(3) Laboratory tests

The mean values of resistivity and chargeability on each rock facies are shown below. Samples from MJVS-1 and MJVS-4 located in high chargeability zones are excluded for calculating the mean of chargeability. Ore samples are collected from lumps around the pit located at the Suoi Boc mineralized zone.

Rock	Resistivity (ohm-m)	Chargeability (ms)
Limestone	13,230	1.8
Sandstone and siltstone	3,056	5.5
Mudstone	256	3.3
Lead-Zinc ore	9,768	5.7

The resistivuties of each rock facies are lined up from mudstone, sandstone and siltstone to limestone ascendingly. The resistivity of Pb-Zn ore is high as compared with common sulfide ore.

The chargeability of rock samples is low except samples from MJVS-1 and MJVS-4.Especially, the limestones have little IP effect. In the Pb-Zn ores, the mean value is low value of 5.7 ms as compared with common sulfide ores. This can be understood from the reason that metallic minerals are mainly composed of sphalerite and cerrusite which have not so strong IP effect. The sandstone and siltstone show almost the same value as the Pb-Zn ores and are high as compared with common sedimentary rocks.

The samples collected from MJVS-1 and MJVS-4 have high chargeability as follows. These results are in harmony with the field survey results.

	Mean Value (ms)	Maximum Value (ms)
MJVS-1	162.5	372.6
MJVS-4	44.0	70.5

2-4-4. Consideration

(1) Resistivity

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

Judging from the results of the laboratory tests, it is clear that limestone has high resistivity and mudstone has low resistivuity. Thus, the low reistivity zones (the area from the northeastern edge to central part of the survey area) on the contour map of apparent resistivity reflect the distribution of mudstone. On the contrary, the high resistivity zones on the contour map of apparent resistivity reflect the distribution of limestone.

(2) Chargeability

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

The chargeability of the ore samples, which are collected from lumps around the pit, are not so high and are of little difference from the chargeability of sandstone. It is considered that no IP anomalies were detected on the Suoi Boc mineralized zone, owing to composite effect of this fact and the small size of mineralized zone.

The strong IP anomalies were detected in the northeastern edge and middle east edge of the survey area. The chargeability of the cores collected from drill holes is so high as the measurement results in the survey area. It is considered that strong IP anomalies result from graphite according to the microscopic observations for drilled cores.

2-5. Trench Survey

2-5-1. Outline of the Trench Survey

Pb-Zn geochemical anomalies were detected in four zones. These anomalous zones are situated around the Suoi Boc mineralized zone, at the south and north of the mineralized zone and at the central part of the Suoi Boc zone.

Trench survey was carried out at above two geochemical anomalous zones to elucidate geology and the characteristics of mineralization.

Three trenches were dug. The length of each trench was 200 m with directions of N80° E or N90° E. The trenches had 1 m wide and were stripped to basement. Three trenches were named MJT-1, MJT-2 and MJT-3 northward.

The location of trenches is shown in Figure 2-10. Interpretation result is shown in Figure 2-11.

2-5-2. Geology

Geology of three trenches consists of limestone, fine- to coarse-grained sandstone and siltstone of Middle Triassic, and Cretaceous aplite.

Limestone is macroscopically divided into four rock facies : black massive limestone, gray massive limestone, limestone breccia and banded limestone.

Black limestone consists of aphanitic carbonates and a small amount of quartz and organic matter. Network of calcite is frequently observed in this limestone.

Gray massive limestone is constituted by fine-grained carbonates.

Limestone breccia contains fragments of black limestone and their size is less than 10 cm. Limestone breccia contains also quartz fragments. The matrix of this breccia is composed of calcite, dolomite, quartz and mica. The size of calcite crystal in the matrix is greater than that in breccia and is similar to that in gray limestone.

Banded limestone has white and gray bands alternately with 10 cm wide. These bands strike N-S and dip 40° to 70° E. This limestone is composed of fine-grained calcite. Many calcite veinlets occur in this limestone.

Clastic sedimentary rocks in the trench are fine- to coarse-grained sandstone and siltstone. These clastic rocks occur only in MJT-1 and are strongly weathered and loose.

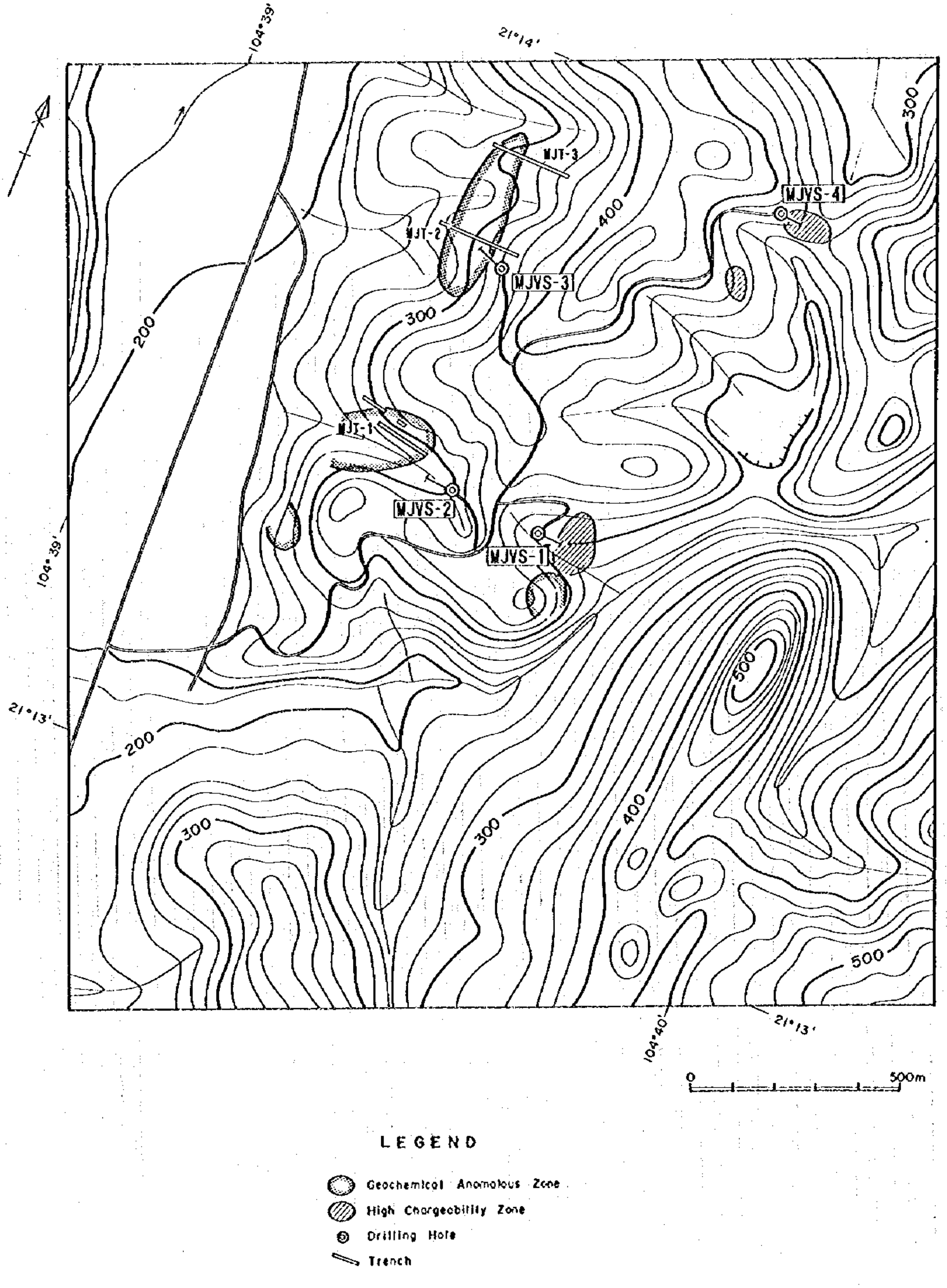

Fig. 2-10 Location Map of Drill Holes and Trenches

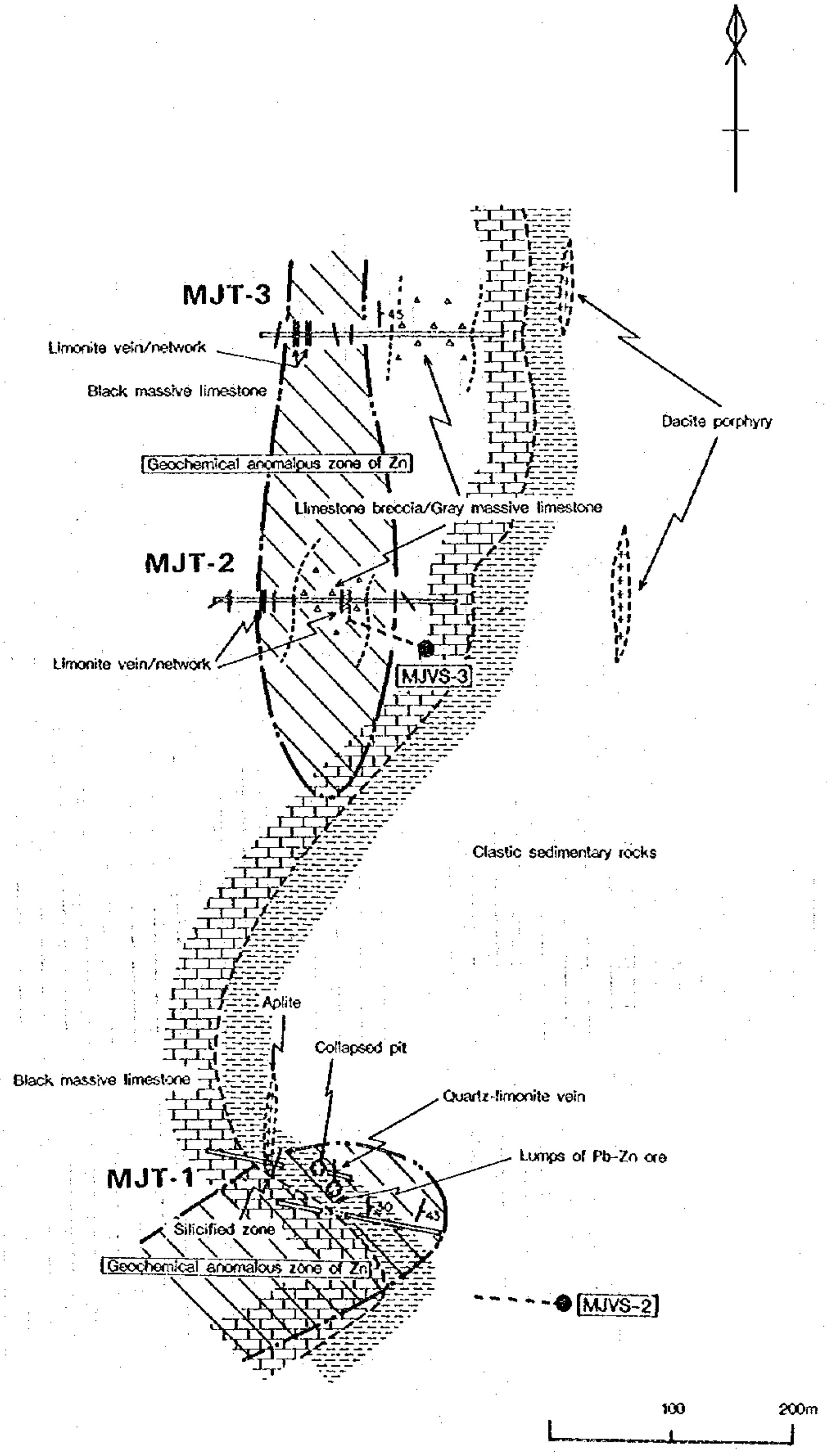

Fig. 2-11 Interpretation Map of Trench Survey

Aplite occurs in MJT-1 and intrudes into fine-grained sandstone and siltstone with 3m wide, and strikes N-S direction.

Geologic structure of the range from the Suoi Boc mineralized zone to the north of this zone studied by three trenches, is summed up as follows.

Almost all limestone is massive. The geologic structure in limestone is no clear. Limestone has partly banded structure. These bands strike N-S and dip generally 45° to 60°E.

Clastic sedimentary rocks are partly bedded with general strike of N-S to NNE-SSW and main dip of 27° to 50°E.

Clastic rocks around aplite strike NNE-SSW and dip 5° to 25°W. Small-scaled faults occur around aplite dike.

It is concluded that sedimentary rocks around three trenches show monoclinal structure with general strike of N-S to NNE-SSW, and dip easterly. It is supposed that a small anticlinal or dome structure occurs around the area where clastic sedimentary rocks dip gently to west from intruded part to limestone in MJT-1.

2-5-3. Mineralization and Alteration

There is some difference of mineralization in clastic rocks and limestone.

Brecciated vein, network and veinlets occur in limestone.

The width of brecciated vein in limestone is 20 cm in maximum and varies frequently. The vein contains a large amount of limestone fragments with matrix of mainly goethite and a small amount of hematite, quartz and mica. There is a fracture zone with 7.5 m wide in limestone breccia of MJT-2. This zone is filled up by limestone fragments, goethite, hematite, quartz and mica.

Network and veinlets are composed of hematite. Veinlets are distributed in whole limestone. Parallel veinlets are found in MJT-3.

Quartz vein, vein-form silicified zone, network and dissemination occur in clastic sedimentary rocks.

Three vein-form silicified zones are found in MJT-1. They are silicified fine-grained sandstone. The boundary between silicified part and unsilicified part is sharp and is nearly vertical.

One silicified zone is accompanied by quartz vein with a width of 10 cm and contains limonite and hematite. There is an old pit at 15 m south of this silicified zone, and this direction coincides with the strike of this silicified zone. Silicified rocks containing of sphalerite, galena and limonite are found in the waste dump of this pit.

Network occurs in fine-grained sandstone and is constituted with hematite veinlets with a width from 2 to 3 mm. The total width of network zone is less than 1 m.

Hematite disseminated bodies in irregular shape with discontinuous veinlets are found in fine-grained sandstone and aplite.

All mineralized zones in trenches have been weathered, and accordingly content of lead and zinc is extremely low.

2-5-4. Discussions on the Results of Trench Survey

Straight expression of Pb-Zn mineralization is ore lumps containing Pb-Zn, dug out from old pits. These ore lumps include cerussite, sphalerite, pyrite, galena, anglesite, limonite and quartz.

The silicified zone accompanying with quartz vein is 1.2m wide, has a strike of N-S and a dip of 80°E. Ore lumps containing Pb-Zn have been dug out from the pit that is located at 15 m south of the silicified zone. The mineralized zone in the pit has almost the same width as the silicified zone in MJT-1. It is consequently considered that the silicified zone in MJT-1 is continuous from the mineralized zone in the pit.

Main fault system in the Suoi Boc zone has NNE-SSW direction.
From the above facts, it is concluded that the geologic structure of the zone is characterized by N-S to NNE-SSW direction.

Quartz vein and silicified zone revealed in clastic sedimentary rocks by trench survey have strikes of N-S direction. Also brecciated veins in limestone are oriented from NNW-SSE, N-S to NNE-SSW direction.

The mineralization occurred in this zone is some lumps of Pb-Zn ore dug out from the pit prepared by GSV. This lumps of ore consist mainly of cerussite and sphalerite with a small amount of pyrite, galena, and anglesite. According to GSV, mineralized zone in the pit has 0.1 to 1.0 m in width. It is presumed that this mineralized zone is hosted by clastic sedimentary rocks, as there is an extremely large amount of clastic rocks in the waste dump of the pit.

The extension of quartz bearing silicified zone reaches to the above mentioned pit in a distance of about 15 m. The width of this silicified zone is nearly equivalent to that of the mineralized zone. Also this mineralized zone is hosted by clastic rocks. Consequently it is supposed that the silicified zone is continuous to the mineralized zone and this Pb-Zn mineralization is vein-type one hosted by clastic rocks.

Four soil samples collected around the Suoi Boc mineralized zone contain more than 0.1 % Zn. Two of those samples contain 1.1% and 7.4% Zn. The geochemically anomalous samples collected in the north of the mineralized zone contain slightly higher than 0.1% Zn. The content of Zn in the former anomalous zone is rather high in comparison with the latter.

The sample point of 7.4% Zn in content is located near to the above mentioned pit. It is supposed that this soil sample containing fragments of ore dug out from pits or old tunnel was collected.

It is considered that the content of Zn in this soil sample indicates not to have formed through weathering but to have resulted from the artificial addition of zinc contained materials

Soil samples in the geochemical anomalous zone have 0.12 to 0.20% Zn, where was detected in the north of the Suoi Boc mineralized zone. Two trenches, namely MJT-2 and MJT-3, were prepared in this anomalous zone. The geology of these trenches is limestone. No skarn minerals are found in the trenches. Brecciated vein, network and veinlets that contain limonite, are found. The extent of concentration of brecciated vein, network and veinlets conforms to that of geochemical anomalies.

It is concluded that the geochemical anomalies in the north of the Suoi Boc zone detected a mineralization constituted by brecciated vein, network and veinlets in limestone.

2-6. Drilling Survey

2-6-1. Survey Method

Geological anomalous zones and high chargeability zones of the Suoi Boc zone were extracted as promising area for ore deposits through regional geological survey in the first phase and detailed geological survey, geochemical exploration and geophysical survey in the second phase.

Drilling survey comprising four holes totaling 742.70 m in length was executed in the geochemical anomalous zones and high chargeability zones for the purpose of elucidating the subsurface mineralization.

Details of each hole are summarized in Table 2-3.

The drilling locations and geologic cross sections are shown in Figures 2-10 and 2-12, respectively.

Four drilling machines were prepared for drilling work. Four holes, namely, MJVS-1, MJVS-2, MJVS-3 and MJVS-4 were drilled.

Table 2-3 Coordinates of Drill Holes and Hole Length

Hole No.	Latitude - Longitude		Altitude	Azimuth	Inclination	Drilled Length
MJVS-1	21°13'26"N	104°39'37"E	310 m	S85°E	-70°	166.40 m
MJVS-2	21°13'28"N	104°39'27"E	330 m	N85°W	-70°	210.00 m
MJVS-3	21°13'44"N	104°39'25"E	365 m	N70°W	-70°	206.30 m
MJVS-4	21°13'55"N	104°39'45"E	370 m	S85°E	-70°	160.00 m

2-6-2. Geology and Mineralization

(1) Geology

The rocks drilled are Middle Triassic clastic sedimentary rocks and limestone. In the holes fracture zones are frequently found.

Clastic sedimentary rocks consist of coarse-grained to fine-grained sandstone, siltstone and mudstone. Sandstone is composed of mineral fragments, such as quartz, feldspar and mica, and rock fragments, namely shale, quartzite and limestone, and matrix of mainly clay minerals, namely illite and chlorite, and quartz with a small amount of aphanitic carbonate. Siltstone is composed of the same fragments as sandstone. Mudstone is black colored, and contains a small amount of organic matters. Calcareous mudstone is rarely found.

Limestones include black massive limestone, gray massive limestone and limestone breccia. Many caves are observed in limestones. These caves are interpreted as limestone caves. Black and gray massive limestones were accompanied by many calcite veinlets.

Geology of MJVS-1 and MJVS-4 consists mainly of fracture zone. Breccia of mudstone, fine-grained sandstone, siltstone, calcareous mudstone and calcite is included in the fracture zone

Breccia of mudstone is dominant in the western part of fracture zone, but amount of other rocks increases eastward in the fracture zone. Fine-grained sandstone contains a small amount of graphite.

Limestone caves are developed to the deeper part of limestone bodies. Water flows on the Boc River of the eastern part of the zone. The Boc River is more than 220 m above sea level. It is supposed that ground water level was rather low in the past, because the bottom of MJVS-2 is 140 m above sea level. The thickness of Quaternary sediments is possibly big at the western part of the zone.

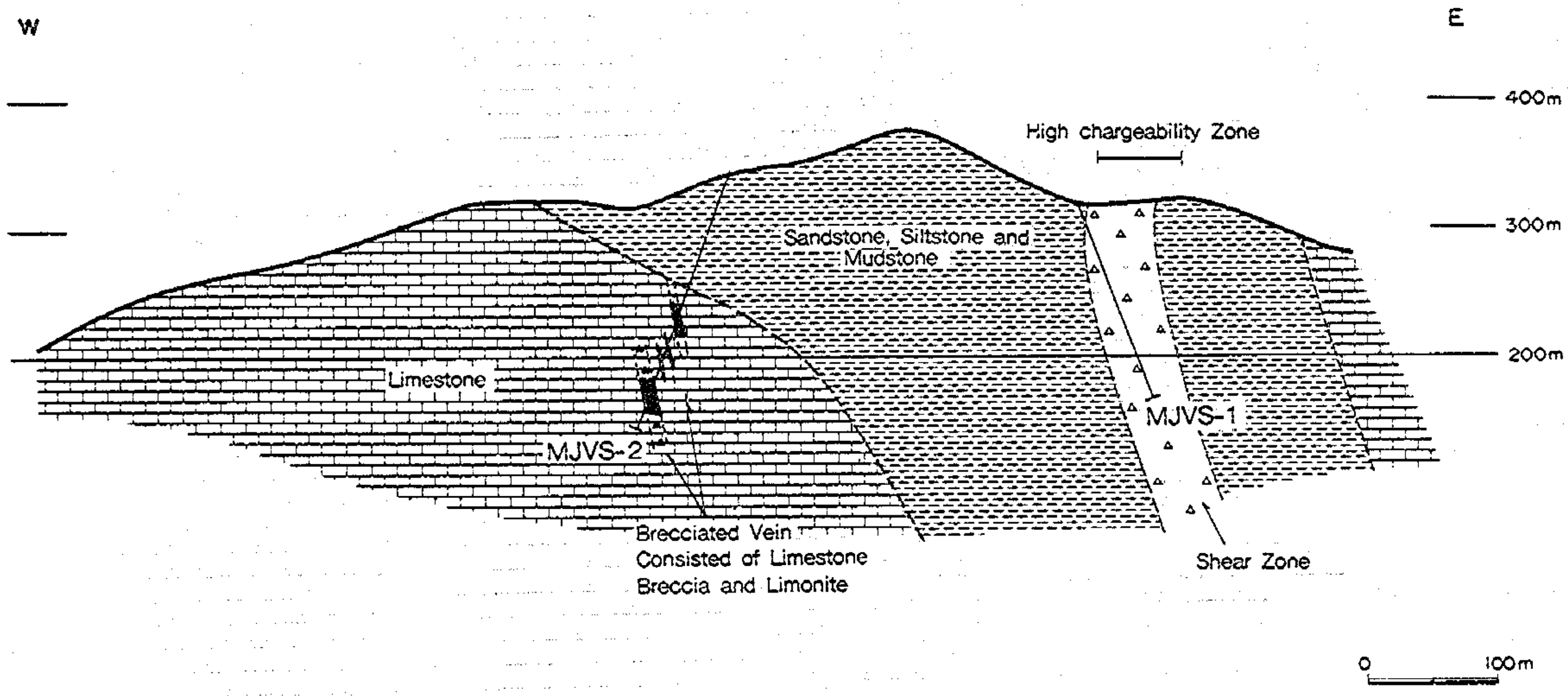

Fig. 2-12 Geologic Cross Sections of the Suoi Boc Zone (1)

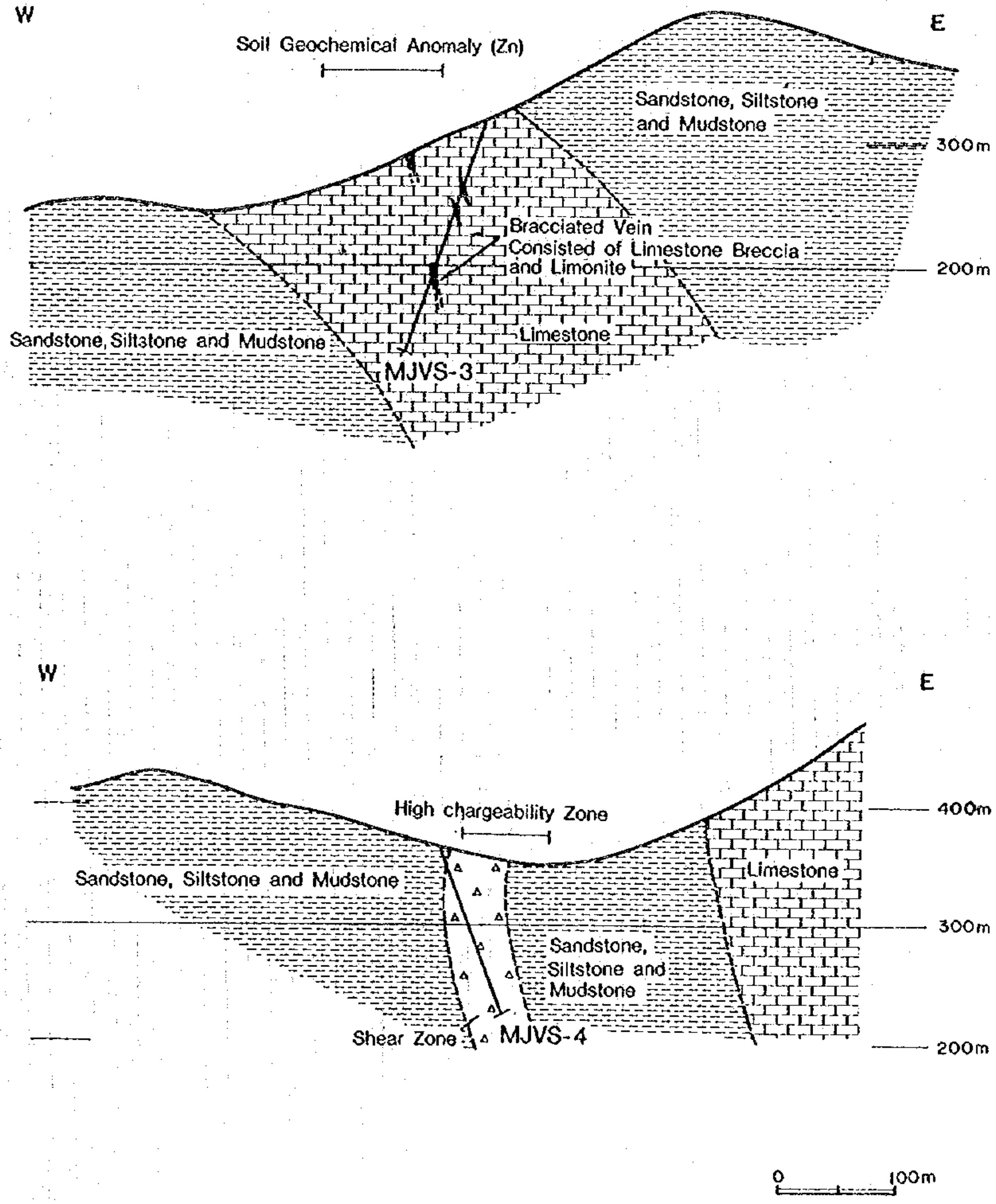

Fig. 2-12 Geologic Cross Sections of the Suoi Boc Zone (2)

The comparison between the geology of the drill holes and the surface geology reveals the followings.

The geology of the drilling survey area consists of limestone, sandstone and siltstone, and mudstone ascendingly. The geologic structure of this area is monoclinic with strikes of N-S to NNE-SSW and dips of 20° to 70° E.

(2) Mineralization

Ore minerals observed in drill cores are pyrite, chalcopyrite, hematite and goethite. Gangue minerals are carbonate and quartz.

The mineralization in the cores consists of brecciated vein, veinlets, network and dissemination.

The mineralization in clastic rocks is veinlets, network and dissemination. Limonite veinlets and network are intermittently found from the surface to 95.3 m in depth of MJVS-2. Pyrite dissemination is found in the clay of fracture zone, and in the fragments of black mudstone and fine-grained sandstone of MJVS-1 and MJVS-2. The disseminated sulfide includes chalcopyrite. A quartz-pyrite veinlet is found in the black mudstone of MJVS-4.

The mineralization of limestone is brecciated vein, veinlets and network. The number of brecciated veins is four in MJVS-2 (drilled length is from 1.7 m to 17.0 m), and six in MJVS-3 (drilled length is 0.4 to 6.3 m). All of brecciated veins contain a lot of fragments of limestone and limonite or limonite bearing clay fills fragments. Veinlets and network are 1 to 2 mm wide and are accompanied by some goethite.

2-6-3. Discussions on the Results of the Drilling Survey

Pb-Zn vein or skarn deposits have been expected to occur according to the results of the survey done until last year.

Geochemical anomalous zones and high chargeability zones targeted by drilling survey, are distributed in the western part and eastern part of the zone separately. Both anomalous zones are discussed below individually.

Drilling was done in the two geochemical anomalous zones. One is around the Suoi Boc

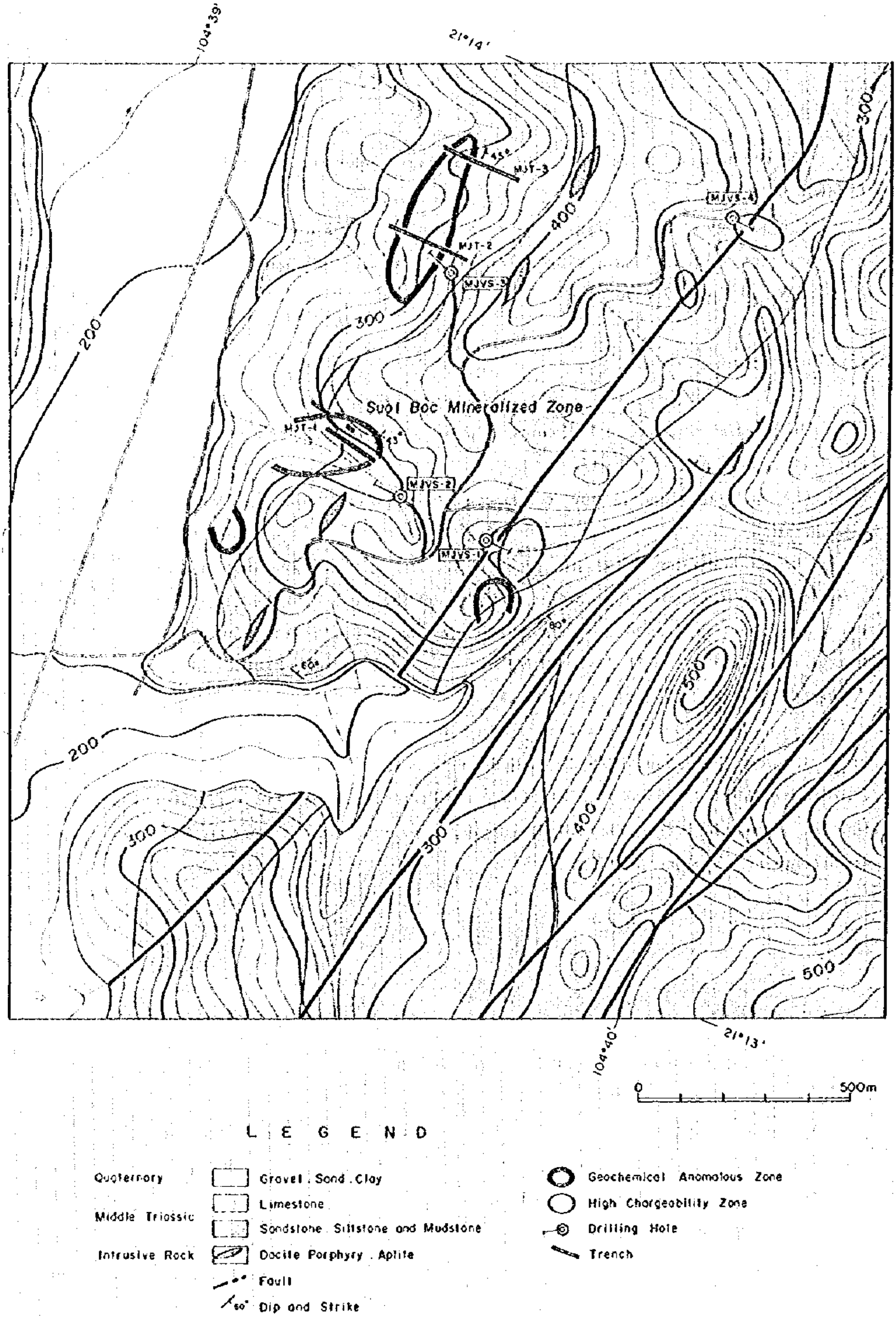

Fig. 2-13 Integrated Interpretation Map of the Suoi Boc Zone

mineralized zone. The other is the anomalous zone extended northerly from the north of the Suoi Boc mineralized zone. MJVS-2 and MJVS-3 have had a task to clarify the condition of mineralization below the geochemical anomalous zones. Concurrently the trench of MJT-1 was dug around MJVS-2 and that of MJT-2 was around MJVS-3.

The geology of MJVS-2 consists of clastic rocks and limestone. Limestone constitutes the cores of MJVS-3. These results reveal that sedimentary rocks have strikes of N-S to NNE-SSW and dips of almost 30°E to 100 m in depth.

The mineralization observed in MJVS-2 and MJVS-3 is brecciated vein, network and veinlets. No skarn minerals are found in limestone and clastic rocks. Weak silicification is hosted by clastic rocks of MJVS-2. Consequently no skarn ore deposits possibly occur in the zone.

Veins, network and veinlets are accompanied by oxidized iron minerals such as limonite. No Pb-Zn minerals are found in the drilling cores. The results of ore assay support this fact.

Clastic sedimentary rocks occur from the surface to about 100 m in depth in MJVS-2. Deep weathering is recognized in these clastic rocks. It is supposed that ground water has freely flowed down through limestone caves around MJVS-2 and MJVS-3. It is considered that no primary sulfides have been left to the depth surveyed by the drill holes because oxidation and dissolution of sulfides reached to deeper part of the zone.

The Suoi Boc mineralized zone has galena, sphalerite etc. The reason that sulfide minerals remain in this mineralized zone, is interpreted that the weathering to this zone was obstructed due to the permeability lowered by strong silicification.

No big Pb-Zn ore deposits at the shallow part below the geochemical anomalous zone are accordingly expected to occur.

The results of drilling survey done at the high chargeability zones are discussed below.

Two high chargeability zones were assessed by two drill holes.

The geology of the holes consists of black mudstone and fracture zone in MJVS-1 and MJVS-4. The fracture zone is constituted with fragments of fine-grained sandstone, black mudstone, limestone and calcareous mudstone, and a matrix of pelitic materials.

Pyrite dissemination and veinlets of quartz-pyrite are found in the fragments of the fracture zones. Weak pyrite dissemination is recognized in part of pelitic materials.

The results of geophysical properties measurement show that a fragment of limestone with pyrite dissemination has extremely high chargeability. A fragment of fine-grained sandstone has high chargeability as the former pyrite-disseminated limestone. Fragments of fine-grained sandstone, calcareous mudstone and limestone without pyrite dissemination that have collected from MJVS-1 and MJVS-4, have higher chargeability than limestone from MJVS-2 and MJVS-3.

Polished section microscopy for clastic rocks of MJVS-1 and MJVS-4 shows that all of the polished sections contain of graphite. Graphite generally has strong IP effect (high chargeability).

It is consequently proved that high chargeability anomalies detected by IP survey last year were caused by graphite and don't indicate the existence of sulfide minerals.

One high chargeability zone other than above two zones was detected. These three high chargeability zones were aligned on NNE-SSW direction. The clastic sedimentary rocks of this zone strike N-S to NNE-SSW. The three high chargeability zones are distributed on the fracture zone encountered by MJVS-1 and MJVS-4. It is accordingly supposed that high chargeability was caused by partial distribution of rocks rich in graphite

One geochemical anomalous zone neighbors on the high chargeability zone around MJVS-1. It is supposed that geochemical anomaly is caused by a small-scaled Pb-Zn mineralization, as the geophysical anomalies have been caused by graphite.

One geochemical anomaly is extracted other than above three geochemical anomalous zones. The former is constituted with one anomalous point. No big Pb-Zn ore deposits are expected to occur around this anomaly because the extent of this anomaly is small comparing with the anomalous zones around the Suoi Boc mineralized zone and the north of the Suoi Boc mineralized zone.

Dacite porphyry and aplite dike are found in the Suoi Boc zone. The age of intrusion is supposed Cretaceous. Vein deposit to be expected to occur in the zone is possibly considered to have been formed with these acidic intrusions.

CHAPTER 3. COMPREHENSIVE DISCUSSIONS

3-1. Relationship between Geology, Geologic Structure and Mineralization

3-1-1. Regional survey area

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

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. 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.

Copper mineralization is found in quartz veins with a small amount of copper minerals. These veins are mainly situated in the Lower Triassic area. Quartz veins cut the schistosity of host rocks and are not metamorphosed. The forming of these veins is supposed to be related with the Cretaceous felsic volcanism.

The mineral showings of lead and zinc are concentrated in the areas of the Middle Devonian, Carboniferous to Permian and Middle Triassic carbonate rocks.

The proximity of lead and zinc mineralization zones and felsic bodies could not be ascertained except the Suoi Boc mineralized zone. The relation between structural control and mineralization is not clear.

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

3-1-2. The Suoi Boc Zone

The geology of the Suoi Boc zone consists of Middle Triassic sedimentary rocks, Cretaceous dacite porphyry and aplite, and Quaternary sediments. The Middle Triassic occurs in the main part of the zone and is divided into two rock facies. One is the clastic sedimentary rocks composed chiefly of black mudstone with siltstone and sandstone subordinately. Siltstone and sandstone predominate in the western part of the zone, whereas mudstone replaces the former in the eastern part. The other is pale gray to black colored limestone.

The beddings are partly developed in mudstone, siltstone and sandstone in the zone. The beds have generally N-S to NNE-SSW strikes and dips from 20° to 70°E.

The Quaternary occurs as a belt in the western lowland extending in the N-S direction.

Dacite porphyry and aplite are intruded into clastic sedimentary rocks near the boundary between the clastic rocks and limestone, and are aligned in NNE-SSW direction.

Main fault system in the zone has NNE-SSW direction.

From the above facts it is concluded that the geologic structure of the zone is characterized by N-S to NNE-SSW system.

Quartz vein and silicified zone revealed in clastic sedimentary rocks by trench survey have strikes of N-S direction. Also brecciated veins in limestone are oriented from NNW-SSE, N-S to NNE-SSW direction.

The mineralization confirmed in this zone is some lumps of Pb-Zn ore dug out from a pit prepared by GSV. This lumps of ore consist mainly of cerussite and sphalerite with a small amount of pyrite, galena, and anglesite. According to GSV, mineralized zone in the pit has 0.1 to 1.0 m in width. It is presumed that this mineralized zone is hosted by clastic sedimentary rocks, as there is an extremely large amount of clastic rocks in the waste dump of the pit.

The extent of quartz bearing silicified zone leads to the above mentioned pit in a distance of about 15 m. The width of this silicified zone is nearly equal to that of the mineralized zone. Also this mineralized zone is hosted by clastic rocks. Consequently it is supposed that the silicified zone is continuous to the mineralized zone and this Pb-Zn mineralization is vein-type one hosted by clastic rocks.

3-2. Geochemical Anomalies and Mineralization

3-2-1. Regional Survey Area

Of the stream sediment geochemical anomalies detected in the survey area, the following relation with mineralization was confirmed by the present survey.

Geochemical Au-Cu anomalies were obtained around the Suoi Tiat Mine. The Suoi Tiat deposit is bedded cupriferous pyrite deposit containing gold and chalcopyrite. The type of mineralization is in harmony with the geochemical anomaly.

The Pb-Zn geochemical anomalies are distributed in the area of 10 by 4 km revolving the 4 km northwest of Phu Yen located in the northwest of the area. This area overlies widely the Cretaceous rocks and accompanies with syenite intrusive rocks. In this area Ban Cho Mineral showing (floats of Galena, sphalerite and quartz) is found.

The Ni-Cr geochemical anomalies occur around the 6 km southwest of Lang Phat and around the 5 km south of Ban Suoi Hang. These areas are intruded by numerous ultramafic bodies.

In addition to above geochemical anomalies, Ag, Pb-Zn, As and Hg geochemical anomalies were obtained in the survey area, but the details of these anomalies are not clear.

3-2-2. The Suoi Boc Zone

As a result of the soil geochemical exploration in the Suoi Boc zone, four anomalous zones for Pb and Zn were detected. Three of those anomalies are aligned in a line nearly oriented to NNE-SSW direction. The Suoi Boc mineralized zone is located within the one anomalous zone of those three. The another one geochemical anomaly neighbors on a high chargeability anomaly obtained by geophysical survey.

There are two types of mineralization in the trenches dug on the geochemical anomalous zone around the Suoi Boc mineralized zone. One is limonite bearing silicified zones hosted by clastic sedimentary rocks. The another type is limonite network and veinlets hosted by limestone.

It is consequently considered that geochemical anomaly around the Suoi Boc mineralized zone has detected vein-type mineralization in clastic rocks and limestone.

Soil samples in the geochemical anomalous zone have from 0.12 to 0.20% Zn,which is detected in the north of the Suoi Boc mineralized zone. Two trenches, namely MJT-2 and MJT-3, were prepared in this anomalous zone. The geology of these trenches consists of limestone. There are brecciated vein, network and veinlets, that contain limonite. The extent of dense distribution of brecciated vein, network and veinlets corresponds with that of geochemical anomalies.

It is concluded that the geochemical anomalies in the north of the Suoi Boc zone have detected a mineralized zone constituted by brecciated vein, network and veinlets in limestone.

3-3. Geophysical Anomalies and Mineralization

The strong IP anomalies were detected in two localities of the northeastern part and one locality of central part of the zone. These anomalies are aligned in NNE-SSW direction and lie in clastic rocks beside the boundary between clastic rocks and limestone.

Two anomalies were examined by drilling, namely MJVS-1 and MJVS-4.

The geology of drilling holes consists of black mudstone and shear zone. The shear zone is constituted by fragments of fine-grained sandstone, black mudstone, limestone and calcareous mudstone with a matrix of pelitic materials.

The results of geophysical properties measurements are follows.

Limestone breccia with pyrite dissemination has high chargeability. One fine-grained sandstone sample shows the same chargeability as the pyrite disseminated limestone breccia. Fragments without sulfide minerals such as fine-grained sandstone, calcareous mudstone and limestone collected from MJVS-1 and MJVS-4 have higher chargeability than limestone from MJVS-2 and MJVS-3.

Microscopical observations on polished sections of core samples revealed the existence of graphite. It is widely accepted that graphite causes strong IP anomaly.

From the above facts, it is concluded that high chargeability anomalies have been caused by graphite, and they don't show the occurrence of sulfide mineralization.

3-4. Potential of Resources
3-4-1. Regional Survey Area

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

(1) Gold deposits

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.

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 %. The grade improves neither vertically nor horizontally, and the vein-type mineralization is not considered to be promising in this area.

(3) Lead and zinc deposits

Some lead and zinc mineral showings were hosted by Middle Devonian, Carboniferous to Permian and Middle to Late Triassic limestone. The nature of these showings is not clear because detailed exploration has not been conducted. The size of mineralization is observed on the surface is small, and it is not expected that bigger ore deposits occur in the survey area.

(4) Platinum, copper and nickel deposits

The mineralization with platinum, copper and nickel is characterized by the dissemination of fine-grained sulfide minerals in the ultramafic bodies. The assay results for platinum are very low, and big ore deposit is not possibly expected to occur.

3-4-2. The Suoi Boc Zone

As a result of the second phase survey, it was concluded that geochemical anomalies and high chargeability anomalies in the Suoi Boc zone have been promising for Pb-Zn ore deposits.

Trench survey and drilling survey were conducted in two geochemical anomalies. The results of these works are follows.

Geochemical anomalies were caused by the existence of vein-type mineralization. Skarn ore deposits are not expected to occur in these anomalies, because no skarn minerals are found in clastic rocks and limestone below the surface.

Vein-type mineralization occurs mainly in limestone. There are limestone caves in the limestone formation of the Suoi Boc zone. Sulfide minerals were weathered to deeper part by free ground water through these caves. The weathering may reach to deeper than 200 m below the surface, but the limit of weathering to sulfide minerals is unknown. Pb-Zn content of veins in the shallow part of the zone will be low due to the weathering to the depth of 200 m below the surface.

The width of brecciated veins containing of limonite in the trenches is 0.2 m in maximum. The width of the similar veins in the drill holes reaches up to 1.5 m. No big Pb-Zn vein deposit is possibly expected to occur, because the width of vein in the deeper part than 200 m below the surface is not reasonable to become sharply thicker.

Shear zones composed of limonite and clay, are found in trenches and drill holes. The width of these zones is 7.5 m in the trench. Many shear zones are found in the drilling holes. The genesis of these shear zones is interpreted in two ways. One is the weathered products of sulfide bearing brecciated veins. The alternative is that shear zone is composed of limestone fragments and surface soil collapsed into ancient dolines. High content of Pb-Zn is rare in the deeper part of the veins, as the limestone fragments occupy the main part of the veins even though the genesis is the former one.

Two high chargeability zones of three ones detected by previous geophysical work were examined by two drill holes. It became clear that high chargeability anomalies were caused by the existence of graphite in the clastic sedimentary rocks. No lead and zinc ore deposit is expected to occur in the high chargeability zones.

PART 3. WESTERN THANH HOA AREA

PART 3. WESTERN THANH HOA AREA

CHAPTER 1. REGIONAL GEOLOGICAL SURVEY

1-1. Introduction

The survey area is located at 150 km southwest from the Van Yen areas and 150 km southwest from Hanoi. It covers 1,300 km^2 in area. Regional geological and geochemical survey was conducted from first to second phase.

1-2. Geological Survey

1-2-1. Survey Method

Conventional field methods were used for geological survey. Topographic maps at a scale of 1:10,000 enlarged from the 1:50,000 published maps were used in the field and route mapping was carried out at this scale. Photogeological interpretation using aerial photographs was conducted for mapping in some areas without field reconnaissance as a supplement. Localities in the field were sometimes confirmed by means of GPS (global positioning system). Results of the geological survey were compiled on geological map at a scale of 1:50,000.

Schematic columnar section and geologic map are shown in Fig. 2-1 and 2-2, respectively.

1-2-2. Stratigraphy

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

The geologic units of the survey area comprise the Cambrian metamorphic basement, the unconformably overlying Ordovician to Triassic metamorphic rocks and marine and continental sedimentary rocks, a large amount of Jurassic pyroclastic rocks (partly interbedded with sedimentary rocks), and unconsolidated Quaternary sediments in ascending order.

Since the objective of the field work 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

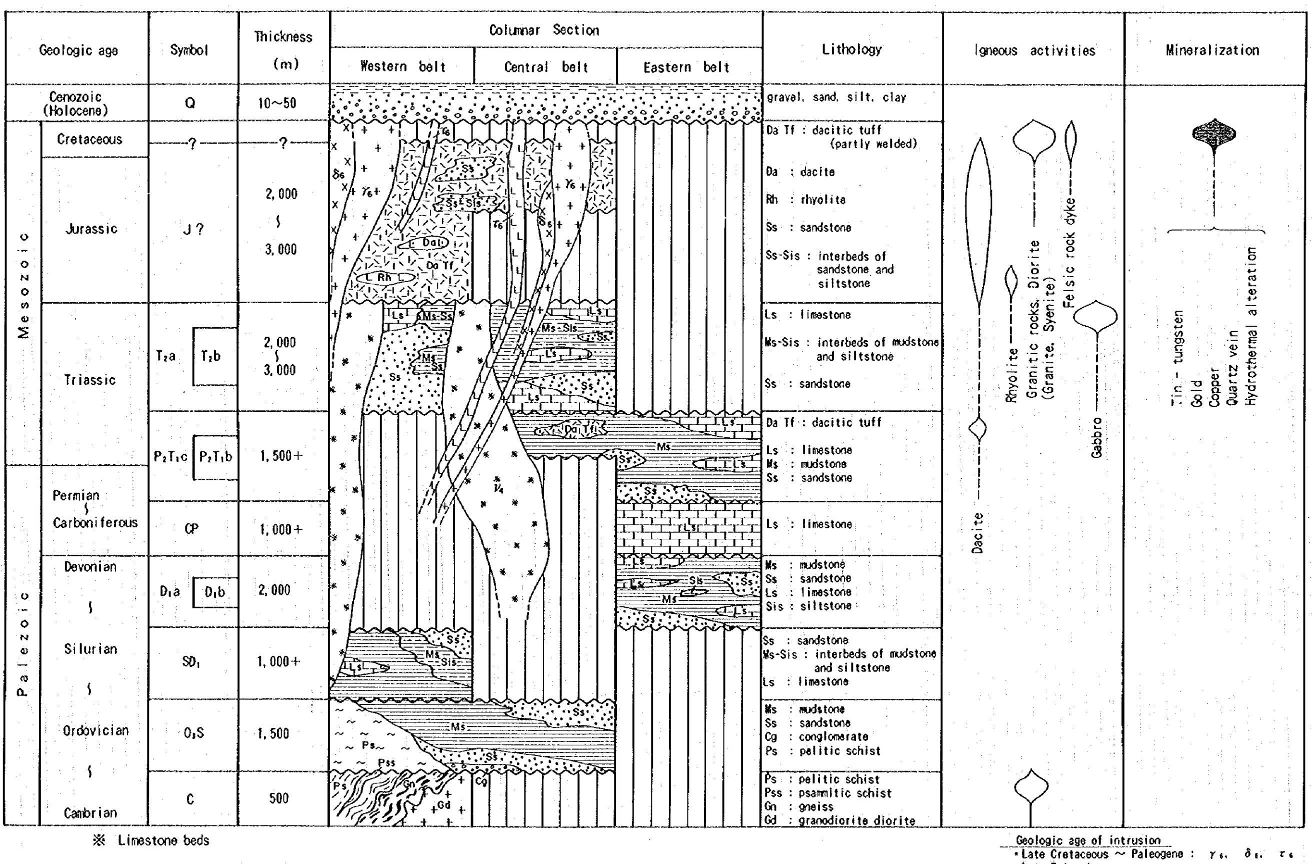

Fig. 3-1 Schematic Columnar Sections of the Western Thanh Hoa Area

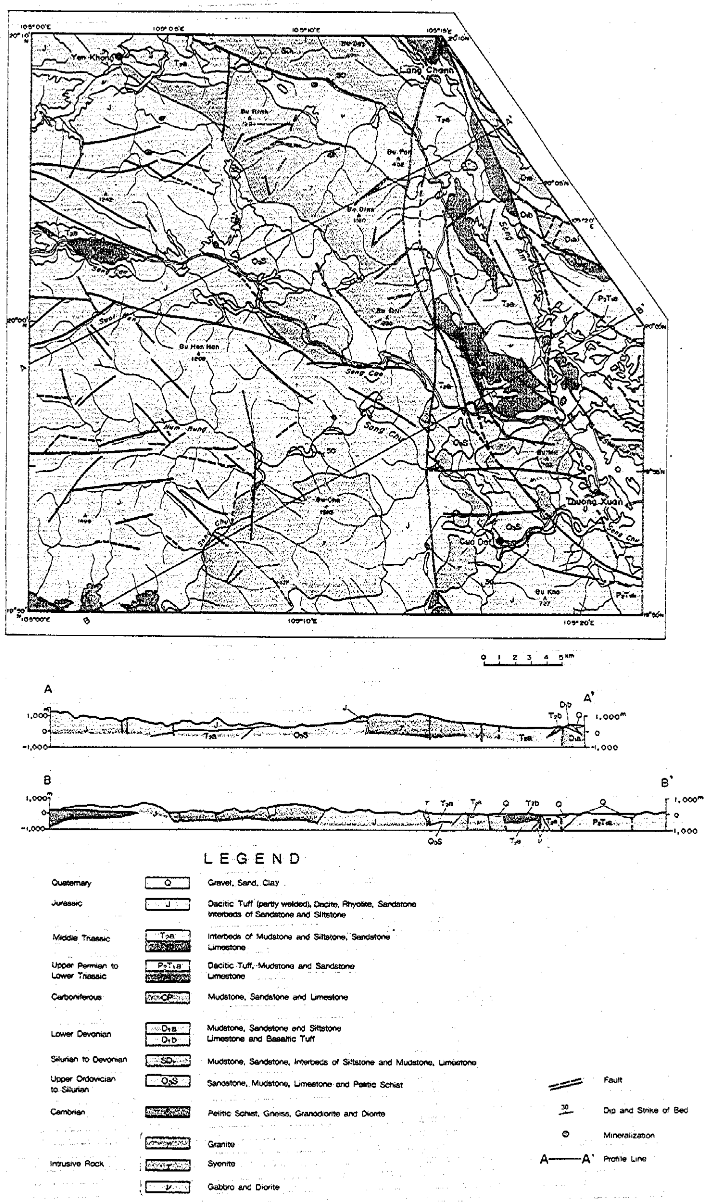

Fig. 3-2 Geologic Map and Cross Sections in the Western Thanh Hoa Area

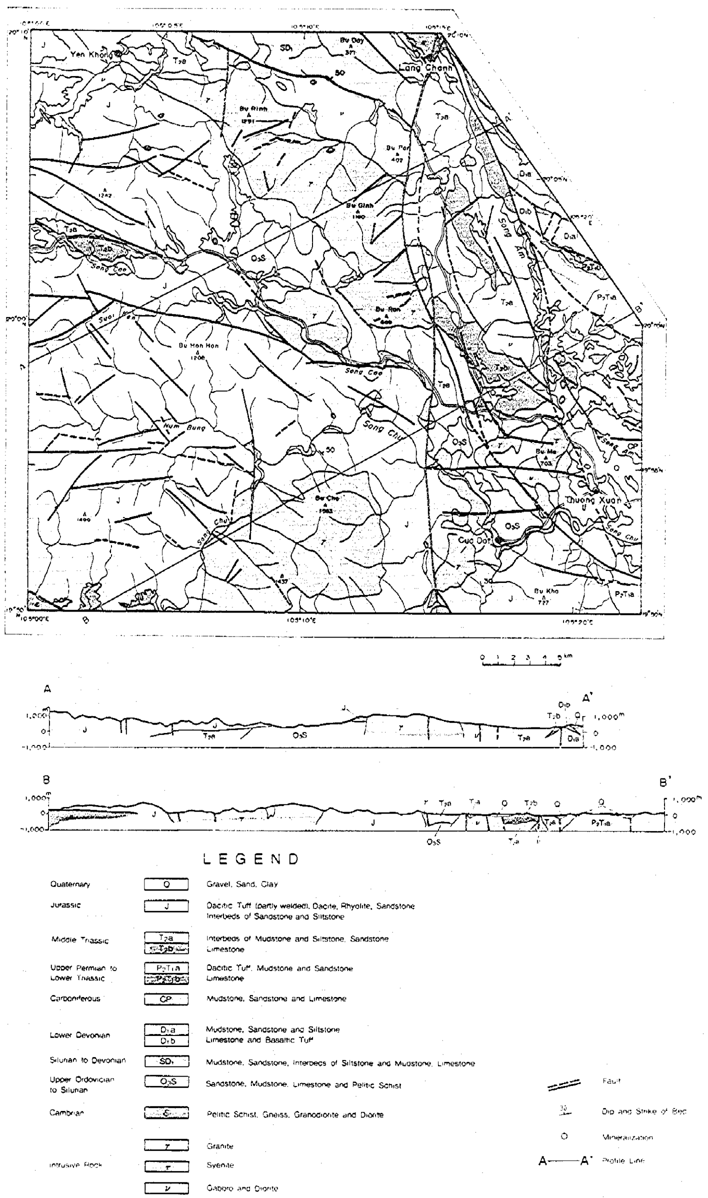

Fig. 3-2 Geologic Map and Cross Sections in the Western Thanh Hoa Area

thick limestone beds contained in the Middle Triassic Series are delineated in the geologic map as independent lithofacies units, because those beds are effective for interpretation of regional geologic structure.

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.

(1) Cambrian System

This System lies in the northeastern edge and southwestern edge of the area. The extent of distribution is very restricted. The System extends in the NW-SE direction with 1.5 to 2 km width.

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

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

The System in the northeastern edge is in fault with the Middle Triassic, and in the southwestern edge is in fault or unconformable contact with the overlying Undiscriminated Jurassic.

(2) Upper Ordovician Series to Silurian System

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 or Undiscriminated Jurassic. Intrusive rocks such as granite have intruded into some places.

The major part of this system in the southeastern part 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.

The major part of this unit in the central part consists of dark gray banded pelitic schist and most of the rocks change to medium-grained hornfels which contains biotite and hornblende.

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

(3) Silurian System to Lower Devonian Series

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

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

The apparent thickness area is estimated to be 1,000 m.

(4) Upper Devonian Series

This Series occurs 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. With the Upper Permian to Lower Triassic Series on the south, it also lies in fault contact.

This Series is divided into two subunits: the clastic sedimentary rocks consisting of the major part of the unit and limestones interbedded separately in the lower to upper part of the unit. Dark gray to green mudstone and fine-grained sandstone are predominant in the clastic rocks with subordinate amounts of intercalated dark grey siltstone. Limestone 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

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 Upper Permian to Lower Triassic on the north. The whole of this System consists of dark gray somewhat massive limestone. The thickness of this System is estimated to be more than 1,000 m.

(6) Upper Permian to Lower Triassic Series

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. 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.

This Series also is divided into two subunits in the same way as the Upper Devonian Series mentioned above; namely, the clastic sedimentary rocks constituting of the major part of the Series and limestones interbedded in the middle to upper part of the Series. The clastic rocks occur widely, but the distribution of the limestone is extremely restricted.

The clastic rocks consist mostly of gray to dark gray mudstone. Many outcrops are weathered, where the rocks are light brown to light yellow. The clastic rocks contain gray 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 limestone subunit is composed chiefly of gray limestone with poor stratification.

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

(7) Middle Triassic Series

This Series occurs continuously as a belt in the northern and west-central parts of the area. Topography of this area consists of hilly terrain with low relief energy.

This Series is bounded by two major faults, N-S and NNW-SSE system in the eastern part. The Series generally extends in the NNW-SSE direction with 4 to 7 km width.

The Series in the northwestern edge has a granitic intrusion and is partly overlain by the

Undiscriminated Jurassic (J?). In the western edge, a part of this Series is in fault contact with the Jurassic, but most of the unit is overlain by the Jurassic. The Series in the western edge and northwestern edge generally extends in the WNW-ESE direction with 2 to 3 km width.

This Series is divided into two subunits, namely, the clastic sedimentary rocks constituting of the major part of the unit and limestones interbedded separately in the lower and upper parts of this Series.

The clastic rocks in the eastern part are composed mainly of alternating beds of gray or black mudstone and gray siltstone, and are interbedded with gray to light gray, massive fine to medium-grained sandstone in the lower and upper parts of the unit. Sandstone of the lower part is especially prevalent in the southern edge of this part.

The clastic rocks in the northwestern and western edge are composed mainly of gray to light gray fine-grained sandstone, and are interbedded with black hard mudstone in the middle to upper part of the unit. Light gray siltstone is intercalated in the upper part of the west-central block. Sandstone located near granitic bodies changes to hornfels.

The limestone consists of dark gray massive limestone and is classified into three members that are situated in the lower, middle, and upper parts of the whole unit. The thickness of each member is, from the base upward, 500 m, 200 to 500 m, and 300 m.

The limestone subunit consists of dark gray massive limestone and widely occurs in the western part of the area.

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

(8) Undiscriminated Jurassic System

This System occurs widely in the southwestern side of the area.

The System is characterized by the prevalence of very intense felsic volcanic activity and exhibits roughly homogeneous lithofacies covering a wide area. Generally it is made up mainly of light gray to dark gray or light green to dark green, hard compact dacitic crystal tuff, and is accompanied by subordinate dacite and rhyolite lavas with clear flow structure in the lower part, and a small amount of light gray to white conglomerate in the basal part. Besides, conglomerate and fine-grained sandstone are partly interbedded in the upper part of the System.

The matrix of the tuff consists of dark grey glass with a large amount of crystal fragments of quartz and plagioclase. Quartz fragments largely vary in size from 1 to 8 mm and plagioclase from 1 to 5 mm. Two to 5 mm rock fragments are found occasionally. They consist mainly of light greenish grey tuff and black mudstone. Typical welded structure is often observed in the southern half of the survey area.

Besides, conglomerate and fine-grained sandstone are partly interbedded in the upper part of the System.

Sandstone in general is light gray to white, medium to coarse-grained, and shows massive, hard and compact characteristics. The sandstone of the central 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 gray 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.

1-2-3. Intrusive Rocks

Mafic and felsic plutonic rocks and a felsic dike occur in this area. The geologic ages of these intrusions have been clarified by the Geological Survey of Vietnam (GSV,1991). The lithology of the plutonic rocks is classified by chemical composition into gabbroic rocks, dioritic rocks and granitic rocks. Although the felsic dikes are 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.

(1) Late Triassic gabbroic rocks

The gabbroic rocks intruded mainly into the Middle Triassic Series. They generally extend in the WNW-ESE direction. The dimensions of each body vary considerably, ranging from 2 km by 1 km to 10 km by 5 km.

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

(2) Late Cretaceous to Paleogene granitic rocks

The granitic rocks intruded into the Lower Paleozoic rocks, the Middle Triassic Series, the Undiscriminated Jurassic System, and gabbroic rocks. Sixteen bodies of various dimensions are found in this survey area. Three bodies in the central-north to central-south part 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 eastern part.

Lithofacies of the rocks is generally white to light pink, medium to coarse-grained holocrystalline, and biotite and muscovite are observable. Some part of the large body 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 south is probably porphyritic syenite.

(3) Late Cretaceous to Paleogene dioritic rocks

The dioritic rocks intruded into the same geologic units as the granitic rocks, and three small bodies are found in the central to southeastern 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.

(4) Late Cretaceous to Paleogene felsic dike

Three 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.

1-2-4. Geologic Structure

(1) Folds

There is a large difference in occurrence of geologic units and intrusive rocks among the "Western belt", "Central belt", and "Eastern belt". Schistosity and stratification is highly developed in the Paleozoic sedimentary rocks. However, rocks of the Upper Permian to Middle Triassic and Jurassic 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. Therefore, it appears that a series of folds with the same trend of axes occurs 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 Cambrian are not very clear because they are confined to small areas. The structure of the Upper Ordovician to Silurian consists of a series of NW-SE trending folds with about 1 km wavelength, and those folds as a whole are inferred to form a large anticlinorium within this unit. The strata of the Silurian to Lower Devonian strike WNW-ESE and very steeply dip NNE or SSW (nearly vertical). This unit is considered to be made up of a series of WNW-ESE trending folds with about 1 to 3 km wavelength.

The strata of the Middle Triassic Series steeply dip NNE or SSW exceeding 60°. This Series is believed to consist of a series of WNW-ESE trending anticline and syncline with about 1 km wavelength.

Based on the distribution pattern of the Jurassic System, it seems that dips of the strata are gentle and any conspicuous folds are not formed within the System.

Eastern belt

The structure of Upper Ordovician to Silurian 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 Upper Permian to Lower Triassic strike NNW-SSE and dip 40 to 50° ENE.

The Middle Triassic rocks 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 tends to appear in ascending order toward the northeast.

The Jurassic System surrounds the basement rocks and it is inferred to form a domical folding.

Eastern edge

The Upper Devonian has 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 Carboniferous to Permian strike E-W and dip 40 to 50° N. No fold is recognized within the geologic units, Upper Devonian and Carboniferous to Permian.

The major part of the Upper Permian to Lower Triassic 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 of Silurian to Lower Devonian is restricted by one WNW-ESE fault. This fault has long extension northwestward outside the area. The vertical displacement along this fault is considered to attain several kilometers.

Eight faults parallel to the above fault were found in the northern half of the survey area.

General trend of intrusion of granitic body is also WNW-ESE in the north. Thus the faults of this trend are thought to contribute a significant control to the macroscopic structure of the northern half of the area.

In the southern half of the area, on the other hand, there are four systems of faults. They are E-W, NW-SE, NE-SW, and N-S systems. These faults occur in a complex pattern and most of them are present within the Jurassic area. Therefore the order of formation on those fault systems is not clear in the southern half of the area.

Eastern 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 displacement by those faults is believed to be roughly 200 to 300 m in view of the distribution patterns of the rocks concerned.

Eastern edge

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.

1-2-5. Mineralization

Gold, copper, tin, tungsten and other deposits and mineral showings have been found in this area. They are Luong Son mineralized zone (Au), Hon Mo mineralized zone (Cu), Northern Hon Mo mineral showing (Cu), and Bu Me mineralized zone (Sn and W). The locations of these mineralized zones are shown in Figure 3-3.
Quartz veins and pyrite disseminated zones occur in the area, but no remarkable mineralization was found.

(1) Luong Son mineralization zone

This mineralization zone is located in the Luong Son district in the central part of the area and

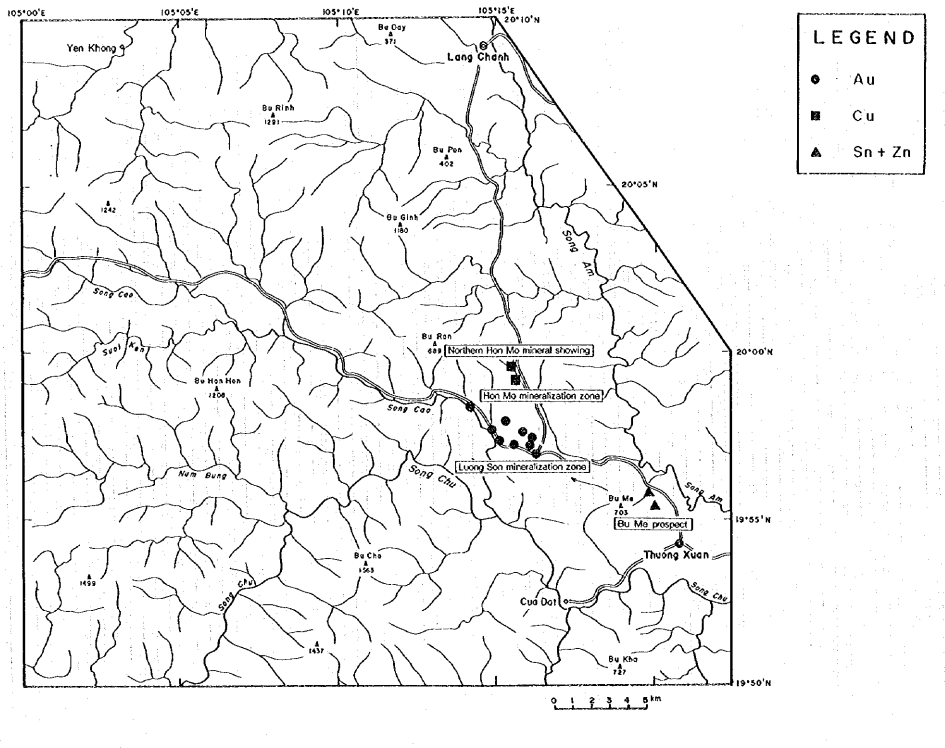

Fig. 3-3 Distribution Map of the Mineralized Zones in the Western Thanh Hoa Area

consists of ten and more quartz veins within an area of 2 km width. 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. Most 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. Veinlets and stockwork of quartz and limonite are occasionally found on both hanging and foot wall sides of the quartz veins for 1 m. All vein quartz is translucent to colorless and massive. Some veins occur along shear zones.

The hydrothermal alteration occurs 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 survey are less than 0.2 ppm Au.

(2) Hon Mo mineralized 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. Locality of the old stope is unknown at present, but a dump with a large amount of wastes has been left. 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.

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 dimension 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 is 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 a lot of fragments of vein quartz in the above dump, with minor amount of blocks containing malachite.

(3) 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.

(4) Bu Me mineralized zone

The details of this zone are described in Chapter 2.

1-3. Regional Geochemical Exploration

1-3-1. Stream Sediment Geochemical Exploration

(1) Objectives

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

(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 1,001 in total. Samples were analyzed for eleven elements of Au, Ag, Cu, Pb, Zn, Ni, Cr, As, Hg, Sn and W. Detection limits are shown below.

Elements	Au	Ag	Cu	Pb	Zn	Ni	Cr	As	Hg	Sn	W
Detection Limit	1 ppb	0.02ppm	0.2 ppm	0.5 ppm	1 ppm	1 ppm	1 ppm	0.2 ppm	10 ppb	2 ppm	2 ppm

Basic statistic parameters calculated with common logarithm for analytical values are shown in Table 2-1. On the occasion of values below the detection limit, one half of detection limit values were substituted. Correlation coefficients of elements are shown in Table 2-2.

Table 3-1 Basic Statistics of Analytical results of Stream Sediments in the Western Thanh Hoa Area

	Au	Ag	Cu	Pb	Zn	Ni	Cr	As	Hg	Sn	W
Max. Value	186	11.33	254	1,138	601	1,056	6,158	544.6	7755	643	1,643
Min. Value	<1	<0.02	<0.2	2.2	6	<1	1	<0.2	<10	<2	<2
Geometric Mean	<1	0.34	7.5	29.0	56	18	53	3.8	20	4	7
M+2xSD*1	2	3.2	76.5	91.9	180	166	785	82.7	288	27	73
PDL*2	91%	3%	3%	-	-	-	-	10%	26%	20%	13%

M+2xSD*1 : Added double standard deviations to geometric means

PDL*2 : Frequency of samples that have analytical values below detection limits

Table 3-2 Correlation Coefficients of Analytical Results of Stream Sediments in the Western Thanh Hoa Area

	Au	Ag	Cu	Pb	Zn	Ni	Cr	As	Hg	Sn	W
Au											
Ag	0.03										
Cu	0.16	0.00									
Pb	-0.01	0.15	0.14								
Zn	0.11	0.10	0.39	0.49							
Ni	0.09	-0.05	0.50	0.08	0.38						
Cr	0.06	-0.02	0.33	0.08	0.34	0.87					
As	0.08	-0.01	0.14	0.34	0.20	-0.24	-0.26				
Hg	0.09	0.05	0.11	0.11	0.12	0.00	0.02	0.13			
Sn	-0.00	0.14	-0.15	0.28	0.11	-0.14	-0.06	0.22	0.05		
W	0.02	0.16	-0.19	0.26	0.13	-0.03	0.16	0.20	0.10	0.53	

The highest correlative combination of elements is Ni-Cr. The combinations of Cu-Ni and Pb-Zn are relatively correlative.

2) Determination of threshold value

In order to determine threshold values, Lepelitier's method (1969) with cumulative frequency distribution diagrams drawn by logarithm of analytical values was adopted.

The threshold values for each element are follows.

Au: Cumulative frequency distribution diagram shows L-shaped pattern, and no turning point is in the higher range. The threshold value is decided at 10 ppb.

Ag: The distribution diagram is an S-shaped, and two turning point on the distribution diagram occur at 1 and 5 ppm. The threshold is set at 5 ppm.

Cu: Two turning points in the higher range of cumulative frequency distribution diagram are found. The threshold is higher turning point (70 ppm).

Pb: A turning point in the higher range of cumulative frequency distribution diagram is found. This value is threshold(100 ppm).

Zn: This distribution diagram is approximately straight line. The sum of geometric mean and double value of standard deviation is threshold(180 ppm).

Ni: This distribution diagram is an S-shaped. The whole population consists of two populations. The higher population has more than 100 ppm. The sum of geometric mean and standard deviation in the higher population is threshold(290 ppm).

Cr: This diagram is an S-type curve. It is consequently supposed that the distribution includes two populations. The population in the higher range has values over 400 ppm. The sum of geometric mean and standard deviation in the higher population is threshold(1,215 ppm).

As: A turning point on the distribution diagram is threshold(30 ppm).

Hg: This distribution diagram shows an S-shape. It is supposed that the distribution is composed of two populations. The population in the higher range has values over 600 ppb. The sum of geometric mean and standard deviation is threshold(2,750 ppb).

Sn: The distribution diagram has two turning points (10 and 50 ppm). The threshold is the higher turning point.

W: The diagram is an S-type curve, and has two turning points (40 and 400 ppm). Higher turning point is the threshold.

(3) Geochemical anomalous zones

Anomalous points of each element extracted on the basis of the above threshold values are plotted in Figure 3-4.

Areas with concentration of anomalous points are listed for each element below. In principle, concentration means cases with nearby (about 1 km) two points or with 3 or more points closely (3 to 4 km) distributed. Anomalous points for Ni-Cr are restricted to be anomalous in both elements, because the correlation of both elements is higher.

The geochemical anomalous zones are as follows.

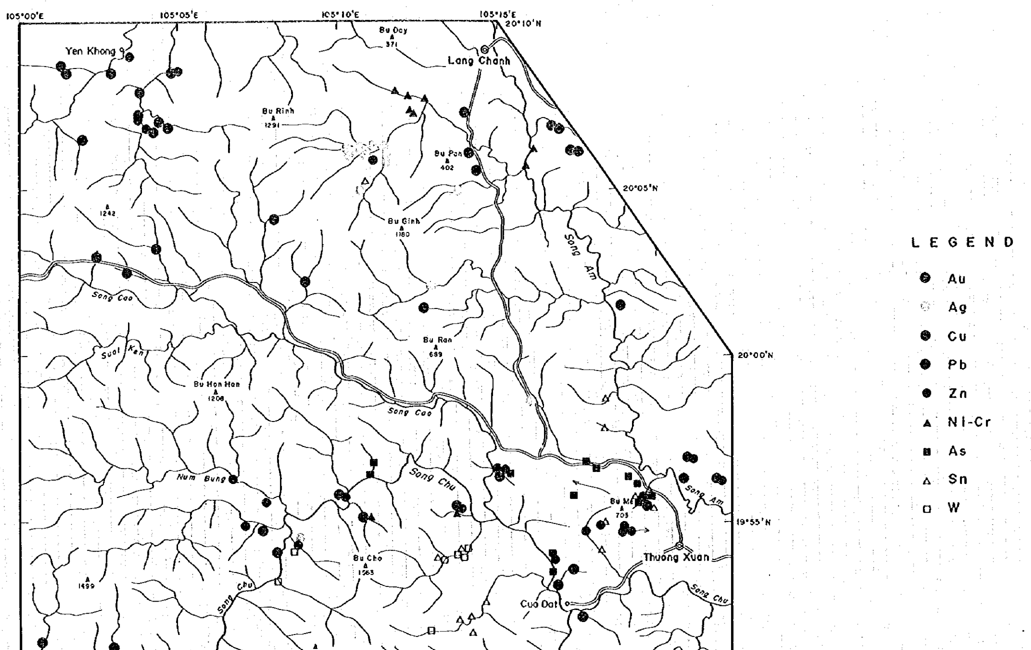

Fig. 3-4 Distribution Map of Geochemical Anomalies of Stream Sediment in the Western Thanh Hoa Area

a) Around the 1.5 km west of Ban Pang (Au)

b) Around the 8 km southwest of Lang Chanh (Ag)

c) Around the 9 km west-southwest of Lang Chanh (Ag)

d) Around the 10 km west-southwest of Lang Chanh (Ag)

e) Around the 11 km southwest of Lang Chanh (Ag)

f) Around the 4 km west of Yen Khong (Pb)

g) Around the 5 km south of Yen Khong (Pb)

h) Around the 18 km west-southwest of Thuong Xuan (As)

i) Around the 4 km north-northwest of Lang Duc (Hg)

j) Around the 4 km north-northeast of Lang Duc (Hg)

k) Around the 12 km west-southwest of Thuong Xuan (Sn)

l) Around the Bu Me mineralized zone (W(-Sn))

m) Around the 12 km west of Thuong Xuan (W)

n) The area centering Mt. Te Leo at the 17 km west-southwest of Thuong Xuan (W)

(5) Relationship between geochemical anomalous zones and geology - geologic structure

a) Around the 1.5 km west of Ban Pang (Au)

Geochemical anomalies are situated near the boundary between the Jurassic rocks and granitic rocks, but no mineralization is found. Au value of this area (0.03 to 0.09 ppm) is low compared with those obtained around the Suoi Tiat Mine (0.8 to 2.5 ppm).

b - e) Southwest to west-southwest of Lang Chanh (Ag)

Four anomalous zones are aligned in the NW-SE direction near the northeastern edge of the granitic rock that extends in the same direction. In the nearby granitic rock, small-scaled pyrite dissemination is found, but the origin of geochemical anomaly is indistinct.

f) Around the 4 km west of Yen Khong (Pb)

These anomalies are obtained in the area of gabbroic rocks, where no mineralization occurs. The origin of these Pb anomalies is not clear.

g) Around the 5 km south of Yen Khong (Pb)

The geochemical anomalies are situated in the Jurassic Series. Pyrite dissemination is observed at about 1 km east of these anomalies, but any phenomena are not found to explain the anomalies.

h) Around the 18 km west-southwest of Thuong Xuan (As)

The As anomalies occur in the Jurassic rocks. Pyrite dissemination is known at the upper reaches of the geochemical anomalous points. It is considered that such a dissemination of sulfide is probably the origin of the anomalies.

i - j) Around the 4 km north-northwest and north-northeast of Lang Due (Hg)

The anomalies are distributed on the Upper Ordovician to Silurian and Jurassic. Any clue to elucidate these anomalies has not been obtained through regional geological survey.

k) Around the 12 km west-southwest of Thuong Xuan (Sn)

The geochemical anomalies are located in the Jurassic rocks. Quartz vein and geochemical anomalies of W occur at the upper side of this stream. Granitic rock is found at the west and east of the anomalies. Analytical values of W in this anomalies are similar to those in the anomalies around the Bu Me mineralized zone

l) Around the Bu Me mineralized zone (W(-Sn))

The geochemical anomalies concentrate in the area of 1.5 km by 2.5 km revolving the Bu Me mineralized zone. As anomalous values at the northwestern flank of the Bu Me and Zn anomalous values at the southwestern flank are detected. Bu Me ore deposit consists of quartz-cassiterite-wolframite vein and network, and cassiterite dissemination that are hosted by porphyritic granite and hornfels. This deposit accompanies with arsenopyrite. The combination of minerals is in harmony with the elements of geochemical anomaly.

Zn anomalies in the southwestern flank of Bu Me is situated in rhyolitic rocks and gabbro. The origin of these anomalies is indistinct.

m) Around the 12 km west of Thuong Xuan (W)

The anomalies are located in the Jurassic area. Analytical values of these anomalies are higher than those of Bu Me mineralized zone. One Sn anomaly occurs in this W anomalous zone.

n) The area centering Mt. Te Leo at the 17 km west-southwest of Thuong Xuan (W)

This area is located within the granitic rocks. The area is constituted by three anomalous points. One point of three has higher W value than the values obtained around the Bu Me mineralized zone. The large area around Mt. Te Leo is not surveyed yet.

1-3-2. Panned Concentrate Geochemical Exploration

(1) Objectives

The gold, copper and tin-tungsten-molibdenum mineralization confirmed by the previous geologic and metallogenic data in this regional survey area. This exploration was carried out in the survey area in order to evaluate the characteristics of heavy minerals in the mineralized 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 regional geological survey. The total number of panned concentrates is 433 samples in this area. Each sample was collected by five-times panning (approximately 25 liters). The samples were dried up and weighed.

(3) Results of the mineral identification

The identified minerals are magnetite, ilmenite, limonite, hematite, galena, staurolite, epidote, siderite, tourmaline, chromite, pyroxene, serpentine, wolframite, cassiterite, malachite, zircon, rutile, cinnabar, pyrite, native gold, and arsenopyrite.

(4) Distribution of heavy minerals

The heavy minerals related to mineralization in this area are considered to be native gold, cassiterite and wolframite. The location detected three heavy minerals is shown in Figure 3-5.

Areas with concentration of heavy minerals are listed for each element below. In principle, concentration means cases with nearby (about 1 km) two points or with 3 or more points closely (3 to 4 km) distributed. In the case of cassiterite, detection means samples contained weighable amounts of copper minerals.

The geochemical anomalous zones are as follows.

a) Native gold

a-1) Around the 6 km southeast of Lang Chanh

a-2) Around the 10 km west-southwest of Thuong Xuan

b) Cassiterite

b-1) The southeastern area of Bu Me

b-2) The area revolving Mt. Te Leo

c) Wolframite

c-1) The southeastern area of Bu Me

c-2) The eastern flank of Mt. Te Leo

(5) Geology and heavy minerals

The relation between the distribution of heavy minerals and geology is summarized as follows.

a) Native gold

a-1) Around the 6 km southeast of Lang Chanh

Native gold was obtained in the area of the Lower Devonian and Middle Triassic. Granitic rocks are distributed

a-2) Around the 10 km west-southwest of Thuong Xuan

Native gold was found in the undiscriminated Jurassic formation. Cassiterite also occurs in

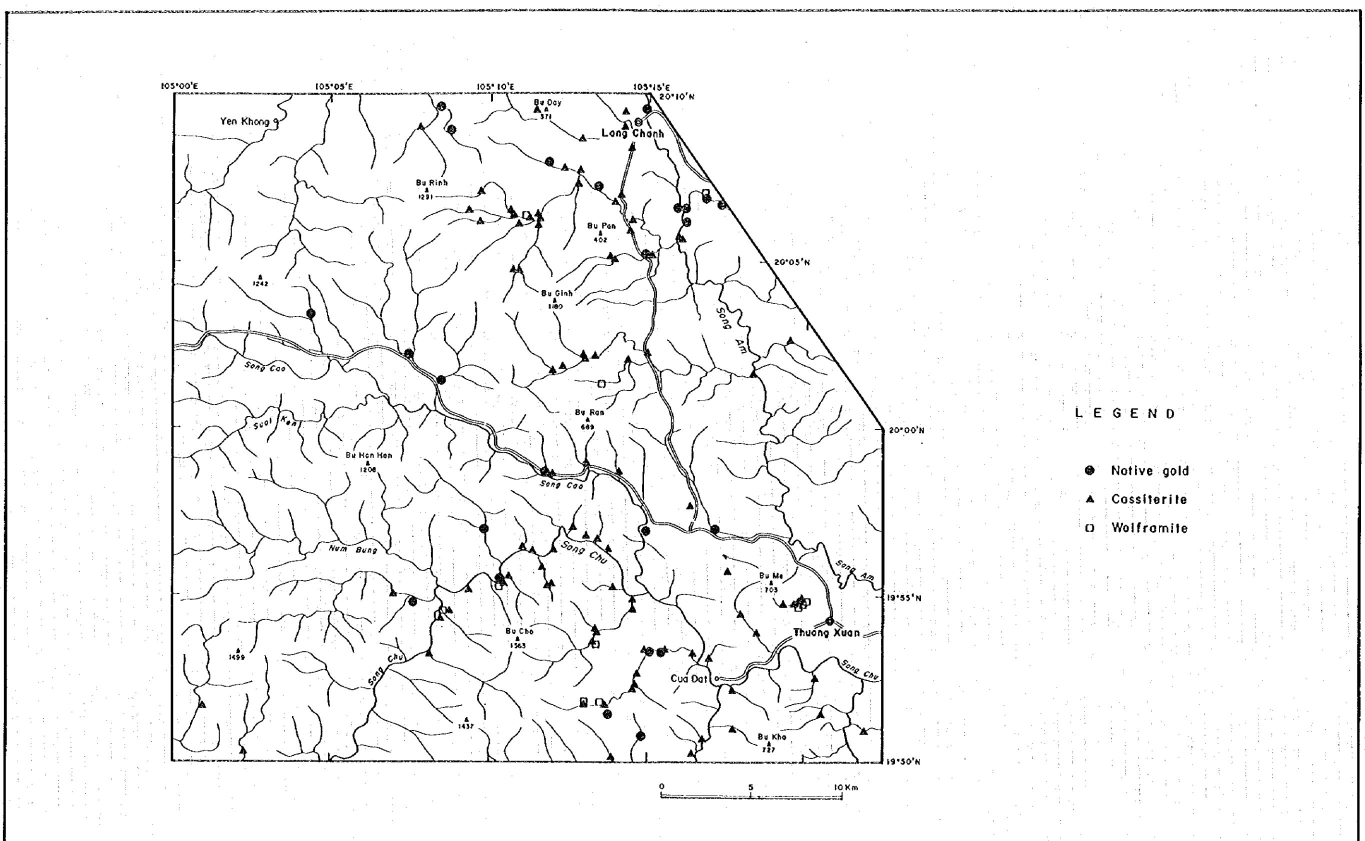

Fig. 3-5 Distribution Map of Heavy Mineral in the Western Thanh Hoa Area

the same area. The origin of gold grains is not clear for lack of gold mineralization around the area.

b) Cassiterite

b-1) The southeastern area of Bu Me

This corresponds to the area from Bu Me mineralized zone to the south of the zone. Geology of this area consists of rhyolitic rock, granitic rock and Middle Triassic.

b-2) The area revolving Mt. Te Leo

Geology of this area is composed of undiscriminated Jurassic and intrusive granitic rock. No mineral showing is found in this area.

c) Wolframite

c-1) The southeastern area of Bu Me

This area is the same as of cassiterite described above.

c-2) The eastern flank of Mt. Te Leo

This area is on the upper reaches at the eastern flank of Mt. Te Leo. Cassiterite and wolframite coexist in the area of granitic rocks.

CHAPTER 2. BU ME ZONE

2-1. Outline of the zone

This zone 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 were carried out in this prospect such as geological survey, geochemical exploration, geophysical prospecting (electric and magnetic surveys), trenching, and shallow pit survey. 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 20,000,000 t (Sn+W: 0.18 %). 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).

2-2. Geology

Two large and a small intrusive bodies occur in the Bu Me Prospect aligned in the N-S direction (Figure 3-6).

The small body is situated in the northern part with occurrence of elliptical shape and areal extent of 600 m by 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 part 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.

2-3. Mineralization and alteration

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, bismuthinite, 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

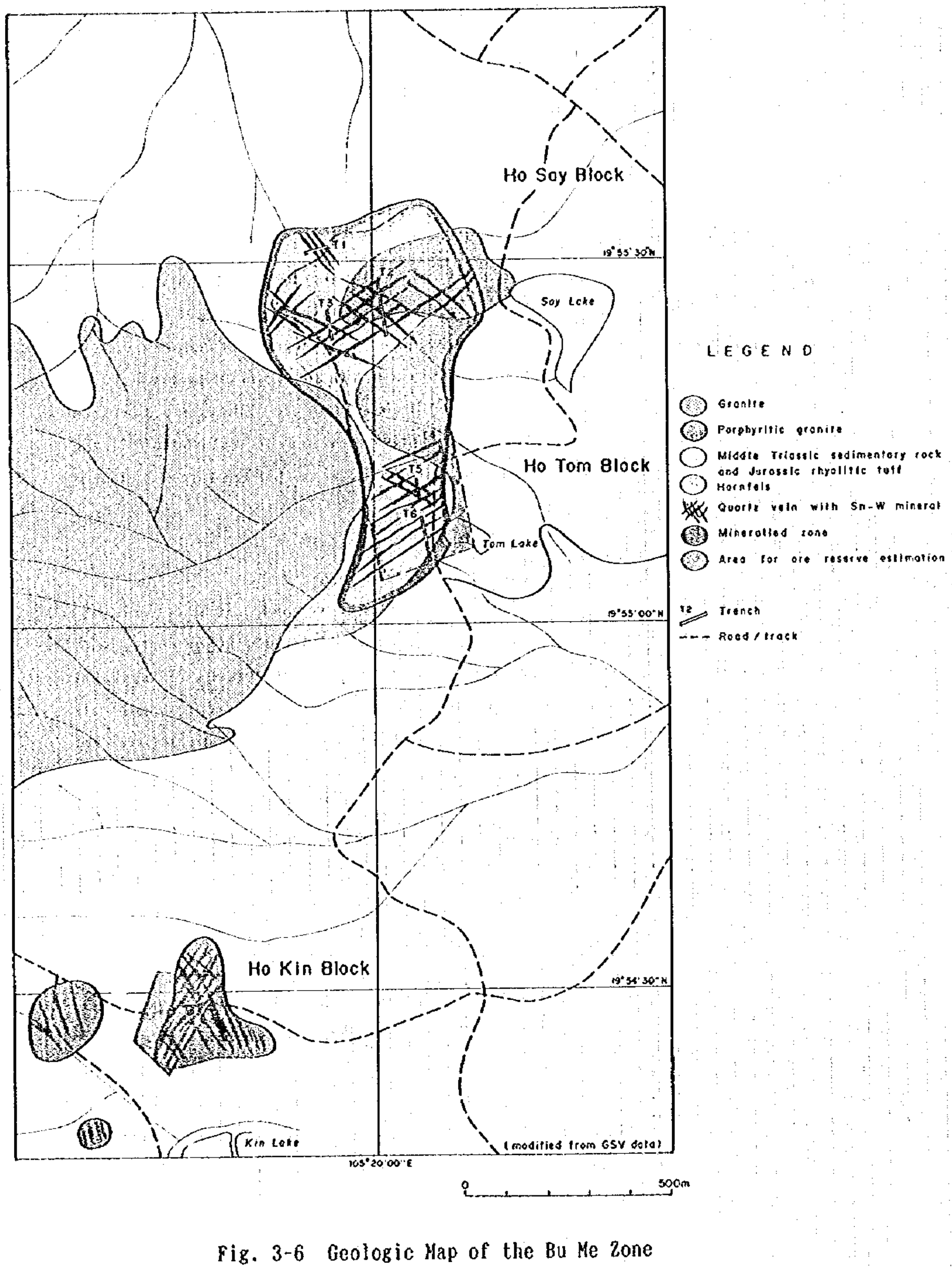

Fig. 3-6 Geologic Map of the Bu Me Zone

is not clear without distinctive discontinuity. The boundary of the last two is also not clear because of the paddy field 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.

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 kaolin. 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. Among them, the areal extents of the largest and smallest bodies are 400 m by 300 m and 100 m by 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.

2-4. Soil Geochemical Exploration

2-4-1. Objectives

The Bu Me tin-tungsten Prospect is developed in and around felsic intrusive rocks as previously stated. This prospect has stockworks, veins, and dissemination. However, the areal extent of the prospect is not clear because of wide soil cover. Therefore, soil geochemistry was employed for the following purposes during the present survey.

a) to delineate the mineralization zone in the Ho Say Block and the Ho Ton Block
b) to study potential of mineral deposits in an unsurveyed area between the Ho Ton Block and the Ho Kin Block

2-4-2. Sampling and chemical analysis

Seventeen nearly straight sampling lines and sampling points of every 20 m apart on each sampling line were fixed as shown in Plate 13 and about 100 g of samples were collected from a soil layer about 30 cm deep (B-layer) at each point. Number of samples is 241.

Samples were sieved after drying and a fraction of 1mm under was sent to the laboratory, and were analyzed for 13 elements of Au, Ag, Cu, Pb, Zn, As, Cr, Hg, Mn, Ni, Sb, Sn, and W. Magnesium was also analyzed for information and the results are recorded in Appendix 8. Detection limits and analytical methods used are the same as those of the Van Yen Area.

2-4-3. Statistical data-processing

The methods of statistical data-processing are same as those employed in the other geochemical exploration.

The principal component analysis was carried out in order to evaluate the nature of correlation for 13 elements. The following table shows the results of the analysis.

Element	Au	Ag	As	Cr	Cu	Hg	Mn	Ni	Pb	Sb	Sn	W	Zn
Z(1)	0.32	0.08	0.35	0.17	0.36	0.28	0.37	0.14	0.15	0.12	0.34	0.34	0.37
Z(2)	-0.10	-0.46	-0.07	0.47	0.08	-0.01	-0.13	0.49	-0.09	0.30	-0.04	-0.04	-0.04
Z(3)	-0.25	0.15	0.11	0.00	-0.06	-0.17	-0.06	-0.02	0.66	0.58	0.14	-0.10	-0.09

The first principal component is summarized by Au-As-Cu-Mn-Sn-W-Zn. This indicates that they are in high correlation. The second and third principal components are summarized by Cr-Ni and Pb-Sb, respectively.

Samples collected on the mineralized zone are about 15% among whole samples. The mineralized zone contains cassiterite, wolframite, pyrite and pyrrohtite. A majority of elements analyzed is contained by above minerals. Thus, it is considered that the first principal component will express the mineralization.

Positive factor scores of the first principal component are found around the mineralized zone. The distribution of factor scores is shown in Figure 3-7.

It is concluded that the Ho Say - Ho Tom zone will continue northward, and a mineralized zone will occur between Ho Say - Ho Tom block and Ho Kin block.

CHAPTER 3. LUONG SON ZONE

3-1. Outline of the zone

Regional geological survey revealed that auriferous quartz veins occur in this zone, and detailed geological survey and geochemical exploration were conducted. This area is located in the southwest of the Western Thanh Hoa area and covers 4 km^2 in area.

3-2. Geological survey

3-2-1. Geology

The geology of the survey area consists of Middle Triassic sedimentary rocks, Undiscriminated Jurassic pyroclastic rock, unconsolidated Quaternary sediments, and gabbroic intrusive bodies of Late Triassic time.

The Middle Triassic widely occurs in the whole of survey area and is made up mainly of gray to dark gray, hard, fine- to medium-grained sandstone. The black mudstone is intercalated with the sandstone at one place of the eastern part.

The Undiscriminated Jurassic covers a small area of the southeastern edge and comprises gray dacitic crystal tuff. Only several floats of tuff were found in this area, but it is believed that the tuff unconformably overlies the Middle Triassic sandstone.

The Quaternary occurs along the Cao River in the southwestern edge of the area.

Five gabbroic bodies intruded into the Middle Triassic sandstone area. The bodies are

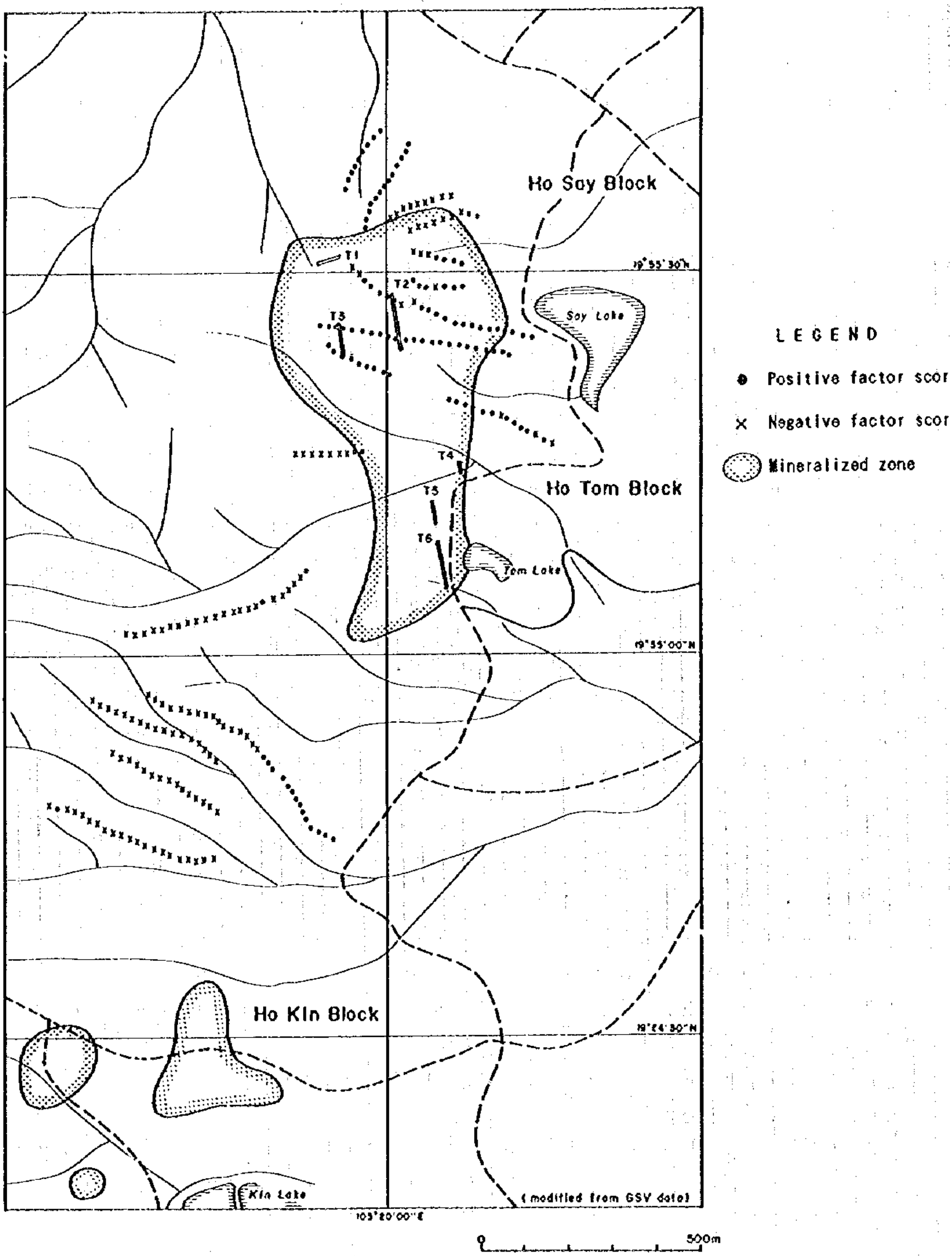

Fig. 3-7 Distribution Map of Factor Scores by Principle Component Analysis with Soil Analytical Results in the Bu Me Zone

generally dark gray and coarse-grained. They are 100 m to 300 m wide and extend roughly in the N-S direction.

3-2-2. Geologic structure

The sandstone of the Middle Triassic widely occurs in the survey area, but most of the rocks are massive and bedding planes were recognized only at six places. Although dips and strikes of the beds are not constant, they generally extend in the NNW-SSE direction. It is inferred from the data obtained through the field survey that the sandstone beds constitute a series of folds with flanks of gentle to moderate dips (30 to 50°) and with about 2 km wavelength.

Two faults were found in the eastern and southern parts of the area, and they run in the NNW-SSE and NW-SE direction, respectively. The Undiscriminated Jurassic and one gabbroic body are cut by the former fault. Sandstone beds near the latter fault are milonitized. These faults are thought not to control the major structure of the whole survey area.

3-2-3. Mineralization

This mineralized zone is the most representative gold mineralized zone and is characterized by concentrating gold-bearing hydrothermal quartz veins.

During first phase, three sites of quartz vein were examined. They are located in the vicinity of the car-road which passes through the central part of this zone. The veins are hosted by the Middle Triassic sandstone and black mudstone. The principal vein systems are divided into two, that is, NNW-SSE and NE-SW. The veins have steep dips ranging from 70° to vertical and 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. Veinlets and stockwork of quartz and limonite are occasionally found on both hanging and foot wall sides of the quartz veins for 1 m. All vein quartz is translucent to colorless and massive. The chemical analysis of the collected samples revealed that the highest content of gold was 0.24 g/t.

Eight outcrops of quartz vein and 15 sites of float zones of vein quartz were newly discovered through the detailed geological survey. Most of the quartz veins are hosted by sandstone, but two of them by a gabbroic body. The veins have various strikes and dips of more than 60°. They range in width from several centimeters to 30 cm. The maximum size of float is 2 m long (stockwork) and part of vein is 50 cm wide in maximum. The host rocks of sandstone and gabbro are intensely silicified on both hanging and foot wall sides near the veins and a large amount of chlorite was found

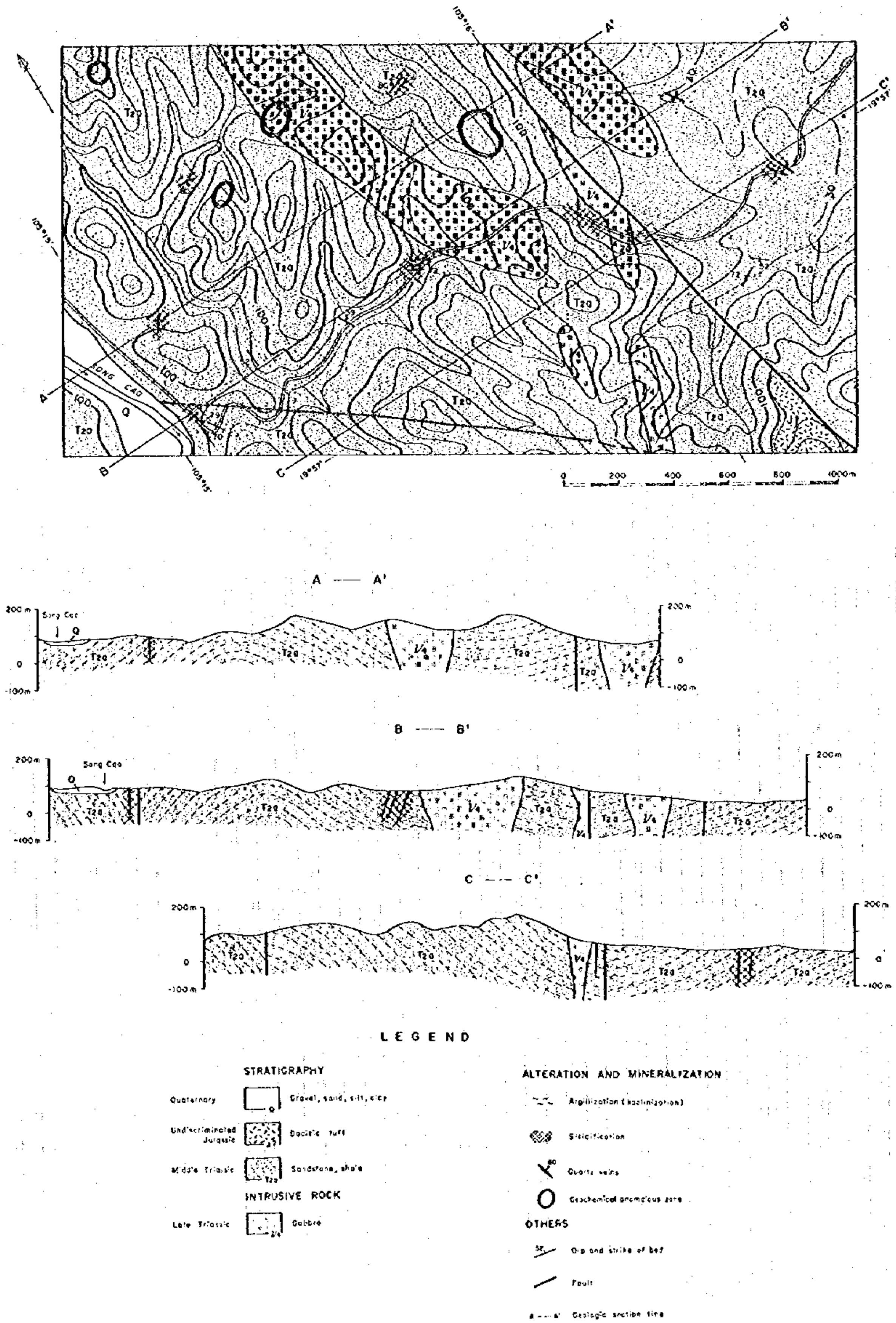

Fig. 3-8 Geologic Map and Cross Section of the Luong Son Zone

within the gabbroic body. All vein quartz is translucent to colorless. Not only pyrite and goethite but also a minor amount of chalcopyrite was observed microscopically in some veins.

The hydrothermal alteration zone of kaolin minerals occurs on the east of a gabbroic body located in the central part of this area. The detailed geological survey revealed that the zone is about 600 m wide and extends roughly in the N-S direction. Kaolinite and a small amount of jarosite and alunite were detected as alteration minerals.

3-3. Soil Geochemical Exploration

3-3-1. Objectives

This exploration was carried out in order to extract new potential areas for mineral deposit based on the geochemical characteristics of the survey area.

3-3-2. Sampling and chemical analysis

Soil samples were collected from the residual soil (B-layer) 30 to 40 cm deep from the surface. The sampling lines were laid out every 200 m apart in the northeastern part, where the topography is rather flat. In the other parts the sampling was carried out along the ridges. The sampling interval was every 100 m along the lines and ridges. About 100 g each of samples was collected and a number of samples is 207 in total. The samples were sieved after drying and under 1 mm fraction was sent to the same laboratory as the case of the Suoi Boc Prospect. They were analyzed for 8 elements of Au, Ag, Cu, Pb, Zn, As, Sb, and Hg. Analytical methods used and detection limits of the above elements are the same as those in stream sediment geochemistry in the Van Yen Area.

3-3-3. Statistical data-processing

(1) Basic statistics

Basic statistics are shown in Table 3-3. On the occasion of values below the detection limit, one half of detection limit values were substituted. Au contents are rather high in the area, namely the mean value is 20 ppb and the maximum value is 220 ppb.

Table 3-3 Basic Statistics of Analytical Results of Soils in the Luong Son Zone

	Au (ppb)	Ag (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	As (ppm)	Sb (ppm)	Hg (ppb)
Max. Value	<1	<0.02	1.9	12.2	13	0.4	1.6	36
Min. Value	220	0.76	301.1	843.8	372	171.1	19.7	228
Geometric Mean	19.5	0.16	48.4	94.7	54	21.5	2.7	29

(3) Correlation among elements

Correlation coefficients are shown in Table 3-4. Elements are less correlative in the area. Only combinations of Cu-Pb-Zn and As-Sb show very weak correlation coefficient. Although Au contents are high in the area, there is no element correlated to Au.

Table 3-4 Correlation Coefficients of Analytical Results of Soils in the Luong Son Zone

	Au	Ag	Cu	Pb	Zn	As	Sb	Hg
Au								
Ag	-0.16							
Cu	-0.09	-0.13						
Pb	-0.18	0.07	0.26					
Zn	-0.09	-0.13	0.52	0.67				
As	-0.03	0.24	-0.05	0.34	0.23			
Sb	0.05	0.06	0.23	0.47	0.48	0.51		
Hg	-0.14	0.01	0.33	0.33	0.36	0.04	0.22	

3-3-4. Geochemical anomalies and anomalous zones

(1) Determination of threshold value

In order to determine threshold values, the same method used in the soil geochemical exploration in the Suoi Boc - Suoi Cu mineralization zone was adopted.

The diagram of Au, though it is a little bit uneven, shows turning point around 5 ppb. Twenty percent of samples are above 5 ppb, and the threshold value is determined 50 ppb that breaks higher population of upper 2.5%.

Since the rest of elements do not show clear breaking point, it is considered that no geochemical anomaly exists about these elements.

(2) Anomalous zones

Anomaly map for Au is shown in Figure 3-8. Since Au anomalous points are sporadically distributed, it seems difficult to delineate anomalous zones.

3-3-5. Consideration

(1) Relationship with geology and geologic structure

The area is underlain mainly by sandstone and gabbroic intrusive rocks of N-S trend. Abundant quartz veins hosted in these rocks are developed in the area. The veins are of changeful strikes and steep dips, and are observed on outcrops to be unextended and of rather small-scale.

There is no connection between distribution of Au anomalous zones and distribution of host rocks and quartz veins. It is supposed that above phenomena are caused by the discontinuity and varied width of quartz veins.

CHAPTER 4. COMPREHENSIVE DISCUSSIONS

4-1. Relationship between Geology, Geologic structure and Mineralization

4-1-1. Regional survey area

The survey area is divided lithologically into two parts, namely the eastern sedimentary and western igneous parts. Mineral showings are concentrated mainly in the western igneous part. The igneous activities of the survey area are characterized by the initial Triassic mafic intrusion followed by intense Jurassic felsic volcanism, and the ending in granitic intrusion of the Cretaceous.

Mafic bodies of various sizes are aligned in the central part of the survey area with NNW-SSE trend. One weak copper mineralization (the Hon Mo mineralization zone) was confirmed in the periphery of the gabbroic body which is situated in the central part of the area of the gabbroic bodies. In addition to this, Cu anomalies are concentrated in the vicinity of mafic rocks. Thus, copper mineralization is seemed to be related to the mafic igneous activity.

Tin - tungsten mineralization, on the other hand, is related to the granitic intrusion. Tin and tungsten mineralization occurs around a stock of porphyritic granite in the Bu Me zone. Furthermore, Sn and W anomalies are concentrated near the granitic bodies. With respect to heavy minerals, cassiterite and wolframite grains were observed in and around the granitic bodies. From the above, it is believed that tin and tungsten mineralization is closely related to the Cretaceous granite. However, tin and tungsten mineralization is restricted to the specific granitic bodies.

Gold-bearing quartz veins occur in the survey area, and they are associated with a wide acidic alteration zone (kaolinite and alunite). The relationship between gold mineralization and geology is not yet clear.

4-2. Relationship between Geochemical Anomalies and Mineralization

4-2-1. Regional Survey Area

Gold anomalies are generally scattered and their concentration was detected only in the Coc Thuong mineralization zone. Here they are very concentrated and overlap those of the other elements with positive correlation.

Copper shows strong positive correlation with Ni and Cr. Their anomalies are in relatively dense distribution in and around gabbroic bodies. The copper mineral showings are found in some parts of gabbroic bodies. From the above, these anomalies suggest the existence of copper mineralization accompanied by mafic rocks.

Arsenic is intensely correlative with Sn, W, and other elements. Arsenic minerals (arsenopyrite, scorodite, beudantite) are paragenetically close to tin-tungsten minerals in the Bu Me Prospect. Thus, the As anomalies account for the characteristics of tin-tungsten mineralization of this area. Therefore, the superimposed As anomalies with Sn and W anomalies should be noted. The granite area in the southwestern edge of the survey area is in the above condition.

Tin and W anomalies lie on the known tin-tungsten mineralization zones in the vicinity of granitic bodies. There is a large possibility that the anomalies indicate tin-tungsten mineralization.

Chromium is highly correlative with Ni with the correlation coefficient of 0.90. Their anomalies are concentrated in and around gabbroic bodies. This is a common feature and does not necessarily suggest the existence of mineralization. Therefore, it is necessary to evaluate these anomalies together with other factors. It is believed that these anomalies detected by the present exploration are not related to mineralization, since any chromium and nickel mineral showings were not found in and around mafic bodies of the survey area up to date.

4-2-2. Luong Son Zone

As a result of the soil geochemical exploration in the Luong Son Mineralization Zone, four strong anomalous zones for Au were detected in the northwestern part of the survey area. The maximum content of Au is as high as 220 ppb. These anomalous zones are believed to imply gold mineralization in view of high Au contents of the anomalies.

4-3. Potential of Resources

This survey area has mineral potential for gold, copper, tin, and tungsten.

(1) Gold

Gold deposits are likely to occur as hydrothermal gold-bearing quartz veins in the Western Thanh Hoa Area. The promising areas for gold deposits are follows.

Abundant quartz veins and quartz vein floats occur in the Luong Son zone. Gold contents are generally low, but some veins show Au grade of 0.2 g/t. Soil geochemical anomalies are scattered, and the content of gold does not exceed 200 ppb.

From the above, it is concluded that quartz veins are discontinuous and the grade of gold is not high.

The Coc Thuong zone and the surrounding areas occupy an NW-SE trending hill where quartz veins are concentrated. A weak gold showing and a float with Au grade of 0.1 g/t were found in this zone. Although stream sediment Au anomalies are found, the possibility of being high grade gold veins is low.

(2) Copper

Mineral showing and geochemical anomaly of copper are found in the Hon Mo mineralized zone related to mafic igneous activity. The grade of copper (0.7 %) in the ore is not high. Big copper deposit will not be probably expected to occur in this zone, since geological survey could not reveal strong mineralization.

(3) Tin - tungsten

Further detailed survey and exploration are needed for the final evaluation of tin-tungsten potential of the Bu Me Prospect. The ore assay results obtained from the previous and present surveys revealed that the contents of tin and tungsten were not so high.

Tin and tungsten anomalies (stream sediments) are concentrated around the granite body in the southwestern edge of the survey area. Additionally, many cassiterite grains were confirmed from panned concentrate samples collected from the same localities as the above anomalies. From these facts, an area in and around the granite body has high potential for tin-tungsten mineralization.

PART 4. CONCLUSIONS AND RECOMMENDATION

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CHAPTER 1. CONCLUSIONS

1-1. Van Yen Area

Regional geological survey and geochemical exploration were executed in this area.

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

(1) This survey area belongs to the West Bacbo tectonic province. The basement of the area comprises the Proterozoic metamorphic rocks represented mainly by gneisses. Unconformably overlying the basement are metamorphic and sedimentary rocks of Cambrian to Permian age, pyroclastic and sedimentary rocks of Triassic age, Alkali volcanic and pyroclastic rocks and neritic sedimentary rocks of Cretaceous age, intrusive rocks and unconsolidated Quaternary sediments. Plutonic and hypabysal rocks of Permian to Cretaceous age are distributed. They are divided into ultramafic to mafic rocks, intermediate to felsic rocks. The intrusive bodies are commonly small.

(2) 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. The area is tectonically divided into three parts, namely northeastern to southeastern part, northwestern to central part and southwestern part. The northeastern to southeastern part of the area consists of Proterozoic to Ordovician and is controlled by NW-SE trending structure as principal structure of "West Bacbo". The northwestern to central part is underlain by Devonian to Cretaceous and is characterized by the structure of WNW-ESE to E-W direction. Lower Triassic to Cretaceous extends in NW-SE direction in the southwestern part.

(3) The major mineralization in this survey area is those of gold, copper, lead - zinc, and platinum - copper - nickel. They are summarized below.

a) The major gold mineralization of this area is that associated by bedded cupriferous pyrite deposits. It is believed that the deposits 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 a large number of ore bodies, but they are not extensive.

b) The relatively large quartz veins of about 2 m in width occur in the survey area, and are accompanied occasionally by copper minerals. However, the content of copper is not of significant commercial value.

c) The lead-zinc mineralization is represented by hydrothermal vein type, and is mostly hosted by the Middle Triassic limestone. It is believed that size of ore deposits is small, although grade of ore is locally high.

d) Platinum-copper-nickel mineralization occurs in and around ultramafic bodies which intruded during the Permian time. The bodies are generally small with several meters to 100 m width. The assay results for platinum are not high with the maximum being 40 ppb. The contents of copper and nickel are approximately 0.1 %. Thus, this type mineralization is very weak in this area.

e) As a result of stream sediment and pan concentrate geochemistry, there is no anomalous zone to indicate significant mineralization.

1-2. Suoi Boc Zone

Geological survey, geochemical exploration, geophysical survey (IP method), trench survey and drilling survey were conducted. The following result is consequently obtained.

(1) The geology of the Suoi Boc zone consists of Middle Triassic sedimentary rocks, Cretaceous dacite porphyry and aplite, and Quaternary sediments. The Middle Triassic is divided into clastic sedimentary rocks and limestone. The Triassic clastic sedimentary rocks tend to strike N-S to NNE-SSW direction and to dip mostly from 20° to 70°E.

(2) The geological structure of the zone is characterized by the N-S to NNE-SSW direction that is expressed as the strikes of sedimentary rocks and faults, the distribution of igneous rocks and the extension of Quaternary sediments.

(3) Geochemical anomalies in the zone indicate the vein-type mineralization. The potential for skarn ore deposits is low, because skarn minerals are absent in the Triassic rocks of these anomalous zones.

(4) The high chargeability zones detected by IP survey, are interpreted to have been caused by graphite contained in the clastic sedimentary rocks. Therefore it has been proved that new Pb-Zn ore deposits are not expected to occur in the high chargeability zones.

(5) The vein-type mineralization in this zone contains Pb-Zn, but it is supposed that size of ore deposit is small.

1-3. Western Thanh Hoa Area

Regional geological survey and geochemical exploration were done in this area. The conclusions of these studies are follows.

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

(2) The geology of this area is controlled by the NW-SE trending main structure of the "Truongson". Two major N-S trending faults extend in the central part of the survey area.

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

a) Gold is associated by quartz veins, but is poor in content.

b) Copper mineralization occurs in the Hon Mo mineralized zone. The copper content is low at the outcrop.

c) The tin-tungsten Bu Me Prospect is believed to be a pneumatolytic to hydrothermal mineralization zone associated with porphyritic granitic intrusion. The ore minerals of this prospect are mainly cassiterite and wolframite, and the prospect occurs in the granitic body and the surrounding hornfels zone. Areal extent of the major mineralization zone is estimated to be 1,200 m by 400 m. The average grade of Sn+W is 0.33 % along trenches with about 320 m in total length.

(4) The present geochemical exploration revealed that the southwestern granite area is the most promising for tin-tungsten mineralization, excluding the Bu Me Prospect. However, any interesting

area for future exploration is not extracted by the present geological survey.

1-4. Luong Son Zone

Detailed geological survey and soil geochemical exploration were executed in this zone.

(1) The zone is underlain mainly by the Middle Triassic sandstone, Jurassic dacitic crystal tuff, and Late Triassic intrusive gabbro. The sandstone occurs in a major part of the area and extends generally in the NNW-SSE direction. The strata are inferred to consist of a series of folds with about 2 km wavelength. The gabbroic bodies intruded into sandstone area and extend roughly in the N-S direction.

(2) The gold-bearing hydrothermal quartz veins are concentrated in this zone. They are hosted by the Middle Triassic sandstone and mudstone as well as Late Triassic gabbroic bodies. Chemical analysis of the collected samples revealed that the highest content of gold was 0.24 g/t.

(3) As a result of the soil geochemical exploration, four strong anomalous zones for Au sporadically scattered and have less than 200 ppb in content.

CHAPTER 2. RECOMMENDATION FOR FUTURE EXPLORATION

Geological survey, geochemical exploration, geophysical survey, and drilling survey were conducted in the Van Yen and Western Thanh Hoa areas. It is considered that no further exploration is necessary, since no indication to show the existence of new ore deposits is obtained.

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