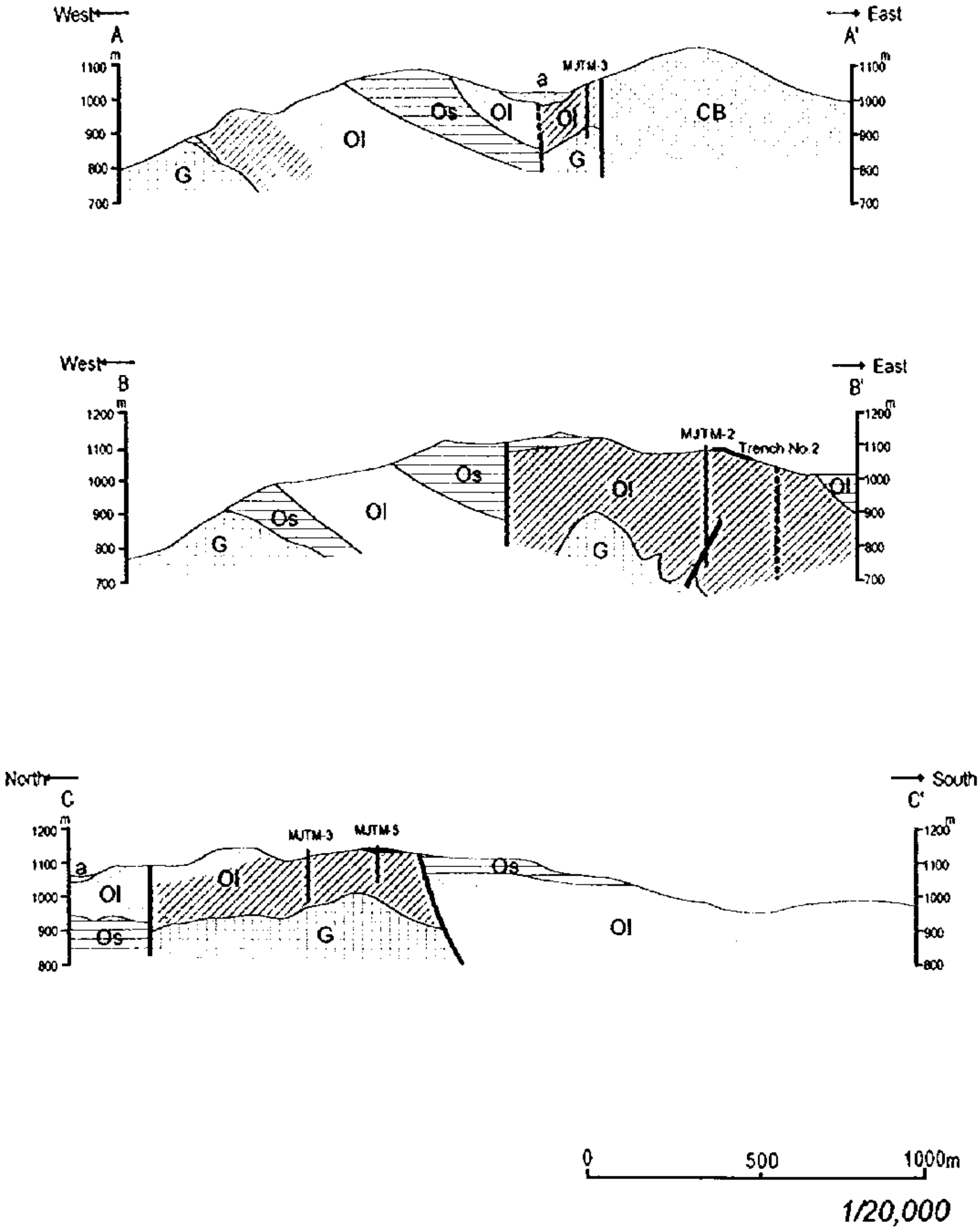


Fig. II-1-1-2 Geologic profile of the Dong Noi Area

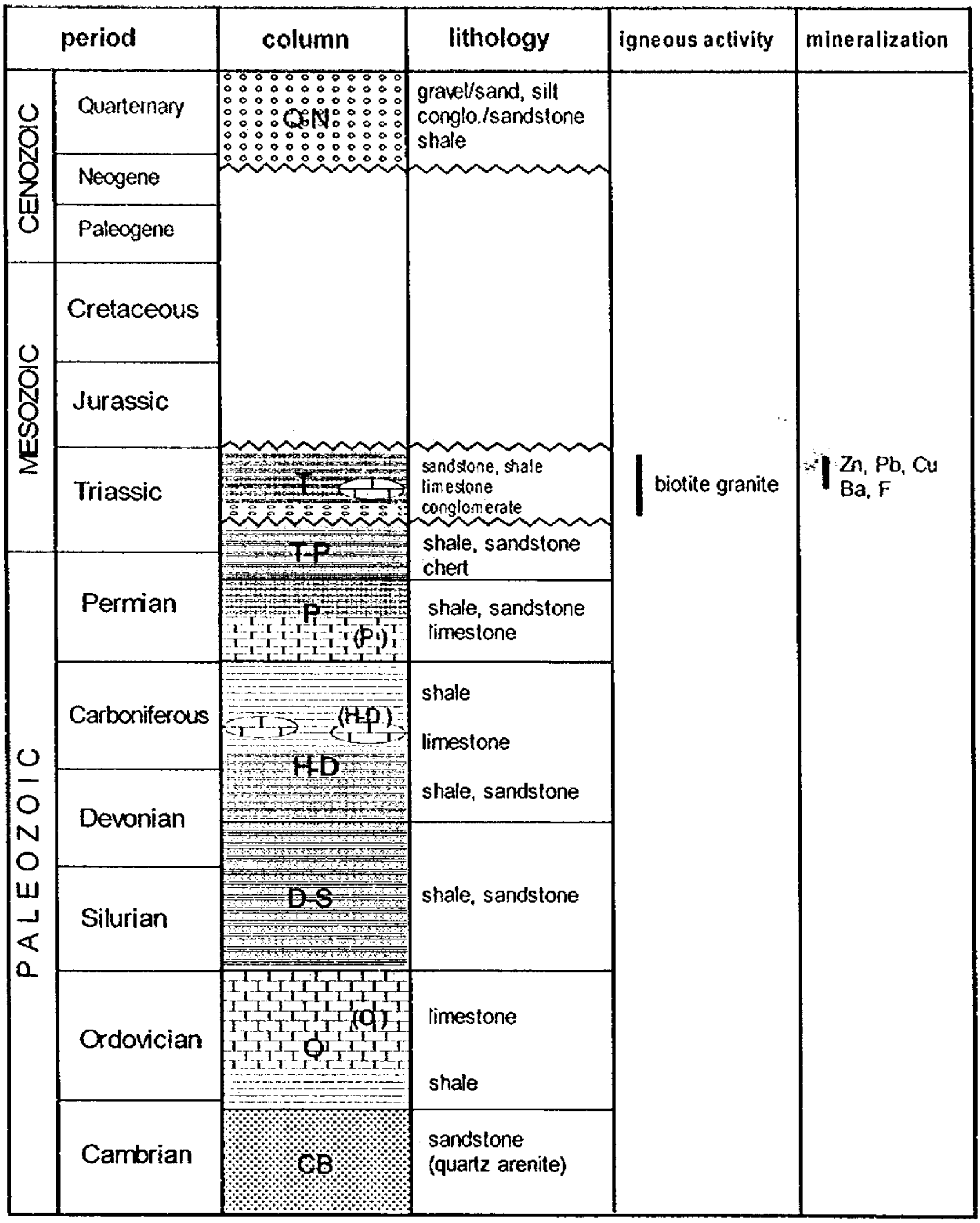


Fig.II-1-1-3 Schematic geologic column of the Mae Sariang Area rocks. The aplitic granite contains a small amount of disseminating pyrite.

The distribution of crystalline limestone and pelitic hornfels, and the skarn-type mineralization detected by the drilling survey shows that the granite bodies or some stocks widely intrude underneath the sedimentary rocks. The drill hole MJTM-3 encountered aplitic granite and porphyritic biotite granite at 123 meters depth to the bottom. It means that the top of the granite body is rather shallow around the Dong Noi mineral occurrences.

### 1-3 Geological Structure

The Dong Noi area is divided into blocks by the east-west and north-south striking faults. Thereby the Cambrian sedimentary rocks and the Ordovician sedimentary rocks are in fault contacts. The Ordovician sedimentary rocks are observed intense folding on outcrops. However, judging from the strikes of argillaceous layers in limestone and those of shale, the formation steeply dips east at the western part, and eastward they gradually dips gently southeast.

### 1-4 Mineral Occurrences

Fig. II-1-4-1 shows the locations of mineral occurrences in the Dong Noi area.

#### 1-4-1 The Dong Noi mineral occurrence

The Dong Noi mineral occurrence occurs at the central part of the Dong Noi area. Many floats containing a large amount of galena-barite are found around a small hill. The drill hole MJTM-5 was drilled on the top of this hill. The result of the drilling survey is described on Chapter 1-6.

#### 1-4-2 Gossaneous zone

Many gossan floats are distributed an area of 50 meters east-west and 25 meters north-south at the southern part of the Dong Noi area. These floats (DN-G1 to DN-G5) generally contain 600 to 800 ppm Cu, whereas no anomalous Zn and Pb values are detected.

#### 1-4-3 The Huai Wak mineral occurrence

A copper and lead mineral occurrence occurs at the west bank of Nam Mae Rit nearby Ban Huai Wak, around 5 kilometers south-southeast of the Dong Noi area, (coordination: Easting 402.2 km, Northing 1990.2 km, Zone 47Q ). The sketch of this occurrence shows in Fig. II-1-4-2.

This area consists of sandstone, shale and a fine alternating shale and limestone. The northern boundary and the upper part of the ridge occur dolomitic limestone. The mineralization is dissemination and stockworks of sulfide minerals, and relates to several faults striking north-south and northwest-southeast. Ore minerals are composed mainly of chalcopyrite, galena, pyrite and pyrrhotite, with subordinate amount of secondary copper minerals. A granite body crops out at the several hundred meters lower stream of the occurrence. Three exploration adits occur in this occurrence, though no record has remained. The length of these adits ranges from 5

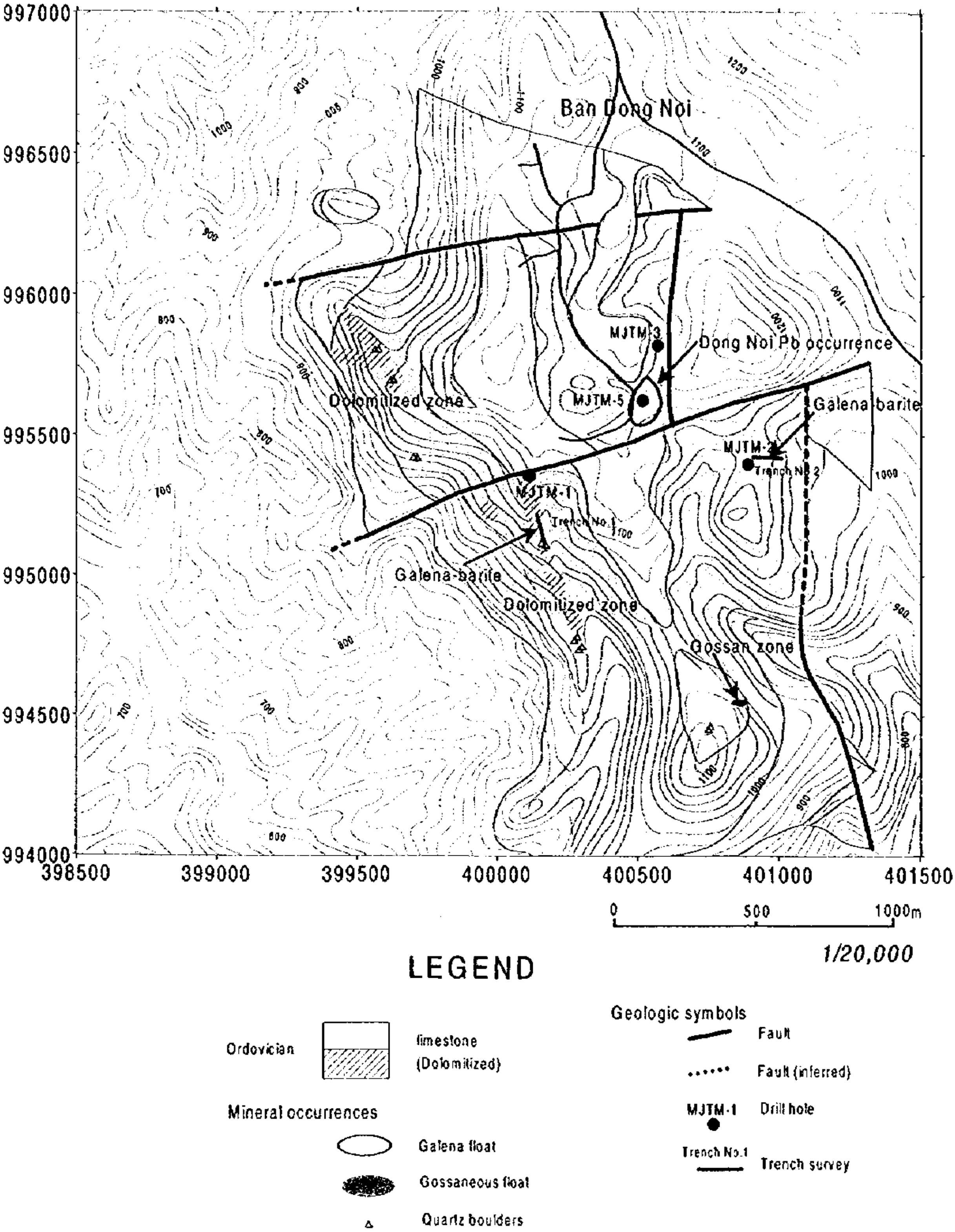


Fig.II-1-4-1 Mineral occurrences of the Dong Noi Area

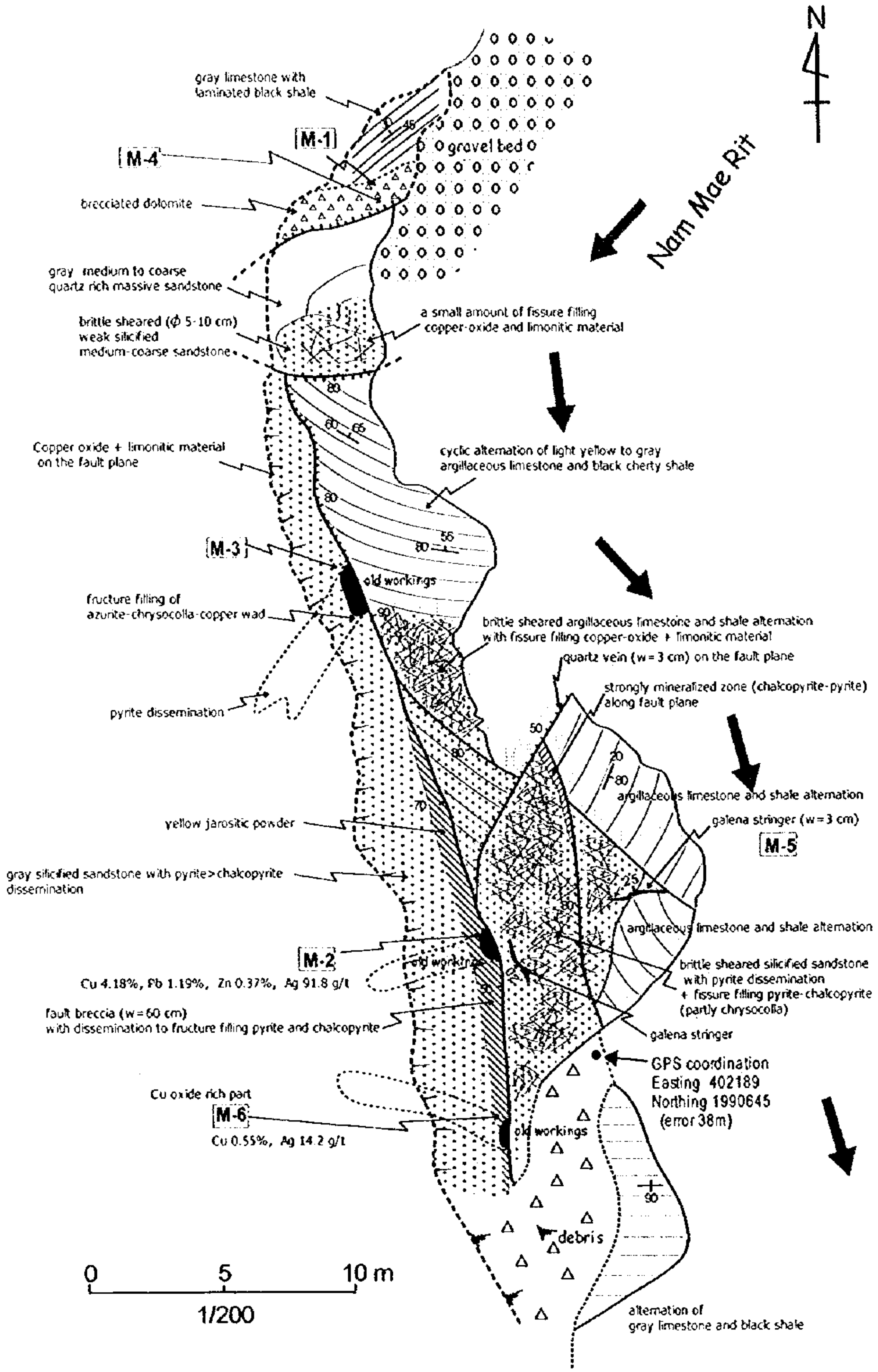


Fig. II-1-4-2 Sketch of the Huai Wak Cu-Pb occurrence to 7 meters. The chalcopyrite and related secondary copper mineralization is abundant at the mouth of the adits, however only pyrite dissemination occurs in the adits. It appears that the copper mineralization is rather confined around the fault planes.

## 1-5 Geochemical Survey

The soil geochemical survey continues for this phase exploration in the Dong Noi area. The anomaly was open to the outside of the Phase I exploration area, though the soil geochemical survey for the Phase I exploration revealed clearly the anomaly of Zn and Pb in the Dong Noi area. Therefore the soil sampling is planned to delineate the anomaly around the Phase I area, and adopted the same sampling method and condition with the phase I survey.

Additional soil sampling of five sampling line (Line F to Line J) is also conducted to check the mineralization style of the gossan zone discovered in the southern part of the Dong Noi area.

### 1-5-1 Sampling

Sampling lines and sampling points are surveyed by using pocket compasses and measuring tapes. Sample points are arranged at a spacing of 25 m in principle except the work in the gossan zone at a spacing of 10 m.

The number of soil samples is 497, and total number of samples is 1,173 in the Dong Noi area.

### 1-5-2 Statistical analysis

All samples are used for the statistic processing in the Dong Noi area.

The common logarithm value of each analysis value is used for analysis. As for an analysis value lower than a detection limit value, a half of that value is adopted in the statistical processing. Also as for an analysis value higher than a maximum detection limit value, a limit value is adopted. Table II-1-5-1 shows statistic quantities of each element.

Table II-1-5-1 Geochemical basic statistic quantities of soil samples in the Dong Noi Area

| Element | Unit | Lower Detection Limit | Maximum Value | Minimum Value | Average | Standard Deviation (Log) |
|---|---|---|---|---|---|---|
| Au | ppb | 5 | 50 | <5 | 2.93 | 0.2017 |
| Ag | ppm | 0.2 | 31 | <0.2 | 0.22 | 0.5628 |
| As | ppm | 2 | 830 | <2 | 130.57 | 0.2850 |
| Ba | ppm | 10 | >10,000 | 60 | 467.21 | 0.4145 |
| Cd | ppm | 0.5 | 37 | <0.5 | 0.72 | 0.5055 |
| Cu | ppm | 1 | 1,925 | 8 | 58.62 | 0.3960 |
| Fe | % | 0.01 | 15 | 2 | 6.56 | 0.1963 |
| Hg | ppb | 10 | 1,080 | <10 | 26.38 | 0.3292 |
| Mg | % | 0.01 | 7 | 0 | 0.23 | 0.4480 |
| Mn | ppm | 5 | >10,000 | 320 | 4,774.32 | 0.3095 |
| Pb | ppm | 2 | 43,500 | 24 | 271.46 | 0.5245 |
| Sb | ppm | 2 | 188 | <2 | 5.47 | 0.5486 |
| Zn | ppm | 2 | 7,500 | 20 | 321.76 | 0.4162 |

Table II-1-5-2 shows correlation coefficients matrix of element. The principal component analysis is made on this matrix. Table II-1-5-3 shows the eigenvalues and main three factor loadings. On the basis of the principal component analysis, the elements are summarized two groups. One is Ag-As-Ba-Cu-Fe-Pb-Sb-Mn group, and there is a strong correlation each other. The other is Zn-Cd-Mg group.

Table II-1-5-2 Correlation Coefficient of soil samples in the Dong Noi Area

| | Au | Ag | As | Ba | Cd | Cu | Fe | Hg | Mg | Mn | Pb | Sb | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Au | 1.0000 | | | | | | | | | | | | |
| Ag | -0.0760 | 1.0000 | | | | | | | | | | | |
| As | 0.0650 | 0.3900 | 1.0000 | | | | | | | | | | |
| Ba | -0.0550 | **0.6130** | 0.5000 | 1.0000 | | | | | | | | | |
| Cd | -0.0120 | 0.3560 | 0.1570 | 0.2930 | 1.0000 | | | | | | | | |
| Cu | -0.0280 | 0.5570 | **0.6390** | **0.7240** | -0.0130 | 1.0000 | | | | | | | |
| Fe | -0.1070 | **0.6030** | **0.6010** | **0.6670** | 0.0160 | **0.7790** | 1.0000 | | | | | | |
| Hg | 0.0300 | 0.3330 | 0.2540 | 0.3580 | 0.3160 | 0.2160 | 0.3130 | 1.0000 | | | | | |
| Mg | -0.1350 | 0.4470 | -0.0250 | 0.3570 | **0.5170** | 0.0160 | 0.0070 | 0.0750 | 1.0000 | | | | |
| Mn | -0.0520 | 0.3710 | 0.5000 | **0.5300** | 0.4460 | 0.4320 | **0.5600** | 0.2700 | 0.1490 | 1.0000 | | | |
| Pb | -0.0150 | **0.7460** | 0.4360 | 0.5330 | 0.5000 | 0.4600 | 0.4530 | 0.3340 | 0.4030 | 0.5010 | 1.0000 | | |
| Sb | -0.0780 | **0.6580** | **0.6050** | **0.6360** | 0.1440 | **0.6900** | **0.7800** | 0.3600 | 0.1310 | 0.4760 | 0.5950 | 1.0000 | |
| Zn | 0.0120 | 0.2420 | 0.1140 | 0.1510 | **0.7870** | -0.1040 | -0.1470 | 0.2170 | **0.5240** | 0.4030 | **0.5750** | 0.0520 | 1.0000 |

Table II-1-5-3 Result of the principal component analysis of soil samples in the Dong Noi Area

| Component | Eigenvalue | Percent | Cumulative |
|---|---|---|---|
| Z-01 | 5.54 | 42.59 | 42.59 |
| Z-02 | 2.46 | 18.93 | 61.51 |
| Z-03 | 1.13 | 8.72 | 70.23 |
| Z-04 | 0.87 | 6.68 | 76.91 |
| Z-05 | 0.82 | 6.30 | 83.21 |
| Z-06 | 0.56 | 4.28 | 87.49 |
| Z-07 | 0.43 | 3.33 | 90.82 |
| Z-08 | 0.32 | 2.49 | 93.31 |
| Z-09 | 0.25 | 1.96 | 95.27 |
| Z-10 | 0.23 | 1.77 | 97.04 |
| Z-11 | 0.17 | 1.32 | 98.36 |
| Z-12 | 0.12 | 0.95 | 99.31 |
| Z-13 | 0.09 | 0.69 | 100.00 |

| Factor Loading | Z-01 | Z-02 | Z-03 |
|---|---|---|---|
| Au | -0.0751 | 0.0197 | -0.8004 |
| Ag | **0.8111** | -0.0607 | 0.2300 |
| As | **0.6842** | 0.2916 | -0.2922 |
| Ba | **0.8278** | 0.1139 | 0.1078 |
| Cd | 0.4722 | **-0.7579** | -0.1325 |
| Cu | **0.7510** | 0.4914 | 0.0394 |
| Fe | **0.7855** | 0.4842 | 0.0651 |
| Hg | 0.4755 | -0.0883 | -0.2948 |
| Mg | 0.3730 | **-0.6414** | 0.3919 |
| Mn | **0.7022** | -0.0885 | -0.2127 |
| Pb | **0.8040** | -0.2914 | 0.0135 |
| Sb | **0.8224** | 0.3020 | 0.0518 |
| Zn | 0.3665 | **-0.8385** | -0.1753 |

1-5-3 Distribution of geochemical amonaly values

The main objective of the geochemical soil survey in the Dong Noi area is to confirm the extent of the geochemical anomaly area detected in the Phase I survey. Therefore the same threshold values as phase I survey are adopted for this survey. Table II-1-5-4 shows a threshold value of each element. Fig. II-1-5-1 to 11 shows an anomaly value distribution chart of each element.

On the basis of the anomaly value distribution charts, pathfinder elements are classified into three categories: Cu group elements (Ag, Ba, Cu, Fe, Sb), Zn group elements (Cd, Zn), and Pb group elements (As, Mn, Pb). The anomaly of Cu group elements and the that of Zn group elements are clearly separate distributions each other. The anomaly of Pb group elements overlaps with both of the Cu group anomaly and Zn group anomaly. It means that the elements related to the Z-01 factor loading of principal component analysis are divided into further two category.

Table II-1-5-4 Division into geochemical anomaly levels of soil samples in the Dong Noi Area

| element | unit | background | anomaly | Highanomaly |
|---|---|---|---|---|
| Au | ppb | 5 | 10 | |
| Ag | ppm | 2.2 | 6.0 | 12.0 |
| As | ppm | 260 | 480 | |
| Ba | ppm | 1,311 | 3,772 | |
| Cd | ppm | 1.9 | 7.0 | |
| Cu | ppm | 209 | 586 | |
| Fe | % | 12.1 | | |
| Hg | ppb | 81 | 182 | |
| Mg | % | 0.99 | 2.19 | |
| Mn | ppm | 9,192 | | |
| Pb | ppm | 623 | 3,053 | 10,882 |
| Sb | ppm | 21.6 | 53.6 | |
| Zn | ppm | 727 | 1,199 | 2,538 |

**1. The distribution of Zn group elements (Zn, Cd)**

The Zn anomaly values are clustered at two areas: the western limestone area and the limestone area to the south of Doi Dong Luang around the drill hole MJTM-2. The anomaly of the western limestone is coincident with the dolomitized zone. Therefore it means that the dolomitization is close relationship with the zinc mineralization at the western part of the Dong Noi area. The distribution of Cd anomalies is quite similar to those of Zn.

**2. The distribution of Cu group elements (Cu, Ag, Ba, Fe, Sb)**

The Cu anomaly values are concentrated at the Dong Noi mineral occurrence. The anomaly zone is an elliptic shape with the major axis trending north-northwest to south-southeast. The weak anomaly values are widely distributed at the meta sandstone area. This broad anomaly indicates the high Cu background of meta sandstone.

The Ag and Ba anomalies are almost coincident with the Cu anomaly, though the strong anomaly of Ag, Ba extends ranging from the Dong Noi to about 300 meters south-southwestward.

The anomaly values of As and Sb are clustered at the Dong Noi occurrence and the area along the north-south striking fault.

**3. The distribution of Pb group elements (Pb, Mn, As)**

The highest anomaly of Pb is the area around Dong Noi occurrence. It appears that this anomaly has a close association with the north-south striking fault zone on the west of Dong Noi occurrence.

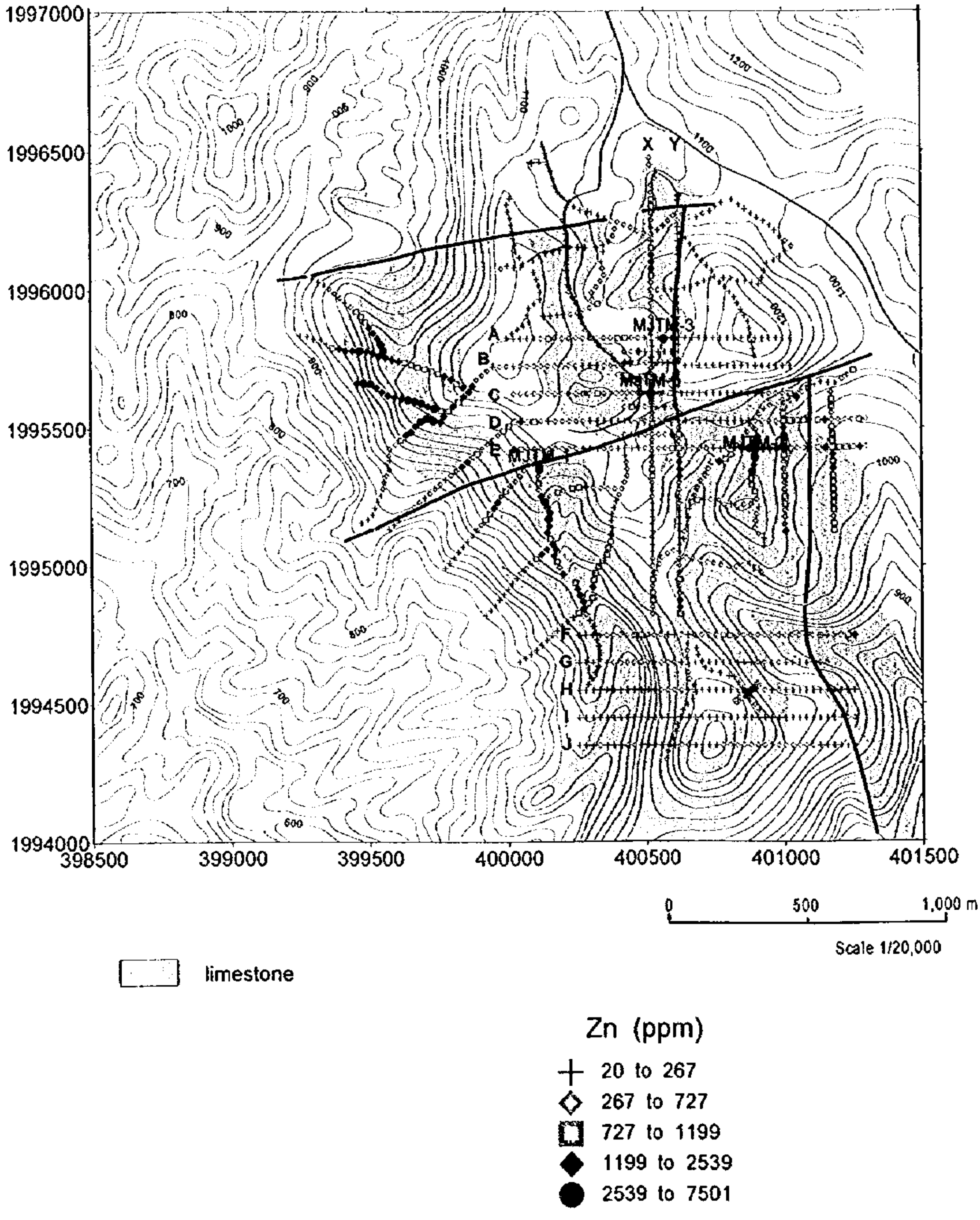


Fig .II-1-5-1 Geochemical map of Zn content in the soil of the Dong Noi Area

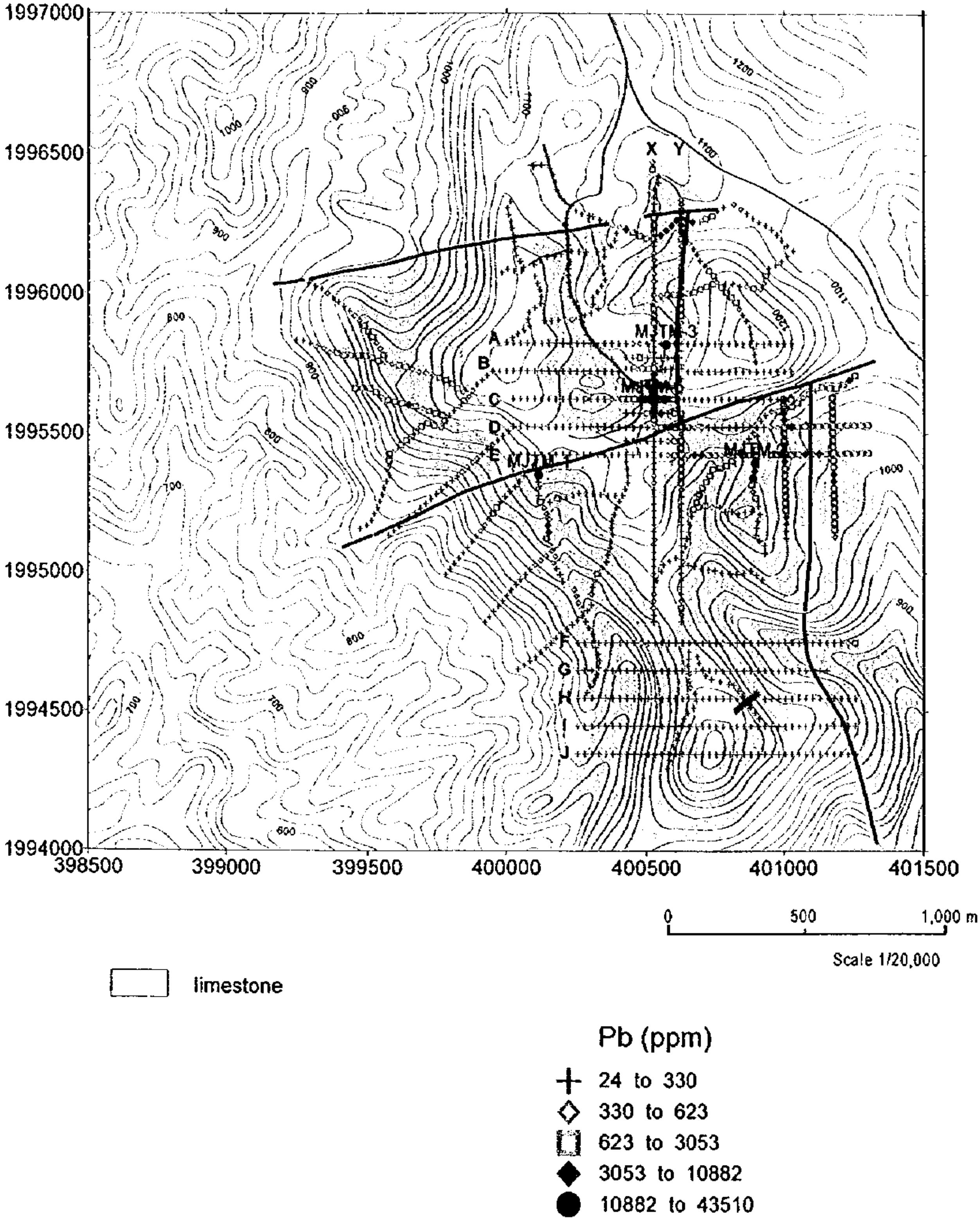


Fig .II-1-5-2 Geochemical map of Pb content in the soil of the Dong Noi Area

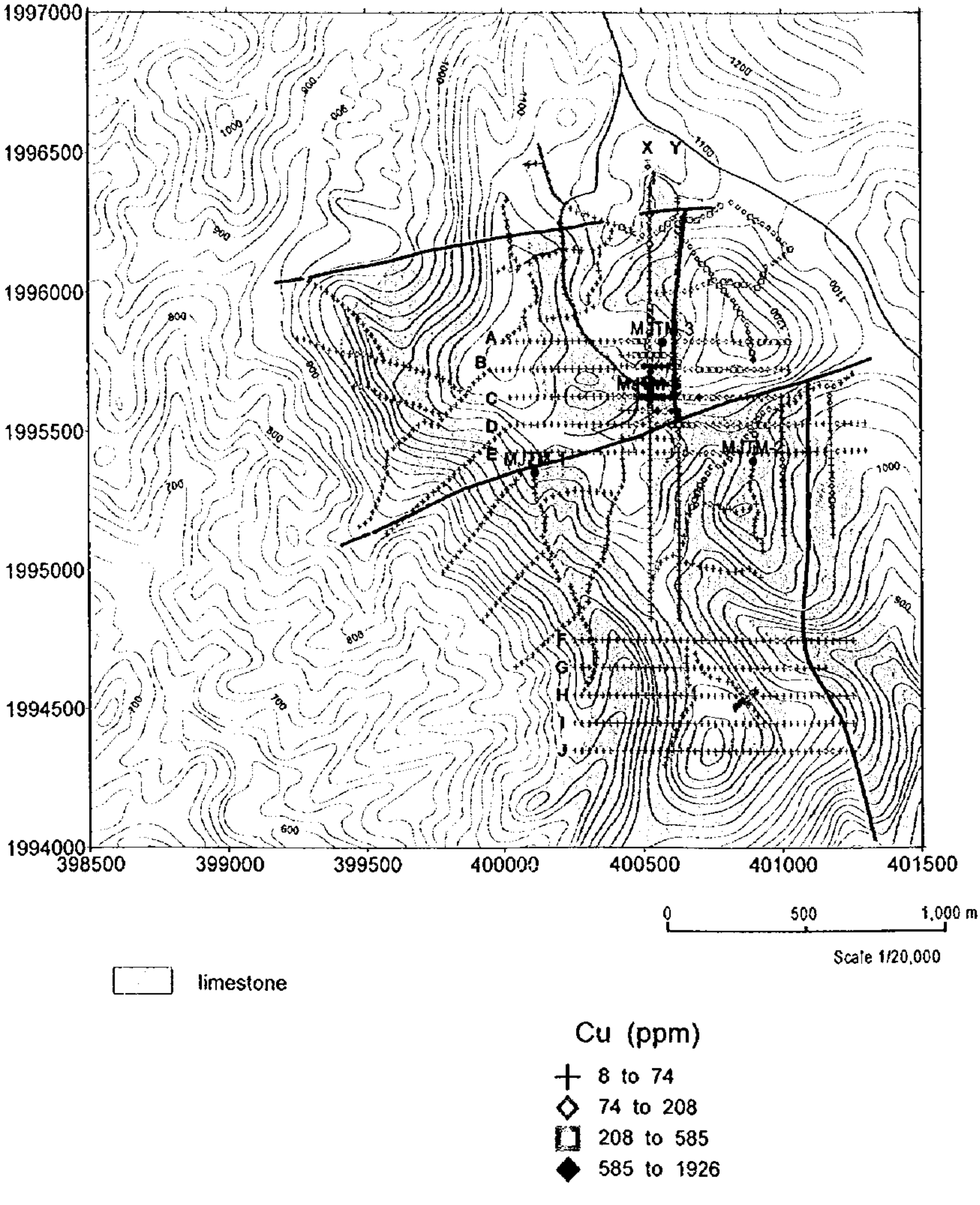


Fig .II-1-5-3 Geochemical map of Cu content in the soil of the Dong Noi Area

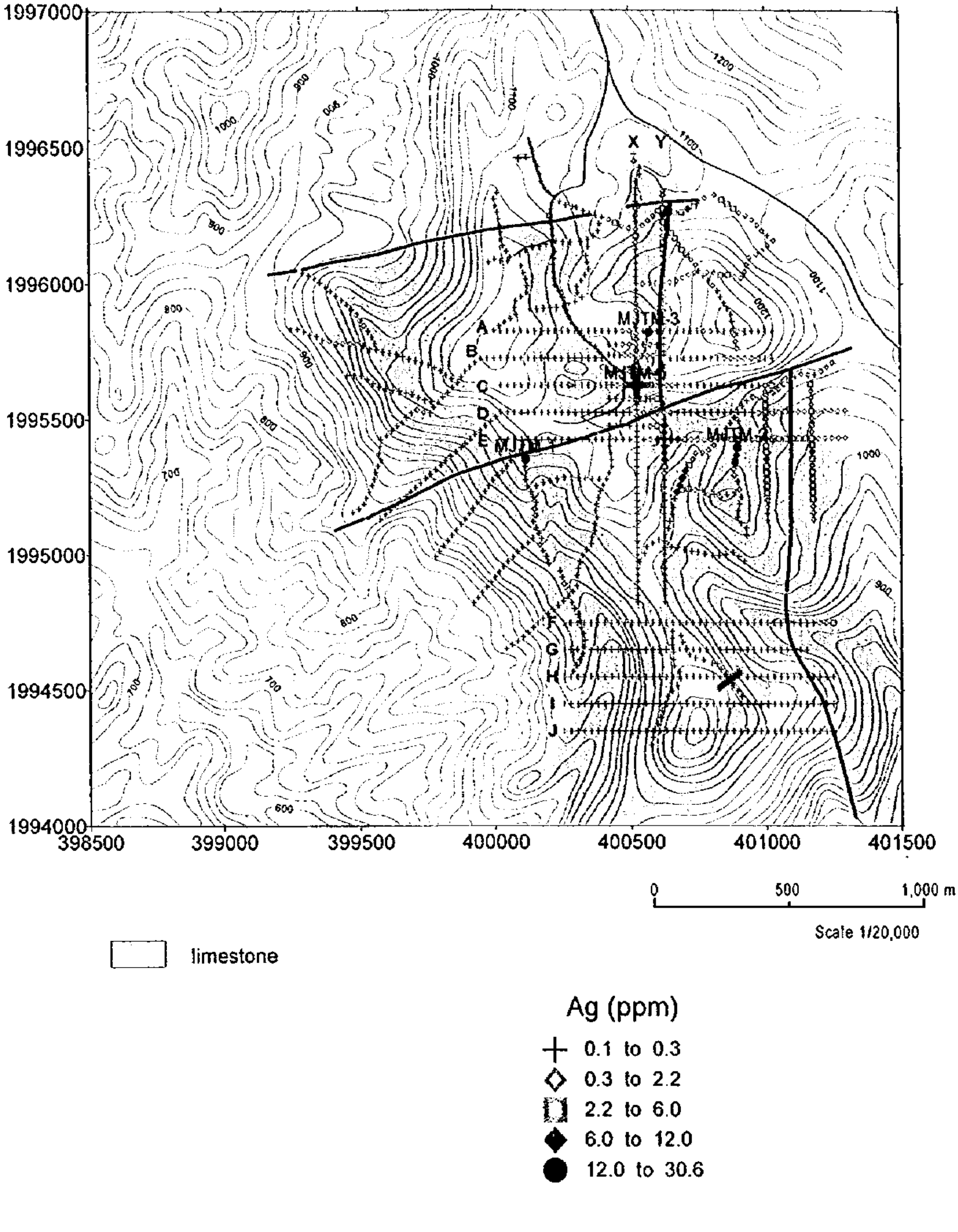


Fig .II-1-5-4 Geochemical map of Ag content in the soil of the Dong Noi Area

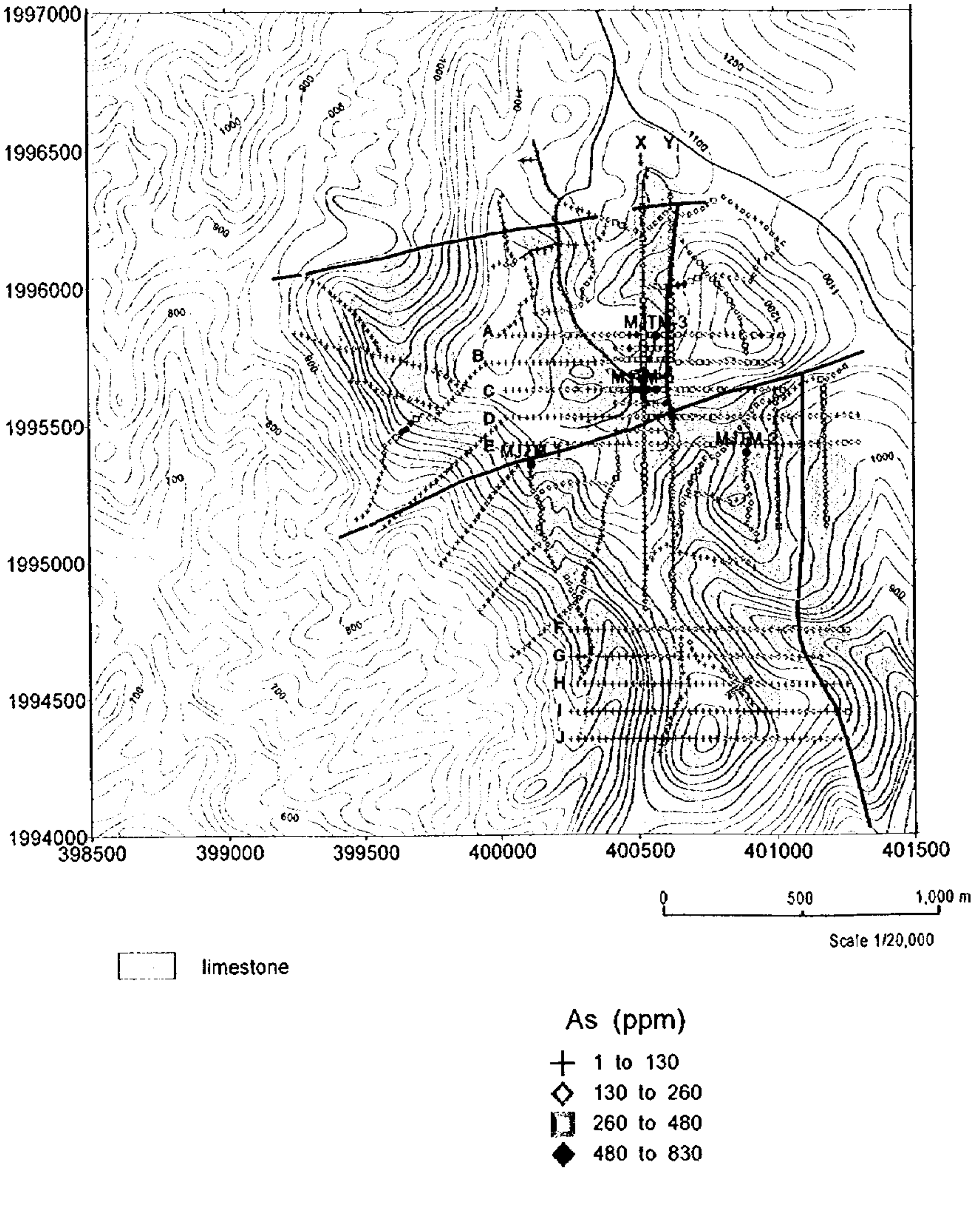


Fig .II-1-5-5 Geochemical map of As content in the soil of the Dong Noi Area

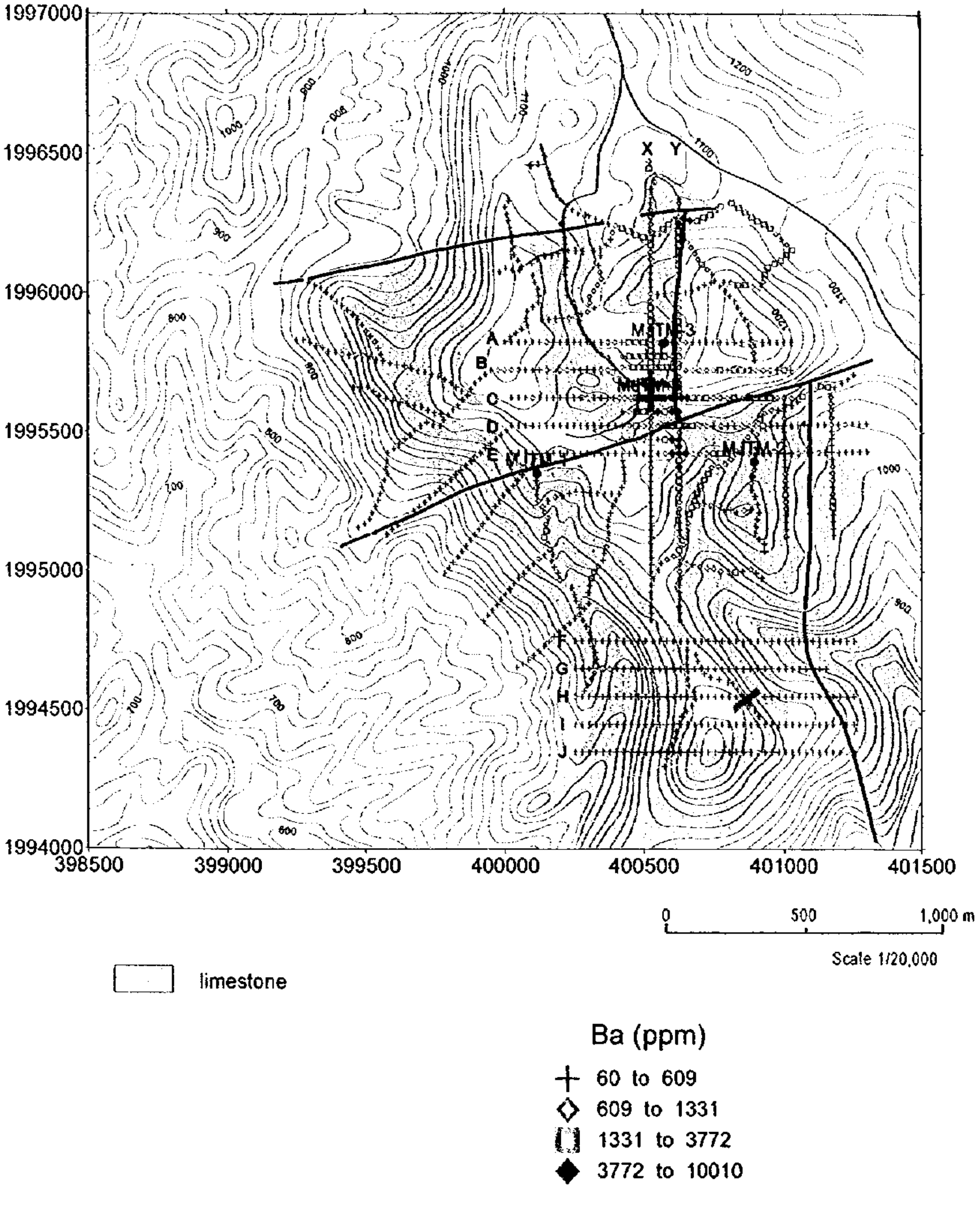


Fig .II-1-5-6 Geochemical map of Ba content in the soil of the Dong Noi Area

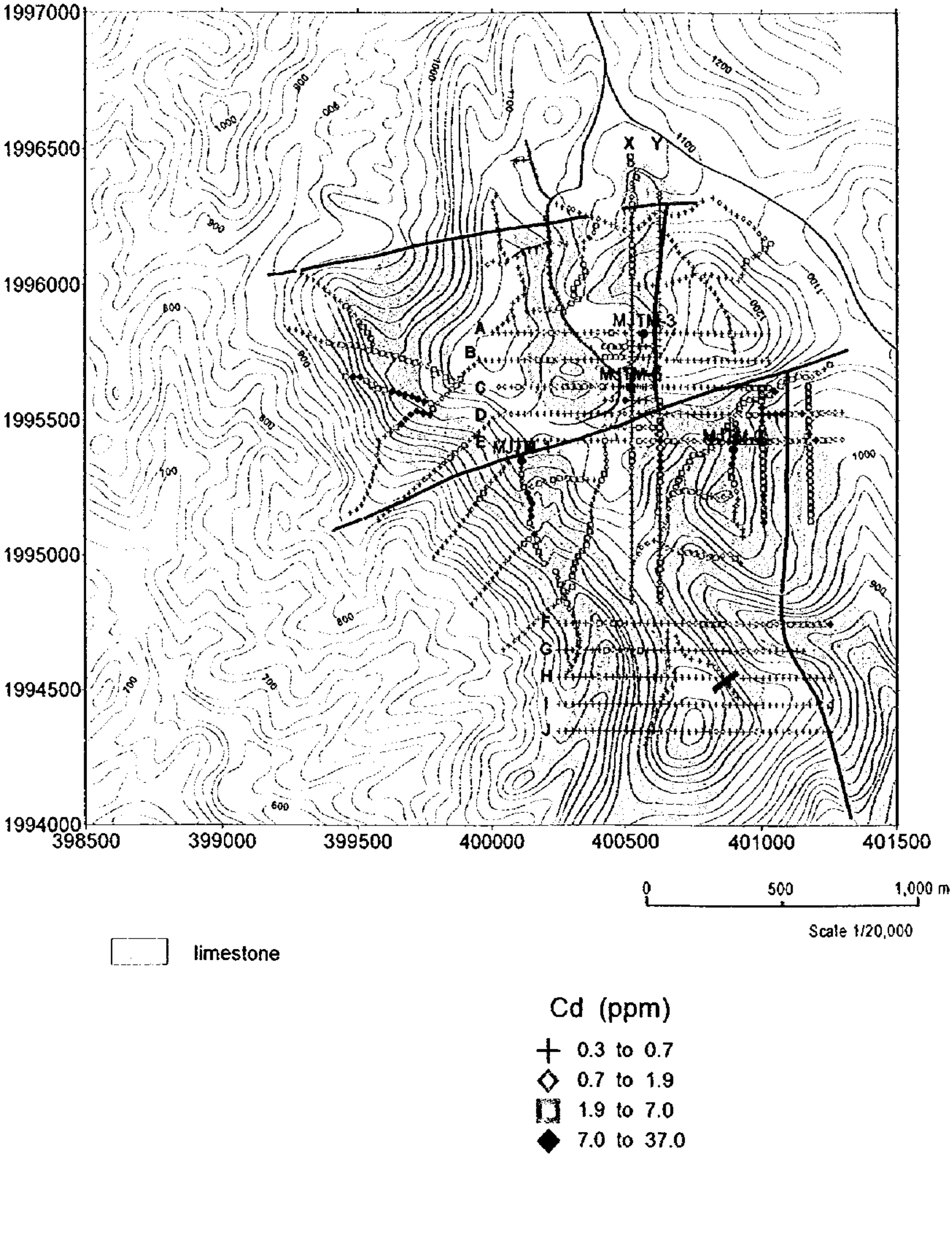


Fig .II-1-5-7 Geochemical map of Cd content in the soil of the Dong Noi Area

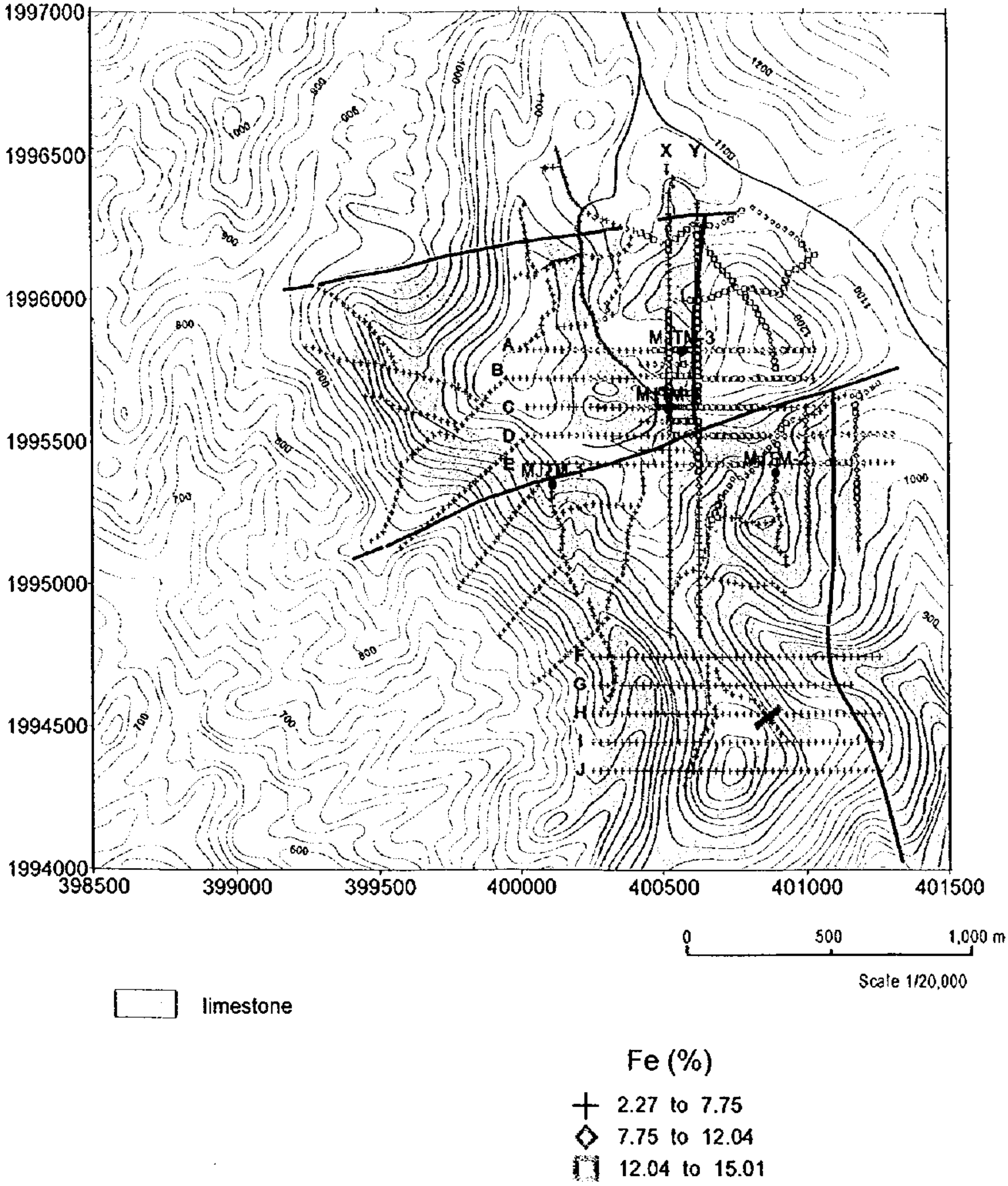


Fig .II-1-5-8 Geochemical map of Fe content in the soil of the Dong Noi Area

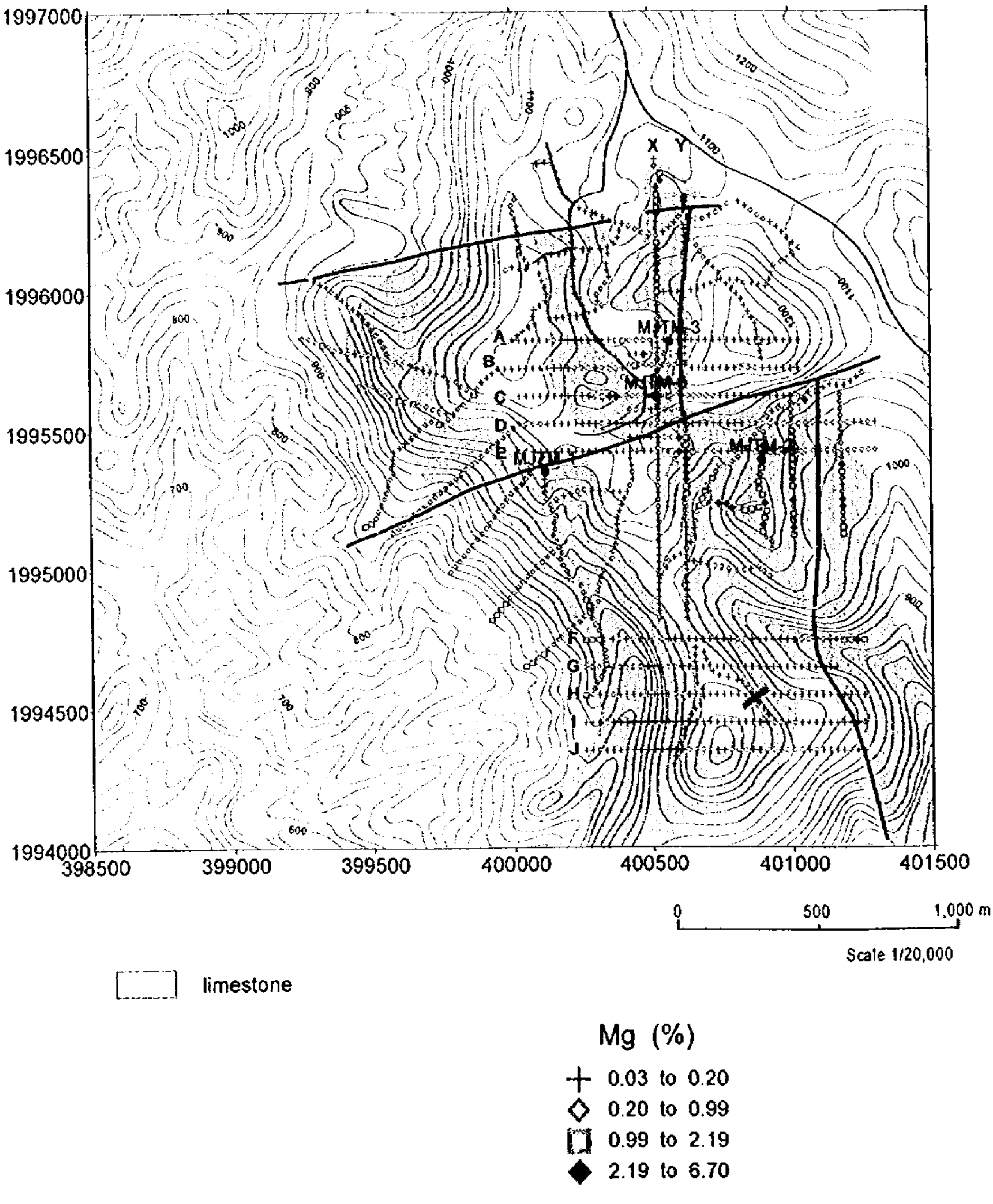


Fig .II-1-5-9 Geochemical map of Mg content in the soil of the Dong Noi Area

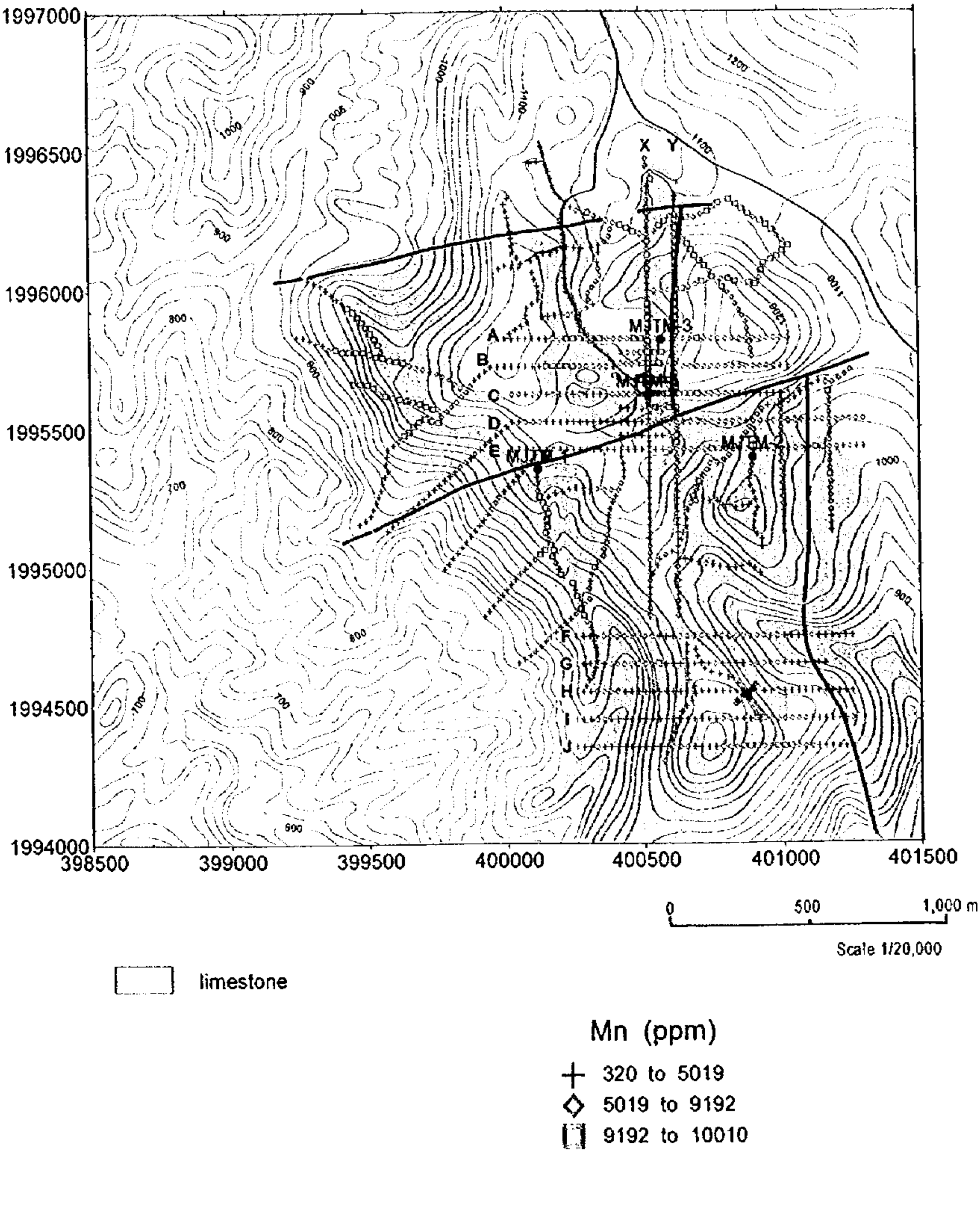


Fig .II-1-5-10 Geochemical map of Mn content in the soil of the Dong Noi Area

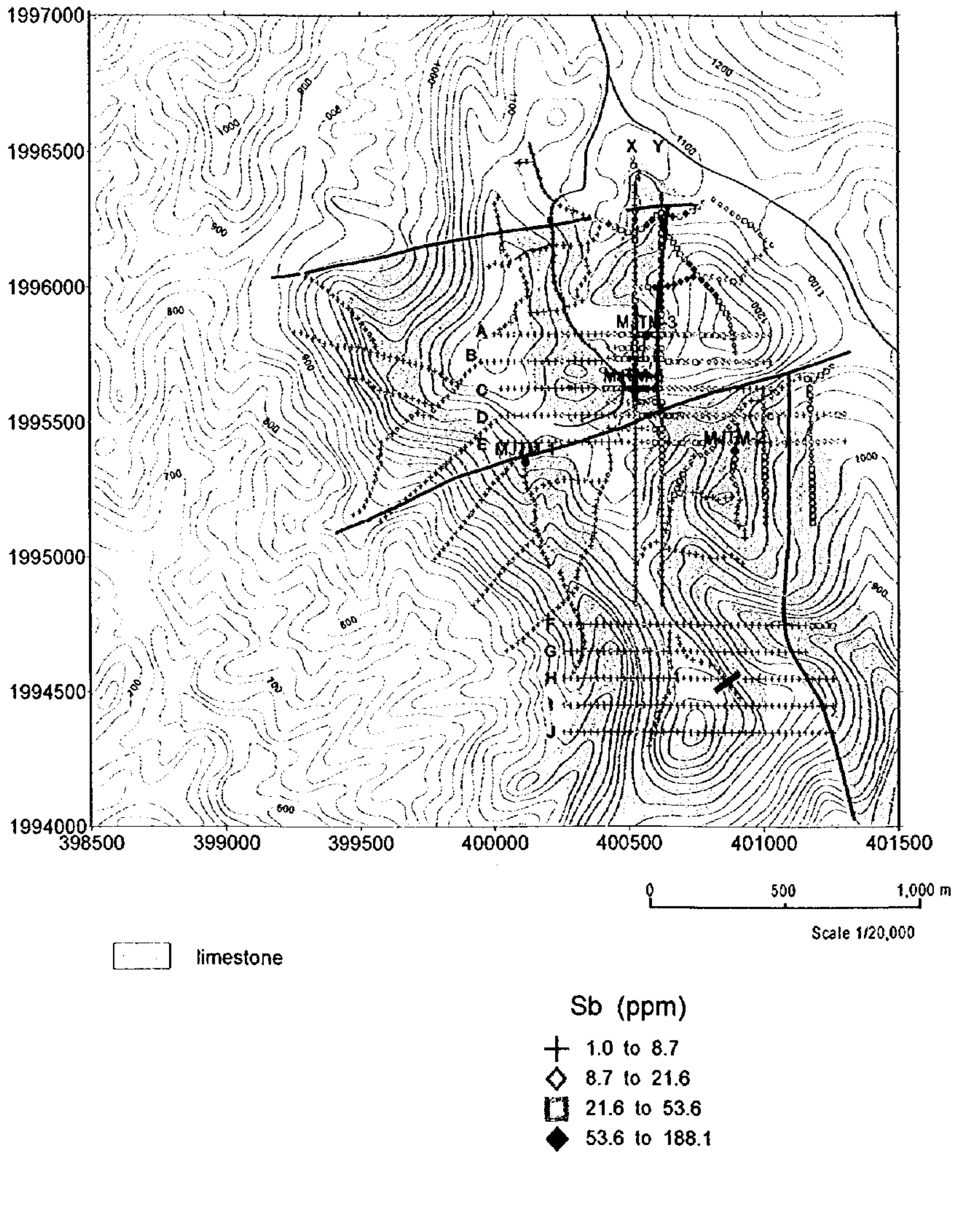


Fig .II-1-5-11 Geochemical map of Sb content in the soil of the Dong Noi Area

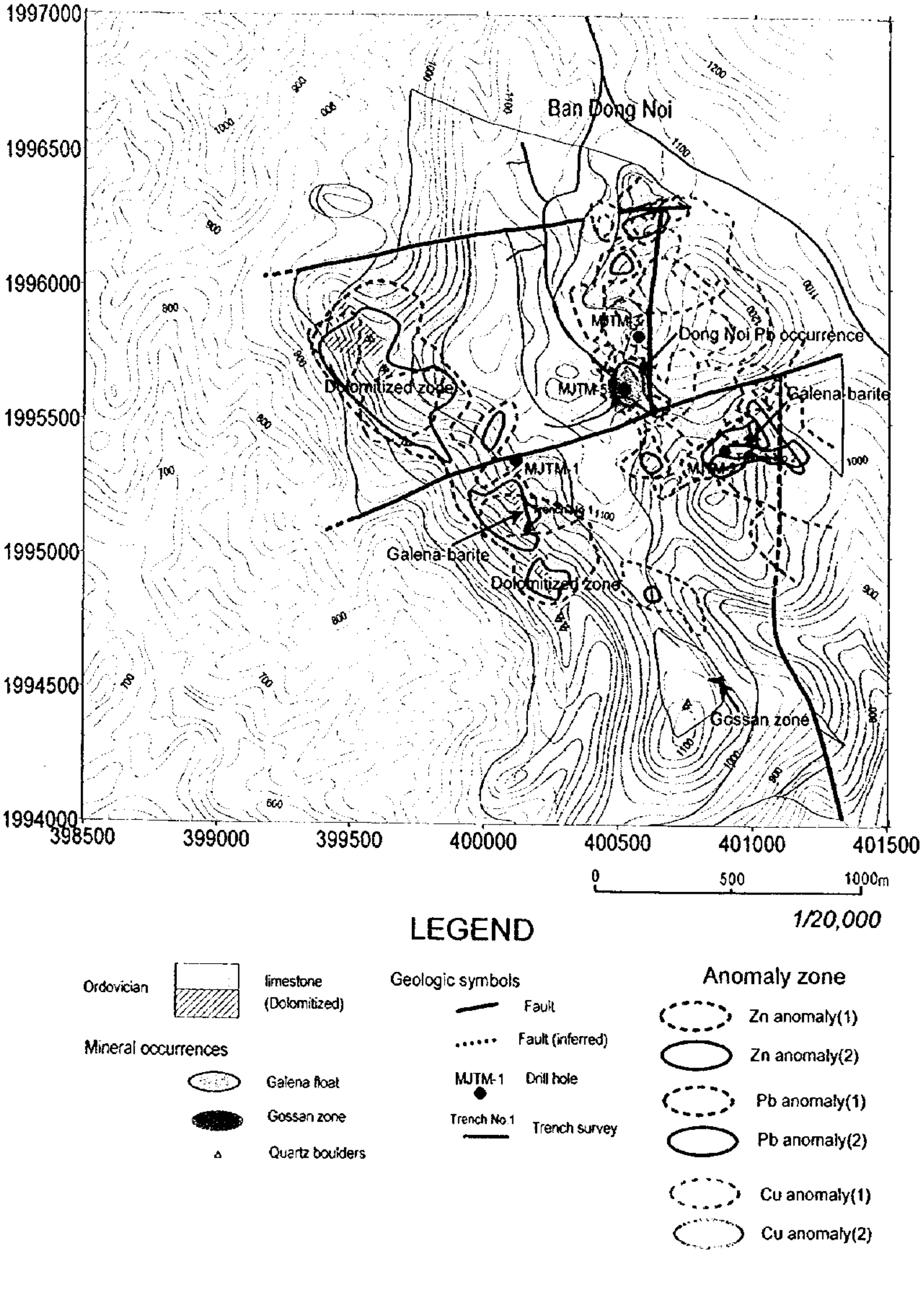


Fig.II-1-5-12 Geochemical interpretation map of the Dong Noi Area

Other anomalies are distributed at the western limestone area and the limestone area to the south of Doi Dong Luang around the drill hole MJTM-2, that are similar to the anomaly area of Zn. The distribution of Mn and As anomalies is similar to those of Pb.

The result of the soil geochemical survey at the gossan zone is also shown in Fig. II-1-5-1 to 11. Though the geochemical anomalous values of almost pathfinder minerals are not detected around the gossan zone, the copper soil values of the gossan zone are relatively higher than the background. The Cu level of the gossan zone is above 100 ppm, whereas the background ranges from 40 ppm to 70 ppm. The Au values are also high at the gossan zone and ranges from 30 to 40 ppm, while the Au values of the other part of Dong Noi area are normally 5 ppm or less.
The mineralization related is unique in the Dong Noi area, though the detected anomaly level is rather lower.

### 1-5-4 Results of the geochemical soil suvey

The geochemical anomaly areas of the Zn, Pb and Cu, representing the pathfinder element groups, are integrated in Fig. II-1-5-12.
The Zn anomaly is only confined to the carbonate rock area, and clearly overlaps with the dolomitized area in the western limestone area.
The Pb anomaly overlaps with the Zn anomaly and the Cu anomaly. An extraconventional high Pb anomaly is limited to the area around the Dong Noi occurrence, where is also recognized the very high Cu anomaly.

## 1-6 Geophysical Survey

### 1-6-1 Process and purpose of the survey

This survey has a purpose to define the resistivity structure and the IP anomaly area of the alteration zone that relates to the mineralized zone and mineralization in the Mae Sariang area with the knowing of ore bearing of lead and zinc by means of TDIP method.

### 1-6-2 Survey location and survey amount

The survey location was 2 areas and as for one the Dong Noi area, the other the Mae Kanai area.
Survey amounts in each area is shown below.

Table II-1-6-1 Survey amounts of IP survey

| Area | Length | Number of lines | Number of points |
|---|---|---|---|
| Dong Noi | 1.0km | 1.0kmx 1 lines | 26 |
| Mae Kanai | 20.0km | 2.0kmx10 lines | 660 |
| Total | 21.0km | 11 lines | 686 points |

1-6-3 Survey method

1. Measurement method

It made electrode arrangement dipole-dipole array with pole interval 100m and pole separation coefficient from N=1 to 4.

The plot concept figure of the dipole dipole array and the measurement data is shown in Fig. II-1-6-1.

It measured IP method in the time domain, it floated down the pause corrugation of 1/8 Hz as the principle and it measured decay voltage after electric current cutting.

An output corrugation from the transmitter is shown in Fig.II-1-6-2 and the example of sampling of the time domain data is shown in Fig.II-1-6-3.

2. Instrumentation

The instrumentation to have used for this survey is the system made by the PHOENIX GEOPHYSICS LIMITED in Canada. It writes down below about the specification of the equipment.

Table II-1-6-2 Specification of TDIP survey instruments

| | |
|---|---|
| Receiver | Phoenix Multi-purpose Receiver V5-16 |
| Number of Channels | 8 maximum |
| Dynamic Range | (+/-) 5 V |
| Gain | from 1 to 2,048 |
| Resolution of A/D Conversion | 16 bits |
| Notch Filter | 50/60 Hz ,21st order harmonics maximum |
| Transmitter | Phoenix IPT1 |
| Maximum Output Power | 2 kW |
| Output Current | 10 A maximum |
| Frequency | 0.125 Hz , 50% duty cycle |
| Generator | Phoenix MG-2 |
| Maximum Output Power | 2 kW |
| Output Frequency | 400 Hz , 3 Phase |
| Engine | 4 cycle , 5 HP |
| Potential Electrode | Phoenix Non-polarizable Pb/PbCl2 Pot |

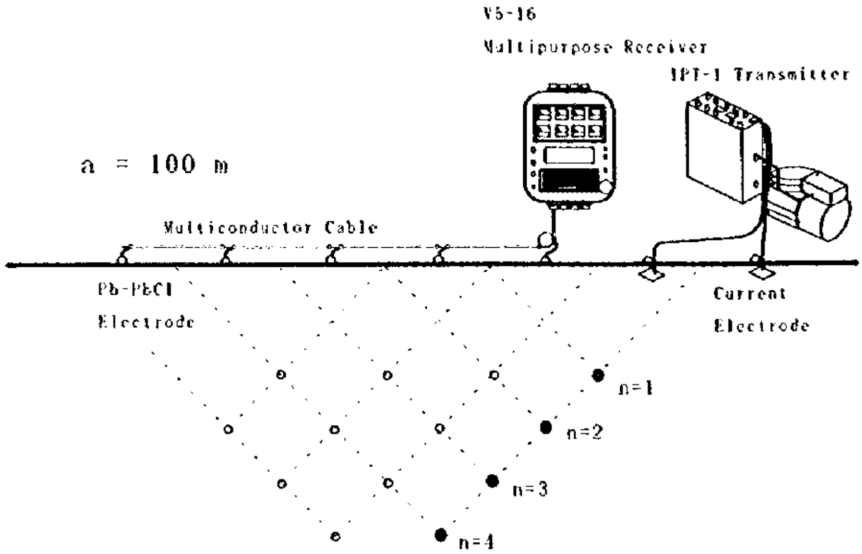


Fig.II-1-6-1 Dipole-dipole array and plotting procedure

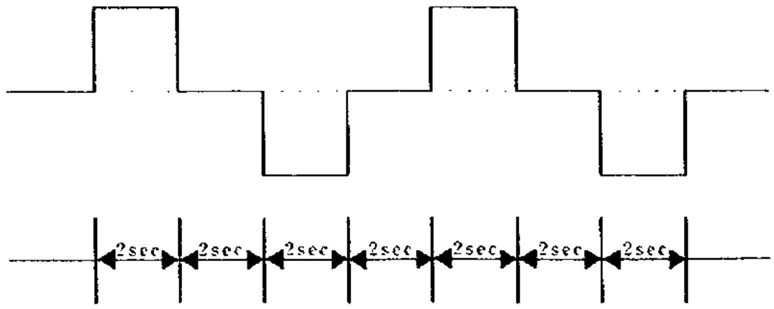


Fig.II-1-6-2 Waveform produced by the transmitter

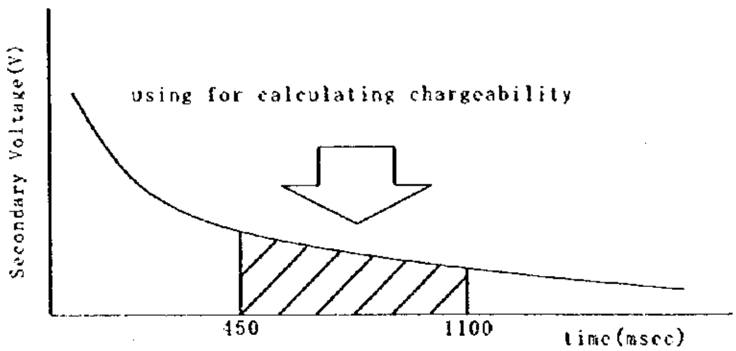


Fig.II-1-6-3 Sampling span for chargeability

1-6-4 Analysis method

**1. Data processing**

Apparent resistivity and chargeability are given by the following formula.

Apparent resistivity and chargeability are automatically calculated in V5 when measuring and it is possible for the data to evaluate quality in the place.

a) Apparent resistivity ($\rho_a$)

$$\rho_a = \frac{\pi \times V}{I} \times a \times n \times (n+1) \times (n+2)$$

V : received voltage(volt)

a : electrode spacing

n : separating coefficient

I : transmitted current (ampere)

b) Chargeability (M)

$$M = \frac{1}{(T_2 - T_1)Vp} \times \int_{T1}^{T2} Vs$$

Vp : primary voltage(volt)

Vs : secondary voltage(volt)

T 1 : sampling time of secondary voltage(450 milli-second)

T 2 : sampling time of secondary voltage(1100 milli-second)

**2. Topographical correction**

When calculating apparent resistivity, it supposes a pole arrangement coefficient as the one to have arranged a pole in the infinite plan.

However, the apparent resistivity that the earth was calculated even if it was homogeneous electrically is influenced by the topography.

It is detected that the apparent resistivity is low in the place of the valley topography in the dipole-dipole type array by the IP method and that it is high in the ridge topography.

On the other hand, it is hardly influenced in the topography, because chargeability is calculated from the transition phenomenon with potential after electric current cutting.

It is conspicuous that either of the topography heaves about the Dong Noi area and the Mae Kanai area that implemented this year survey. Therefore, topographic correction using the finite element method of two-dimensional was carried out in the all measurement lines. After correction, the value of apparent resistivity was revised and using these corrected values, pseudo sections and plan maps were made.

**3. Two Dimensional model analysis**

In this investigation, it analyzed in simulation by the finite element method of Two-dimensional (2-D) about all lines.

It used model computation (Forward Modeling) by the finite element method and the 2-D inversion analysis method (Sasaki, 1988) which composes an automatic analysis method by the non-linear least square method each other for the computation.

In the model analysis of 2-D, it gives all the blocks identical resistivity as the first basic model and it calculates a theoretical value with apparent resistivity and chargeability to this model. Next, for residuals with this theoretical value and measurement value to become small, it corrects a model by the automatic iteration analysis by the least square approximation method and it calculates replying to the correction model. Then, it does this work repeatedly, and it makes a theoretical value approximate a measurement value and it estimates optimal underground structure.

In this investigation, it provided a resistivity block boundary for the middle of basically marching station and moreover, it made the all sides -shaped block that divided a block under each station to become thin at the shallow part and thick at the deep part to the direction of the depth. Then, it transforms this according to the topography of the surface of the ground, in the level direction, it made and it used the resistivity block that becomes parallel to the topography for the analysis.

Incidentally, in partial lines, because the convergence was bad in the bigness of the difference between the theoretical value and the measurement value, it computed, increasing a block to the line both edge part and it made an effort toward the improvement of the analysis precision.

### 1-6-5 Measurement of rock properties

#### 1. Method of measurement

By the purpose to collect the electric characteristic data of rock, samples (37) of rock and ore were collected from the Dong Noi area and the Mae Kanai area. After adjusting the body of the samples and soaking in distillation water for 2 days, it measured apparent resistivity and chargeability by the time domain IP method.

Incidentally, as for the chargeability, it calculated a value using the 2nd potential from 450 milli-second to 1100 milli-second, which is the same as the field measurement.

1-6-5-2 Measurement result The measurement result of rocks and ore samples were shown in Table II-1-6-3, Fig.II-1-6-4. Also, the rock acquisition location of the Dong Noi area was shown in Fig.II-1-6-5.

In the Dong Noi area, it acquired 6 samples. The apparent resistivity shows from 105 to 27500 Ω·m value and the chargeability shows a maximum of 54mV·sec/V.

As for the resistivity, sandstone (JM-03) shows low value. This is the core sample of MJTM-3, which depth is from 14.00 to 14.08m. The other samples are acquired from the surface, and the resistivity shows relatively high value. The samples of limestone (DLR-01, DM-12) and gossan (DJ-16) show especially high value.

As for the chargeability, sandstone (JM-03) shows low value, but the sample of limestone (DM-12) and gossan (DJ-16) show high value more than 20mV·sec/V. DM-12 and DJ-16 were acquired from the mineral occurrence near the station 600 of Line DH. Black shale (DQ-03) shows the highest value (54mV･sec/V). This sample was acquired from the point 200m south of station 900.

Table II-1-6-3 Resistivity and chargeability of rock samples in the Dong Noi area

| Sample name | Rock name | Resis. (Ω･m) | Charge. (mV･sec/V) |
|---|---|---|---|
| DJ-12 | Fine sandstone | 1085 | 16.0 |
| DJ-16 | Gossan | 10800 | 26.6 |
| DLR-01 | Limestone | 11200 | 16.1 |
| DM-12 | Crystalline limestone | 27500 | 29.4 |
| DQ-03 | Black shale | 2216 | 53.9 |
| JM-03 | Sandstone | 105 | 2.6 |

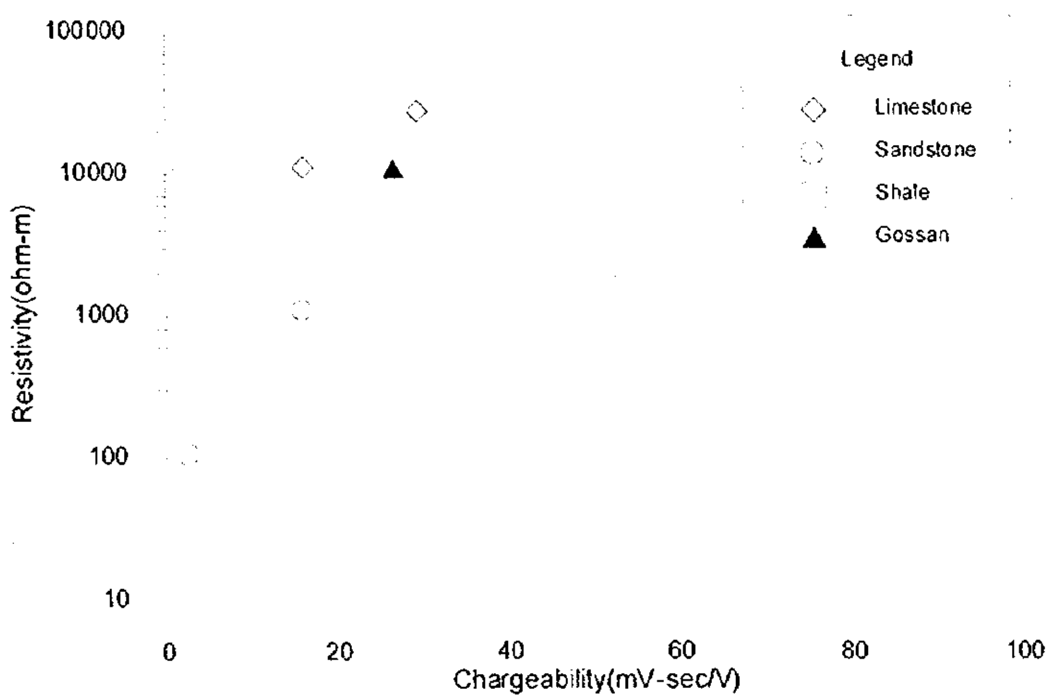


Fig.II-1-6-4 Resistivity and chargeability of rock sample in the Dong Noi area