

**REPORT  
ON  
THE COOPERATIVE MINERAL EXPLORATION  
IN  
THE VAN YEN AND WESTERN THANH HOA AREAS,  
THE SOCIALIST REPUBLIC OF VIETNAM  
PHASE II**

**FEBRUARY 1995**

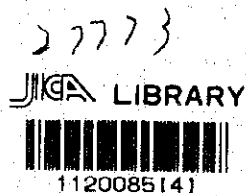
**JAPAN INTERNATIONAL COOPERATION AGENCY**

**METAL MINING AGENCY OF JAPAN**

<b>MPN</b>
<b>CR (2)</b>
<b>95-045</b>

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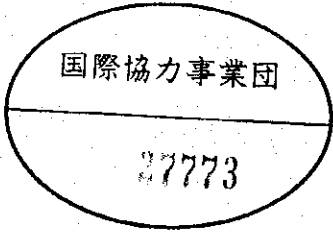
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JAPAN INTERNATIONAL COOPERATION AGENCY

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## PREFACE

In response of the request of the Government of the Socialist Republic of Vietnam, the Japanese Government decided to conduct a Mineral Exploration Project in the Van Yen and Western Thanh Hoa Areas and entrusted the survey to the Japan International Cooperation Agency (JICA) and the Metal Mining Agency of Japan (MMAJ).

This is the second phase survey. The JICA and MMAJ sent a survey team headed by Mr. Masataka Ochi to the Socialist Republic of Vietnam from 17 October, 1994 to 4 January, 1995.

The team exchanged views with the officials concerned of the Government of the Socialist Republic of Vietnam and conducted a field survey in the Van Yen and Western Thanh Hoa areas. After the team returned to Japan, further studies were made and the present report is the result.

We hope that this report will serve for the development of this 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 Socialist Republic of Vietnam for the close cooperation extended to the team.

February, 1995



Kimio FUJITA

President,

Japan International Cooperation Agency



Takashi ISHIKAWA

President,

Metal Mining Agency of Japan



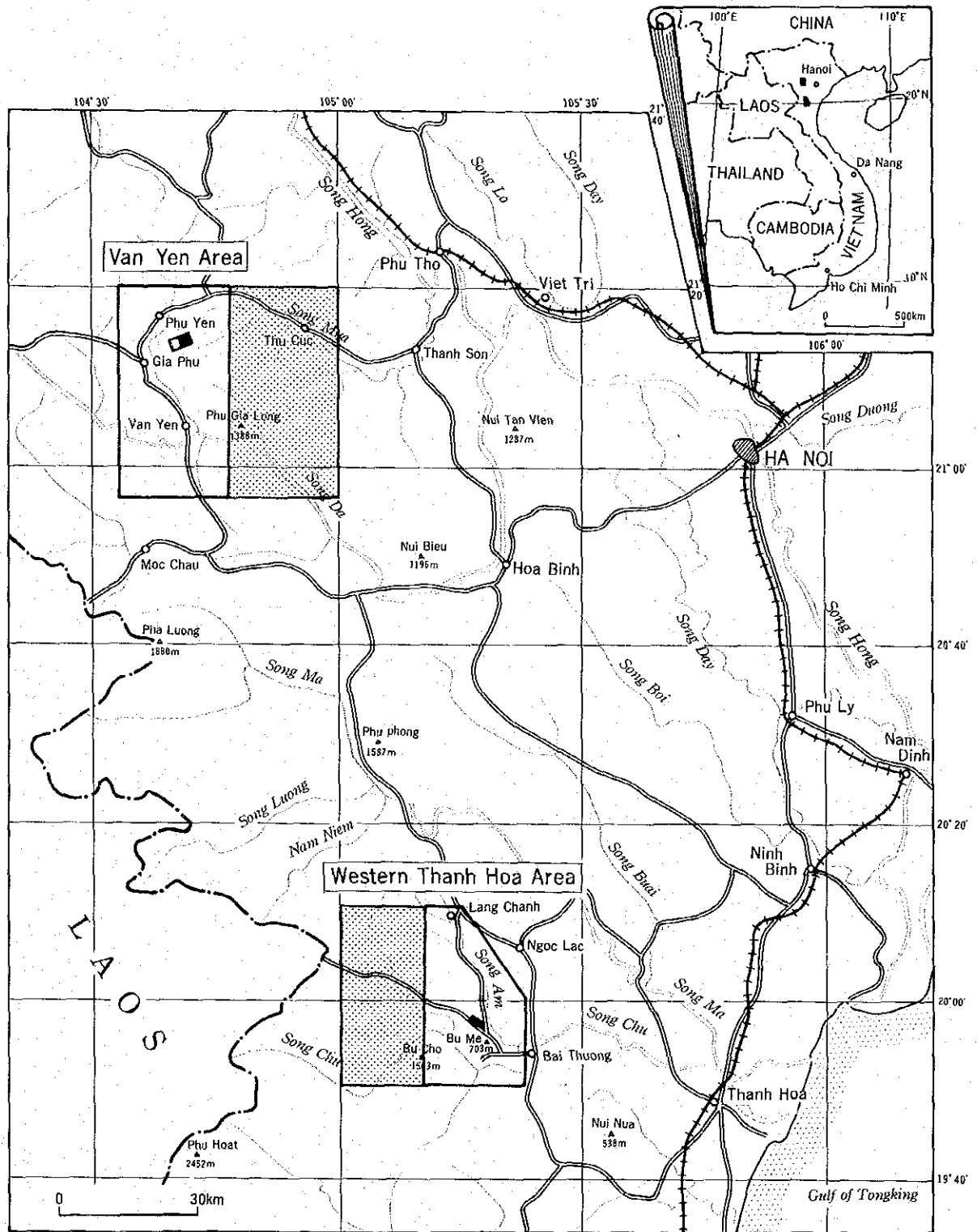


Fig.1 Location Map of the Survey Areas



## SUMMARY

The survey of this year is the second phase of the three-phase Cooperative Mineral Exploration in the Van Yen and Western Thanh Hoa Areas of the Socialist Republic of Vietnam. This report presents the results of the survey of the second phase. The project is based on the "Scope of Work" concluded between the Geological Survey of Vietnam (GSV) and the Japan International Cooperation Agency (JICA) as well as the Metal Mining Agency of Japan (MMAJ) on 23 June 1993.

The objective of this project is to evaluate the mineral potential of the areas through geoscientific investigation and to discover new mineral deposits.

The survey of this phase consists of 1) regional geological survey, 2) detailed geological survey, and 3) geophysical survey (IP method). The regional geological survey was conducted in the Van Yen (1,000 km<sup>2</sup>) and Western Thanh Hoa (650 km<sup>2</sup>) Areas. The both areas are located adjacent to the first phase areas. The detailed geological survey areas are called The Suoi Boc - Suoi Cu (10 km<sup>2</sup>) and Luong Son (4 km<sup>2</sup>) Mineralization Zones selected within the first phase areas. Furthermore, the geophysical survey was carried out in the area surrounding the Suoi Boc Prospect (3 km<sup>2</sup>).

The following summarizes the results of the second phase survey and recommendations for the third phase survey.

### 【Van Yen Area】

#### (1) Regional geological survey

The major geoscientific work carried out in this area are geological survey and soil and panned concentrate geochemical exploration. Maps showing their results have been prepared at a scale of 1:200,000. Geologic mapping at a scale of 1:50,000 by GSV is presently underway. The previous geoscientific work revealed that the survey area has mineral potential for gold, lead-zinc, and platinum-copper-nickel.

This survey area belongs to the "West Bacbo" tectonic province. The basement of the area comprises the Proterozoic metamorphic rocks. Unconformably overlying the basement are Paleozoic metamorphic and sedimentary rocks, Triassic pyroclastic and sedimentary rocks, and intrusive rocks. The intrusive rocks are classified mainly into Proterozoic granitic rocks, Permian ultramafic rocks, and Early Triassic gabbroic rocks.

The whole area is divided tectonically into three blocks, that is, the northeastern and southeastern, central, and southwestern parts. The Proterozoic to Ordovician rocks occur in the northeastern and southeastern



parts of this area and are controlled by NW-SE trend which is the principal structural trend of the "West Bacbo". The rocks of the central part is characterized by the structural trend of WNW-ESE to E-W, and Devonian to Permian strata form two anticlinoriums which have parallel alignments and plunge westward. Additionally, Carboniferous to Upper Triassic strata extend in the N-S to NNW-SSE direction in the southwestern part of the area.

The mineralization in this survey area are those of gold, lead-zinc, and platinum-copper-nickel. However, in all cases the mineralization are very weak. Although the origin of the gold mineralization is supposed to be gold-bearing quartz veins, the essential characteristics of primary deposits remain unknown because the deposits were not discovered through this field survey. The lead-zinc mineralization is represented by the Suoi Can mineral showing of vein type hosted by the Middle Devonian limestone. The content of lead is 8.86 %, and the exposed ore body has very small dimensions with 30 cm width. Platinum-copper-nickel mineralization occur in and around ultramafic bodies, but the bodies are generally small with less than 100 m width. The contents of platinum are not high with the maximum being 40 ppb. The contents of copper and nickel are also more or less 0.1 %. Thus, this type mineralization is very weak.

As a result of stream sediment and panned concentrate geochemistry, no anomalous zone related to significant mineralization was found with regard to the elements examined.

Taking all information on geology, mineralization, and geochemistry into consideration, it is not necessary to select areas for further detailed survey within this regional survey area.

## (2) Detailed geological survey

The Suoi Boc - Suoi Cu Mineralization Zone is underlain chiefly by the Middle Triassic limestone, mudstone, sandstone, siltstone, and conglomerate. These rocks are classified into two rock facies consisting limestone and the other clastic rocks. The strata of two rock facies extend in the N-S direction with faults parallel to this direction and the strata form complicated folds.

The detailed geological survey in the whole area revealed that no new mineralization zone similar to the known two zones was present. It has been pointed out through Phase I survey that the Suoi Boc Prospect can be of massive metasomatic lead-zinc type hosted by limestone. However, judging from the results of the detailed survey of this phase, this Prospect has a possibility to be of hydrothermal vein type hosted by sandstone with a strike of N30°W.

As a result of the soil geochemical exploration, four anomalous zones for Pb and Zn were detected including one centering around the known mineralization zone. The anomalous zones are believed to indicate lead-zinc mineralization.

### (3) Geophysical survey

The low resistivity zones less than 50 ohm-m are detected in the northeastern edge and central part of the survey area. The low resistivity zones less than 100 ohm-m are scattered in the areas connected the low resistivity zones less than 50 ohm-m. These low resistivity zones reflect the distribution of mudstone which showed the lowest resistivity in laboratory.

On the Suoi Boc Prospect (around the measuring point No.234), the chargeability is only several ms higher than the mean value and thus no IP anomaly was detected. This can be understood from the reason that two factors work together. One is the little difference between ore and sandstone in chargeability (proved by the laboratory tests). Another is the small size of the mineralization zone.

Two IP anomalies more than 60 ms are detected in the northeastern edge and middle east edge of the survey area. The anomaly in the northeastern edge is the strong one containing the measuring point more than 100 ms. It is inferred that the strong IP anomalies result from mineralization containing pyrite, graphite, or clay under the ground. Moreover, the IP anomaly in the middle east edge is noteworthy because it and a Pb-Zn soil geochemical anomalous zone partly correspond each other.

### (4) Recommendations for Phase III Survey

From the results obtained through the Phase I and Phase II survey, the following work is recommended for Phase III survey.

- 1) Drilling exploration for an area around the Suoi Boc Prospect
- 2) Detailed geological survey in the northwestern part of the Phase I area for an areal extent of 5 km × 8 km where Pb and Zn stream sediment geochemical anomalies are concentrated

### **【Western Thanh Hoa Area】**

#### (1) Regional geological survey

The major geoscientific work carried out in this area is only geological survey. Maps showing the results have been prepared at scales of 1:1,500,000 and 1:200,000.

The geoscientific studies of the previous work revealed that the survey area has mineral potential for lead and zinc.

This survey area is situated at the northern edge of the "Truongson" tectonic province. The area is underlain by the Cambrian metamorphic basement, the unconformably overlying Ordovician to Triassic metamorphic and sedimentary rocks, a large amount of Jurassic pyroclastic rocks, and intrusive rocks. The intrusive rocks are classified into Late Triassic gabbros and Late Cretaceous to Paleogene granitic rocks.

The strata of this area generally have NW-SE to WNW-ESE structural trend, and the trend is roughly controlled by the major one of the "Truongson" province. In the northern half of the area, faults are developed in the WNW-ESE direction, but in the southern half of the area, faults of four systems represented by E-W, NW-SE, NE-SW, and N-S occur in a complex pattern.

The mineralization is very weak in the whole area and no remarkable mineralization was found except for only one copper mineral showing called the Western Muong Ly mineral showing. It comprises four copper-bearing quartz veins within an area of about 20 m width. The veins are hosted by Middle Triassic conglomerate and sandstone with the maximum width being 7 cm. In view of the small dimensions of the showing and low content of copper (0.69 %), the showing is not noteworthy for copper mineralization.

The stream sediment geochemical exploration revealed that no anomalous zone related to significant mineralization was detected with regard to all eleven elements examined.

Judging from the data on geology, mineralization, and geochemistry, no further exploration is needed in this regional survey area.

## (2) Detailed geological survey

The Luong Son Mineralization Zone is underlain mainly by the Middle Triassic sandstone and Late Triassic intrusive gabbro. The sandstone extends generally in the NNW-SSE direction and is inferred to consist of a series of folds with about 2 km wavelength. The gabbroic bodies intruded into the sandstone and extend roughly in the N-S direction.

The gold-bearing quartz veins are concentrated in this Mineralization Zone. They are hosted by the sandstone and mudstone as well as gabbroic bodies. During Phase I survey, three sites of quartz vein were examined and the chemical analysis of the collected samples revealed that the highest content of gold was 0.24 g/t. Eight outcrops and 15 float zones of quartz vein were newly discovered through the detailed survey of this phase. The highest content of gold obtained is 0.05 g/t, as a result of chemical analysis for samples collected from those localities. The hydrothermal alteration zone with kaoline minerals occurs on the east of a gabbroic body located in the central part of this area. The zone was disclosed to be of about 600 m width

and extends roughly in the N-S direction through the present detailed survey.

As a result of the soil geochemical exploration, four strong Au anomalous zones were detected in the northwestern part of the area, and the zones are believed to imply gold mineralization.

(3) Recommendations for Phase III Survey

The following work is recommended for Phase III survey on the basis of the results obtained through Phase I and Phase II survey.

- 1) Trenching on the Au soil geochemical anomalous zones for the Luong Son Mineralization Zone
- 2) Detailed geological survey for the Coc Thuong mineralization zone and the surrounding area in the southeastern part of the Phase I area, where quartz veins are concentrated



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**PART I OVERVIEW**



## PART I OVERVIEW

### CHAPTER 1. INTRODUCTION

#### 1.1. Background and Objectives

In response of the request by the Government of the Socialist Republic of Vietnam to conduct mineral exploration, the Japanese Government dispatched a preparatory survey team to discuss the details of the project. As a result of the consultations between the Geological Survey of Vietnam (GSV) of the Ministry of Heavy Industry and the Metal Mining Agency of Japan, an agreement was reached for cooperative exploration of the Van Yen and Western Thanh Hoa Areas. The "Scope of Work" (SW) was signed by the representatives of both governments in June 1993. The objective of this project is to assess the mineral potential of the areas through geological survey, geochemical exploration, geophysical survey, and drilling exploration during the period of three years from 1993 to 1995.

#### 1.2. Conclusions and Recommendations of Phase I Survey

##### 1.2.1. Conclusions and recommendations of the Van Yen Area

###### 【Conclusions】

(1) The field work was carried out in this area during the period from 24 November to 20 December, 1993. The scope of the work during Phase I is as follows.

- Geological survey: 1,000 km<sup>2</sup>
- Geochemical exploration (collected samples):
  - Stream sediments 899 samples
  - Panned concentrates 193 samples

(2) The survey area belongs to the "West Bacbo" tectonic province. This area is underlain chiefly by the Devonian to Permian shallow-marine sedimentary basement which is overlain by the Triassic and Cretaceous alkali volcanic and pyroclastic rocks, shallow-marine sedimentary rocks, and unconsolidated Quaternary sediments. Small bodies of gabbroic rocks, quartz-bearing trachyte, and syenite intruded the Lower Triassic rocks in the central part of the survey area.

(3) The geology of this area is strongly controlled by the NW-SE trending main structure of the "West Bacbo", and the NW-SE direction is predominant in both



major faults and foldings. This structure also controls the direction of intrusive bodies and gold-copper deposits in this area.

(4) The major mineralization in this survey area are those of gold, copper, lead, and zinc. They are summarized below.

a) The major gold mineralization of this area is that associated with bedded cupriferous pyrite deposits. It is believed that the deposits are of metamorphic origin and have close genetic relation to the Early Triassic mafic to intermediate alkali volcanism. The ore bodies are narrow ranging in width from 0.2 to 0.5 m and the contents of gold and copper are relatively high (Au: 1 to 6 g/t, Cu: 1 to 7 %). There are many ore bodies, but they are not large. Therefore, possibility exists for finding deposits of this type with gold content sufficient for mining. The most promising area is in the vicinity of the Suoi Tiat mine, where many mineral showings and Au-Cu anomalies are concentrated.

b) The relatively large quartz veins of about 2 m in width occur in the central part of the survey area, and are accompanied occasionally by copper minerals. However, the content of copper is not of significant commercial value. Additionally, copper content does not improve in veins of different levels and in veins along the extension of the same level. Therefore, high mineral potential is not expected laterally and vertically for quartz veins of this type. The width of the veins varies considerably, resulting in unstable content of minerals.

c) Some metasomatic lead and zinc mineralization zones and mineral showings occur in the central part of the survey area, and are hosted mainly by the Middle Triassic carbonate rocks. The details of the dimensions and other characteristics of mineralization are not known because of the thick soil cover. However, further exploration is needed for these prospects because the contents of lead and zinc are very high (Pb: 12 to 26 %, Zn: 29 to 39 %). The above assay results are from chip samples of floats. The most promising area is the Suoi Boc mineralization zone and followed by the Suoi Cu and Ban Suoi Tion mineral showings.

#### **【Recommendations for Phase II Survey】**

From the conclusions reached during the Phase I survey, the following work is recommended for Phase II survey to be carried out in Fiscal 1994.

- (1) Detailed geological survey in the vicinity of the Suoi Tiat mine for an areal extent of 6 km × 3 km
- (2) Detailed geological survey and geophysical prospecting (IP method) for the Suoi Boc mineralization zone
- (3) Detailed geological survey for the Suoi Cu mineral showing
- (4) Detailed geological survey for the Ban Suoi Tion mineral showing

#### 1.2.2. Conclusions and recommendations of the Western Thanh Hoa Area

##### **【Conclusions】**

(1) The field work was carried out in this area during the period from 29 October to 20 November, 1993. The scope of work during Phase I is as follows.

- Geological survey: 650 km<sup>2</sup>
- Geochemical exploration (collected samples):
  - Stream sediments 532 samples
  - Panned concentrates 147 samples
  - Soils 241 samples

(2) The survey area belongs to the "Truongson" tectonic province which is the Late Paleozoic to Early Triassic mobile belt. This area is underlain mainly by the Cambrian metamorphic basement, the overlying Ordovician to Triassic marine and continental sedimentary rocks, and the Jurassic (?) volcanic and pyroclastic rocks. The intrusive rocks of the survey area are classified into Triassic gabbro, Jurassic felsic rocks, and Late Cretaceous to Paleogene granitic rocks.

(3) The geology of this area is controlled by the NW-SE trending main structure of the "Truongson". Two major N-S trending faults extend in the eastern and western parts of the survey area. These faults were formed during Tertiary time and the granitic rocks are cut by the faults. These faults are post-mineralization.

(4) Gold, copper, tin, and tungsten mineralization occur in the survey area.

a) Gold is associated with quartz veins. Quartz veins are relatively concentrated in the Luong Son mineralization zone, where the existence of gold

was confirmed through chemical analysis of vein samples and geochemical samples. Further point of interest is the existence of a wide acidic alteration zone around the mineralization zone. Quartz veins are concentrated also in the Coc Thuong mineralization zone where the presence of gold was confirmed at some places. Gold and Cu anomalies are found to occur concentrated over this mineralization zone. Thus, this zone is considered to be promising for future exploration for gold.

b) Regarding copper mineralization, the Hon Mo mineralization zone is promising. This zone is hosted by gabbroic body and has massive and dissemination type of occurrence. The copper content is low at the outcrop, however, there is a possibility for this zone to be an orthomagmatic deposit associated with mafic intrusive rocks. The mineralization contains also gold. From the above, this zone is concluded to be one of the priority areas for future exploration.

c) The tin-tungsten Bu Me Prospect is believed to be a pneumatolytic to hydrothermal mineralization zone associated with porphyritic granitic intrusion. The ore minerals of this prospect are mainly cassiterite and wolframite, and the prospect occurs in the granitic body and the surrounding hornfels zone. Areal extent of the major mineralization zone is estimated to be 1,200 m x 400 m. The average grade of Sn+W is 0.33 % along trenches with about 320 m in total length. Although sufficient exploration was not conducted up to present time, it is believed that time is not mature to proceed to the detailed geological survey and drilling exploration due to the following three factors.

- Relatively low content of tin and tungsten
- Low level of tin market
- Worldwide prevalence of exploitation from placer deposits with low price

The present geochemical exploration revealed that the southwestern granite area is the most promising for tin-tungsten mineralization other than the Bu Me Prospect. However, access to the area is not favorable, and transportation costs will be a negative factor for the undertaking of development. The survey for calculating reserves can be carried out in the area, but the priority of mineral exploration is low considering the commercial value.

## **【Recommendations for Phase II Survey】**

The following work is recommended for Phase II survey on the basis of the above conclusions.

(1) Detailed geological survey and geophysical survey covering the area from the Luong Son to Hon Mo mineralization zone.

— It is convenient to conduct the detailed geological survey for an area covering the above two zones because they are closely located.

— Geophysical survey (IP method) for selected areas

(2) Detailed geological survey for the Coc Thuong mineralization zone and the surrounding area.

### **1.3. Outline of Operations of Phase II Survey**

#### **1.3.1. Contents of the survey**

The Phase II survey consists of (1) regional geological survey, (2) detailed geological survey, and (3) geophysical survey (IP method). Table I-1 shows the contents of the Phase II survey. The geological survey incorporating the above (1) and (2) consists of the following three activities.

1) Analysis of available relevant data

2) Geological survey

3) Geochemical exploration

Laboratory works conducted for each area are laid out in Table I-2.

#### **1.3.2. Survey areas**

##### **(1) Regional geological survey**

The regional survey of this project was carried out in two areas, the Van Yen and Western Thanh Hoa Areas. These areas are located in the northern part of the Socialist Republic of Vietnam as shown in Figure 1. The two areas are enclosed by the following coordinates.

##### **【Van Yen Area】**

Northern Limit: 21° 20' N

Southern Limit: 20° 56' N

Eastern Limit : 105° 00' E

Western Limit : 104° 33' E

##### **【Western Thanh Hoa Area】**

Northern Limit: 20° 10' N

Southern Limit: 19° 50' N

Eastern Limit : 105° 22' 30" E

Western Limit : 105° 00' E

Table I -1 Survey Contents

Van Yen Area		Western Thanh Hoa Area	
<b>Regional Geological Survey</b>			
Areal extent	1,000 km <sup>2</sup>	Areal extent	650 km <sup>2</sup>
Length of traverse	502 km	Length of traverse	250 km
Panned concentrates	240 pcs	Panned concentrates	120 pcs
<b>Detailed Geological Survey</b>			
(1) Suoi Boc - Suoi Cu Mineralization Zone • Areal extent : 10 km <sup>2</sup> • Length of traverse : 19 km		<b>【Luong Son Mineralization Zone】</b> (including soil geochemical exploration) • Areal extent : 4 km <sup>2</sup> • Length of traverse : 32 km • Soil samples : 207 pcs • Panned concentrates : 15 pcs	
(2) Suoi Boc Prospect (including soil geochemical exploration) • Length of traverse : 9 km • Soil samples : 100 pcs			
<b>Geophysical Survey (IP method)</b>			
[Gradient Array]			
<b>【Suoi Boc Prospect】</b>			
Areal extent	3 km <sup>2</sup>		
Length of lines	15.8 km		
Measuring points	306 points		
Potential electrode spacing	50 m		

Table I -2 Laboratory Studies

(Both Areas)

ITEMS	NUMBER OF SAMPLES
(1) Thin section observation	79
(2) Polished section observation	37
(3) X-Ray diffraction analysis	17
(4) Whole rock analysis (SiO <sub>2</sub> , TiO <sub>2</sub> , Al <sub>2</sub> O <sub>3</sub> , Fe <sub>2</sub> O <sub>3</sub> , FeO, MnO, CaO, Na <sub>2</sub> O, MgO, K <sub>2</sub> O, P <sub>2</sub> O <sub>5</sub> , LOI ; 12 components)	42 (504 components)

(Van Yen Area)

ITEMS	NUMBER OF SAMPLES
(1) Chemical analyses	
a) Stream sediments (Au, Ag, Cu, Pb, Zn, As, Hg, Cr, Ni ; 9 elements)	915 (8,235 elements)
b) Soil (Au, Ag, Cu, Pb, Zn, Cd, As, Sb, Hg ; 9 elements)	100 (900 elements)
c) Ore assay (Au, Ag, Cu, Pb, Zn, Cr, Ni, Mn, Pt ; 9 elements)	47 (423 elements)
(2) Resistivity and chargeability	24

(Western Thanh Hoa Area)

ITEMS	NUMBER OF SAMPLES
(1) Chemical analyses	
a) Stream sediments (Au, Ag, Cu, Pb, Zn, As, Hg, Cr, Ni, Sn, W ; 11 elements)	469 (5,159 elements)
b) Soil (Au, Ag, Cu, Pb, Zn, As, Sb, Hg ; 8 elements)	207 (1,656 elements)
c) Ore assay (Au, Ag, Cu, Pb, Zn, Cr, Ni, Mn, Sn, W ; 10 elements)	46 (460 elements)

During the Phase II survey carried out in fiscal 1994, the regional survey was conducted in the eastern and western halves of the Van Yen and Western Thanh Hoa Areas, respectively. These areas are enclosed by the following coordinates.

**【Van Yen Area】**

Northern Limit: 21° 20' N  
Southern Limit: 20° 56' N  
Eastern Limit : 105° 00' 00" E  
Western Limit : 104° 46' 30" E

**【Western Thanh Hoa Area】**

Northern Limit: 20° 10' N  
Southern Limit: 19° 50' N  
Eastern Limit : 105° 10' 30" E  
Western Limit : 105° 00' 00" E

(2) Detailed geological survey

The detailed geological survey was carried out in the following mineralization zones selected within the Phase I area (Figure 1). Those areas are enclosed by the coordinates of four corners shown below.

**【Van Yen Area】**

Suoi Boc - Suoi Cu Mineralization Zone

NE-Corner : 21° 14' 41" N, 104° 41' 15" E  
SE-Corner : 21° 13' 35" N, 104° 41' 43" E  
NW-Corner : 21° 13' 45" N, 104° 38' 46" E  
SW-Corner : 21° 12' 38" N, 104° 39' 15" E

**【Western Thanh Hoa Area】**

Luong Son Mineralization Zone

NE-Corner : 19° 57' 06" N, 105° 16' 38" E  
SE-Corner : 19° 56' 26" N, 105° 16' 11" E  
NW-Corner : 19° 57' 58" N, 105° 15' 14" E  
SW-Corner : 19° 57' 16" N, 105° 14' 46" E

(3) Geophysical survey

The geophysical survey was conducted in the area centering around the Suoi Boc mineralization zone located in the west of the above Suoi Boc - Suoi Cu Mineralization Zone.

1.3.3. Objectives of Phase II survey

The Phase II survey was carried out with the following major objectives.

**【Regional and detailed geological survey】**

1) Collection and analysis of available relevant data

This work was done in order to formulate detailed exploration program through the study of the previous surveys on geology, geologic structure, and mineralization with respect to the areas concerned.

2) Selection of promising areas

These areas were selected through the elucidation of relationship between geology, geologic structure and mineralization on the basis of the effective field survey supported by the analysis of the available relevant data.

**【Geophysical survey】**

The objective of the geophysical survey is to detect IP anomalies related to mineralization and thus delineate the prospective parts within and around the geochemical anomalies extracted during the Phase I in the vicinity of the Suoi Boc mineralization zone.

1.3.4. Duration of the work

The duration of the work of this phase is listed in Table I -3.

1.4. Organization of the Survey Team

The preparatory survey team visited Vietnam for the preliminary survey and conclusion of scope of work during the period from 13 to 29 July, 1993.

1.4.1. Preparatory survey team

(1) Vietnamese members

Tran Dy	(Director General, GSV)
Tran Van Tri	(Deputy Director General, GSV)
Vu Ngoc Xuan	(Director, Industrial Department, State Planning Committee)
Pham Xuan Hoang	(Deputy Director, International Cooperation Department, Ministry of Heavy Industry)
Doan Ky Thuy	(Director, International Cooperation Division, GSV)
Le Van De	(Deputy Director, International Cooperation Division, GSV)

(2) Japanese members

Katsuo YOKOYAMA	(Team leader; Metal Mining Agency of Japan)
Masayoshi SHIMODE	(Metal Mining Agency of Japan; Bangkok)
Kousuke TAKAMOTO	(Metal Mining Agency of Japan)



Table I -3 Schedule of the Work

ITEMS OF THE WORK	94/Oct.	Nov.	Dec.	95/Jan.	Feb.	REMARKS
Travel to Vietnam	(GS) 14	(GP) 14				GS:one day GP:one day
Analysis of available relevant data	18 20					one day for courtesy calls, various arrangements, and discussions two days for data analysis
Preparation	21 23	18 21				GS:three days GP:four days including courtesy calls and discussions
Field Survey						
Van Yen Area	24	(GS) 25	(GP) 16			GS:33 days, GP:25 days
Western Thanh Hoa Area		22 26	(GS) 23			GS:28 days
Analysis in Vietnam			(GP) 17	3 (GS) 23		11 days(GS) and seven days (GP) for compilation, analysis, and interim reporting
Return trip to Japan			(GP) 24	4 (GS) 5		GS:one day GP:one day
Analysis in Japan			25		27	
Presentation of report					28	

GS : Geological Survey GP : Geophysical Survey

Taro KAMIYA (Metal Mining Agency of Japan)  
Koh NAITO (Japan International Cooperation Agency)

1.4.2. Field inspection (from 17 to 29 November, 1994)

Naoki SATO (Metal Mining Agency of Japan)

1.4.3. Field survey team (from 17 October, 1994 to 4 January, 1995)

(1) Vietnamese members

【Van Yen Area】

Geological survey staff

Nguyen Dai Lu (Team leader; Geological Mapping Division, GSV)  
Pham Van Duong (Geological Mapping Division, GSV)  
Nguyen The Cu (Geological Mapping Division, GSV)  
Nguyen Huy Than (Geological Mapping Division, GSV)  
Tran Dang Hung (Geological Mapping Division, GSV)  
Dan Nguyen Viet (Geological Mapping Division, GSV)

Geophysical survey staff

Nguyen Xuan Dong (Geological Mapping Division, GSV)  
Nguyen Duc Nhuong (Geological Mapping Division, GSV)  
Tran Thanh Dy (Geological Mapping Division, GSV)

【Western Thanh Hoa Area】

Ho Nhiem (Team leader; Division No.4, GSV)  
Dau Ba Quang (Division No.4, GSV)  
Nguyen The Phuc (Division No.4, GSV)  
Tran Cong Bong (Division No.4, GSV)  
Nguyen Xuan Toan (Division No.4, GSV)  
Nguyen Phi Tien (Division No.4, GSV)

(2) Japanese members

Geological survey staff

Masataka OCHI (Team leader; Nikko Exploration & Development Co., Ltd.)  
Motomu GOTO (Nikko Exploration & Development Co., Ltd.)  
Masami HIGASHIHARA (Nikko Exploration & Development Co., Ltd.)  
Takumi ONUMA (Nikko Exploration & Development Co., Ltd.)  
Kazuyasu SUGAWARA (Nikko Exploration & Development Co., Ltd.)  
Tomoji SANGA (Nikko Exploration & Development Co., Ltd.)

Geophysical survey staff

Takashi YAMAISHI (Nikko Exploration & Development Co., Ltd.)  
Shinichi SUGIYAMA (Nikko Exploration & Development Co., Ltd.)  
Tadanori IWASAKI (Nikko Exploration & Development Co., Ltd.)

## CHAPTER 2. GEOGRAPHY

### 2.1. Location and Access

#### (1) Van Yen Area

The regional survey area is located about 100 km west of Hanoi and belongs to three provinces of the Son La, Vin Phu, and Ha Son Binh in terms of administrative district. The largest village called Thu Cuc lies in the northern part of the area. Its population is about 2,000. Small villages of highland tribe are scattered in the intra-montane basins and uppermost reaches of many tributaries. There are two routes to reach Thu Cuc from Hanoi, the northern and southern routes. The northern one leads to Thu Cuc via Son Tay along the Hong River. The distance along the road is approximately 130 km and it is about five hours drive by jeep. In this route it is necessary to cross the Da River by ferry at the point to the west of Ba Vi. The road is flat and paved from Hanoi to Ba Vi, while from the Da River westward the road is unpaved and leads to Thu Cuc via Thanh Son.

The southern route leads to Thu Cuc via Hoa Binh and Thanh Son through the national roads No.6 and No.24. The distance along the roads is approximately 170 km and it takes roughly six hours by jeep from Hanoi. The road No.6 is flat and paved from Hanoi to Hoa Binh, but the road No.24 is unpaved and narrow with one track on one side from the dam constructed near Hoa Binh up to Thu Cuc.

The car-road network is very sparse in this survey area. There are six roads for vehicle transport through the northern part of this area, four are the north-south direction and the rest east-west. The footpaths are developed with relatively high density along the major tributaries and on the ridges. Various sizes of motor boats are available in the villages along the dammed up Da River of 800 m wide to cross any parts of the River. Thereby the boats are useful for the survey along the River.

The Suoi Boc - Suoi Cu Mineralization Zone for the detailed geological survey as well as geophysical survey is located in the northern part of the Phase I area, and is about 4 km south-southeast of Phu Yen, the largest village of the Phase I area. There is one road for vehicle transport to the survey area from Phu Yen.

#### (2) Western Thanh Hoa Area

The regional survey area lies about 120 km to the south-southwest of the

above Van Yen Area. The central part of the area is about 130 km southwest as the crow flies from Hanoi. The area belongs to the Thanh Hoa and Nghe An provinces in terms of administrative district. The route passing through Thanh Hoa is useful to approach the area. The distance is roughly 150 km from Hanoi to Thanh Hoa along the national road No.1 and it takes about four hours by car. About another four hours are needed to reach the eastern edge of the survey area by vehicle on the provincial road from Thanh Hoa with the distance of about 80 km. The road No.1 is paved from Hanoi to Thanh Hoa, but most parts of the road are unpaved from Thanh Hoa to the survey area.

There are two roads for vehicle transport through the northern half of this area. They are of the east-west direction. One is located in the northern part and the other in the central part of the area. However, those roads are made of red-soil and are narrow. Thus, travel is difficult with even light rain. The car-road network is not present within the southern half of the survey area. The footpath-network is also very sparse in the whole survey area, especially, there is no footpath even along the principal rivers in wide area from the west-central to southwestern part of this area. It is necessary to use bamboo rafts to cross the Chu River in the south.

The Luong Son Mineralization Zone for the detailed geological survey is located in the central part of the Phase I area, and is about 10 km northwest of Thuong Xuan, the largest village of the Phase I area. There is one road for vehicle transport within the survey area. It takes roughly one hour by jeep from Thuong Xuan to Luong Son village which is situated 1 km east of the area.

## 2.2. Topography and Drainage Systems

### (1) Van Yen Area

The regional survey area is situated within the steep mountains whose altitude ranges from 200 m to 1,400 m and generally decreases from west eastward. The ridges run in parallel with the major geologic structures. Namely the ridges extend in the NW-SE, N-S, and WNW-ESE to E-W directions, respectively in the northeastern to southeastern, the southern, and the other parts of the area. Limestone beds occur in the central, northern, and southern parts of the area and the parts are characterized by the karst landforms. Nui Voi (altitude: 1,386 m) in the central part and Phu Gia Long (altitude: 1,349 m) in the southwest are the representative high peaks in the area.

The major drainage system also flow in the NW-SE, N-S, and WNW-ESE to E-W directions parallel to the major faults. The tributaries flow into the main rivers from the north, south, northwest, and southwest. The largest river in this area is named the Da River whose origin is in China and it flows southeastward in the southern part of the area. A large dam for electric power has been constructed at Hoa Binh on this river. Thus, the river is 800 m wide in the survey area, and many old small villages are now submerged. Other large rivers are the Mua, Khac, and Duo-Khoang Rivers.

The Suoi Boc - Suoi Cu Mineralization Zone for the detailed geological survey as well as geophysical survey is also situated in the mountainous belt that ranges in altitude from 200 m to 700 m. The principal stream of the Boc Stream flows westward. The major trend of ridges and drainage system is characterized mainly by the N-S direction.

## (2) Western Thanh Hoa Area

The topography of the whole regional survey area consists of mountain chains with 800 m to 1,300 m peaks. The altitude of the ridges generally decreases from west eastward. The ridges run in the N-S and E-W directions in the northern part, and in the NW-SE to WNW-ESE direction in the central to southern part of the survey area. Bu Rinh (altitude: 1,291 m) in the northeast, Bu Hon Han (altitude: 1,208 m) in the middle, and Pan May (altitude: 1,288 m) in the southeast are the representative high peaks in the area.

The main streams of the principal rivers generally flow eastward. Large rivers are the Chu, Cao, and Num Bung Rivers, and the first is several hundreds meters wide and the water flow is very large even in the dry season. Many V-shaped valleys are present along the main stream and tributaries of the Chu River in the south, where the valley walls are 200 m to 500 m high.

The Luong Son Mineralization Zone for the detailed geological survey shows hilly landforms that range in altitude from 20 m to 240 m. The major trend of ridges and drainage system is characterized mainly by the N-S direction.

## 2.3. Climate and Vegetation

The whole of Vietnam belongs to the Asian monsoon climatic zone. Climate is similar for the Van Yen and Western Thanh Hoa Areas, since both areas are located in the humid, semi-tropical climatic region. The areas have two

seasons, rainy (May to October) and dry (November to April). The precipitation is low during the dry season in these areas. There were three to four rainy days periodically within seven to ten days during this field survey from November to December. Rainy days are frequent until the middle of October, but almost everyday is fine from the beginning of November.

Table I-4 Monthly Meteorological Data in Hanoi

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Temperature(°C)												
Maximum	20.4	20.4	23.1	27.3	31.7	32.8	32.7	32.0	30.9	28.8	25.6	22.0
Minimum	13.8	14.7	17.5	20.8	23.9	25.5	25.7	25.4	24.3	21.6	18.2	15.0
Average	16.6	17.1	19.9	23.5	27.1	28.7	28.8	28.3	27.2	24.6	21.2	17.9
Average humidity(%)	80	84	88	87	83	83	83	85	85	85	81	81
Precipitation (mm)	18	26	48	81	194	236	302	323	262	123	47	20

(Japan External Trade Organization, 1990)

Hot days continue until the end of November with the temperature approaching 30°C, while from December, the temperature fluctuates from 20°C in the day time to below 10°C at night.

The climatic data have not been obtained for the survey areas concerned. The monthly data in Hanoi is listed in Table I-4 for reference. The temperature and precipitation are respectively lower and higher in the mountainous survey areas than the data below.

The areas of low altitude are covered by subtropical rain forest in both regional survey areas. Most of the mountainous parts, on the other hand, belong to the tropical high forest zone, and generally are covered by the dense evergreen broadleaf and coniferous trees. Most of the lowlands have been cultivated for paddy rice because of much river water supply, and many places have also been cultivated for upland rice by the slash-and burn agriculture even on the steep mountain sides.

### CHAPTER 3. GENERAL GEOLOGY AND MINERALIZATION

Comprehensive review of geology and mineral resources of Vietnam was carried out by Dang Trung Ngan et al., (1981), GSV (1990), UNESCAP (1990), and GSV (1991).

These are excellent reference material for understanding the geologic conditions of the country. UNESCAP (1990) is based principally on a book titled "Geology and Mineral Resources of Viet Nam", issued by the General Department of Mines and Geology (GDMG) of Viet Nam in December 1988.

Although stratigraphy of each geologic province has been reported using representative stratigraphic names in GSV (1991), these names are not accepted in this report due to difficulty in specifying their type localities, but the symbols of the geologic units in the above report are adopted as a rule.

#### 3.1. General Geology

The geology of the northern part of Vietnam is divided into four tectonic provinces bounded. They are the "Littoral Bacbo" and "Vietbac" provinces in the north-east and the "West Bacbo" and "Truongson" provinces in the south-west (GSV, 1991) as shown in the Figure I-3-1. The Van Yen Area is located in southern end of the "West Bacbo" and the Western Thanh Hoa Area is situated in northern end of the "Truongson" province.

The "West Bacbo" tectonic province is in fault contact with the "Truongson" province. This is the Ma River fault trending in the NW-SE direction along the Ma River. The Paleozoic, Mesozoic, and Cenozoic strata are accumulated successively over the Proterozoic units in both provinces, however, there are some geological differences (see Figure I-3-2 and I-3-3).

In and around the survey areas, the Proterozoic to Cambrian ( $PR_{1,2}$ ,  $PR_3 \in_1$ ), Cambrian to Lower Ordovician ( $\in_0$ ), Lower to Middle Devonian ( $D_{1,2}$ ), and Upper Permian to Upper Triassic ( $P_2 T_1$ ,  $T_2$ ,  $T_{2,3}$ ,  $T_3$ ) strata are widely developed, and the Ordovician to Silurian (SO), Upper Silurian to Lower Devonian ( $S_2 D_1$ ), Upper Jurassic to Upper Cretaceous ( $J_3 K$ ,  $K_2$ ) units are partly found. The Cenozoic formations with the exception of the Quaternary unit is restricted and sporadic.

The Proterozoic to Cambrian ( $PR_{1,2}$ ,  $PR_3 \in_1$ ) and Cambrian to Lower Ordovician ( $\in_0$ ) units occur mainly on the right banks of the Da and Ma

Rivers, and are composed of metamorphic rocks, namely crystalline schist, quartzite, and marble as well as limestone. The Lower to Middle Devonian ( $D_{12}$ ) are composed of terrestrial red clastic rocks and marine sedimentary rocks consisting mainly of shale and sandstone, and occur on the periphery of the Proterozoic to Cambrian and Cambrian to Lower Ordovician masses. The Upper Permian to Upper Triassic ( $P_2T_1, T_2, T_{23}, T_3$ ) units occur most widely in the survey areas. They are composed mainly of sedimentary rocks, namely carbonate rocks, sandstone, and shale and occur partly with volcanic and pyroclastic rocks, such as andesite, basalt, and rhyolite. Felsic volcanic rocks judged to be the Jurassic to Cretaceous also widely occur in the "Truongson" province in the south.

Intrusive magmatism in the northern part of Vietnam took place in four stages, namely, Proterozoic, Early to Middle Paleozoic, Late Paleozoic to Early Mesozoic, and Late Mesozoic to Early Cenozoic times (Figure I-3-1 and I-3-2).

In and around the survey areas, the Proterozoic intrusives ( $\gamma_1, \gamma_2$ ) intruded concordantly into the Proterozoic metamorphic rocks on the right bank of the Hong River. Besides, Early to Middle Paleozoic felsic rocks ( $\gamma_3$ ) consisting of diorite and granite and Late Paleozoic to Early Mesozoic felsic rocks ( $\gamma_4$ ) of same nature as the above are located on the right bank of the Ma River ("Truongson" province) occurring as fairly large masses. Regarding ultramafic and mafic rocks, Early to Middle Paleozoic rocks ( $\sigma_3, \nu_3$ ) and Late Paleozoic to Early Mesozoic rocks ( $\sigma_4, \nu_4$ ) are found. They consist of dunite and gabbro and turn out generally in the shape of small lenticular bodies. Although Late Mesozoic to Early Cenozoic intrusives ( $\gamma_5$ ) are widely developed in the Tu Le region, the central part of the "West Bacbo" province, they are restricted in the southern part of the Western Thanh Hoa Area.

### 3.2. General Geologic Structure

Geologic structure of the northern part of Vietnam is complicated from repeated tectonic movements extending over long geological age. Every tectonic province, such as "West Bacbo", "Truongson" and others, is aligned basically in the NW-SE direction. Boundaries of tectonic provinces are the main tectonic lines which extend in the NW-SE direction along the Hong and Ma Rivers. Many NW-SE faults parallel to the main tectonic lines exist in the tectonic provinces and control the occurrence of strata. Furthermore, intrusive rocks occur concordantly with the NW-SE structures.



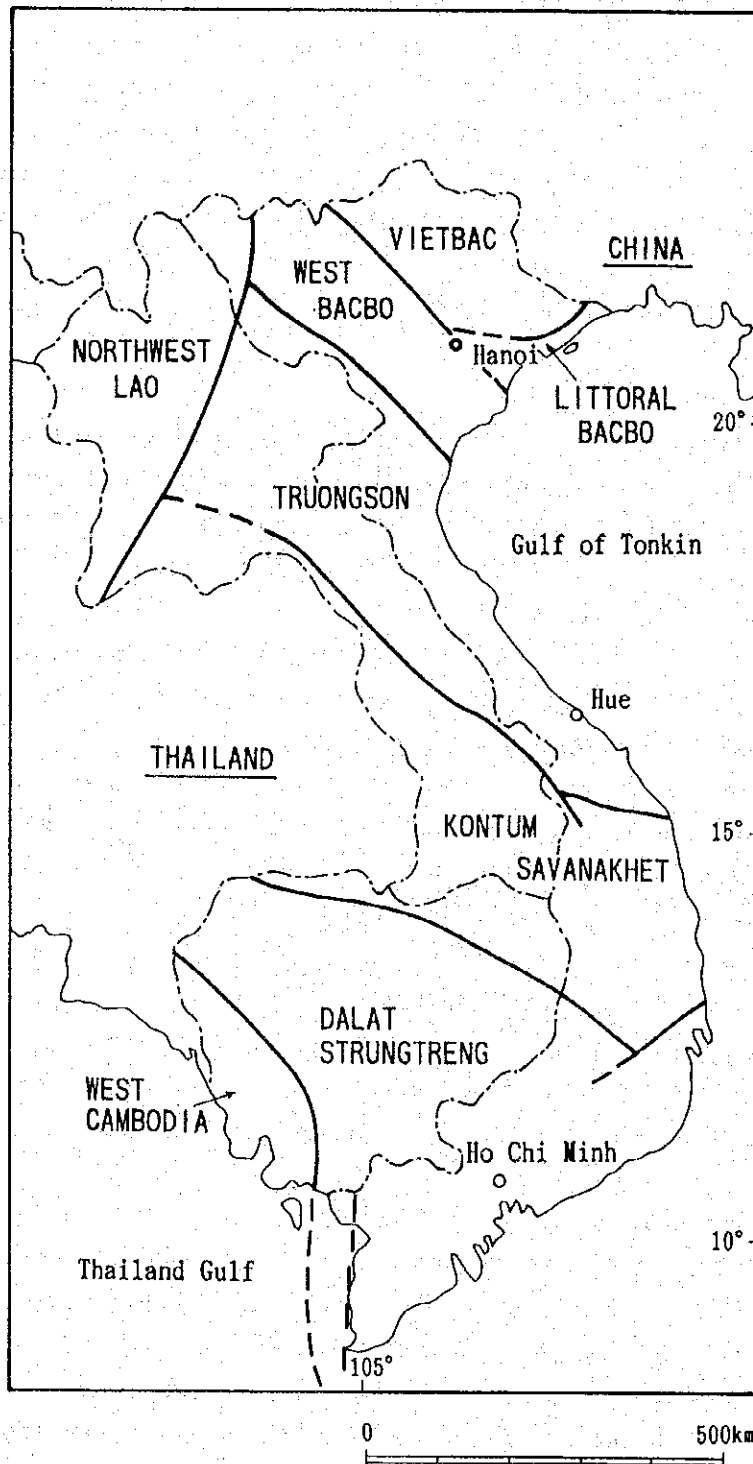


Fig. I -3-1 Tectonic Provinces of Vietnam, Laos, and Cambodia

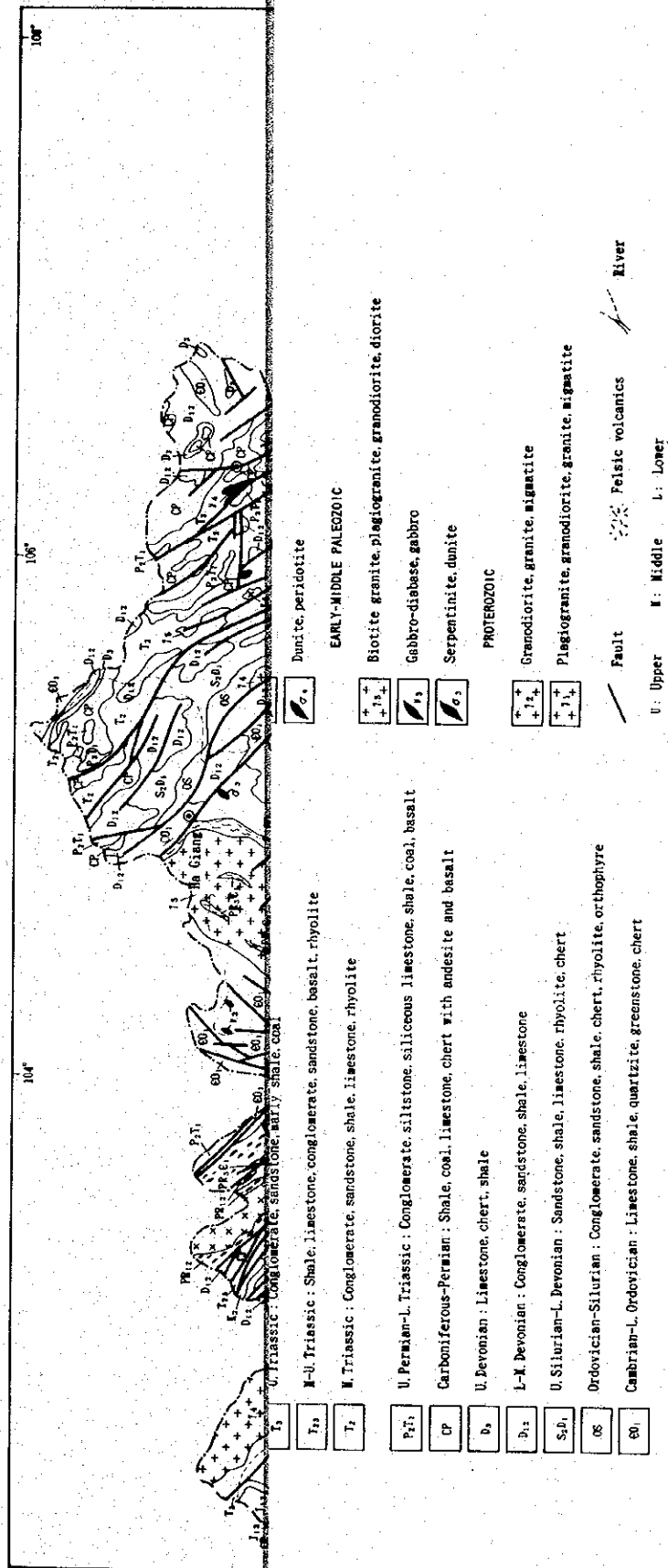
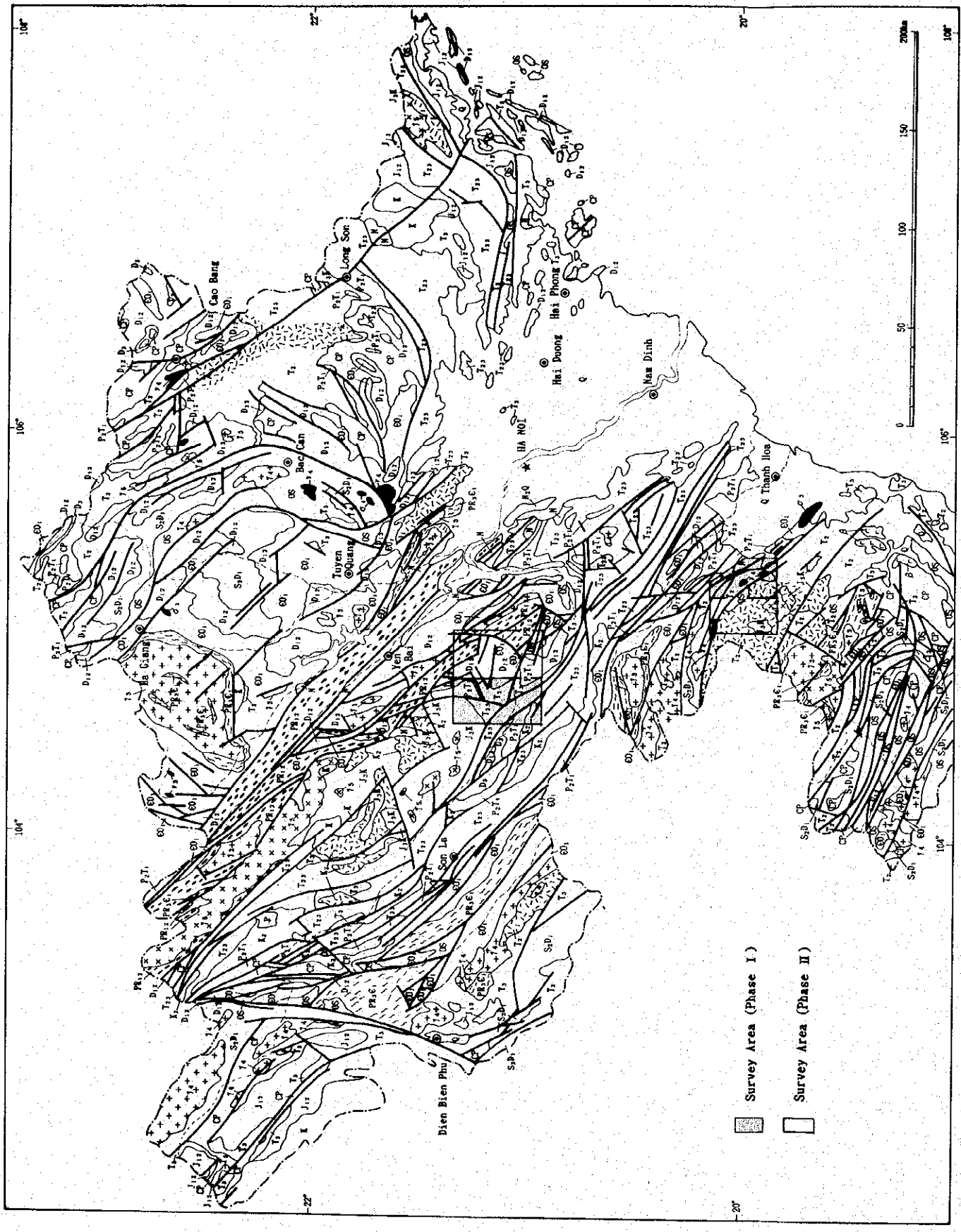


Fig. I -3-2 Generalized Geologic Map in the Northern Part of Vietnam



(Simplified from ESCAP, 1990)

LEGEND

STRATIFIED ROCKS

- Q  $\beta$  Quaternary : Alluvium with marine deposits in coastal area.  $\beta$  : Basalt
- N<sub>0</sub> Neogene-Quaternary : Gravel, clay, pebble, laterite
- N Neogene : Conglomerate, sandstone, claystone, lignite
- P Paleogene : Trachyte, leucitophyre
- K<sub>1</sub> U. Cretaceous : Red continental deposits-conglomerate, sandstone, siltstone
- K Cretaceous : Red continental deposits of conglomerate, sandstone, siltstone, rhyolite
- J<sub>1</sub> U. Jurassic-Cretaceous : Orthophyre, tuff, basalt, rhyolite
- J<sub>2</sub> L-M. Jurassic : Continental deposits of conglomerate, sandstone, siltstone
- T<sub>1</sub> U. Triassic : Conglomerate, sandstone, shaly shale, coal
- T<sub>2</sub> M-U. Triassic : Shale, limestone, conglomerate, sandstone, basalt, rhyolite
- T<sub>3</sub> M. Triassic : Conglomerate, sandstone, shale, limestone, rhyolite
- P-T<sub>1</sub> U. Permian-L. Triassic : Conglomerate, siltstone, siliceous limestone, shale, coal, basalt
- CP Carboniferous-Permian : Shale, coal, limestone, chert with andesite and basalt
- D<sub>1</sub> U. Devonian : Limestone, chert, shale
- D<sub>2</sub> L-M. Devonian : Conglomerate, sandstone, shale, limestone
- S<sub>1</sub> U. Silurian-L. Devonian : Sandstone, shale, limestone, rhyolite, chert
- OS Ordovician-Silurian : Conglomerate, sandstone, shale, chert, rhyolite, orthophyre
- G Cambrian-L. Ordovician : Limestone, shale, quartzite, greenstone, chert

- U Proterozoic-L. Cambrian : Schist, quartzite, dolomite
- L-M Proterozoic : Gneiss, amphibolite, quartzite, marble

INTRUSIVE ROCKS

- LATE MESOZOIC-EARLY CENOZOIC
  - Granodiorite, granite, granosyenite, diorite
- LATE PALEOZOIC-EARLY MESOZOIC
  - Biotite granite, granophyre, granodiorite, diorite
  - Gabbro
  - Dunite, peridotite
- EARLY-MIDDLE PALEOZOIC
  - Biotite granite, plagiogranite, granodiorite, diorite
  - Gabbro-diorite, gabbro
  - Serpentinite, dunite
- PROTEROZOIC
  - Granodiorite, granite, migmatite
  - Plagiogranite, granodiorite, granite, gneiss

- Fault
- U : Upper M : Middle L : Lower
- Felsic volcanics
- River

Fig. I -3-2 Generalized Geologic Map in the Northern Part of Vietnam





The "West Bacbo" and "Truongson" provinces are situated at the contact of South China and Indochina plates. It is generally believed that the separation and joining of these two plates had been repeated during Paleozoic to Cenozoic times, but detailed tectonics are not verified yet. These plate movements were accompanied with the formation of rift zones, obduction zones, and subduction zones, as well as with sedimentation, NW-SE striking strata, and the formation of tectonic lines.

Structural control in the NW-SE direction is remarkable also in the survey areas. The wide spread Upper Permian to Upper Triassic ( $P_2T_1$ ,  $T_2$ ,  $T_{2,3}$ ,  $T_3$ ) units cover an area of 20 to 40 km wide elongated in the NW-SE direction. The Proterozoic to Cambrian ( $PR_{1,2}$ ,  $PR_3 \in_1$ ) and Lower Paleozoic ( $\in_0$ ,  $S_0$ ,  $D_{1,2}$ ) units are also located in a horseshoe-shaped area elongated in the NW-SE direction. These strata use to contact with each other by NW-SE trending faults. Intrusives on the right bank of the Ma River are concordant with the NW-SE structures and small lenticular ultramafic to mafic intrusives also occur scattered along the NW-SE trending tectonic lines.

### 3.3. Mineralization

The long and eventful tectonic movements in Vietnam resulted in a variety in mineralization. Metallogenic epochs can be divided into the following five.

- Precambrian epoch
- Early to Middle Paleozoic epoch
- Indosinian epoch (Late Carboniferous to Late Triassic)
- Late Mesozoic to Early Cenozoic epoch (mainly Cretaceous to Paleogene)
- Neogene to Quaternary epoch

Many useful mineral deposits and showings are located in the northern part of Vietnam as shown in Figure I-3-4. Based on the UNESCAP (1990), several mineral deposits and showings of gold, copper-nickel, tin-tungsten, and placer chromite are revealed in and around the survey areas. Lead-zinc deposits and showings are also observed, but they seem to be small.

Known mineral deposits in and around the survey areas are summarized below.

As gold deposits, the Kim Boi deposit in the central part of the Ha Son Binh Province, and the Lang Neo, the Lang Mo, and Cam Tam deposits in the northern part of the Thanh Hoa Province are known. These are vein deposits

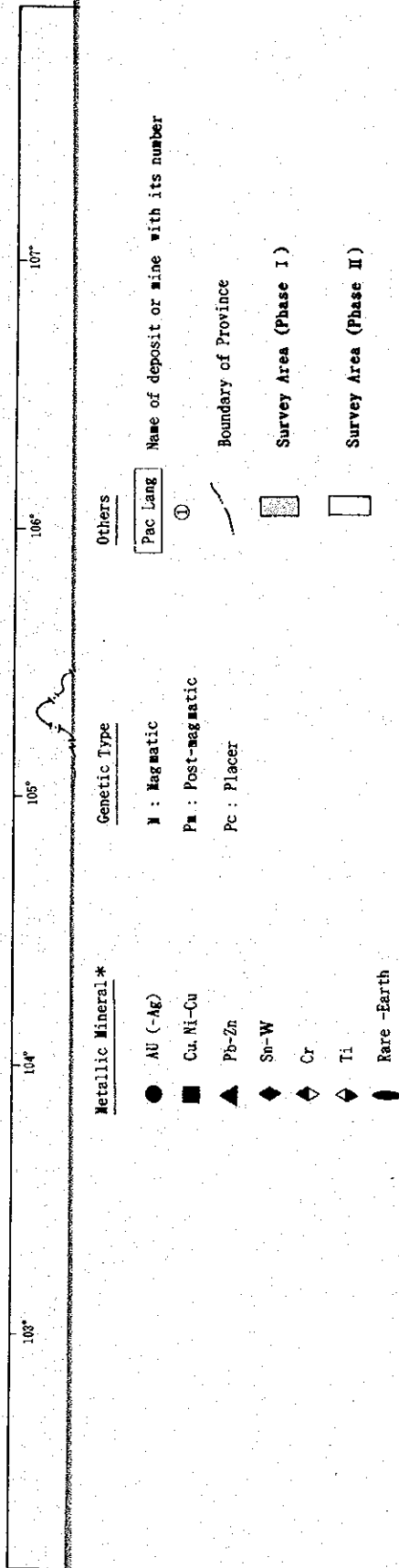
emplaced in the Cambrian limestone, Late Permian and Early Triassic mafic volcanics and Triassic sediments. The Suoi Tiat mine is now under operation in the western part of the Van Yen Area as gold bearing copper deposit. Placer gold deposits are found in most of the streams in the mountains. These are rather small and not known in detail.

As a representative nickel-copper deposit, the Ban Phuc deposit is known in Ta Khoa region, Son La Province. This largest nickel-copper sulfide deposit in Vietnam is of vein and dissemination type accompanying ultramafic bodies of Permian to Triassic age. This deposit is located on the right bank of the Da River in the Da River Mobile Belt.

As tin-tungsten deposit, the Quy Hop deposit composed mainly of placer is known in the Nghe An Province. Also cassiterite-sulfide veins are found in crystalline schist in the vicinity. Tin-tungsten pneumatolytic to hydrothermal mineralization zones are developed in the Bu Me Prospect in the Western Thanh Hoa Area. This is now being explored by GSV.

As placer chromium deposit, one in Nui Nua region in the eastern part of Thanh Hoa Province is known. This deposit is situated around an Early to Middle Paleozoic ultramafic body and has been mined for a long time in large scale.

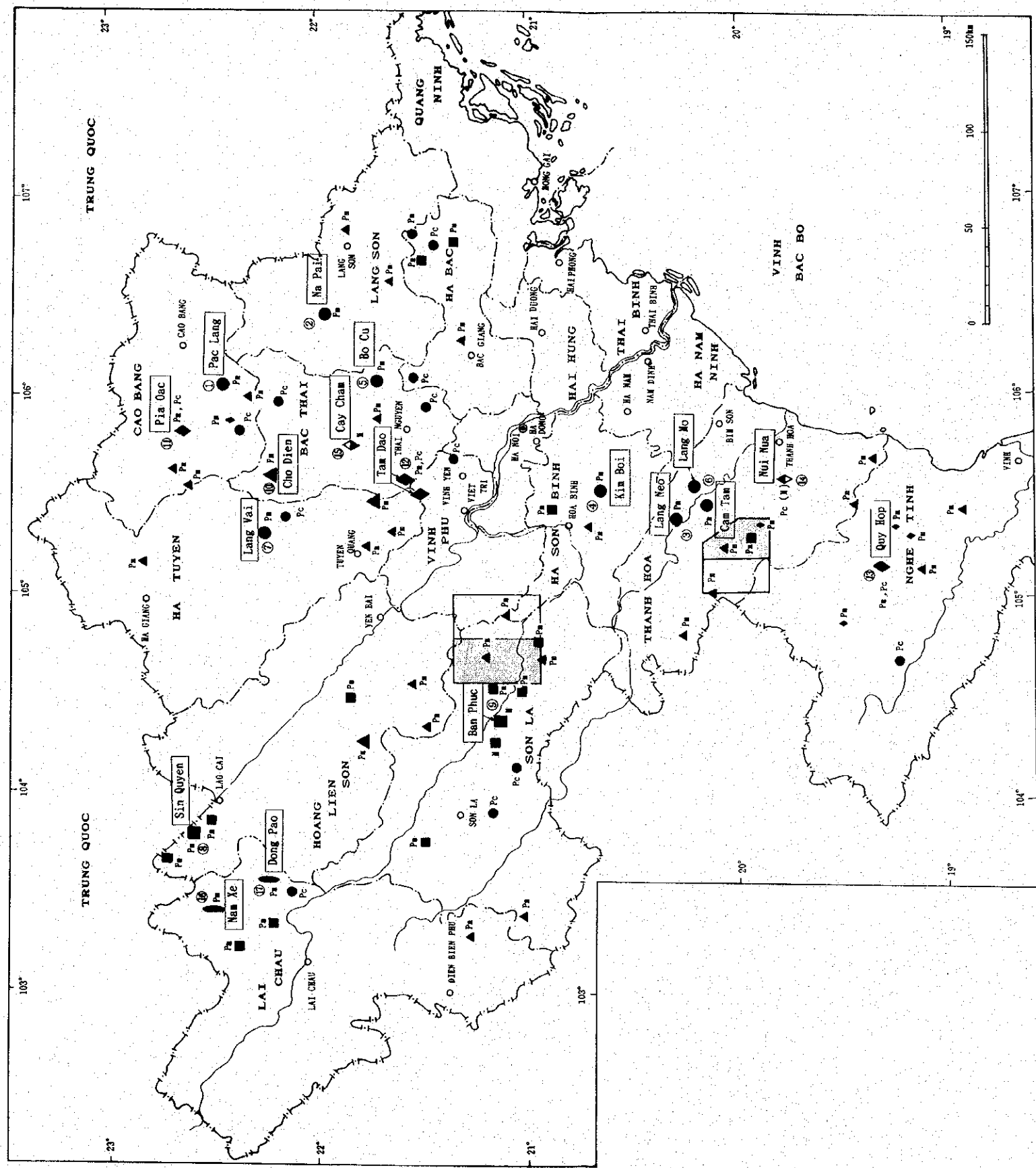
As lead-zinc deposit, the Cho Dien deposit in the Bac Thai Province is well known. In the survey areas, however, lead-zinc deposits are sporadically located, and details on dimensions and location are not known.



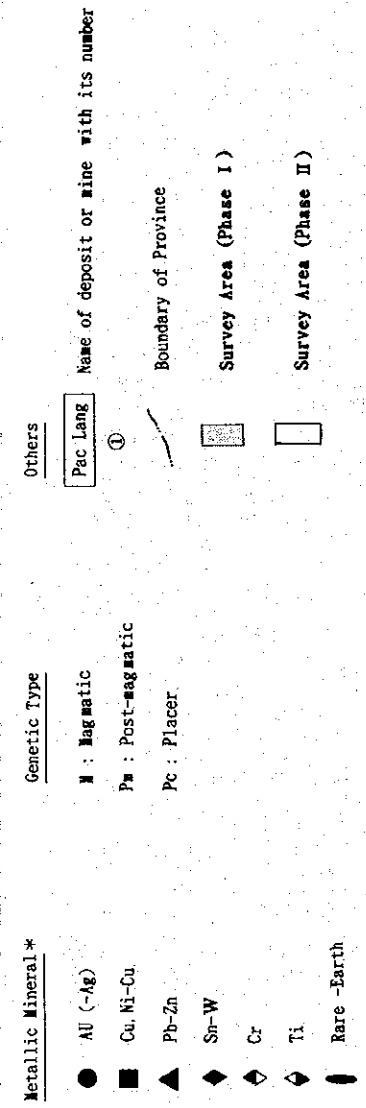
\*Smaller size symbols may show occurrences of the minerals concerned. They have not been described in the text of ESCAP REPORT, 1990.

Fig. I -3-4 Distribution Map of the Major Ore Deposits in the Northern Part of Vietnam





(Simplified from ESCAP, 1990)



\*Smaller size symbols may show occurrences of the minerals concerned. They have not been described in the text of ESCAP REPORT, 1990.

Fig. I -3-4 Distribution Map of the Major Ore Deposits in the Northern Part of Vietnam



**PART II ANALYSIS OF AVAILABLE  
RELEVANT DATA**



## **PART II ANALYSIS OF AVAILABLE RELEVANT DATA**

### **CHAPTER 1. PREVIOUS SURVEYS**

#### **1.1. Van Yen Area**

The geological surveys and geochemical exploration have been carried out covering the whole regional geological survey area. Some geologic maps have already been published at scales of 1:1,500,000, 200,000, and 50,000, but the 1:50,000 maps have not been completed.

Soil and panned concentrate geochemical exploration was done in the past with considerably high density. The amount of collected samples is not disclosed, but it is inferred to amount to more than 5,000. The panned-concentrate sampling is particularly popular in Vietnam. Thus, the panning skill is high. The compilation results of the above data are shown in Plate 1. Within the Suoi Boc - Suoi Cu Mineralization Zone for the detailed geological survey as well as geophysical survey, the electric (IP method) survey was conducted in and around the Suoi Cu mineral showing.

The available relevant data in both areas are laid out in Table II-1-1. Additionally, a list of the known mineral showings in the regional survey area is given in Table II-1-2.

#### **1.2. Western Thanh Hoa Area**

The geological survey was carried out covering the whole regional geological survey area in the past. Two kinds of geologic map have already been published at scales of 1:1,500,000 and 200,000. In addition to those surveys, the detailed geological survey was conducted in the Luong Son Mineralization Zone for the detailed geological survey and 1:10,000 scale geologic map has been prepared. In this Zone the electric (resistivity method), magnetic, and radiometric surveys were conducted along one survey line (2,750 m long) running through the central part of the zone. Moreover, the trenching was carried out at a quartz-vein float belt which is located in the southwestern part of the Mineralization Zone.

Table II-1-1 List of the Available Relevant Data

1. Van Yen Area

Name of Data	No. of Sheet	Scale	Author
1. Geologic and mineral resources map with geochemical anomalies of the Van Yen Area	3	1:50,000	GSV
2. Map of geophysical survey lines and results of electrical survey of the Suoi Cu mineral showing	1	1:10,000	GSV
3. Geophysical profiles with geologic section of the Suoi Cu mineral showing	1	1:10,000	GSV
4. Plan map of $\eta_K$ , $\rho_K$ , and $\Delta V$ profiles of the Suoi Cu mineral showing	1	1: 2,500	GSV
5. Stratigraphic column of the Van Yen Area	1	1:25,000	GSV

2. Western Thanh Hoa Area

Name of Data	No. of Sheet	Scale	Author
1. Geologic map of the Luong Son Mineralization Zone	1	1:10,000	GSV
2. Profiles of electrical, magnetic, and radiometric surveys in the Luong Son Mineralization Zone	1	1:25,000	GSV

Table II-1-2 Characteristics of the Known Mineral Showings Based on the Available Relevant Data

Mineral showing	Location	Type	Ore Mineral	Gangue mineral	Ore grade	Host rock	Exploration
Suoi Can	Uppermost reaches of the Suoi Can	vein	Ga, Sph, Py	Cal	Pb : 3.4~5.9% Zn : 4.19%	Limestone	Trench
Suoi Khoang A	Right bank of the Suoi Khoang	vein	Ga, Sph, Py	Cal, Ba	Pb : 0.2~2.08% Zn : 4.9%	Limestone	
Suoi Khoang B	ditto	vein	Ga, Sph, Py	Cal	Pb : 2.4% Zn : 4.9%	Limestone	
Kiet Son	6 km southeast of Kiet Son	?	Pt, Ni, Cp	?	?	Peridotite	
Suoi Nho	Lowermost reaches of the Suoi Nho	?	Pt, Ni, Cp	?	?	Mudstone	
Suoi Tioun A	Upper reaches of the Suoi Tioun	?	Ni, Cp, (Pt)	?	?	Peridotite	
Suoi Tioun B	Lower reaches of the Suoi Tioun	?	Pt, Ni, Cp	?	?	Mudstone	
Xom Lai	Uppermost reaches of the Suoi Nghi	diss	Pt, Ni, Cp	?	Cu : 0.03~0.09%	Peridotite	

[Abbreviation] Ga : galena, Sph : sphalerite, Py : pyrite, Pt : platinum, Ni : nickel minerals  
Cp : chalcopyrite, Cal : calcite, Ba : barite, diss : dissemination

## CHAPTER 2. ANALYSIS OF AVAILABLE RELEVANT DATA

### 2.1. Mineralization

#### 2.1.1. Van Yen Area

The following characteristics regarding mineralization of the regional geological survey area have been recognized in the data acquired by the past exploratory work. Gold, lead-zinc, and platinum-copper-nickel mineralization is known in this area.

Gold grains were microscopically confirmed and three zones in this area are high in density of the localities where the grains were observed. However, the essential characteristics of gold mineralization as primary deposits still remain unsolved.

The lead-zinc mineralization is found in the areas of Devonian and Carboniferous to Permian carbonate rocks. No intrusive body except for ultramafic rocks occurs in the areas. Nevertheless some subsurface contact metasomatic deposits are inferred to have possibly been emplaced in the wide areas of carbonate rocks (see Plate 1).

Platinum-copper-nickel mineral showings are recognized within the ultramafic intrusive bodies in the western and central parts of this area. This mineralization seems to have close genetic relation to those intrusive bodies.

Additionally, the Suoi Cu mineral showing consists of vein-type lead-zinc deposits emplaced in Middle Triassic limestone.

#### 2.1.2. Western Thanh Hoa Area

Only one lead-zinc mineral showing has been described in this regional geological survey area (see Plate 2). Additionally, one copper mineral showing was found near a gabbroic body in the vicinity of the northern end of the survey area (outside the area). The characteristics such as occurrence and dimensions are not known from the data of the past exploratory work. The lead-zinc mineralization is present within the Undiscriminated Jurassic felsic pyroclastic area. It is said that the regional survey area has not been sufficiently studied yet due to difficult accessibility.

In the southeastern part of the Phase I area, on the other hand, the tungsten mineralization is observed in the Bu Me Prospect. The mineralization



zones are developed in the center and peripheries of the Cretaceous granites and the mineralization has close genetic relation to the rocks. The Cretaceous granitic bodies are also recognized in several parts of the regional survey area of this phase. Thus the tin-tungsten mineralization similar to that of the Bu Me Prospect possibly occur in and around the bodies.

## 2.2. Previous Geochemical Exploration

### 2.2.1. Van Yen Area

As previously mentioned in the section 1.1., soil and panned concentrate geochemical exploration was carried out in this regional survey area. The pathfinder elements were Au, Cu, Pb, Zn, Ni, Cr, and Co. Heavy minerals were observed under microscope in the panned concentrate samples. During the present survey, Plate 1 showing the geochemical anomalous zones was compiled from the existing data. The results of the previous exploration can be summarized as follows.

#### Au:

Localities where gold grains were confirmed microscopically are plotted and the extent of these localities are delineated on the map. The map shows that these localities are densely distributed in the lower reaches of the Mua River in the north, on the left bank of the Da River in the central part, and in the southeastern part of the survey area.

#### Cu:

The map shows the zones of anomalies of soil geochemistry ( $\text{Cu} \geq 0.003$  and  $0.005$  %). Most of these zones are scattered in a wide area except for the northeastern and southwestern parts of the area. Each zone is generally wide.

#### Pb:

The anomalous zones ( $\text{Pb} \geq 0.002$  %) of soil geochemistry are delineated in the map. These zones are located in the northwestern edge, east-central part, and southwestern part (on the right bank of the Da River) of the area.

#### Zn:

The map shows the zones of anomalies of soil geochemistry ( $\text{Zn} \geq 0.015$  %), and they are sporadically scattered in the eastern part of the area.

#### Ni:

The anomalous zones ( $\text{Ni} \geq 0.01$  %) were detected through soil geochemistry. These zones roughly overlap those of Cu.

#### Cr:

Two kinds of anomalous zones ( $\text{Cr} \geq 0.005$  % and  $\text{CrO} \geq 12$  g/m<sup>3</sup>) were obtained through the soil and panned concentrate geochemistry. They are abundant and found in an area from the northwest to central part of this survey area.

Co:

Many anomalous zones ( $Co \geq 0.003 \%$ ) of soil geochemistry are shown on the map. They are located in the central part, and most of them roughly overlap those of Cu, Ni, or Cr.

In addition to the above zones, occurrence of non-metallic minerals such as apatite, barite, and others were also examined together with the above metallic minerals.

#### 2.2.2. Western Thanh Hoa Area

The geochemical exploration was not conducted both for the soil and panned concentrate samples over the whole regional survey area. Therefore, the anomalies of metallic minerals are not known at present in this area.

### 2.3. Previous Geophysical Survey

#### 2.3.1. Van Yen Area

As previously mentioned in the section 1.1., the electrical survey (IP method) was conducted in the Suoi Cu mineral showing which is located in the east of the detailed geological survey area of this phase. Plate 3 was prepared showing the location of survey lines, distribution of IP anomalous zones and so on. Fourteen survey lines of 50 m or 100 m interval were laid out extending in the direction of  $N60^\circ E$ . The survey method is the horizontal electric profiling by means of the Schlumberger's electrode array. The potential electrode spacing is horizontally 5 m. The summary of the results of the survey is as follows.

High FE (frequency effect) was detected at four points including a known ore vein on the line perpendicular to the outcrop of the vein. The values of MCF (metal conduction factor;  $\eta_k^* = \% / 0-m$ ) are also relatively high at those points. Thus it is interpreted that other three anomalies should indicate the occurrence of veins near the surface of the line in addition to the known vein. Three IP anomalous zones were detected in the survey area. They extend roughly in the NNW-SSE direction and are 50 m to 70 m wide.

#### 2.3.2. Western Thanh Hoa Area

The electrical (resistivity method), magnetic, and radiometric surveys were carried out along one survey line which runs through the central part of the Luong Son Mineralization Zone. The results of the previous detailed geological survey and profiles of the above three kinds of survey were compiled in Plate 4. The following results were obtained through the

geophysical surveys.

The resistivity ( $\rho_k$ ) is high on the east of the gabbroic body located in the central part of the area of Phase II. The high anomalous zone appears as the topographical affection because the part geomorphologically forms a remarkable ridge zone extending in the N-S direction. The total magnetic intensity ( $\Delta T$ ) is extremely high in the northeastern part of the area, where mafic rocks with ferromagnetism can occur underground. Additionally, radioactive intensity ( $I_r$ ) is relatively low on the zone of the above gabbroic body and in the northeastern part, and relatively high in sandstone area. Several peaks are observed within the profile of sandstone area and two of them coincide with the localities of quartz-vein outcrops.

#### 2.4. Promising Areas Based on the Available Relevant Data

##### 2.4.1. Van Yen Area

The principal mineralization of this regional survey area is interpreted to be gold, lead-zinc, and platinum-copper-nickel from the results of previous work. As described earlier, primary deposits of gold are unknown. Lead-zinc mineralization can be metasomatic type in Devonian and Carboniferous to Permian limestone area, and platinum-copper-nickel mineralization is considered to be accompanied by the ultramafic intrusive activities. Therefore the higher priority was given to the following areas in terms of exploration program of this phase than to the other.

- (1) Three zones where the gold grains were confirmed from panned concentrate samples
- (2) Devonian and Carboniferous to Permian limestone area
- (3) Area of high density of ultramafic bodies

Regarding gold mineralization, three zones of the above (1) was paid attention because the primary gold deposits have not discovered yet.

The Devonian and Carboniferous to Permian limestone area is promising for lead-zinc mineralization, particularly in the west to east-central wide part of this survey area. Some mineral showings of lead-zinc have been found in this part. Occurrence of skarn type deposits is a possibility in the part in view of the above showings and the presence of geochemical anomalous zones of Pb.

There are an alignment of six Cu, Cr, Ni, and Co geochemical anomalous

zones in the west to east-central part of the area. These zones occur superimposed, and abundant ultramafic bodies intruded into this part. Furthermore, the Ban Phuc deposit is located 40 km west of the survey area. It is an orthomagmatic nickel-copper deposit associated with ultramafic rock bodies. Therefore, these zones may have mineral potential similar to the Ban Phuc deposit, including platinum mineralization.

#### 2.4.2. Western Thanh Hoa Area

The principal mineralization is of lead-zinc, tin-tungsten, and copper in this regional survey area, based on the results of past work. It is supposed that the above mineralization has genetic relation to the Undiscriminated Jurassic (?) felsic volcanic activity, Cretaceous granitic intrusion, and Triassic mafic rock intrusion, respectively. Thus special attention should be paid to the alteration zones of Jurassic (?) felsic pyroclastic rock area, and occurrence of granitic bodies as well as mafic intrusive bodies.

The following metallic mineral deposits are possibly found in three parts of the survey area shown below.

- (1) Pb-Zn: western part
- (2) Sn-W : eastern half
- (3) Cu : northern part

In the Luong Son Mineralization Zone, on the other hand, some peaks on the radioactive intensity profile may indicate occurrence of subsurface quartz veins, in addition to the coincidence between the known veins and peaks.