Series (T_2) of the A zone. These faults extend in the NW-SE direction with good continuity. Faults of this system are also found within some geologic units. Some of those faults are discontinuous because they are cut by other E-W or N-S trending faults. The apparent vertical displacements by those continuous faults are unknown since most of the units are in fault contact with one another. Nevertheless, at least several kilometers of vertical displacements can be estimated between the units T_2 and D_{2s}. Some small faults near Van Yen and inferred faults derived from the fracturing along the axial planes of the folds are not shown on Figure Ⅲ-1-2 (geologic map).

1.6. Mineralization

Many gold, copper, lead, zinc and other deposits and mineral showings have been found in this survey area, but only the Suoi Tiat mine with gold-bearing copper deposit is presently under operation. In addition to the above, some other showings have been explored by means of galleries and pits as well as trenches.

The following mineralization was investigated during the course of this survey.

1.6.1. Gold

There are two types of mineralization. One is associated with the activity which formed the bedded cupriferous pyrite deposits (mentioned later), and the other resulted in gold-bearing quartz vein. The former type of mineralization will be reported in 1.6.2. The above deposits and showings are plotted on the Figure Ⅲ-1-5.

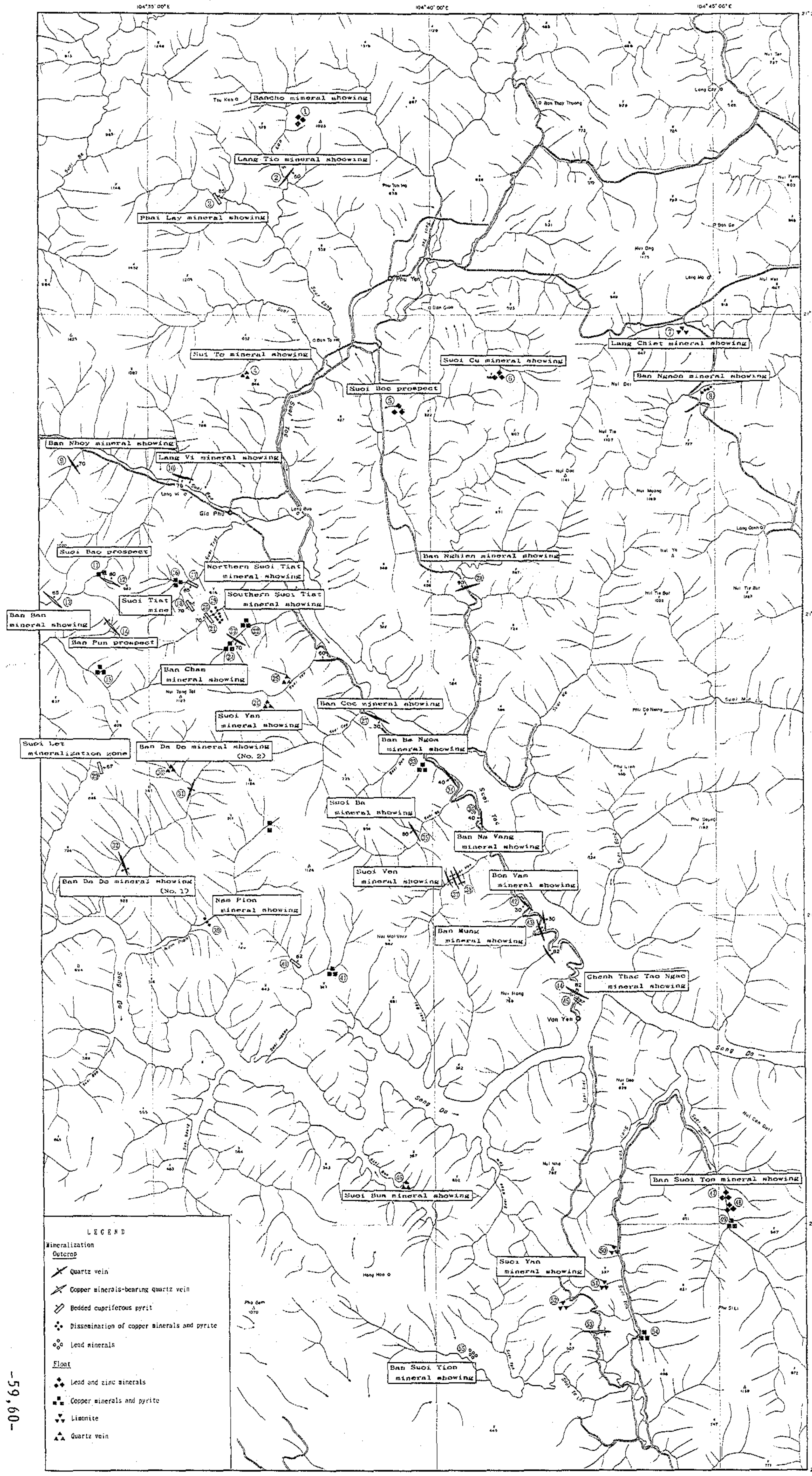
The total number of sampled gold-bearing quartz veins during this survey is 18. Most of them are concentrated within the Lower Triassic T_1 Series bounded by the Toc and Da Rivers.

The veins are mostly less than 1 m wide. The gold contents of veins range from several to several tens ppb. Table Ⅲ-1-1 shows the characteristics of quartz veins investigated by the present survey.

Table Ⅲ-1-1 Characteristics of Quartz Veins in the Van Yen Area

Name of mineralization zone	Features of deposit	Country rock	Strike and dip	Mineral	Sample No.	Wd(m)	Ore grade							
							Au	Ag	Cu	Pb	Zn	Cr	Mn	Ni
Suoi To(2)	Float			Qz,Lm	VNM 2		1	< 2	< 0.001	0.003	0.003	0.013	0.003	0.009
Ban Nhoj	Vein	Batf	N40°W/70°N	Qz	VFM 1	0.60	3	< 2	< 0.001	< 0.001	0.007	0.010	0.059	0.001
Lang Vi	Vein	Rhy	N-S/76°S	Qz,Lm	VFM 2	1.00	19	< 2	0.001	0.003	0.012	0.022	0.107	0.011
Do	Vein	Rhy		Qz,Lm	VFM 3	0.40	29	< 2	< 0.001	0.001	0.007	0.023	0.157	0.011
Do	Vein	Rhy		Qz,Lm	VFM 4	0.10	14	< 2	< 0.001	0.001	0.008	0.034	0.074	0.007
Ban Nghiem	Vein	Sh	N70°E/80°N	Qz	VNM 1	0.50	1	< 2	< 0.001	0.003	0.003	0.013	0.012	0.009
Suoi Yan(1)	Floats			Qz	VGM 6		8	< 2	0.035	0.007	0.012	0.016	0.072	0.002
Do	Floats			Qz,Cp	VGM 9		8	< 2	0.001	0.006	0.006	0.023	0.010	< 0.001
Do	Floats			Qz,Cp	VGM10		12	< 2	0.102	0.004	0.004	0.021	0.108	< 0.001
Ba Da Do(No.1)	Vein	Ba	N20°E/90°	Qz	VGM25	0.20	3	< 2	0.001	0.001	0.002	0.041	0.024	0.003
Ba Da Do(No.2)	Vein	Batf	N20°W/90°	Qz	VGM24	0.10	8	< 2	0.250	0.002	0.007	0.036	0.110	0.005
Ban Coc	Vein	Tf	N70°W/30°	Qz	VNM 4	0.30	6	37	0.003	0.021	0.004	0.139	0.029	0.023
Ba Ba Ngoa	Vein	Batf	N30°W/40°	Qz	VNM 3	0.60	< 1	< 2	< 0.001	0.003	0.002	0.030	0.042	< 0.001
Ban Na Vang	Vein	Sh	N50°W/70°S	Qz	VGM 4	0.40	< 1	< 2	< 0.001	0.003	0.005	0.026	0.050	< 0.001
Suoi Ba	Vein	Batf	N30°W/70°S	Py,Qz	VGM 5	1.00	3	< 2	< 0.001	0.003	0.004	0.035	0.243	0.001
Suoi Ven	Vein	Batf	N30°W/90°	Qz	VGM 2	1.10	1	< 2	0.005	0.007	0.007	0.045	0.015	0.001
Do	Vein	Sdytf	N30°W/40°W	Qz	VGM 3	0.40	7	< 2	< 0.001	0.004	0.006	0.034	0.032	0.002
Bon Van	Vein	Batf	N45°W/30°S	Qz	VGM22	0.20	3	< 2	< 0.001	< 0.001	< 0.001	0.026	0.018	0.003
Ban Mung	Stockwork	Batf	N50°W/90°	Qz	VGM21	7.00	< 1	< 2	< 0.001	< 0.001	0.006	0.031	0.110	0.003

Ba:Basalt, Batf:Basaltic tuff, Rhy:Rhyolite, Sh:Shale, Sdytf:Sandy tuff, Qz:Quartz, Py:Pyrite, Lm:Limonite,
Cp:Chalcopyrite Au:ppb, Ag:ppm, orther elements:%



Sample	wd m	Au ppb	Ag ppm	Cu %	Pb %	Zn %	Cr %	Mn %	Ni %
Bancho mineral showing									
① Pb-YFK32	-	5	<2	0.016	34.542	0.025	0.027	0.028	0.002
Lang Tio mineral showing									
② Cp-YSM 1	1.50	50	<2	1.651	0.005	0.112	0.064	0.060	0.002
Phai Lay mineral showing									
③ Cp-YFK21-1	0.30	<1	5	0.877	0.012	0.259	0.073	0.018	0.022
Cp-YFK21-2	0.10	12	3	0.410	0.006	0.012	0.049	0.027	0.002
Cp-YFK21-3	0.10	1	<2	0.043	<0.001	0.011	0.056	0.042	0.002
Sui To mineral showing									
④ Qz-VNM 2	-	6	<2	<0.001	0.002	<0.001	0.012	0.003	<0.001
Suoi Boc prospect									
⑤ Zn-YFK22	-	1	431	0.025	11.874	39.414	0.009	0.053	0.002
Suoi Cu mineral showing									
⑥ Zn-YFK27	-	1	75	0.128	25.819	28.893	0.034	0.208	0.002
Zn-YFK28	-	19	<2	0.011	0.964	37.775	0.604	0.265	0.001
Zn-YFK29	-	5	3	0.003	0.051	0.147	0.030	0.044	0.002
Lang Chiet mineral showing									
⑦ Fe-YNM 1	-	10	<2	0.038	0.281	0.184	0.017	0.018	0.003
Ban Ngnon mineral showing									
⑧ Cp-YNM 2	2.20	2	<2	0.011	0.012	0.016	0.039	0.104	0.036
Ban Nhoy mineral showing									
⑨ Qz-YFM 1	0.60	3	<2	<0.001	<0.001	0.007	0.010	0.059	0.001
Lang Vi mineral showing									
⑩ Qz-YFM 2	1.00	19	<2	0.001	0.003	0.012	0.022	0.107	0.011
Qz-YFM 3	0.40	29	<2	<0.001	<0.001	0.007	0.023	0.157	0.011
Qz-YFM 4	0.10	14	<2	<0.001	<0.001	0.008	0.034	0.074	0.007
Suoi Bao prospect									
⑪ OxCp-YFK18	-	36	22	0.969	<0.001	<0.001	0.061	0.003	0.004
⑫ OxCp-YFK19-1	0.80	2	<2	0.549	0.001	0.002	0.049	0.011	0.002
OxCp-YFK19-2	0.60	24	<2	0.446	<0.001	0.003	0.050	0.025	0.002
OxCp-YFK19-3	0.50	<1	<2	0.143	<0.001	0.014	0.026	0.100	0.006
OxCp-YFK19-4	0.45	6	<2	0.058	<0.001	0.005	0.053	0.027	0.002
OxCp-YFK20	0.70	8	<2	0.803	<0.001	0.001	0.048	0.003	0.001
Ban Ban mineral showing									
⑬ Cp-YFK26-1	1.70	1	<2	0.082	0.014	0.038	0.031	0.116	0.008
Cp-YFK26-2	1.30	<1	197	0.033	0.012	0.021	0.039	0.018	0.003
Ban Pun prospect									
⑭ OxCp-YFK24-1	0.50	25	<2	0.152	0.026	0.055	0.008	0.059	0.002
OxCp-YFK24-2	0.60	1	<2	0.040	0.014	0.038	0.004	0.122	0.002
Van Bras Pun mineral showing									
⑮ Cp-YFK23	-	<1	<2	0.003	0.201	0.410	0.050	0.019	0.002
Northern Suoi Trat mineral showing									
⑯ Cp-YFK11	-	4	<2	0.007	0.001	0.002	0.017	0.073	0.002
⑰ Cp-YFM 5	0.10	3	<2	0.026	0.019	0.009	0.005	0.061	0.005
Suoi Trat mine									
⑱ Cp-YFM 6	-	5810	6	6.618	0.016	0.058	0.034	0.161	0.003
Cp-YFM 7	-	184	<2	0.922	<0.001	0.011	0.022	0.139	0.003
Cp-YFM 8	-	203	<2	1.601	<0.001	0.006	0.008	0.309	0.002
Cp-YFM 9	-	1740	3	3.429	0.004	0.012	0.010	0.197	0.003
Cp-YFM10	-	1160	<2	0.179	0.007	0.009	0.064	0.301	0.002
Cp-YFK30	-	5180	2	1.541	0.014	0.029	0.066	0.207	0.003
Cp-YFK31	0.60	471	100	1.822	0.020	0.030	0.025	0.249	0.006
Southern Suoi Trat mineral showing									
⑲ Py-YFK12	0.60	1	<2	0.018	0.005	0.043	0.011	0.013	<0.001
⑳ Py-YFK13	4.00	3	<2	0.003	0.005	0.026	0.018	0.060	0.002
㉑ Py-YFK14	-	<1	<2	0.004	0.002	0.008	0.022	0.090	0.006
Py-YFK15	-	5	<2	0.003	0.003	0.009	0.021	0.098	0.006
Py-YFK16	-	1	<2	0.003	0.003	0.007	0.018	0.108	0.005
Py-YFK17	-	<1	<2	0.003	0.005	0.006	0.027	0.061	0.009
Ban Cham mineral showing									
㉒ Qz-VGM14	-	9	<2	<0.001	0.004	0.007	0.003	0.088	<0.001
㉓ Py-VGM11	-	<1	<2	0.012	0.004	0.015	0.015	0.145	0.005
Qz-VGM12	0.05	12	<2	0.006	0.004	0.057	0.007	0.252	0.003
㉔ Py-VGM13	-	7	<2	<0.001	0.003	0.035	0.014	0.068	<0.001
Suoi Yan mineral showing									
㉕ Qz-VGM 6	-	8	<2	0.035	0.007	0.012	0.016	0.072	0.002
㉖ Cp-VGM 9	-	8	<2	0.001	0.006	0.006	0.023	0.010	<0.001
Cp-VGM10	-	12	<2	0.102	0.005	0.004	0.021	0.108	<0.001
Ban Coc mineral showing									
㉗ Qz-YNM 4	0.30	6	37	0.003	0.021	0.004	0.139	0.029	0.022
Ban Nghien mineral showing									
㉘ Qz-YNM 1	0.50	1	<2	<0.001	0.003	0.003	0.012	0.012	0.009
Suoi Let mineralization zone									
㉙ Cp-YFK25	0.27	27	<2	2.187	0.020	0.042	0.141	0.097	0.108
Ban Da Do mineral showing (No. 2)									
㉚ Qz-VGM26	-	<1	69	<0.001	<0.001	<0.001	0.038	0.005	0.003
㉛ Qz-VGM25	0.20	3	<2	0.001	0.001	0.002	0.041	0.024	0.003
Ban Da Do mineral showing (No. 1)									
㉜ Qz-VGM24	0.10	8	<2	0.250	0.002	0.007	0.036	0.110	0.005
Ban Ba Ngoa mineral showing									
㉝ Qz-VGM 1	-	25	<2	<0.001	0.007	0.005	0.066	0.006	0.003
㉞ Qz-YNM 3	0.60	<1	<2	<0.001	0.003	0.012	0.030	0.042	<0.001
Suoi Ba mineral showing									
㉟ Py-VGM 5	1.00	3	<2	<0.001	0.003	0.004	0.035	0.243	0.001
Ban Na Vang mineral showing									
㊱ Qz-VGM 4	0.40	<1	<2	<0.001	0.003	0.005	0.026	0.050	<0.001
Suoi Yen mineral showing									
㊲ Qz-VGM 2	1.10	1	<2	0.005	0.007	0.007	0.045	0.015	0.005
㊳ Qz-VGM 3	0.40	7	<2	<0.001	0.064	0.006	0.034	0.022	0.005
Nam Pion mineral showing									
㊴ Py-YSM 2	3.92	1	<2	0.007	<0.001	0.005	0.025	0.054	0.011
Suoi Hanne mineral showing									
㊵ Cp-YNM 6	0.30	1	<2	0.104	0.008	0.009	0.035	0.069	0.004
㊶ Cp-YNM 5	-	19	<2	0.027	0.006	0.007	0.025	0.022	0.004
Ban Yaa mineral showing									
㊷ Qz-VGM22	0.20	3	<2	<0.001	<0.001	<0.001	0.026	0.018	0.003
Ban Rung mineral showing									
㊸ Qz-VGM21	1.00	<1	<2	<0.001	<0.001	0.006	0.031	0.110	0.003
Chenh Thac Tao Ngao mineral showing									
㊹ OxCp-YNM 4	0.10	33	<2	0.983	0.022	0.022	0.023	0.055	<0.001
㊺ Qz-YNM 3	-	8	<0.001	0.023	0.077	0.036	0.023	0.001	
Suoi Bun mineral showing									
㊻ Qz-VGM23	-	2	<2	<0.001	<0.001	0.021	0.028	0.013	0.002
Ban Suoi Tion mineral showing									
㊼ Py-VGM20	-	<1	<2	0.013	0.002	0.034	0.045	0.188	0.004
㊽ Py-VGM19	3.00	2	<2	0.053	<0.001	0.001	0.035	0.004	0.003
㊾ Py-VGM18	-	8	<2	0.191	0.062	0.023	0.022	0.014	<0.001
Suoi Yan mineral showing									
㊿ Lim-VGM15	-	10	<2	<0.001	0.002	0.002	0.013	0.320	0.005
(51) Lim-VGM16	-	<1	<2	0.006	0.049	0.017	0.137	0.701	0.015
(52) Lim-VGM28	-	<1	<2	<0.001	0.052	0.003	0.012	0.182	0.005
(53) Qz-VGM29	0.32	5	<2	0.099	0.086	0.009	0.017	0.154	0.006
(54) Cp-VGM17	-	6	<2	0.030	0.143	0.008	0.099	0.099	0.020
Ban Suoi Ton mineral showing									
(55) Pb-VGM27	-	26	<2	0.009	17.244	0.004	0.005	<0.001	0.001

YFK 1 Sample number

Abbreviations
Cp : Chalcopyrite
OxCp: Oxidized copper minerals
Pb : Galena
Zn : Sphalerite
Py : Pyrite
Pyr : Pyrrhotite
Lim : Limonite
Qz : Quartz vein
wd : Sampling width

Fig. III-1-5 Distribution Map of the Mineral Showings in the Van Yen Area

1.6.2. Copper

The copper mineralization is divided into the following three types.

(1) Bedded cupriferous pyrite deposit type

(2) vein type

(3) dissemination type associated with mafic rocks

(1) Bedded cupriferous pyrite deposit type

The deposits of the Suoi Tiat mine is one of the most representatives of this type. These deposits have the following characteristics.

a) The deposits are bedded, platy, lenticular, and disseminated. The deposits are harmonious with the structure of host rocks (schistosities).
b) The ores are mainly relatively compact aggregates of pyrite and chalcopyrite with a small amount of galena and covelline as well as a trace amount of native gold and monazite.
c) Sulfide minerals are generally more abundant than gangue minerals.
d) The host rock is trachybasaltic pyroclastic rocks (mostly fine tuff) that has been subjected to, low grade regional metamorphism.

The following mine, mineralization zones, and mineral showings are of this type.

1) Suoi Tiat mine
2) Northern Suoi Tiat mineral showing
3) Southern Suoi Tiat mineral showing
4) Phai Lay mineral showing
5) Suoi Let mineralization zone
6) Nam Pion mineral showing

Of the above, the names for 2), 3), 4), and 6) are provisional.

1) Suoi Tiat mine

This mine produces only gold at present, however, it is categorized as copper deposit because the principal ore minerals are pyrite and chalcopyrite.

The mine is located at the upper reaches of the Tiat Stream, a tributary

of the Bua River in the central to western part of the survey area. The altitude near the mine ranges from 500 to 620 m. A footpath has been constructed along the above stream from the junction between the stream and Bua River, and it takes about two hours to reach the mine site. Local inhabitants (about 50 workers on December, 1993) work for in the small-scale production. The deposit is mined by underground working. The ores are pulverized by crusher, hammer, and stone mill, and the gold is recovered through washing-gravitational recovery or mercury amalgam. The monthly production is said to be about 100 g Au. It was about 400 g by roughly 250 workers in 1992, but the production is in a declining trend.

Eight roughly east-trending cross-cut galleries each with 100 m length have been opened from a slope of a stream. They are arranged stepwise with intervals of about 10 m as shown in Figure Ⅲ-1-6. The observable ore body in the cross-cut gallery of 530 m level is located about 70 m east from the pit mouth. As seen in Figure Ⅲ-1-6, the ore body is concordant with the well-developed schistosities of the trachybasaltic tuff. The ore body strikes N30°W and dips 70°WSW with 0.40 m width. The ore body consists of the parallel assembly of banded ores with 1 to 5 cm width, and these ores are interbedded with chloritized host rocks. A similar ore body also occurs parallel to the body in the foot wall of the body for a distance of 2 m. The easternmost part of the cross-cut gallery has been mined out into a cave.

Some galleries were opened from the opposite side 200 m east of the operating galleries, but all of them are now abandoned. It is inferred that those galleries were used for underground prospecting when the mining was active.

According to the people of the mine, the unit ore body is 10 m long with 0.05 to 0.50 m width, and several similar bodies occur in parallel pattern.

From the above characteristics, it is pointed out that several ore bodies of 0.05 to 0.50 m width (at least more than three bodies) are developed in parallel arrangement within a zone of 200 m with a maximum width. No data is available for number, extensions along the strike and dip.

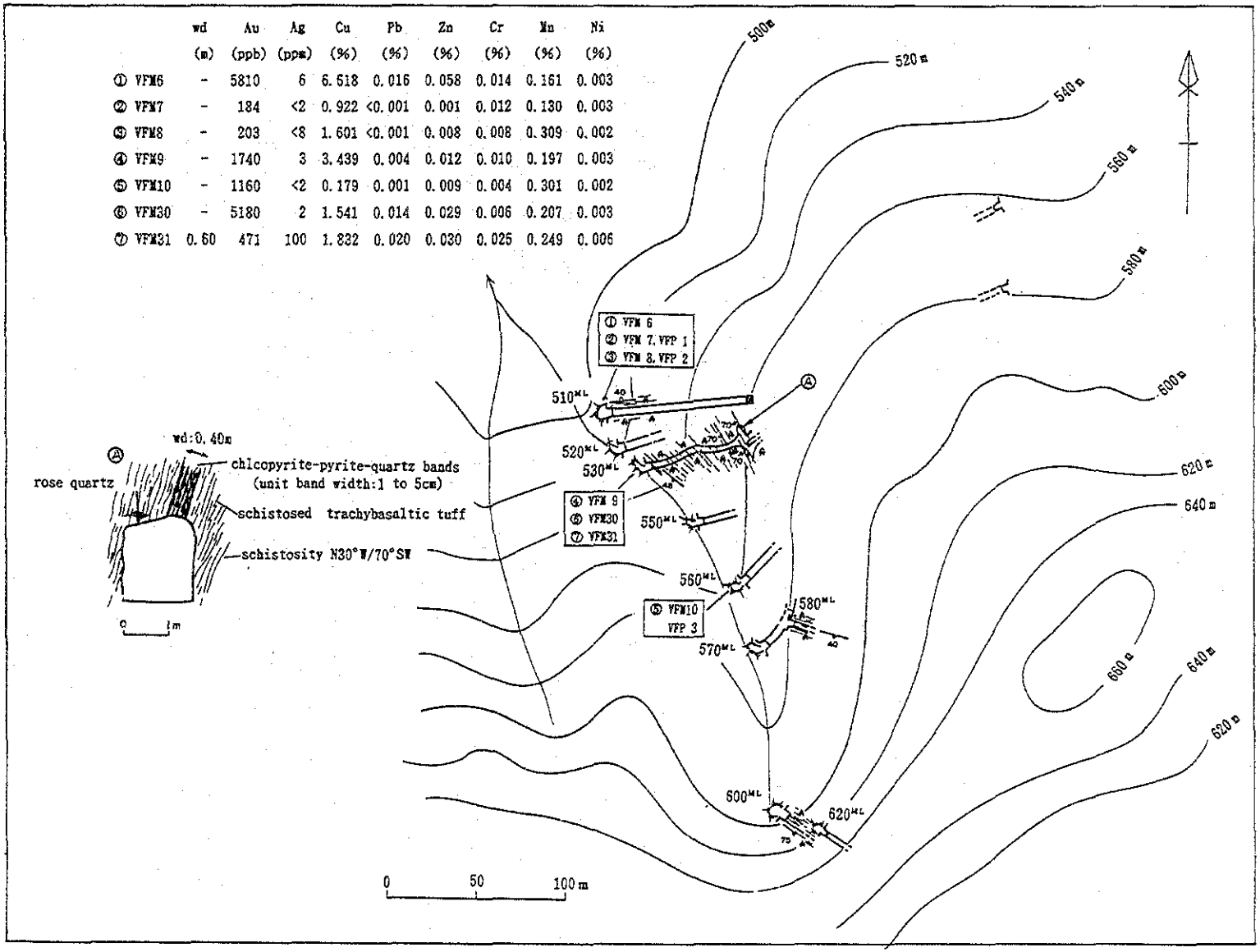


Fig.Ⅲ-1-6 Plan Map of the Suoi Tiat Mine

The principal ore minerals are pyrite and chalcopyrite, and they are accompanied with a small amount of malachite as well as a trace amount of native gold, galena, covelline, bithmuthinite, and monazite. Gold grains of 15 μm in diameter occur in cavities of euhedral crystals of pyrite (see Photograph; VFP-1 in Photo.3.). The main gangue minerals are translucent to colorless massive quartz and chlorite with a trace amount of barite. Gangue minerals are less abundant than ore minerals.

Chloritization is the only host rock alteration recognized in this deposit. But calcite, dolomite, and muscovite were detected by X-ray diffraction in a host rock sample from the ore body.

The assay results of the representative ore samples are laid out in Figure Ⅲ-1-6. Contents of gold and copper are 0.2 to 6 g/t and 1 to 6 %, respectively.

2) Northern Suoi Tiat mineral showing

This showing is exposed on the right bank of the middle reaches of the Tiat Stream (altitude: approximately 300 m), and is located about 1 km north of the Suoi Tiat mine. No previous exploration was carried out for this showing.

Limonite banded ores are developed parallel to the schistosity of the Lower Triassic trachybasaltic tuff. The banded ores are 0.03 to 0.10 m wide. The ore assay results of the representative sample are as follows.

Sample No.	Sampling width(m)	Au	Ag	Cu	Pb	Zn	Cr	Mn	Ni
VFM 5	0.10	3	< 2	0.026	0.019	0.009	0.005	0.061	0.005

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

3) Southern Suoi Tiat mineral showing

This showing crops out in the middle reaches of a stream (altitude: about 270 m) flowing northeastward parallel to the Tiat Stream in the south.

The showing consists of lenticular bodies of pyrite-quartz along the schistosities of the Lower Triassic trachybasaltic tuff. Many lenses occur parallel with about 10 cm intervals. Each lens is several centimeters wide and the mineralization zone as a whole is 5 m wide. This showing is located about 600 m southeast of the Suoi Tiat mine and is situated stratigraphically about 200 m in the foot wall horizon. The lenticular ore bodies strike N48°W and dip 70°SW parallel to the ore bodies of the Suoi Tiat mine. Host rocks have been intensely chloritized within the mineralization zone.

The ores are similar to those of dissemination zone found in Japanese bedded cupriferous pyrite deposits. The list below shows the assay results of the representative samples.

Sample No.	Sampling width(m)	Au	Ag	Cu	Pb	Zn	Cr	Mn	Ni
VFM 14	0.10	< 1	< 2	0.004	0.002	0.008	0.022	0.090	0.008
VFM 15	0.25	5	< 2	0.003	0.003	0.009	0.021	0.098	0.008
VFM 16	0.15	1	< 2	0.003	0.001	0.007	0.018	0.108	0.006
VFM 17	0.20	< 1	< 2	0.003	0.005	0.008	0.027	0.061	0.009

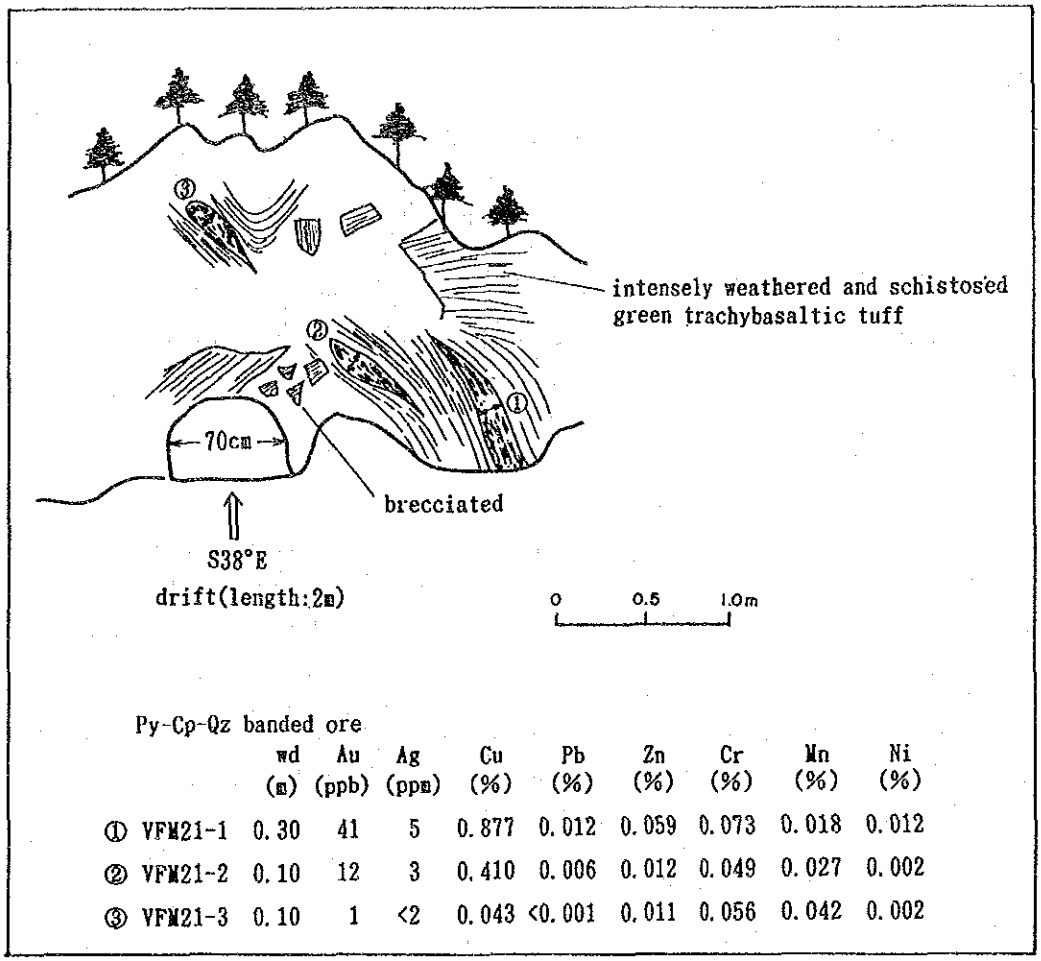
Au is in ppb, Ag in ppm, and other elements in percent.

4) Phai Lay mineral showing

This showing is located on the right bank of the middle reaches (altitude: about 400 m) of the Lang River that flows southeastward in the northwestern part of the survey area. Several lenticular ore bodies are developed in this showing as shown in Figure Ⅲ-1-7. All bodies occur parallel to the schistosities of the Cretaceous trachybasaltic tuff, but host rocks are separated into several blocks near the surface.

Each ore body is 0.1 to 0.3 m wide and 1 to over 3 m long. Ore minerals are pyrite and chalcopyrite, and gangue mineral is translucent massive quartz. A cross-cut gallery has been opened with 2 m length on the foot wall side of the ore body, but no mineralization occurs in the gallery.

The assay results of the ore samples are shown in Figure Ⅲ-1-7.



Py-Cp-Qz banded ore

	wd (m)	Au (ppb)	Ag (ppm)	Cu (%)	Pb (%)	Zn (%)	Cr (%)	Mn (%)	Ni (%)
① VFM21-1	0.30	41	5	0.877	0.012	0.059	0.073	0.018	0.012
② VFM21-2	0.10	12	3	0.410	0.006	0.012	0.049	0.027	0.002
③ VFM21-3	0.10	1	<2	0.043	<0.001	0.011	0.056	0.042	0.002

Fig.Ⅲ-1-7 Geologic Sketch of the Phai Lay Mineral Showing

5) Suoi Let mineralization zone

This zone is located about 1.2 km southeast of Ban Suoi Dam in the central to western part of the survey area. The zone is hosted by the Lower Triassic trachytic basaltic tuff and consists of banded ores of chalcopyrite and pyrite developed in the parallel arrangement along the schistosities of the host rocks. The ores are accompanied by subordinate amounts of malachite, covelline, specularite, and quartz. The ore bodies strike N15°W and dip 67°E with 0.27 m width. A drift was opened, but it is flooded at present as shown in Figure Ⅲ-1-8. Additionally a trench perpendicular to the strike of the ore body has been made about 45 m south of the drift. However, no mineralization is observed in the trench. Dimensions of the trench are 0.7 m wide, 1.5 to 4.0 m deep, and 50 m long. The host rocks dip steeply and exhibit intense minor foldings forming an anticline.

Many remnants of placer golds panning are scattered on the upper and lower reaches of the stream which flow through this mineralization zone. Figure Ⅲ-1-8 shows the assay results of the representative ore samples.

6) Nam Pion mineral showing

This showing is located in the middle reaches of the Nam Pion River in the western part of the survey area. The showing is composed of disseminated pyrites with 3 m width along the schistosities of the Lower Triassic trachybasaltic tuff. The foot wall and hanging wall sides of the dissemination zone consist of trachybasalt lava and its tuff, respectively.

The assay results of the representative sample are as follows.

Sample No.	Sampling width(m)	Au	Ag	Cu	Pb	Zn	Cr	Mn	Ni
VSM 2	3.00	3	< 2	0.007	< 0.001	0.005	0.025	0.054	0.011

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

(2) Vein type

The vein type mineral showings containing copper will be reported below. The veins consist generally of prevalent quartz with copper minerals. The

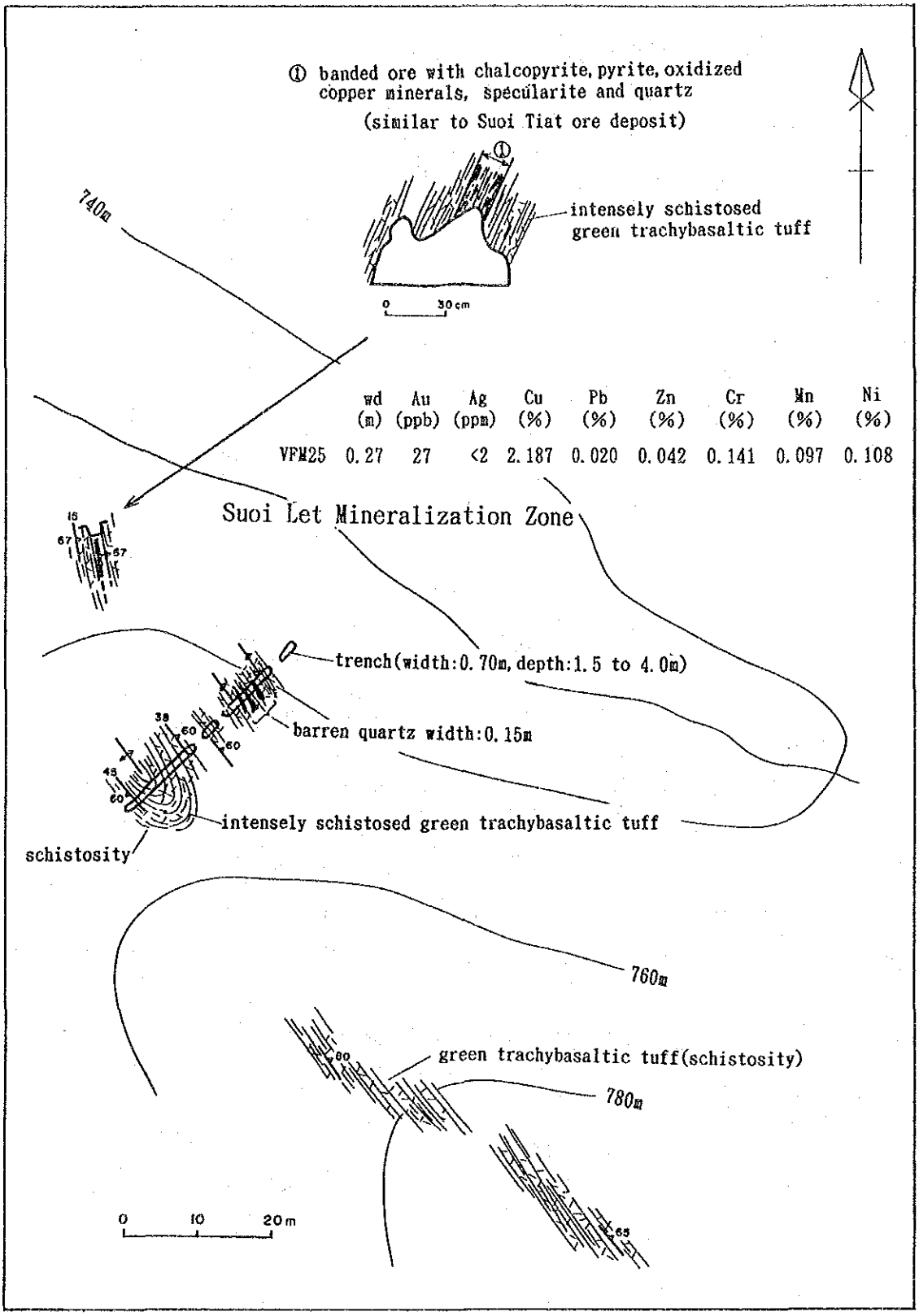


Fig.Ⅲ-1-8 Plan Map of the Suoi Let Mineralization Zone

Suoi Bao Prospect is the most representative in this type, and other similar several showings are present in the survey area. Most of them are concentrated within an area of the Lower Triassic (T_1) in the western part of the area.

The following prospect, mineralization zones, and mineral showings have relatively wide copper-bearing quartz veins. Some quartz veinlets occur in other places with several centimeters to 10 cm in width, but they usually contain trace amounts of metals of commercial value. Figure Ⅲ-1-5 shows the dimensions and occurrence of the above showings. Many floats of veins of this type were also found in the area of the Lower Triassic volcanic rocks (T_1). Their locations and assay results are also shown in the above figure.

1) Suoi Bao Prospect
2) Lang Tio mineral showing
3) Ban Ban mineral showing
4) Ban Pun mineralization zone
5) Suoi Hanne mineral showing

Among the above, four names except the Suoi Bao Prospect were given tentatively in this survey.

1) Suoi Bao Prospect

This prospect is located about 2.5 km west of the Suoi Tiat mentioned already. The prospect consists predominantly of a wide quartz vein. Two drifts were driven with about 10 m level difference, but the details such as extensions are unknown because both drifts are flooded at present. It is inferred that both drifts are several meters long from the amounts of waste on the dumps. These two veins are more than 2.35 m and 1 m wide in the lower and upper drifts, respectively. The two drifts most probably mined one vein in view of the strike. No other veins occurs in the vicinity of the vein.

The quartz vein contains a very small amount of chalcopyrite, pyrite, and specularite in a scattered occurrence, and malachite is observed along the fractures of the vein. The quartz is translucent and massive. Many fractures

are developed parallel and perpendicular to the vein. Horse stone is present with 0.5 m width in the vein of the lower drift, and several quartz veinlets with several centimeters width occur within it. The quartz vein occurs along the schistosities of host rock, trachybasaltic tuff. The host rock has been undergone intense regional metamorphism. However, the quartz vein has drusy cavities. Milonitic structure or recrystallization are not observed in the vein. From the above it appears that the mineralization took place after the metamorphism.

The analytical results of the samples collected is laid out in Figure Ⅲ-1-9, showing very low grades of metallic elements.

2) Lang Tio mineral showing

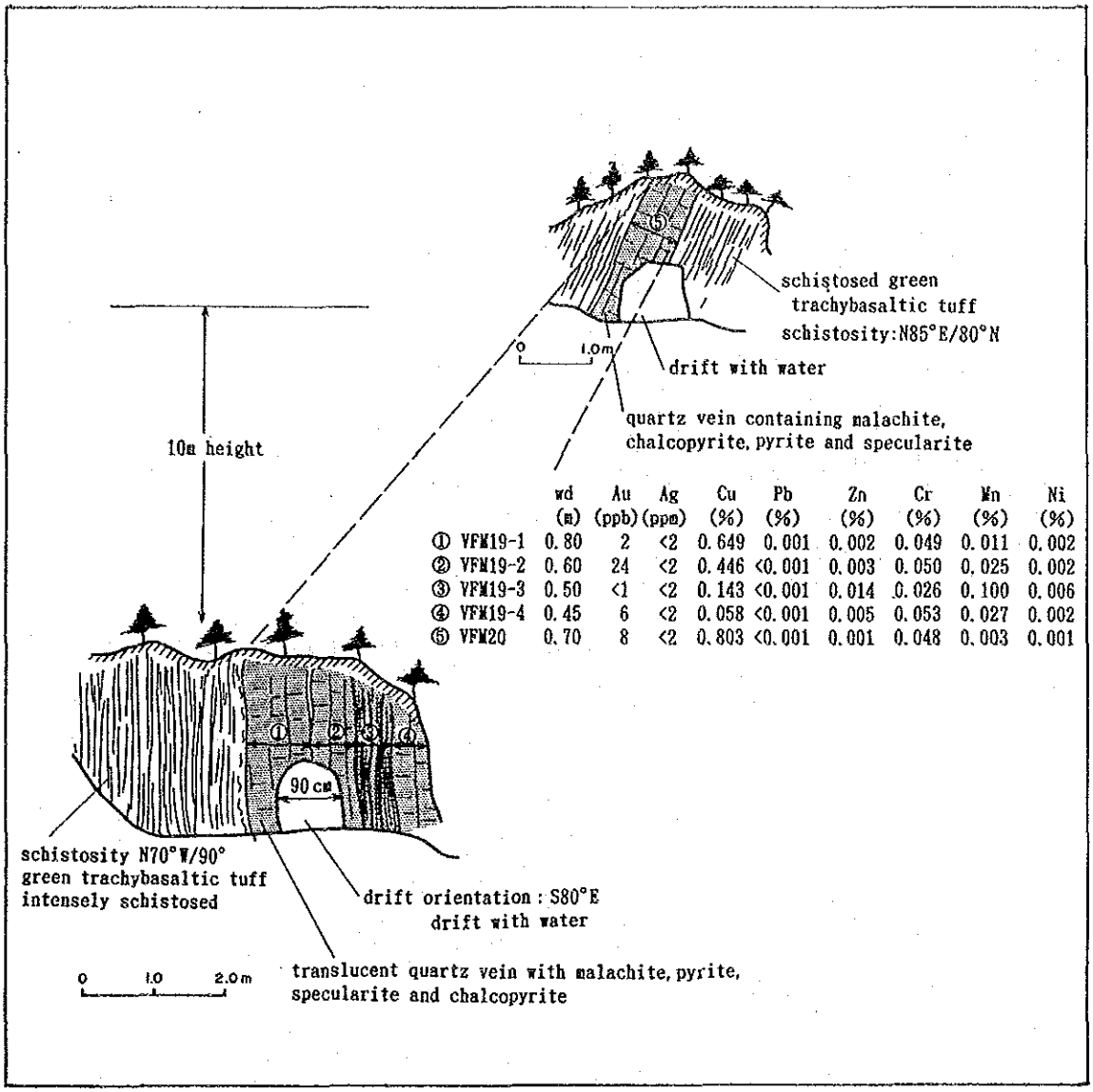
This showing is located in the middle reaches of the Kan Stream in the northwestern part of the survey area. One quartz vein occurs in this locality. The vein strikes N40°E and dips 50°NE with 1.50 m width. The quartz vein contains small amounts of chalcopyrite and specularite. The host rock is the Cretaceous sandstone. The assay results of the samples collected are as follows.

Sample No.	Sampling width(m)	Au	Ag	Cu	Pb	Zn	Cr	Mn	Ni
VSM 1	1.50	50	< 2	1.651	0.005	0.112	0.064	0.060	0.002

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

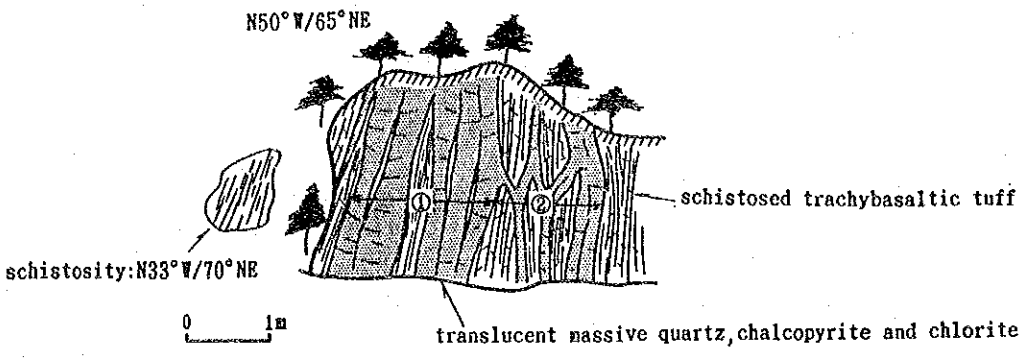
3) Ban Ban mineral showing

This showing is located about 1.8 km west-southwest of the above Suoi Bao Prospect. The stockwork of quartz occur in this showing as illustrated in Figure Ⅲ-1-10. The stockwork as a whole is 3 m wide with abundant horse stones. The host rock is the Lower Triassic (T_1) trachybasaltic tuff in which the schistosities are well developed. The stockwork generally strike N50°W and dip 65°NE. This structure is in acute angle with the schistosities (N33°W/70°NE). The vein quartz is colorless to translucent, massive and the vein is almost barren with trace amounts of chalcopyrite. The width of vein varies considerably and it pinches out 5 m northwest of the outcrop. The



	wd (m)	Au (ppb)	Ag (ppm)	Cu (%)	Pb (%)	Zn (%)	Cr (%)	Mn (%)	Ni (%)
① VFM19-1	0.80	2	<2	0.649	0.001	0.002	0.049	0.011	0.002
② VFM19-2	0.60	24	<2	0.446	<0.001	0.003	0.050	0.025	0.002
③ VFM19-3	0.50	<1	<2	0.143	<0.001	0.014	0.026	0.100	0.006
④ VFM19-4	0.45	6	<2	0.058	<0.001	0.005	0.053	0.027	0.002
⑤ VFM20	0.70	8	<2	0.803	<0.001	0.001	0.048	0.003	0.001

Fig.Ⅲ-1-9 Geologic Sketch of the Suoi Bao Prospect



	wd (m)	Au (ppb)	Ag (ppm)	Cu (%)	Pb (%)	Zn (%)	Cr (%)	Mn (%)	Ni (%)
① VFM26-1	1.70	1	<2	0.082	0.014	0.038	0.031	0.116	0.008
② VFM26-2	1.30	<1	197	0.033	0.012	0.021	0.039	0.018	0.003

Fig.Ⅲ-1-10 Geologic Sketch of the Ban Ban Mineral Showing

	wd (m)	Au (ppb)	Ag (ppm)	Cu (%)	Pb (%)	Zn (%)	Cr (%)	Mn (%)	Ni (%)
① VFM24-1	0.50	25	<2	0.152	0.026	0.055	0.008	0.059	0.002
② VFM24-2	0.60	1	<2	0.040	0.014	0.038	0.004	0.122	0.002

Fig.Ⅲ-1-11 Geologic Sketch of the Ban Pun Mineralization Zone

analytical results of samples collected from the outcrop are laid out in Figure Ⅲ-1-10, showing very low grade of metallic elements.

4) Ban Pun mineralization zone

This mineralization zone is located about 1.5 km south of the Suoi Bao Prospect. Limonite veins occur along a sheared zone of 1.10 m width and they are accompanied by a small amount of oxidized copper minerals (see Figure Ⅲ-1-11). The eastern half of the sheared zone contains the above minerals with 0.05 m width. The sheared zone has an N45°W strike and a vertical dip. This structure is oblique to the schistosity (N55°W/50°W) of the host rock, the Lower Triassic trachybasalt. One drift was driven along the sheared zone, but its extension is not clear because the drift is flooded at present. It seems to be 3 m long according to a local guide. The veins are almost barren as shown in Figure Ⅲ-1-11.

5) Suoi Hanne mineral showing

This showing is located in the upper reaches of the Hanne Stream (Suoi Hanne), that is a tributary of the Da River. Copper mineralization is found along the schistosities of the Lower Triassic trachybasaltic tuff similar to the other mineral showings. The showing consists mainly of stockwork of quartz with a small amount of pyrite and chalcopyrite. In addition to those minerals, covelline, limonite, and ilmenite are observed under microscope. The width of quartz veins varies considerably, ranging from 0.3 to 2 m.

Local inhabitants are collecting panning gold at one site down stream.

The assay results of a sample collected from the representative vein are as follows.

Sample No.	Sampling width(m)	Au	Ag	Cu	Pb	Zn	Cr	Mn	Ni
VMM 6	0.30	1	< 2	0.104	0.008	0.009	0.035	0.069	0.004

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

(3) Dissemination type associated with mafic rocks

Only one showing of this type was confirmed by this survey. The showing is tentatively called the Ban Ngnon mineral showing.

This showing is located about 3.3 km west of Ban Ngnon in the northeastern part of the survey area. A dolerite dike has dissemination of chalcopyrite and sphalerite and contains a relatively large amount of ilmenite and a small amount of limonite. The dike is 2.2 m wide. It strikes N39°E and dips 61°SE. The dike intruded into the Upper Carboniferous to Permian limestone.

The assay results of a sample collected from the dissemination zone are as follows.

Sample No.	Sampling width(m)	Au	Ag	Cu	Pb	Zn	Cr	Mn	Ni
VMM 2	2.20	2	< 2	0.011	0.019	0.016	0.039	0.104	0.010

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

1.6.3. Lead and zinc

Five mineral showings of lead and zinc were confirmed through the Phase I survey in this area. Among them, two showings have outcrops and the remaining three are the dumps from pits or floats. The mineralization is divided into two types, namely metasomatic and vein types. There are three metasomatic and two vein type showings. They are as follows from the north southward.

1) Ban Cho mineral showing
2) Suoi Cu mineral showing
3) Suoi Boc mineralization zone
4) Ban Suoi Tion mineral showing (tentative name)
5) Ban Suoi Ton mineral showing (tentative name)

1) Ban Cho mineral showing

There are no outcrops but floats in this showing. One sample was

collected from floats at the uppermost tributary (altitude: about 800 m) of the upper reaches of the Kan Stream in the northwestern part of the survey area. There are a few floats of cobble size. The floats contain veins of galena, sphalerite, and quartz. The host rock appears to be Cretaceous muddy tuff from the floats.

The assay results of a sample are shown below for reference.

Sample No.	Sampling width(m)	Au	Ag	Cu	Pb	Zn	Cr	Mn	Ni
VFM 32	0.10	5	< 2	0.016	34.542	0.025	0.027	0.008	0.002

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

2) Suoi Cu mineral showing

This showing is located about 2.5 km southeast (altitude: about 450 m) of Phu Yen. Ore floats are scattered along a small dry stream which is a tributary on the upper reaches of the Suoi Cu. Trenching was done in two sites by the Mapping Division of GSV during April to May 1993. Dimensions of trenches are 4 to 5 m long, 0.7 to 1.0 m wide, and 1.5 to 3.0 m deep. They are located parallel to the N55°W direction.

One 130 cm × 70 cm massive ore occurs in breccias of limestone at the western wall of the eastern trench, where the matrix consists of soil. The eastern wall of this trench is composed only of breccias of limestone. Thus, the massive ore does not extend eastward.

The massive ore contains mainly smithsonite and cerussite with subordinate amounts of sphalerite and anglesite. The limestone is greyish white, fine-grained crystalline, and is recrystallized to marble. Some similar brecciated ores are scattered from the trench to 30 m south. One sample of a float of massive ore (sample No. VFM 28) collected 30 m south of the trench consists of galena, sphalerite, and calcite. The float has a size of 50 cm and 50 cm. Only the breccias of greyish white, fine-grained crystalline limestone were confirmed at the western trench. Ore similar to those of the eastern trench was not found. This showing lies in the Middle

Triassic (T_2) area. The above floats are believed to be almost autochthonous because the ore and limestone are angular in shape.

The list below shows the assay results of the representative samples of this showing for reference.

Sample No.	Sampling width(m)	Au	Ag	Cu	Pb	Zn	Cr	Mn	Ni
VFM 27	–	1	75	0.128	25.819	28.892	0.004	0.208	0.002
VFM 28	–	19	< 2	0.61	0.964	37.775	0.004	0.265	0.001
VFM 29	–	5	3	0.003	0.051	0.147	0.005	0.044	0.002

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

3) Suoi Boc mineralization zone

This zone is located about 4 km south of Phu Yen, where the area is underlain by the Middle Triassic limestone. There are no outcrops but floats of ore brought from some pits.

Although it is said that the tunnel exploration (cross-cut gallery) was carried out by Chinese engineers in this zone about 1982 to 1983, the tunnel could not be confirmed during this survey. In addition to the above, the Mapping Division of GSV dug five trenches around the tunnel, but they have collapsed and the details are not clear. According to GSV, the pits were 8 to 10 m deep and mineralization zone of galena and sphalerite was found with 0.1 to 1.0 m width at one pit whose wall consists of brecciated limestone.

Microscopically one ore sample collected from the stock pile near a pit consists mainly of cerussite and sphalerite with a small amount of pyrite, galena, and anglesite.

The assay results of the sample are given below.

Sample No.	Sampling width(m)	Au	Ag	Cu	Pb	Zn	Cr	Mn	Ni
VGM 22	–	1	431	0.025	11.9	39.4	0.009	0.053	0.002

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

4) Ban Suoi Tion mineral showing

This showing is located on the middle reaches of the Han Stream in the southeastern part of the survey area. There are no outcrops but two floats were found. Both of them are quartz veins accompanied by a small amount of galena and anglesite. One sample (No. VGM 19) contains also a trace amount of covelline.

The assay results of samples collected from the floats are as follows.

Sample No.	Sampling width(m)	Au	Ag	Cu	Pb	Zn	Cr	Mn	Ni
VGM 19	—	2	< 2	0.053	< 0.001	0.001	0.035	0.004	0.003
VGM 20	—	< 1	< 2	0.013	0.002	0.004	0.045	0.188	0.004

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

5) Ban Suoi Ton mineral showing

This showing is located about 1.5 km south of Ban Suoi Ton, and only this has an outcrop among all of lead and zinc mineral showings. The mineral showing is exposed in the Middle Triassic (T_2) limestone area. The ore consists mainly of galena with a small amount of anglesite and barite. The details are not clear regarding the occurrence of the mineralization zone because of poor exposure.

The host rock limestone is white, fine-grained, crystalline, and is recrystallized to marble. No granitic bodies are found near this showing.

The assay results of one representative sample are given below.

Sample No.	Sampling width(m)	Au	Ag	Cu	Pb	Zn	Cr	Mn	Ni
VGM 27	0.5	26	< 2	0.009	17.24	0.004	0.005	< 0.001	0.001

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

1.6.4. Gossan occurrence (Suoi Yan No.2 mineral showing)

Gossan floats were found at three sites in a zone from the middle reaches of the Yan River to Phu Ke Teo west of the River. The floats consist of limonite and carbonate minerals. There is a large similarity in constituent minerals and texture among these floats. In addition to a large amount of goethite, the ore contains a trace amount of sphalerite and pyrolusite as a relic in goethite as well as monazite. Thus, the ore possibly is of lead and zinc.

The list below shows the assay results of three representative samples collected from floats of the above three sites.

Sample No.	Sampling width(m)	Au	Ag	Cu	Pb	Zn	Cr	Mn	Ni
VGM 15	–	10	< 2	< 0.001	0.002	0.003	0.013	0.320	0.005
VGM 16	–	< 1	< 2	0.006	0.049	0.017	0.137	0.701	0.075
VGM 28	–	< 1	< 2	< 0.001	0.052	0.003	0.012	0.182	0.005

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

CHAPTER 2. GEOCHEMICAL EXPLORATION

2.1. Stream Sediment Geochemical Exploration

2.1.1. Objectives

Stream sediment geochemistry was carried out aiming to extract promising areas for mineral deposit based on geochemical characteristics of the area.

2.1.2. Sampling and chemical analysis

About 100 g of stream sediments with under 80 mesh size were collected for stream sediment geochemistry sample. A number of samples is 899 in total. Samples were sieved into under 80 mesh fraction in the field and were sent to the laboratory (Geoscience Laboratory of Bishimetal Co., Ltd.) for chemical analysis after drying. Samples were analyzed for 11 elements of Au, Ag, Cu, Pb, Zn, As, Sb, Cr, Ni, Hg, and Mn. Magnesium was also analyzed for information and the results are recorded in Appendix 6. Localities of samples are shown in Plate 9. Detection limits and analytical methods used are shown below.

Analytical Methods and Detection Limits

Element	Digestion and Methods	Detection Limits
Au	AAS	1 ppb
Ag	AAS	0.02 ppm
As	ICP	0.2 ppm
Cr	ICP	1 ppm
Cu	ICP	0.2 ppm
Hg	CV-AAS	10 ppb
Mn	ICP	5 ppm
Ni	ICP	1 ppm
Pb	ICP	0.5 ppm
Sb	ICP	0.2 ppm
Sn	ICP	2 ppm
W	ICP	2 ppm
Zn	ICP	1 ppm

AAS: Atomic Absorption Spectrometry

ICP: Inductivity Coupled Prasma Emission Spectrometry

CV-AAS: Cold Vapor Atomic Absorption Spectrometry

2.1.3. Statistical data-processing

Histograms of each elements were prepared and statistical elements were calculated in this single fluent analysis. It is known that geochemical data follow generally with a distribution of approximate log-normal. Therefore, statistical elements were calculated by natural logarithm of analytical values. In case of values below the detection limit, one half of detection limit values were substituted.

(1) Analytical values

Analytical values of each element are listed in Appendix 7. Their Characteristics are as follows:

Au

The maximum value is 2,460 ppb, the minimum value is < 1 ppb and mean value is 0.7 ppb. Contents of 23 % of samples are above the detection limit, of which 91 % are below 10 ppb.

Ag

The maximum value is 2.2 ppm, the minimum value is < 0.2 ppm and mean value is 0.1 ppm. Contents of 97 % of samples are above the detection limit. Maximum value is very low as 2.2 ppm.

Cu

The maximum value is 17,393 ppm, the minimum value is 0.7 ppm and mean value is 28.8 ppm. No samples are below the detection limit. Contents of 92 % of samples are below 100 ppm.

Pb

The maximum value is 257.6 ppm, the minimum value is 0.5 ppm and mean value is 17.8 ppm. Content of only one sample is below the detection limit. Contents of 99 % of samples are below 100 ppm.

Zn

The maximum value is 934 ppm, the minimum value is 8 ppm and mean value is 76 ppm. No samples are below the detection limit.

As

The maximum value is 138 ppm, the minimum value is < 0.2 ppm and mean value is 3.3 ppm. Contents of 7 % of samples are below the detection limit. Seven percent is above 10 ppm among the samples with content above the detection limit.

Mn

The maximum value is 7,786 ppm, the minimum value is 50 ppm and mean value is 998 ppm. No samples are below the detection limit.

Ni

The maximum value is 747 ppm, the minimum value is 3 ppm and mean value is 40 ppm. No samples are below the detection limit.

Cr

The maximum value is 5,543 ppm, the minimum value is 10 ppm and mean value is 154 ppm. No samples are below the detection limit.

Sb

The maximum value is 19.2 ppm, the minimum value is < 0.2 ppm and mean value is 0.2 ppm. Contents of 64 % of samples are below the detection limit.

Hg

The maximum value is 803 ppb, the minimum value is < 10 ppb and mean value is 16 ppb. Contents of 24 % of samples are below the detection limit.

(2) Elemental statistics

Elemental statistic parameters are shown in Table Ⅲ-2-1.

(3) Histograms of assay results

Histograms of assay results of each elements are shown in Figure Ⅲ-2-1.

Table Ⅲ-2-1 Elemental Statistics Parameters in Stream Sediment Geochemistry of the Van Yen Area

Element	Minimum value	Maximum value	Meam(M)	Standard deviation	Threshold	
					M+σ	M+2σ
Au(ppb)	0.5	2460	0.75	0.44	2.07	5.77
Ag(ppm)	0.01	2.23	0.13	0.60	0.52	2.09
As(ppm)	0.1	138	3.33	0.57	12.51	47.03
Cr(ppm)	10	5543	153.65	0.50	485.32	1532.95
Cu(ppm)	0.7	17393	28.76	0.43	77.01	206.21
Hg(ppb)	5	803	16.46	0.39	40.53	99.82
Mg (%)	0.01	9.86	0.64	0.46	1.85	5.29
Mn(ppm)	50	7785.99	998.1	0.39	2466.95	6097.44
Ni(ppm)	3	747	39.72	0.39	98.32	243.37
Pb(ppm)	0.25	257.6	17.80	0.25	31.29	55.01
Sb(ppm)	0.1	19.2	0.20	0.44	0.53	1.46
Zn(ppm)	8	934	76.02	0.26	139.49	255.94

Table Ⅲ-2-2 Correlation Coefficients between Elements Pairs in Stream Sediment Geochemistry of the Van Yen Area

	Au	Ag	As	Cr	Cu	Hg	Mg	Mn	Ni	Pb	Sb
Ag	0.0709										
As	-0.0046	0.0933									
Cr	0.1364	-0.1211	-0.1429								
Cu	0.4533	0.2895	0.0213	0.4118							
Hg	0.1921	0.0387	0.1585	0.1693	0.3124						
Mg	0.2356	0.0120	-0.1122	0.7844	0.6728	0.2223					
Mn	0.2100	0.3930	-0.0681	0.3621	0.7121	0.2110	0.6386				
Ni	0.1801	-0.0783	-0.0376	0.9052	0.5236	0.2691	0.7961	0.3502			
Pb	0.0619	0.1922	0.2656	0.0193	0.3165	0.2567	0.1942	0.5153	0.0327		
Sb	-0.0444	-0.0073	0.3102	-0.1063	-0.0272	0.0317	-0.0878	0.0316	-0.0876	0.3555	
Zn	0.1954	0.2448	0.0510	0.4214	0.6174	0.2392	0.6531	0.7991	0.4268	0.6621	0.1978

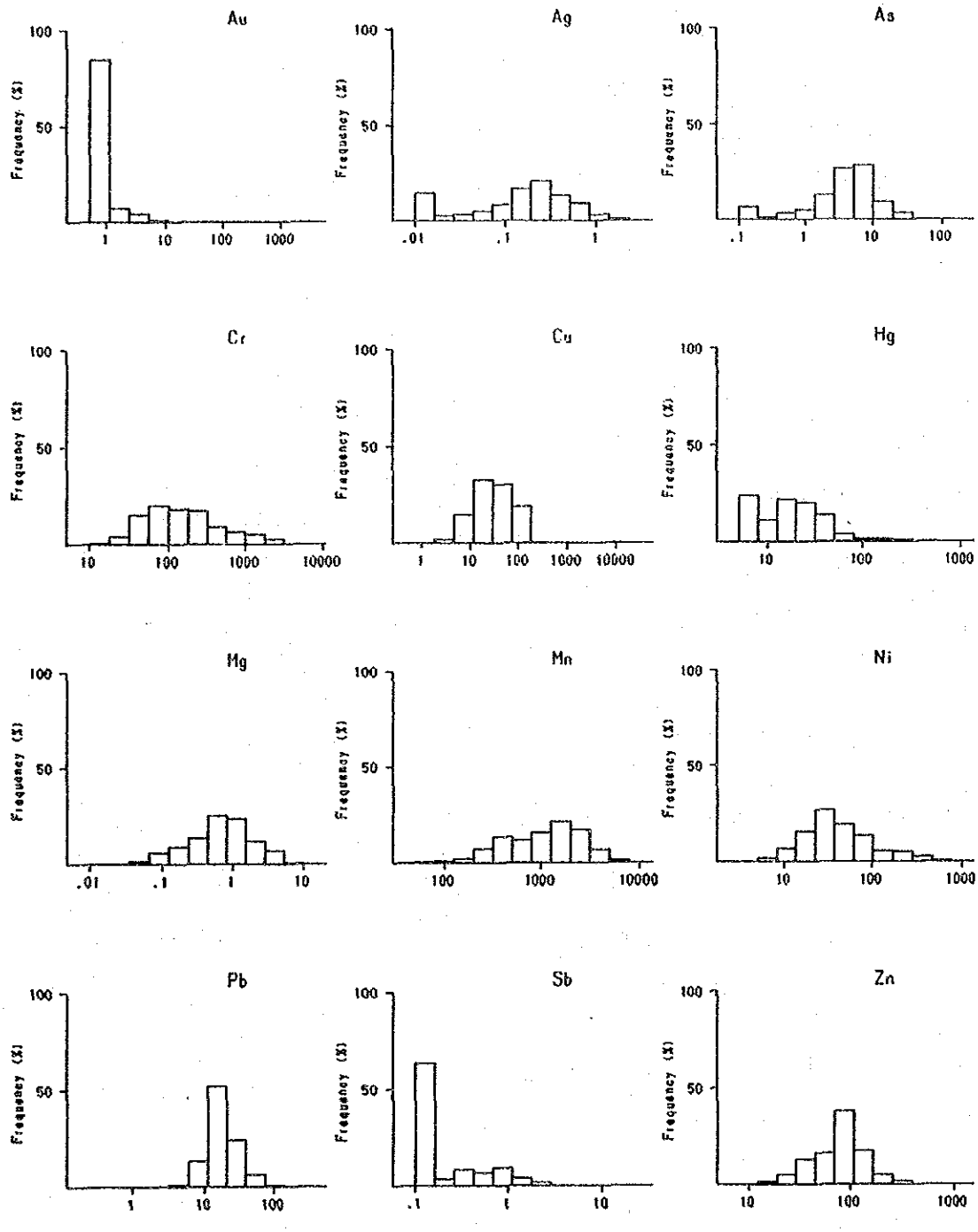


Fig.Ⅲ-2-1 Histograms of Assays on Stream Sediment Geochemical Samples Collected in the Van Yen Area

Elements except Au, Hg and Sb follow log-normal distribution. Frequency peaks of Au and Sb are at the field below detection limit.

(4) Correlation

Correlation coefficients are listed in Table Ⅲ-2-2. The following five pairs show good correlation with coefficients over 0.600.

Ni-Cr (0.9052), Zn-Mn (0.7991), Cu-Mn (0.7121)

Pb-Zn (0.6621), Cu-Zn (0.6174)

2.1.4. Geochemical anomalies and anomalous zones

(1) Threshold values and anomalies

The values of mean value+standard deviation ($M+\sigma$) are used for threshold values. According to the above threshold values, the following two grades of anomalies are adopted.

Strong anomalies : $M+2\sigma \leqq$

Weak anomalies : $M+\sigma \leqq$, $< M+2\sigma$

The list below shows ranges of threshold values for strong and weak anomalies on each element.

Element	Threshold values W.A	Threshold values S.A.	Element	Threshold values W.A.	Threshold values S.A.
Au(ppb)	2.07≦ < 5.76	5.76≦	Sb(ppm)	0.53≦ < 1.46	1.46≦
Ag(ppm)	0.52≦ < 2.09	2.09≦	Cr(ppm)	485.32≦ <1532.95	1532.95≦
Cu(ppm)	77.01≦ <206.21	206.21≦	Ni(ppm)	98.32≦ < 243.37	243.37≦
Pb(ppm)	31.29≦ < 55.01	55.01≦	Hg(ppb)	40.53≦ < 99.82	99.82≦
Zn(ppm)	139.49≦ <255.94	255.94≦	Wn(ppm)	2466.95≦ <6097.44	6097.44≦
As(ppm)	12.51≦ < 47.03	47.03≦			

W.A.: Weak anomaly

S.A.: Strong anomaly

(2) Anomalies and anomalous zones

Number of anomalies picked up are counted as follows:

Number of anomalies of each elements

Element	Weak anomalies	Strong anomalies	Element	Weak anomalies	Strong anomalies
Au	36	27	Sb	136	39
Ag	117	2	Cr	103	41
Cu	141	6	Ni	79	45
Pb	78	32	Hg	91	27
Zn	73	21	Mn	127	5
As	73	9			

Localities of anomalies are plotted in Appendix 11. Anomalous zones of each element and their characteristics are as follows:

Au

a) Strong anomalies are concentrated in the area around 3 km southwest of Gia Phu
b) Strong and weak anomalies around about 3 km west-southwest of Nui Ton Tat
c) Strong and weak anomalies around about 6 km south-southwest of Nui Ton Tat

Ag

a) Wide area between Nui Ton Tat and Nui Han
b) Area centering around Nui Pha
c) Area located 4 km west-southwest of Pha Bem

Cu

a) Wide area extending from Nui Han to about 20 km northwestward. Eighty percent of strong anomalies are concentrated in the Trat Stream flowing northeastward through the area on 500 m southwest of Gia Phu
b) Area around 1 km east of Nui Pha

Pb

a) Wide area (12 km × 5 km) centering around about 4 km northwest of Phu Yen
b) Area centering around about 4 km northwest of Gia Phu
c) Area around about 5.6 km south of Phu Yen

Zn

a) Wide area (9 km × 5 km) centering around Phu Yen (the same place as Pb anomaly a) above, where 86 % of strong anomalies are concentrated)
b) Zone extending east-west centering around about 2.4 km south of Nui Ong

As

a) Area around about 6 km east of Nui Ton Tat
b) Area around about 5 km south of Nui Pha
c) Area around about 9 km south of Nui Pha
d) Area around about 4 km west of Ha Bem

Sb

Antimony anomalies are abundant. Although they tend to be scattered throughout the area, some of them are relatively concentrated on the following areas.

a) Area centering around about 5 km northwest of Phu Yen
b) Area centering around about 5 km southwest of Gia Phu
c) Area centering around about 4 km east of Gia Phu
d) Area around 6 km east of Nui Ton Tat
e) Area centering around about 3 km north of Pha Bem

Ni

a) Area centering around about 5 km north of Nui Nuon
b) Area centering around about 3 km north of Phu Suon
c) Area extending NW-SE direction centering around about 6 km west of Nui Mat Vark

Cr

Distribution pattern of anomalies is very similar to that of Ni above.

Hg

a) Area centering around about 4 km northwest of Gia Phu
b) Area centering around about 2.5 km southwest of Gia Phu
c) Area centering around about 4 km east-southeast of Gia Phu

d) Area around about 4.4 km south-southwest of Nui Mat Vark

Mn

a) Area centering around about 5 km northwest of Phu Yen

b) Area centering around about 5 km north of Phu Yen

c) Area centering around Nui Mat Vark

d) Area around 1.3 km east of Nui Pha

2.1.5. Consideration

(1) Results of analysis and statistics

An average composition of elements concerned in the earth's crust and principal rocks are reported as follows:

Table Ⅲ-2-3 Average Composition of Elements Concerned in the Earth's Crust and Principal Rocks

Element	Earth's crust	Ultra mafic rocks	Mafic rocks	Granite	Lime-stone	Sand-stone	Shale
Au(ppb)	4	3.2	3.2	2.5	5	5	4
Ag(ppb)	70	60	100	37	100	250	190
As(ppm)	1.8	1.0	1.5	2.1	1.1	1.2	12
Cr(ppm)	100	1980	170	4.1	11	35	90
Cu(ppm)	55	42	72	12	5	10	42
Hg(ppb)	80	4	10	40	40	30	20-400
Mn(ppm)	950	1040	1500	390	1100	-	850
Ni(ppm)	75	2000	130	4-5	20	2	68
Pb(ppm)	13	1	4	18	5	10	25
Sb(ppm)	0.2	0.1	0.1	0.2	0.3	1.0	1-2
Sn(ppm)	2	0.5	1.5	3.0	-	0.6	6
W (ppm)	1.5	0.1	1.0	1.5	0.5	1.6	1.8
Zn(ppm)	70	58	94	51	21	40	100

Although the average composition above cannot be compared directly with geochemical contents, some studies are done for reference as in the following.

Elements with threshold values for strong anomalies being nearly ten times of the average composition are Ag, Cr, and Hg. Therefore, it is inferred that the these strong anomalies result from supply of the said elements.

Threshold values for strong anomalies of Au, Cu, Pb, Zn, Ni, and Sb are about one to three times of the average composition. Since it is doubtful whether strong anomalies of these elements are true anomalies or mere anomalies caused by statistical processing, another view points is necessary on consideration about mineralization.

Threshold values for strong anomalies of Mn and As are around four times of the average composition. It can not be judged that these elements belong which case.

(2) Correlation

In accordance with results of correlation between elements shown in Table Ⅲ-2-2, elements with good relation are grouped as follows:

a) Cr-Cu-Mn-Ni-Zn

b) Ag-As-Pb-Sb

Elements of the group a) tend to be concentrated in mafic rocks, ultramafic rocks or shale. Therefore, it is inferred that anomalies of elements of the group a) are related to distribution of mafic rocks.

Elements of the group b) have high values in the shale as shown in Table Ⅲ-2-3. Thus, anomalies of elements of the group b) appear to be related petrographically to mudstone.

(3) Relationship with geology and geologic structure

Anomalous zone of Cu, Mn, and Ag well coincide with areas where Lower Triassic volcanics and tuffaceous rocks of trachybasaltic or trachyandesitic nature are predominant and many gabbroic bodies intruded into the area of the above rocks.

Anomalous zone of Ni and Cr are, as already stated, distributed in three separated areas. Two of them in the east of the area seem to be related to doleritic and peridotic dikes intruding along fissures such as faults. Although mafic or ultramafic rocks are not confirmed in the anomalous area in the west, it is anticipated that mafic or ultramafic rocks exist along faults like two areas in the east, because extension of Ni and Cr anomalous zones is parallel to that of faults, and ultramafic rocks are predominant on the western extension of the anomalous zone (outside the survey area).

As already mentioned, anomalous zones of Pb, Zn, and Sb overlap one another showing similar patterns on the area centering around about 4 km northwest of Phu Yen. Syenite bodies are concentrated in this area. Therefore, it is inferred that these anomalies are closely related to the syenite bodies.

Note: The average composition of syenite is as high shown below.
Zn: 130 ppm Pb: 12 ppm Sb: 0.X ppm (Turekian & Wedepohl, 1961)

2.2. Panned Concentrate Geochemical Exploration

(1) Objectives

The gold, copper, lead, and zinc mineralization represented by the Suoi Tiat mine and others was confirmed by the previous geologic and metallogenic data in this area. This exploration was carried out in the survey area in order to evaluate the characteristics of heavy minerals in the mineralization zones and to discover new potential areas.

(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 193 samples in this area. Each sample was collected by five-times panning (approximately 25ℓ). The samples were dried up and weighed. The heavy minerals were identified based on the method shown in Figure Ⅲ-2-2.

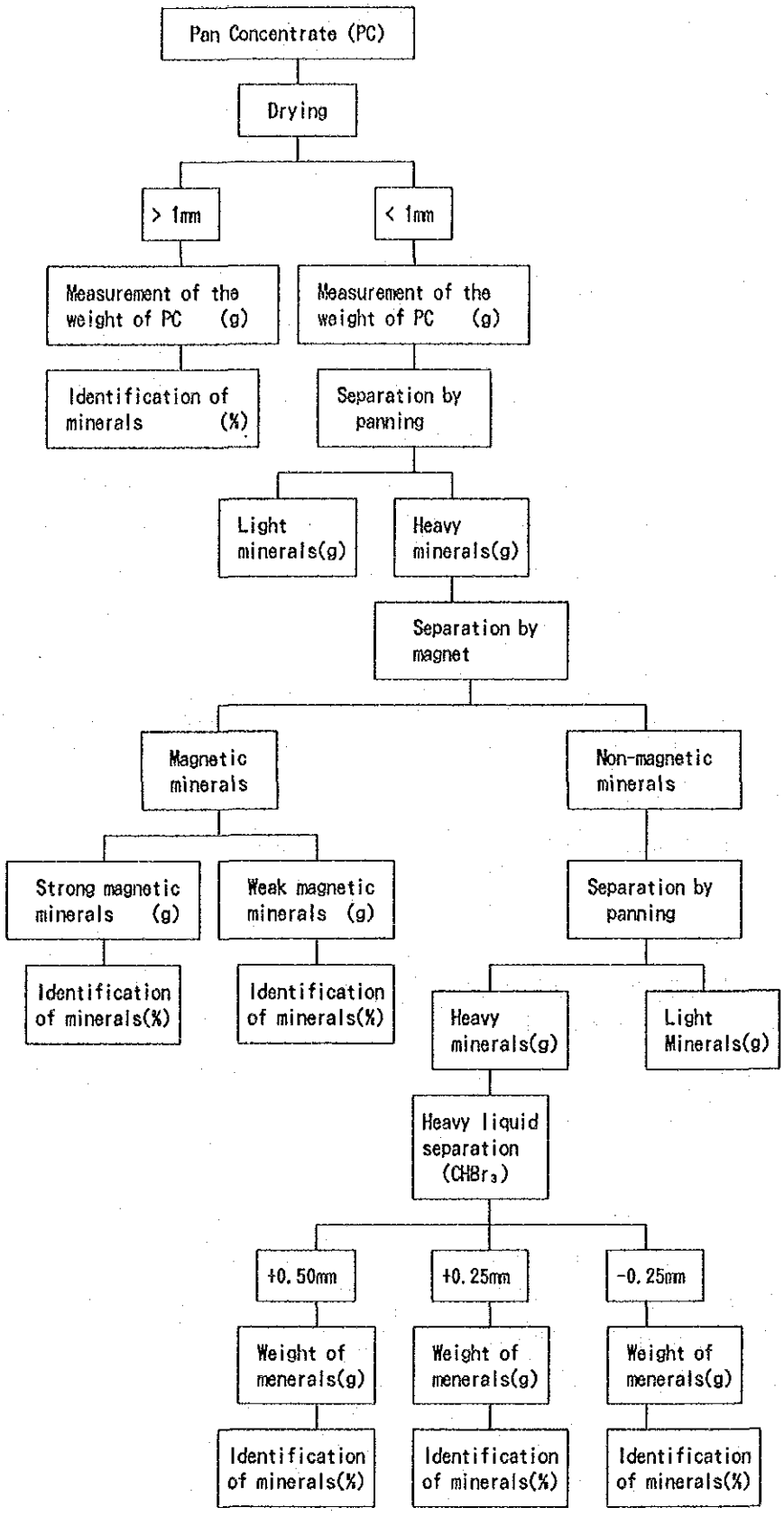


Fig.Ⅲ-2-2 Flow Chart of the Methods for Identification of Heavy Minerals

(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, chromite, wolframite, chalcopyrite, malachite, goethite, zircon, rutile, mercury, pyrite, cassiterite, and native gold. The heavy minerals related to mineralization in this area are considered to be native gold and copper minerals.

The number of their localities is as follows.

- Gold: 13
- Copper minerals: 14
- Sphalerite: 3
- Garnet: 6

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

(4) Distribution of heavy minerals

The localities of heavy minerals confirmed microscopically for native gold and copper minerals are shown in Figure Ⅲ-2-3 and described below.

【Native gold】

1) Upper reaches of the Toc River, 3 km northeast of Phu Yen
2) Middle reaches of the Lang Stream, 4 km west of Phu Yen
3) Two tributaries of the Bua River, 2 to 3 km west of Gia Phu
4) Middle reaches of the Tiat Stream, 2 km south of Gia Phu
5) Upper reaches of the Tiat Stream, 5 km southeast of Gia Phu
6) Tributary of the Da River, 16 km west of Van Yen
7) Tributary of the Da River, 14 km west of Van Yen
8) The Khao Tom Stream, tributary of the Da River, 5 km southwest of Van Yen
9) The Boung Stream, tributary of the Da River, 12 km southwest of Van Yen

【Chalcopyrite and malachite】

1) The Lang Stream, 4 km west of Phu Yen
2) Tributary of the Toc River, 3 km southeast of Phu Yen

3) The stream from outside the survey area, 10 km southeast of Van Yen
4) Tributary of the Bua River, 5 km west of Gia Phu
5) The Tiat Stream, south of Gia Phu
6) Tributary of the Da River, 16 km west of Van Yen
7) Tributary of the Da River, 14 km west of Van Yen
8) The Nam Pion Stream, tributary of the Da River, 12 km west of Van Yen
9) The Boung Stream, tributary of the Da River, 12 km southwest of Van Yen
10) Other localities

(5) Discussion

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

The distribution of gold seems to be related to three geologic units.

1) Lower Triassic Series (T_1) on the central part
2) Cretaceous System (K) on southwestern part
3) Cretaceous System (K) on the northwestern part

Localities of native gold grains are concentrated in the northwestern area of the Lower Triassic Series (T_1) in the central part of the survey area. Many gabbroic and trachytic bodies intruded into the area of this Series. The Cretaceous System (K) in the southwestern part is composed of conglomerate which probably contains gold grains. Syenite stocks intruded into the Cretaceous System (K) in northwestern part. The Suoi Tiat mine is located in the north of the Lower Triassic Series (T_1).

Copper minerals are distributed within all geologic units. But they are in relatively dense distribution in the western part of the survey area. The distribution of copper mineral grains tends to involve the distribution of native gold grains.

From the above characteristics, it is considered that the mineralization in the area is controlled by not stratigraphy but geologic structure. Particularly, localities of the grains of gold and copper minerals are concentrated in the area from the Tiat Stream, 2 km south of Gia Phu, southward.

Van Yen Area

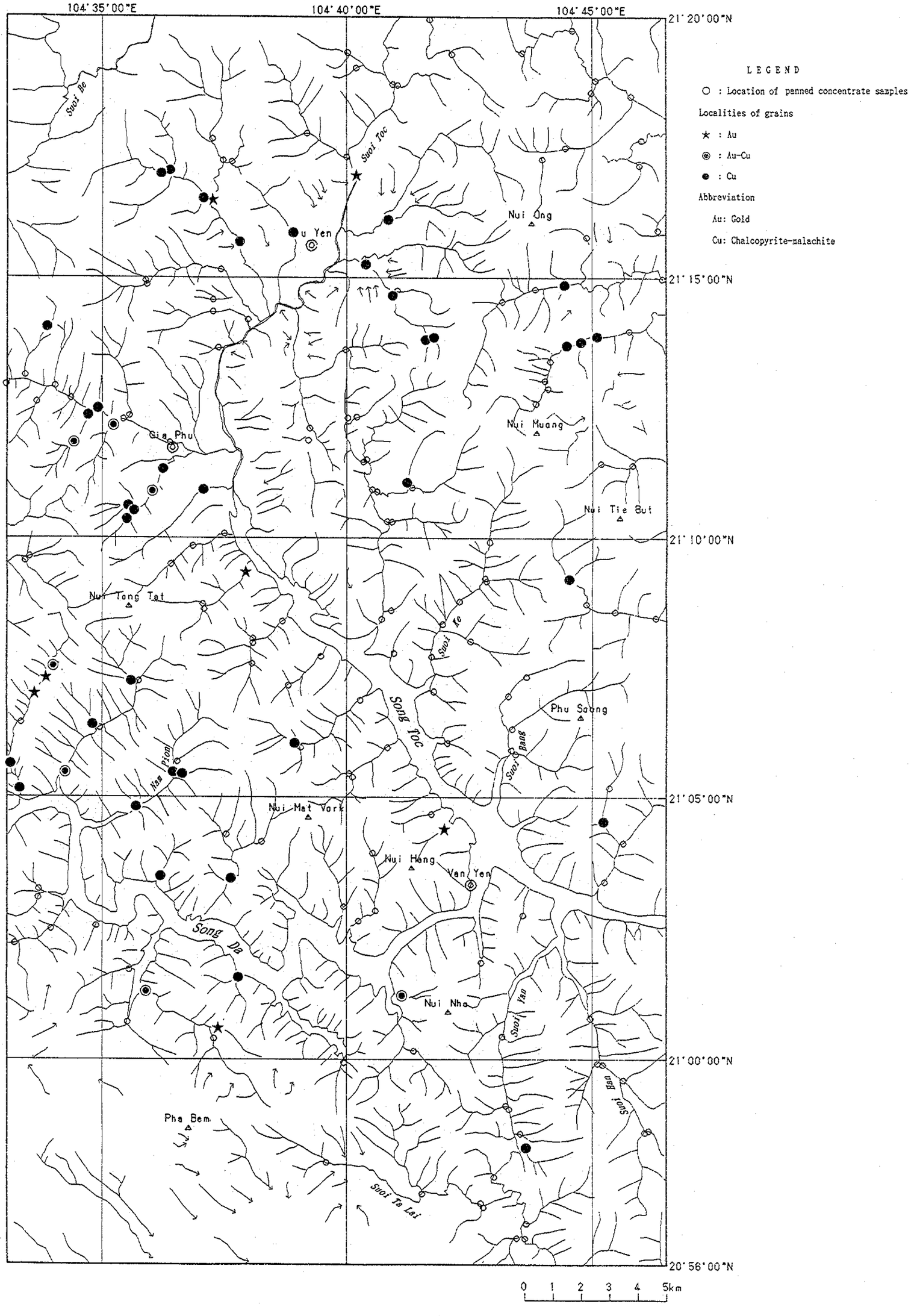


Fig.Ⅲ-2-3 Locality Map of Heavy Minerals in the Van Yen Area

CHAPTER 3. COMPREHENSIVE DISCUSSIONS

3.1. Relationship between Geology, Geologic Structure and Mineralization

The survey area is characterized by the mineralization of gold, copper, lead, and zinc. Gold is mainly associated with the mineralization of bedded cupriferous pyrite deposits. This type of mineralization is concentrated in the area of the Lower Triassic mafic to intermediate alkali volcanic rocks (T_1). Therefore, it is thought that this type of mineralization has close genetic relation to volcanism. The volcanism started in the Early Triassic.

The Da River Mobile Belt was in the period of rifting at that time, and the active alkali volcanic activities took place along the submerged belt bounded by many normal faults. It is inferred that the gold-bearing mineralization was associated with the volcanic activities. The old submerged belt is now a belt with the boundaries of the NW-SE trending "Toc River Fault Zone" and a fault along the Da River. Most of the gold-bearing copper deposits occur concordant to the structure of this belt, and it is obvious that the deposits are controlled by the major structure of this belt.

There are many large quartz veins with a small amount of copper minerals in parts of the Lower Triassic area. These veins probably were formed after metamorphism because the veins cut through the structure of host rocks (schistosities). The Lower Triassic volcanic rocks have chemically mafic to intermediate alkali composition. Thus, the quartz veins cannot be related to these silica-deficient volcanic activities. It is inferred that formation of those quartz veins was related to the Cretaceous felsic volcanism.

The mineral showings of lead and zinc are concentrated in the areas of the Middle Triassic (T_2) carbonate rocks, and there is a large difference in localities between these and showings of gold and copper. In this area, it is clear that lead-zinc and gold-copper are of different genesis. At the present state of the survey, it is not possible to state with clarity the processes leading to the concentration of lead and zinc. One of the possibilities is mineralization associated with Cretaceous felsic igneous activities. Although

the proximity of lead and zinc mineralization zones and felsic bodies could not be ascertained, small mineral showings are found in areas of Cretaceous rocks and it is surmised that the above is a possibility. This problem needs to be further pursued.

3.2. Relationship between Geochemical Anomalies and Mineralization

Of the stream sediment geochemical anomalies detected in the survey area, the following relation with mineralization was confirmed by the present survey. Further survey is necessary to assess the significance of other anomalies.

It was mentioned earlier that the geochemical Au anomalies of the stream sediment samples of this area occurred relatively concentrated in three zones. The strong anomalies in the zone a) are considered to have been derived from the Suoi Tiat deposit in the upper reaches of the Tiat Stream. Those in the zone b) are inferred to have been derived from the Suoi Let mineralization zone in the upstream areas of the Let Stream. The source of the anomalies in the zone c) has not been confirmed yet, but it is believed that the existence of a zone similar to the above Suoi Let mineralization can be expected. The other Au anomalies found in this area are not considered to indicate gold mineralization because they are not concentrated.

Copper stream sediment anomalies occur, as reported earlier, in three zones. Those in the Tiat Stream obviously are derived from the Suoi Tiat deposits upstream, but the source of other two anomalous zones, namely, a) and b) could not be confirmed by this survey.

There are three Pb stream sediment anomalous zones as reported earlier. Those in c) are believed to be derived from the Suoi Boc mineralization zone upstream. But the relation of the other two anomalous zones and mineralization is not yet clear.

3.3. Mineral Potential

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

(1) Gold deposits

Regarding gold deposits, the potential for gold-bearing copper appears to be most promising in this area. Deposits of this type will be described in the following (2). As for the other types of mineralization, many quartz veins are developed in this area, but this gold content is very low. Several veins of ore system was investigated laterally for more than 20 km and vertically for 500 to 600 m, but no change in gold content was recognized. Considering all aspects of present knowledge, high gold potential cannot be expected for this type of quartz veins.

(2) Copper deposits

The copper mineralization is divided into two types, bedded cupriferous pyrite deposits and veins. The former deposits may have relatively higher potential than the latter, because geologic environment of the area is favorable for the formation of bedded cupriferous pyrite deposit. Namely, the Lower Triassic belt to the southwest of the "Toc River Fault Zone" consists mainly of mafic to intermediate alkali volcanic rocks in the rift zone and the rocks were subjected to the subsequent regional metamorphism. Furthermore, bedded cupriferous pyrite deposits (Suoi Tiat mine) exist in this belt.

The copper contents of the vein samples were all less than 1 %. And the grade improves neither vertically nor horizontally and the vein-type mineralization is not considered to be promising in this area.

Although large deposits probably do not occur, small gold-bearing deposits of the above type can be expected to occur. Particularly, many mineral showings with dissemination ore are found near the Suoi Tiat mine for an area of several square kilometers. The dissemination ore is similar to those found near the peripheries or intersections between two bodies of the same type of deposits in Japan.

(3) Lead and zinc deposits

Some lead and zinc mineral showings were confirmed hosted by Middle to Late Triassic limestone (T_2 and T_3). The nature of these showings is not clear because detailed exploration has not been conducted. Although intrusive bodies were not confirmed in the vicinity, such bodies possibly occur in shallow subsurface parts because limestone near the showings is recrystallized to marble. It is clear from floats that metasomatic lead and zinc ore hosted by carbonate rocks exists. But sufficient information regarding the scale of mineralization is not yet obtained.

Promising lead and zinc mineral showings of types different from the above were not found through the previous exploration. This present survey arrived at similar results. There is small mineral potential of lead and zinc types other than metasomatic mineralization.

CHAPTER 4. CONCLUSIONS AND RECOMMENDATIONS

4.1. 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 this phase is as follows.

- Geological survey: 1,000 km^2
- 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 Ton mineral showings.

4.2. 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 Ton mineral showing

PART IV WESTERN THANH HOA AREA

PART IV WESTERN THANH HOA AREA

CHAPTER 1. GEOLOGICAL SURVEY

1.1. Survey Methods

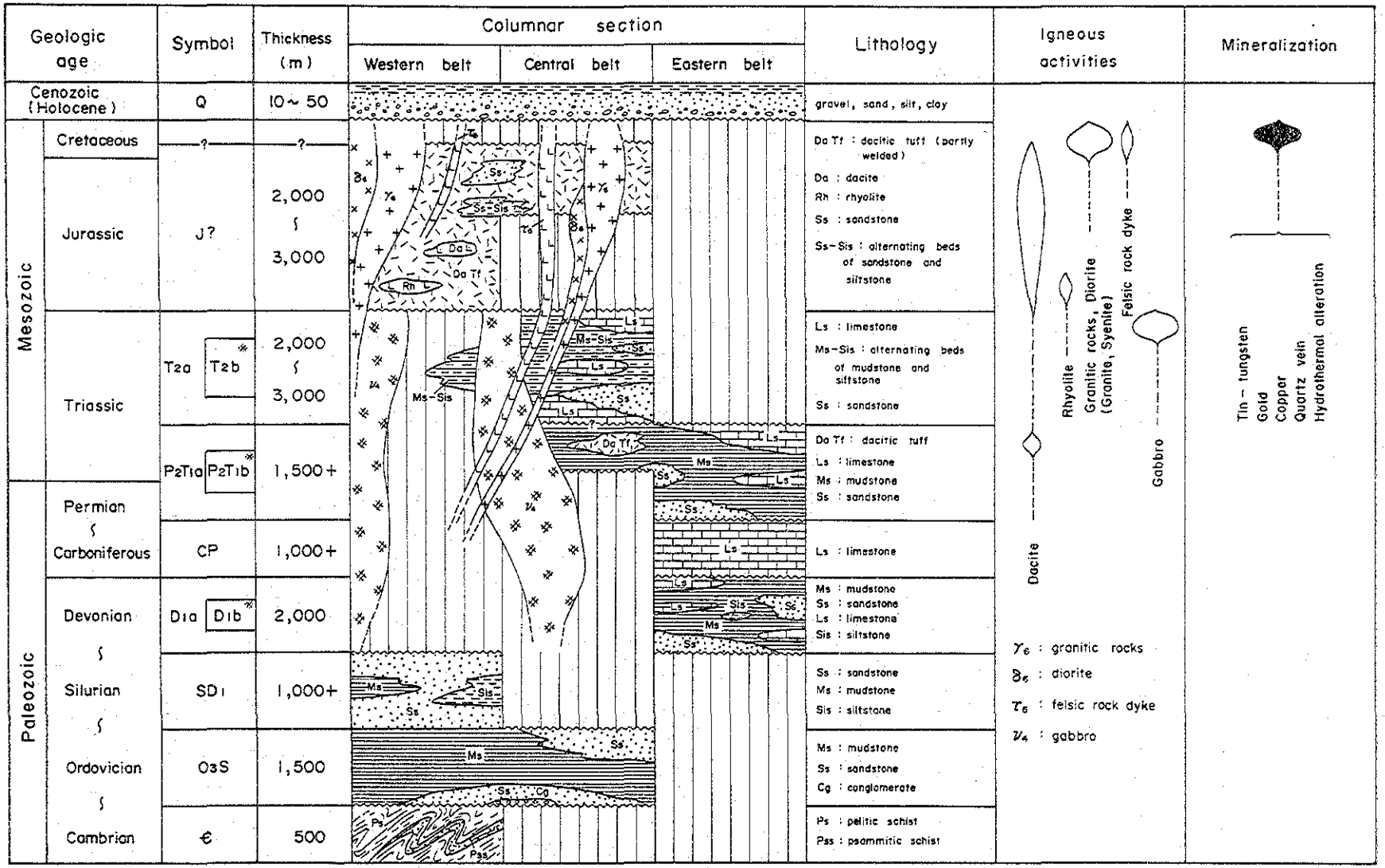
The survey methods are the same as those used for the Van Yen Area previously described in Part Ⅲ.

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 Upper Paleozoic carbonate rocks and marine and continental sedimentary rocks occur in the northern and eastern parts of the survey area. With regard to intrusive rocks, Late Triassic gabbros, Late Cretaceous to Paleogene granitic rocks occur widely in the southern to western 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 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 Upper Devonian, Upper Permian to Lower Triassic, and 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.

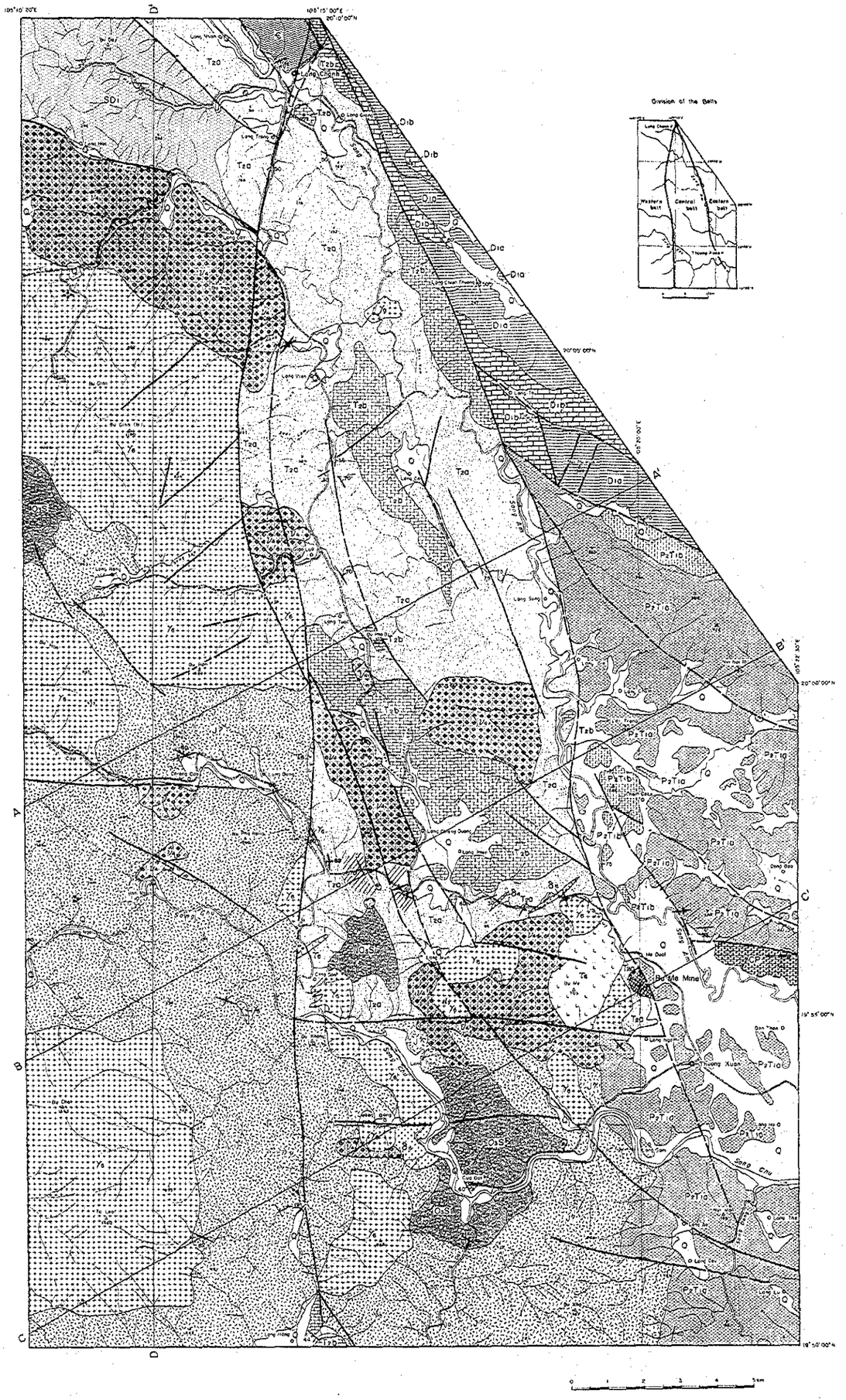


※ Limestone beds

Geologic age of intrusion

- Late Cretaceous ~ Paleogene : γ_6, δ_6, τ_6
- Late Triassic : ν_4

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



LEGEND

STRATIGRAPHY

- Quaternary
- Undiscriminated Jurassic (mainly dacitic tuff)
- Middle Triassic
  - a : sedimentary rocks excluding limestone
  - b : limestone
- Upper Permian to Lower Triassic
  - a : sedimentary rocks excluding limestone
  - b : limestone
- Carboniferous to Permian
- Lower Devonian
  - a : sedimentary rocks excluding limestone
  - b : limestone
- Silurian to Lower Devonian
- Upper Ordovician to Silurian
- Cambrian

INTRUSIVE ROCKS

Late Cretaceous to Paleogene

- Granitic rock
- Dioritic
- Felsic rock

Late Triassic

- Gabbro

OTHERS

- Fault (certain / inferred or covered by the Quaternary)
- Dip and strike of bed
- Anticlinal axis
- Quartz (-Sulfide) Vein
- Mineralization
- Greisenization Zone
- Hydrothermal alteration
- Operating Mine
- A — A' Geologic Section line

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

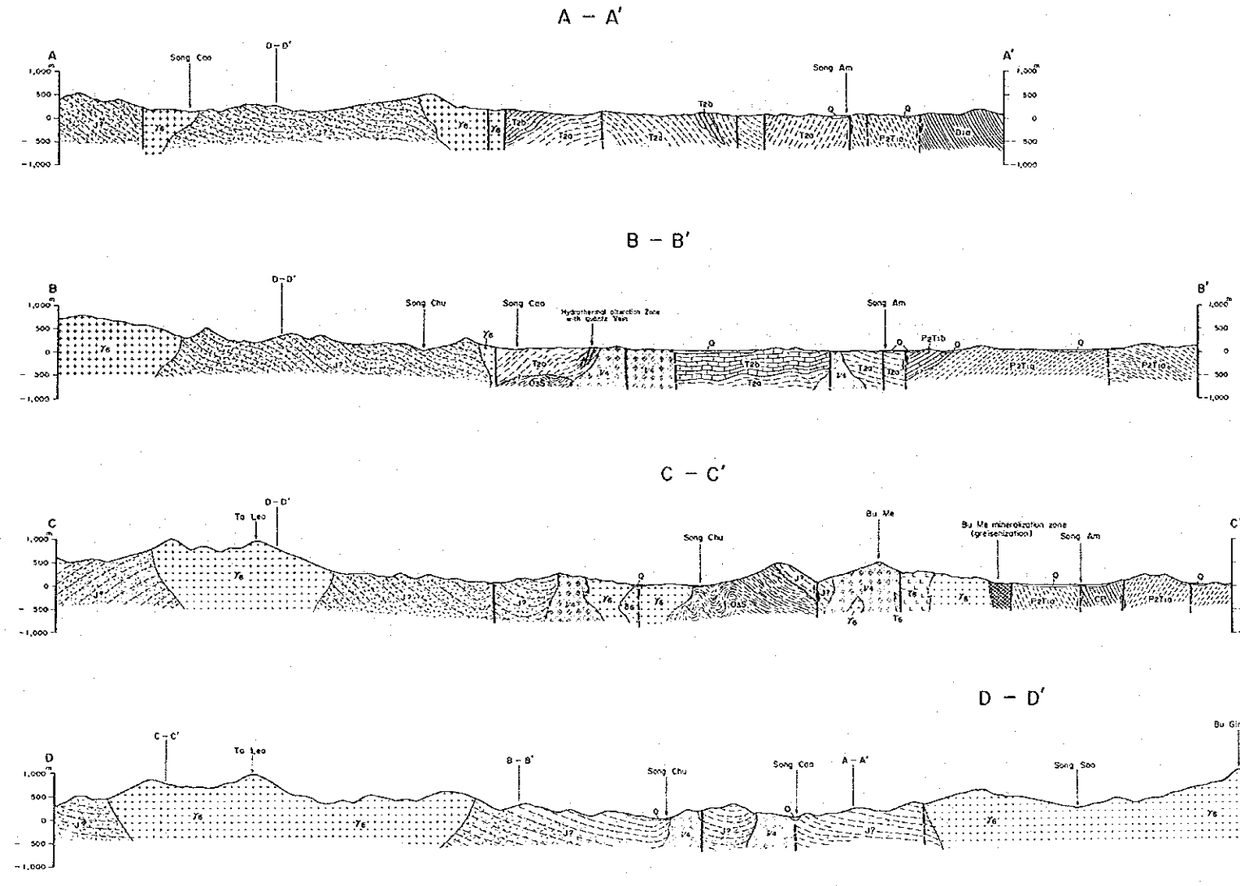


Fig.IV-1-3 Geologic Sections of the Western Thanh Hoa Area

Two continuous faults occur with N-S and NNW-SSE directions in the central to western and eastern parts of the survey area. The area can be divided into three belts bounded by the above two faults. There are clear differences in the mode of occurrence of intrusive rocks of the above three belts. Therefore, schematic columnar sections are shown separately in the "Western belt", "Central belt", and "Eastern belt" from the west eastward. The description of those intrusive rocks will be discussed in section 1.4.

(1) Cambrian System (Є)

This System lies to the north of Lang Chanh located in the northern edge of the area. The extent of distribution is very restricted. The System extends in the NW-SE direction with 1.5 km width. Although the System is in fault contact with the Middle Triassic limestone beds (T_2b; mentioned later), the other sedimentary rocks of the Middle Triassic Series (T_2a) unconformably overlie this System.

The System consists mainly of black to grey pelitic schist, and is partly interbedded with grey fine-grained psammitic schist. It is estimated to be 500 m thick in the survey area.

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

This geologic unit forms three uplifted zones. One of them occur near the summit of Mt. Ginh (C) in the western edge of the area. The remaining two occur in the vicinity of the Chu River in the central to southern part of the area. They have irregular shapes of distribution, however, they are arranged linearly roughly in the NW-SE direction. These uplifted zones are unconformably overlain by the Middle Triassic Series (T_2a) or Undiscriminated Jurassic (J?). A few kinds of intrusive rocks such as granite (γ_6) have intruded into some places of this O_3S.

The major part of O_3S is made up of black phyllitic mudstone, but brown to reddish brown hard and compact medium-grained sandstone are well developed in the lower and partly upper parts. A layer of conglomerate containing pebbles of quartzite is present in the basal part.

This O_3S is estimated to be 1,500 m thick.

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

This geologic unit lies only in the northwestern edge of the area. It extends in the WNW-ESE direction with 2 to 4 km width and continues outside the area. It occurs in fault contact with both a gabbro body on the south and the Middle Triassic Series (T_2a) on the north. In contrast to that, the eastern edge is unconformably overlain by the Series T_2a.

The SD_1 of this area consists mainly of grey, somewhat massive fine to very fine-grained sandstone and contains two kinds of intercalated sequences in the middle part. One is composed of black to blackish green phyllitic mudstone, and another comprises dark grey to greenish grey micaceous siltstone. Both rocks have well-developed stratifications.

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

(4) Upper Devonian Series (D_1a, D_1b)

This Series occur only in the northeastern edge of the area. It extends generally in the NW-SE direction with about 3 km width in the survey area. It does not continue northwestward and is in fault contact with the Middle Triassic Series (T_1a, T_1b). With the Upper Permian to Lower Triassic Series (P_2T_1a, P_2T_1b) on the south, it also lies in fault contact.

This Series is divided into two subunits: the sedimentary rocks (D_1a; excluding limestones) consisting of the major part of the unit and limestones (D_1b) interbedded separately in the lower to upper part of the unit. Dark grey to green mudstone and fine-grained sandstone are predominant in the subunit D_1a with subordinate amounts of intercalated dark grey siltstone. Limestone of the subunit D_1b is light brown and forms regularly alternating beds with thin chert in few places.

The Series is estimated to be 2,000 m thick.

(5) Carboniferous to Permian System (CP)

This System is distributed on the left bank of the Am River. The extent of distribution is limited, trending in the E-W direction with about 800 m width. The System occurs in fault contact with the subunit P_2T_1a on the north. The whole of this System consists of dark grey somewhat massive limestone. The thickness of this System is estimated to be more than 1,000 m.

(6) Upper Permian to Lower Triassic Series (P_2T_1a, P_2T_1b)

This Series occupies widely the eastern part of the survey area. The northern part (on the left bank of the Am River) extends in the NW-SE direction with about 8 km width. In that part it is bounded by a major NNW-SSE fault to the Middle Triassic Series (T_2a). This fault extends roughly along the Am River. The southern part extends in the NNW-SSE direction with about 5 km width in the area, and is unconformably covered by the overlying Undiscriminated Jurassic (J?).

This Series also is divided into two subunits in the same way as the Upper Devonian Series mentioned above; namely, the sedimentary rocks (P_2T_1a; excluding limestones) constituting of the major part of the Series and limestones (P_2T_1b) interbedded in the middle to upper part of the Series. The subunit P_2T_1a occurs widely, but the distribution of the subunit P_2T_1b is extremely restricted. The subunit P_2T_1a consists mostly of grey to dark grey mudstone. Many outcrops are weathered, where the rocks are light brown to light yellow. The P_2T_1a contains grey massive medium-grained sandstones intercalated in the lower and middle parts of this subunit. Additionally light green dacitic tuffs are found in the part on the right bank of the Chu River (in the southeastern edge of the survey area). The subunit P_2T_1b is composed chiefly of grey limestone with poor stratification.

The Series is estimated to exceed 1,500 m in thickness.

(7) Middle Triassic Series (T_2a, T_2b)

This Series occurs widely and continuously as a belt from the central-southern part to the northern edge of the area. Topography of the T_2 area consists of hilly terrains with low relief energy. This Series is bounded by

two major faults, N-S and NNW-SSE systems. The Series generally extends in the NNW-SSE direction with 4 to 7 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, middle, and upper parts of the T_2. The subunit T_2a is composed mainly of alternating beds of grey or black mudstone and grey siltstone, and is interbedded with grey to light grey, massive fine to medium-grained sandstone in the lower and upper parts of the unit. Sandstones of the lower part are especially prevalent in the southern edge of the T_2 area. The subunit T_2b consists of dark grey massive limestone and is classified into three members that are situated in the lower, middle, and upper parts of the whole unit. The extending pattern of the subunit T_2b is in good accordance with the macroscopic structure of the T_2. The thickness of each member is, from the base upward, 500 m, 200 to 500 m, and 300 m.

This Series as a whole is estimated to be 2,000 to 3,000 m thick.

(8) Undiscriminated Jurassic System (J?)

This System occupies wide areas in the southwestern part of the 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 Chu and Cao Rivers and the principal ridges are aligned in the NW-SE direction. It appears from the above morphologic features that the 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. It generally is made up mainly of grey to light greenish grey, massive dacitic crystal tuff, and is accompanied by subordinate dacite and rhyolite lavas with clear flow structure in the lower part. 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 mmm rock fragments occasionally are found. They consist mainly of light greenish grey tuff and black mudstone. Welded structure is well developed in the tuff in the vicinity of the main stream of the Chu River.

This System is interbedded with alternating beds of sandstone and siltstone, and sandstone beds in the middle and upper parts, respectively. Sandstone in general is light grey to white, medium to coarse-grained, and shows massive, hard and compact characteristics. No stratification was observed in the sandstone. The sandstone of the western part in the vicinity of granite intrusion has been subjected to intense contact metamorphism and changed to hornfels (in the part of the left bank of the Cao River). Siltstone is grey or black and fissile.

This System is inferred to be 2,000 to 3,000 m thick.

(9) 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 widely cover the areas on both banks of lower reaches of the Am River (in the southeastern part of the survey area), where the rocks of the Upper Permian to Lower Triassic Series (P_2T_1a, P_2T_1b) are found in a scattered pattern like residual hills. The alluvium hardly occur along the Chu River of the largest one in this area, because the downward erosion of the river is relatively more intensive than the sedimentation. In the basins of the wide hilly zones of the central part, the Quaternary System is sporadically scattered in an irregular pattern.

1.4. Intrusive Rocks

Plutonic rocks of various composition and felsic dikes occur in this area. The geologic ages of these intrusions have been clarified by the Geological Survey of Vietnam (GSV,1990). The lithology of the plutonic rocks is classified by chemical composition into gabbroic rocks (ν_4), granitic

rocks (γ_6), and dioritic rocks (δ_6). Although the felsic dikes (τ_6) is divided lithologically into two types, there is only a small difference of chemical composition between the two and thus they are treated as one unit. These intrusive rocks crop out in the "Western belt" and "Central belt". No intrusive rocks were found in the "Eastern belt" of the area.

(1) Late Triassic gabbroic rocks (ν_4)

The gabbroic rocks intruded mainly into the Middle Triassic Series (T_2a, T_2b) and 10 bodies were found in this area (see Figure IV-1-2). The dimensions of each body vary considerably. The largest body bounded by the N-S fault occurs in the northwestern part of the survey area and is more than 9 km long and 3 km wide. The rock body near the Bu Me mineralization zone is 5 km long and 3 km wide and some felsic rocks intruded into this body. The E-W faults cut this body into several blocks. Although no clear trend of arrangement is recognized for these bodies, it seems possible that they have the sporadic NNW-SSE alignment within a zone about 11 km wide in view of the macroscopic distribution pattern of the bodies. The zone lies across both the "Western belt" and "Central belt" of the survey area.

The rocks are generally dark greenish grey or grey, compact medium to coarse-grained, and holocrystalline. Microscopic studies reveal that they are composed essentially of clinopyroxene and plagioclase with subordinate amounts of secondary chlorite and actinolite. They occasionally contain hornblende and the size of the above clinopyroxene attains a maximum of 10 mm. Some of those bodies altered to be metagabbros.

The list below shows the results of whole rock analysis of the representative rock samples collected from three bodies.

Sample No.	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI
TFR 1	46.90	0.09	25.45	0.86	1.99	0.05	5.42	14.85	1.71	0.19	0.42	1.78
TFR 3	49.39	1.92	13.86	2.87	7.89	0.19	8.18	10.44	3.12	0.57	0.20	0.90
TGR 11	46.43	0.17	22.26	0.71	3.29	0.08	7.37	13.93	2.60	0.29	0.005	2.49

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). Sixteen bodies of various dimensions are found in this survey area. Three bodies in the "Western belt" are of large-scale and the largest one is more than 13 km long by 6 km wide. The bodies do not exceed 4 km in length in the "Central belt". Two and five bodies that are found respectively in the northwestern part and near Mt. Me (Bu Me) intruded closely related with the gabbroic bodies, and form the rock masses of plutonic complex accompanied by faults.

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. Some bodies near Mt. Me occasionally exhibit porphyritic texture. Microscopic studies indicate that a small body in the southwest is probably porphyritic syenite.

The whole rock analysis of the representative samples collected from two 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 3	78.00	0.13	10.87	0.26	1.25	0.03	0.005	0.30	3.12	5.22	0.02	0.39
TMR 6	75.90	0.10	12.32	0.19	1.25	0.02	0.005	1.11	3.79	4.42	0.02	0.43

Unit: percent

(3) Late Cretaceous to Paleogene dioritic rocks (δ_6)

The dioritic rocks intruded into the same geologic units as the granitic rocks, and three small bodies are found in the central to southern part of the survey area. One body located in the right bank of the Chu River is medium-grained holocrystalline, and it contains of a large amount of amphibole and plagioclase. Two bodies to the north of the Bu Me plutonic complex, on the contrary, intruded as a dike, extending in the NE-SW direction. They have porphyritic texture. Therefore, it is considered that they are hypabyssal rocks which were derived from the subsurface rock mass.

(4) Late Cretaceous to Paleogene felsic dikes (τ_6)

Three τ_6 dikes occur in this area. Two are exposed along the long N-S fault that bounds the "Western belt" and "Central belt", and one intruded into the Bu Me plutonic complex. These dikes are lithologically divided into two types. The two along the fault are dacite porphyries. The rest consists of rhyolitic rock, but the central part of the body exhibits porphyritic texture. This intrusive body within the Bu Me plutonic complex is large, extending in the N-S direction with about 1.5 km width at the center near the summit of Mt. Me (altitude: 703 m).

1.5. Geologic Structure

(1) Folds

There is a large difference in occurrence of geologic units and intrusive rocks described sections 1.3. and 1.4. among the "Western belt", "Central belt", and "Eastern belt". Stratification is highly developed in the Paleozoic sedimentary rocks. However, rocks of the Series P_2T_1 and the System J (?) are massive with poor structural elements except for some pelitic rocks. Therefore, detailed fold patterns cannot be clarified in this area. Nevertheless, the sedimentary and pyroclastic rocks of all geologic ages generally have NW-SE to NNW-SSE structural trend as described in section 1.3. Therefore, it appears that a series of folds with the same trend of axes occur in this survey area.

The characteristics of folds for each belt are explained as follows on the basis of data obtained from this survey.

【Western belt】

Folds in the System ϵ and the unit O_3S are not very clear because they are confined to small areas. The structure of SD_1 consists of a series of WNW-ESE trending folds with about 3 km wavelength. The rocks of the System J(?) strike generally NW-SE and dip NE in the wide basins of the Chu and Cao Rivers. However, based on the structure of the partly interbedded sandstone and siltstone, it is interpreted that a series of gentle folds are formed in the System J(?) with 1 to 2 km wavelength.

【Central belt】

The structure of the basement rocks of O_3S in the southern part of this survey area consists of a series of NW-SE trending folds with about 500 m wavelength in the south. In the north the beds gently dip NE without exception, and those folds as a whole are considered to form an anticlinorium within this unit. The beds of the subunit P_2T_1a strike NNW-SSE and dip 40 to 50° ENE in the southeastern part of the survey area.

The subunits T_2a and T_2b lie widely in the central to the northern part of the survey area. They have been cut by N-S and NNW-SSE trending faults into several blocks. Nevertheless, those blocks generally are composed of a series of NNW-SSE trending anticline and syncline. The folds plunge SSE. The feature of this structure continues to the northern part, but in general, the upper sequence of this Series tend to appear in ascending order toward the northeast.

The System J(?) of the southern part of the survey area surrounds the basement rocks and it is inferred to form a domical folding.

【Eastern belt】

The subunits D_1a and D_1b in the north have been partly cut by faults into several blocks, but the beds strike constantly NW-SE and dip 40 to 70° NE. The beds of the Series CP strike E-W and dip 40 to 50° N. No fold is recognized within the geologic units, D_1a-D_1b and CP. The major part of the Series P_2T_1a-P_2T_1b that is widely distributed from the central part southward, on the other hand, is supposed to consist of the NW-SE trending anticline with about 10 km wavelength. The flanks of the anticline generally have gentle dips with a maximum of 50°.

(2) Faults

Based on the results of photogeological interpretation of SPOT HRV image (XS mode), this area is divided into three belts by two major faults of the N-S and NNW-SSE directions. The former extends towards north even outside the survey area with another fault of the same direction branching out. This fault system largely controls the distribution of the geologic units for the

wider region including the survey area. This major fault certainly exists because milonitization was observed in sandstone and tuff located near the fault. This fault system has not been shown in any previously prepared geologic maps. Therefore, it is worth noting that this fault system is a newly discovered structural information from the present survey by interpretation of image and ground survey.

The fault patterns in each belt are described below.

【Western belt】

The occurrence of the geologic unit SD_1 is restricted by two WNW-ESE faults. These faults have long extension northwestward outside the area. The vertical displacement for the northern fault is considered to attain several kilometers. No fault was found within SD_1. The NE-SW trending faults (2 to 3 km long) occur in a parallel arrangement within the granitic body (γ_6) in the northern part. Few faults are thought to exist within the unit J(?), and only four faults of the NW-SE and E-W systems are recognized.

【Central belt】

Three E-W trending faults are present within and to the south of the Bu Me plutonic complex. One of them located in the middle part extensively controls the configuration of geologic units of this belt. The vertical displacement of the fault is inferred to be more than 1 km. In other localities the NNW-SSE to NW-SE trending faults are prevalent. However, the vertical displacements by those faults is believed to be roughly 200 to 300 m in view of the distribution patterns of the rocks concerned.

【Eastern belt】

The NW-SE trending faults are predominant in this belt. Faults of other systems are also recognized in the NE-SW or E-W direction that is perpendicular or oblique to the NW-SE faults, but all of them have been cut by the NW-SE trending faults.

1.6. Mineralization

Many mineralization zones and mineral showings have been found for gold,

copper, tin, tungsten and other metals in this survey area. The Bu Me Prospect is under active exploration for tin-tungsten at present.

1.6.1. Gold

Gold mineralization is accompanied with quartz veins in the survey area. Quartz veins occur relatively concentrated in the vicinity of Luong Son and are scattered in other parts of the area, as shown in Plate 10. The characteristics of the Luong Son mineralization zone (tentative name) is described below. Quartz veins of the other mineral showings were summarized in Table IV-1-1.

【Luong Son mineralization zone】

This mineralization zone is located in the Luong Son district in the central part of the area and consists of ten and more quartz veins within an area of 2 km width (see Figure IV-1-4). Host rocks are the Middle Triassic black shale, sandstone, and siltstone. The principal vein systems are NNW-SSE and NE-SW, and the former system is predominant. The veins have steep dips ranging from 70° to vertical. Many of them are about 1 m wide. The main constituent minerals are quartz, limonite and goethite. A trace amount of chalcopyrite is also observed microscopically in one vein (Figure IV-1-5; sample No. TGP 1). Veinlets and stockwork of quartz and limonite are occasionally found on both hanging and foot wall sides of the quartz veins for 1 m (see Figure IV-1-6). All vein quartz are translucent to colorless and massive. Some veins (sample No. TGM 1-1, TFM 20) occur along shear zones.

The hydrothermal alteration occurred in both hanging and foot wall sides of the veins in this mineralization zone for width of more than 1 km. The direction of the alteration zone is not clear, but the zone seems to extend in the NNW-SSE direction.

A small amount of kaolinite, jarosite, and alunite was detected as alteration minerals along some of the quartz veins.

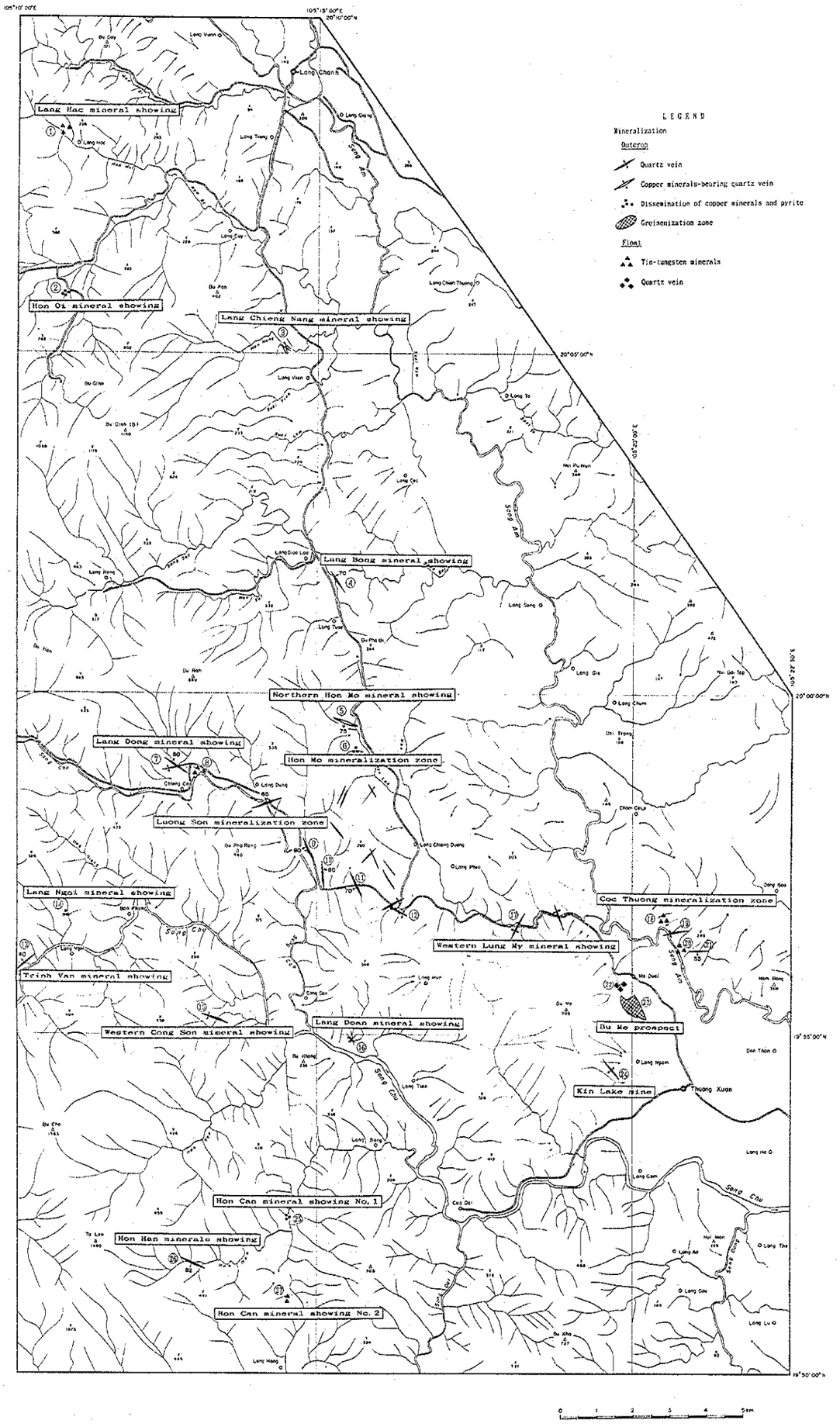
The ore assay results of the representative samples collected from the veins in Phase I survey are as follows for principal elements. The results

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

Name of mineralization zone	Features of deposit	Country rock	Strike and dip	Mineral	Sample No.	Wd(m)	Ore grade									
							Au	Ag	Cu	Pb	Zn	Cr	Mn	Ni	Sn	W
Long Hac	Floats			Qz,Lm	TGM10	-	<1	< 2	0.009	0.001	0.007	0.021	0.048	0.003	< 0.001	< 0.001
Hon Oi	Diss	Granite		Py	TMM 5	-	3	< 2	< 0.001	< 0.001	< 0.001	0.013	0.004	< 0.001	< 0.001	0.002
Lang Chieng Nang	Stockwork	Sil.rock		Qz	TNM 8	0.60	1	< 2	0.001	0.003	< 0.001	0.024	0.005	< 0.001	< 0.001	0.004
Lang Bong	Vein	Phy(T_2)	N35°W/70°N	Qz,Lm	TFM 1	0.60	2	< 2	0.004	0.001	0.001	0.030	0.008	0.001	< 0.001	< 0.001
Lang Dong	Vein	Ss(J)	N80°E/90°	Qz	TNM 2	0.30	1	< 2	< 0.001	1.006	0.044	0.021	0.016	0.002	< 0.001	< 0.001
Western Lung My	Vein	Ss(T_2)	N30°W/90°	Qz,Lm	TGM 3	1.00	5	< 2	0.004	0.009	0.003	0.009	0.002	< 0.001	< 0.001	0.001
Coc Thuong	Floats			Qz,Lm	TGM 5	-	110	< 2	0.019	0.006	0.009	0.008	0.059	0.005	< 0.001	< 0.001
〃	Vein	Sh(T_2)	N80°W/90°	Qz,Lm	TGM 6	2.00	22	< 2	0.004	0.002	0.002	0.036	0.029	0.001	< 0.001	0.001
〃	Floats			Qz,Lm	TGM 7	-	4	< 2	0.005	0.002	0.010	0.009	0.371	0.003	< 0.001	< 0.001
〃	Vein	Sh(T_2)	EW/33°S	Qz,Lm	TGM 8	14.00	2	16	0.015	0.002	0.050	0.013	2.425	0.006	< 0.001	< 0.001
〃					TGM 9	-	3	2	0.013	0.002	0.021	0.007	1.934	0.026	< 0.001	< 0.001
Lang Ngai	Diss	Da(J)			TNM 5	-	18	< 2	0.001	0.019	0.029	0.021	0.007	< 0.001	< 0.001	< 0.001
Trin Van	Vein	Da(J)	N50°E/40°N	Qz	TNM 4	0.04	2	< 2	< 0.001	< 0.001	< 0.001	0.047	0.006	< 0.001	< 0.001	0.003
Western Cong Son	Vein	Da(J)	N70°W/90°	Qz,Lm	TFM 4	1.60	1	< 2	< 0.001	0.001	0.001	0.008	0.003	< 0.001	< 0.001	< 0.001
Hon Can(No.1)	Diss	Da(J)		Py,Ga	TMM 2	-	2	< 2	< 0.001	0.001	0.001	0.016	0.004	< 0.001	< 0.001	< 0.001
Hon Han	Vein	Da(J)	N67°W/82°S	Qz	TMM 4	0.03	2	< 2	< 0.001	0.002	0.002	0.010	0.002	< 0.001	< 0.001	0.001
Hon Can(No.2)	Floats				TMM 3	-	1	< 2	0.001	< 0.001	0.003	0.023	0.005	< 0.001	< 0.001	0.003

※Au:ppb, Ag:ppm, orther elements:%

Abbreviation Da:dacite, Diss.:dissemination, Ga:galena, Lm:limonite, Phy:phyillite, Py:pyrite, Qz:quartz, Sh:shale, Sil:siliceous, Ss:sandstone



LEGEND

Mineralization

Outcrop

- Quartz vein
- Copper minerals-bearing quartz vein
- Dissemination of copper minerals and pyrite
- Greisenization zone

Float

- Tin-tungsten minerals
- Quartz vein

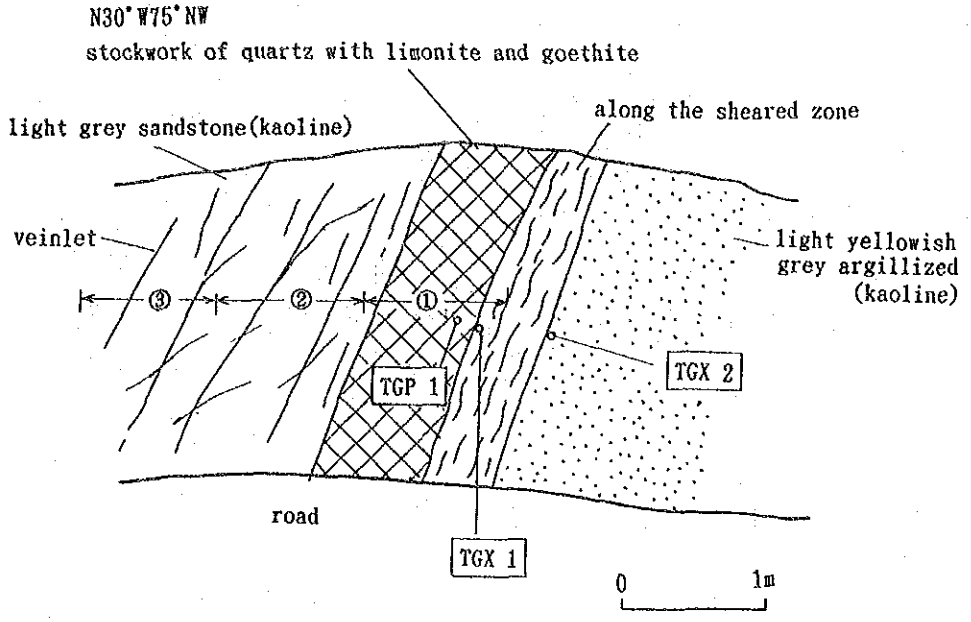
	wd	au	Ag	Cu	Pb	Zn	Cr	Mn	Mo	Sn	W
	m	ppb	ppm	%	%	%	%	%	%	%	%
Lang Nac mineral showing											
① Qz-TGN10	-	<1	<2	0.009	0.001	0.007	0.023	0.048	0.003	<0.001	<0.001
Hon Oi mineral showing											
② Py-TNN 8	-	5	<2	<0.001	<0.001	<0.001	0.013	0.004	<0.001	<0.001	0.002
Lang Chieng Nang mineral showing											
③ Cx-TNN 8	-	1	<2	0.001	0.003	<0.001	0.024	0.005	<0.001	<0.001	0.004
Lang Bong mineral showing											
④ Qz-TFN1	0.80	2	<2	0.004	0.001	0.001	0.030	0.008	0.001	<0.001	<0.001
Northern Hon Mo mineral showing											
⑤ Cp-TFN 2	0.25	0	<2	0.004	<0.001	0.006	0.006	0.072	0.003	<0.003	<0.001
Hon Mo mineralization zone											
⑥ PyrCp-TFN18	-	293	12	0.781	0.032	0.011	0.011	0.012	0.213	<0.001	0.211
PyrCp-TFN19	-	135	44	2.321	0.016	0.037	0.030	0.022	0.004	0.002	0.004
Lang Dong mineral showing											
⑦ Qz-TNN 2	0.60	2	<2	<0.001	1.006	0.044	0.021	0.016	0.002	<0.001	<0.001
⑧ Qz-TNN 1	-	2	<2	<0.001	<0.001	0.001	0.062	0.018	<0.001	<0.001	0.003
Qz-TNN 3	0.10	1	<2	<0.001	0.001	0.003	0.049	0.031	0.001	<0.001	<0.001
Lang Son mineralization zone											
⑨ Qz-TGN 4	1.00	1	<2	<0.001	0.002	0.001	0.006	0.007	<0.001	<0.001	0.002
⑩ Qz-TFN29	0.60	101	<2	0.017	0.010	0.012	0.025	0.006	0.001	<0.001	0.003
Lia-TFN23	0.40	243	<2	0.006	0.059	0.020	0.007	0.225	0.003	<0.001	<0.001
Qz-TFN22	0.30	21	<2	0.009	0.024	0.045	0.022	0.025	0.003	<0.001	0.002
⑪ Qz-TGN1-1	1.00	<1	<2	0.034	0.019	0.044	0.021	0.015	0.002	<0.001	0.003
Qz-TGN1-2	1.00	<1	<2	0.002	0.007	0.005	0.017	0.003	<0.001	<0.001	<0.001
Qz-TGN1-3	0.05	<1	<2	0.003	0.015	0.023	0.020	0.005	0.002	<0.001	0.001
⑫ Qz-TGN 2	3.00	2	<1	<0.001	<0.001	<0.001	0.012	0.004	<0.001	<0.001	0.025
Trinh Van mineral showing											
⑬ Qz-TNN 4	0.04	2	<2	<0.001	<0.001	<0.001	0.047	0.006	<0.001	<0.001	0.003
Lang Ngoi mineral showing											
⑭ Py-TFN 5	-	16	<2	0.001	0.019	0.029	0.021	0.007	<0.001	<0.001	<0.001
Western Cong Son mineral showing											
⑮ Qz-TFN 4	1.00	1	<2	<0.001	0.001	0.001	0.021	0.006	0.003	<0.001	<0.001
Lang Doan mineral showing											
⑯ Qz-TFN 3	-	51	<2	0.002	0.004	0.019	0.008	0.030	0.002	<0.001	<0.001
Western Lung My mineral showing											
⑰ Qz-TGN 5	1.00	5	<2	0.004	0.003	0.003	0.009	0.002	<0.001	<0.001	0.001
Coc Thuong mineralization zone											
⑱ Qz-TGN 5	-	110	<2	0.019	0.006	0.009	0.004	0.059	0.020	<0.001	<0.001
⑲ Qz-TGN 6	2.00	22	<2	0.004	0.002	0.002	0.005	0.029	0.002	<0.001	0.005
⑳ Qz-TGN 7	-	4	<2	0.005	0.002	0.010	0.009	0.371	0.005	<0.001	<0.001
㉑ Qz-TGN 8	-	2	16	0.015	0.002	0.050	0.013	2.425	0.006	<0.001	<0.001
Qz-TGN 9	-	3	2	0.013	0.002	0.021	0.007	1.554	0.026	<0.001	<0.001
Bu Mo prospect											
㉒ Sn-TNN 1	-	2	<2	0.002	<0.001	0.003	0.043	0.032	<0.001	0.001	0.564
㉓ Sn-TFN 5	-	<1	<2	<0.001	0.000	0.003	0.008	0.090	0.001	0.006	<0.001
Sn-TFN 6	-	<1	<2	<0.001	0.005	0.013	0.013	0.176	<0.001	0.018	0.017
Sn-TFN11	-	1	<2	0.011	0.029	0.011	0.014	0.259	<0.001	0.053	0.009
Sn-TFN12	-	<1	<2	0.001	0.006	0.008	0.022	0.364	<0.001	0.020	0.783
Sn-TFN13	-	7	<2	0.005	0.011	0.020	0.014	0.152	<0.001	0.010	0.034
Sn-TFN14	-	4	5	0.035	0.068	0.011	0.015	0.182	<0.001	0.050	0.033
Sn-TFN14-1	-	<1	<2	0.004	0.035	0.002	0.023	0.026	<0.001	0.483	0.313
Sn-TFN15	-	4	<2	0.005	0.007	0.001	0.024	0.075	<0.001	0.066	4.687
Sn-TFN16	-	<1	<2	<0.001	0.002	0.002	0.033	0.007	<0.001	<0.015	2.343
Sn-TFN17	-	2	2	0.002	0.000	0.002	0.017	0.008	<0.001	0.022	0.044
Kin Lake mine											
㉔ Sn-TFN 1	0.15	<1	<2	0.005	0.009	0.005	0.006	0.070	0.001	0.011	0.004
Sn-TFN 8	0.60	2	<2	0.004	0.007	0.004	0.005	0.046	<0.001	0.018	0.002
Sn-TFN 9	0.30	2	<2	0.004	0.007	0.007	0.009	0.095	0.001	0.009	0.002
Sn-TFN10	-	3	2	0.003	0.010	<0.001	0.021	0.092	<0.001	0.003	0.001
Hon Can mineral showing No.1											
㉕ Py-TNN 2	-	2	<2	<0.001	0.001	0.001	0.016	0.004	<0.001	<0.001	<0.001
Hon Han mineralo showing											
㉖ Qz-TFN 4	0.05	2	<2	<0.001	0.002	0.002	0.010	0.002	<0.001	<0.001	0.001
Hon Can mineral showing No.2											
㉗ Qz-TNN 3	-	1	<2	0.001	<0.001	0.003	0.022	0.005	<0.001	<0.001	0.003

TFN 1 Sample number

Abbreviations

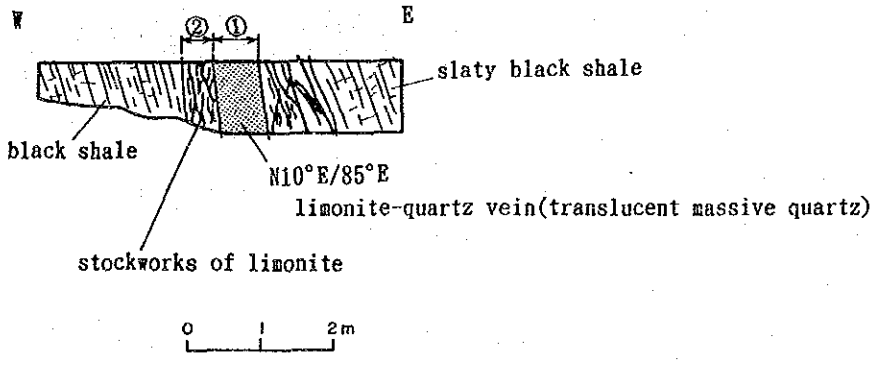
- Cp : Chalcopyrite
- Pb : Galena
- Py : Pyrite
- Pyr : Pyrrohtite
- PyrCp: Paragenecsis of pyrrohtite and chalcopyrite
- Sn : Cassiterite
- Lim : Limonite
- Qz : Quartz vein
- wd : Sampling width

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



	wd (m)	Au (ppb)	Ag (ppm)	Cu (%)	Pb (%)	Zn (%)	Cr (%)	Mn (%)	Ni (%)	Sn (%)	W (%)
① TGM1-1	1.00	<1	<2	0.004	0.019	0.044	0.031	0.015	0.002	<0.001	0.003
② TGM1-2	1.00	<1	<2	0.002	0.007	0.005	0.017	0.003	<0.001	<0.001	<0.001
③ TGM1-3	0.95	<1	<2	0.003	0.015	0.023	0.020	0.005	0.002	<0.001	0.001

Fig.Ⅳ-1-5 Geologic Sketch of the Luong Son Mineralization Zone; No.1



	wd (m)	Au (ppb)	Ag (ppm)	Cu (%)	Pb (%)	Zn (%)	Cr (%)	Mn (%)	Ni (%)	Sn (%)	W (%)
① TFM20	0.60	101	<2	0.017	0.010	0.012	0.025	0.006	0.001	<0.001	0.001
② TFM21	0.40	243	<2	0.006	0.050	0.030	0.007	0.222	0.002	<0.001	<0.001

Fig.Ⅳ-1-6 Geologic Sketch of the Luong Son Mineralization Zone; No.2

for other elements are laid out in Appendix 4. The results revealed that some veins contain a small amount of gold.

Sample No.	Kind of sample	Sampling width(m)	Au	Ag	Cu	Pb	Zn	Cr	Sn	W
TGM 4	Quartz vein	1.00	1	<2	<0.001	0.003	0.001	0.036	<0.001	<0.001
TFM 20	Quartz vein	0.61	101	<2	<0.017	0.010	0.012	0.025	<0.001	0.001
TFM 21	Limonite	0.40	243	<2	0.006	0.050	0.030	0.007	<0.001	<0.001
TFM 22	Quartz vein	0.03	21	<2	0.009	0.024	0.065	0.023	<0.001	0.002
TGM 1-1	Quartz vein	1.00	<1	<2	0.004	0.019	0.044	0.031	<0.001	0.003
TGM 1-2	Quartz veinlet	1.00	<1	<2	0.002	0.007	0.005	0.017	<0.001	<0.001
TGM 1-3	Quartz veinlet	0.95	<1	<2	0.003	0.015	0.023	0.020	<0.001	0.001
TGM 2	Quartz vein	3.00	2	<2	<0.001	<0.001	<0.001	0.012	<0.001	0.003

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

1.6.2. Copper

The copper mineralization is sparsely found in the survey area, and the following two zones were investigated in this phase I survey.

1) Hon Mo mineralization zone

2) Northern Hon Mo mineral showing (tentative name)

These two occur within or in the vicinity of the gabbroic body located in the central part of the survey area. The map prepared by GSV previously indicates some other showings near the gabbroic body located at the western foot of Mt. Me, however, they have not been confirmed during this survey.

1) Hon Mo mineralization zone

This mineralization zone is located in a tributary on the upper reaches of the Hon Luo River which flows southward in the central part of the survey area. It is said that this zone was exploited by the Chinese in 1930 or there abouts. Locality of the old stope is unknown at present, but a dump with a large amount of wastes has been left as shown in the geologic sketch of Figure IV-1-7. The dump is 50 m long, 20 m wide, and 1.9 m high. One very small

stope is located in the northern edge of the dump on the left side of a small stream as shown in Figure IV-1-7.

Massive sulfide ore occurs in this stope hosted by diorite. The exposed ore is 70 cm deep, 50 cm high, and 160 cm wide. The whole dimensions is unknown, however, since the lower limit of the ore is buried. This massive ore body changes its occurrence to be stockworks and pinches out near the boundary with the host rock of the hanging wall side. Dissemination of pyrite and pyrrhotite occurs discontinuously with the surrounding host rocks of the body.

The principal ore minerals are pyrite and pyrrhotite within which very fine-grained chalcopyrite is sporadically scattered. In addition to these minerals, a small amount of goethite was microscopically observed together with a trace amount of bithmuthinite and galena. Gangue mineral is quartz.

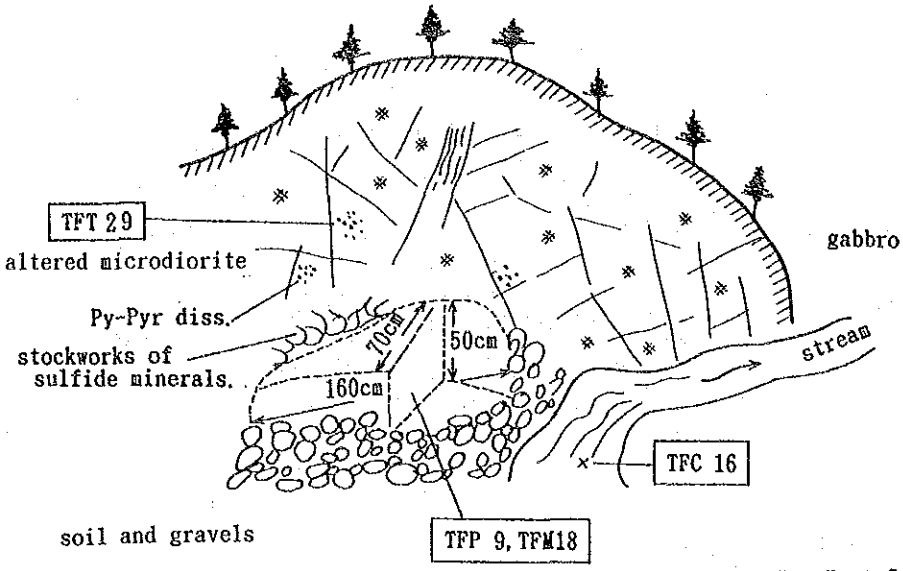
The host rock diorite is fine-grained holocrystalline, and all mafic minerals are altered. A large amount of carbonate minerals, chlorite, and actinolite are observed as alteration minerals with subordinate amount of sericite. This dioritic body occupies the marginal part of the wide gabrroic body (5 km by 1.2 km) on the south side of the dioritic body.

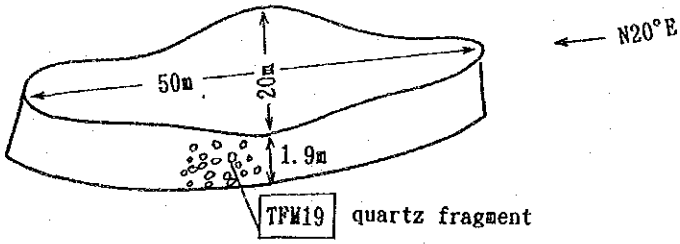
There are many fragments of vein quartz in the above dump, with minor amount of blocks containing malachite.

The ore assay results for main elements of the representative samples are as follows, revealing relatively high content of copper.

Sample No.	Kind of sample	Au	Ag	Cu	Pb	Zn	Ni	Cr
TFM 18	Chips from ore body	293	12	0.701	0.002	0.011	0.011	0.013
TFM 19	Fragments of vein quartz from wastes	135	44	2.321	0.016	0.037	0.030	0.004

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





A dump of waste showing the dimensions
(waste:pebble-size quartz and occasionaly malachite)

An outcrop(see the left)is located on the north of this dump.

	Au (ppb)	Ag (ppm)	Cu (%)	Pb (%)	Zn (%)	Cr (%)	Mn (%)	Ni (%)	Sn (%)	W (%)
TFM18	293	12	0.701	0.002	0.011	0.011	0.012	0.013	<0.001	0.011
TFM19	135	44	2.321	0.016	0.037	0.030	0.022	0.004	0.002	0.004

Fig.IV-1-7 Geologic Sketch of the Hon Mo Mineralization Zone

2) Northern Hon Mo mineral showing

This showing is located about 800 m north of the above Hon Mo mineralization zone and consists of a calcite vein accompanied by dissemination of pyrite and chalcopyrite. The vein strikes N78°W and dips 75°SW with 0.25 m width. The host rock is the Middle Triassic marble which lies around the above gabbroic body.

The ore assay results for main elements of the vein are as follows.

Sample No.	Kind of sample	Sampling width	Au	Ag	Cu	Pb	Zn	Ni	Cr
TFM 2	Calcite vein	0.25 m	2	<2	0.009	<0.001	0.006	0.006	0.003

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

1.6.3. Tin-tungsten

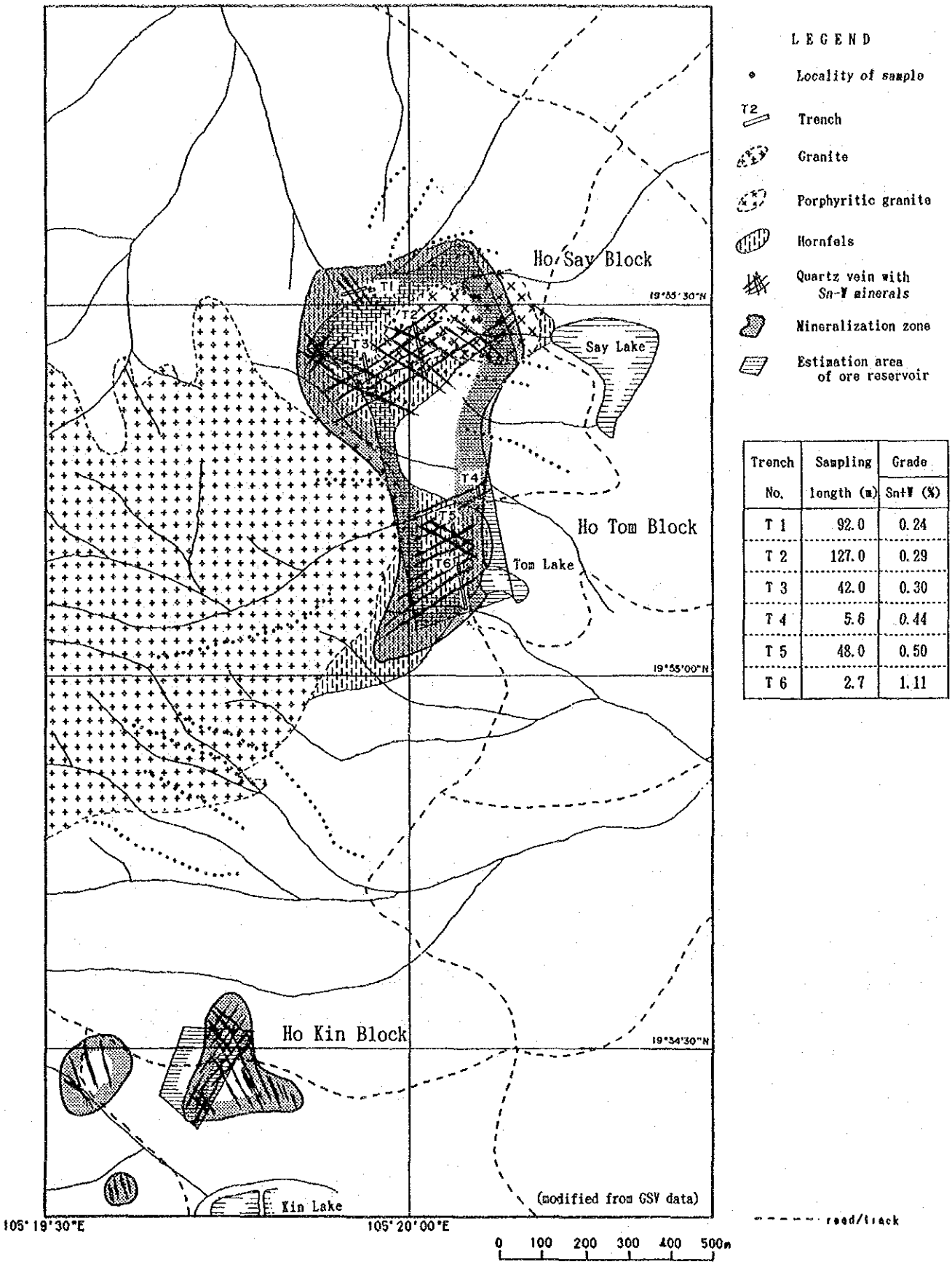
The Bu Me Prospect consists of tin-tungsten mineralization, and is presently under active exploration by the Party 401 of the Division No.4, GSV.

(1) Bu Me Prospect

This prospect is located on the eastern foot of Mt. Me, at the northern edge of Thuong Xuan in the southeastern edge of the survey area. There is one road passable by car to this prospect, and the access is very easy. Many kinds of exploration was carried out in this prospect such as geological survey, geochemical exploration, geophysical prospecting (electric and magnetic surveys), trenching, and shallow pit survey, as reported in Part II, Chapter 2. Subsurface conditions of the deeper parts are unknown since drilling was not conducted in the past. Nevertheless, the past GSV work indicates that ore reserves are expected to be about 20,000 t (Sn+W: 0.18 %). Seven technical personnel of GSV were being engaged in exploration at the site of the prospect on November 1993. Also the local inhabitants were exploiting in a small-scale (underground exploitation and panning) in the southern part of this prospect (the Ho Kin Block to be mentioned later).

Two large and a small intrusive bodies occur in the Bu Me Prospect aligned in the N-S direction (Figure IV-1-8). The small body is situated in

Bu Me Area



Trench No.	Sampling length (m)	Grade Sn+W (%)
T 1	92.0	0.24
T 2	127.0	0.29
T 3	42.0	0.30
T 4	5.6	0.44
T 5	48.0	0.50
T 6	2.7	1.11

Fig.IV-1-8 Plan Map of the Bu Me Prospect

the northern part with occurrence of elliptical shape and areal extent of 600 m x 200 m. The lithology of this body is porphyritic granite with porphyritic texture. The body has been partly subjected to the greisenization and contains topaz and phlogopite. Some parts of the body has been also affected by hydrothermal alteration because quartz phenocrysts are partly cemented by clear hydrothermal secondary quartz. The large body consists of granite stock with holocrystalline subeuhedral medium- to coarse-grained texture. The shape of the body is elliptical with areal extent of 1,600 m by 1,100 m. This body is weakly altered. Both bodies intruded into the Middle Triassic siltstone and sandstone as well as Undiscriminated Jurassic rhyolitic tuff, resulting in the formation of a hornfels zone with 100 to 200 m width (Figure IV-1-8).

The tin-tungsten mineralization occurs mainly within the porphyritic granite and hornfels zone. In the large body, however, the mineralization is sparsely found along the marginal parts. The principal ore minerals are cassiterite, wolframite, pyrite, and arsenopyrite, and they are accompanied by subordinate amount of molybdenite, chalcopyrite, zircon, and xenotime. Pyrrhotite, bismutite, beudantite, and others are rarely contained in the ore. Gangue mineral is quartz. This mineralization occurs as veins, stockworks, disseminations and so on. Wolframite and molybdenite are usually associated with quartz veins.

This mineralization zone is divided into the following three blocks from the north southward.

1) Ho Say Block
2) Ho Tom Block
3) Ho Kin Block

The first two blocks are treated as one block in this report because the boundary between the two is not clear without distinct discontinuity. The boundary of the last two is also not clear because of the paddyfield cover, but there seems to be a discontinuity considering the geochemical anomalous zone delineated by GSV.

1) Ho Say - Ho Tom Block

The mineralization zone, incorporating the two blocks, is 1,200 m long north-south and 400 m wide west-east. The mineralization is found mostly within the porphyritic granite and surrounding hornfels belt. The ore deposits occur as fissure-filling veins or as replacement of mafic minerals of host rock. The previous trenching revealed that the veins occur with about 5 m intervals where they are concentrated. However, thin veinlets of several centimeters width are well developed between the above veins with 20 to 50 cm intervals. There are two prevalent vein systems of N60 to 70°E and N60°W. Both systems are developed in the porphyritic granite zone, but the former system is predominant in the hornfels zone in the south.

Random sampling was carried out mainly from floats of porphyritic granite with mineralization in the Ho Say Block through this survey. The ore assay results of those samples are as follows.

Sample No.	Kind of sample	Au	Ag	Cu	Pb	Zn	Cr	Mn	Ni	Su	W
TFM 5	Float of stockwork of quarts vein	<1	<2	<0.001	0.005	0.025	0.008	0.093	0.001	0.006	<0.001
TFM 6	Float of quartz vein	1	<2	<0.001	0.005	0.013	0.013	0.176	<0.001	0.019	0.017
TFM 11	Float of quartz vein	1	<2	0.011	0.029	0.011	0.014	0.252	<0.001	0.053	0.009
TFM 12	Float of quartz vein	<1	<2	0.001	0.006	0.008	0.022	0.364	<0.001	0.020	3.783
TFM 13	Quartz veinlet from dumps	7	<2	0.005	0.011	0.030	0.014	0.153	<0.001	0.010	0.034
TFM 14	Quartz veinlet from dumps	4	5	0.005	0.068	0.011	0.018	0.182	<0.001	0.050	0.093
TFM 14-1	Quartz veinlet from dumps	<1	<2	0.004	0.035	0.002	0.023	0.026	<0.001	0.483	0.013
TFM 15	Dissemination ore from dumps	4	<2	0.003	0.007	0.001	0.024	0.076	<0.001	0.066	4.687
TFM 16	Quartz vein from dumps	11	<2	<0.001	0.002	0.002	0.033	0.307	<0.001	0.015	2.247
TFM 17	Float of dissemination ore	2	2	0.002	0.009	0.002	0.017	0.008	<0.001	0.023	0.044

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

Additionally the following ore assay results were provided for samples collected from the previous trenching (Figure IV-1-8).

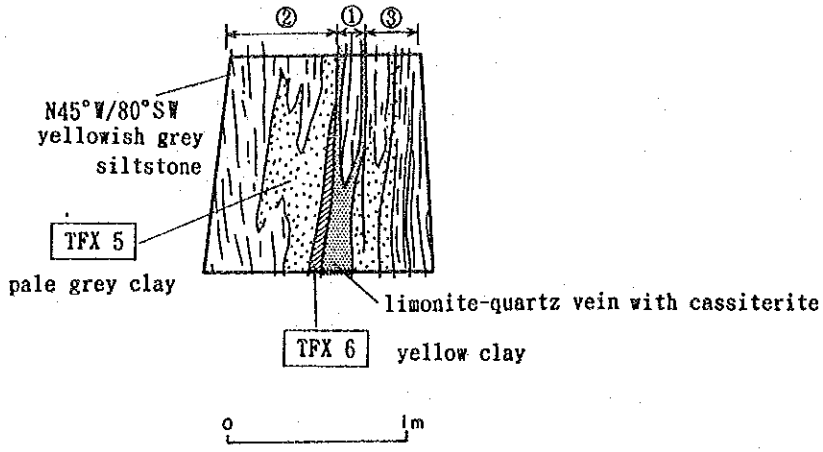
	Sampling length(m)	Sn+W (%)		Sampling length(m)	Sn+W (%)
Tch 1	92	0.24	Tch 4	5.6	1.44
Tch 2	127	0.29	Tch 5	48	0.50
Tch 3	42	0.3	Tch 6	2.7	1.11
total	261	0.29	total	56.3	0.62

2) Ho Kin Block

This block is located 600 m south of the southern edge of the above block. In other words, it is situated about 200 m south of the above granite stock (the large body) and is not in contact with intrusive rocks. Quartz veins are mined by underground working and about 10 shafts were sunk, but only one shaft is operating presently. All shafts are said to be about 15 m deep. Small-scale mining is done by local inhabitants. Thus, the details of this block such as ore reserves are unknown.

Host rock is the Triassic siltstone with general weak alteration. Grayish white weak argillization zones are found on the hanging and foot wall sides of the above outcrops. The X-ray diffraction study revealed that the argillized rocks contain muscovite and a small amount of kaoline. Hornfels zone is not confirmed in the mineralization zone of this block.

The previously prepared maps show that the mineralization zone of this block can be divided into three groups of veins (Figure IV-1-8). Among them, the areal extents of the largest and smallest bodies are 400 m × 300 m and 100 m × 100 m, respectively. The veins are locally concentrated, but they are generally sparse. The trend of the veins is irregular. The exploited quartz veins are 10 to 40 cm wide and have many cavities. The cavities are filled by ore minerals. Scorodite and arsenopyrite are observed under microscope. The quartz veins have a large amount of limonite. Abundant quartz veins of many cavities occur in some outcrops hosted by siltstone as shown in Figure IV-1-9. The veins are 15 cm wide and the cavities are filled



	wd (m)	Au (ppb)	Ag (ppm)	Cu (%)	Pb (%)	Zn (%)	Cr (%)	Mn (%)	Ni (%)	Sn (%)	W (%)
① TFM 7	0.15	<1	<2	0.005	0.009	0.005	0.006	0.070	0.001	0.119	0.004
② TFM 8	0.60	2	<2	0.004	0.007	0.004	0.006	0.046	<0.001	0.018	0.002
③ TFM 9	0.30	2	<2	0.004	0.007	0.007	0.009	0.095	0.001	0.018	0.002

Fig.IV-1-9 Geologic Sketch of the Ho Kin Block in the Bu He Prospect

mainly by limonite.

The ore assay results of samples collected from the gallery and outcrops are given below for principal elements. The results revealed that tin and tungsten are of very low grade in all samples. The results for other elements are laid out in Appendix 4.

Sample No.	Kind of sample	Sampling width(m)	Au	Ag	Cu	Pb	Zn	Sn	W
TFM 7	Ore of outcrop	15	<1	<2	0.005	0.009	0.005	0.011	0.004
TFM 8	Host rock of foot wall side of outcrop	60	2	<2	0.004	0.007	0.004	0.010	0.002
TFM 9	Host rock of hanging wall side of outcrop	30	2	<2	0.004	0.007	0.007	0.009	0.002
TFM 10	Ore in gallery	10	3	2	0.003	0.010	<0.001	0.003	0.001

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

The trenching was previously done with about 390 m of total length in the Ho Kin Block, and the ore assay results are given for one sample with the grade of Sn+W being 0.42 % from a 1.00 m wide sample.

CHAPTER 2. 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 survey area (650 km^2) selected through the study of previous survey data, and to extract promising areas for mineral deposits based on characteristics obtained.

2.1.2. Sampling and chemical analysis

For stream sediment geochemistry, 532 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 13.

Samples were sent to Japan and analyzed. Elements analyzed, analytical methods used and detection limits are the same as those of the Van Yen Area.

2.1.3. Statistical data-processing

The methods of statistical data-processing are same as those employed in the Van Yen Area.

(1) Analytical values

Analytical values of each element are listed in Appendix 7. Their characteristics are as follows:

Au

Gold contents range from below the detection limit to maximum value of 188 ppb, and mean value is 0.6 ppb. The rate of samples with contents below the detection limit is 500/532 (94 %).

Ag

Silver contents range from below the detection limit to maximum value of 8.42 ppm, and mean value is 0.31 ppm. The rate of samples with contents below the detection limit is 21/532 (4 %).

As

Arsenic contents range from below the detection limit to maximum value of 544.6 ppm, and mean value is 1.9 ppm. The rate of samples with contents below the detection limit is 95/532 (18 %).

Cr

Chromium contents range from 2 ppm to maximum value of 6,158 ppm, and mean value is 106 ppm.

Cu

Copper contents range from below the detection limit to maximum value of 174.8 ppm, and mean value is 6.5 ppm. The rate of samples with contents below the detection limit is 25/532 (5 %).

Hg

Mercury contents range from below the detection limit to maximum value of 420 ppb, and mean value is 13 ppb. The rate of samples with contents below the detection limit is 185/532 (35 %).

Mn

Manganese contents range from 31 ppm to maximum value of 13,313 ppm, and mean value is 506 ppm.

Ni

Nickel contents range from below the detection limit to maximum value of 1,056 ppm, and mean value is 28 ppm. The rate of samples with contents below the detection limit is 1/532 (less than 1 %).

Pb

Lead contents range from 2.2 ppm to maximum value of 1,138 ppm, and mean value is 27 ppm.

Sb

Antimony contents range from below the detection limit to maximum value

of 13.4 ppm, and mean value is 0.8 ppm. The rate of samples with contents below the detection limit is 124/532 (23 %).

Sn

Tin contents range from below the detection limit to maximum value of 643 ppm, and mean value is 4 ppm. The rate of samples with contents below the detection limit is 143/532 (27 %).

W

Tungsten contents range from below the detection limit to maximum value of 1,643 ppm, and mean value is 9 ppm. The rate of samples with contents below the detection limit is 51/532 (10 %).

Zn

Zinc contents range from 10 ppm to maximum value of 601 ppm, and mean value is 57 ppm.

(2) Elemental statistics

Elemental statistical parameters are shown in Table Ⅳ-2-1.

(3) Histograms of assay results

Histograms of assay results of each element are shown in Figure Ⅳ-2-1. Elements of Ag, Mn, Pb, and Zn follow log-normal distribution. Au is out of log-normal distribution. The rest of elements show more broad distribution.

(4) Correlation between elements

Correlation coefficients were calculated in order to clarify relations between elements, and the results are shown in Table Ⅳ-2-2.

The following three pairs show good correlation with coefficient over 0.600.

Ni-Cr (0.9069) Ni-Cu (0.6108) Zn-Mn (0.6693)

Furthermore, the following six pairs show fairly good correlation with coefficient over 0.400.

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

Element	Minimum value	Maximum value	Mean(M)	Standard deviation	Threshold	
					M+σ	M+2σ
Au(ppb)	0.5	186	0.60	0.28	1.15	2.20
Ag(ppm)	0.01	8.42	0.31	0.52	1.01	3.36
As(ppm)	0.1	544.6	1.95	0.76	11.25	64.96
Cr(ppm)	2	6158	106.26	0.52	348.53	1143.17
Cu(ppm)	0.1	174.8	6.45	0.61	26.36	107.62
Hg(ppb)	5	420	13.18	0.37	30.86	72.30
Mg (%)	0.05	5.12	0.18	0.40	0.45	1.13
Mn(ppm)	31	13313	505.55	0.49	1567.69	4861.42
Ni(ppm)	0.5	1056	28.42	0.53	95.89	323.51
Pb(ppm)	2.2	1138	26.96	0.24	47.39	83.30
Sb(ppm)	0.1	13.4	0.85	0.62	3.56	14.99
Sn(ppm)	1	643	4.17	0.49	12.97	40.33
W (ppm)	1	1643	8.78	0.55	31.26	111.27
Zn(ppm)	10	601	57.17	0.25	100.94	178.19

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

	Au	Ag	As	Cr	Cu	Hg	Mg	Mn	Ni	Pb	Sb	Sn	W
Ag	0.0297												
As	0.1443	-0.1141											
Cr	0.0706	0.0862	-0.0027										
Cu	0.1999	-0.0639	0.0903	0.4540									
Hg	0.1446	0.1197	0.1364	0.1162	0.1193								
Mg	0.0601	-0.0661	0.0498	0.4406	0.2972	0.0214							
Mn	0.1318	0.3381	0.0072	0.3916	0.2200	0.0980	0.3549						
Ni	0.0904	0.0502	-0.0485	0.9069	0.6108	0.1212	0.3600	0.3204					
Pb	0.0383	0.1156	0.3380	0.1885	0.0788	0.0951	0.1900	0.1731	0.1405				
Sb	0.0056	-0.0113	0.5310	-0.1282	-0.2602	0.0696	0.0560	-0.1549	-0.2409	0.2531			
Sn	-0.0346	0.1321	0.2445	-0.0753	-0.1725	0.0625	-0.0004	0.0827	-0.1446	0.3246	0.3687		
W	0.0080	0.1192	0.3735	-0.1073	-0.3010	0.0685	0.0386	0.1263	-0.2280	0.3481	0.5583	0.5829	
Zn	0.1854	0.1425	0.2427	0.4880	0.3804	0.1465	0.4605	0.6693	0.4683	0.4708	0.0501	0.1223	0.1582

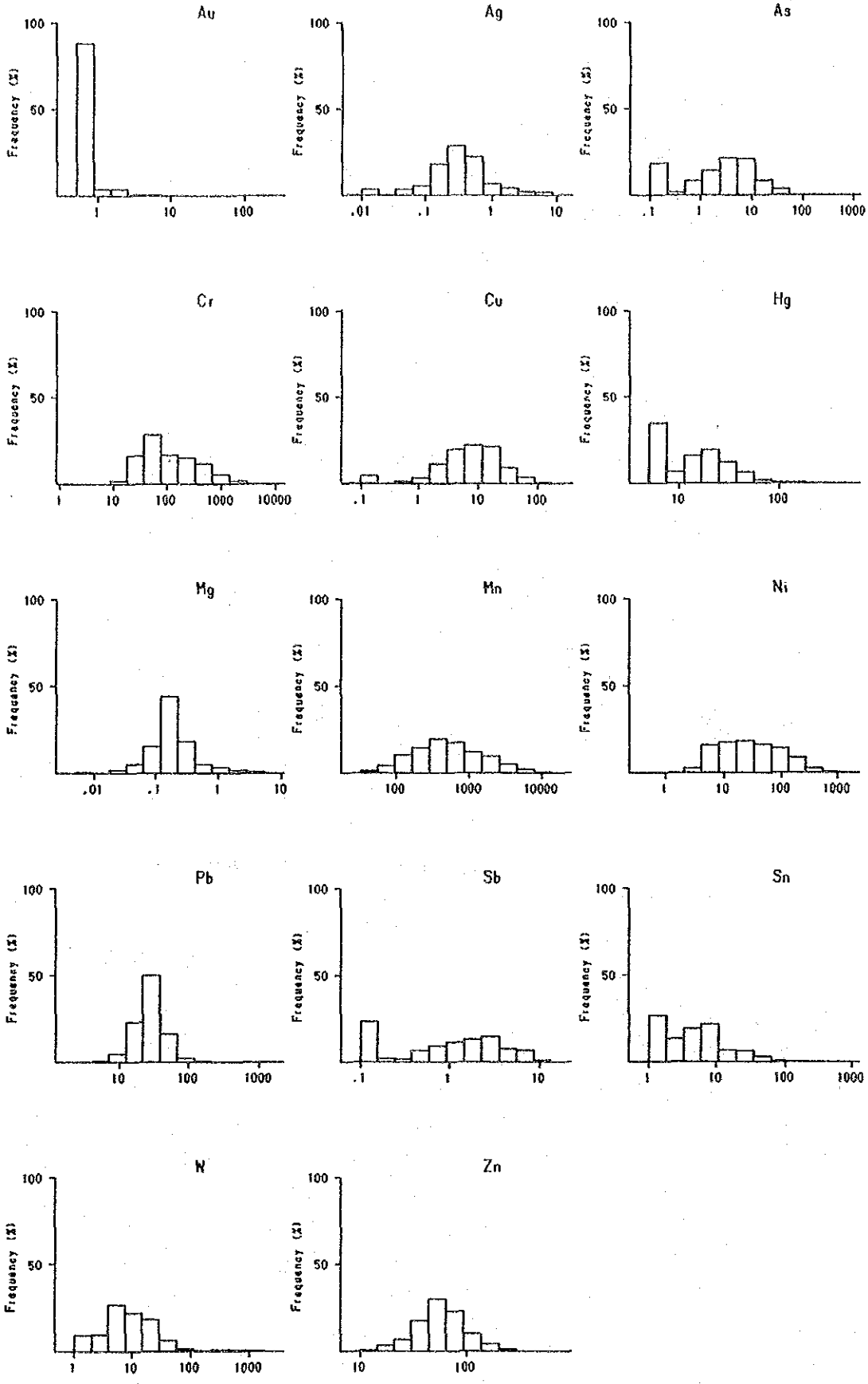


Fig.IV-2-1 Histograms of Assays on Stream Sediment Geochemical Samples Collected in the Western Thanh Hoa Area

Cu-Cr (0.4540)　　Sb-As (0.5310)　　W -Sb (0.5583)

W -Sn (0.5829)　　Zn-Ni (0.4683)　　Zn-Pb (0.4708)

2.1.4. Geochemical anomalies and anomalous zones

(1) Threshold values and anomalies

The threshold values of elements are determined in accordance with elemental statistic parameters. Anomalies are ranked into weak anomalies "M + σ ≦, M + 2 σ <" and strong anomalies "M + 2 σ ≧".

Element	Threshold values		Element	Threshold values	
	W.A.	S.A.		W.A.	S.A.
Au(ppb)	1.15≦ < 2.20	2.20≦	Sb(ppm)	3.56≦ < 14.99	14.99≦
Ag(ppm)	1.01≦ < 3.36	3.36≦	Cr(ppm)	348.53≦ <1143.17	1143.17≦
Cu(ppm)	26.36≦ <107.62	107.62≦	Ni(ppm)	95.89≦ < 323.51	323.51≦
Pb(ppm)	47.39≦ < 83.30	83.30≦	Hg(ppb)	30.86≦ < 72.30	72.30≦
Zn(ppm)	100.94≦ <178.19	178.19≦	Mn(ppm)	1567.69≦ <4861.42	4861.42≦
As(ppm)	11.25≦ < 64.96	64.96≦	Sn(ppm)	12.97≦ < 40.33	40.33≦
			W (ppm)	31.26≦ < 111.27	111.27≦

W.A.: Weak anomaly

S.A.: Strong anomaly

(2) Anomalous zones

Anomalous zones (above weak anomalies) confirmed are shown in Appendix 12 and located in the following zones.

Au

a) Northern tributary of the Nam Bo River, 4 km south of Lang Chanh in the northern part of the survey area

b) Eastern tributary of the Am River, 13 km southeast of Lang Chanh

c) Eastern foot of Mt. Me, 3 km northwest of Thuong Xuan

d) Eastern tributary of the lower reaches of the Cao River, 11 km west-northwest of Thuong Xuan

e) Western tributary of the upper reaches of the Chu River, 19 km west of Thuong Xuan

f) Southern tributary of the lower reaches of the Chu River, 7 km west of Thuong Xuan

Very high contents showing ten times (22.0 ppb) of threshold value for the strong anomaly were detected within the above six zone.

Ag

a) Upper reaches of the Num Bo River, 8 km southwest of Lang Chanh in the northern part of the survey area
b) Upper reaches of the Hon Nang River, 7 km south of Lang Chanh

As

a) Area around 4 km north of Thuong Xuan in the southern part of the survey area
b) Piedmont of Mt. Me, 4 km northwest of Thuong Xuan
c) Northern tributary of the Chu River, 18 km west-northwest of Thuong Xuan
d) Southern tributary of the Chu River, 18 km west-northwest of Thuong Xuan

Anomalous zone with very high anomalous contents (114.4 ppm, 126.0 ppm and 544.6 ppm) is detected on the east of Mt. Me in the above area b).

Cr

a) Area of 17 km extension in NW-SE around Bu Pan, 6 km southwest of Lang Chanh
b) Stream of the Am River, 6 km southeast of Lang Chanh
c) Area around 4 km north of Thuong Xuan
d) Southwest foot of Mt. Me, 3 km northwest of Thuong Xuan
e) Northern tributary of the Cao River, 16 km northwest of Thuong Xuan

Cu

a) Area enclosed between Hon Mui and Nam Bo, 6 km southwest of Lang Chanh
b) Eastern tributary of the Am River, 7 km southeast of Lang Chanh
c) Area around 4 km north of Thuong Xuan
d) Southwest of Mt. Me, 5 km west of Thuong Xuan

Hg

a) Upper reaches of the Bo River, 10 km southwest of Lang Chanh

b) Area around 4 km north of Thuong Xuan

c) Area around Mt. Me, 4 km northwest of Thuong Xuan

Mn

a) Eastern foot of Bu Pan, 6 km south of Lang Chanh

b) Area around 4 km north of Thuong Xuan

c) Area around Mt. Me, 4 km northwest of Thuong Xuan

d) Lower reahces of the Hon Yen River, 12 km west of Thang Xuan

Ni

a) Northwest of Bu Pan, 6 km southwest of Lang Chanh

b) On the Vien Stream, 9 km south of Lang Chanh

c) Around the junction of the Sao and Hon Sat Rivers, 13 km south of Lang Chanh

d) Area around 4 km north of Thuong Xuan

e) Southwest of Mt.Me, 4 km west-northwest of Thuong Xuan

f) Northern tributary of the upper reaches of the Cao River, 16 km northwest of Thuong Xuan

Pb

a) East of Bu Pan, 6 km south of Lang Chanh

b) Eastern foot of Mt. Me, 4 km northwest of Thuong Xuan

c) Northeastern tributary of the middle reaches of the Chu River, 6 km southwest of Thuong Xuan

d) Northeastern tributary of the middle reaches of the Chu River, 7 km west of Thuong Xuan

Sb

a) Area around Mt. Me, 4 km northwest of Thuong Xuan

b) Upper reaches of the Chu River and lower reaches of the Hon Yen River, 12 km west of Thuong Xuan

c) Eastern tributary of the upper reaches of the Chu River, 17 km west-northwest of Thuong Xuan

d) Middle reaches of the Hon Hon River, 13 km west-southwest of Thuong Xuan
e) Western tributary of the Dang River, 7 km south of Thuong Xuan

Sn

a) Eastern foot of Mt. Me, 4 km northwest of Thuong Xuan
b) West of Mt. Me, 5 km west-northwest of Thuong Xuan
c) Middle reaches of western tributary of the upper reaches of the Chu River, 11 km west-southwest of Thuong Xuan
d) Lower reaches of the Hon Hon River, 12 km west-southwest of Thuong Xuan

Anomalous zone with very high content (over 403.3 ppb) is detected in the zone a). The content is 643 ppm.

W

a) Eastern foot of Mt. Me, 4 km northwest of Thuong Xuan
b) Stream of the Hon Yen River, 12 km west of Thuong Xuan
c) Eastern tributary of the upper reaches of the Chu River, 18 km west-northwest of Thuong Xuan
d) Upper reaches of the Hon Hon River, 12 km west-southwest of Thuong Xuan

Anomalous zone with very high contents (over 1,000 ppm) is detected in the zones a) an b). These contents are 1,078 ppm in the area a) and 1,109 ppm, 1,284 ppm and 1,284 ppm in the area b).

Zn

a) Eastern tributary of the Am River, 6 km southeast of Lang Chanh
b) Eastern tributary of the Am River, 13 km southeast of Lang Chanh
c) Area around 4 km north of Thuong Xuan
d) Area around Mt. Me, 4 km west-northwest of Thuong Xuan

2.1.5. Consideration

(1) Results of analysis and statistics

An average composition of elements concerned in the earth's crust and principal rocks are shown in Part Ⅲ, Chapter 2.

Although the average composition can not be compared directly with

geochemical contents, some studis are done for reference as in the following.

In case of Au and Hg, even the threshold values for strong anomalies are below the average composition.

Mean values of Cu and Mn are below the average composition, but their threshold values for strong anomalies are over the average composition.

Mean values of As, Cr, and Zn are almost same as the average composition.

Mean values of Ag, Sb, Pb, Sn, and W are more than double of the average composition. Therefore, it is inferred that the survey area is rather rich in Ag, Sb, Pb, Sn, and W elements.

Elements with threshold values for weak anomalies being exceeded five times of the average composition are Ag, As, Sb, Sn, and W.

Elements with maximum values exceeding 100 times of the average composition are Ag, As, Sn, and W, and ten times are Cu, Hg Ni, and Zn. Maximum value of Au is about 50 times of the average composition.

(2) Correlation

Correlation coefficient are listed in the Table Ⅳ-2-2, and pairs with good or fairly good correlation are already stated. Based on the correlation, elements with good relation are grouped as follows:

a) Cu-Ni-Cr

b) Pb-Zn-Mn

c) Sn-W-Sb-As

Elements of the group a) appear to be related petrographically to mafic rocks, namely to gabbroic bodies in the area. Contents of these elements are relatively lower than the average composition.

Elements of the group b) seem to be related petrographically to mafic rocks or shale. Contents of these elements are also relatively lower than the average composition.

It is clear that elements of the group c) result from mineralization, because their threshold values for weak anomalies are tens times as large as the average composition.

(3) Relationship with geology

Gold anomalous zones are located mainly along tectonic lines such as