2.3. and Plate 3).

Samples for assay were collected at 10 localities except for the above two mineralization zones during the detailed geological survey of this phase. Most of them are limestone with weak dissemination of very fine-grained black metallic minerals. The assay results of the samples are laid out in Plate 10. No remarkable lead-zinc mineralization is recognized from the results.

3.3. Soil Geochemical Exploration

3.3.1 Objectives

This exploration was carried out aiming to extract new potential areas for ore body similar to the known Suoi Boc Prospect around the Prospect.

3.3.2. Sampling and chemical analysis

Soil samples were collected from the residual soil (B-layer) 30 to 40 cm deep from the surface. The sampling points are arranged along the geophysical survey lines with intervals of every 100 m apart (every 50 m near the Suoi Boc Prospect; see Plate 10). One hundred samples of about 100 g each were collected. The samples were sieved after drying and under 1 mm fraction was sent to the laboratory (the Geoscience Laboratory of Bishimetal Exploration Co., Ltd.). They were analyzed for 9 elements of Au, Ag, Cu, Pb, Zn, Cd, As, Sb, and Hg. Analytical methods used and detection limits of 7 elements except for Cd and Sb are the same as those of stream sediment geochemistry in the Van Yen Area described in the Chapter 2 of Part Ⅲ. Two elements of Cd and Sb were analyzed by the method of ICP and their detection limits are 0.1 ppm and 0.2 ppm, respectively.

3.3.3. Statistical data-processing

(1) Elemental statistics

Analytical values of each element are recorded in Appendix 10. Elemental statistics parameters calculated by anti-logarithm and common logarithm for analytical values are shown in Table Ⅲ-3-1. On the occasion of values below the detection limit, one half of detection limit values were substituted.

(2) Frequency distribution

Histograms of analytical values of each element drawn by logarithm are shown in Figure Ⅲ-3-2. There is no element of which histogram follows normal or log-normal distribution. This is mainly attributed to the fact that number of samples is rather small as one hundred and samples are composed of soil collected from particular area where ore deposits are believed to exist.

Element Au of which most of values are below the detection limit shows the L-shape pattern and the rest of elements show the irregular pattern with gently-sloping part on higher-value side.

(3) Correlation among elements

Correlation coefficients and correlation diagrams are shown in Table Ⅲ-3-2 and Figure Ⅲ-3-3, respectively. Elements except Au and As are correlative in the area. Especially, elements Pb, Zn, Cd, and Sb show strong normal correlation. Furthermore, Ag, Cu, Hg, and said four elements show relatively good correlation. It thus appears that these seven elements behaved together in a group.

3.3.4. Geochemical anomalies and anomalous zones

(1) Determination of threshold value

In order to determine threshold values, the same method used in the stream sediment geochemical exploration in the Van Yen Area was adopted. The cumulative frequency distribution diagrams of each element were drawn on logarithmic probability graph paper (Figure Ⅲ-3-4).

Diagrams of Pb and Zn show clear breaking points and consequently indicate existence of high content population. On Pb diagram, value at the breaking point is around 60 ppm and 35 % of samples are above this value. While on Zn diagram, value at the breaking point is around 250 ppm and 20 % of samples are above this value. Difference of percentages of samples above threshold values between Pb and Zn is probably due to insufficient quantity of samples.

As for the rest of elements, cumulative frequency distribution diagrams are uneven owing to insufficiency of samples. Therefore, clear breaking points are not observed and existence of high content population is uncertain. However, elements Ag, Cu, Cd, Sb, and Hg show good correlation with Pb and Zn, and this leads to estimation that these elements have the same high content parts with Pb and Zn.

As above, it is difficult to institute threshold values by the cumulative frequency distribution diagrams in the case of insufficient quantity of about 100 samples. In consequence, elements Pb and Zn which show the clear breaking points on the cumulative frequency distribution diagrams were remarked here. High content zones of elements Pb and Zn are delineated in maps of Appendix 15 (anomaly map) by means of iso-content contours, and further, anomalous points with values above threshold are also plotted on the maps. The threshold

Table Ⅲ-3-1 Elemental Statistics Parameters in Soil Geochemistry of the Suoi Boc - Suoi Cu Mineralization Zone

Antilog	Au	Ag	Cu	Pb	Zn	Cd	As	Sb	Hg
Minimum	0. 5	0. 01	8. 0	13. 3	38	0. 05	0. 1	0. 1	36
Maximum	6	14. 36	159. 6	29, 842. 8	73, 754	165. 2	439. 5	31. 5	810
Average (m)	0. 7	0. 72	24. 2	618. 7	1, 281	2. 5	34. 5	1. 1	88
Standard deviation (σ)	0. 6	1. 86	17. 5	3, 136. 6	7, 523	16. 6	58. 4	3. 8	125
PLDL*[1]	84%	17%	0%	0%	0%	6%	13%	64%	0%

*[1] : Percentage of less than detection limit

Log	Au	Ag	Cu	Pb	Zn	Cd	As	Sb	Hg
Minimum	-0. 301	-2. 000	0. 903	1. 124	1. 580	-1. 301	-1. 000	-1. 000	1. 556
Maximum	0. 778	1. 157	2. 203	4. 475	4. 868	2. 218	2. 643	1. 498	2. 909
Average (m)	-0. 234	-0. 750	1. 326	1. 842	2. 165	-0. 638	0. 950	-0. 614	1. 815
Antilog	*0. 6*	*0. 18*	*21. 2*	*69. 6*	*146*	*0. 2*	*9*	*0. 2*	*65*
Standard deviation (σ)	0. 178	0. 756	0. 203	0. 661	0. 616	0. 621	0. 945	0. 614	0. 258

Table Ⅲ-3-2 Correlation Coefficients between Element Pairs in Soil Geochemistry of the Suoi Boc - Suoi Cu Mineralization Zone

	Au	Ag	Cu	Pb	Zn	Cd	As	Sb	Hg
Au	1								
Ag	-0. 226	1							
Cu	-0. 086	0. 647	1						
Pb	-0. 172	**0. 712**	**0. 701**	1					
Zn	-0. 163	0. 679	**0. 732**	**0. 959**	1				
Cd	-0. 189	0. 641	0. 649	**0. 907**	**0. 930**	1			
As	-0. 086	0. 683	0. 529	0. 593	0. 530	0. 450	1		
Sb	-0. 048	0. 607	0. 685	**0. 893**	**0. 901**	**0. 828**	0. 538	1	
Hg	-0. 032	0. 513	0. 609	**0. 809**	**0. 828**	**0. 813**	0. 323	**0. 776**	1

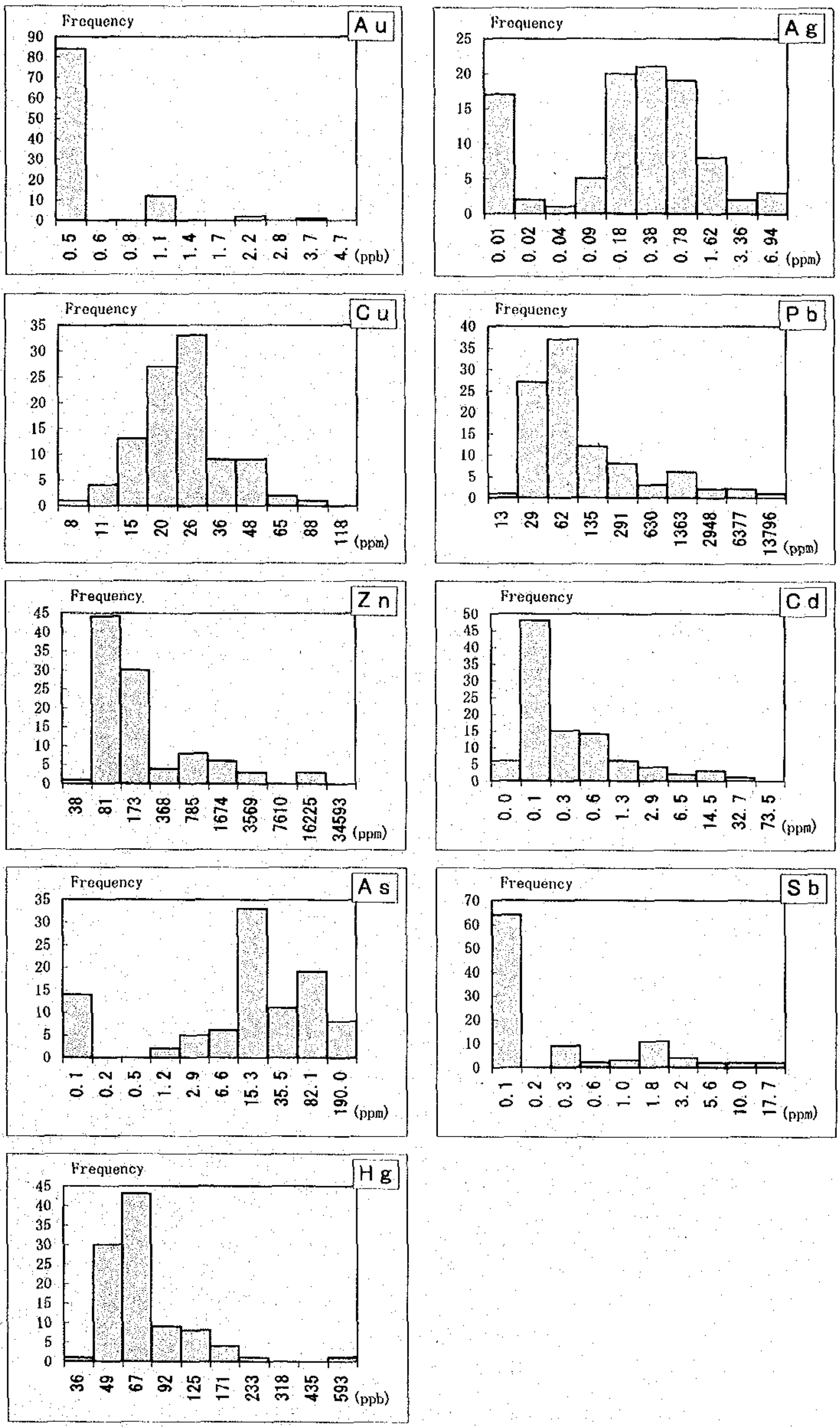


Fig.Ⅲ-3-2 Histograms of Assays on Soil Geochemical Samples Collected in the Suoi Boc - Suoi Cu Mineralization Zone

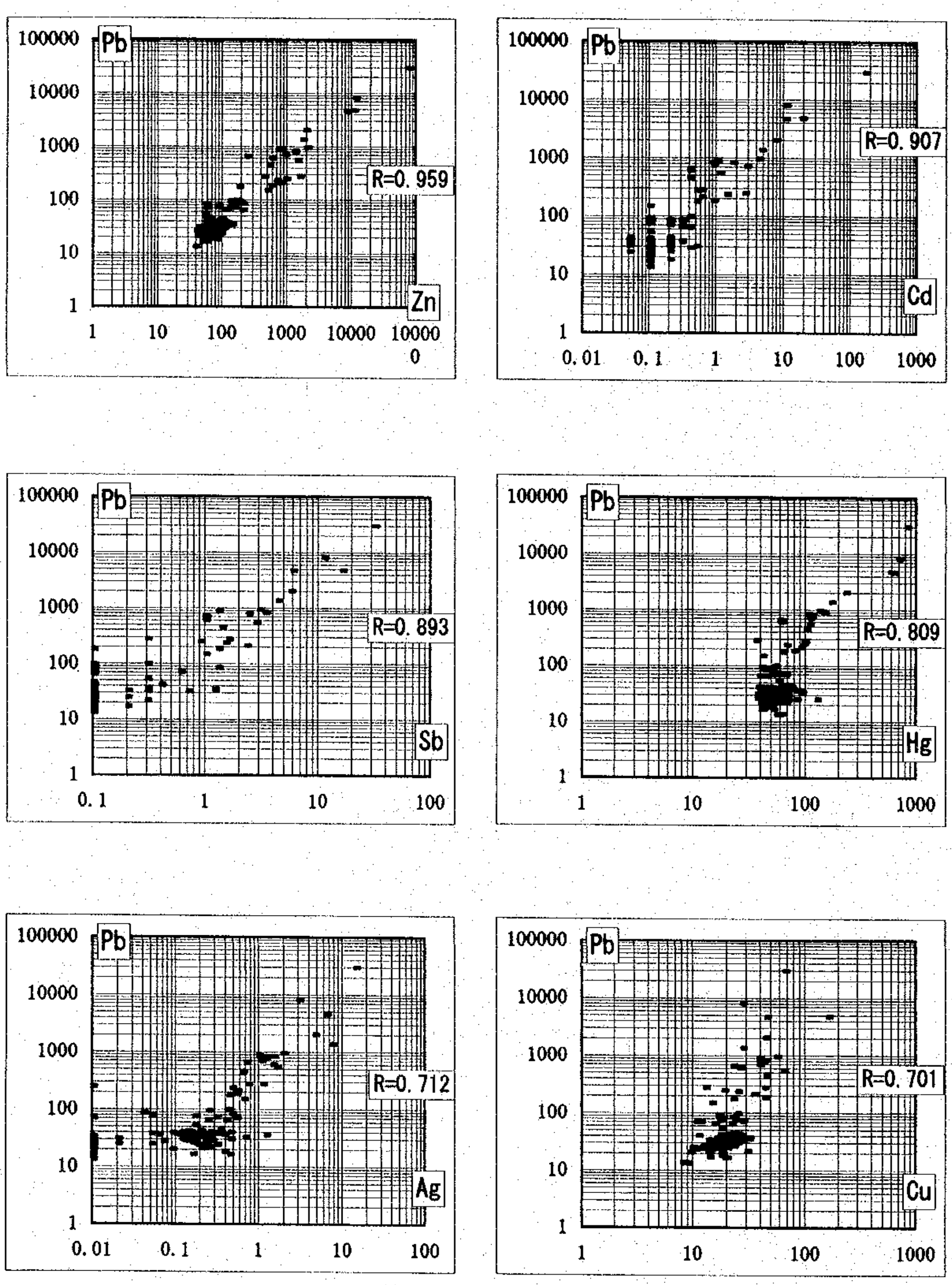


Fig.Ⅲ-3-3 Correlation Diagram between Element Pairs on Soil Geochemical Samples Collected in the Suoi Boc - Suoi Cu Mineralization Zone

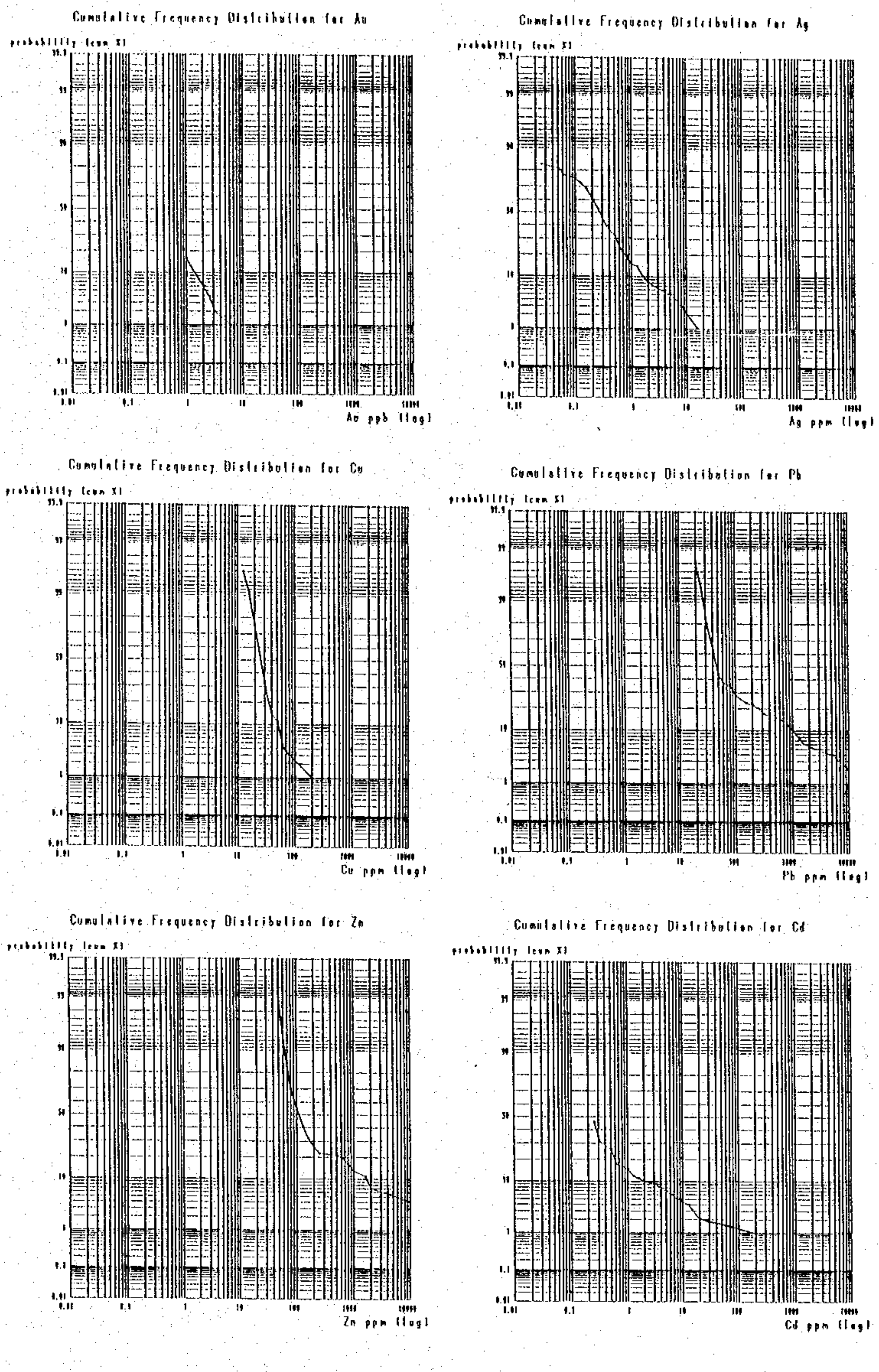
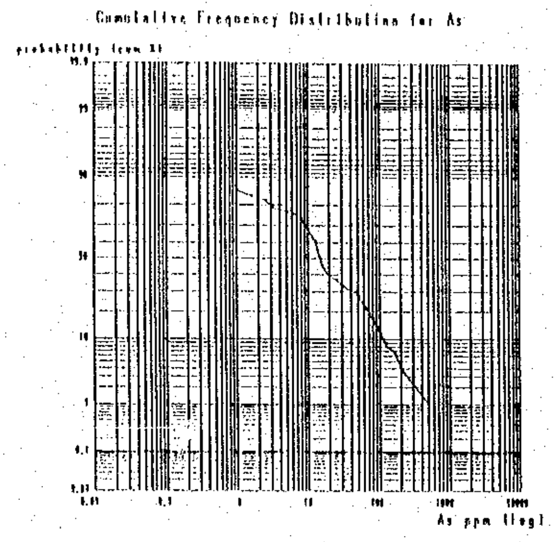
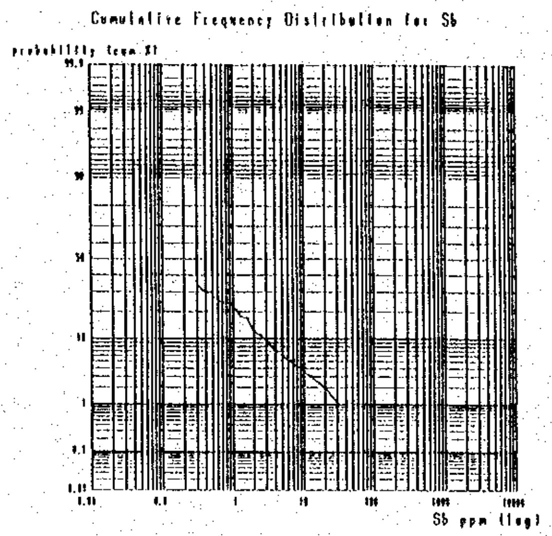


Fig.Ⅲ-3-4 Cumulative Frequency Distribution of Assays on Soil Geochemical Samples Collected in the Suoi Boc - Suoi Cu Mineralization Zone (1)





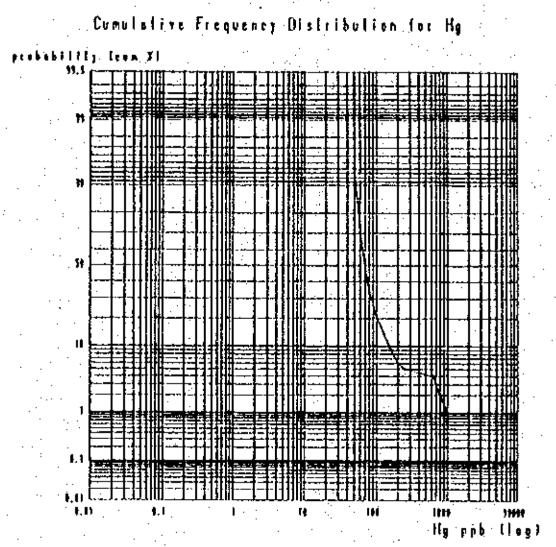


Fig.Ⅲ-3-4 Cumulative Frequency Distribution of Assays on Soil Geochemical Samples Collected in the Suoi Boc - Suoi Cu Mineralization Zone (2) values for Pb and Zn are as follows.

Pb: weak anomaly (≧60 ppm, <1,000 ppm)
; value at the breaking point
strong anomaly (≧1,000 ppm)
; higher 10 % of the whole analytical values

Zn: weak anomaly (≧250 ppm, <1,000 ppm)
; value at the breaking point
strong anomaly (≧1,000 ppm)
; higher 10 % of the whole analytical values

(2) Anomalous zones

Since there are strong correlations among seven elements out of nine analyzed elements, those high content zones are delineated on the almost same parts of the anomaly maps. Therefore, four high content zones of Pb and Zn are representatively mentioned hereunder. Background values of Pb and Zn are estimated to be respectively 40 to 60 ppm and 100 to 200 ppm through their histograms.

On the Pb anomaly map, clear high content zones are detected in two parts, in the western and southeastern parts of the area. Values at the center of the high content zones are 5,000 to 29,000 ppm, hundreds times or more higher than background values. High content points are not separated but concentrated, and values become smaller abruptly into background values on the outskirts of the zones.

The other two high content zones with values ranging from 1,000 ppm to 1,300 ppm, values about one-tenth of said high content zones, are widely present in the northwestern part and in the southwestern end of the area. They are located on the borders of the area, hence these centers are indistinct.

In the case of Zn anomaly map, two clear high content zones are also detected in the similar parts to those of the Pb anomaly map (in the western and southeastern parts). Values at the center of these zones are 10,000 to 70,000 ppm, indicating hundreds times or more higher than background values. High content points are not separated but concentrated, and values become smaller abruptly into background values on the outskirts of the zones.

The other two high content zones, which are present also in the similar parts to those of the Pb anomaly map (in the northwestern part and in the southwestern end), have anomalous points with values ranging from 1,700 to 2,000 ppm.

3.3.5. Consideration

(1) Results of analysis and statistics

As mentioned above, anomalous zones of Pb and Zn are found in the area. Since these two elements are highly correlative and show anomalous zones of similar distribution pattern, it is inferred that Pb and Zn have been supplied from some identical source. Anomalous zones are clear and those contents are hundreds to thousands times higher than background values.

Elements Ag, Cu, Cd, Sb, and Hg show relatively good correlation with elements Pb and Zn, and those high content zones are of the same distribution pattern with Pb and Zn. Therefore those five elements are considered to be brought from the same source with Pb and Zn. However, the supply of those five elements resulted to heighten values to merely about ten times of mean background values.

From these facts, it is concluded that supply of elements by some mineralization occurred mainly for Pb and Zn and was accompanied by Ag, Cu, Cd, Sb, and Hg.

(2) Relationship with geology and geologic structure

The area is underlain by alternating beds of mudstone and sandstone and beds of limestone. As aforesaid, four Pb-Zn anomalous zones are detected in the area. The highest content anomalous zone in the western part of the area is spreaded over both of the alternating beds of mudstone and sandstone and the beds of limestone. The next higher content anomalous zone in the southeastern part of the area is extended on the limestone beds. Other two anomalous zones are stretched over both of the alternating beds of mudstone and sandstone and the beds of limestone. Thus, there is no correspondence of anomalous zones and geology.

CHAPTER 4. GEOPHYSICAL SURVEY

4.1. Outline of Survey

4.1.1. Objectives

The objectives of the geophysical survey are to detect IP anomalies related to mineralization and thus delineate the prospective parts within and around the geochemical anomalies (Pb stream sediment anomalies) extracted during the first phase in the vicinity of the Suoi Boc Prospect (Figure Ⅲ-4-1) in the Van Yen Area.

4.1.2. Exploration method

Electrical method (time domain IP method) was employed with gradient array.

4.1.3. Amount of geophysical survey

Amount of Geophysical survey is as follows.

1) Total length of lines : 15.8 km
2) Measuring points : 306 points
3) Laboratory test : 24 pcs

4.2. Survey Methods

4.2.1. Time domain IP method

The IP method is the exploration method to observe electric polarization effect (IP effect) in the earth. The IP effect is caused by the following phenomenon.

When direct current flows through the rocks containing metallic minerals, electric potential difference is generated between the surface of metallic minerals and pore water around it, electric charge is stored, and therefore electric polarization is resulted in. This electric charge is discharged gradually after current is terminated. It forms the residual voltage decaying with the passage of time. However, the IP effect occurred not only in the rocks containing metallic minerals, but also in some sedimentary rocks containing clay.

In the time domain IP method, on and off alternating current in the shape of rectangular wave, as shown in Figure Ⅲ-4-2, is generally used as transmitter current. Received voltage, as shown in Figure Ⅲ-4-3, is composed of the primary voltage V_p observed while current is on and the decay voltage

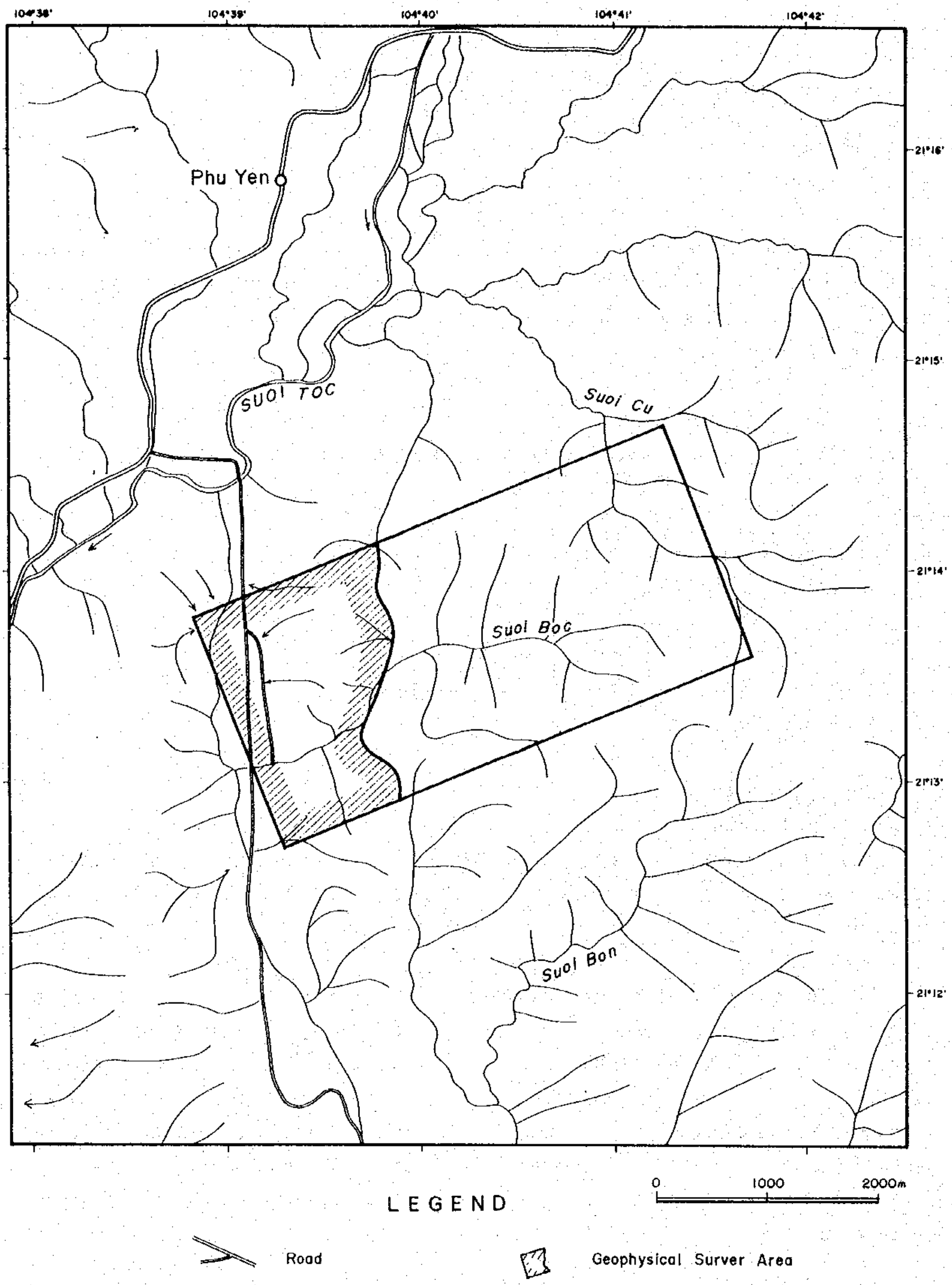


Fig.Ⅲ-4-1 Location Map of the Geophysical Survey (secondary voltage V_s) observed while current is off. Chargeability is calculated with received voltage as index to express quantity of IP effect.

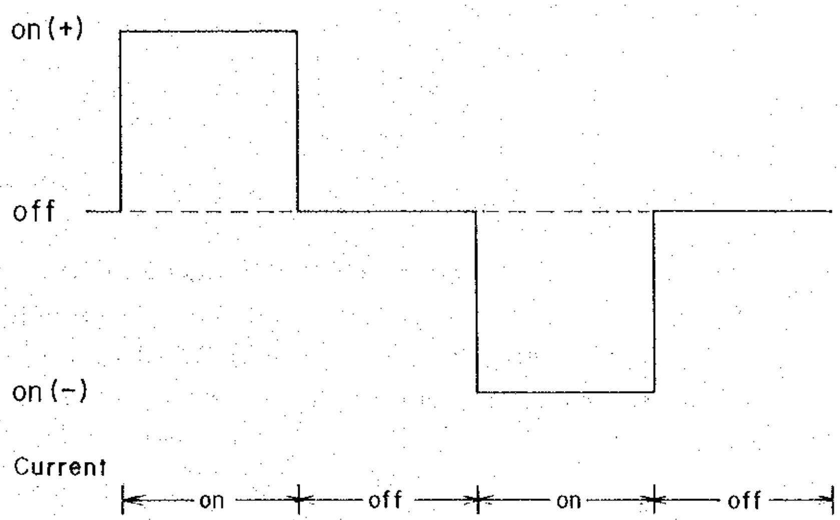


Figure Ⅲ-4-2 Wave Form of Transmitter Current

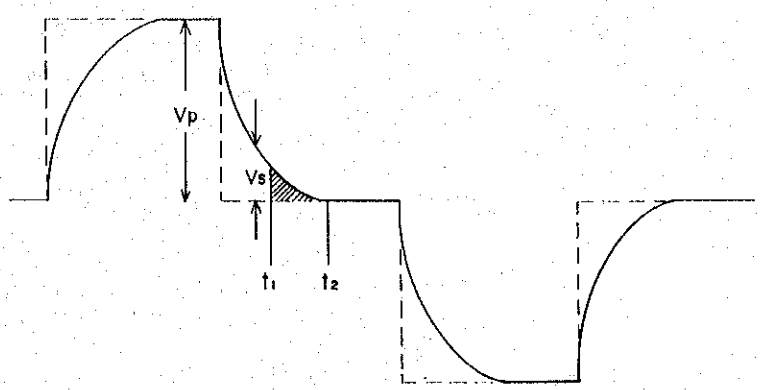


Figure Ⅲ-4-3 Wave Form of Received Voltage

The chargeability M is shown in equation (Ⅲ-4-1). It is the proportion of time integral of secondary voltage to primary voltage. Its unit is ms (mili-seconds).

$$M = \frac{1}{V_P} \int_{t2}^{t1} V_s \, dt \qquad (\text{III-4-1})$$

4.2.2. Measurement method

The specification of measurement is as follows.

1) Electrode configuration : Gradient array
2) Potential electrode spacing : 50 m
3) Period of transmitter current: 8 s
4) Measurement quantity : Electric potential difference and chargeability

The gradient array is applied to fast mapping of electric quantity in large survey area. Current electrode A and B (Figure Ⅲ-4-4), whose spacing is very large, are fixed in location. The rectangular survey area is laid out in the central part of AB. The potential electrode M and N, whose direction is parallel to the direction of current electrode and whose spacing is small, are moved for measurement.

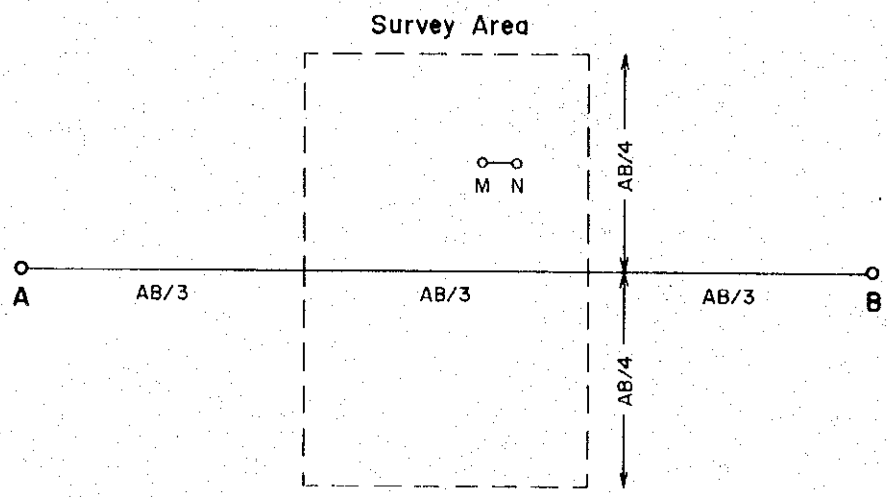


Figure Ⅲ-4-4 Illustration of Gradient Array

The apparent resistivity is calculated with measured electric potential difference according to the following equation.

$$\rho_a = \frac{2\pi V}{I \cdot (1/AM - 1/AN - 1/BM - 1/BN)} \qquad (Ⅲ\text{-}4\text{-}2)$$

ρ_a : Apparent resistivity (ohm-m)
V : Primary Voltage (V)
I : transmitter current (A)

4.2.3. Location of current electrode and measuring points

Two sets of current electrode (NO.1 and NO.2), whose directions are NNW-SSE, were laid out as shown in Figure Ⅲ-4-5. The current electrode NO.1 (about 2,810 m in spacing) was applyed to the measurement of the northern part of the survey area. The current electrode NO.2 (about 2,720 m in spacing) was applyed to the measurement of the southern part of the survey area.

As shown in Figure Ⅲ-4-6, 306 measuring points are laid out almost uniformly in the survey area. However, measuring points around the geochemical anomaly extracred during the first phase are laid out densely. Especially, measuring point No.234 is the very point over the pit. In Figure Ⅲ-4-6, coordinate axes X and Y are plotted to specify the location of the measuring points. The axes X and Y correspond to the E-W and N-S directions respectively.

4.2.4. Laboratory test

Resistivity and chargeability of rock and ore samples in the survey area were measured in laboratory. The same method as in the field measurement was applied. Twenty-four and ore samples were measured in laboratory.

4.2.5. Equipment

The equipment used in this survey is shown in Table Ⅲ-4-1.

Table Ⅲ-4-1 List of the Equipment for the Geophysical Survey

ITEM	NAME	SPECIFICATION
Transmitter	Zonge GGT-5 Transmitter	Output voltage : 250,500,750,1,000 V Output current : 0.2～25 A Wave form : Rectangular wave Frequency range : 1/8～2,048 Hz Weight : 57 kg
Transmitter controller	Zonge XMT-1 Transmitter controller	Frequency range : DC～2,048Hz Power : 12V Battery Weight : 5.8 kg
Engine generator	Zonge ZMG-5 Engine generator	Output power : 5 kW Frequency : 400 Hz Output voltage : 115 V Engine : 5 HP, 4 Cycle
Receiver	Zonge GDP-12/2GB Data Processor	Frequency range : 1/8～2,048Hz Sensitivity : 0.2 μV Power : 12V Battery Weight : 15 kg
Electrode	Current Potential	Stainless rod Non polarization $CuSO_4$ porous pot

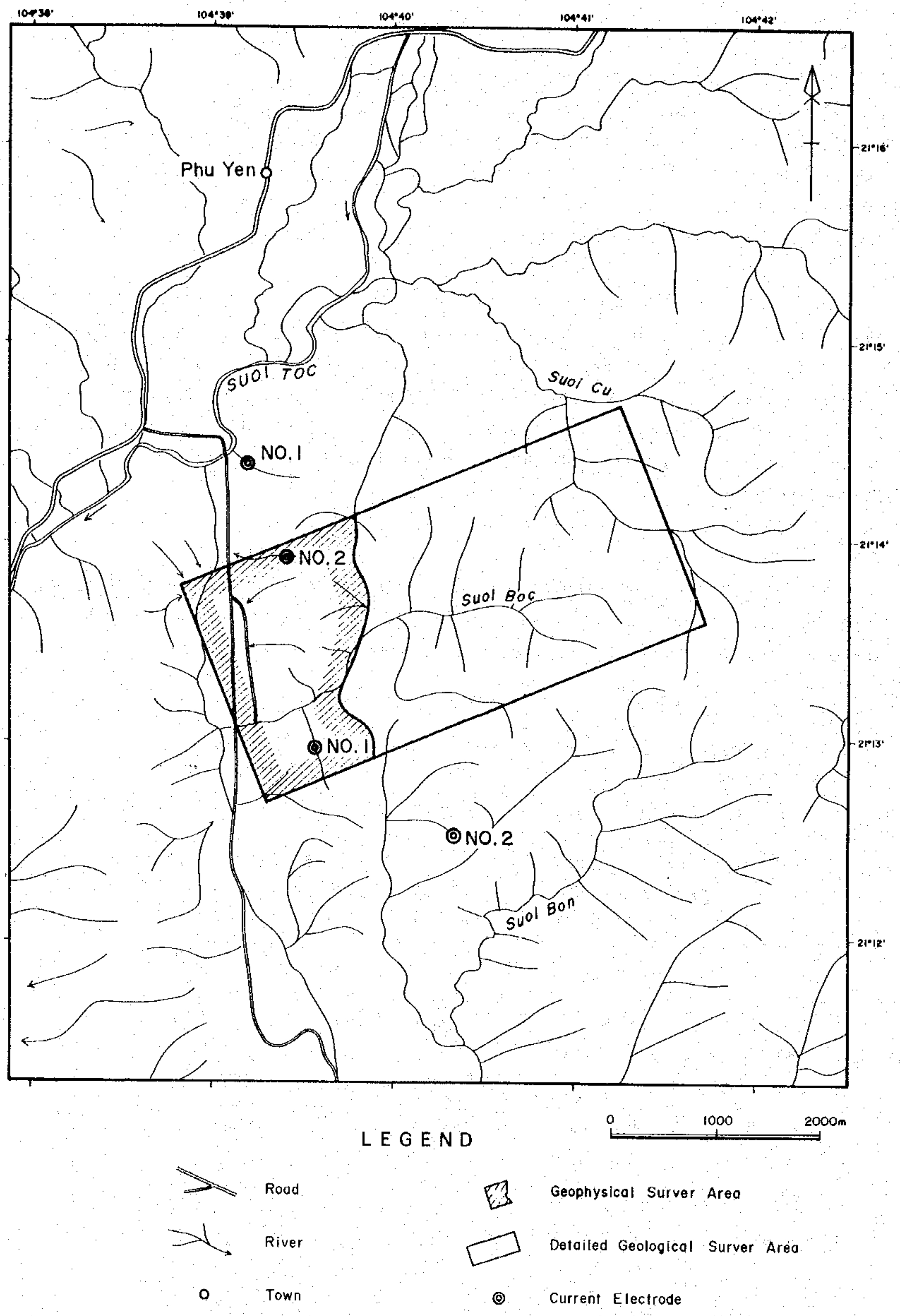
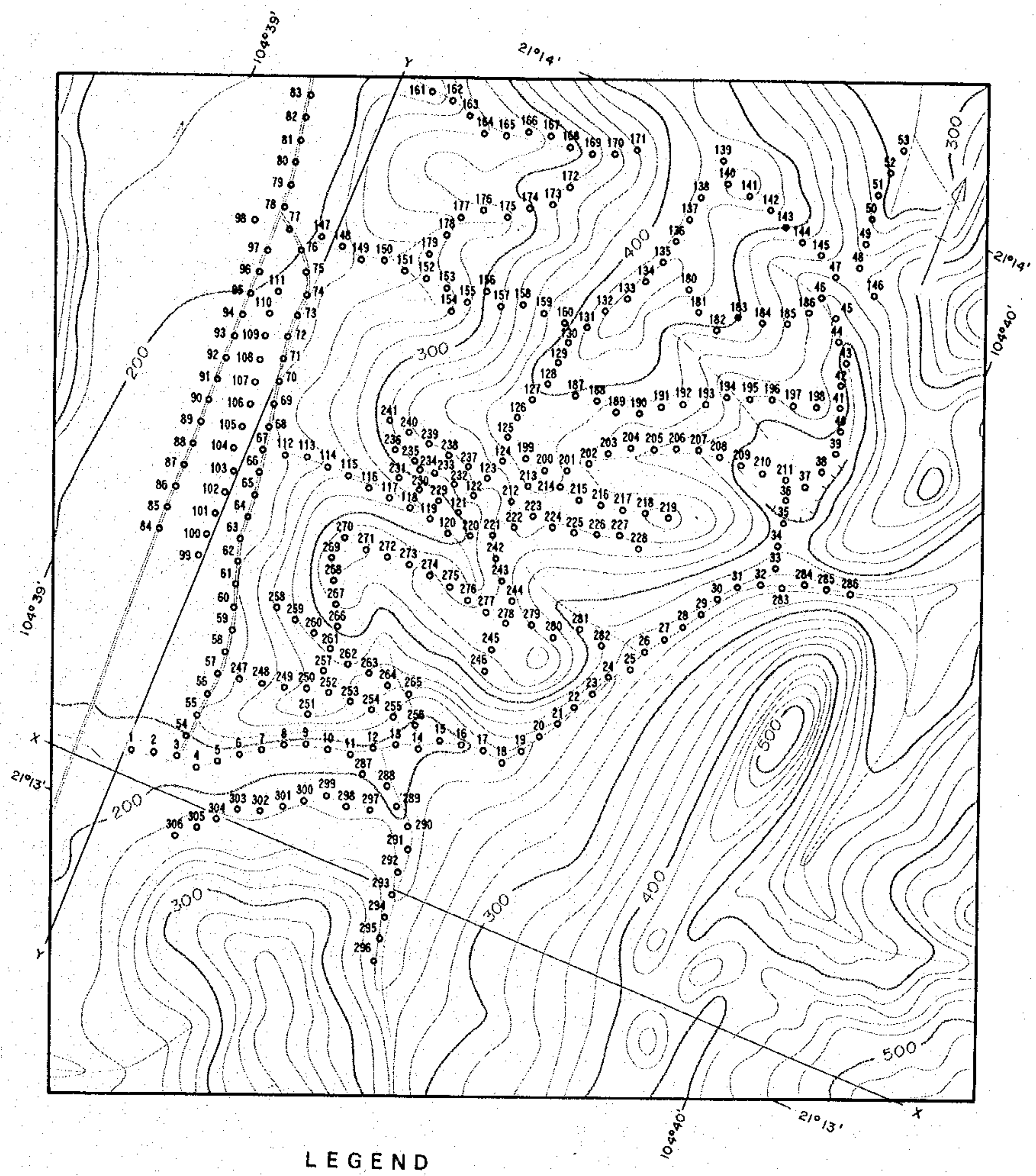


Fig. III-4-5 Location Map of the Current Electrode



LEGEND

0 500m

216 o Measuring point

Fig.Ⅲ-4-6 Location Map of Measuring Points

4.3. Results of Survey

4.3.1. Apparent resistivity

The contour map of apparent resistivity is shown in Figure Ⅲ-4-7. The mean value of apparent resistivity of the survey area is 208 ohm-m (calculated with logarithm value). The minimum value is 36 ohm-m at the measuring point No.271. The second lowest value is 38 ohm-m at No.145 and No.146. The maximum value is 1,083 ohm-m at No.35.

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.

It is somewhat difficult to see the other distinctive feature about apparent resistivity in Figure Ⅲ-4-7. The relief energy of the topography in this area is very high because of a typical karst landform. Therefore, it is considered that the apparent resistivity suffors from strong topographic effect. That causes the difficulty in interpreting the map of apparent resistivity.

4.3.2. Chargeability

The contour map of chargeability is shown in Figure Ⅲ-4-8. The mean value of chargeability in this area is a little high value of 33 ms. The maximum value is 120 ms at No.48. There are 84 ms at No.145 and 80 ms at No.281 as the other higher values. The minimum value is 7 ms at No.289.

Two IP anomalies (high chargerbility 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.

On the Suoi Boc Prospect (around the measuring point No.234), the chargeability are only several ms higher t2han the mean value and thus no IP anomalies were detected.

4.3.3. Laboratory tests

The results of laboratory tests are shown in Table Ⅲ-4-2. The mean values of resistivity and chargeability for each rock are as follws. The ore samples were collected from lumps around the pit located at the measuring point No.234.

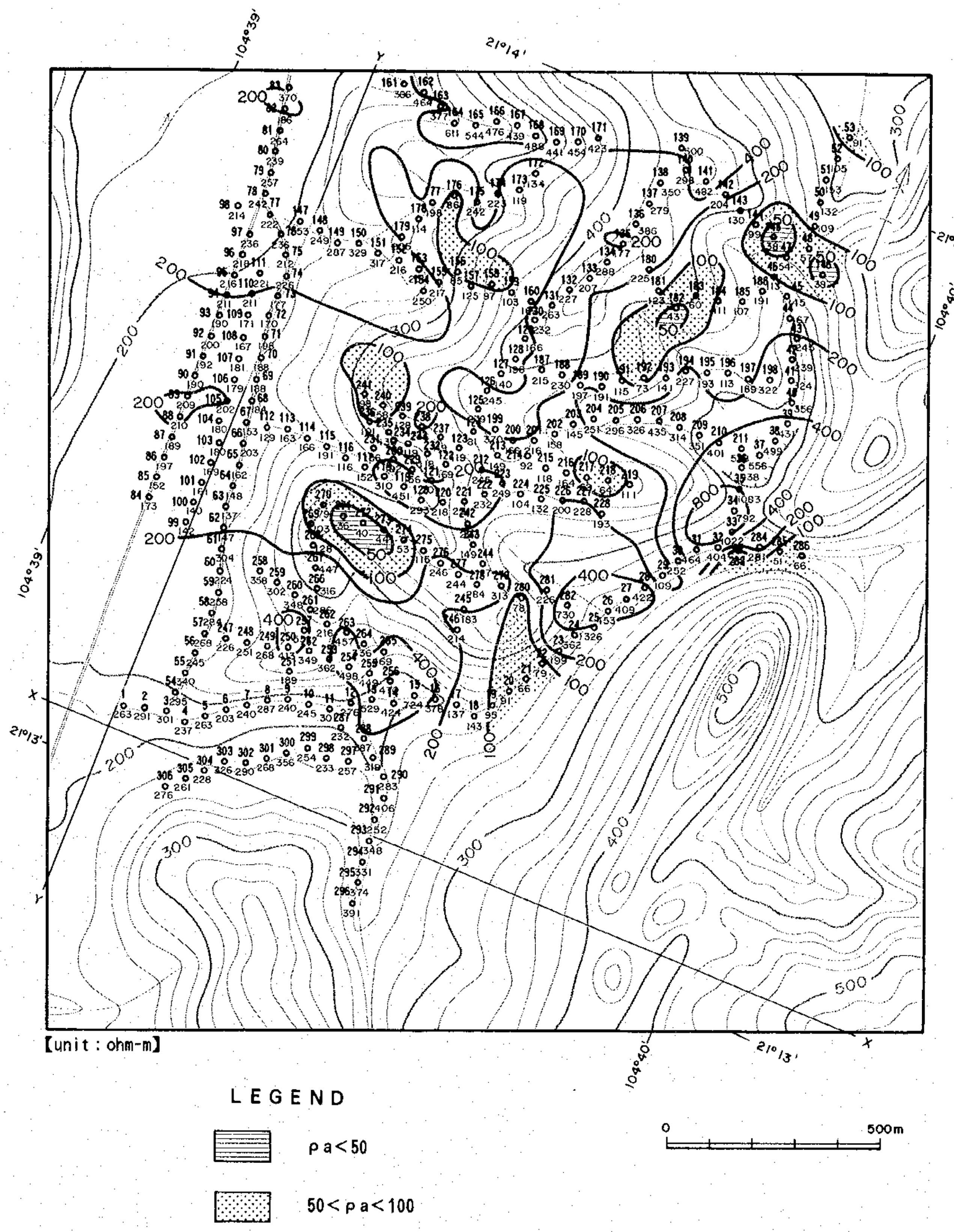


Fig.Ⅲ-4-7 Contour Map of Apparent Resistivity

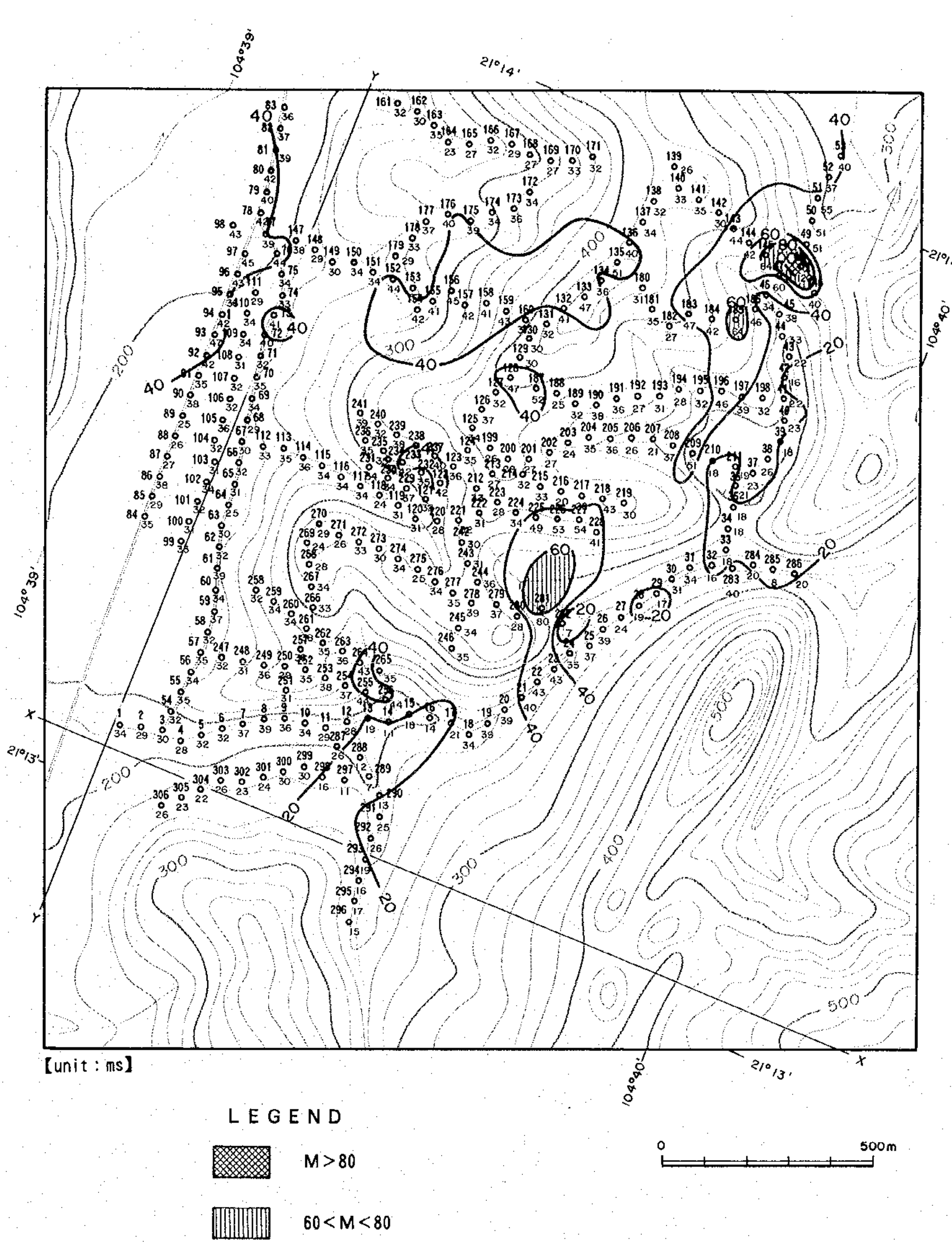


Fig.Ⅲ-4-8 Contour Map of Chargeability

Rock	Resistivity (ohm-m)	Chargeability (ms)
Limestone	14,510	1.25
Sandstone and siltstone	2,074	5.54
Mudstone	239	3.34
Lead-zinc ore	9,768	5.65

It is considered that the resistivity of limestone is relatively high, that of sandstone and siltstone is medium, and mudstone is low. The resistivity of lead-zinc ores is high as compared with general ores.

The chargeability of rock samples is low as a whole. Especially, the limestones have little IP effect. In the lead-zinc ores, the mean value is low value of 5.7 ms as compared with general ores, though the sample No.15 shows the highest value. This can be understood from the reason that the metallic minerals are mainly composed of sphalerite and cerussite which have not so strong IP effect. The sandstone and siltstone show almost the same value as the lead-zinc ores and are high as compared with common sedimentary rocks.

Table Ⅲ-4-2 Results of Laboratory Tests

No.	Rock	Resistivity (ohm-m)	Chargeability (ms)	Remark
1	Black phyllitic mudstone	268	3.63	near No.47
2	Black phyllitic mudstone	220	3.82	near No.48
3	Dark grey limestone	14,370	1.52	
4	Dark grey limestone	23,149	0.93	
5	Black phyllitic mudstone	228	2.57	
6	Dark grey limestone	14,408	1.36	
7	Dark grey limestone	6,032	1.14	
8	Grey brecciated limestone	18,481	1.42	
9	Light grey brecciated limestone	10,882	1.36	
10	Grey coarse-grained sandstone	1,626	8.87	
11	Brown very fine-Grained sandstone	325	5.51	
12	Black limestone	14,041	1.11	
13	Grey micaceous siltstone	1,157	5.16	
14	Grey brecciated limestone	15,606	0.57	
15	Lead-zinc ore	4,744	10.41	at No.234
16	Dark grey limestone	16,122	1.04	
17	Reddish grey coarse-grained sandstone	3,924	1.47	
18	Dark grey brecciated limestone	15,833	1.45	
19	Light grey limestone	8,266	2.71	
20	Light grey coarse-grained sandstone	3,337	6.70	
21	Lead-zinc ore	13,608	4.47	at No.234
22	Calcite	16,925	0.35	
23	Lead-zinc ore	8,486	3.51	at No.234
24	Lead-zinc ore	12,233	4.19	at No.234

4.4. Consideration

The integrated interpretation map of the geophysical survey results overlaid on the geologic map is shown in Figure Ⅲ-4-9. The results of the field survey and the laboratory test are interpreted as follows.

4.4.1. Resistivity

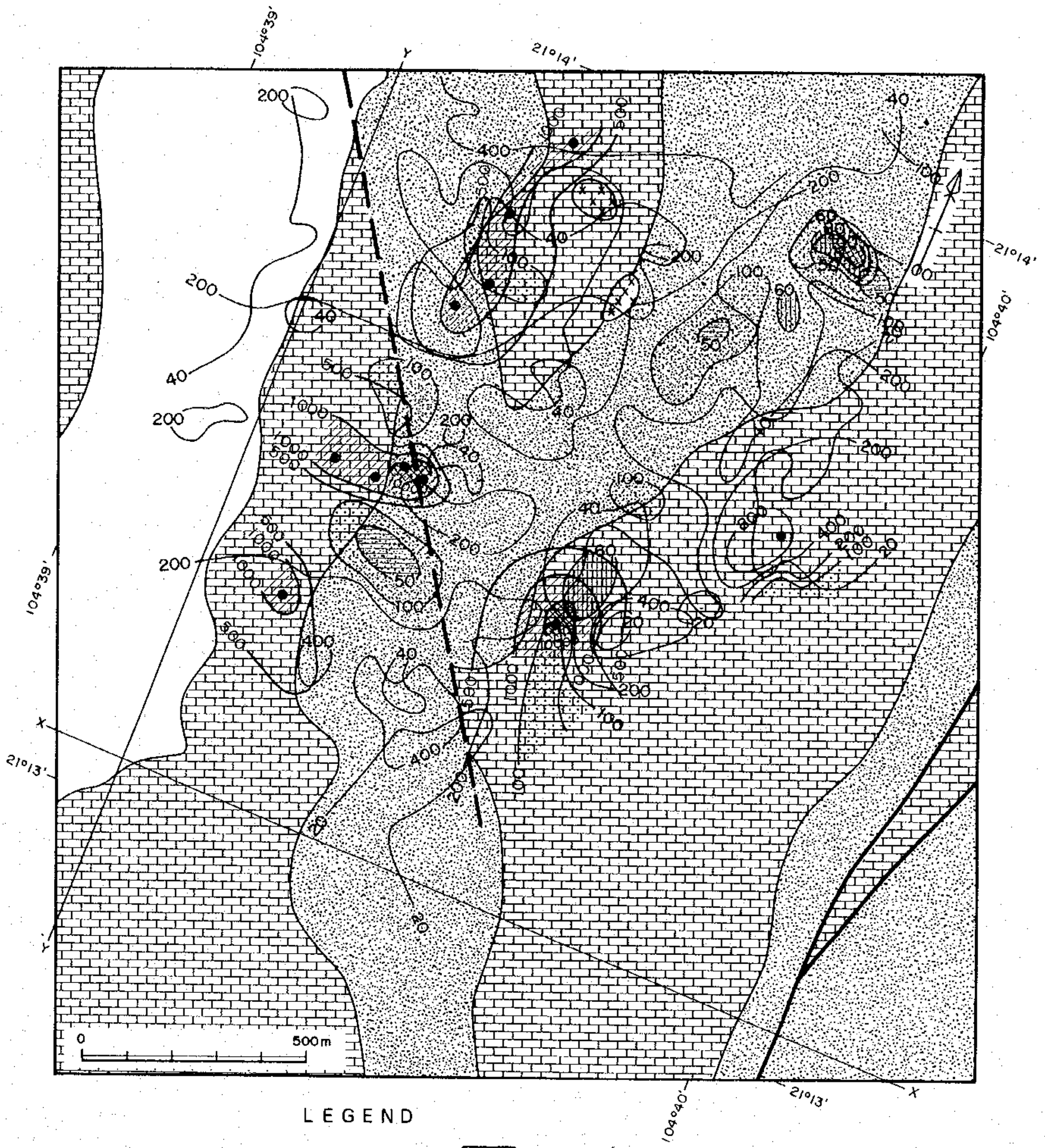
The apparent resistivity measured in the survey area was a figure larger than the resistivity of rock samples in laboratory. The rock samples in laboratory have no weak parts (high permeable, that is high conductible), such as subsurface weathering zone and fracture zone. Consequently, their resistivity is generally measured larger than resistivity of rock under the ground. However, it is considered that the contour map of apparent resistivity in the survey area reflects the relative contrast of the resistivity of the rock samples in laboratory.

Judging from the results of the laboratory test, it is clear that limestone has high resistivity and mudstone has low resistivity. Thus, the low resistivity zones (the area between the northeastern edge and the central part of the survey area) on the contour map of apparent resistivity reflect the distribution of mudstone. The sample No.1 and No.2 were collected in the northeastern edge where the lowest resistivity was detected in the survey area. The low resistivity zones stated above are in the area of mudstone and sandstone on the geologic map. On the contrary, the high resistivity zones on the contour map of apparent resistivity reflect the distribution of limestone.

4.4.2. Chargeability

The mean value of chargeability measured in the survey area is high value of 33 ms as compared with the chargeability of rock sample in laboratory which is less than 10 ms. The capacitive coupling effect is regarded as the reason for this difference. The capacitive coupling effect is generated in such case of extremely long transmitter current cable (about 5 km long in this survey) that used for electrode configuration in this survey. In the case of long transmitter current cable, leakage current becomes large in proportion to the distributed capacity between transmitter current cable and the earth, and therefore the phenomenon same as IP effect is produced. It is considered that the chargeability measured in the survey area is added to 20 to 30 ms by the capacitive coupling effect.

The chargeability of the ore samples, which are collected from lumps around the pit at the measuring point No.234, are not so high and are of



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Apparent Resistivity (unit : ohm-m)

ρa<50

50<ρa<100

Chargeability (unit : ms)

M>80

60<M<80

Quaternary — Gravel, sand, clay

Middle Triassic — Limestone

Mudstone, sandstone, siltstone, conglomerate

Intrusive rock

Dacite porphyry (Cretaceous?)

Fault(Certain/inferred or covered by the Quaternary)

Lead and zinc mineralization

● Zn> 1000ppm

1000 500 (ppm) Soil geochemical anomalous zone

Fig.Ⅲ-4-9 Integrated Interpretation Map of the Geophysical Survey Results

little difference from the chargeability of sandstone of host rock. It is considered that no IP anomalies were detected on the Suoi Boc Prospect, owing to composite effect of this fact and the small size of mineralization zone.

The strong IP anomalies were detected in the northeastern edge and middle east edge of the survey area. 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.

CHAPTER 5. COMPREHENSIVE DISCUSSIONS

5.1. Relationship between Geology, Geologic Structure and Mineralization

5.1.1. Regional survey area

Gold, lead-zinc, and platinum-copper-nickel mineralization was recognized in this area. As a result of the field survey and chemical analysis of collected samples, it can be stated that no remarkable mineralization of other metallic elements is present in the area.

Although the gold mineralization is supposed to be associated with quartz veins, any primary deposits (hydrothermal gold-bearing quartz vein) with a considerable content of gold were not found in the course of the present survey. Native gold grains from the panned concentrate samples were microscopically confirmed at nine localities by this survey. In addition to this, the past exploratory panning work revealed that three zones were recognized with high density of localities where gold grains were microscopically confirmed. However, it is not clear whether gold mineralization would be controlled or not by the specified geologic unit and structure, because the data were not obtained with regard to the primary deposits.

Lead-zinc mineralization in this area is present as the hydrothermal vein-type deposits which are hosted by a part of Middle Devonian and Carboniferous to Permian limestone. There is a common feature that all of the mineral showings are hosted by limestone, but the mineralization is not found over the whole limestone area. Thus, at the present state of the survey, it is not possible to state clearly the processes of concentration of lead and zinc. No felsic igneous rock body occurs in the vicinity of the mineral showings, and it is hard to mention that the showings are situated in the specified geologic structure. Nevertheless, one of the possibilities is that the mineralization has a genetic relation to pseudohydrothermal solution squeezed out from strata underneath, since the host-rock limestone was underlain by Lower Devonian mudstone-sandstone sequence which was possibly rich geochemically in lead-zinc and other base metals before deformation of the host-rock limestone (see Chapter 2). Further detailed study is necessary in order to clarify the genetic processes of this mineralization.

Platinum-copper-nickel mineralization is characterized by its concentration in and around small ultramafic bodies. These bodies occur in many places of a wide area from the western to eastern part of this area, and the intrusion was reported to take place during the Permian time (GSV, 1991). The Da River Mobile Belt was in the period of rifting at that time, and the numerous bodies intruded along the submerged belt bounded by many normal faults. The faults systems at present are NW-SE and WNW-ESE to E-W, and most of the intrusive bodies are concordant with those systems. Because of these viewpoints, this mineralization is controlled by the regional geologic structure of this area.

5.1.2. Detailed survey area

The survey area is located in the northeastern part of Middle Triassic (T_2) area delineated by the geological survey of the first phase. The Middle Triassic area differs from the areas of other geologic units in some points. That is, the constituent rocks and faults of the Middle Triassic area extend in the N-S direction. Although the Suoi Boc Prospect and Suoi Cu mineral showing are located respectively in the western and eastern parts of the survey area, no other lead-zinc mineralization were found over the T_2 area. Because of this, the reason why the Prospect and showing are embedded in those localities is not clear. Apart from this, there is no common feature of host rock between the Suoi Boc Prospect and Suoi Cu mineral showing since the former is hosted by sandstone and the latter by limestone. Both mineralization zones have a possibility to be of hydrothermal vein type with NW-SE strikes on the basis of data obtained from the field survey. However, the shape of the deposits has not been precisely clarified yet because outcrops of the ore bodies cannot be observed in detail in both mineralization zones.

It can be thought that there is a spatial arrangement of mineralization type. That is, the gold-copper mineralization belt represented by the Suoi Tiat mine is situated at the center surrounded by the lead-zinc mineralization belt on the north and east. In this connection, it can be stated that this survey area is located in the eastern end of the above lead-zinc belt on the east of T_1 gold-copper belt.

No large intrusive body crops out over T_1 and T_2 areas, however, small bodies of dacite porphyry (probably of the Cretaceous activity) were found to the north of the Suoi Boc Prospect through the detailed geological survey of this phase. It seems possible that the mineralization in this area is associated with the activity of the dacite porphyry. Many problems need to be further pursued with regard to relationship between geology, geologic structure and mineralization, including the shape and genesis of the deposits.

5.2. Relationship between Geochemical Anomalies and Mineralization

5.2.1. Regional survey area

Regarding nine elements examined, one to five anomalous zones for each element were recognized in the whole survey area. However, threshold values of seven elements except for Ni and Cr are merely one to three times of the average composition of rocks concerned. Furthermore, localities of those anomalies are generally scattered. From these facts, it is hard to mention that geochemical anomalies of those elements have originated in mineralization. Nevertheless localities of strong Ni and Cr anomalies are concentrated in the western and central parts of this area and ultramafic bodies occur in the upper reaches of those localities. Thus, it can be interpreted that nickel and chromium mineralization are present in those ultramafic bodies.

5.2.2. Detailed survey area

As a result of the soil geochemical exploration in the detailed survey area centering around the Suoi Boc Prospect, four anomalous zones for Pb and Zn were detected. The anomalous zones are independently located in the western, southeastern, northwestern, and southwestern parts of the survey area. Of these, the first two are strong anomalous zones whose central points indicate very high analytical values of Pb and Zn, showing more than one hundred times (Pb: 5,000 to 29,000 ppm, Zn: 10,000 to 70,000 ppm) of the background values. Especially, the Suoi Boc Prospect is situated near the center of the strong anomalous zone of the western part, thus, the soil geochemical anomalous zone occurs in good agreement with the mineralization zone. The rest two belong to the weak anomalous zone, but Pb and Zn contents of the central points are over ten times (Pb: 1,000 to 1,300 ppm, Zn: 1,700 to 2,000 ppm) as compared with the background values. Taking the high contents of Pb and Zn in those anomalous zones into consideration, it is interpreted that the anomalous zones indicate lead-zinc mineralization.

5.3. Relationship between IP Anomalies and Mineralization

The electric property of the ore on the Suoi Boc Prospect was proved as below by the laboratory tests.

1) The chargeability is not so high (not so strong in IP effect) as compared with general ores.
2) The Resistivity is high as compared with general ores, and relatively high in the rocks of this survey area.

Therefore, the following results of this geophysical survey are expected if the mineralization containing same ore as the Suoi Boc Prospect exist underground.

1) Resistivity is medium.
2) Weak IP anomalies are detected.

However, on the Suoi Boc Prospect, no IP anomaly was detected, owing to composite effect of the comparative high IP effect of host rock sandstone and the small size of mineralization zone.

The strong IP anomalies were detected in the northeastern edge and middle east edge of the survey area. If these IP anomalies are related to mineralization, it is inferred that the mineralization containing considerable amount of pyrite exists 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.

5.4. Mineral Potential

5.4.1. Regional survey area

The gold, lead-zinc, and platinum-copper-nickel are the metals which can be expected to be concentrated to form economic deposits in this survey area.

(1) Gold deposits

native gold grains from the panned concentrate samples were microscopically confirmed at nine localities. The origin of these grains is supposed to be hydrothermal quartz veins, but the nature of the primary deposits still remains unknown. Although quartz veins and floats of vein quartz were found at eight localities in this area, the assay results show that they are almost barren quartz. At the present state of the data, it is believed that there is small mineral potential of gold in this area.

(2) Lead-zinc deposits

Three lead-zinc mineral showings of vein type were confirmed in this area. They are hosted by the Devonian and Carboniferous to Permian limestone. The nature of these showings is not clear because detailed exploration has not been conducted. There is not large mineral potential for minable scale, taking small dimensions of ore bodies and no occurrence of parallel veins into consideration.

(3) Platinum-copper-nickel deposits

This mineralization is genetically related to the activity of ultramafic rocks. the mineral showings were confirmed within five bodies by the previous work. Fourteen bodies were examined in the course of the present survey and assay results were obtained for Pt and Cu+Ni to be 40 ppb and 0.1 % in maximum, respectively. The dimensions of bodies are generally small. Thus, there is small mineral potential for these metals.

5.4.2. Detailed survey area

This survey area has mineral potential for lead and zinc. No new mineralization zone similar to the Suoi Boc Prospect and Suoi Cu mineral showing has not been discovered through the detailed geological survey in the whole survey area. Apart from this, the soil geochemical exploration for the area centering around the Suoi Boc Prospect resulted in the detection of four anomalous zones for Pb and Zn. One of them corresponds to the locality of the Suoi Boc Prospect and contents of Pb and Zn in the central point are over 29,000 ppm and 70,000 ppm, respectively. In the central points of other three anomalous zones, the contents of Pb and Zn exceed 1,000 ppm. From the above data, the area around the Suoi Boc Prospect is promising for finding lead-zinc deposits similar to the Prospect. However, the details are not clear for directions of ore bodies and so forth.

CHAPTER 6. CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

The survey of this phase consists of 1) regional geological survey, 2) detailed geological survey, and 3) geophysical survey (IP method). The areas concerned and amount of works are as follows.

1) Regional geological survey: the area on the east of the Phase I area
- Areal extent : 1,000 km^2
- Stream sediments : 915 samples
- Panned concentrates: 240 samples

2) Detailed geological survey: the Suoi Boc - Suoi Cu Mineralization Zone
- Areal extent: 10 km^2
- Soil : 100 samples (around the Suoi Boc Prospect)

3) Geophysical survey: the Suoi Boc Prospect
- Areal extent : 3 km^2
- Total length of lines: 15.8 km
- Measuring points : 306 points

The following conclusions were obtained through the above field survey and subsequent analysis.

6.1.1. Regional geological survey

(1) This survey area belongs to the "West Bacbo" tectonic province. The basement of the area comprises the Proterozoic metamorphic rocks represented mainly by gneisses. Unconformably overlying the basement are metamorphic and sedimentary rocks of Cambrian to Permian age, pyroclastic and sedimentary rocks of Triassic (Early and Late) age, and unconsolidated Quaternary sediments. Granitic and gabbroic bodies intruded into the Proterozoic area and abundant small ultramafic bodies are recognized in the central part of the area.

(2) The principal structural trend of the "West Bacbo" is NW-SE system. The Proterozoic rocks in the northeastern and southeastern parts of this area are intensely controlled by the above structure with some faults of the same trend. 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 plung westward. Some faults are developed parallel to the above structure. Additionally, Carboniferous to Upper Triassic strata extend in the N-S to NNW-SSE direction in the southwestern part of the area. Thus, the whole area is divided tectonically into three blocks.

(3) 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 and no widespread mineralization zone has not been found in the area.

a) Although the origin of the gold mineralization is supposed to be hydrothermal gold-bearing quartz veins, the essential characteristics of primary deposits remain unknown because the deposits were not discovered through this field survey.

b) The lead-zinc mineralization is represented by the Suoi Can mineral showing of hydrothermal vein type. The showing is hosted by the Middle Devonian limestone. The exposed ore body is 30 cm wide and no parallel vein was observed near the body. The content of lead is 8.86 %, but the exposed ore body has very small dimensions.

c) Platinum-copper-nickel mineralization occur in and around ultramafic bodies which intruded during the Permian time. The bodies are generally small with several meters to 100 m width. The assay results for 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 in this area.

(4) As a result of stream sediment geochemistry, there is a possibility that the element of Cr is concentrated in some ultramafic bodies. However, the geochemical exploration revealed that no anomalous zone related to significant mineralization was found with regard to the other elements.

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

6.1.2. Detailed geological survey

(1) 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.

(2) 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.

(3) As a result of the soil geochemical exploration in the area centering around the Suoi Boc Prpspect, four anomalous zones for Pb and Zn were detected. In the center of one strong anomalous zone, Pb and Zn contents are very high (Pb: 29,000 ppm, Zn: 70,000 ppm). The Suoi Boc Prospect is located near the center of the anomalous zone, thus the soil geochemical anomalous zone occurs in good agreement with the mineralization zone. In other three zones, Pb and Zn contents of the central points are also high (Pb and Zn: over 1,000 ppm). Thus, these zones are believed to indicate lead-zinc mineralization. From this fact, it is concluded that the area around the Suoi Boc Prospect is promising for finding lead-zinc deposits other than the known one.

6.1.3. Geophysical survey

(1) 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.

(2) 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 chageability (proved by the laboratory tests). Another is the small size of the mineralization zone.

(3) 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.

6.2. Recommendations for Phase III Survey

From the conclusions reached during the Phase I and Phase II survey, the following work is recommended for Phase III survey to be carried out in Fiscal 1995.

(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 ; Stream sediment geochemical anomalies for Pb and Zn are concentrated in this part, but its significance on geology and mineralization still remains unsolved.

PART IV WESTERN THANH HOA AREA

PART IV WESTERN THANH HOA AREA

CHAPTER 1. REGIONAL GEOLOGICAL SURVEY

1.1. Survey Methods

The survey methods are the same as those used for the Van Yen Area previously described in Part III.

1.2. Geologic Setting

This area is situated at the northern edge of the "Truongson" tectonic province. The major part of the area lies in the "Sam Neua Basin" which is composed mainly of the Triassic and Jurassic volcanic rocks. In fault contact with the above basin, the Lower to Middle Paleozoic metamorphic rocks and marine and continental sedimentary rocks occur in the northern, eastern, and southern parts of the survey area. With regard to intrusive rocks, Late Triassic gabbros, Late Cretaceous to Paleogene granitic rocks occur widely in the northern to southeastern part of the area.

1.3. Stratigraphy

The geologic units of the survey area comprises the Cambrian metamorphic basement, the unconformably overlying Ordovician to Triassic metamorphic rocks and marine and continental sedimentary rocks, a large amount of Jurassic pyroclastic rocks (partly interbedded with sedimentary rocks), and unconsolidated Quaternary sediments in ascending order. Figure IV-1-1 shows the schematic columnar sections, and geologic map and sections are given in Figures IV-1-2 and IV-1-3, respectively. Since the objective of the field work of this phase is not to pursue the detailed lithology of the geologic units, they were classified into the "Systems" and "Series" as shown in geologic map. However, relatively thick limestone beds contained in the Middle Triassic Series are delineated in the geologic map as independent lithofacies units, because those beds are effective for interpretation of regional geologic structure. The symbols of each geologic unit were simplified similarly to those of the Van Yen Area as shown in Figure IV-1-2. The description of intrusive rocks will be discussed in section 1.4.

(1) Cambrian System (Є)

This System lies in the southwestern edge of the area. The extent of distribution is very restricted. The System extends in the NW-SE direction with about 2 km width. The System is in fault or unconformable contact with the overlying Undiscriminated Jurassic (J?; mentioned later).

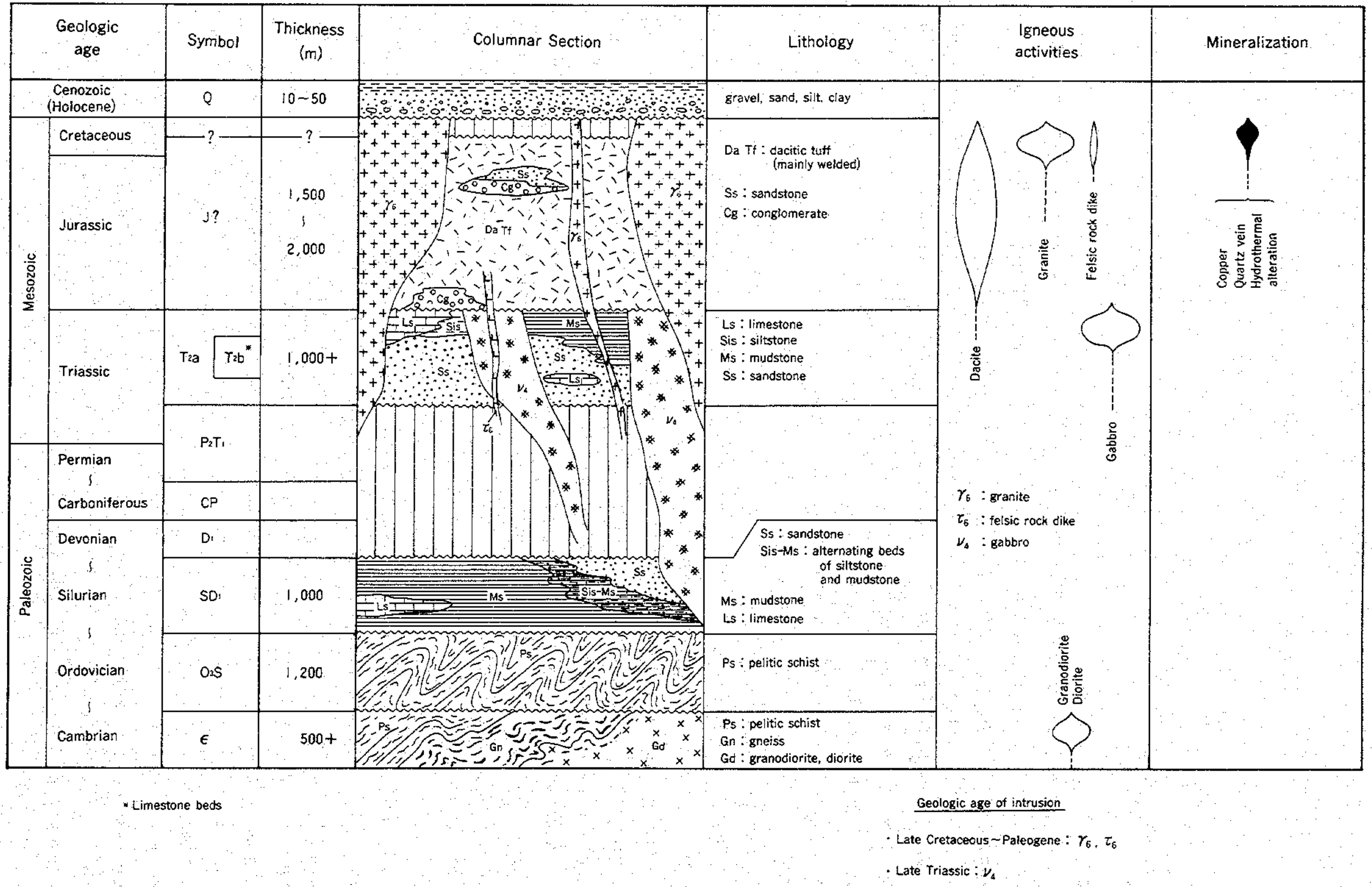


Fig.IV-1-1 Schematic Columnar Sections of the Western Thanh Hoa Area

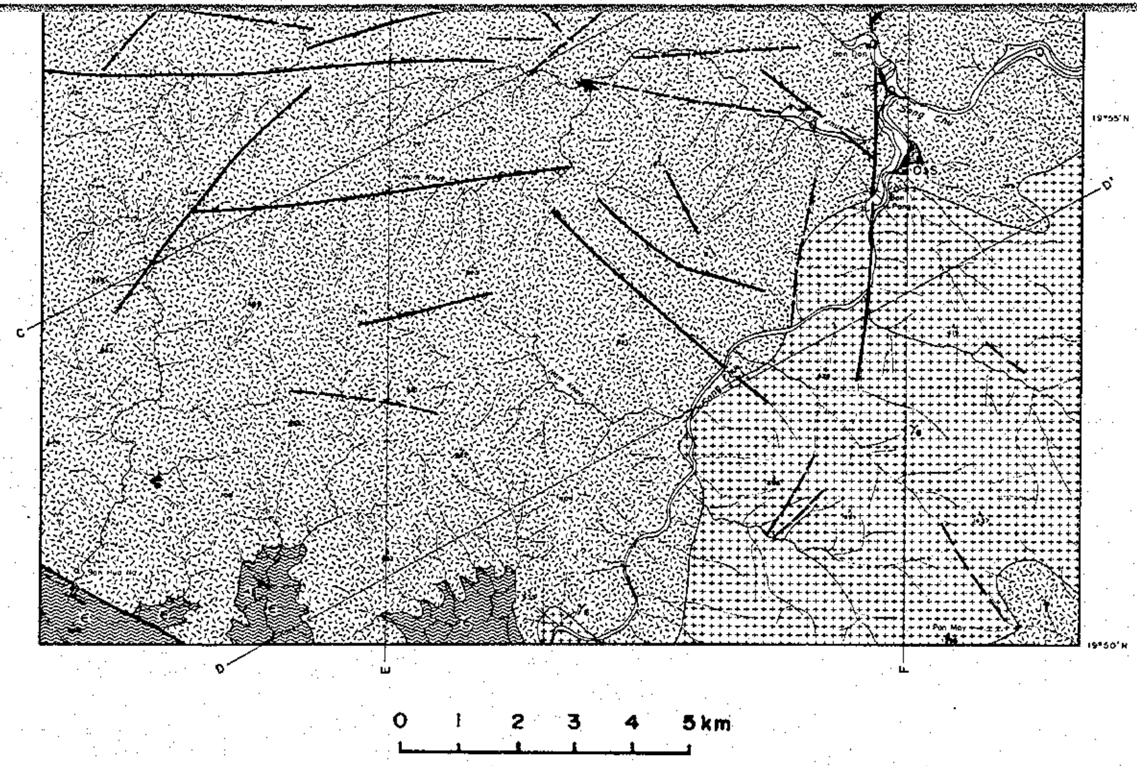


Fig.IV-1-2 Geologic Map of the Western Thanh Hoa Area

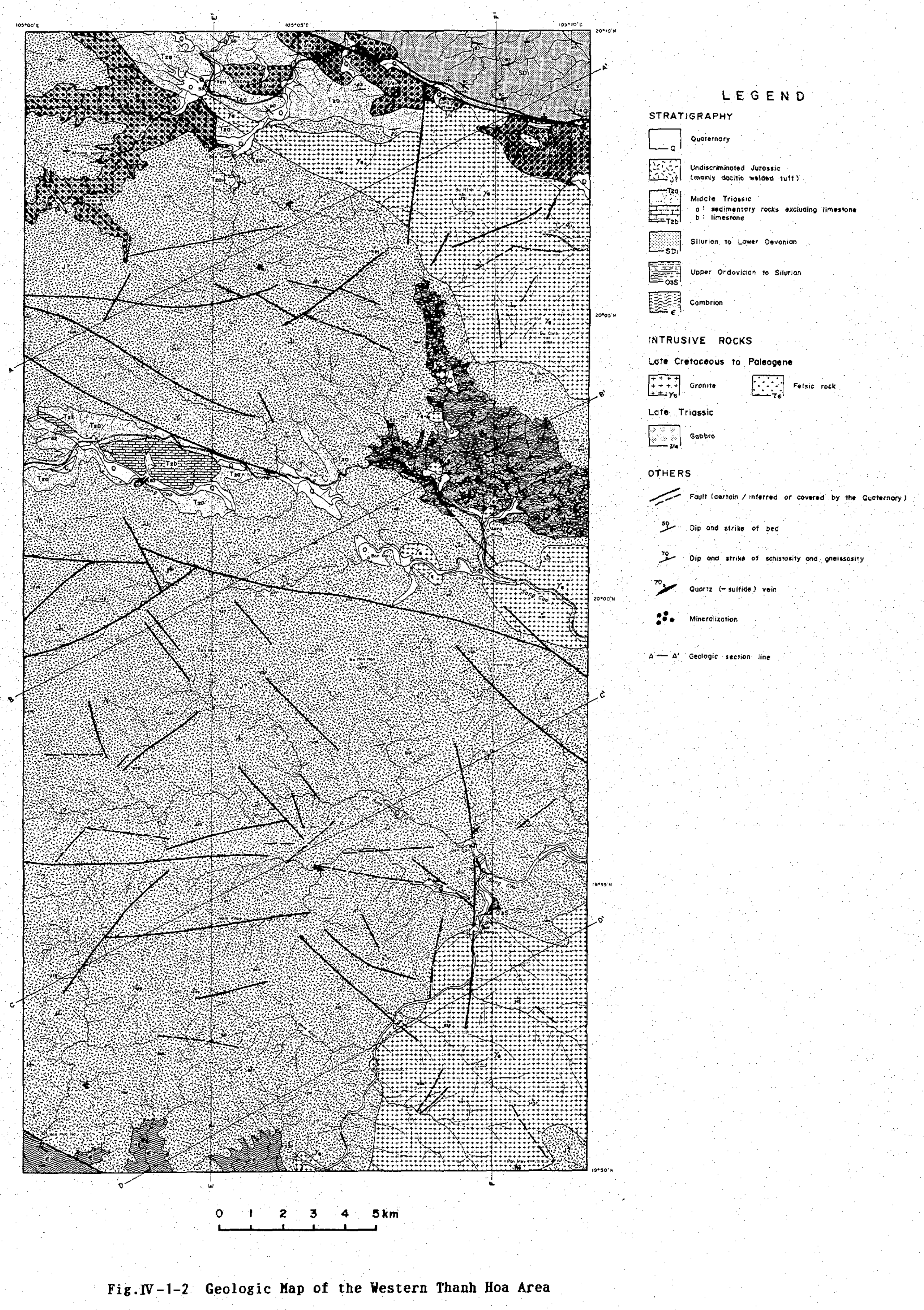


Fig.IV-1-2 Geologic Map of the Western Thanh Hoa Area

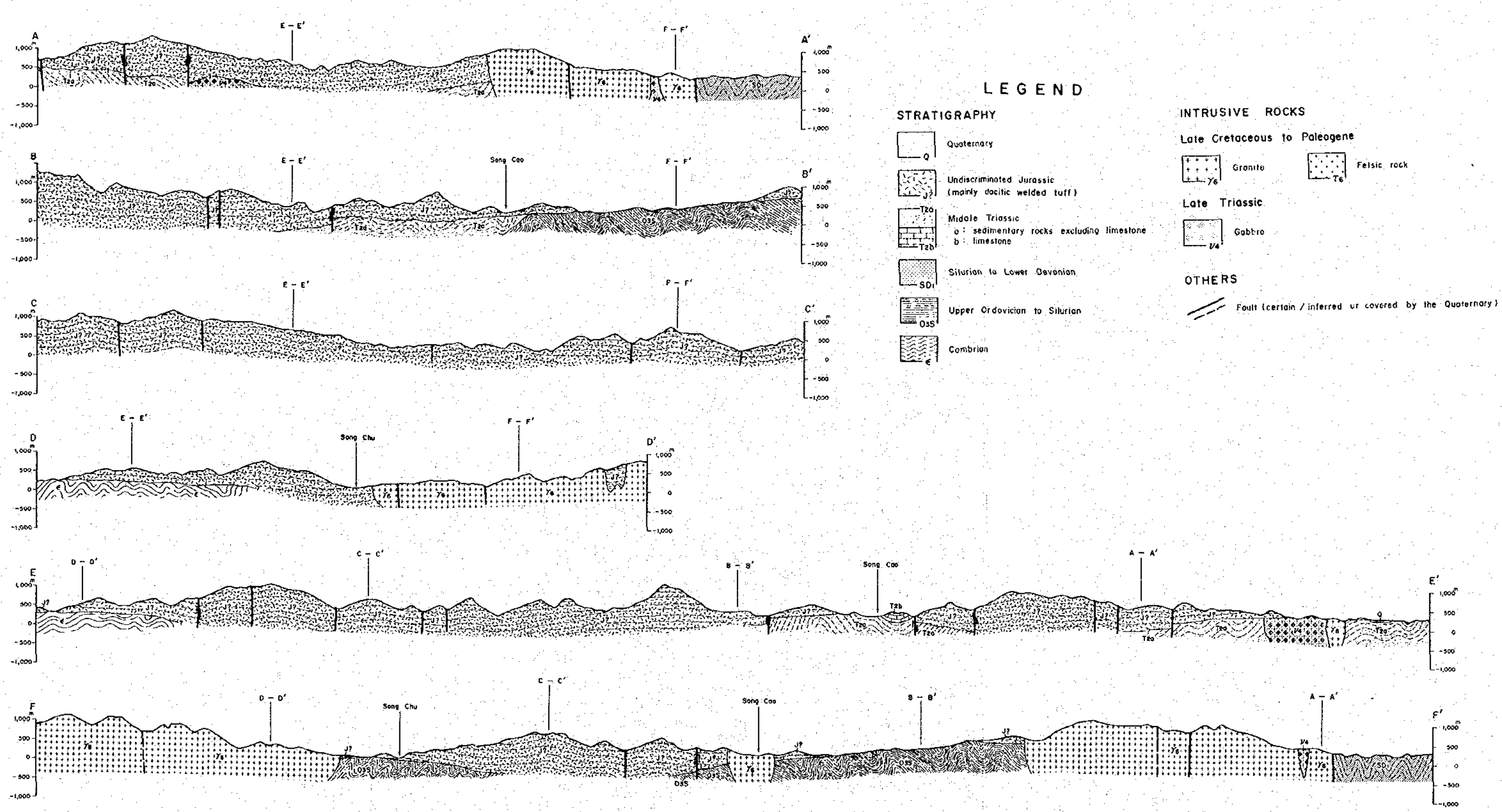


Fig.IV-1-3 Geologic Sections of the Western Thanh Hoa Area

The System forms igneous-metamorphic complex consisting of granodiorite to diorite, gneisses, and pelitic schists. The gneisses are originated from granodiorite to diorite. The unmetamorphosed rocks are made up mainly of grey coarse-grained biotite granodiorite.

It is estimated to be more than 500 m thick in the survey area.

(2) Upper Ordovician Series to Silurian System (O_3S)

This geologic unit forms one uplifted zone centering around tributaries of the Cao River. This uplifted zone is unconformably overlain by the Undiscriminated Jurassic (J?). Four small granitic bodies (γ_6) have intruded into the area of this O_3S.

The major part of the unit O_3S is made up of dark grey banded pelitic schist and most of the rocks change to medium-grained hornfelse which contains biotite and hornblende.

This O_3S is estimated to be 1,200 m thick.

(3) Silurian System to Lower Devonian Series (SD_1)

This geologic unit lies only in the northeastern edge of the area. It extends in the WNW-ESE direction with more than 3 km width and continues outside the area. It occurs in fault contact with a gabbro body on the south. This unit is also intruded by a gabbro body.

The unit SD_1 of this area consists mainly of black to dark grey phyllitic mudstone, and contains intercalated sequences of dark grey compact fine-grained limestone, grey micaceous siltstone, and grey fine-grained sandstone in the middle to upper part. The siltstone partly shows rhythmical alternating beds with mudstone.

The apparent thickness calculated within the SD_1 area is estimated to be 1,000 m.

(4) Middle Triassic Series (T_2a, T_2b)

This Series occurs continuously as a belt in the northern and west-central parts of the area. Topography of the T_2 area consists of hilly terrains with low relief energy. The Series has a granitic intrusion and is partly overlain by the Undiscriminated Jurassic (J?) in the northern part. In the west-central part, a part of this Series is in fault contact with the J?, but most of the unit is overlain by the J?. The Series generally extends in the WNW-ESE direction with 2 to 3 km width.

This T_2 Series is divided into two subunits, namely, the sedimentary rocks (T_2a; excluding limestones) constituting of the major part of the unit and limestones (T_2b) interbedded separately in the lower and upper parts of the T_2. The subunit T_2a is composed mainly of grey to light grey fine-grained sandstone, and is interbedded with black hard mudstone in the middle to upper part of the unit. Light grey siltstone is intercalated in the upper part of the west-central block. Sandstone located near granitic bodies changes to hornfelse. The subunit T_2b consists of dark grey massive limestone and widely occurs in the west-central part of the area.

This Series as a whole is estimated to be more than 1,000 m thick.

(5) Undiscriminated Jurassic System (J?)

This System occurs in wide areas occupying about 70 % of the whole survey area. The general structural trend of this System is not clearly recognized because faults of various directions are developed in this System, and the Paleozoic System and intrusive rocks such as granite crop out in a complex pattern. However, the tributaries of the Cao and Nam Bung Rivers and the principal ridges are aligned in the NW-SE to WNW-ESE direction. It appears from the above morphologic features that this direction indicates the macroscopic structural trend.

The System is characterized by the prevalence of very intense felsic volcanic activity and exhibits roughly homogeneous lithofacies covering a wide area. Generally it is made up mainly of light grey to dark grey or light green to dark green, hard compact dacitic crystal tuff, and is accompanied by a small amount of light grey to white conglomerate in the basal part. Besides, conglomerate and fine-grained sandstone are partly interbedded in the upper part of the System. The conglomerate contains quartzite pebbles with 0.5 to 2 cm in diameter. The matrix of the tuff consists of dark grey glass with a large amount of crystal fragments of quartz and plagioclase. Quartz fragments largely vary in size from 1 to 8 mm and plagioclase from 1 to 5 mm. Two to 5 mm rock fragments are found occasionally. They consist mainly of light greenish grey tuff and black mudstone. Typical welded structure is often observed in the southern half of the survey area.

This System is inferred to be 1,500 to 2,000 m thick.

(6) Quaternary System (Q)

The Quaternary System in this area is composed of fan sediments in the intra-montane basins, recent fluviatile sediments and so on which correspond to the Holocene alluvium. The sediments consist of gravel, sand, silt, and clay. Most of these sediments cover the areas along the main rivers and in the vicinity of confluences of those rivers in the northern part, and along the main stream of the Cao River in the central part. The alluvium hardly occur along the Chu River which is the largest one and located in the south of this area, and along its tributaries, because the downward erosion of the river is relatively more intensive than the sedimentation.

1.4. Intrusive Rocks

Mafic and felsic plutonic rocks and a felsic dike occur in this area. The geologic ages of these intrusions have been clarified by the Geological Survey of Vietnam (GSV,1991). The lithology of the plutonic rocks is classified by chemical composition into gabbroic rocks (ν_4) and granitic rocks (γ_6). The lithology of the felsic dike (τ_6) is dacite porphyry. These intrusive rocks crop out in the northern, eastern, and southeastern parts of the area.

(1) Late Triassic gabbroic rocks (ν_4)

The gabbroic rocks intruded mainly into the Middle Triassic Series (T_2a) and 4 bodies were found in this area (see Figure Ⅳ-1-2). They generally extend in the WNW-ESE direction. The dimensions of each body vary considerably, ranging in length by width from 2 km x 1 km to 10 km x 5 km. Although no clear trend and extent of intrusion is recognized for the body located in the northwestern edge because of unconformable cover by the overlying J? System, it seems possible that it has an extent of more than 6 km x over 6 km at least.

The rocks are generally dark green, compact coarse-grained, and holocrystalline. Microscopic studies reveal that they are composed essentially of clinopyroxene and plagioclase with subordinate amounts of secondary actinolite and epidote. They occasionally contain hornblende and olivine. Some of those bodies altered to metagabbros or are brecciated.

The list below shows the results of whole rock analysis of the representative rock samples.

Sample No.	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI
TMR 52	48.72	0.22	19.01	1.24	5.02	0.11	9.23	12.25	1.87	0.07	0.01	1.80
TMR 53	49.37	1.16	15.49	2.06	7.09	0.19	9.13	8.78	3.13	0.23	0.13	2.66

Unit: percent

(2) Late Cretaceous to Paleogene granitic rocks (γ_6)

The granitic rocks intruded into the Lower Paleozoic rocks (O_3S), the Middle Triassic Series (T_2a), the Undiscriminated Jurassic System (J?), and gabbroic rocks (ν_4). Eleven bodies of various dimensions are found in this survey area. Among these bodies, three located in the northern, eastern, and southeastern parts are continuous from the area of Phase I. One body in the north is of large-scale showing the extent of more than 15 km long and 6 km wide, and extends roughly in the E-W direction. This body intruded closely related with the gabbroic bodies, and form large rock masses accompanied by faults. Five bodies in the eastern part are of small-scale, where the largest one is 1.5 km long and 1 km wide. But one body has an areal extent of more than 3.5 km long and 3 km wide. One body located in the southeast, on the other hand, widely occurs with extent of over 8 km long and more than 7 km wide.

Lithofacies of the rocks is generally white to light pink, medium to coarse-grained holocrystalline, and biotite and muscovite are observable. Some parts of the large body of the northwest contains a large amount of coarse potash feldspar (microcline) with 10 mm in diameter.

The whole rock analysis of the representative samples collected from three bodies has revealed the following chemical composition.

Sample No.	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI
TMR 55	75.31	0.13	12.98	0.36	1.40	0.03	0.19	1.25	3.31	4.14	0.02	0.56
TGR 51	74.46	0.15	12.95	0.53	1.35	0.03	0.32	1.32	3.34	4.48	0.02	0.75
TGR 60	76.94	0.07	11.81	0.30	1.11	0.05	0.06	0.55	3.60	4.51	<0.01	0.48
TSR 52	70.99	0.56	13.42	0.46	3.11	0.07	0.89	0.71	2.40	5.36	0.16	1.37

Unit: percent

(3) Late Cretaceous to Paleogene felsic dike (τ_6)

This dike intruded into gabbroic body and the Undiscriminated Jurassic System (J?) in the northwestern part. Only one τ_6 dike occurs in this area. The dike extends in the NW-SE direction and exhibits lithofacies of dacite porphyry.

1.5. Geologic Structure

(1) Folds

Schistosities and bedding planes are highly developed in the Paleozoic metamorphic and sedimentary rocks. However, rocks of the T_2 Series and J (?) System are massive with poor structural elements except for some pelitic rocks. Therefore, detailed fold patterns cannot be clarified in this area. Nevertheless, the metamorphic, sedimentary, and pyroclastic rocks of all geologic ages generally have NW-SE to WNW-ESE structural trend. Therefore, it appears that a series of folds with the same trend of axes occur in this survey area.

Some characteristics of folds for each geologic unit are explained as follows on the basis of data obtained from this survey.

1) Lower to Middle Paleozoic (Є, O_3S, SD_1)

Folds in the Є System are not very clear because it is confined to small areas. The structure of the unit O_3S consists of a series of NW-SE trending folds with about 1 km wavelength, and those folds as a whole are inferred to form a large anticlinorium within this unit. The strata of the unit SD_1 strike WNW-ESE and very steeply dip NNE or SSW (nearly vertical). This unit is considered to be made up of a series of WNW-ESE trending folds with about 1 km wavelength.

2) Middle Triassic Series, Undiscriminated Jurassic System (T_2a, T_2b, J?)

The strata of the T_2a and T_2b steeply dip NNE or SSW exceeding 60°. This Series is believed to consist of a series of WNW-ESE trending anticline and syncline with about 1 km wavelength. The J? System unconformably overlies the underlying units except for the units SD_1 and γ_6. Based on the distribution pattern of the System in the whole survey area, it seems that dips of the strata are gentle and any conspicuous folds are not formed within the System.

(2) Faults

The occurrence of the geologic unit SD_1 is restricted by one WNW-ESE fault. This fault has long extension northwestward outside the area. The vertical displacement along this fault is considered to attain several kilometers. Eight faults parallel to the above fault were found in the northern half of the survey area. General trend of intrusion of granitic body (γ_6) is also WNW-ESE in the north. Thus the faults of this trend is thought to contribute a significant control to the macroscopic structure of the northern half of the area. In the southern half of the area, on the other hand, there are four systems of faults. They are E-W, NW-SE, NE-SW, and N-S systems. These faults occur in a complex pattern and most of them are present within the J? area. Therefore the order of formation on those fault systems is not clear in the southern half of the area.

1.6. Mineralization

The whole area for regional geological survey is generally free from any intense sign of mineralization. No remarkable mineralization was found except for only one locality of copper mineralization through this field survey (Figure Ⅳ-1-4).

1.6.1. Copper mineralization

The copper mineralization of this area is associated with quartz vein, and it is found in the Western Muong Ly mineral showing (tentative name).

【Western Muong Ly mineral showing】

This mineral showing is located in the main stream of the Cao River flowing eastward in the west-central part of the area and consists of four quartz veins within an area of about 20 m width (Figure Ⅳ-1-5). Host rocks are the Middle Triassic (T_2a) purplish grey conglomerate and light grey medium-grained sandstone. The veins have NE-SW strikes and SE dips. The dips range from 20° to 60°. The veins are more or less 5 cm wide (7 cm in maximum) and exposed parts are only 1 to 2.5 m long. Quartz is generally colorless.

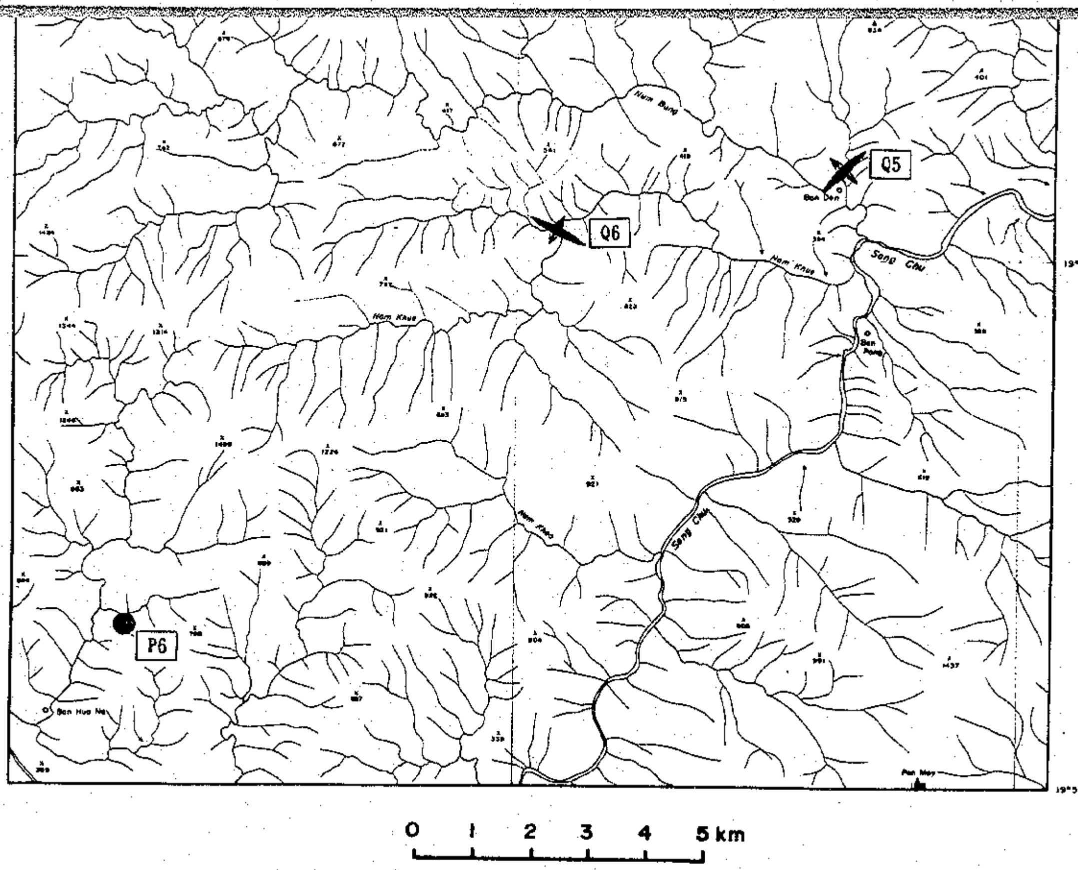
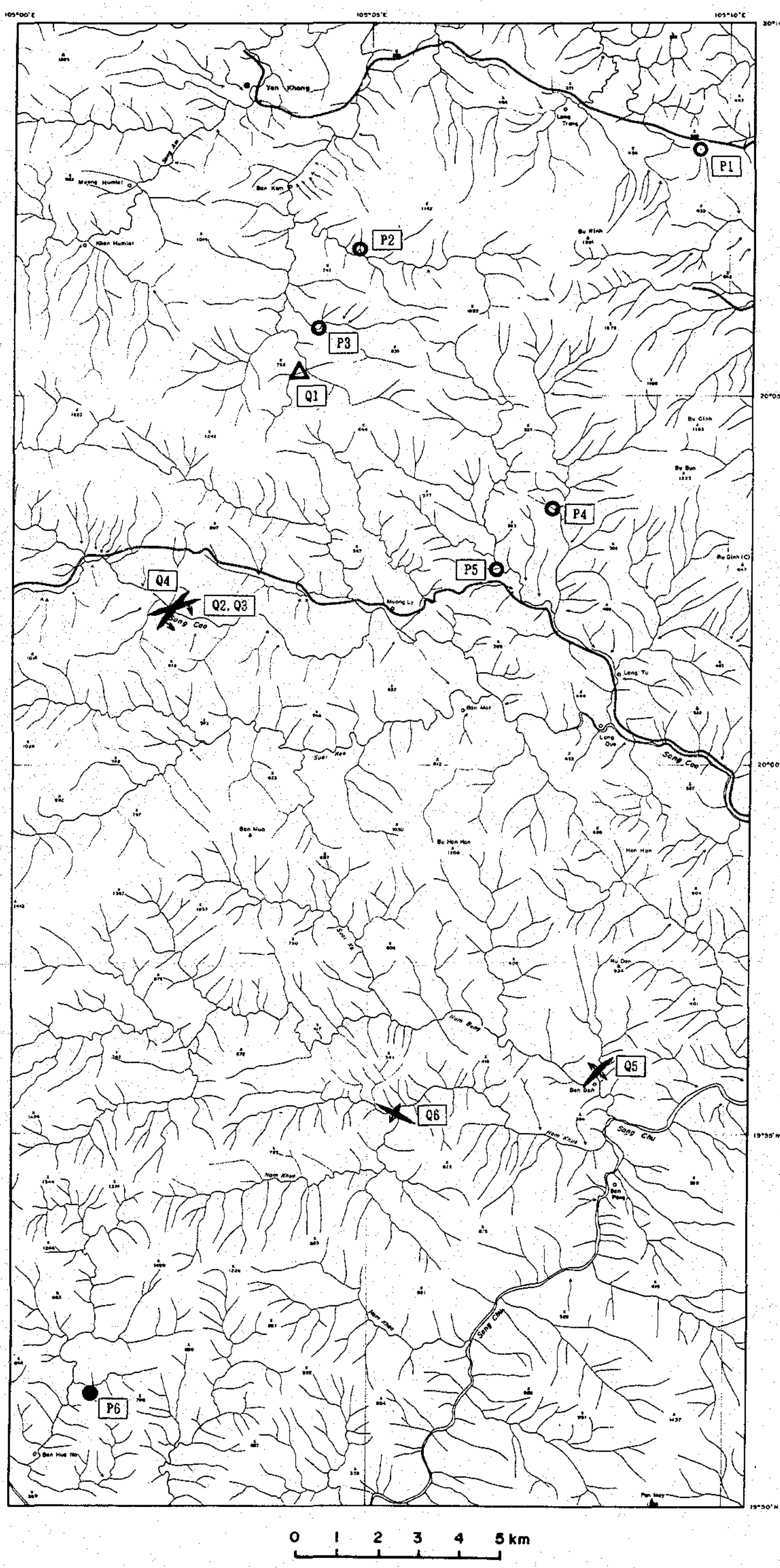


Fig.IV-1-4 Distribution Map of the Mineral Showings in the Western Thanh Hoa Area



L E G E N D

Mineralization

Outcrop

Quartz vein

Pyritization zone

Float

Quartz vein

Pyrite dissemination

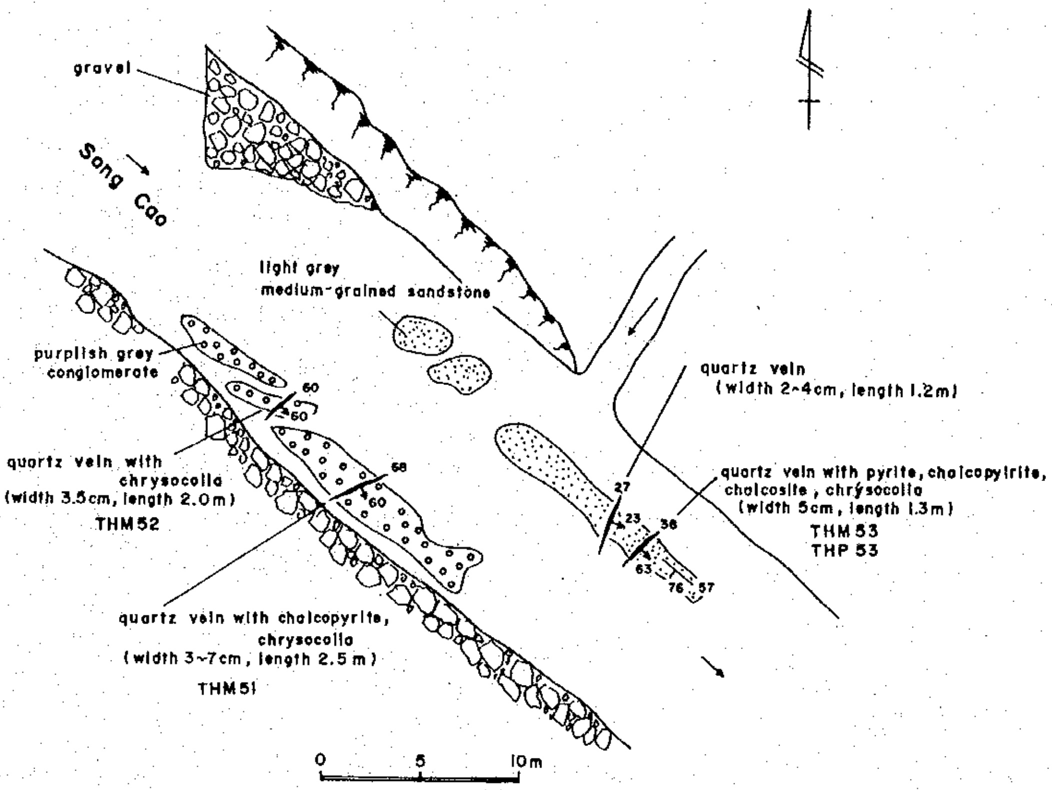
Location of sample for chemical analysis

Q 1:Quartz vein

P 1:Pyrite dissemination

No	Sample No.	vd Cm	Au ppb	Ag ppm	Cu %	Pb %	Zn %	Ni %	Cr %	Mn %	Sn %	W %
Q1	TAN53	-	<1	<2	0.019	0.002	0.009	0.007	0.049	0.022	<0.001	0.001
Q2	TMN51	0.7	<1	<2	0.146	0.001	0.002	<0.001	0.023	0.008	<0.001	0.001
Q3	TMN52	3.5	4	<2	0.290	0.003	0.005	0.001	0.029	0.010	<0.001	<0.001
Q4	TMN53	5.0	<1	3	0.691	0.002	0.019	<0.001	0.017	0.007	<0.001	<0.001
Q5	TSN60	10.0	<1	<2	<0.001	0.004	0.011	0.001	0.038	0.019	<0.001	0.002
Q6	TGN58	30.0	<1	<2	<0.001	0.003	0.002	<0.001	0.063	0.005	<0.001	0.002
P1	TAN51	-	<1	<2	0.009	0.003	0.088	0.009	0.031	0.034	<0.001	0.003
P2	TAN52	-	<1	<2	<0.001	0.003	0.034	0.003	0.012	0.032	<0.001	0.001
P3	TAN54	-	<1	<2	<0.001	0.009	0.027	0.001	0.011	0.006	<0.001	<0.001
P4	TGN53	-	5	<2	0.005	0.016	0.047	0.006	0.016	0.065	0.001	<0.001
P5	TGN54	-	1	<2	0.002	0.014	0.036	0.004	0.020	0.041	<0.001	<0.001
P6	TAN55	-	1	<2	<0.001	0.007	0.044	0.001	0.014	0.042	<0.001	<0.001

Fig.IV-1-4 Distribution Map of the Mineral Showings in the Western Thanh Hoa Area



Sample No.	wd (m)	Au (ppb)	Ag (ppm)	Cu (%)	Pb (%)	Zn (%)	Ni (%)	Cr (%)	Mn (%)	Sn (%)	W (%)
THM51	0.7	<1	<2	0.146	0.001	0.002	<0.001	0.023	0.008	<0.001	0.001
THM52	0.2	4	<2	0.290	0.003	0.005	0.001	0.029	0.010	<0.001	<0.001
THM53	0.5	<1	3	0.691	0.002	0.019	<0.001	0.017	0.007	<0.001	<0.001

Fig.IV-1-5 Geologic Sketch of the Western Muong Ly Mineral Showing

The main copper mineral is chrysocolla, but occasionally chalcopyrite and a trace amount of chalcosite are also observed microscopically.

The list below shows the assay results of three samples collected from three veins.

Sample No.	Sampling width(cm)	Au	Ag	Cu	Pb	Zn	Ni	Cr	Mn
THM 51	7.0	<1	<2	0.146	0.001	0.002	<0.001	0.023	0.008
THM 52	3.5	4	<2	0.290	0.003	0.005	0.001	0.029	0.010
THM 53	5.0	<1	3	0.691	0.002	0.019	<0.001	0.017	0.007

Au is in ppb, Ag in ppm, and other elements in percent.

In addition to this showing, quartz veins were found at four localities. Of the four, three samples were collected from three localities (Q1, Q5, and Q6 in Figure Ⅳ-1-4) for chemical analysis. The characteristics of those veins and this showing were summarized in Table Ⅳ-1-1.

1.6.2. Pyritization zone

Apart from the Muong Ly mineral showing and the other four quartz veins reported above, six pyritization zones were found in the area (Figure Ⅳ-1-4). Five zones of these six comprise floats. One zone (P6) located in the south and hosted by dacitic crystal tuff (J?) contains stockwork of quartz. This pyritization can hardly be classified into the category of mineralization for the same reason as that mentioned in the Van Yen Area. Table Ⅳ-1-2 shows the characteristics of the above pyritization zones together with assay results of collected samples for referential data.

Table IV-1-1 Characteristics of Quartz Veins in the Western Thanh Hoa Area

No.	Sample locality	Occurr-ence	Host rock	Mineral assemblage	Sample No.	Dimentions & trend (m)	Ore grade									
							Au ppb	Ag ppm	Cu %	Pb %	Zn %	Ni %	Cr %	Mn %	Sn %	W %
Q1	Southern Ban Kem	Floats	Dacitic crystal tuff	Py	TAM 53	—	< 1	< 2	0.019	0.002	0.009	0.007	0.049	0.022	< 0.001	0.001
Q2	Western Muong Ly	Vein	Conglo-merate	Cp,Cc	THM 51	N68E ,60S wd=3-7cm l=2.5m	< 1	< 2	0.146	0.001	0.002	< 0.001	0.023	0.008	< 0.001	0.001
Q3	Western Muong Ly	Vein	Conglo-merate	Cp,Cc	THM 52	N60E ,60S wd=3.5cm l=2.0m	4	< 2	0.290	0.003	0.005	0.001	0.029	0.010	< 0.001	< 0.001
Q4	Western Muong Ly	Vein	Sandstone	Cp,Cc	THM 53	N38E ,63S wd=5cm l=1.3m	< 1	3	0.691	0.002	0.019	< 0.001	0.017	0.007	< 0.001	< 0.001
Q5	Ban Don	Vein	Dacitic crystal tuff	Py	TSM 60	N40E ,90 wd=2&10c m	< 1	< 2	< 0.001	0.004	0.011	0.001	0.038	0.019	< 0.001	0.002
Q6	Western Ban Pang	Vein	Dacitic crystal tuff	Py dissemination	TGM 58	N77W ,90 wd=0.3m 2 veins	< 1	< 2	< 0.001	0.003	0.002	< 0.001	0.063	0.005	< 0.001	0.002

Py:Pyrite Cp:Chalcopyrite Cc;Chalcocite

Table Ⅳ-1-2 Characteristics of Pyritization Zones in the Western Thanh Hoa Area

No.	Sample locality	Occurrence	Host rock	Mineral assemblage	Sample No.	Dimentions & trend (m)	Ore grade									
							Au ppb	Ag ppm	Cu %	Pb %	Zn %	Ni %	Cr %	Mn %	Sn %	W %
P1	Eastern Lang Trang	Floats	Granite	Py,Po dissemination	TAM 51	—	< 1	< 2	0.009	0.003	0.088	0.009	0.031	0.034	< 0.001	0.003
P2	Eastern Ban Kem	Floats	Dacitic crystal tuff	Py dissemination	TAM 52	—	< 1	< 2	< 0.001	0.003	0.034	0.003	0.012	0.032	< 0.001	0.001
P3	Southern Ban Kem	Floats	Dacitic crystal tuff	Py disseminaton	TAM 54	—	< 1	< 2	< 0.001	0.009	0.027	0.001	0.011	0.006	< 0.001	< 0.001
P4	Sorth-western Lang Tu	Floats	Sandstone	Goe,Py dissemination	TGM 53	—	5	< 2	0.005	0.016	0.047	0.006	0.016	0.065	0.001	< 0.001
P5	Eastern Muong Ly	Floats	Biotite schist ?	Cp,Py dissemination	TGM 54	—	1	< 2	0.002	0.014	0.036	0.004	0.020	0.041	< 0.001	< 0.001
P6	Ban Huo Na	Stockwork+ dissemination	Dacitic crystal tuff	Cp,Py	TAM 55	—	1	< 2	< 0.001	0.007	0.044	0.001	0.014	0.042	< 0.001	< 0.001

Py:Pyrite Po:Pyrrhotite Goe:Goethite Cp:Chalcopyrite

CHAPTER 2. REGIONAL GEOCHEMICAL EXPLORATION

2.1. Stream Sediment Geochemical Exploration

2.1.1. Objectives

Stream sediment geochemistry was carried out aiming to grasp characteristics of mineralization and related elements in the present regional survey area, and to extract promising areas for mineral deposits based on characteristics obtained.

2.1.2. Sampling and chemical analysis

For stream sediment geochemistry, 469 samples of stream sediments were collected. Sediments were sieved into under 80 mesh fraction, and about 100 g of samples were prepared for chemical analysis after drying. Sample localities are shown in Plate 14.

Samples were sent to Japan and analyzed. Samples were analyzed for 11 elements of Au, Ag, Cu, Pb, Zn, Ni, Cr, As, Hg, Sn, and W. Nine elements except for the last two (Sn and W) were analyzed also in the Van Yen Area. Analytical methods used and detection limits of the above 9 elements are the same as those of the Van Yen Area. Two elements of Sn and W were analyzed by the method of ICP and their detection limits are both 2 ppm.

2.1.3. Statistical data-processing

(1) Elemental statistics

Analytical values of each element are recorded in Appendix 7. Elemental statistics parameters calculated by anti-logarithm and common logarithm for analytical values are shown in Table IV-2-1. On the occasion of values below the detection limit, one half of detection limit values were substituted.

(2) Frequency distribution

Histograms of analytical values of each element drawn by logarithm are shown in Figure IV-2-1. Histograms of four elements Cu, Pb, Zn, and As follow log-normal distribution, while those of the rest of elements do not follow normal or log-normal distribution. Element Au of which most of values are below the detection limit shows the L-shape pattern. Element Hg shows the pattern with double frequency peaks, and elements Sn and W show the irregular patterns.

(3) Correlation among elements

Correlation coefficients is shown in Table IV-2-2. Only one pair of Ni-

Table Ⅳ-2-1 Elemental Statistics Parameters in Stream Sediment Geochemistry of the Western Thanh Hoa Area

Antilog	Au	Ag	Cu	Pb	Zn	Ni	Cr	As	Hg	Sn	W
Minimum	0.5	0.01	0.2	7.5	6	2	0.5	0.1	5	1	1
Maximum	92	11.33	254.0	356.7	285	337	1,083	26.4	7,755	40	1,580
Average (m)	1.0	0.64	11.45	38.1	64.6	16	47	9.6	204	5	13
Standard deviation (σ)	4.8	1.04	13.2	31.0	39	25	101	4.8	697	3	79
PLDL*[1]	94.0%	1.7%	0.2%	0.2%	0.2%	0.9%	1.1%	0.9%	16.8%	12.8%	17.3%

*[1] : Percentage of less than detection limit

Log	Au	Ag	Cu	Pb	Zn	Ni	Cr	As	Hg	Sn	W
Minimum	-0.301	-2.000	-0.699	0.876	0.778	0.301	-0.301	-1.000	0.699	0	0
Maximum	1.964	1.054	2.404	2.552	2.454	2.528	3.034	1.422	3.890	1.602	3.199
Average (m)	-0.251	-0.409	0.949	1.497	1.737	1.051	1.363	0.909	1.525	0.602	0.709
Antilog	*0.6*	*0.39*	*8.9*	*31.4*	*55*	*11*	*23*	*8.1*	*34*	*4*	*5*
Standard deviation (σ)	0.241	0.435	0.328	0.252	0.261	0.290	0.483	0.306	0.682	0.295	0.438

Table Ⅳ-2-2 Correlation Coefficients between Element Pairs in Stream Sediment Geochemistry of the Western Thanh Hoa Area

	Au	Ag	Cu	Pb	Zn	Ni	Cr	As	Hg	Sn	W
Au	1										
Ag	-0.012	1									
Cu	0.021	-0.047	1								
Pb	-0.041	-0.003	0.031	1							
Zn	0.036	-0.078	0.135	0.435	1						
Ni	-0.016	-0.068	0.269	0.229	0.156	1					
Cr	-0.016	-0.013	0.391	0.143	0.104	0.887	1				
As	0.041	-0.110	-0.060	0.207	0.210	-0.105	-0.143	1			
Hg	0.018	-0.026	-0.042	0.031	0.109	0.213	0.121	-0.037	1		
Sn	0.007	0.053	-0.077	0.098	0.023	-0.120	-0.117	0.316	0.001	1	
W	-0.009	0.098	-0.021	0.063	-0.033	-0.010	0.008	-0.014	0.051	0.564	1

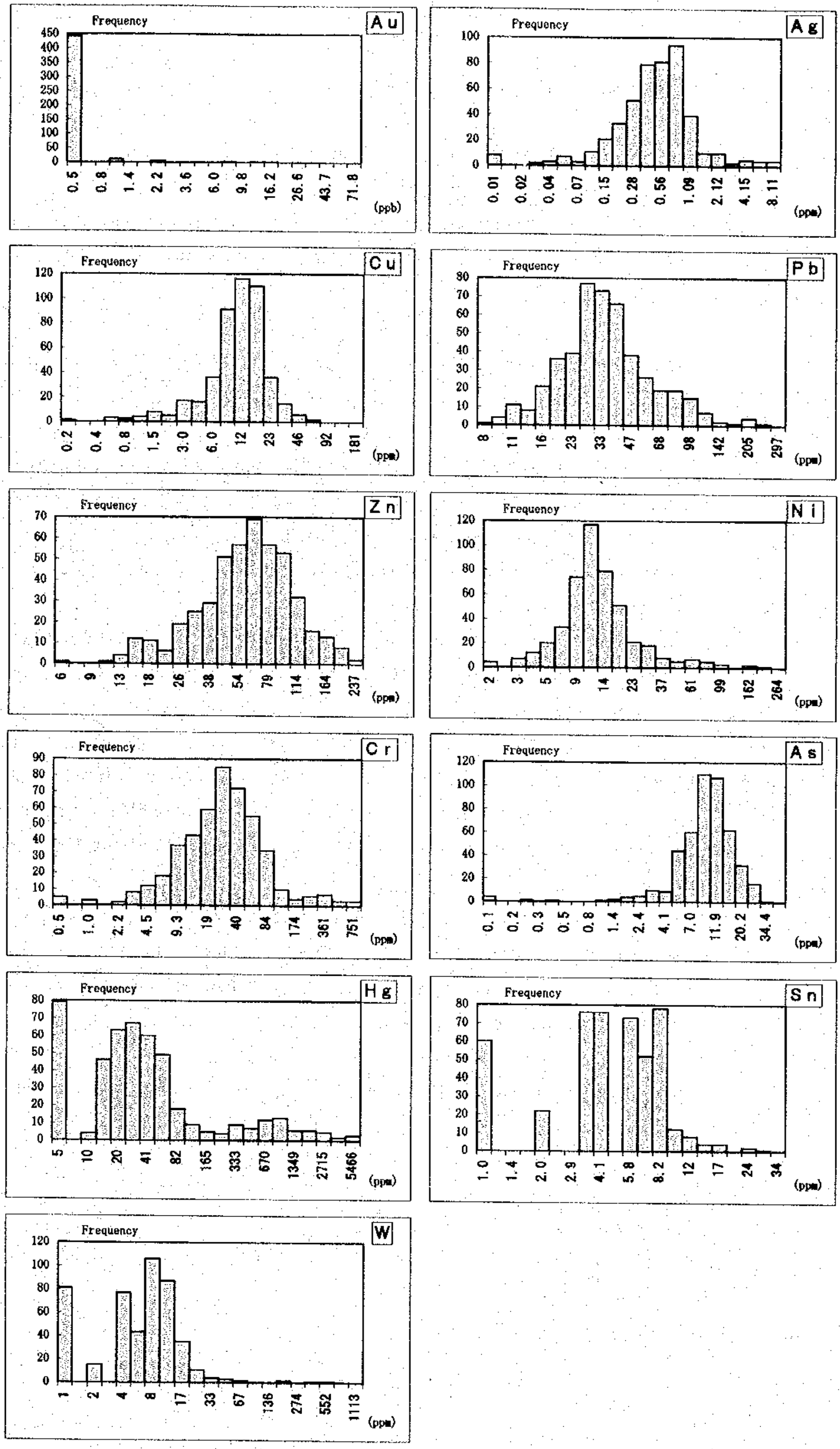


Fig.IV-2-1 Histograms of Assays on Stream Sediment Geochemical Samples Collected in the Western Thanh Hoa Area

Cr shows significant correlation coefficient (R=0.8865).

2.1.4. Geochemical anomalies and anomalous zones

(1) Determination of threshold value

In order to determine threshold values, the same method used in the Van Yen Area was adopted. The cumulative frequency distribution diagrams were drawn by logarithm of analytical values.

Cumulative frequency distribution diagrams of each element were drawn on logarithmic probability graph paper (Figure IV-2-2).

Diagrams of four elements Cu, Pb, Zn, and As of which histograms show log-normal distribution indicate rectilineal pattern, so that these values are considered to belong to single population. Therefore, the values of mean value + standard deviation x 2 ($m+2\sigma$) are used for threshold values of these elements to check higher grade parts.

As for Au, values of 94 % of samples are below the detection limit, and distribution pattern itself is indistinct. Therefore the detection limit is treated as threshold value.

Diagrams of Ag, Ni, Cr, Sn, and W show breaking points around probability of several percent. Therefore, values at these points are used for threshold values of these elements. However, it is uncertain whether the breaking point indicates disparity of populations or not, because differences of inclination are slight.

On the other hand, diagram of Hg of which histogram has double frequency peaks shows S-shape curve and indicate these values belong to typical composite population. As for this element, the value at point of minimum frequency between two peaks is used for threshold value.

Based on the above threshold values, the following anomalies were instituted.

Au:	weak anomaly	(≧1 ppb, <10 ppb)
	strong anomaly	(≧10 ppb)
Ag:	anomaly	(≧3 ppm)
Cu:	anomaly	(≧40.2 ppm)
Pb:	anomaly	(≧100.5 ppm)
Zn:	anomaly	(≧182 ppm)
Ni:	anomaly	(≧40 ppm)
Cr:	anomaly	(≧130 ppm)

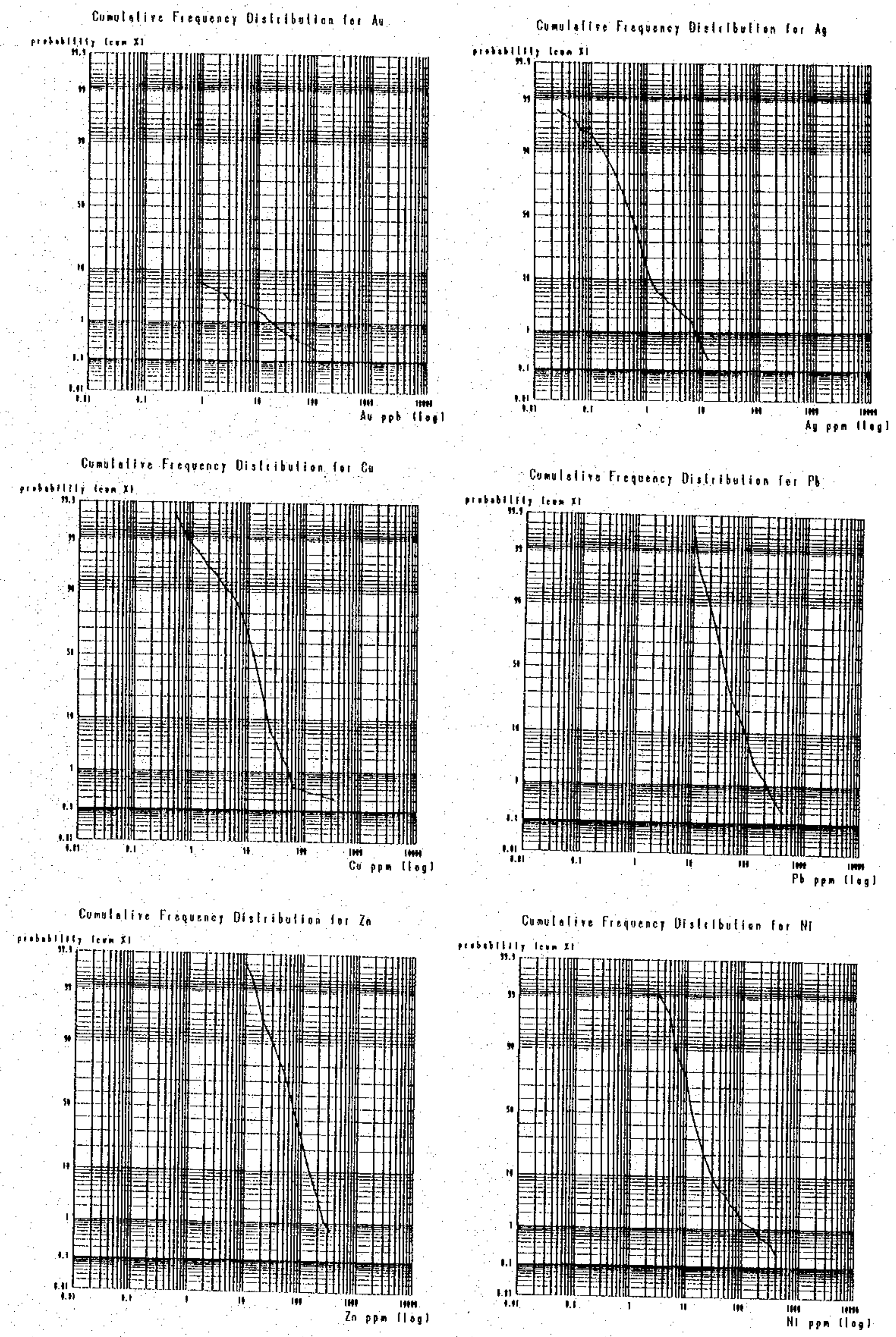


Fig.Ⅳ-2-2 Cumulative Frequency Distribution of Assays on Stream Sediment Geochemical Samples Collected in the Western Thanh Hoa Area (1)

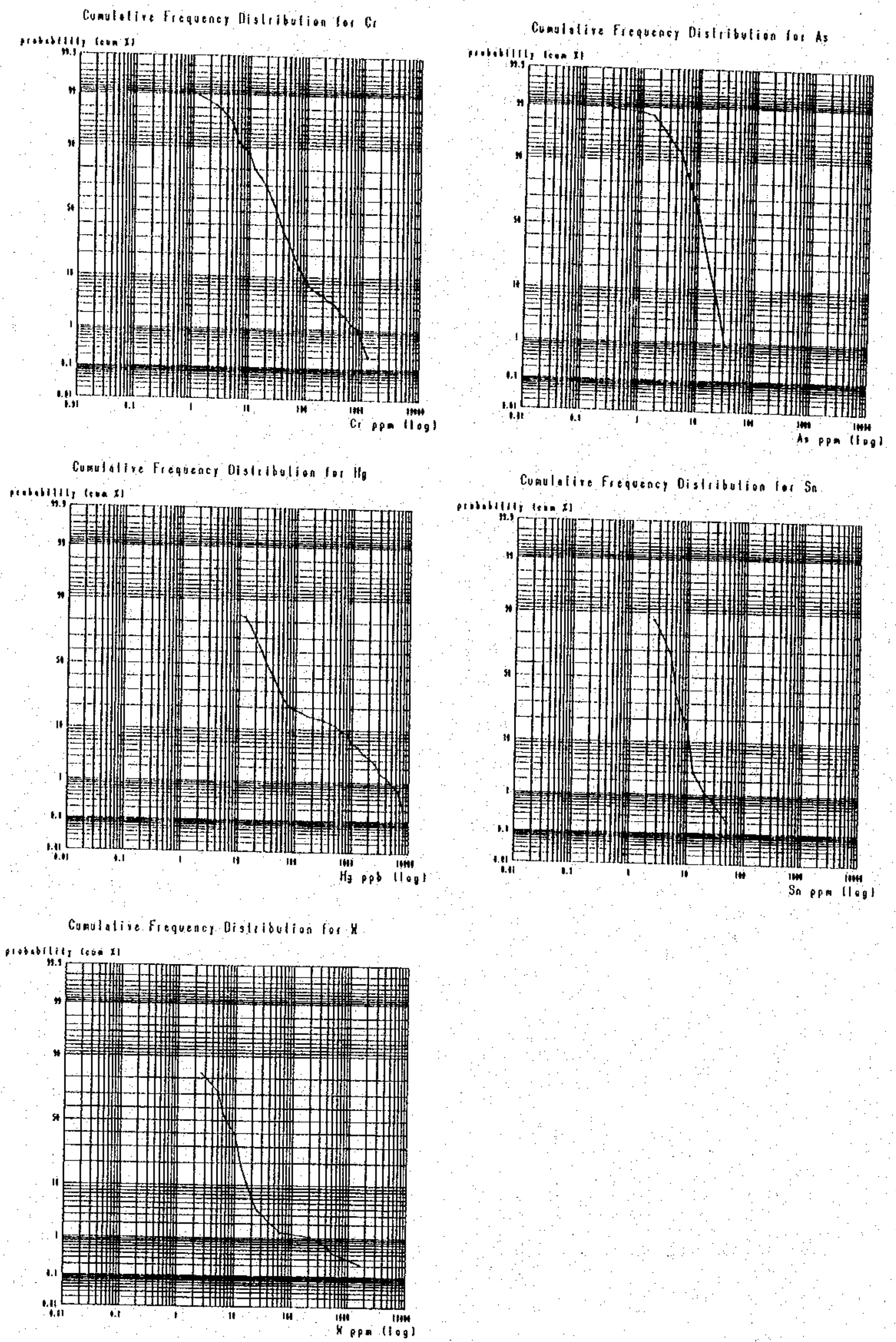


Fig.Ⅳ-2-2 Cumulative Frequency Distribution of Assays on Stream Sediment Geochemical Samples Collected in the Western Thanh Hoa Area (2)

As: anomaly (≥32.2 ppm)

Hg: weak anomaly (≥200 ppb, <800 ppb)

; value at point of minimum frequency between two peaks

medium anomaly (≥800 ppb, <2,500 ppb)

; value at righthand frequency peak

strong anomaly (≥2,500 ppb)

; 2.5 % of the whole analytical values

Sn: anomaly (≥13 ppm)

W: anomaly (≥60 ppm)

(2) Anomalous zones

Anomalous points of each element extracted on the basis of the above threshold values are plotted in Appendix 14. Here anomalous zone includes weak to strong anomalous zone unless noted.

Areas with concentration of anomalous points are listed for each element hereunder. In principle, concentration means cases with nearby (about 1 km) two points or with 3 or more points closely (3 to 4 km) distributed.

Au:

a) Western part of the area; around 8 km west of Muong Ly

b) Central part of the area; around 2 km south of Ban Mot

Ag:

a) Northeastern part of the area; around Lang Trang

b) Northeastern part of the area; around 4 km southeast of Lang Trang

Cu:

a) Northeastern part of the area; around 4 km east of Lang Trang

Pb:

a) Northwestern part of the area; around 4 km west of Yen Khong

b) Northwestern part of the area; around Ban Ken

Zn:

a) Northwestern part of the area; around Ban Ken

b) Southeastern part of the area; around Ban Pang

Ni:

a) Northeastern part of the area; around Lang Trang

b) Northeastern part of the area; around 4 km southeast of Lang Trang

c) Northwestern part of the area; around 3 km north of Yen Khong

d) Eastern part of the area; around Lang Due

e) Eastern part of the area; around 4 km north of Lang Due

Cr:

a) Northeastern part of the area; around Lang Trang; corresponding to the area of Ni anomalous zone a) to b)

b) Northeastern part of the area; around 4 km northwest of Lang Trang

c) Northwestern part of the area; around 3 km north of Yen Khong; corresponding to Ni anomalous zone c)

d) Eastern part of the area; around 4 km north of Lang Due; corresponding to Ni anomalous zone e)

As:

There is no analytical value more than $m+2\sigma$ because the histogram has the pattern with gentle slope toward the side of low values, and no anomaly was detected.

Hg:

a) Strong anomaly concentration in a relatively wide area from Muong Ly to the north of Lang Due in the central part of the area

b) Strong anomaly concentration in a relatively wide area centering around Ban Pan in the southeastern part of the area

Sn:

a) Southeastern part of the area; around Ban Pan

b) Southwestern part of the area; around Ban Hua Na

W:

a) Southeastern part of the area; around Ban Pan

2.1.5. Consideration

(1) Results of analysis and statistics

Element Hg is noteworthy one in this area. As indicated in the histogram, the analytical values of Hg belong to two populations. The average of the population in lower-value side is about 30 ppm and that in higher-value side indicates around 1,000 ppm. The former value is in a similar level to the average of Hg in the Phase I survey area located on the east of this area. Thus, it can be stated that this population shows the background values of this area. The population in higher-value side, on the other hand, has high average of about one hundred times compared with that in lower-value side, and anomalies are concentrated. Therefore, it should be considered that the element Hg has been supplied for some reason in anomalous zones of this area. Threshold values of other elements are merely one to three times of the average composition of the earth's crust. Consequently, it is hard to mention that geochemical anomalies of these elements have originated in mineralization.

(2) Relationship with geology and geologic structure

Two Hg anomalous zones are present in this area. One zone is underlain by pelitic schist and dacitic crystal tuff, and another by granite and dacitic crystal tuff. Because of this, the above two zones have no relation to lithology. Additionally any clear relationship with faults is not recognized. One possibility is that element Hg has been supplied along some underground faults, but no data was obtained to support this idea. At the present state of knowledge of this area, the reason of Hg concentration still remains in question.

Anomalous zones of Ni and Cr overlap one another in the northeastern part of the area. These elements are believed to have been supplied from gabbroic bodies because the bodies occur in the vicinity of those anomalous zones. However, the zones themselves can not be regarded as remarkable anomalous zones related to mineralization in view of the fact that values of these anomalies are in similar levels to those of average composition of the earth's crust or mafic rocks.

2.2. Panned Concentrate Geochemical Exploration

(1) Objectives

The lead-zinc and copper mineral showings were confirmed by the previous geologic and metallogenic data, and tin-tungsten mineralization possibly occurs in this regional survey area. This exploration was conducted in the survey area in order to obtain the characteristics of heavy minerals in the mineral showings and to discover new potential areas. Furthermore, in the Luong Son Mineralization Zone for the detailed geological survey area, the exploration was carried out in order to discover new quartz veins in addition to the known veins.

(2) Collection, treatment, and identification of panned concentrates

The sampling of panned concentrates was carried out along the main streams and their tributaries, and at the streams around the known mineralization zones during the course of the geological survey. The total number of panned concentrates is 135 samples in this area. Fifteen of them were collected in the Luong Son Mineralization Zone. The sample was collected by five-times panning (approximately 25ℓ). The samples were dried up and weighed. The heavy minerals were identified based on the methods employed in the Van Yen Area.

(3) Results of the mineral identification

The results of the mineral identification are laid out in Appendix 9.

The identified minerals are magnetite, ilmenite, limonite, hematite, garnet, staurolite, epidote, siderite, tourmaline, pyroxene, serpentine, chromite, wolframite, monazite, cassiterite, malachite, zircon, rutile, cinnabar, pyrite, and native gold. The heavy minerals related to mineralization in this area are considered to be native gold, copper minerals (malachite), cassiterite, and wolframite.

The number of their localities is as follows.

- Gold: 7
- Malachite: 1
- Cassiterite: 12
- Wolframite: 1

The heavy minerals of magnetite, ilmenite, zircon, and rutile were usually observed in this area.

(4) Distribution of heavy minerals

The localities of heavy minerals confirmed microscopically for native gold, malachite, cassiterite, and wolframite are shown in Figure Ⅳ-2-3 and described below.

【Native gold】

1) Tributary of the Am River, 1.5 km northeast of Lang Trang
2) Tributary of the Am River, 2 km east of Lang Trang
3) Tributary of the Cao River, 3 km north of Muong Ly
4) Tributary of the Cao River, 4 km east of Muong Ly
5) Tributary of the Cao River, 1.5 km north-northeast of Lang Due
6) Tributary of the Chu River, 2.5 km east of Bu Don (altitude: 834 m)
7) Lower reaches of the Nam Khue Stream, tributary of the Chu River

【Malachite】

1) Same locality as that of 4) of native gold

【Cassiterite】

1) Northern part of the area; 4 localities
2) Main stream and tributaries of the Chu River; 6 localities
3) In the vicinity of Ban Hua Na in the southwestern part of the area; 2 localities

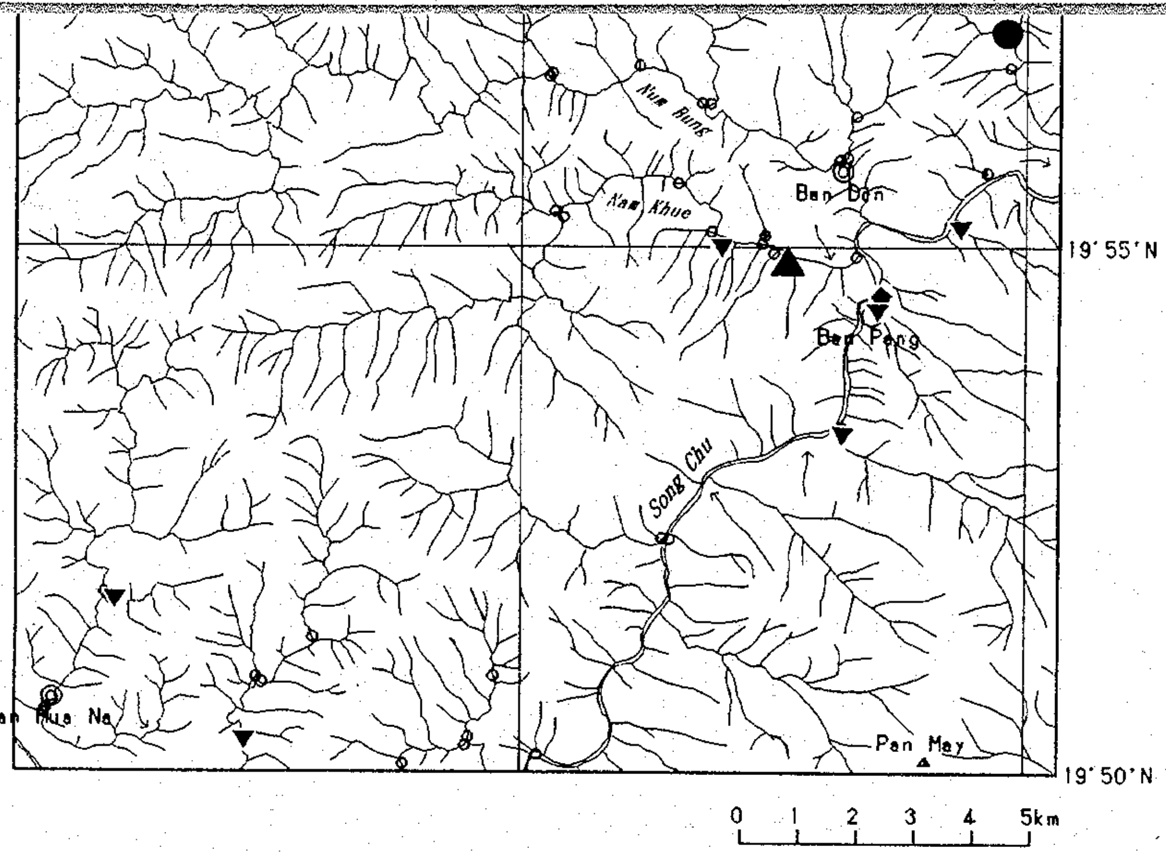
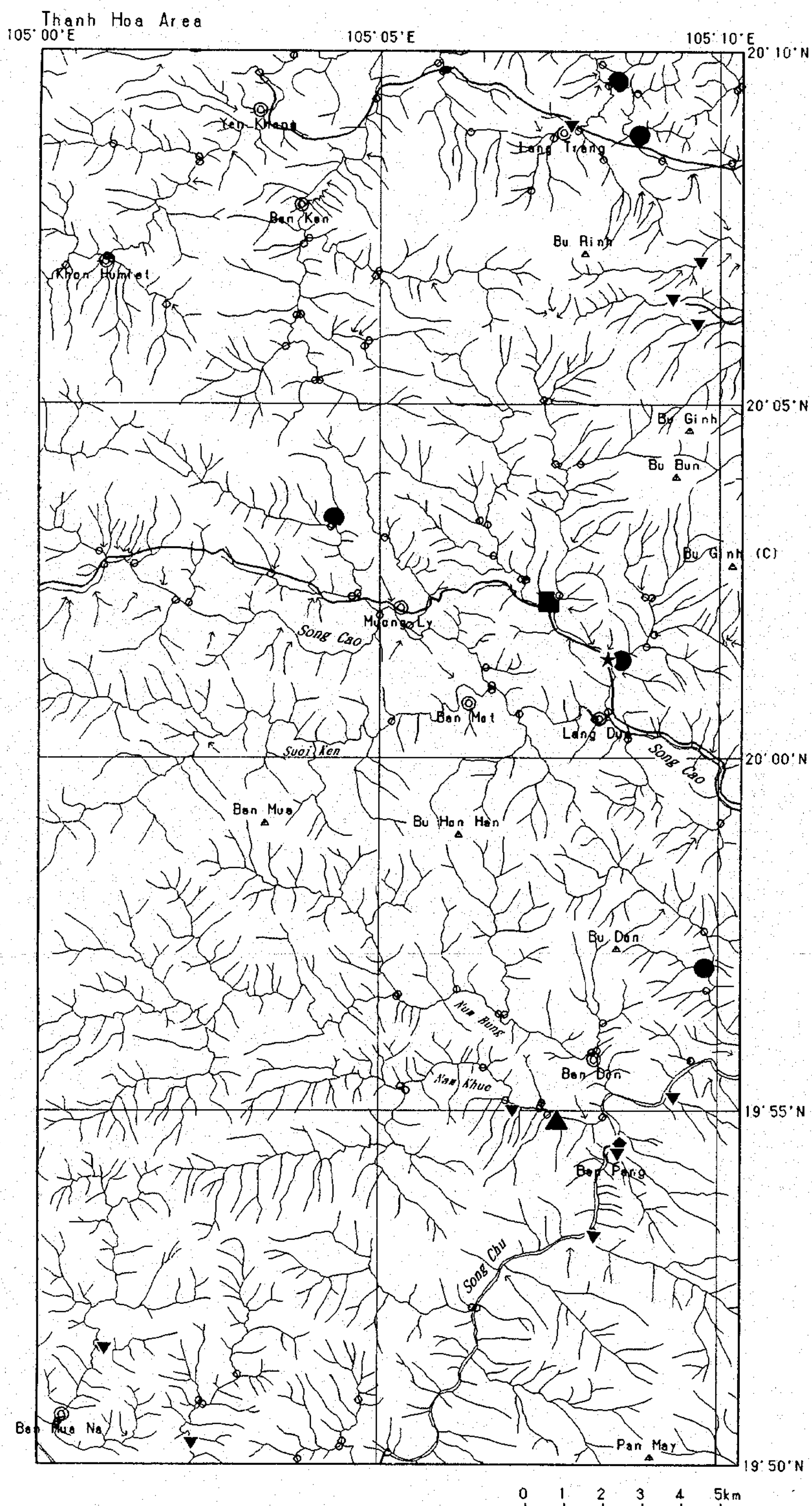


Fig.IV-2-3 Locality Map of Heavy Minerals in the Western Thanh Hoa Area



LEGEND

○ : Location of panned concentrate samples

Localities of grains

● : Au

■ : Au-Mc

▲ : Au-Cs

★ : Mc

▼ : Cs

◆ : Cs-wf

Abbreviation

Au : Gold

Mc : Malachite

Cs : Cassiterite

Wf : Worframite

Fig.IV-2-3 Locality Map of Heavy Minerals in the Western Thanh Hoa Area

【Wolframite】

1) Tributary of the Chu River in the southeastern part of the area (with cassiterite)

(5) Discussion

The following relationship was recognized between the localities of heavy minerals and the geology.

The localities of confirmed native gold and malachite grains are sparse in this survey area, and are considered to have no relation to the specified geologic units. Moreover, quartz veins were not found at present in the upper reaches of the streams of those localities.

Cassiterite and wolframite grains were confirmed in and around the granitic bodies which occur in the northern and southeastern parts of the area except for two localities of 3) mentioned above. Thus, the origin of those minerals is considered to be controlled by the granitic intrusion. However, those minerals were not always found in and around all of granitic bodies of this area.