No. 34

REPORT
ON
THE MINERAL EXPLORATION
IN
THE [illegible] AREA

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MARCH [illegible]

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

REPORT
ON
THE MINERAL EXPLORATION
IN
THE BOLIVAR AREA
REPUBLIC OF ECUADOR

CONSOLIDATED REPORT

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PREFACE

In response to the request of the Government of the Republic of Ecuador, the Japanese Government decided to conduct a Mineral Exploration Project in the Bolivar area and entrusted the survey to the Japan International Cooperation Agency (JICA) and the Metal Mining Agency of Japan (MMAJ).

The JICA and MMAJ sent to the Republic of Ecuador a survey team headed by Dr. Hideo Kuroda for three years for carrying out the project.

The team exchanged views with the officials concerned of the Government of the Republic of Ecuador and conducted a field survey in the Bolivar area. After the team returned to Japan, further studies were made and the present report has been prepared.

This consolidated report summarizes the servey results of those three years.

We hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

We wish to express our deep appreciation to the officials concerned of the Government of the Republic of Ecuador for their close cooperation extended to the team.

February 1991

Kensuke Yanagiya
President
Japan International Cooperation Agency

Genichi Fukuhara
President
Metal Mining Agency of Japan

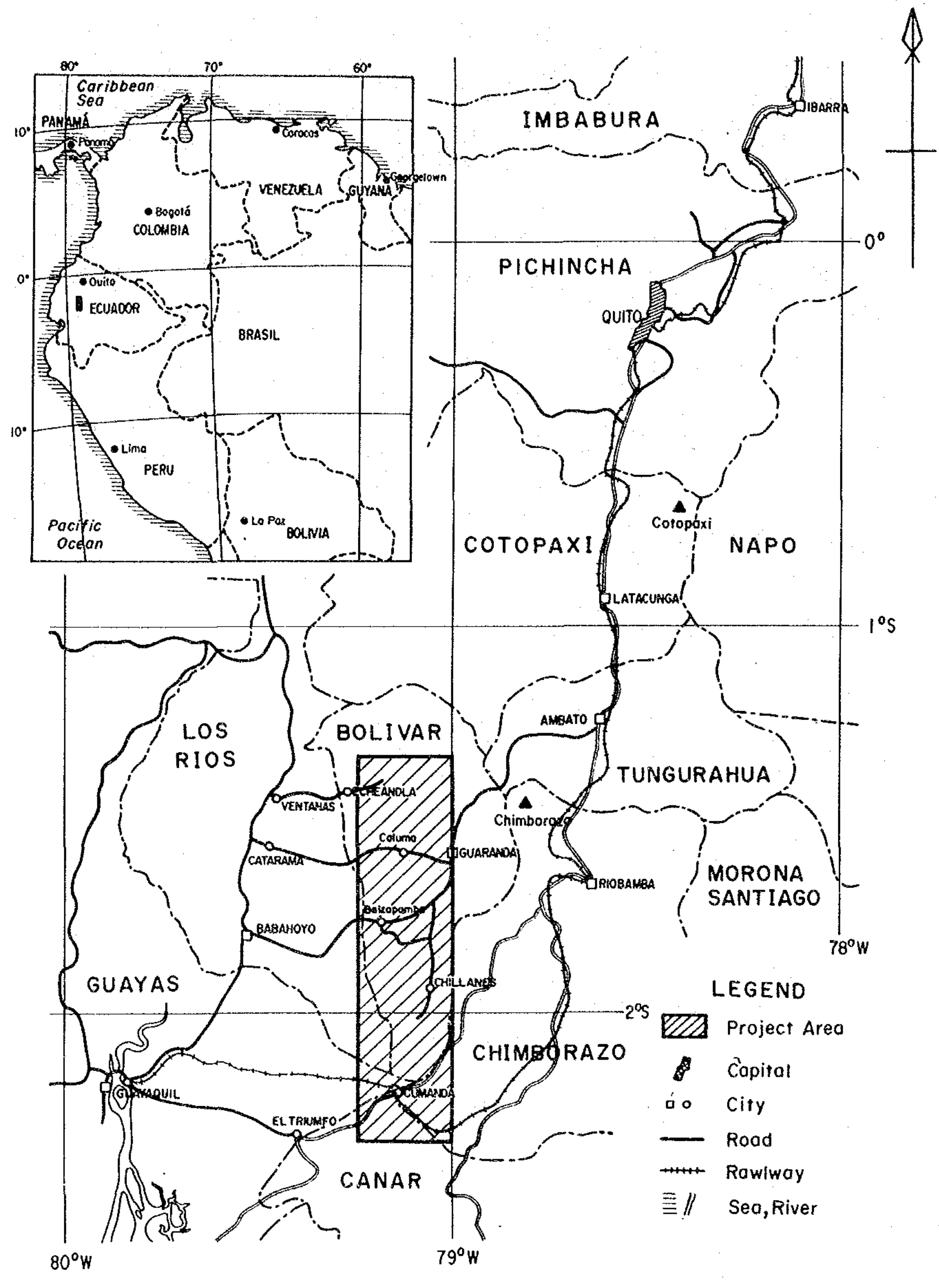

Fig.I Location map of the project area

ABSTRACT

The survey of the Bolivar Project in the Republic of Ecuador has been conducted for three years to confirm the potentiality of mineral deposits by clarifying the geological and mineralogical conditions. Finally 12 areas have been investigated and evaluated. Followings are the summary of conclusions:

(1) Balzapamba area

1) Balzapamba area

The geology of this area consists of the Macuchi formation of Late Cretaceous and granitic rocks of Oligocene to Miocene that intruded into this formation.

Mineralization in this area can be broadly classified into three types that are porphyry copper type, vein type and hot spring type. Porphyry copper type mineralization occurs in granitic rocks and adjacent Macuchi formation, and vein type and hot spring type in Macuchi formation.

Mineralized zones found in El torneado, Osohuayco and Las Juntas belong to porphyry copper type, ones in El Cristal belong to vein type, and ones in Las Palmas and Cochapamba belong to hot spring type.

El torneado and Osohuayco zones are investigated in detail separately, therefore they are described in other sections.

Las Juntas: chalcopyrite-pyrite dissemination ingranodiorite and quartz diorite and pyrite-quartz networked veins in Macuchi formation. Each mineralized zone is small in scale.

El Cristal: pyrite-limonite-chalcopyrite-quartz vein in Macuchi Formation with the strike of E-W, width of about 17 m, and length of about 30 m. The mineralized zone is small in scale.

Las Palmas and Cochapamba: both alteration zones extend widely, resulted from acid alteration (quartz-kaoline-halloysite) relating to hot spring period. Dissemination of pyrite or hematite-quartz-clay veins are recognized locally. As a whole mineralization is weak.

2) El Torneado zone, Balzapamba area

Mineralization observed in the El Torneado zone is of the porphyry copper type, and is divided into two sub-zones on the basis of their modes of occurrence: namely, a "dis-

semination" zone and a "network" vein zone. The former extends over an area of about 400 m x 400 m. The latter is distributed within the former zone in the direction of NNE-SSW, at a scale of 40 to 70 meters in width and 70 to 350 meters in length. The two zones are distributed in the manner where the former zone is cut by the latter. The geologic age of mineralization is earlier in the former.

Mineralized zone is generally low in grade. The geological and drilling surveys had revealed the conditions of mineral occurrence horizontally and vertically, as well as the states of paragenesis and alteration of constituent minerals microscopically. Since the results of the Phase II drilling indicate that the lower limit of the network vein zone was penetrated and that of the disseminated zone was almost reached in this drilling, it may be assumed that the center of mineralization in the El Torneado zone had been subjected to erosion, exposing as a result the lower most part of mineralization on the existing ground surface. The mineralized zone, therefore, may not be the potential target area of a mine.

3) Osohuayco zone, Balzapamba area

The geology of the area consists of Macuchi Formation and granodiorite which intruded into Macuchi Formation.

Two mineralized zones are recognized in this area, one is Osohuayco North mineralized zone and the other Osohuayco South mineralized zone. Drilling survey was carried out to disclose geological and mineralogical conditions of the IP anomaly which showed high apparent resistivity and high FE (more than 5 %) around the Osohuayco South mineralized zone, as a result of previous year geophysical survey. Any mineralization, however, associating with skarnization was not encountered. Drill hole intersected disseminated mineralized zone of chalcopyrite and pyrite in hornfelsinized andesite of Macuchi Formation (AAn). The assay discolsed the grade of the minerqlized zone to be very low at a whole, actual range was 0.01 to 0.18 Cu (average 0.05 % Cu).

(2) Chaso Juan area

Mineralization observed in the Chaso Juan area is of the porphyry copper type, and is grouped into four zones: namely, the North zone, the West zone, the South zone, and the Central zone.

Each mineralized zone is small in scale and discontinuous compared with other surveyed areas.

As the results of geophysical survey, IP anomalies were found in the midway between central and south mineralized zones, and in the west mineralized zone extending north-south direction. The former indicates extension of south mineralized zone, and latter indicates a direction of mineralization. Priority of exploration, however, low in this area.

(3) Telimbela area

1) Telimbela area

The porphyry copper type mineralization observed in the Telimbela area is the largest in scale in the entire Bolivar area, and its strong mineralization extends to the Macuchi Formation.

Centering around each of the seven mineralized locations within this area, pyrite dissemination and veinlets are widely distributed in granitic rocks. Macroscopically, the seven mineralized zones in this area, which are generally arranged in the NE-SW direction, are grouped into the Central, South and North zones.

In the North zone distributed are Mineralized Zones V and VI, which are new and large zones found in the Phase II survey. These mineralized zones are described in the following section.

2) Northeast zone, Telimbela area

The geology of the area consists of Macuchi Formation and Granites which intruded into the Macuchi Formation. Granites are composed of Hornblende-biotite quartzdiorite, hornblend qurtzdiorite, melanocratic qurtzdiorite dike and coarse quartzdiorite dike. Those rock bodies are distributed and arranged in the NE-SW direction.

Porphyry copper type mineralized zone in the surveyed area is proved to be as a dissemination and network zone of chalcopyrite and pyrite.

These mineralized zones are macroscopically lined up in the direction of NE-SW and mineralization is centered in Hornblende quartzdiorite and affects thoroughly such country rocks as Macuchi Formation intensely.

Mineralized outcrops scatter in the area of 1.5 km X 1.0 km in and along Q. Ugshacocha and Q. Ashuaca, high grade ores are notably destributed in an area of 400 m X 600 m close to the Ashuaca achool, where dissemination and network zone of chalcopyrite and pyrite are recognized to exist not only in quartzdiorite but also in Macuchi Formation intensely. Moreover, molibdenite is observed in forms of dissemination and/or films scattered.

The assay revealed that southern mineralized part cropping out along Q. Ugshacocha contains 0.71 to 1.38 % Cu and that northern mineralized part cropping out along Q. Ashuaca 0.78 to 0.89 % Cu.

Outer part of the mineralized zone is to be dissemination and network zone of pyrite only. As a result of IP method electric survey, distinguished were 6 of high FE anomalies. FE anomaly corresponds generally to mineralization, while high resistivity anomaly to silicification and low resistivity to argilization.

Drilling survey was conducted at the west and east of the Ashuaca school, results of which are as follows: On the drill hole core MJE-8, intense dissemination of chalcopyrite and pyrite was observed through the hole (from the surface to the bottom).

Principal mineralized zones encountered by drill hole are interval between 21 to 102 m in depth with 0.02 to 0.72 % Cu (average, 0.468 % Cu). Adding this, several other intervals are recognized to show copper contents more than 0.10 %.

Mineralization tends to be dominant in the parts of angular xenoliths of andesite and in the the parts of auto-brecciated zone of quartzdiorite.

On the drill core MJE-9, intense mineralization of chalcopyrite and pyrite was observed through the hole from the surface to the bottom (205.00 m in depth).

Principal mineralized zones encountered by drill hole are intervals between 80 to 105 m in depth with a grade of 0.10 to 0.33 % cu (average, 0.229 % Cu) and between 124 to 161 m with a grade of 0.08 to 0.55 % Cu (average, 0.207 % cu). Adding those mineraization, several intervals are also recognized, which show copper contents more than 0.10 %.

As a whole, MJE-9 contains less andesite breccias and shows less auto-brecciation. Therefore, average grade of mineralized parts of MJE-9 was relatively lower than that of MJE-8.

To conclude data and information described above following three mineralized zones are delineated as potential zones of mineralization:

1) "Ashuaca mineralized zone"

As a result of geological survey, a number of intense mineralization of chalcopyrite and pyrite have been recognized around Ashuaca school. IP method electric survey disclosed that the deep low resistivity-high FE anomaly "A" which corresponds to the "Ashuaca mineralized zone".

Moreover, low apparent-resistivity anomaly was recognized at the intense mineralized parts of chalcopyrite-pyrite in and along Quebradas, west and south of Ashuaca.

2) Ugshacocha mineralized zone

Ugshacocha mineralized zone distributes about 500 m southeast of Ashuaca school. Through detailed geological survey, recognized is intense mineralization of chalcopyrite-pyrite, while this mineralization is confirmed to be corresponded to low resistivity-high FE zone "A" which has been selected as a tangue shape anomalous zone extendiong from the Northeast of the Ashuaca to the Southeast.

3) Las Tres Cruces minerlized zone

Las Tres Cruces mineralized zone is distributed about 600 m western northwest of Ashuaca school.

As a result of geological survey, intense pyrite dissemination accompanying chalcopyrite are recognized. Furthermore, low resistivity-high FE anomaly "B" is delineated as a narrow and elongated zone with the dirrection of NNE-SSW by IP method electric survey.

This anomaly implies that hidden mineralized zone may exist in the depth of Macuchi Formation.

(4) La Industria-Yatubi area

Mineralization observed in this area is of two types: namely, hot-spring type Au mineralization and porphyry-copper type mineralization. In the former type of mineralization, a white argillized zone (kaolin) and a silicified zone are distributed in the lower and upper parts respectively. Across the two zones, network veins are recognized, which consist of metallic sinter-acicular minerals-hematite-quartz-kaolin. The assay result shows the maximum Au content of 0.3 g/t. The silicified outcrops are recognized only at the top of mountains (Cerro Barranco Amarillo and Caimito South), the silicified zone turns downward to the kaolinized zone which were observed below the mountaintop. The silicified zone is, therefore, considered to be eroded largely, and the silicified parts at the mountaintop to be the relics of the lower part of the silicified zone.

An alteration zone, which consists of sericitization and weak silicification, is also accompanied by pyrite. This alteration is probably associated with the porphyry copper type mineralization in the northern part of the area.

(5) Las Guardias area

Mineralization of the porphyry copper type is recognized at 12 locations, all of which are distributed along melanocratic diorite intrusive rocks and a fault in the direction of NW-SE. This direction is in a marked contrast to the NE-SW direction of the mineralization zones and intrusive rocks in other areas. Extension of each mineralized zone is less than 100 m, small in scale and discontinuous in surveyed area.

(6) Other areas

Other areas include following seven areas: Tres Hermanas area; San Miguel area; Sicota area; Tambillo area; Tablas Pamba area; Balaron area; and Chilcales Alto area. Mineralized zone of each area was small in scale and low in grade.

Based on the findings of Phase I, Phase II and Phase III surveys, the following recommendations are made for the future survey.

(1) Osohuayco zone, balzapamba area (Fig.III-2-1)

The Osohuayco North mineralized zone, mineralized outcrops of which are confirmed through geological survey of Phase III, is extensive in scale and comparatively high grade in copper content.

This mineralized zone occurs in hornblende-biotite granodiorite (Gd). Distribution area of these mineralized outcrops corresponds with the IP anomaly area delineated on the high resistivity-high FE values of Phase II geophysical survey.

Therefore, drilling survey is recommended to disclose the condition and extent of mineralization in detail, the locations of which are shown in Fig.III-2-1. For example, 300 m deep X 2 holes in Osohuayco North mineralized zone.

(2) Northeast zone, Telimbela area (Fig.III-2-2)

"The Ashuaca mineralized zone", which is confirmed thoroughly by Phase III geological, geophysical and drilling survey, is extensive in scale and high in grade of metal (copper) content. This mineralized zone is also peoved to have close relationship of distribution with hornblende quartzdiorite (HQd). Adding this, potential areas have been delineated around "Ashuaca mineralized zone".

Furthermore, through geophysical survey, IP anomlies are distinguished in the depth of "Ashuaca mineralized zone" where recognized are chain of mineralized outcrops.

Therefore, drilling survey is recommended to disclose the condition and extent of mineralization in detail, the locations of which are shown in Fig.III-2-2 . For example, 200 m deep X 3 holes in "ashuaca mineralized zone"; 200 m deep X 2 holes in Ugshacocha mineralized zone; and 200 m deep X 1 hole in Las Tre Cruces mineralized zone.

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PART I GENERAL

Chapter 1 Outline of the survey

1-1 Area and purpose of survey

1) Area of survey

In the western half of the Occidental (Western) Cordilleta of Ecuador, a porphyry copper belt extends from north to south. The Bolivar project area lies on this belt (Fig. 1 and Fig.I-1-1).

The survey was consisted to investigate areas as follows: detailed geological survey in a area (Balzapamba) and semi-detailed geological survey in eleven areas (other areas).

Balzapamba area situates in the central part of the survey area and Telimbela locates about 10 km north of Balzapamba and Other areas scatter widely in 100 km of distance.

2) Purpose of survey

The purpose of the Project is to evaluate the potential of the mineral deposits in the Project area of Ecuador.

1-2 Method and amounts of survey

1) Method of survey

To initiate the survey, twelve areas were selected by document survey. Geological and geochemical surveys then clarified relationship of mineralization and geo-techtonic and igneous activities. Taking account of those results comprehensively, distribution characteristics of mineralization (or mineralized zones) were delineated and investigated to select further promising mineralized zones for target areas of the project.

Geophysical survey followed this to investigate fairly limited areas which were selected as results of geological survey, and detected continuity and intensity of porphyry copper mineralization horizontally and vertically. After clarifying relationship between minerlized zone and geological structure, anomalous areas were distinguished, which anomalous may be resulted from mineralization. Those areas may be some exact points for further investigation by means of drilling survey.

Finally, Drilling survey was adopted to confirm the continuity and intensity of mineralization at the depth. Those geological and mineralogical information are essential for estimating economical feasibility of the mineralized zone.

The flow of the survey works are shown in Fig.I-1-2.

Through the survey following procedure were conducted: one area for detailed survey

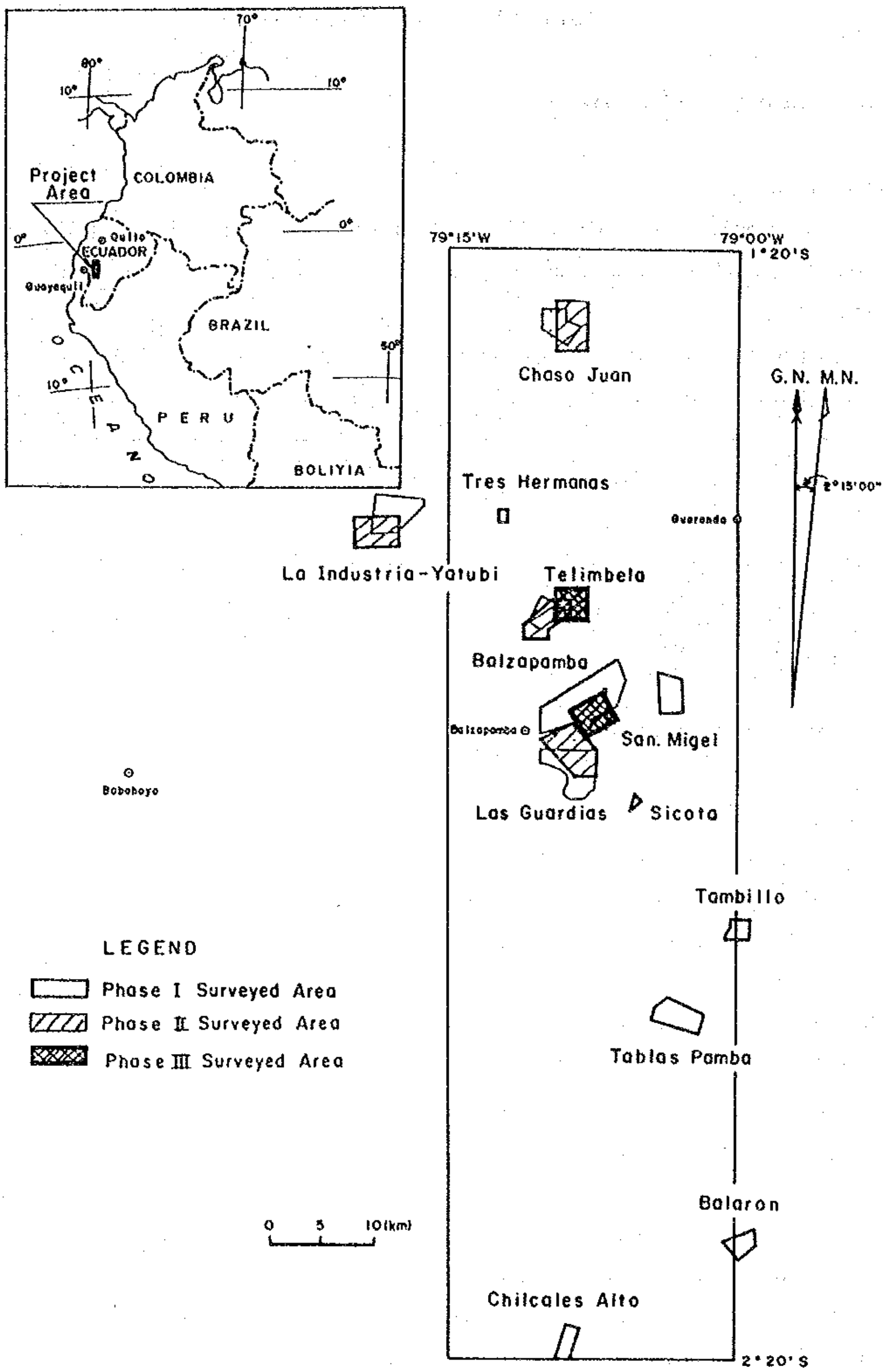


Fig.I-1-1 Location map of the surveyed area

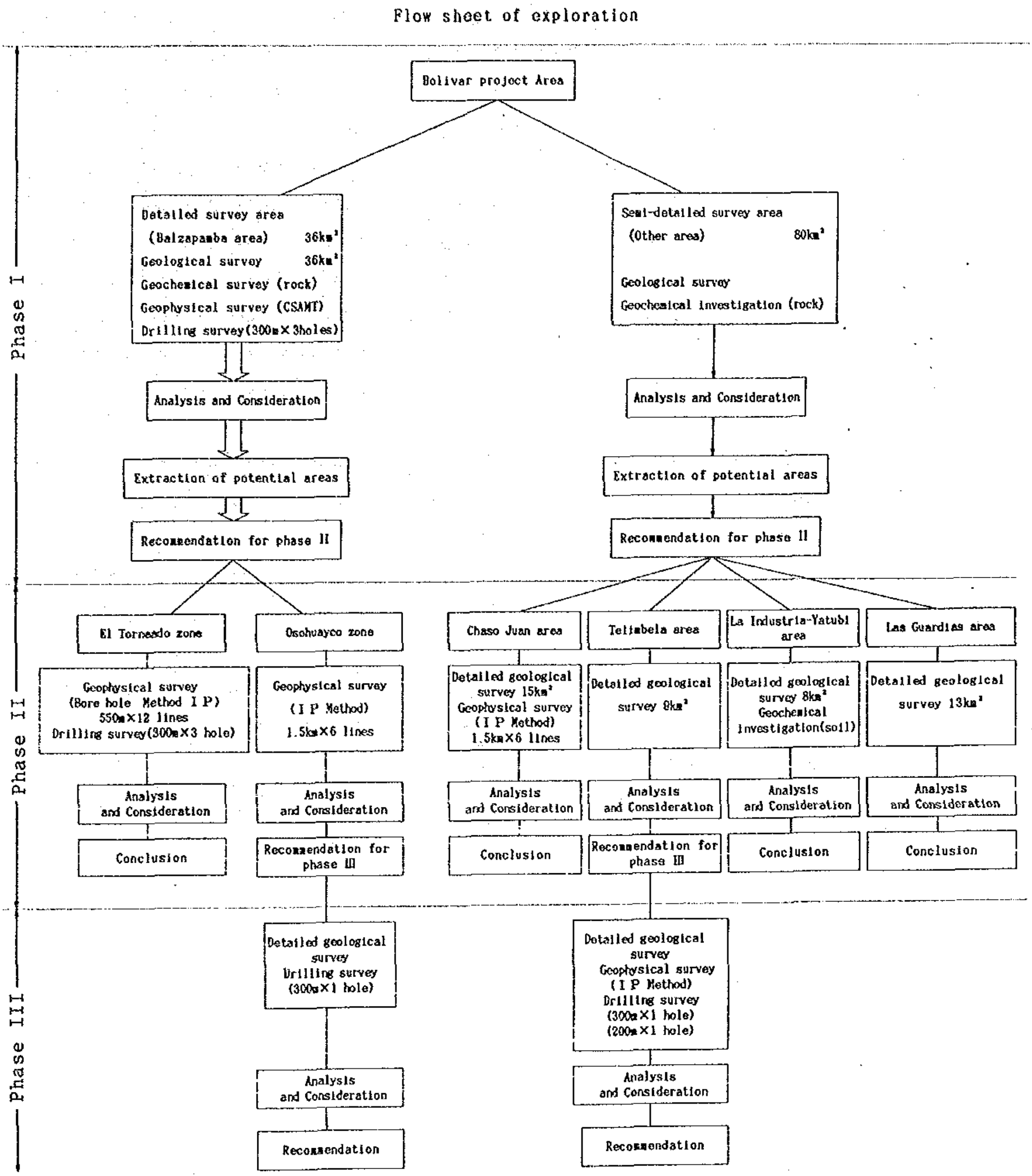


Fig. I-1-2 Flowsheet of the survey

first, while eleven areas for semi-detailed survey; in Balzapamba area, geological, geophysical and drilling surveys; in El Torneado, geological survey, rock-geochemical survey, geophysical survey and drilling survey; in Osohuayco, semi-detailed geological survey, rock-geochemical survey, detailed geological survey, geophysical survey and drilling survey; in Chaso Juan, semi-detailed geological survey, rock-geochemical survey, detailed geological survey and geophysical survey; in Telimbela, semi-detailed geological survey, rock-geochemical survey, detailed geological survey, geophysical survey and drilling survey; in La Industria-Yatubi, semi-detailed geological survey, rock-geochemical survey, detailed geological survey and soil-geochemical survey; in Las Guardias, semi-detailed survey, rock-geochemical survey and detailed geological survey; in other areas (such as Tres Hermanas, San Miguel, Sicota, Tambillo, Tablas Pamba, Baalaron and Chilcales Alto), only semi-detailed geological survey and rock-geochemical survey.

For Phase II survey, five areas were selected out of twelve areas. And following surveys were adopted: in El Torneado, geophysical survey (Bore hole IP method) and drilling survey; in Osohuayco, geophysical survey (IP method); in Chaso Juan, detailed geological survey and geophysical survey (IP method); in La Industria-Yatubi, detailed geological survey and soil-geochemical survey; and in Telimbela and Las Guardias, detailed geological survey only.

For Phase III survey, survey were concentrated on two areas only, Osohuayco and Telimbela. In Osohuayco, detailed geological survey and drilling survey were adopted; and in Telimbela, detailed geological survey, geophysical survey (IP method) and drilling survey were adopted.

2) Amounts of survey

The amounts of the survey were listed on Tables I-1-1 and I-1-2.

1-3 Period and members of survey

1) Periods of survey

From August 2, 1988 to February 20, 1991.

2) Members of administration and survey team

Members of administration and survey team are listed on Table I-1-3.

Table I-1-1 List of survey amounts

Items	Quantity		
1. Geological and geochemical survey	Area (km²)	Survey length(km)	
1) Balzapamba	36	84.8	
2) Others	80	157.5	
2. Geophysical survey	Area (km²)	Survey length(km)	
1) Balzapamba (CSAMT)	36	104 (points)	
3. Drilling	Depth (m)	Dip(°)	
(1) El Torneado, Balzapamba area			
1) MJE-1	305.40	-90°	
2) MJE-2	305.40	-90°	
3) MJE-3	303.30	-90°	
1. Geological and geochemical survey	Area (km²)	Survey length(km)	
1) Chaso Juan	15	36.0	
2) Telimbela	9	26.9	
3) La Industria-Yatubi	8	21.9	
4) Las Guardias	13	33.0	
2. Geophysical survey	Area (km²)	Survey length(km)	
1) Balzapamba			
El Torneado (Bore Hole IP)	0.26	6.9	
Osohuayco (IP Method)	2.0	9.6	
2) Chaso Juan (IP Method)	2.4	9.6	
3. Drilling	Depth (m)	Dip(°)	
(1) El Torneado, Balzapamba area			
4) MJE-4	305.30	-90°	
5) MJE-5	305.20	-90°	
6) MJE-6	353.00	-90°	
1. Geological survey	Area (km²)	Survey length(km)	Pit
1) Balzapamba			
Osohuayco	10	27.2	5
2) Telimbela			
Northeast	9	38.3	10
2. Geophysical survey	Area (km²)	Survey length(km)	
3) Telimbela			
Northeast (IP Method)	2.4	9.6	
3. Drilling	Depth (m)	Dip(°)	
(2)Osohuayco, Balzapamba area	305.00	-90°	
1) MJE-7			
(3) Northeast, Telimbela			
1) MJE-8	301.00	-90°	
2) MJE-9	205.00	-90°	

Table I-1-2 List of lavolatory works

Method / Area	Thin section	Polished section	Dating (K-Ar)	Chemical Analyses			X-ray diffractive analysis	Resistivity
				Whole rock	Ore (Au, Ag, Cu, Pb, An, Mon)	Soil (Au, Ag, Cu, Pb, Zn, Mo As, Hg)		
Drill core	5	5	0	0	216	0	20	25
Balzapamba	13	7	1	1	44	33	30	26
Chaso Juan	4	6	2	2	20	5	10	10
Telimbela	6	13	3	3	73	6	46	21
La Industria-Yatubi	2	-	1	1	17	(Soil;205) 4	10	-
Las Guardias	6	3-	3	3	17		6	-
Others	2		-	-	10		13	-
Total	51	55	10	10	397	205 67	121	82

Table I-1-3 Member list of project administration and survey team

Survey Period	Phase I From May 15, 1988 To Feb 10, 1989	Phase II From July 2, 1989 To Jan 31, 1990	Phase III From June 29, 1990 To Feb 20, 1991
Planing and administration	Yoshio Matsukawa[4] Yoshiyuki Isoda[1] Hideiku Shinokawa[2] Hiroyasu Kainuma[3] Naotaka Adachi[4]	Yoshio Matsukawa Kyoichi Koyama[4] Hiroyasu Kainuma Hideya Metsugi[4]	Kyoichi Koyama Hideya Metsugi
	Leonardo Elizalde Guillermo Bixby Wilson Santamaria Marco Marin Edgar Lopez Luis Quevedo	Leonardo Elizalde Wilson Santamaria Marco Marin Edgar Lopez Luis Quevedo	Leonardo Elizalde Wilson Santamaria Marco Marin Edgar Lopez Luis Quevedo
Field survey	Hideo Kuroda[5] Hirofumi Taniguchi[5] Norio Ikeda[5] Toshimasa Tajima[5] Manabu Kaku[5] Makoto Tsuchiya[5] Kooji Kudoh[5] Takashi Matsuoka[5] Tsukasa Anbo[5]	Hideo Kuroda Hiroshi Kusaka[5] Norio Ikeda Toshimasa Tajima Manabu Kaku Nobuyuki Sasaki[5] Takashi Matsuoka Tsukasa Anbo	Hideo Kuroda Hiroshi Kusaka Motomu Goto[5] Manabu Kaku Kazuto Matsukubo[5] Nobuyuki Sasaki Takashi Matsuoka Tsukasa Anbo
	Vicente Fiallos Guillermo Aguilera Alfredo Zamora Xavier Bermudez Edgar Lopez Luis de La Torre Alfonso Vaca Cesar Cardenas	vicente Fiallos Alfredo Zamora Xavier Bermudez Gabriel Unda Edgar Lopez Luis de La Torre Alfonso Vaca Cesar Cardenas	Alfredo Zamora Bolivar Carelo Gabriel Varensuela Victor Citinbaiyo Edgar Lopez Luis de La Torre Alfonso Vaca Cesar Cardenas

1) Ministry of Foreign Affairs 2) Ministry of Trade and Industry
3) Japan International Cooperation 4) Metal Mining Agency of Japan
5) Bishimetal Exploration Company Ltd.

Chapter 2 Previous works

2-1 Outline of previous works

In a period from 1975 to 1982, the San Miguel project was undertaken over an area of 6,100 km^2, which covers the present project area, with British technical cooperation. Of the total survey period, the earlier period of 1979 was devoted to a regional geochemical survey.

Through this survey, 2,500 samples of stream sediments and panned heavy minerals were collected and analyzed for Cu, Pb, Zn, Co and Ni by the atomic absorption method, and for CxCu and CxHm, by the colorimetric cold extraction method.

As the results of chemical analyses of these samples, 17 zones were interpreted to be related to Cu mineralized zones, six to Pb-Zn zones, three to Cu-Ni zones, and one to Zn zone. While remaining 11 zones reflected geochemical survey, further detailed surveys were conducted in four promising areas of Balzapamba, Chaso Juan, Telimbela and San Miguel from 1976 four areas. Anomalous zones were also recommended. An outline of the four areas is given in detail. In the Balzapamba, the regional survey and subsequent detailed survey led to discovery of mineral showings of el Torneaso, Osohuayco, Las Juntas, El Cristal, Las Palmas and Cochapamba.

In Balzapamba, Chaso Juan and Telimbela, Porphyry copper mineralization was observed mainly in acid to intermediate intrusive rocks emplaced in the Macuchi Formation. Based on these results, recommendations consisting of detailed geological survey, soil geochemical exploration, geophysical exploration were made for these areas. Particularly, drilling (5 holes, 1,125 m) was also recommended for the Balzapamba area (INEMIN, 1988).

In San Miguel, dissemination and veins of sulfide minerals were noted in hydrothermal alteration zones of the Lourdes Volcanic Rocks. Thus, detailed geological survey and sjoil geochemical exploration were recommended. However, this area is considered to be less priority than other three areas which are mentioned above (INEMIN, 1988).

Chapter 3 General Geology

3-1 Geology and geological structure

In termes of geological structure, Ecuador belongs to so-called mobile belt of the Andes geocyncline which formed in a narrow stripe along the western margin of the Guiana-Brazil shield.

The geology of the Bolivar area mainly consists of basic to intermediate volcanic rocks of the Macuchi formation of Late Cretaceous period, thickness of which is estimated to be about 5,000 m (NRNE/DGGM, 1979, 1982). These rocks are intruded by acidic tointermediate plutonic rocks.

Stratigrahic correlation around the project area is shown in Fig. I-3-1.

Henderson (1979) stated that the Macuchi Formation contains marine fossil fauna and foraminifer of Late Cretaceous, and foraminifers of Eocene, and that K-Ar isotopic ages of the Macuchi indicated 51.5±2.5 Ma (early Eocene). Furthermore, K-Ar isotopic ages were determined to be 19.2±3 Ma to 30.8±1 Ma for plutonic rocks from the Las guardias area.

The principal geological structure runs in NNE-SSW to NE-SW direction, for extreme instance Guayaquil-Pallatanga fault.

3-2 Metalogenic zone

Ecuador has two major metallogenic provinces, Oriental and Occidental metallogenic provinces, each of which is subdivided into three and five metallogenic zones respectively. The classification of these zones is interpreted in Table.I-3-1, and their distribution in Fig.I-3-2.

The Bolivar area is situated in the metallogenic zone VII, a anticlinorium-synclinorium of Occidental metallogenic province. The zone VII has a high potential of porphyry
copper type ore deposits.

Mineralization in this area comprises following three types: (1) Porphyry copper type Cu-Mo mineralization observed mainly in intrusive rocks and adjacent country rocks of the Macuchi Formation (Balzapamba, Chaso Juan, Telimbela and Las Guardias areas); (2) Vein type sulfide minerals-quartz mineralization found in the Macuchi Formation (El Cristal area) and in the Lourdes volcanic rocks (San Miguel area); and (3) Hot spring type mineralization consisting of hematite-silica sinter-quartz network, accompanied with acidic hydrothermal alteration, in the Lourdes volcanic rocks (San Miguel area) and that of hematite-quartz network in plutonic rocks (La Industria-Yatubi area).

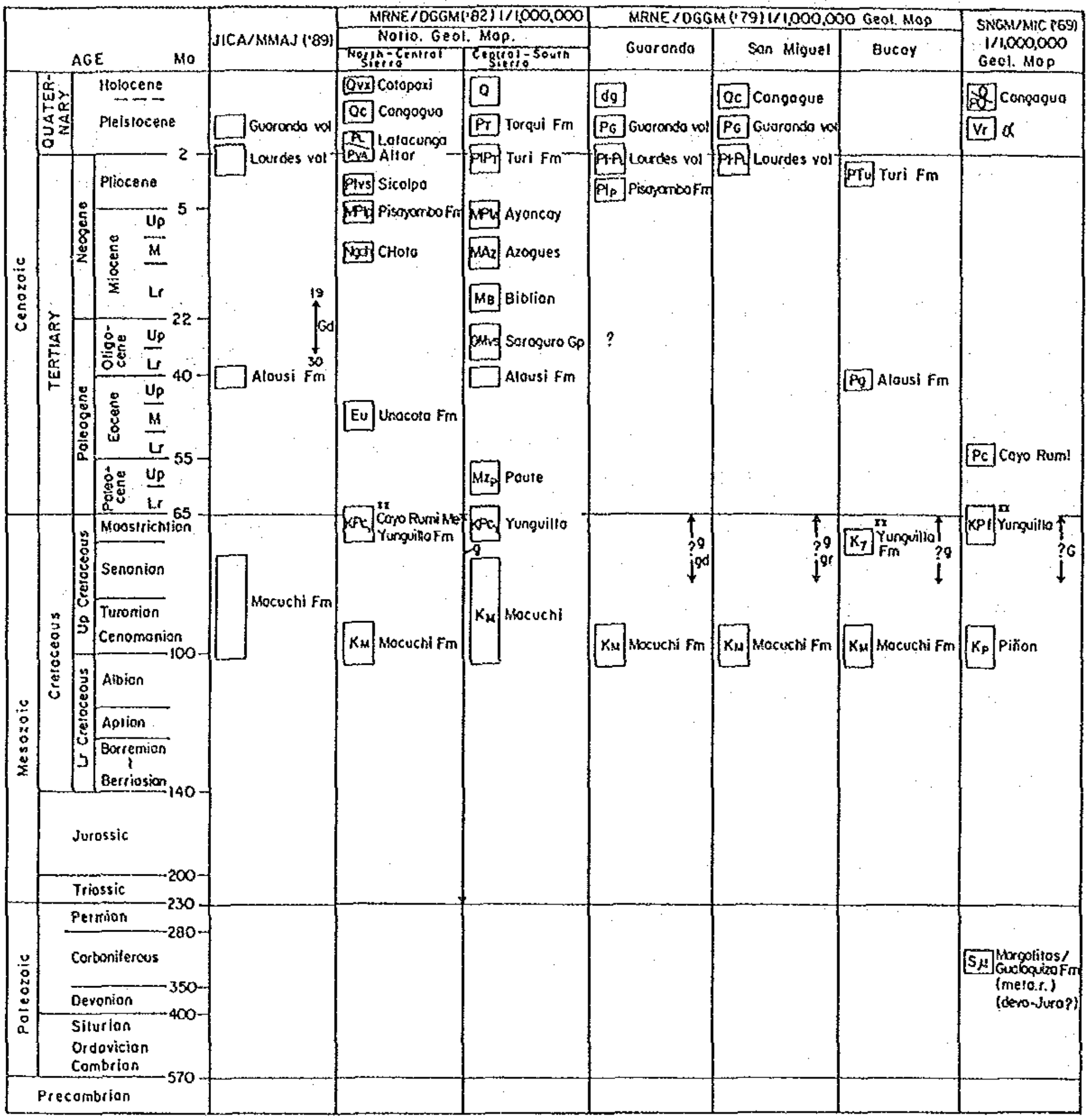


Fig.I-3-1 Stratigraphic correlation around the project area

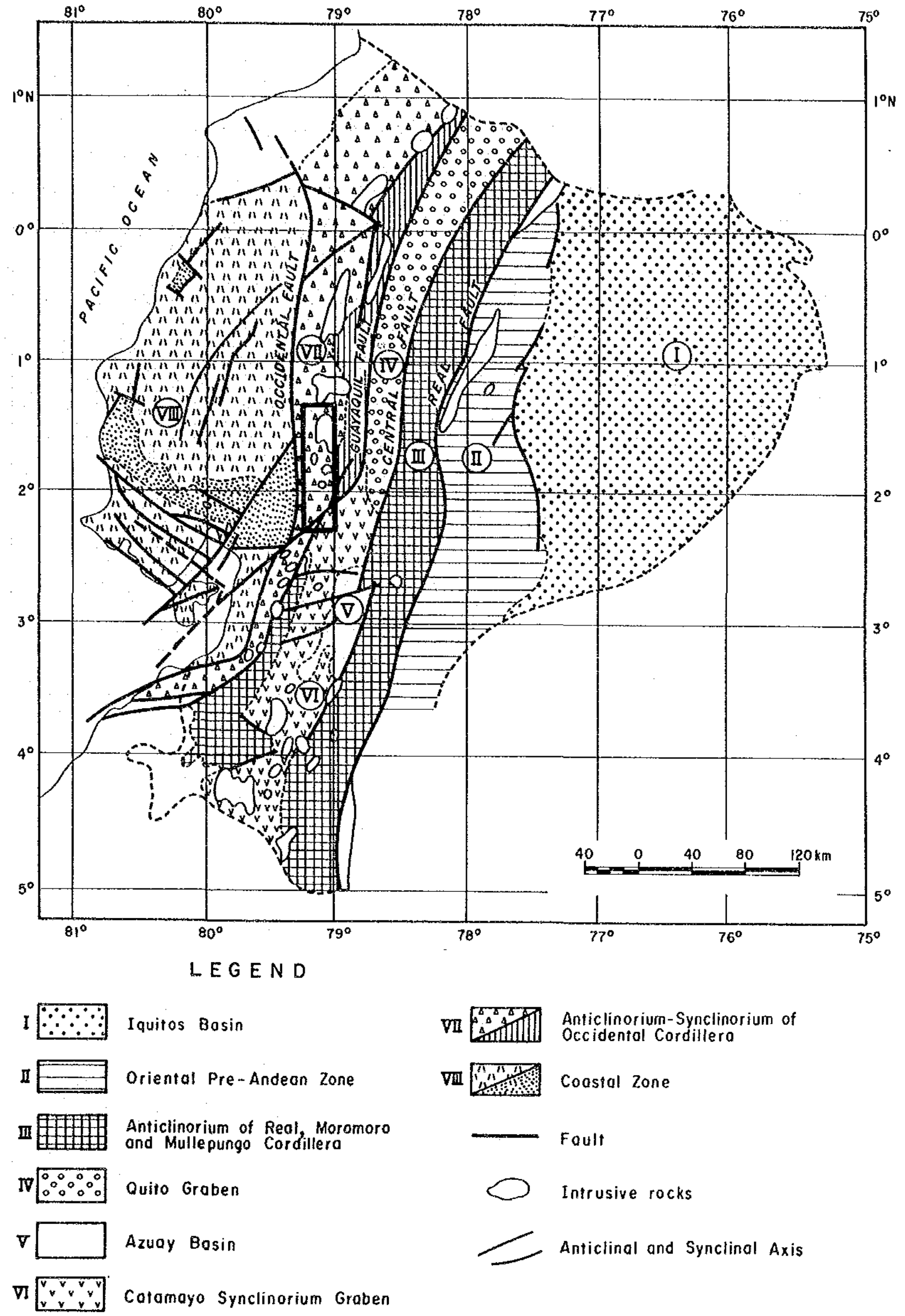


Fig.I.3-2 Geotectonic and metalogenic zone map of Ecuador

Table I-3-1 Classification of metallogenic zones

Topography		Geology	Metallogenic Province	Metallogenic Zone	Metallogenic Sub-Province
Galapagos Islands		Pliocene ~ Quaternary			Cu-Ni-Co Sub-Province of Ocean Floor (Quaternary)
Coast		Pre-Cretaceous ~ Pleistocene (Pinion Formation)	Occidental (Ocean Crust, Eugeosyncline)	VIII. Coastal Zone	Fe-Ti-Pt Sub-Province of Coast (Jura ~ Early Cretaceous)
Mountain Range	Occidental Cordillera	Cretaceous ~ Paleocene (flysh) (Macuchi Formation)		VII. Anticlinorium-Synclinorium of Occidental Cordillera	Cu Sub-Province of Occidental Cordillera (Cretaceous ~ Miocene)
	Interandean Depression	Neogene ~ Holocene		VI. Catamayo Synclinorium Graben	Polymetallic Sub-Province of High Plateau (Paleocene ~ Quaternary)
				V. Azuay Basin	
				IV. Quito Graben	
	Real Cordillera	Metamorphic Rocks of Paleozoic and Mesozoic	Oriental (Continental Crust, Miogeosyncline)	III. Anticlinorium of Real, Moromoro and Mullepungo Cordillera	Sn-W-U Sub-Province of Real Cordillela (Later Paleozoic)
Orient		Carboniferous ~ Cretaceous		II. Oriental Pre-Andean Zone	Au Sub-Province of Orient Basin (Mesozoic ~ Cenozoic)
		Tertiary ~ Quaternary		I. Iquitos Basin	

Chapter 4 Geography of survey area

4-1 Location and access

The survey area includes following areas: Balzapamba, Chaso Juan, Telimbela, La Industria-Yatubi, Las Guardias, and seven other areas (Fig,I-1-1). The project area is situated in the central western part of the Republic of Ecuador (Fig.I and Fig.I-1-1).

Balzapamba, the base of this survey, is located about 190 km to the south-southwest of Quito, the capital of Ecuador, and is accessible in about 7 hour drive via Ambato and Guaranda. Balzapamba is also located about 130 km northeast of Guayaquil, the largest city and port, and is accessible in about 3 hour drive via Babahoyo.

In the project area, there are two East-West trunk roads: Quito-Guayaquil highway (via Babahoyo) and Quito-Guaranda-Guayaquil highway (via San Miguel, Balzapamba and Babahoyo).

Though unpaved, feeder roads are developed east-west direction. However, north-south roads are seldom due to well developed east-west drainage system.

The road distance and necessary time between Balzapamba and each surveyed area are as follows:

Chaso Juan	Car (150 km, 3.0 hours)
La Industria-Yatubi	Car (125 km, 2.5 hours)
Tres Hermanas	Car (130 km, 2.5 hours)
Telimbela	Car (135 km, 3.0 hours)
San Miguel	Car (45 km, 1.0 hour)
Las Guardias	Car (5 km, 0.5 hours)
Sicota	Car (35 km, 1.0 hours)
Tambillo	Car (70 km, 2.0 hours)
Tablas Pamba	Car (80 km, 2.5 hours)
Balaron	Car (230 km, 3.5 hours)
Chilales Alto	Car (170 km, 2.5 hours)

4-2 Topography and environment

1) Topography and drainage

The project area is situated in the western marginal zone of the Occidental (Western) Cordillera and individual survey areas are scattered at an altitude of 200 m to 2,000 m. Mt. Chimborazo (6,267 m), the highest peak in Ecuador, rises in the northeastern outside of the project area. The area is steep in rugged mountainous terrain, and relative heights between the highest altitude and the lowest in each survey area vary from 300 m to 1,000 m. Particularly, the average slope is as high as 40 degrees in the Chaso Juan and Las Guardias areas, where precipitous cliffs form numerous waterfalls. Some waterfalls continue for 400 m in head. Topographic features well reflect different lithology as a result of differential errosion. Generally, granitic rocks form relatively gentle land form, on the contrary Macuchi Formation makes steep and rigged crest. Major rivers rise in the Occidental Cordillera and flow down westward or southwestward. Numerous branches, which flow as northwest-southeast and/or north-south systems, join to those major rivers.

2) Climate and vegetation

Climate in the survey area is tropical,high humidity in lowlands and temperate, dry in highlands. The rainy season runs from December to April. The records show that annual temperature varies from 15°C to 29°C and that annual humidity varies from 65 % to 85 %.

The monthly mean temperature and precipitation are shown in Table I-4-1.

Vegetation mainly consists of jungles. Orange, banana, coffee, cacao, and a few other crop plantations exist in lowlands while corn fields, ranches, etc. are developed in some highland areas.

Table I-4-1 Temperature and precipitation of the project area

	1984		1985		1986		1987		1988	
	Temp ('C)	Precip (mm)	Temp ('C)	Precip (mm)	Temp ('C)	Precip (mm)	Temp ('C)	Precip (mm)	Temp ('C)	Precip (mm)
Jan	20.8	101.7	19.8	155.6	20.4	41.8	21.1	-	21.0	209.9
Feb	20.9	406.4	20.4	113.6	21.2	44.2	21.6	204.0	21.4	362.6
Mar	21.1	462.6	20.8	243.2	21.1	60.0	21.8	484.5	20.9	89.3
Apr	20.9	370.4	20.5	124.4	22.3	18.5	21.4	283.9	22.6	263.0
May	20.6	18.6	20.4	54.3	20.9	16.5	21.2	178.9	21.2	143.5
Jun	20.5	22.8	20.0	19.0	19.7	-	20.7	4.0	20.2	18.8
Jul	19.1	5.1	19.5	2.1	20.4	4.0	21.2	5.7	20.0	6.5
Aug	20.0	4.2	19.8	13.1	20.1	-	20.9	16.2	20.5	5.1
Sep	20.1	33.5	-	-	20.6	-	20.9	13.7	20.4	22.3
Oct	20.4	33.1	20.1	12.5	20.4	5.0	21.2	19.3	20.5	23.3
Nov	20.1	41.5	19.9	8.1	21.8	8.3	22.3	13.8	-	28.3
Dec	20.3	117.5	20.2	151.0	20.1	-	20.0	50.7	20.1	59.0

Around Babahoyo

Chapter 5 general discussion on the survey results

5-1 Survey results in each survey area

5-1-1 Balzapamba area

(1) Balzapamba area

The geology of this area consists of the Macuchi formation of Late Cretaceous and granitic rocks of Oligocene to Miocene that intruded into this formation.

Mineralization in this area can be broadly classified into three types that are porphyry copper type, vein type and hot spring type. Porphyry copper type mineralization occurs in granitic rocks and adjacent Macuchi formation, and vein type and hot spring type in Macuchi formation.

Mineralized zones found in El torneado, Osohuayco and Las Juntas belong to porphyry copper type, ones in El Cristal belong to vein type, and ones in Las Palmas and Cochapamba belong to hot spring type.

Porphyry copper type mineralization in El Torneado extend within 400 m x 400 m and contain five major mineralized zones trending NNW-SSE (named A to E from north to south), and width of which vary from 20 m to 70 m. These mineralized zones consist of bymodal occurrences of sulfide minerals and/or quartz: "dissemination" and "network". For ore minerals, pyrite, chalcopyrite, molybdenite, magnetite, scheelite and pyrrhotite are observed.

The results of drilling revealed that the mineralized zone A continues downward with dipping 60 degrees SE and swells in the depth, and also that a conceald underlying networked mineralized zone exists below the mineralized zone A. The assay of ore samples from the mineralized zones are as follows: 0.09 to 0.66 % Cu for zone A; 0.03 % Cu for zone B and D; and 0.01 to 0.36 % for underlying zone.

Magnetic susceptibility measurements detected low magnetic susceptibility anomalous zones related to demagnetization caused by mineralization over each mineralized zones. Of these anomalous zones, those discovered in El Torneado and Osohuayco mineralized zones are wide in scale.

Factor analysis of geochemical data identified the factors indicating Cu and Mo mineralizations in El Torneado, Osohuayco and Las Juntas mineralized zones.

As a result of the geophysical survey, low resistivity zones were obtained over mineralized zone and alteration zone. Particularly, interesting low resistivity zones were found at the lower parts of El Torneado and Osohuayco mineralized zones.

(2) El Torneado, Balzapamba area

Mineralization observed in the El Torneado zone is of the porphyry copper type, and is divided into two sub-zones on the basis of their modes of occurrence: namely, a "dissemination" zone and a "network" vein zone. The former extends over an area of about 400 m x 400 m. The latter is distributed within the former zone in the direction of NNE-SSW, at a scale of 40 to 70 meters in width and 70 to 350 meters in length. The two zones are distributed in the manner where the former zone is cut by the latter. The geologic age of mineralization is earlier in the former.

The dissemination zone extends from and around Mineralized zone B. The assay results of the samples taken therein show that the representative mineral in this zone is Cu with the maximum metal content of 0.03 %. The network vein zone corresponds to Mineralized Zones A, C, D and E. The representative mineral in these zones is also Cu. The maximum Cu contents are 0.66 % in Zone A and 0.03 % in Zone D.

The Phase II geophysical survey revealed the conditions of occurrence of sulfide minerals in the lower part of the mineralized zones. The geological and drilling surveys conducted in the mineralized zones in which Phase I had revealed the conditions of mineral occurrence horizontally and vertically, as well as the states of paragenesis and alteration of constituent minerals microscopically. Since the results of the Phase II drilling indicate that the lower limit of the network vein zone was penetrated and that of the disseminated zone was almost reached in this drilling, it may be assumed that the center of mineralization in the El Torneado zone had been subjected to erosion, exposing as a result the lower most part of mineralization on the existing ground surface.

(3) Osohuayco, Balzapamba area

Two types of mineralization were recognized in the Osohuayco zone Balzapamba area, one is mineralization in granodiorite and the other in Macuchi Formation.

In this survey area, two IP anomalies have been selected through Phase II geophysical survey. Outline of them is as follows:

1) Osohuayco North IP anomaly indicates an anomaly in granodiorite and a relationship with dissemination or network veinlets of chalcopyrite and pyrite, known as porphyry copper type mineralization (hereinafter refereed Osohuayco North mineralized zone).

2) Osohuayco South IP anomaly indicates anomalies found in grandioite, which was consid-

ered to be a part of porphyry copper type mineralized zone (hereinafter refers as Osohuayco South mineralized zone north side) and anomalies found in Macuchi Formation, which was considered to be skarn mineralized zone (hereinafter refers Osohuayco South mineralized zone south side) of dissemmination and networky thin veins of chalcopyrite and pyrite.

Osohuayco North mineralized zone

This mineralized zone distributed in an area of 900 m x 400 m.

Outcrops distributed in the eastern part of the mineralized zone show dissemination and veinlets of chalcopyrite and pyrite partly or entirely in the brecciated parts of granodiorite.

Characteristics of alteration are silicification and chloritization through outcrops. Silicification are recognized in two different forms: Secondary quartz shows chalcedonic one in the western part of the mineralized zone and crystalline in the eastern part. Quartz replaces rock forming minerals as segregated dots of secondary quartz.

Furthermore, Dissemination of chalcopyrite were recognized locally even in Macuchi Formation toward the eastern ridge and branch river, though only a few mineralized outcrops were available to observe because of weathering.
Assay results of chip sample from the eastern part of the mineralized zone were 1.18% Cu.

Pit survey was adopted to delineate the potential area between eastern and western mineralized outcrops. Each pit revealed limonite veinlets and such intense alteration as chloritization and argillization.

Results of chemical analysis for channel-samples showed 0.06% to 0.17%. These Cu-content values were high enough to distinguish anomalous zone from background (generally under 0.01% Cu.)

Osohuayco South mineralized zone

(North side)

Mineralized parts in granodiorite shows dissemination and veinlets of chalcopyrite and pyrite, and distributes in an area of 200 m x 300 m.

Chip sample from disseminated mineralized zone assayed and proved to be 0.08% Cu.

(South side)

Mineralized parts occurred in Macuchi Formation are mainly limited in siliceous fine tuff and medium to fine tuff. Several thin calcareous beds among these layers are recognized, a part of which is skarnized and accompanied by such sulfide minerals as chalcopyrite and pyrite. Some of these minerals occur in forms of dissemination such spotted or ameba like, and the other in forms of veins (10cm in width) of chalcopyrite-pyrite-calcocite-grossular-quartz.

The outcrops scattered in and along three branch rivers in the vicinity of drill hole site MJE-7. Two principal mineralized horizon are recognized and lower one may be more important with various thickness from 2m to 10m. Chip sample from the lower horizon assayed to be 2.60 % Cu. No mineralized outcrops were confirmed on the ridge between two outcrops.

Drilling survey (MJE-7) was carried out to confirm the IP anomaly (high resistivity and high FE). Drill hole encountered the calcareous fine tuff bed of Macuchi formation at the depth that was estimated by geological mapping and intersected a part of skarnigation. No sulfide mineralization, however, were observed in the calcareous and skarnized part of the drill hole core.

The mineralized zone confirmed by the drill hole core was thought to correspond approximately to IP anomaly (high resistivity and high FE) delineated in Macuchi Formation. The mineralized part showed dissemination actually in the hornfels from andesite mineralyzed zone, which was considered to be principal, were not accompanied by skarn minerals. Therefore, the mineralization should be a porphyry copper type, and the actual mineralized part could be considered to be a extended part of porphyry copper type mineralized zone.

Mineralized zones distributed in the survey area are arranged, macroscopically, in the N-S direction. El Tornedo mineralized zone, Osohuayco North mineralized zone and Osohuayco South mineralized zone, for example, distribute on the straight line from north to South . A N-S fault is recognized,macroscopically, in the western fringe of El Torneado mineralized zone and two other N-S faults are estimated to the west of Osohuayco North mineralized zone.

As the survey result in Osohuayco zone of Balapamba area, no sulfide mineralization in the calcareous beds and the mineralized zone corresponding to IP anomaly in the deep of Macuchi Formation were assayed and revealed to be low grade such as 0.05% Cu in average.

Therefore, the surveyed area has low priority and requires no further exploration.

5-1-2 Chaso Juan area

Mineralization observed in the Chaso Juan area is of the porphyry copper type, and is grouped into four zones: namely, the North zone, the West zone, the South zone, and the Central zone.

In the North zone, mineralized zones are recognized at three locations, each of which extends at a width of 10 to 15 meters and is distributed at an interval of 400 meters. The assay results of the samples taken from one of the three locations are 1.3 g/t in Ag and 0.10 % in Cu.

The West zone is distributed at an approximate width of 25 meters. The assay results of the samples taken from this zone are 0.1 g/t in Au and 1.7 g/t in Ag and 0.24 % in Cu.

In the Central zone, mineral showings are recognized at 11 locations which are distributed sporadically over an area of 600 m x 400 m. The size of the major showing is about 150 meters in length. The assay results are 0.1 g/t in Au, 4.2 g/t in Ag, and 1.41 % in Cu.

The South zone extends over an area of 800 m x 300 m, and is subdivided into the eastern and western parts. The eastern part extends over a length of about 300 meters. The assay results of the samples taken therein are 0.1 g/t in Au, 7.6 g/t in Ag, and 1.46 % in Cu. In the western part, there are two stripes of veinlet extending at a width of 1 to 10 centimeters.

From the viewpoint of mineral exploration, the most significant zone in the Chaso Juan area is that which extends from the Central zone to the South zone, where the geophysical survey revealed the possible existence of IP anomaly sources, indicating the possibility of the known mineralized zone being larger than is currently recognized.

5-1-3 Telimbela area

(1) Telimbela area

The porphyry copper type mineralization observed in the Telimbela area is the largest in scale in the entire Bolivar area, and its strong mineralization extends to the Macuchi Formation. Centering around each of the seven mineralized locations within this area, pyrite dissemination and veinlets are widely distributed in granitic rocks. In terms of mineral exploration, abundance of pyrite is quite significant because it means that there had been active hydrothermal activities in this area. Macroscopically, the seven mineralized zones in this area, which are generally arranged in the NE-SW direction, are grouped into the Central, South and North zones.

In the Central zone are distributed Mineralized Zone I and II. The former extends over an area of 500 m x 350 m, and the latter over an area of 200 m x 400 m. The assay results are 1.6 % maximum Cu content in Zone I, and 0.2 g/t, 1.6 g/t and 0.16 % of Au, Ag and Cu respectively in Zone II.

In the South zone are distributed Mineralized Zones III, IV and VII. Zone III extends over an area of 400 m x 900 m, Zone IV over a length of about 150 m, and Zone VII over a length of about 200 m. In every zone, maximum Cu content is 0.05 %.

In the North zone are distributed Mineralized Zones V and VI, which are new zones found in the Phase II survey. The former extends over an area of 400 m x 1,200 m, and the latter over a length of about 400 m. Maximum Cu contents are 0.8 % in Zone V and 1.65 % in Zone VI.

In these mineralized zones, many intrusive rocks are distributed in the direction of NE-SW. In the same direction, there is a geotectonic line continuing from the central part of Ecuador to the northern part and cutting across northern area. This suggests a close correlation between the development of this tectonic line and the igneous and hydrothermal activities in this area.

(2) Northeast zone, Telimbela area

The type of mineralization of the surveyed area is porphyry copper type which distributes around Ashuaca and is recognized not only in granitic rocks but also in Macuchi Formation.

Mineralized zones are confirmed in an area of 1.5km x 1.0km along Ugshacocha and Ashuaca branch rivers (hereinafter refers Northeast mineralized zone). Especially intense mineralized parts within the Northeast mineralized zone is delineated as an area of 400m X 600m in the central part of the surveyed area and named "Ashuaca mineralyzed zone".

"Ashuaca mineralized zone", which is composed of chalcopyrite and pyrite, occurs in forms of dissemination and network veinlets not only in granitic rocks but also in Macuchi Formation. Molibdenite is also recognized locally in the mineralized zone.

Outer part of the Northeast mineralized zone dominates dissemination and networky veinlets of pyrite mineral only. Amount of pyrite in the disseminated mineralyzed zone is greater in southern fringe than in any other parts.

Drilling survey (2 holes) were carried out to "Asuhuaca mineralized zone". The results of the 2 holes are as follows:

In MJE-8 hole, considerable amount of chalcopyrite are observed even in naked eyes from the surface to the bottom. A assay result is as follows: from 21 to 102 m ; core length 81m; tr to 6.0 g/t of Ag; 0.02 to 0.72 % of Cu, average 0.468 % of Cu.

Intensely Cu-mineralized part of the hole are recogniged not only where the host rock contains a number of brecccias of Macuchi Formation but also where the host rock is brecciated itself completely. Cu-mineralization is confirmed to continue down to the bottom of the hole.

In the MJE-9 hole, large amount of pyrite and small amount of chalcopyrite are observed in naked eyes throughout the hole. A assay result is as follows: from 80 to 105m; core length 25m; tr to 2.6 g/t of Ag; 0.10 to 0.33 % of Cu, average 0.229 % of Cu.
from 124 to 161m: core length 37m; 0.1 to 4.7 g/t of Ag; 0.08 to 0.55 %oof Cu, average 0.207 % of Cu.

Comparatively, mineralization of drill hole MJE-8 is more intense than that of MJE-9. The reason of which may be that the hole MJE-9 shows less brecciation and includes only a few fragment or breccias of the country rocks.

Deformed rock forming minerals are, however, recognized in both holes under microscopic observation.
Intensely mineralized parts are observed in the zone of the intense propilitization.
Mineralization of chalcopyrite, pyrite and molibdenite continues vertically down to the bottom of each hole, MJE-8 and 9, it means that mineralization continues downward at least 180m below the river floor of Q.Ugshacocha where "Ashuaca mineralized zone" is centered.

5-1-4 La Industria-Yatubi area

Mineralization observed in this area is of two types: namely, hot-spring type Au mineralization and porphyry-copper type mineralization. In the former type of mineralization, a white argillized zone (kaolin) and a silicified zone are distributed in the lower and upper parts respectively. Across the two zones, network veins are recognized, which consist of metallic sinter-acicular minerals-hematite-quartz-kaolin. The assay result shows the maximum Au content of 0.3 g/t. The silicified outcrops are recognized only at the top of mountains (Cerro Barranco Amarillo and Caimito South), the silicified zone turns downward to the kaolinized zone which were observed below the mountaintop. The silicified zone is, therefore, considered to be eroded largely, and the silicified parts at the mountaintop to be the relics of the lower part of the silicified zone.

An alteration zone, which consists of sericitization and weak silicification, is also accompanied by pyrite. This alteration is probably associated with the porphyry copper type mineralization in the northern part of the area.

5-1-5 Las Guardias area

Mineralization of the porphyry copper type is recognized at 12 locations, all of which are distributed along melanocratic diorite intrusive rocks and a fault in the direction of NW-SE. This direction is in a marked contrast to the NE-SW direction of the mineralization zones and intrusive rocks in other areas.

In the Angas North mineralized zone, mineral showings are sporadically distributed over an area of 250 m x 500 m. Maximum Cu content is 0.35 %. In the North zone, mineral showings are sporadically distributed in the direction of NW-SE over an area of 100 m x 400 m. Maximum Cu content is 0.04 %. These zones are distributed discontinuously.

5-1-6 Other areas

(1) Tres Hermanas area

The geology of this area consists of alternation of basalt lava (Ba), basaltic andesite (Ban) and fine-grained tuff of Macuchi Formation.

Mineraization are recognized only in the form of dissemination and thin vein of chalcopyrite and pyrite in basaltic andesite lava. However, they are small in scale and low in grade.

(2) San Miguel area

The basement of this area is the Macuchi Formation composed of andesite lava, its pyroclastic rocks (An) and quartz-bearing andesite lava (Qan). Lourdes volcanic rocks (Da, Cgl) comprising dacite and its pyroclastic rocks are of Pliocene to Pleistocene in age and distributed over this basement.

Mineralization in this area occurs in the fault zone mentioned above. Mineralized zones are distributed as echelon in the fault zone of about 100 m in width.The mineralization recognized in the area show two forms: One is chalcopyrite-pyrite networked quartz vein, the other hematite-silica sinter-networked quartz veins which is considered to be hot spring type.

A mineralized zone with sulfide minerals is well observed in dacitic tuffs of the Lourdes Volcanic Rocks intercalating argillaceous patch of pumice. This mineralized zone can be traced in NNW-SSE direction for about 250 m. Analytical results of chip samples collected from this area showed low in grade, as 0.01 % Cu.

Adding these an alteration of host rock is observed, which is mainly consisted of silicification and accompanied by sericitization and chloritization.

(3) Sicota area

Tertiary granodiorite batholith (Gd) is distributed throughout the area. Conglomerate bed of Quarternary covers this rock.

Mineralization in the form of pyrite dissemination are recognized in in altered granodiorite, and those in the form of pyrite-clay in conglomerate. Interstices of these conglomerate formation filled with fine-grained pyrite and white clay.The mineralized zone is small in scale and low in grade.

(4) Tambillo area

The almost all the area is underlain by volcanic rocks of the Macuchi Formation. small dykes of granite porphyry.

Three local mineralized zones are recognized:

One is dissemination of chalcopyrite and pyrite in the granite porphyry dyke and enclosing silicified andesite lava. It can be pursued for about 200 m along Palmar valley. The other two zones are along Placer valley and distribute as dissemination zone of chalcopyrite and pyrite hosted by silicified andesite with an extension of nearly 100 m; and as sparse dissemination of pyrite in silicified andesite, which extends for about 300 m. each mineraized zone is small in scale and low in grade.

(5) Tablas Pamba area

Andesitic volcanic rocks spread over throughout the area. A small diorite stock is exposed only near the northeastern corner of the area.

Chalcopyrite-pyrite dissemination zones, which are hosted by andesite, are recognized with an extension of 300 m x 250 m in the western part of the area. And pyrite dissemination zones are recognized also in an area of 200 m x 500 m in the northern part. Each mineralized zone is small in scale and low in grade.

(6) Balaron area

The area is underlain by volcanic rocks of the Macuchi and Alausi Formations.

The Macuchi Formation occupies most part of the surveyed area and is composed of basalt lava (Ba), and andesite lava (An). The porphyritic andesite lava (Po) of the Alausi Formation overlies on the Macuchi Formation unconformably.

Mineralization in the area is represented by a quartz vein observed at 800 m west of Remigon village and malachite dissemination in a basalt float obtained at the village.

Each mineralized zone is small in scale and low in grade.

(7) Chilcales Alto area

The area is underlain by volcanic rocks of the Macuchi Formation. The Macuchi Formation is comprised mainly of brecciated andesite lava (An) with intercalations of andesitic tuff (Tf) and basaltic andesite flows (Ban).

Dissemination and network of pyrite are recognized in the southern part of the area. Each mineralized zone is small in scale and low in grade.

5-2 General discussion

5-2-1 Characteristics of igneous activities and mineralization

Igneous activities recognized in Project area, Bolivar Province in Ecuador, are as follows: Macuchi Formation of Marine sediments and Pyrocrastics in Late Cretaceous was deformed by Andean Orogeny movement during the period from Eocene through Oligocene. Activities of Plutonic rocks intruded in the period from Oligocene through Miocene is charatcerized that each intrusive body is arranged in the N-S direction.

Age determination of intrusive rocks revealed that Granodiorite botholith in balzapamba area be 20 to 30 Ma, Quartzdiorite in Telimbela area be 19 to 20 Ma, and such dike or stock as melanocratic quartzdiorite, hornblende quartzdiorite and porphyritic quartzdiorite be 15 to 18 Ma.

Hydrothermal activities in the surveyed area are recognized intermittently in the period between Miocene and Pleistocene. The activities are grouped into 3 stages:

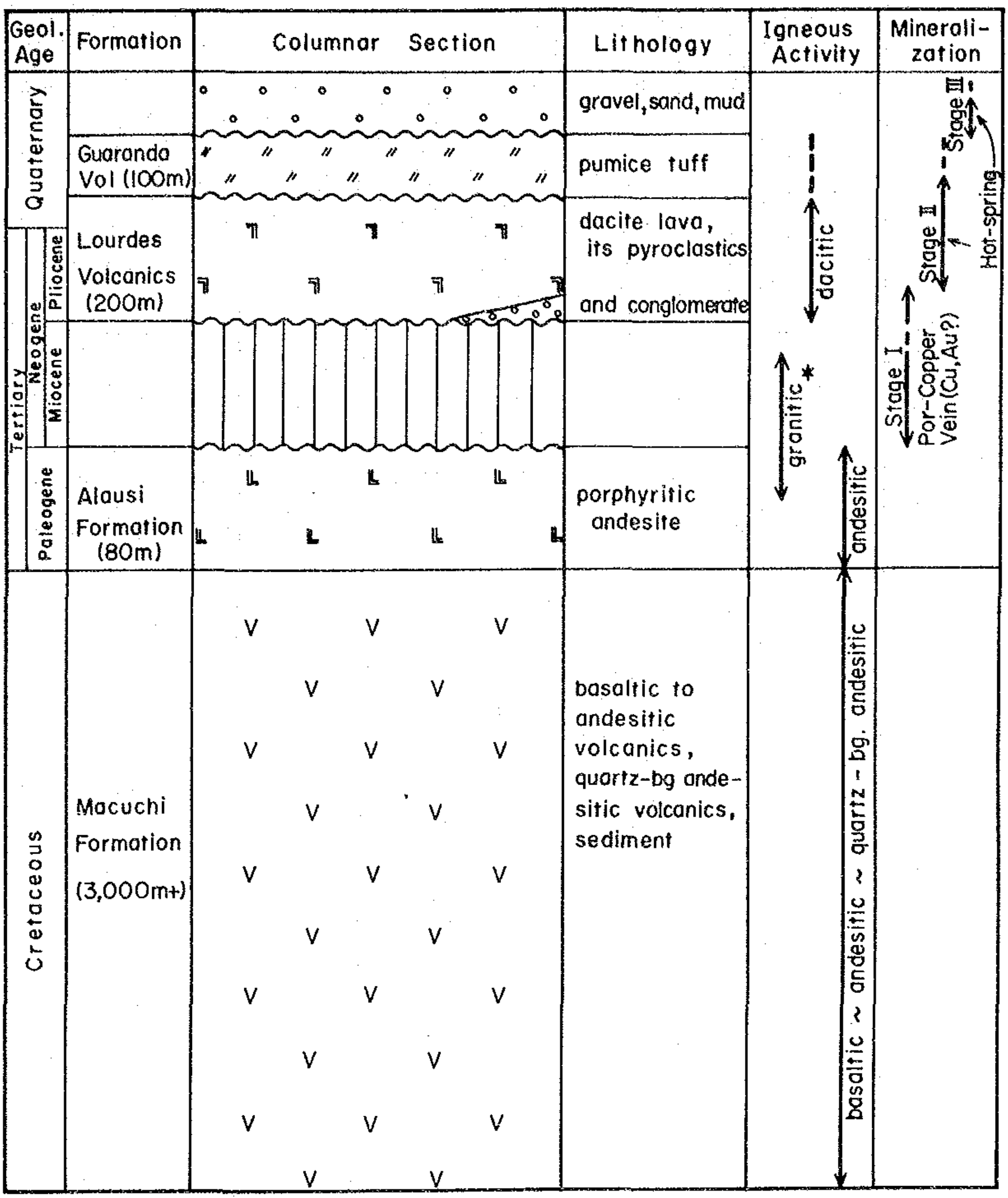
1st stage: activities with sulfide minerals in the peiod between Miocene and Pliocene (all of the ignerous activities mentioned above are included in this stage)

2nd stage: activities with acidic alteration and accompanying hematite in the period between pliocene and pleistocene.

3rd stage: activities with acidic alteration only in the period of Holocene.

Three types of mineralization are recognized in the Bolivar Project area; they are porphyry copper type, vein type, and hot spring type.

Generalized stratigraphy of the project area is shown in Fig.I-5-1 and summary results on both surveyed area, Osohuayco zone of Balzapamba area and Northeast zone of Telimbela area, are listed on Table I-5-1.



*Las Guardias batholith (25.7 ± 0.9 Ma) (30.1 ± 1.1 Ma)
Chaso Juan batholith (20.9 ± 0.7 Ma)
La Industria batholith (25.5 ± 0.9 Ma)
Telimbela batholith (19.4 ± 0.6 Ma)

Fig. I -5-1 Generalized stratigraphy of the project area

Table I-5-1 Summary of survey results with mineral showings (1)

(1)

Type of Survey	Name of Area Invesigated	Area (Km^2)	Geology	Mineralization						Assay Results							Evaluation
				Name of Zone	Type (Occurrence)	Lateral Extension	Ore Minerals	Host Rock	Alteration	Au (g/t)	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)	Mo (%)	W (%)	
Detailed Survey	Balzapamba	36.0	Macuchi Formation of andesite, q-andesite and their pyroclastics, minor calcareous sediments; hornfels near granodio Intrusives of: leuco bio-hb-granodio melano dio trachyande	El Torneado	Por. Cu (network) (diss)	400x400m	Py, Cp, Moly, Po, Mg, Shee,	granodio, hornfels	sil, biotite, argill, chl	0.2 0.1 Tr Tr	2.0 7.7 Tr 1.6	0.66 0.43 0.17 0.05	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.05	0.01 0.42 0.01 0.31	0.00 0.00 0.06 0.05	required further exploration work (geophy, drilling)
				Osohuayco	Por. Cu (diss)	300x100m	Py, Cp, Moly	granodio, hornfels	sil, chl	Tr	Tr	0.08	0.00	0.00	0.00	-	required further investigation (geolo, geophy)
					Por. Cu-Skarn (vein) (NE-SW/35°S)	350m long 10m wide (max)	Cp, Py, Moly Bn	hornfels	sil, skarn	0.4	27.8	2.60	0.00	0.10	0.00	0.00	
				Las Juntas	Por. Cu? (diss)	very local	Cp, Py,	granodio	sil, argill								very poor interest (no further work)
					Vein (network)	10m wide	Py, lim,	hornfels		0.1	1.1	0.11	0.00	0.03	0.00	-	
				El Cristal	Vein (N80°W/86°S)	30m (+) long, 17m wide	Py, (Cp)	hornfels	sil, argill, chl,	0.1 Tr	2.1 Tr	0.16 0.11	0.00 0.00	0.03 0.00	0.00 0.00	- 0.00	poor interest (no furter work)
				Las Palmas	Hot spring? (diss) (network)	2km wide	Py with rare Cp	hornfels, volcanics	extensive sil, argill, chl	0.3	7.6	0.60	0.00	0.01	0.00	0.00	poor interest (no furter work)
				Cochapamba	Hot spring	-	-	volcanics	extensive sil,								very poor interest (no further work)

(Detailed survey area in Phase I)

Table I-5-1 Summary of survey results with mineral showings (2)

Type of Survey	Name of Area Investigated	Area (km^2)	Geology	Name of Mineralized Zone	Occurrence	Mineralization: Lateral Extension	Mineralization: Ore Minerals	Host Rock	Alteration	Assay	Au (g/t)	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)	Mo (%)	Evaluation
				Northern part	Vlet and/or diss (Por-Cu)	L W (?) x 400m											
Detailed	Chaso Juan	15	Macuchi Formation:	Central part	Vlet and/or diss	600 x 400m	Cp, Mo, Py	Gd	wh. arg.	A2011	0.1	0.6	0.13	0.00	0.00	0.00	– Mineralization, which was selected and
			hornfels, andesites		(Por-Cu)				sil	A2015	0.2	1.1	0.33	0.00	0.01	0.00	discussed in the first phase report, has
Geological			& tuff breccias						chl.	A2017	0.1	4.2	1.41	0.00	0.01	0.05	been also proved to be limited in the
										B2002	0.1	1.7	0.24	0.00	0.01	0.00	central part of the survey area.
Survey			Intrusive rocks:	Southern part	Vlet and/or diss	800 x 300m	Cp, Mo, Py	Gd	sil	C2006	Tr	Tr	0.04	0.00	0.00	0.00	Geophysical investigation (IP method)
			(1) Bi-Ho granodio-		(Por-Cu)				chl.	C2009	Tr	1.0	0.24	0.00	0.00	0.00	will be required to test mineral
			rite							C2010	Tr	Tr	0.02	0.00	0.00	0.00	extension horizontally and vertically.
			(2) Melanocratic	Western part	do.	(?) x 200m	Cp, Mo, Py	Gd	sil	C2011	Tr	Tr	0.01	0.00	0.00	0.00	
			diorite							D2008	Tr	Tr	0.01	0.00	0.00	0.00	
Detailed	Telimbela	9	Macuchi Formation:	Zone I	Vlet and/or diss	L W 500 x 350m	Cp, Py, (Mo)	Qd	sil chl	A2024	Tr	0.6	0.04	0.00	0.01	0.00	– Cu-mineralization recognized in
			hornfels & basaltic	Zone II	(Por-Cu)	400 x 200m	Cp, Py, Mo	Qd & Horn	sil chl	A2026	0.2	1.6	0.16	0.00	0.01	0.00	extended area.
Geological			andesite	Zone III		900 x 400m	Py	Qd	sil chl	A2030	0.1	0.9	0.12	0.01	0.01	0.00	(NE-SW direction)
				Zone IV		(?) x 400m	Cp-Py-Mo	Qd	sil chl	A2033	0.1	9.5	0.80	0.01	0.03	0.08	
Survey			Intrusive rocks:							A2035	0.2	5.6	0.47	0.00	0.02	0.00	– Three zones of mineralization are
			(1) Bi-Ho q-diorite	Zone V		1200 x 400m	Cp, Py	Qd & Horn	sil chl	A2041	0.3	5.8	1.65	0.00	0.02	0.05	picked up in 1989. Two of three are
			(2) (Bi)-Ho							A2043	0.2	2.7	0.53	0.00	0.01	0.01	significant mineralization.
			q-diorite	Zone VI		(?) x 400m	Cp, Py	HQd	sil chl	A2045	Tr	1.0	0.13	0.00	0.01	0.00	– Further investigation.
			(3) Ho q-diorite							A2046	0.4	4.2	1.23	0.00	0.01	0.00	
			(4) Melanocratic	Zone VII		(?) x 100m	Cp, Py	Qd	sil chl	B2020	Tr	Tr	0.09	0.00	0.01	0.00	
			diorite							B2021	Tr	Tr	0.08	0.00	0.01	0.00	
			(5) Porphyritic							B2022	Tr	Tr	0.08	0.00	0.01	0.02	
			q-diorite														
			(6) Q porpyry														
Detailed	La Industria-Yatubi	8	Macuchi Formation:	C.B.Amarillos	Goss	L W	Hm-Q-clay	Qd	sil arg	A2068	Tr	Tr	0.00	0.00	0.00	0.01	– Further investigation.
			none		(Hot Spring)	500 x 300m				A2071	Tr	Tr	0.02	0.01	0.00	0.00	
Geological &										A2072	Tr	Tr	0.01	0.00	0.00	0.00	
			Intrusive rocks:	Caimito South	Goss	400 x 200m	Hm-Q	Qd	sil arg	C2029	Tr	Tr	0.00	0.00	0.00	0.02	
Geochemical			(1) q-diorite		(Hot Spring)					C2033	Tr	Tr	0.00	0.00	0.00	0.01	
			(2) melanocratic							E2027	Tr	Tr	0.01	0.01	0.00	0.00	
Survey			diorite							E2028	Tr	Tr	0.01	0.00	0.00	0.00	
Detailed	Las Guardias	13	Macuchi Formation:	Northern part	Vlet and/or diss	L W 400 x 100m	Cp, Py, Mo	Melano Dio	st. sil	A2080	0.2	2.1	0.47	0.00	0.01	0.00	– No further investigation.
			hornfels,		(Por-Cu)			Ande. or Horn		A2091	Tr	Tr	0.04	0.00	0.01	0.00	
Geological			q-andesite,							C2037	Tr	Tr	0.05	0.00	0.00	0.00	
			andesite & pyro-	Center part		350 x 50m	Cp, Py	Gd	sil	C2041	Tr	Tr	0.08	0.00	0.01	0.00	
Survey			clastics						arg	C2043	0.2	8.3	0.35	0.00	0.00	0.79	
										C2044	Tr	2.0	0.26	0.00	0.01	0.04	
			Intrusive rocks:	Southern part		400 x 10?m	(Cp, Py)	Gd & melano Dio	st. sil	D2035	Tr	Tr	0.00	0.00	0.02	0.00	
			(1) granodiorite							D2043	Tr	Tr	0.02	0.00	0.00	0.00	
			(2) melanocratic diorite														
			(3) porphyritic q-diorite	Angas-north		500 x 250m	Cp, Py	Gd & melano Dio	sil								

(Detailed survey areas in Phase II)

Gd: granodiorite, Dio: diorite, Qd: quartz diorite, melano Dio: meranocratic diorite, HQd: hornblende quartz diorite, Horn: hornfels,
Vlet: veinlet, diss: dissemination, Goss: gossan, wh.: white, arg.: argillized, chl.: chloritized, sil.: silicificated, Cp: chalcopyrite,
Mo: molybdenite, Py: pyrite. St.: strong, (Por-Cu): porphyry copper type mineralization, (Hot Spring): hot spring type gold mineralization

Table I-5-1 Summary of survey results with mineral showings (3)

Type of Survey	Name of Area Investigated	Area (Km2)	Geology	Mineralization: Name of Zone	Type	Lateral Extension	Constituent Minerals	Host Rock	Alteration	Assay Results: Au (g/t)	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)	Mo (%)	W (%)	Evaluation
Detailed	Osohuauco	10	Macuchi Formation of	North	diss	900mx400m	Cp,Py,Mo	Gd	Sil	0.2	13.1	4.89	0.00	0.03	0.00	—	Required further
Survey	of		andesite, q-andesite						arg.	Tr	Tr	0.55	0.00	0.01	0.00	—	investigation
	Balzapamba		and their pyroclastics,		film				Bio	0.5	4.1	0.41	0.00	0.00	0.01	—	by meam of
			thin calcareous beds,						Chl.	0.2	6.5	1.18	0.00	0.01	0.01	—	Drilling survey
			hornfels near grano-														
			diorite.														
				South	diss	200mx300m	Cp,Py	Gd	Sil	Tr	Tr	0.08	0.00	0.01	0.01	—	
				(N-side)	film		(Mo)	Horn									
			Intrusire rock of														
			melanocratic grano-														
			diorite.	(S-side)	diss	300m long &	Cp,Py,Mo,Bn	f,Tf	Sil	0.4	27.8	2.60	0.00	0.10	0.00	0.00	
					film	10m wide			Cal	Tr	Tr	0.05	0.00	0.00	0.00	0.00	
Detailed	Northeast	9	Macuchi Formation of	Ashuaca	diss	400mx600m	Cp,Py,Mo	HQd	Sil	0.2	6.1	1.38	0.00	0.02	0.08	—	Required further
Survey	of		andesite and its pyro-		film			Qd	Prop	Tr	3.6	0.71	0.00	0.01	0.01	—	investigation
	Telimbela		clastics;		patch			Horn	Bio	0.1	10.4	0.86	0.00	0.02	0.01	—	by means of
			hornfels near quartz-						Epi	Tr	6.1	0.76	0.00	0.02	0.01	—	Drilling survey
			diorite						Chl	0.2	2.1	0.89	0.00	0.00	0.02		
				ZoneV	diss	1.5kmx1.0km	Cp,Py,Mo	Qd	Sil	0.2	7.5	0.78	0.01	0.07	0.00	—	
				and VI	film			Horn	Rio	Tr	Tr	0.14	0.00	0.00	0.00	—	
					(patch)			Melarro	Epi	Tr	Tr	0.58	0.00	0.01	0.01	—	
									Chl								

(Detailed survey areas in Phase III)

Table I -5-1 Summary of survey results with mineral showings (4)

Type of Survey	Name of Area Investigated	Area (Km2)	Geology	Mineralization						Assay Results							Evaluation
				Name of Zone	Type	Lateral Extension	Constituent Minerals	Host Rock	Alter-ation	Au (g/t)	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)	Mo (%)	W (%)	
Semi-detailed Survey	Tres Hermanas		Macuchi Formation of basalt, andesite and pyroclastics		(diss)	very local		Ande		0.1	4.6	0.03	0.00	0.00	0.00	-	No interest (no further work)
	San Miguel		Macuchi Formation of andesite, qtz-andesite Laurdes Volcanics of dacite and pyroclastics Guaranda Volcanics of pumice tuff		Vein Hot spring (diss and vein)	Local zones along NW-SE fault (within 1.4km)	Cp, Py	Laurdes VolCANICS	sil, strong argill (kao, pyrophy)	Tr Tr	Tr Tr	0.01 0.00	0.00 0.00	0.06 0.00	0.00 0.00	- -	Required further investigation (as hot spring type Au Mineralization)
	Sisota		granodio		(diss)	30m wide	Py	Granodio	sil, argill	0.2	3.9	0.09	0.01	0.01	0.00	-	No interest (No further work)
	Tambillo		Macuchi Formation of andesite and their pyroclastics, qtz-andesite, granite porphyry dyke	West of Tablas Pamba	(diss)	3 small, localized	Cp, Py	Andesite	sil, chl	Tr	Tr	0.07	0.00	0.02	0.00	-	Poor interest (no further work)
	Tablas Pamba		Macuchi Formation of basalt, basaltic andesite and their pyroclastics partially hornfels Small stock of diorite	West of Tablas Pamba Others	(diss) (diss)	300x250m verly localized zones	Cp, Py Py, minor, Cp	Hornfels, basalt, basaltic ande	sil, chl	Tr	Tr	0.02	0.00	0.01	0.00	-	Poor interest (No further work)
	Balaron		Macuchi Formation of basalt, basaltic andesite andesite Alausi Formation of por ande		(diss/vein)	very local	Py, malachite	Basalte, andeSITE	sil, chl	0.1	7.3	1.47	0.00	0.01	0.00	-	No interest (No further work)
	Chilcales Alto		Macuchi Formation of basalt, basaltic ande, andesite and their pyroclastics		(diss and network)	very local	Py	Andesite	sil, chl	Tr	Tr	0.01	0.00	0.03	0.00	-	No interest (No further work)

(Semi-detailed survey areas in Phase I)

5-2-2 Possibilities of locating ore deposits

The mineralization on both surveyed areas are porphyry copper type. Possibilities of locating ore deposits is higher in Northeast zone of Telimbela area than in Osohuayco zone of Balzapamba area.

The mineralized zone in Northeast, Telimbela area is extensive and of high grade of metal contents which is proved by assaying chip samples obtained from mineralized outcrops. Drilling survey has revealed that chalcopyrite dissemination zone continues down to the depth, from surface to the bottom of each hole.

Moreover, mineralized zone is considered to be extensive horizontally, mineralization confirmed by drill holes, therefore, may be important indication for further exploration. Followings are the order of mineralized zones in the view point of potentiality.

1) "Ashuaca mineralized zone"

(corresponds to a part of IP anomaly A) (400 m X 600 m)

-a number of mineralized outcrops of chalcopyrite and pyrite are confirmed through detailed geological survey.

-IP anomaly (low resistivity and high FE) is delineated by IP method electrical survey

-mineralized parts are confirmed to be continue to the depth by drilling core.

2) Ugshacocha mineralized zone

(corresponds also to a part of IP anomaly A) (300 m X 500 m)

-Intense pyrite mineralization accompaning chalcopyrite is recognized through geological survey

-This mineralized zone is considered to be the other part of "Ashuaca mineralized zone", because IP anomaly shows these two mineraiized zones as a continuous one anomaly.

3) Las Tre Cruces mineralized zone (100 m X 500 M)

This mineralized zone situates about 600 m western northwest of Ashuaca school.

- Intense pyrite mineralization accompaning chalcopyrite is recognized through detailed geological survey.

-This mineralized zone is delineated by IP method electrical survey as a elongated anomalous zone of low-resistivity and high FE in the NNE-SSW direction.

And following is another potential area selected in Osohuayco zone, Balzapamba area.

4) Osohuayco North mineralized zone (corresponds to a northeast end of IP anomaly 1) Mineralization of chalcopyrite and pyrite is confirmed in the east side and west side of this mineralized zone through detailed geological survey.
-IP anomaly (low resistivity and high FE) is delineated at the near surface by IP method electrical survey.

5-2-3 Evaluation of survey methods

(1) Magnetic susceptibility measurement

Through Phase I and II survey, magnetic susceptibility measurement proved that demagnetization accompanying mineralization was distinguishable from the variety of its value depend on the difference of rock type. Range of magnetic susceptibility value for each rock type is as follows:

Granodiorite: from 20 to 60 X 10^{-3} SIU; Melanocratic Quartzdiorite: from 40 to 156 X 10^{-3} SIU; Andesite of Macuchi Formation: from 50 to 70 X 10^{-3} SIU; Tuff and sedimentary rocks: under 10 X 10^{-3} SIU. While, Intense mineralized zone: from o.1 to 20 X 10^{-3} SIU; Weak mineralized zone: from 10 to 40 X 10^{-3} SIU.

The survey areas for Phase III were selected on the results of the criterion mentioned above, general tendency of demagnetization is not clear whithin the surveyed area. Fractuation of measured value are distinctive depend on the position of a single outcrop. Magnetic susceptibility measurement is apparently useful to delineate and select potential area in the early atage of exploration for mineral deposits which are considered to be accompanying demagnetization. Especially, this survey method presents that mineralized zone could be treated and selected semi-quantitatively for field consideration in the early atage of exploration.

For further adaptability, it would be desirable to clarify conditions of demagnetization and to consider wheather or not condition of demagnetization of individual outcrops be recognizable.

(2) Geochemical survey

Soil geochemical exploration was conducted in the La Industria-Yatubi area. Anomalous zones delineated by univariate analysis and the high to moderate score zones of the two factors detected by multivariate (factor analysis) were closely examined to extract most significant geochemical anomalous zones. As a result, anomalous zones, particularly those associated with Au, As, and Hg anomalies, were distributed in and around the outcrops of hot spring type mineralization and their boulders.

(3) Bore hole IP method electric exploration

Bore hole IP method electric exploration was conducted with three pairs of electrodes in different configurations, one pair of electrodes are fixed inside the bore hole MJE-1, in order to detect IP anomalous zones at different depths. Sulfide zones, which are confirmed at the lower part of the outcrops or on drill cores as the concealed mineralized zone, generally coincided with the plane distribution patterns of IP anomaly at each depth. This method indicates applicable, therefore, to the porphyry copper type of mineralization though it is accompanied, comparatively, with a small amount of sulfide minerals.

In case of the surface electrode and remote electrode configuration, this survey method was subject to the similar topographic influence as the usual IP survey method. In case of the down hole electrode and remote electrode configuration, however, it should be noted that in steep places where the distances between current and potential electrodes are almost the same, measured values of electric potential become inevitably small, making the data obtained thereby less reliable.

(4) IP method electric exploration

IP method electric exploration was carried out in Northeast,Telimbela area. In the survey area common combinations of anomalies are high resistivity and low FE, or low resistivity and high FE.

This means that the more argillized zone would be the more mineralized zone. Mineralized zone can be detected out as a IP anomaly of low resistivity and high FE. The topography of the surveyed area is so rugged and steep that the S/N was recognized to be decreased, especially signal was weak near the valley. Furthermore, dependability of information for the depth may be decreased by the influence of electro-magnetic coppling or of artifitial structure.

Therefore, these conditions were taken into account for analysing data at the depth. As the result of such consideration, geophysical analysis on IP data is able to clarify the situation of sulfide minerals at the depth correctly. IP method electric exploration was proved to be very effective mean as a exploration means.

Chapter 6 Conclusion

6-1 Conclusions

(1) Balzapamba area

1) Balzapamba area

The geology of this area consists of the Macuchi formation of Late Cretaceous and granitic rocks of Oligocene to Miocene that intruded into this formation.

Mineralization in this area can be broadly classified into three types that are porphyry copper type, vein type and hot spring type. Porphyry copper type mineralization occurs in granitic rocks and adjacent Macuchi formation, and vein type and hot spring type in Macuchi formation.

Mineralized zones found in El torneado, Osohuayco and Las Juntas belong to porphyry copper type, ones in El Cristal belong to vein type, and ones in Las Palmas and Cochapamba belong to hot spring type.

El torneado and Osohuayco zones are investigated in detail separately, therefore they are described in other sections.

Las Juntas: chalcopyrite-pyrite dissemination ingranodiorite and quartz diorite and pyrite-quartz networked veins in Macuchi formation. Each mineralized zone is small in scale.

El Cristal: pyrite-limonite-chalcopyrite-quartz vein in Macuchi Formation with the strike of E-W, width of about 17 m, and length of about 30 m. The mineralized zone is small in scale.

Las Palmas and Cochapamba: both alteration zones extend widely, resulted from acid alteration (quartz-kaoline-halloysite) relating to hot spring period. Dissemination of pyrite or hematite-quartz-clay veins are recognized locally. As a whole mineralization is weak.

2) El Torneado zone, Balzapamba area

Mineralization observed in the El Torneado zone is of the porphyry copper type, and is divided into two sub-zones on the basis of their modes of occurrence: namely, a "dissemination" zone and a "network" vein zone. The former extends over an area of about 400 m x 400 m. The latter is distributed within the former zone in the direction of NNE-SSW, at a scale of 40 to 70 meters in width and 70 to 350 meters in length. The two zones are distributed in the manner where the former zone is cut by the latter. The geologic age of mineralization is earlier in the former.

Mineralized zone is generally low in grade. The geological and drilling surveys had revealed the conditions of mineral occurrence horizontally and vertically, as well as the states of paragenesis and alteration of constituent minerals microscopically. Since the results of the Phase II drilling indicate that the lower limit of the network vein zone was penetrated and that of the disseminated zone was almost reached in this drilling, it may be assumed that the center of mineralization in the El Torneado zone had been subjected to erosion, exposing as a result the lower most part of mineralization on the existing ground surface. The mineralized zone, therefore, may not be the potential target area of a mine.

3) Osohuayco zone, Balzapamba area

The geology of the area consists of Macuchi Formation and granodiorite which intruded into Macuchi Formation.

Two mineralized zones are recognized in this area, one is Osohuayco North mineralized zone and the other Osohuayco South mineralized zone. Drilling survey was carried out to disclose geological and mineralogical conditions of the IP anomaly which showed high apparent resistivity and high FE (more than 5 %) around the Osohuayco South mineralized zone, as a result of previous year geophysical survey. Any mineralization, however, associating with skarnization was not encountered. Drill hole intersected disseminated mineralized zone of chalcopyrite and pyrite in hornfelsinized andesite of Macuchi Formation (AAn). The assay discolsed the grade of the minerqlized zone to be very low at a whole, actual range was 0.01 to 0.18 Cu (average 0.05 % Cu).

(2) Chaso Juan area

Mineralization observed in the Chaso Juan area is of the porphyry copper type, and is grouped into four zones: namely, the North zone, the West zone, the South zone, and the Central zone.

Each mineralized zone is small in scale and discontinuous compared with other surveyed areas.

As the results of geophysical survey, IP anomalies were found in the midway between central and south mineralized zones, and in the west mineralized zone extending north-south direction. The former indicates extension of south mineralized zone, and latter indicates a direction of mineralization. Priority of exploration, however, low in this area.

(3) Telimbela area

1) Telimbela area

The porphyry copper type mineralization observed in the Telimbela area is the largest in scale in the entire Bolivar area, and its strong mineralization extends to the Macuchi Formation.

Centering around each of the seven mineralized locations within this area, pyrite dissemination and veinlets are widely distributed in granitic rocks. Macroscopically, the seven mineralized zones in this area, which are generally arranged in the NE-SW direction, are grouped into the Central, South and North zones.

In the North zone distributed are Mineralized Zones V and VI, which are new and large zones found in the Phase II survey. These mineralized zones are described in the following section.

2) Northeast zone, Telimbela area

The geology of the area consists of Macuchi Formation and Granites which intruded into the Macuchi Formation. Granites are composed of Hornblende-biotite quartzdiorite, hornblend qurtzdiorite, melanocratic qurtzdiorite dike and coarse quartzdiorite dike. Those rock bodies are distributed and arranged in the NE-SW direction.

Porphyry copper type mineralized zone in the surveyed area is proved to be as a dissemination and metwork zone of chalcopyrite and pyrite.

These mineralized zones are macroscopically lined up in the direction of NE-SW and mineralization is centered in Hornblende quartzdiorite and affects thoroughly such country rocks as Macuchi Formation intensely.

Mineralized outcrops scatter in the area of 1.5 km X 1.0 km in and along Q. Ugshacocha and Q. Ashuaca, high grade ores are notably destributed in an area of 400 m X 600 m close to the Ashuaca achool, where dissemination and network zone of chalcopyrite and pyrite are recognized to exist not only in quartzdiorite but also in Macuchi Formation intensely. Moreover, molibdenite is observed in forms of dissemination and/or films scattered.

The assay revealed that southern mineralized part cropping out along Q. Ugshacocha contains 0.71 to 1.38 % Cu and that northern mineralized part cropping out along Q. Ashuaca 0.78 to 0.89 % Cu.

Outer part of the mineralized zone is to be dissemination and network zone of pyrite only. As a result of IP method electric survey, distinguished were 6 of high FE anomalies. FE anomaly corresponds generally to mineralization, while high resistivity anomaly to silicification and low resistivity to argilization.

Drilling survey was conducted at the west and east of the Ashuaca school, results of which are as follows: On the drill hole core MJE-8, intense dissemination of chalcopyrite and pyrite was observed through the hole (from the surface to the bottom).

Principal mineralized zones encountered by drill hole are interval between 21 to 102 m in depth with 0.02 to 0.72 % Cu (average, 0.468 % Cu). Adding this, several other intervals are recognized to show copper contents more than 0.10 %.

Mineralization tends to be dominant in the parts of angular xenoliths of andesite and in the the parts of auto-brecciated zone of quartzdiorite.

On the drill core MJE-9, intense mineralization of chalcopyrite and pyrite was observed through the hole from the surface to the bottom (205.00 m in depth).

Principal mineralized zones encountered by drill hole are intervals between 80 to 105 m in depth with a grade of 0.10 to 0.33 % cu (average, 0.229 % Cu) and between 124 to 161 m with a grade of 0.08 to 0.55 % Cu (average, 0.207 % cu). Adding those mineraization, several intervals are also recognized, which show copper contents more than 0.10 %.

As a whole, MJE-9 contains less andesite breccias and shows less auto-brecciation. Therefore, average grade of mineralized parts of MJE-9 was relatively lower than that of MJE-8.

To conclude data and information described above following three mineralized zones are delineated as potential zones of mineralization:

1) "Ashuaca mineralized zone"

As a result of geological survey, a number of intense mineralization of chalcopyrite and pyrite have been recognized around Ashuaca school. IP method electric survey disclosed that the deep low resistivity-high FE anomaly "A" which corresponds to the "Ashuaca mineralized zone".

Moreover, low apparent-resistivity anomaly was recognized at the intense mineralized parts of chalcopyrite-pyrite in and along Quebradas, west and south of Ashuaca.

2) Ugshacocha mineralized zone

Ugshacocha mineralized zone distributes about 500 m southeast of Ashuaca school. Through detailed geological survey, recognized is intense mineralization of chalcopyrite-pyrite, while this mineralization is confirmed to be corresponded to low resistivity-high FE zone "A" which has been selected as a tangue shape anomalous zone extendiong from the Northeast of the Ashuaca to the Southeast.

3) Las Tres Cruces minerlized zone

Las Tres Cruces mineralized zone is distributed about 600 m western northwest of Ashuaca school.

As a result of geological survey, intense pyrite dissemination accompanying chalcopyrite are recognized. Furthermore, low resistivity-high FE anomaly "B" is delineated as a narrow and elongated zone with the dirrection of NNE-SSW by IP method electric survey.

This anomaly implies that hidden mineralized zone may exist in the depth of Macuchi Formation.

(4) La Industria-Yatubi area

Mineralization observed in this area is of two types: namely, hot-spring type Au mineralization and porphyry-copper type mineralization. In the former type of mineralization, a white argillized zone (kaolin) and a silicified zone are distributed in the lower and upper parts respectively. Across the two zones, network veins are recognized, which consist of metallic sinter-acicular minerals-hematite-quartz-kaolin. The assay result shows the maximum Au content of 0.3 g/t. The silicified outcrops are recognized only at the top of mountains (Cerro Barranco Amarillo and Caimito South), the silicified zone turns downward to the kaolinized zone which were observed below the mountaintop. The silicified zone is, therefore, considered to be eroded largely, and the silicified parts at the mountaintop to be the relics of the lower part of the silicified zone.

An alteration zone, which consists of sericitization and weak silicification, is also accompanied by pyrite. This alteration is probably associated with the porphyry copper type mineralization in the northern part of the area.

(5) Las Guardias area

Mineralization of the porphyry copper type is recognized at 12 locations, all of which are distributed along melanocratic diorite intrusive rocks and a fault in the direction of NW-SE. This direction is in a marked contrast to the NE-SW direction of the mineralization zones and intrusive rocks in other areas. Extension of each mineralized zone is less than 100 m, small in scale and discontinuous in surveyed area.

(6) Other areas

Other areas include following seven areas: Tres Hermanas area; San Miguel area;

Sicota area; Tambillo area; Tablas Pamba area; Balaron area; and Chilcales Alto area. Mineralized zone of each area was small in scale and low in grade.

6-2 Recommendations for the future survey

Based on the findings of Phase I, Phase II and Phase III surveys, the following recommendations are made for the future survey:

(1) Osohuayco zone, Balzapamba area (Fig. III-2-1)

The Osohuayco North mineralized zone, mineralized outcrops of which are confirmed through geological survey of Phase III, is extensive in scale and comparatively high grade in copper content.

This mineralized zone occurs in hornblende-biotite granodiorite (Gd). Distribution area of these mineralized outcrops corresponds with the IP anomaly area delineated on the high resistivity-high FE values of Phase II geophysical survey.

Therefore, drilling survey is recommended to disclose the condition and extent of mineralization in detail, the locations of which are shown in Fig III-2-1. For example, 300 m deep X 2 holes in Osohuayco North mineralized zone.

(2) Northeast zone, Telimbela area (Fig III-2-2)

"The Ashuaca mineralized zone", which is confirmed thoroughly by Phase III geological, geophysical and drilling survey, is extensive in scale and high in grade of metal (copper) content. This mineralized zone is also peoved to have close relationship of distribution with hornblende quartzdiorite (HQd). Adding this, potential areas have been delineated around "Ashuaca mineralized zone".

Furthermore, through geophysical survey, IP anomlies are distinguished in the depth of "Ashuaca mineralized zone" where recognized are chain of mineralized outcrops.

Therefore, drilling survey is recommended to disclose the condition and extent of mineralization in detail, the locations of which are shown in fig.III-2-2 . For example, 200 m deep X 3 holes in "ashuaca mineralized zone"; 200 m deep X 2 holes in Ugshacocha mineralized zone; and 200 m deep X 1 hole in Las Tre Cruces mineralized zone.

PART II DETEILES

Chapter 1 Balzapamba area

In this area, geological and geochemical surveys, geophysical survey and drilling were conducted.

1-1 Geological survey

1-1-1 Geology

Geology of the survey area consists of volcanic rocks of the Macuchi Formation in Late Cretaceous, with intrusion of granitic rocks and trachyandesite.

The Macuchi Formation is further divided into six members, or bottom A through top F. A geological map is shown in Fig.II-1-1, a generalized stratigraphic columnar section in Fig.II-1-2.

Member A (An-1)

This member is distributed in the northern, central eastern and southern parts, as it is encircling granitic rocks. Its thickness is estimated to be more than 1,000 m. It mainly consists of massive pyroxene andesite lava in dark green. It contains rhythmical this alternation of greenish andesitic fine tuffs and dark gray siliceous to calcareous sedimentary rocks along the Alcacer and Las Palmas valleys, in the south of the Osohuayco valley and the east of the Las Juntas valley.

In the area around granitic rocks, hornfels make it impossible to identify minerals and texture of original rocks and hard compact rocks comprising fine grained mafic minerals and/or quartz are distributed.

Member B (Qan-1)

This member is distributed in the eastern part of the Member A. Its thickness is estimated to be 300 to 520 m. It consists of dark green and gray, hard quartz-bearing andesite lava which contains a large amount of idiomorphic quartz crystal in the largest size of 2 mm and secondary quartz plugging gas cavities of about 4 mm. It locally contains its tuffs.

Biotite has mostly been altered into chlorite and epidote, and K-feldspar partially into sericite.

Member C (An-2)

This member is distributed in narrow strips in the midstream of the Gualazay valley and its tributary only, and no development is observed in the south of the Alcacer valley. Its thickness is estimated at 0 to 90 m. It consists of andesite as is the case with the Member A.

Member D (Tf, An-3)

This member is distributed along the east side of the Members A and B in the upstream of the Las Palmas valley to Pallatanga and Bunque Loma. Its thickness is estimated to be 100 to 250 m. It consists of andesitic to quartz-bearing andesitic rocks (Tf) and andesite lava contained therein (An-3).

Tf is andesitic in the Gualzay valley but turns to quartz-bearing andesite in other distribution areas. It consists mostly of coarse to lapilli tuffs but tuff breccia has locally developed in the upstream of the Alcacer valley.

An-3 comprises andesite lava as in the Member A but holds two layers of quartz-bearing andesite lava as in the Member A but holds two layers of quartz-bearing andesite lava in the Gualazay valley.

Member E (An to Qan)

This member is distributed in the Gualazay valley to upstream of the Alcacer valley to Bunque Loma. Its thickness is estimated at 140 to 420 m. It consists of alternation of andesite lava and quartz-bearing andesite lava but the latter dominates in Bunque Loma. It is locally interbedded with their tuffs.

Member F (Qan-2)

This member is distributed in the northeast to the east of the survey area. Its thickness is estimated at 400 to more than 900 m. As is the case with the Member B, it consists of quartz-bearing andesite lava and contains its tuffs in the Padriorco valley.

(2) Intrusive rocks

Intrusive rocks in the survey area consist of granodiorite batholith, small intrusion of melanocratic diorite and trachyandesite and aplite dikes.

Granodiorite (Gd)

It widely occurs to the west from the central area. Lithology comprises granular hornblende-biotite granodiorite. Although virtually no variation in lithology is observed, quartz diorite irregularly occurs in granodiorite in the Las Juntas mineralized zone. In the El Torneado mineralized zone, networked veins are found in host rocks subjected to

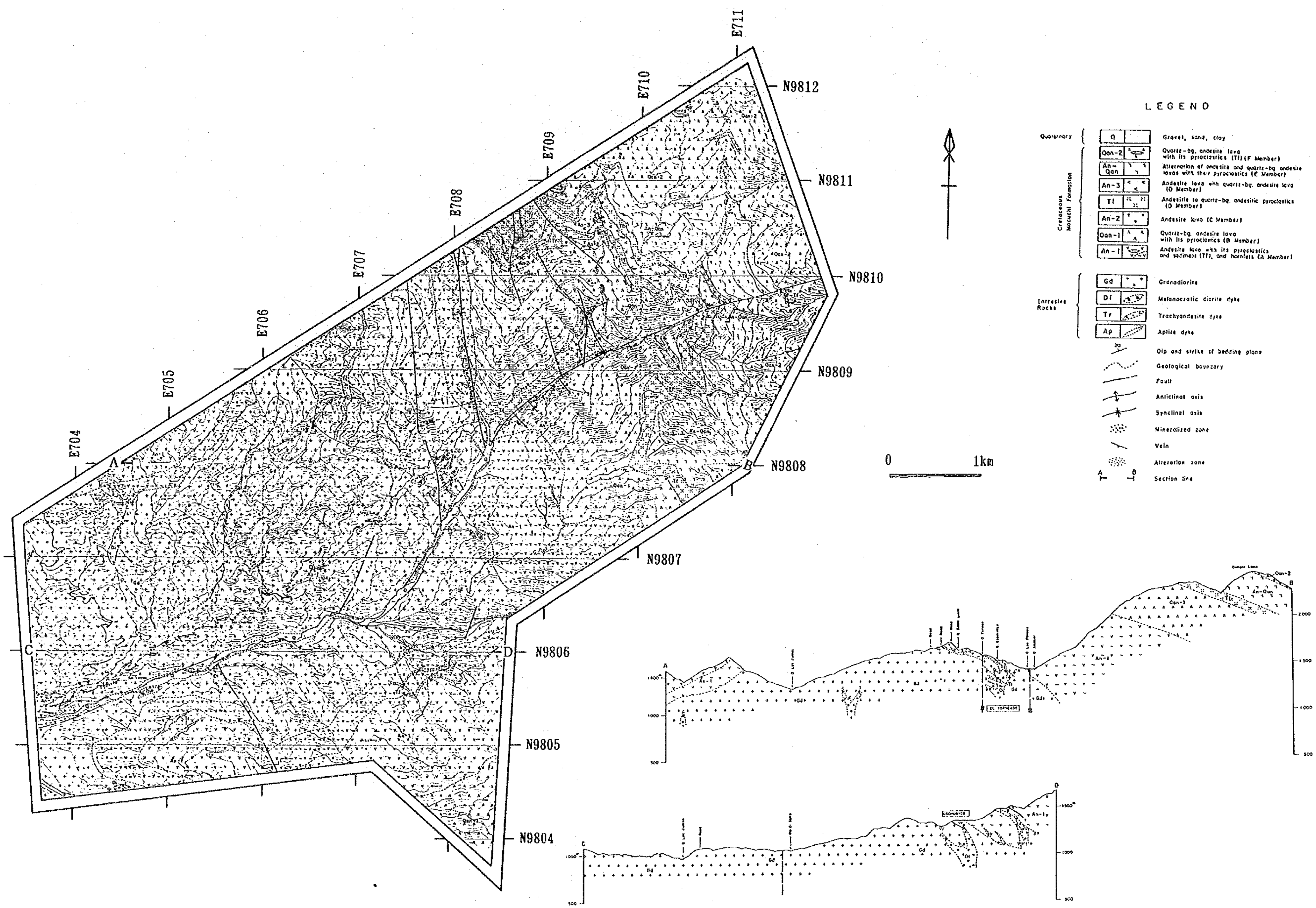
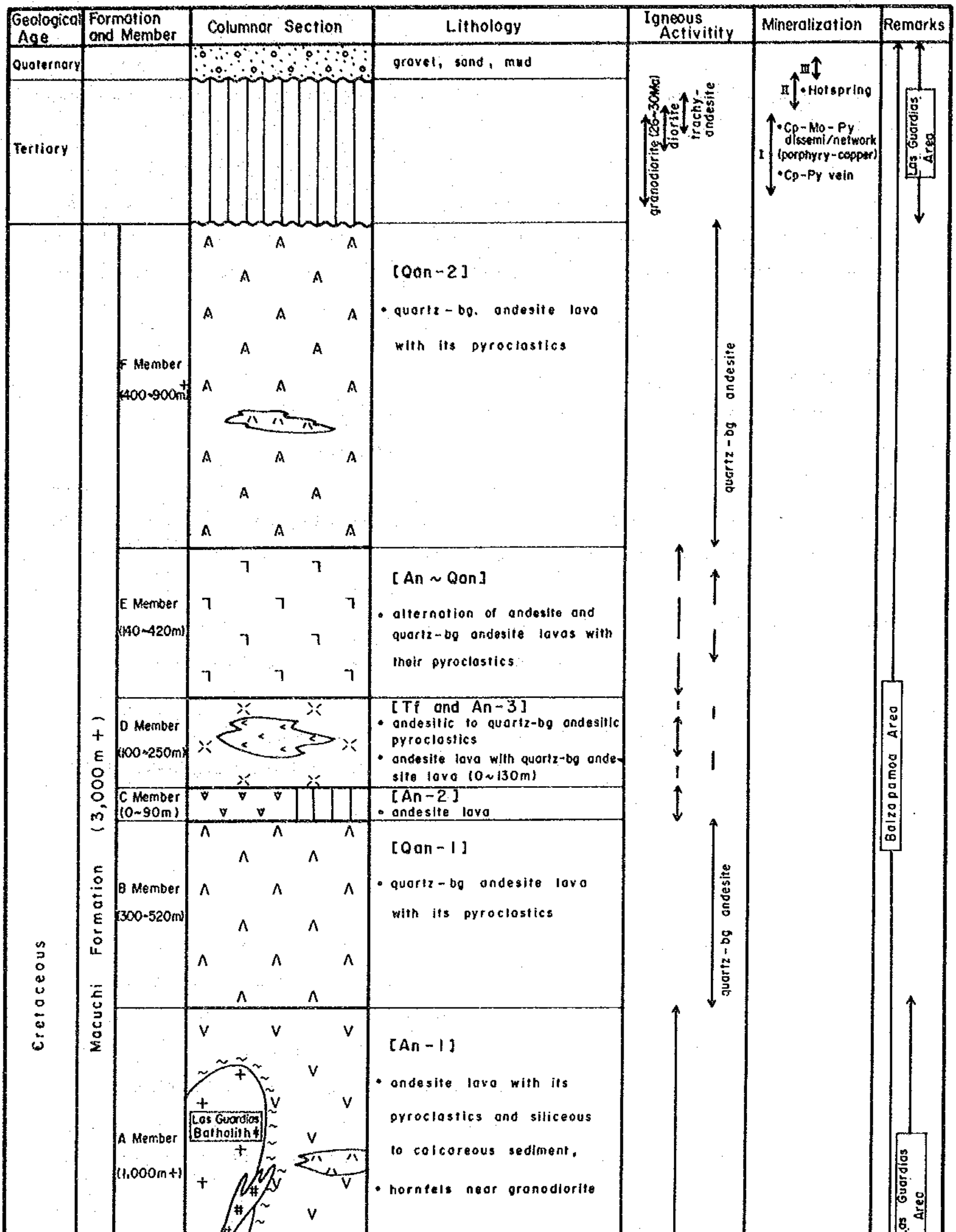


Fig. II-1-1 Geological map of the Balzapamba area



* Las Guardias Batholith does not the geological time of its intrusion but its occurrence.

Fig. II-1-2 Generalized stratigraphic section of the Osohuayco, Balzapamba area argillization and silicification due to mineralization, presenting apparent brecciated texture.

Granodiorite generally intrudes into the Macuchi Formation on steep dipping as seen, for example, in Las Juntas valley. Meanwhile, this rock takes in xenolith of the Macuchi Formation or branches in sheets depending on areas, as observed on the road north of Santa Lucia settlement and along path to El Torneado. In this manner, it presents various aspects.

Melanocratic diorite intrusive rock (Di)

This rock is abundantly distributed in the vicinity of granodiorite batholith and is observed in both El Torneado and Las Juntas mineral showings as well as in the southwestern part. It is black and is a diorite mainly consisting of fine-grained biotite. Intrusive rocks are 20 to 50 m wide and many of them are in the direction of NE-SW. In Esperansa valley, they locally present a porphyritic texture.

Trachyandesite (Tr) and Aplite dikes (Ap)

These dikes, several meters in width, are observed in the El Torneado mineral showings. Trachyandesite dikes are greenish gray in color and contains feldspar with a small quantity of pyroxene phenocryst. Most dikes run is NE-SW to E-W directions.

Aplite dikes mainly comprise colorless minerals with some biotite and NE-SW and NW-SE systems were observed as their direction.

1-1-2 Geological structure

The Macuchi Formation is generally in N-S strike and gently dips toward east as a whole. Gentle folding structures are observed in the east and west of Las Palmas valley and along Alcacer valley. In the south, the strike changes to E-W and dipping steeply increases in the direction of south due to the effect of granodiorite.

Major faults are NE-SW system along El Salto river from upstream of Alcacer valley and NNW-SSE systems are found in the El Torneado mineralized zone, Las Palmas valley and down stream of Gualazay valley. In addition, E-W system develops along Osohuayco valley.

1-1-3 Mineralization and alteration

Mineralization in this area can be classified into three groups of porphyry copper type, vein type and hot spring type. Porphyry copper type includes the El Torneado, Osohuayco and Las Juntas mineralized zones. Vein type includes the El Cristal mineralized zone, and hot spring type, the Las Palmas and Cochapamba alteration zones respectively.

El Torneado mineralized zone is described in the section 1-4 of this chapter and Osohuayco mineralized zone is also in the section 1-5.

(1) Las Juntas mineralized zone

The Las Juntas mineralized zone is situated in a tributary of Las Juntas valley and consists of chalcopyrite-pyrite dissemination zone in granodiorite and quartz diorite and pyrite-quartz networked vein zone in hornfels of the Macuchi Formation.

For the former, there is lack of continuity with a lenticular disseminated zone of less than 2 to 3 m in width observed in two places only. The latter is similar to the El Cristal mineralized zone to be described next. However, only a few veins less than 1 m wide are observed in outcrops of 10 m x 2 m. Results of ore analysis show 1.1 g/t Ag and 0.11 % Cu. According to existing data, chalcopyrite-sphalerite-galena were observed along with pyrite. However, the situation cannot be confirmed at present because most outcrops are buried due to landslide.

(2) El Cristal mineralized zone

The El Cristal mineralized zone is situated in the western end of this area and is a vein type mineralized zone which was formed in hornfels of the Macuchi Formation. Its strike is N80°W, dip 75 to 80°S, extension more than 30 m and vein width 17 m. Principal minerals are pyrite and quartz with chalcopyrite in an extremely small quantity. Pyrite is disseminated and occurs in the entire mineralized zone.

Furthermore, from the center to the hanging wall, pyrite forms three strips of concentration, ranging 0.7 to 1.8 m in width. Quartz is observed in veins in the center, coexisting with a large amount of limonite. Results of ore analysis show 2.1 g/t Ag and 0.16 % Cu.

(3) Las Palmas alteration zone

The LasPalmas alteration zone is distributed over an area of more than 2 km from upstream of Las Plams valley in the northeastern direction. It mainly consist of argillized and silicified rocks with localized hematite. This alteration zone can be classified into (1) products of hydrothermal activities which involve the same type of sulfide minerals in the same period as the activities in El Torneado, and (2) products from later hot spring activities. For the former, chalcoyrite-pyrite dissemination is locally observed while hematite-quartz veinlet is noted in the latter. Results of X-ray diffractive analysis identified assemblage of quartz-chlorite which is considered associaated with the former and of quartz-kaolinite-halloysite which is considered related to the latter.

In the south of this alteration zone, mineral showings are spotted in three places along the fault of N-S system. One of them is a chalcopyrite-chalcocite- pyrite-quartz networked vein in fault breccia zone. The other two are chalcopyrite-pyrite dissemination zones which exist in both granitic rock dikes and highly silicified andesite in the Maacuchi Formation in vicinities of faults. Either of these mineral showings is small in scale, being only about 2 to 3 m in width. Results of ore analysis show 7.6 g/t Ag and 0.60 % Cu for the networked zone and 0.02 % Cu for the disseminated zone. results of X-ray diffractive analysis indicated assemblage of quartz-sericite-chorite in both of them.

(4) Cochapamba alteration zone

Highly silicified alteration zone is widely distributed in volcanic rocks of the Macuchi Formation along Alcacer, Gualazay and Paduriorco valleys. In this alteration zone, pyrite dissemination and argillized alteration are locally observed. X-ray diffractive analysis on the clay identified cholrite and halloysite as in the case of the Las Palmas alteration zone.

1-1-4 Magnetic susceptibility measurement (Fig.II-1-3)

To quantitatively determine demagnetization due to mineralization, magnetic susceptibility was measured, using a portable magnetometer. This magnetometer was Kappameter Model KT-5 of Czechoslovakia and can measure magnetic susceptibility in units of 1 x 10^{-3}SIU.

Before measurement, efforts were made to completely strip weathered portions from outcrops and eliminate surface unevenness to prevent measuring errors due to weathering and surface unevenness. Measurements are made five times and the average of three values was made the measured value by disregarding the highest and lowest values.

Measurement values sharply fluctuated from 0.1 to 156 x 10^{-3} SIU. Fresh granodiorite showed 10 to 20 x 10^{-3}SIU, melanocratic diorite, 40 to 156 x 10^{-3} SUI, andesite lava in Macuchi Formation, 50 to 70 x 10^{-3} SIU, quartz-bearing andesite lava, tuffs and sedimentary rocks in this formation, all less than 10 x 10p-^{3}SIU. Main mineralization in this area was porphyry copper type. With values below 20 x 10^{-3} SIU as anomalously low, anomalous values for low magnetic susceptibility were set as follows: 0.1 to 5.0 x 10^{-3} SIU (extremely low), 5.1 to 10.0 x 10^{-3} SIU (considerably low), 10.1 to 20.0 x 10^{-3} SIU (low), more than 20.1 x 10^{-3} SIU (background). based on these four anomalous values, an analyti-

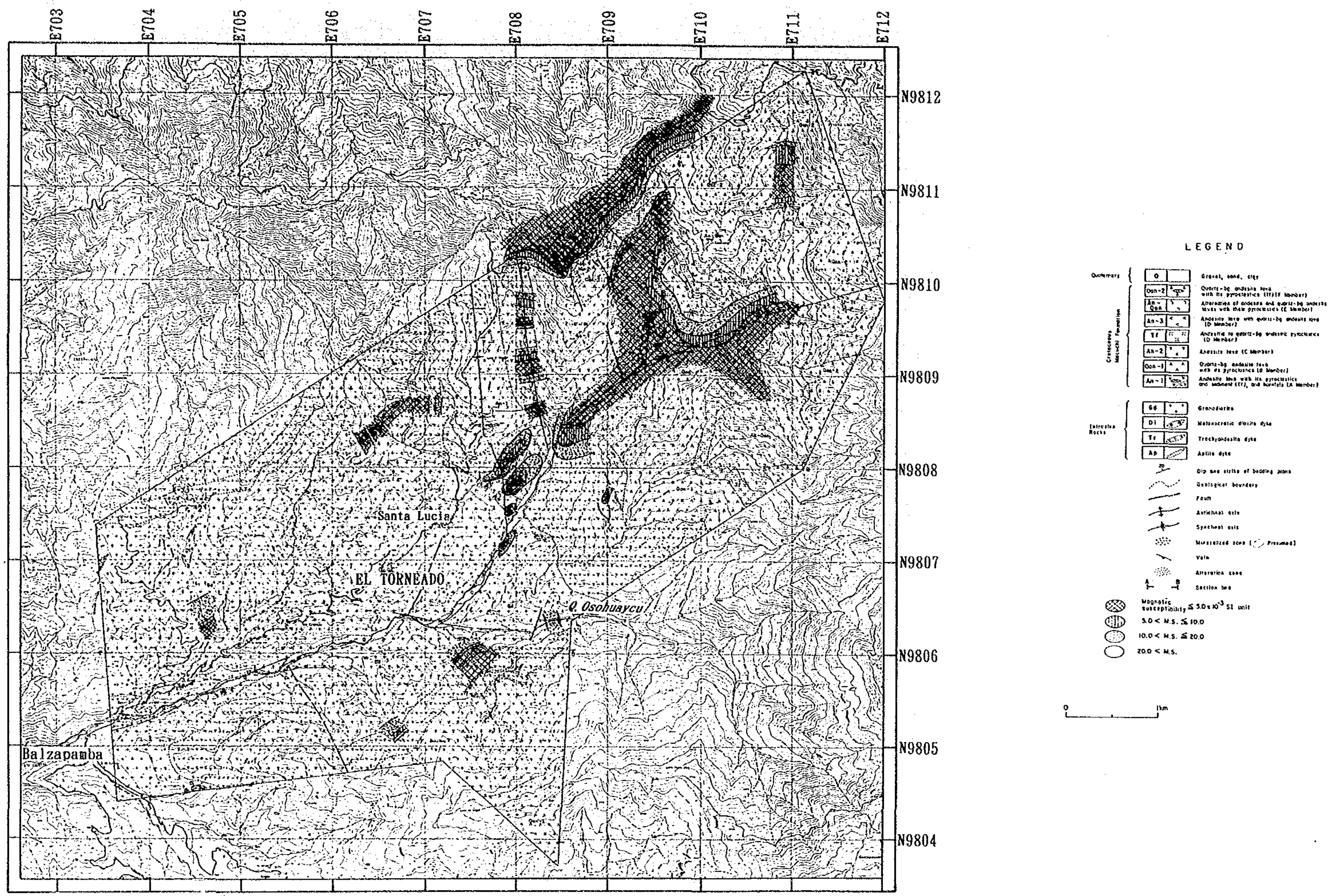


Fig. II-1-3 Interpretation map of the mineralization and magnetic susceptibilitity of the Balzapamba area

cal chart for anomalous zones was prepared.

Distribution of anomalous zones well coincide with that of above mineralized zones. In other words, three anomalous zones in NE-SW direction (0.2 to 20 x 10^{-3} SIU) observed in the El Torneado mineralized zones agree with mineralized zones A,C,D and E in location. In the Osohuayco mineralized zone (0.58 to 12 x 10^{-3} SIU), anomalous znes agree with disseminated zones in granodiorite and veins in the Macuchi Formation. In the Las Juntas mineralized zone, anomalous zones were found in two places for quartz diorite (0.83 to 1.1 x 10^{-3} SIU), and in ore place for the Macuchi Formation (0.4 to 8 x 10^{-3} SIU). The anomalous zone in the Macuchi Formatio amounts to 750 m in width and shows values inherently held by rocks, aside from results of alteration. In the El Cristal mineralizaed zone, pyrite-clay veins are as low as 0.62 to 14 x 10^{-3} SIU while areas containing magnetite have a high value of 75 x 10^{-3} SIU. In the Las Palmas alteration zone, anomalous zones (0.1 to 3 x 10^{-3} SIU) are widely distributed and well coincide with the occurrence of alteration zones. Mineralized zones in three places in the southern part of the Las Palmas alteration zoane are also included in anomalous zones (0.37 to 20 x 10^{-3} SIU). The cochapamba alteration zone is included in anomalous zones (0.3 to 3 x 10^{-3} SIU) found over a wide range of area. These anomalous zones also include low susceptibility zones resulting from quartz-bearing andesite lava, tuffs and sedimentary rocks of the Macuchi Formation.

As described above, magnetic susceptibility measurement was highly effective in understanding characteristics and scale of mineralization and alteration.

1-1-5 Geochemical survey

(1) Collection of samples, components for analysis and analysis method

The purpose of this work is to identify elements which are involved in mineralization of rocks in the vicinities of mineralized zones and to investigate the dispersion of these elements. For geochemical survey, 33 rock samples were obtained and analyzed for the seven elements of Ag, Cu, Pb, Zn, Mo, Co and Ni by inductively coupled argon plasma emission spectrochemical analysis (ICP). Detectable limit of these elements in analysis is 0.1 ppm for Ag and 1 ppm for the Other six elements.

(2) Data processing

A total of 67 rock samples including 34 samples collected in the other areas to be described later were analyzed for seven elements. Results of this analysis were input to computer along with geological units at the sampling points for statistical data processing. To meet the above objects, multivariate analysis rather than univariate is a more effective analysis method.

Multivariate analysis comes in various methods. Among them, factor analysis is effective as an analysis method which is designed to explain variations represented by multiple variables using a much fewer representative, hypothetical variations (factors), thereby scientifically attaining simplicity. To explain relationships of each sample with mineralization or characteristics of host rock, this method indicates which factor approximately in what quantity the sample has by assigning factor score to each sample.

For computation, computer was used and data were processed by varimax rotation, one of factor analysis methods. As a result, four factors were identified, namely (1) Co-Ni-Zn, (2) Ag-Cu, (3) Pb-Zn-Cu and (4) Mo.

Among the existing geochemical survey data, those dealing with rocks number 85 reports. However, these reports were used only as supplementary data because analysis in these reports was limited to the four elements of Cu, Pb, Zn and Mo.

(3) Interpretation results

More than 1 points earned in absolute value for each factor was rated as a high factor score, more than 0.4 and less than 1 as a medium factor score, and more than 0.0 and less than 0.4 as a low factor score.

Samples which earned high to medium factor scores in the second factor (Ag-Cu) were all of rocks in the Macuchi Formation. Samples with low factor scores were found in part of granodiorite in the El Torneado mineralized zone. Thus, this factor is considered reflecting characteristics of host rock and some Zn addition.

Samples which earned high to medium factor scores in the second factor (Ag-CU) were obtained from the El Torneado, Osohuayco, and El Cristal mineralized zones as well as such zones in downstream of Palmas valley. Samples with low factor scores were found in the Las Juntas mineralized zone and the Cochapamba alteration zone. According to existing data, although some of sampling points were different, anomalous Cu zones cover the El Torneado, El Cristal and Las Juntas mineralized zones. This factor is considered characterizing Ag-Cu mineralization.

Samples with high to medium factor scores in the third factor (Pb-Zn-Cu) showed no difference between rocks. Generally speaking, there may be some areal difference because samples with high to medium factor scores were rather concentrated in part of El Torneado, and the Telimbela and San Miguel areas to be described later. It is difficult to estimate the process that characterizes this factor but younger mineralization process involving sulfide minerals as seen in, for example, the San Miguel area can be considered responsible for this factor.

Samples which earned high to medium scores of the fourth factor (Mo) were found in the El Torneado and El Cristal mineralized zones and the Las Palmas alteration zone. However, these samples were obtained from points different from those for samples with high to medium second factor scores, with some exception. The El Torneado mineralized zone shows a phenomenon that sulfide mineral-quartz networked veins containing molybdenite in the latter period cut sulfide mineral disseminated zones. From this phenomenon, this factor is considered to be a factor suggesting mineralization containing Mo that has taken place after mineralization containing Cu.

1-2 Geophysical survey

1-2-1 Purpose of survey

The CSAMT survey was carried out in Balzapamba which was delineated as high mineral potential area in a previous survey, in order to clarify the underground resistivity distribution, to extract the promising zone for occurrence of ore deposits and to assist in the location of a exploratory drilling site.

Although the topography of the survey area is comparatively steep and its altitude range from 800 to 3,000m, the survey was completed on schedule covering an area of $36km^2$ with 104 observed stations.

1-2-2 Survey method

(a) Methodology of CSAMT

The CSAMT (Controlled Source Audio-frequency Magneto-telluric) method was introduced by Goldstein (1971) and Goldstein and Strangway (1975) to overcome the problems encountered by the audio magnetotelluric (AMT) and magnetotelluric (MT) methods.

1-2-3 Results of survey and analysis

(a) Results of Measurement of rock sample

Although it is difficult to uniformly associate rocks classified by geology with their resistivity; fresh igneous rocks, metamorphic rocks, etc. generally have a high level resistivity, indicating more than 10,000 ohm-m. This resistivity may substantially vary depending on the extent of weathering.

Geology of the survey area is classified into two types. One is the Macuchi Formation and other is granodiorite. The Macuchi Formation consists of andesite lava, its tuff, quartz beraing andesite lava and its tuff, which is partly metamorphosed to hornfels by granitic intrusion.

Rock samples collected from the survey area and cores from the drill holes MJE-1, 2 and 3 were measured at laboratory for their electrical properties (resistivity, FE). Those results show that silicified rocks, hornfels and granodiorite have a high resistivity (5,000 to more than 10,000 ohm-m). Quartz bearing andesite lava, its tuff, as well as andesite lava and granodiorite subjected to weathering or alteration have a medium resistivity (1,000 to 1,500 ohm-m) while andesite tuff have a low resistivity (less than 1,000 ohm-m), drilling cores (granodiorite) containing sulfides are generally lower in resistivity than fresh rocks.

The resistivities of rock samples tends to be higher than those measured in the field. When comparative study is made on results of electrical property tests, on the resistivity values of the surface layer (the first layer) obtained by one-dimensional resistivity analysis for each measuring point, and on the type of rocks distributed there, the resistivity of rocks in the survey area can broadly be classified as shown below. The resistivity may also vary depending on the degree of cracks in rocks and the nature of underground water filling these cracks.

Andesite lava metamorphosed to hornfels	More than 10,000 ohm-m
Fresh granodiorite and fine-grained granodiorite	5,000 - 10,000 ohm-m
Rock subjected alteration such as chloritization	1,000 - 1,500 ohm-m
Macuchi Formation (except hornfels)	1,000 - 1,500 ohm-m
Acidic alteration (kaolinite) rocks	Less than 1,000 ohm-m

In the relations between FE value (0.3 to 3.0Hz are used) and sulfide contents in laboratory measurements of cores from MJE-1,2 and 3 drill holes conducted in the El Torneado mineralized zone, FE value tends to be higher as sulfide contents increase. An FE value of 5 to 7% was obtained with 2 to 3% sulfide contents (by macroscopic observation).

Meanwhile, samples showing high FE value contain little sulfide except "station 28" samples. The possibility of keeping microscopic pyrite could be through, for the trace of network of limonite and quartz are recognized.

1-2-4 Discussion

Generally, granitic and andesitic rocks are high in resistivity but rocks in the survey areas greatly vary in resistivity (ranging from tens to tens of thousands ohm-m). As reasons for this great variation, such as decrease in resistivity due to argillization associated with mineralization and rise of resistivity due to silicification can be cited. In addition, differences in progress of weathering or development of cracks, and in the nature of ground water filling these cracks are also responsible for the variation of resistivity. The resistivity distribution in the survey area is deeply related to the location of mineral showings. Mineral showings are generally located in low resistivity area.

The resistivity structure of the survey area consists of two to three layers. These layers greatly vary among measuring points showing a lack of continuity in horizontal direction. In other words, this area, faults of NNE-SSW to NE-SW and NNW-SSE systems develop. Thus, resistivity discontinuities are believed to be reflecting blocking by these faulting structures.

Meanwhile, in comparison with results of drilling (MJE-3 drill hole measuring point 29), the first layer (125 ohm-m, 40m thick) corresponds to an argillized zone. In the deeper zones, the resistivity becomes 560 ohm-m. Thus, the resistivity is much lower than the average of 5,000 to 10,000 ohm-m for granodiorite in the survey area. Sulfide contents are not so large that their effects on resistivity seem small. The low resistivity is considered due to chloritization accompanying alteration and development of cracks. Mineralized zones below a depth of 200m of MJE-3 drill hole show localized argillization and silicification over an extensive area. As a result, it is believed that the resistivity has become around 500 ohm-m as a whole. It is very difficult to detect the thin layer of low resistivity below a depth of 200m by CSAMT survey. Although granodiorite which is not altered was confirmed below 200m by boring, however, it is not reflected in resistivity there is a possibility that the point of MJE-3 might not altered. Other drilling holes are difficult to compare because they are deviated from measuring points.

A rather low measuring density in the current survey, brought limitation in the selection of promising zones based on resistivity structure alone. However, as a characteristic of resistivity structure in mineral showings, it was found that mineralized zones and alteration zones are located on the low resistivity side of the boundary formed by a pair of low and high resistivities.

The boundaries of high and low resistivities are also the boundaries of the Macuchi Formation and graodiorite except the Las Palmas alteration zone, and these boundaries are considered to be metamorphosed by contact. Generally, silicification gives a high resistivity and argillization gives a low resistivity. Because mineralization of this area can be observed in both silicification and agrllization, it is considered that the boundaries of high and low resistivity show difference of alterations. Main mineralized zone especially associated with agrillization are observed at the side of low resistivity.

This resistivity structure is seen extending down to depths in both El Torneado and Osohuayco mineralized zones. In the Osohuayco mineralized zone in particular, low resistivity near the ground surface greatly extends to depths on the southeastern side. From this, continuity of mineralization and alteration zone is considered (Fig.II-1-4).

Characteristics of resistivity structure in the mineral showings as described above have been obtained. However, mineralized zones in this area generally show only a small difference in resistivity from host rocks and this makes resistivity analysis difficult. As strong IP anomaly is observed generally on networked vein and disseminated ore deposits like as this survey area, the SIP and/or IP surveys seems to be suitable method to understand the detailed distribution of the ore deposit in the area. Regarding exploration
understand the detailed distribution of the ore deposit in the area. Regarding exploration
from the ground surface alone, resolution will decrease as the depth increases. For this reason, surface exploration particularly combined with use of drill holes is considered more effective.

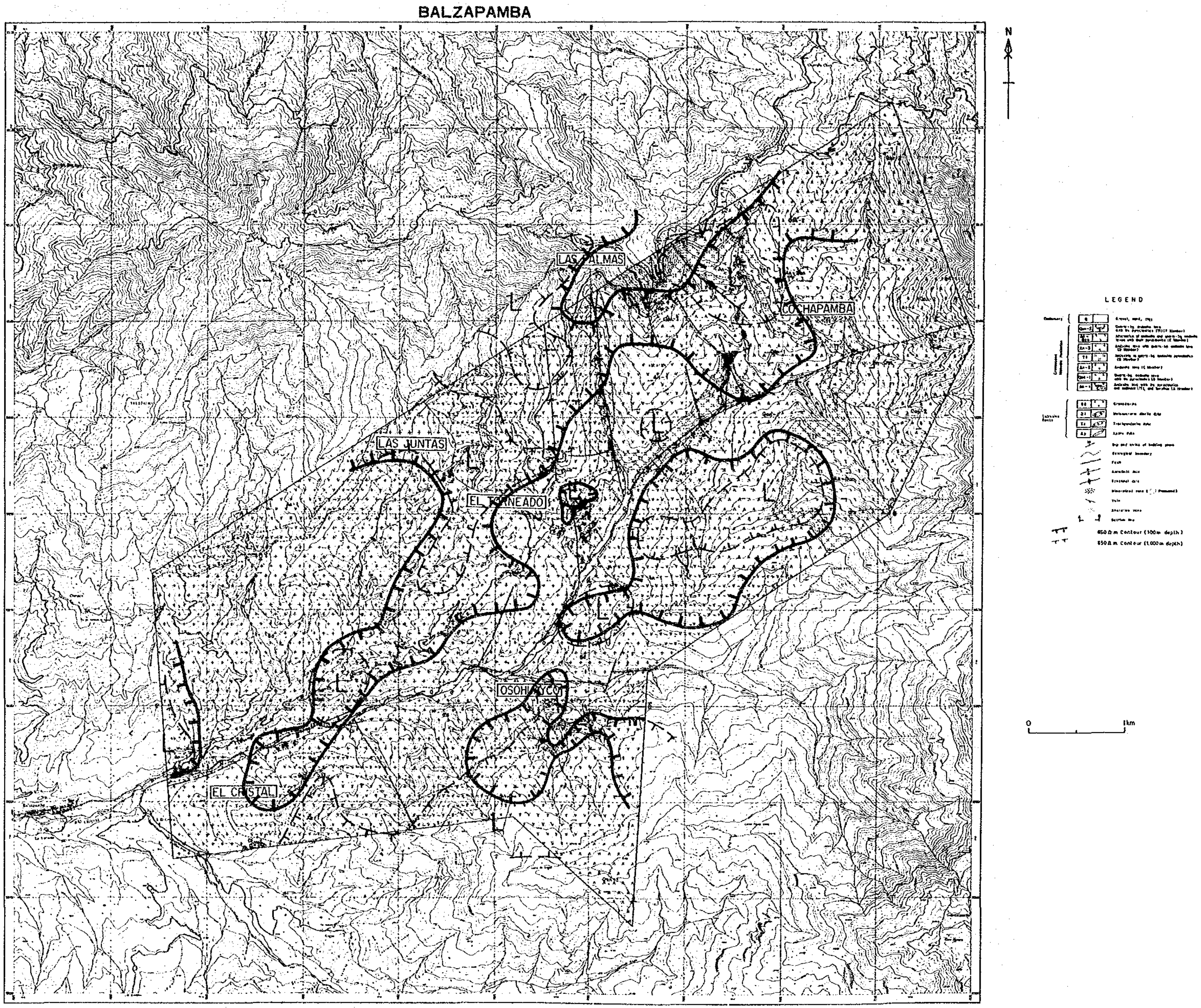


Fig. II－1－4 Interpretation Map of the Low Resistivity Zone and Mineralized Zone of the Balzapamba Area

1-3 Consideration of survey results of Balzapamba area

Detailed geological survey and geochemical survey were conducted as Phase I survey in this area. As the results of the survey followings are clarified:

Geology of this area consists of the Macuchi Formation of Late Cretaceous and granitic rocks of Oligocene to Miocene that intrude into this formation. Intrusive rocks consist of granodiorite batholith, melanocratic diorite,trachyandesite and aplite dikes. Isotopic age determination by K-Ar method proved that granodiorite be 25.7 $\pm$ 0.9 Ma.

Mineralized zones extends in NNE-SSW to NE-SW directions. These directions are consistent with the directions of NNE-SSW to NE-SW system tectonic lines that develop in the northern and southern part of the Bolivar area.

Hydrothermal activities in the Bolivar area can broadly be divided into three types. El Torneado, Osohuayco, and Las Juntas mineralized zones are listed up as porphyry copper type, El Cristal mineralized zone is as vein type, and Las Palmas and Cochapamba alteration zones are as hot spring type.

El Torneado and Osohuayco are described in the different sections in this chapter.

The Las Juntas mineralized zone is situated in granodiorite and quartz diorite in the form of chalcopyrite-pyrite dissemination. Mineraization here is also recognized in hornfels of Macuchi Formation. All of the mineralization observed were weak in intensity and small in scale.

El Cristal mineralized zone consists of veins of pyrite-limonite-chalcopyrie-quartz formed in hornfels of the Macuchi Formation. They strike E-W extending over 30 m with the width of 17 m. However the mineralized zone is small in size and low in grade.

The Las Palmas and Cochapamba alteration zones are characterized by acid hydrothermal alteration (silica-kaolinite-halloysite), silicification with leaching and occasional appearance of hematite-(silica sinter)-clay networked vein zone. Locally recognized only are pyrite dissemination and/or hematite-quartz-clay veins.

These mineraization and relating alteration are quite minor compared with other areas.

1-4 El Torneado zone, Balzapamba area

The survey area situates about 1 km east of Santa Lucia in Balzapamba alrea.

1-4-1 Geological survey

1-4-1-1 Geology

Geological investigation of the Osohuayco zone was conducted during the Phase I survey as a part of Balzapamba area.

1-4-1-2 Mineralization and alteration

The mineralization in this zone is porphyry copper type and distributes macroscopically in the northeastern marginal zone of granodiorite batholith.

El Torneado mineralized zone

This mineralized zone is situated about 1 km east of Santa Lucia settlement and is distributed over a range of about 400 m x 400 m. As the geology in the vicinities of El Torneado, granodiorite, melanocratic diorite, and mafic hornfels of the Macuchi Formation are distributed. Locally, trachyandesite dikes which cut granitic rocks in irregular shapes exist. Mineralized zones are porphyry copper type deposits and occur in granitic rocks. In the Macuchi Formation, mineralized veins exist only locally in the bordering area with granitic rocks. Granitic rocks in this area has the dissemination of pyrite, but principal mineralized zones are five mineralized zones of dissemination and/or networked vein containing chalcopyrite-pyrite-molybdenite, etc., 20 to 70 m wide, 70 to 350 m in extension, and running in NNE-SSW direction.

These mineralized zones can be divided into two types of the disseminated mineralized zone and the networked vein mineralized zone. The disseminated mineralized zones are cut by the networked vein mineralized zones. From this fact, it is considered that the latter was formed after the former.

1) Disseminated mineralized zones: Ore minerals exist wholly as dissemination or film in granitic rocks which do not show brecciated structure. The mineralized zone B falls under this category and a large quantity of pyrite and a small quantity of chalcopyrite are disseminated in granodiorite. Alteration consists of secondary biotization and weak chloritization.

Macroscopically, pyrite with a very small quantity of chalcopyrite is disseminated throughout granodiorite in the El Torneado mineralized zones, and the mineralized zone B is abundant with chalcopyrite.

2) Networked vein mineralized zones: These zones are formed in the brecciated granitic rocks. The interstices of breccias are filled with ore minerals and gangue minerals in irregular network pattern. As ore minerals, a large quantity of pyrite, a small quantity of chalcopyrite and molybdenite and a very small quantity of magnetite and scheelite are observed, along with local occurrence of pyrrhotite. The gangue minerals include quartz, chlorite, and secondary biotite. Epidote locally occurs.

Relatively large ore minerals are observed in these mineralized zones. Chalcopyrite lenses more than 1 cm, pyrite lenses more than 5 cm and molybdenite lenses more than 1 cm are locally observed.

A brecciation is most intense in the mineralized zone, consisting of aggregates of breccias few cm to 30 cm across, and it gradually become weaker toward marginal mineralized zone which only shows twiggy interstice in granitic rocks. A rugged surface of individual breccias generally fit well with surface of adjacent breccias. Each breccia can be easily reconstruct to the primary aspect before the development of brecciation and interstices between breccias are filled with ore and gangue minerals.

Further, the texture representing the early stage of brecciation is observed in the marginal part of the mineralized zone and its peripheral area. These aspects suggest that the brecciation in this area was caused by hydrofracturing during hydrothermal event.

Outcrops of the mineralized zones A, C, D and E are these areas. In the mineralized zones A, C and D, networked veins formed with above ores exist in breccia zones which were subjected to sericite alteration as a whole. Assay results show 0.2 g/t Au, 2.0 g/t Ag and 0.66 % Cu for the mineralized zone A, and 0.03 % Cu for the mineralized zone D. Results of X-ray diffractive analysis show that alteration minerals in these zones comprise potash feldspar, sericite, chlorite and secondary biotite. Kaolin which is considered associated with hot spring activities in the later period also exists in places.

Mineralized zone E is a pyrite-chlorite-quartz networked vein that exists in the bordering area between granodiorite and the Macuchi Formation. Alteration consists of chloritization and silicification at the surroundings of vein only.

1-4-2 Geophysical survey

1-4-2-1 Purpose of survey

The purpose of the survey is to provide useful geophysical results to clarify the lateral and vertical extensions of the mineralization detected in the first phase survey. To meet the above, a borehole IP survey was designed around the borehole MJE-1.

1-4-2-2 Survey method

(1) Borehole IP

The IP (Induced Polarization) method is a geophysical technique which measures an IP phenomenon induced by the electrochemical nature of the minerals and rocks. It has been mainly utilized for detecting sulphide deposits.

Although a conventional IP survey is generally conducted using a Dipole-Dipole configuration, a borehole IP method was adopted in this survey for delineating mineralized zones in this survey area.

The reasons for the adoption of the borehole IP method are as follows:

1) Promising mineralization was intersected at depth by several drillings in the Phase I Survey.
2) The mineralization may not be exactly located by means of a conventional IP survey from the surface, because the mineralizations existing at shallow depth would mask an anomaly from a deeper mineralization zone.

In this area, three different current configurations were utilized for the survey, they are:

a) (Remote-Surface) current electrode configuration (R-S)
b) (Surface-Downhole) current electrode configuration (S-D)
c) (Remote-Downhole) current electrode configuration (R-D)

In case that an observation point (a potential electrode) is located at a distance of 300m from the borehole, the detected 2-dimensional zone of each electrode configuration is shown in the originsl report (Phase II report).

1) R-S electrode configuration

By this configuration, an anomaly source at shallow depths beneath a potential electrode is likely to be detected. The observed potential is strongly affected by the electrical nature in the vicinity of the surface at the borehole.

2) D-S electrode configuration

The anomaly source at middle depth is likely to be detected when the potential electrode is located far away from the borehole, although the effect from the surface current electrode is also dominant when the potential electrode is located near the borehole. In this array, the effect of an existing anomaly is seen displaced from the location beneath the source.

3) D-R Electrode configuration

By this configuration, anomaly sources such as those located at depth near the downhole current electrode or the ones located at depth below a potential electrode are likely to be detected, since the effect from the remote current electrode can be neglected. Furthermore, an anomaly source being located deeper than a downhole current electrode can be detected when the potential electrode is located at relatively long distance from the borehole.

Nevertheless, an anomaly could be found not correlated to the electrode configuration, provided that an anomaly source is located in the vicinity of a potential electrode.

(2) Measurement method

Measurements were done using two kinds of frequencies, 3.0Hz and 0.3Hz.

Twelve radial survey lines of 575m long each one, were spread among each other by keeping a 30° interval around the drill hole MJE-1 as indicated in Fig.II-1-3. The points were numbered from 0 to 23 from the drill hole and spaced by 25m intervals. The measurement were done by moving a 50m spacing potential dipole.

The downhole current electrode was placed at a depth of 290m in the borehole MJE-1, the surface current electrode was at the surface of the borehole and the remote current electrode was in the opposite side at a 575m distance far away from the borehole.

The potential dipole electrode interval was kept in 50m.

1-4-2-3 Discussion

Based on the analysis and interpretation of the data obtained during this survey, a general consolidated map is illustrated in Fig.II-1-5. By taking also into consideration the mineralization of the area, the following discussion was elaborated:

1) Four prominent FE anomaly sources are assumed at shallow depth. A high FE anomaly centered around MJE-1 is seen to correspond to mineralized zone A. One E-W trending anomaly source, is seen dipping steeply to the south and to the north, another N-S trending anomaly source in the west of the area, seem to indicate mineralized zone along faults.

A high FE anomalous source, located in the southwest of the area and running along NW-SE direction is presumed to be due to mineralization related with melanocratic granodiorite intrusive.

2) At middle depth of the survey area, the detected low resistivity and high FE source is assumed to correspond with the mineralization of the Zone D.

3) At middle depth of the western half of the area, a low resistivity source that seems to be widely distributed, is presumed to be caused by argillization. This conductive body is detected as an apparent low resistivity in the nortwestern area and bounded by the lines E 30 and E 210 in the R-S and D-S apparent resistivity plan map.

4) The high resistivity body presumed to be under the conductive layer suggests the existence of fresh or strongly silicified granite.

5) Near the bottom of MJE-1, the interpreted high FE anomalous source seems to reflect buried mineralization, dipping to the south in the north of the borehole MJE-1 and existing flatly in the south of the borehole.

Among the geophysical techniques using a borehole for prospecting metallic deposits, Mise-a-la-masse method has been generally utilized.

This method is a technique that clarifies the distribution, trend and dip of metallic deposits, by investigating potentials which are induced by current to be sent into the metallic deposit.

Although Borehole IP used in this survey is also in a category of Mise-a-la-masse, there are two different points to be mentioned in a survey technique, i.e.,

a) In Mise-a-la-masse, only potentials are detected, but in Borehole IP, potential (resistivity) and FE are the parameters to be measured;

b) There is a difference in the configuration of current and potential electrodes.

From the technical view point on this difference, Mise-a-la-masse may be more effective for prospecting conductive deposits such as massive sulphide ore while, a

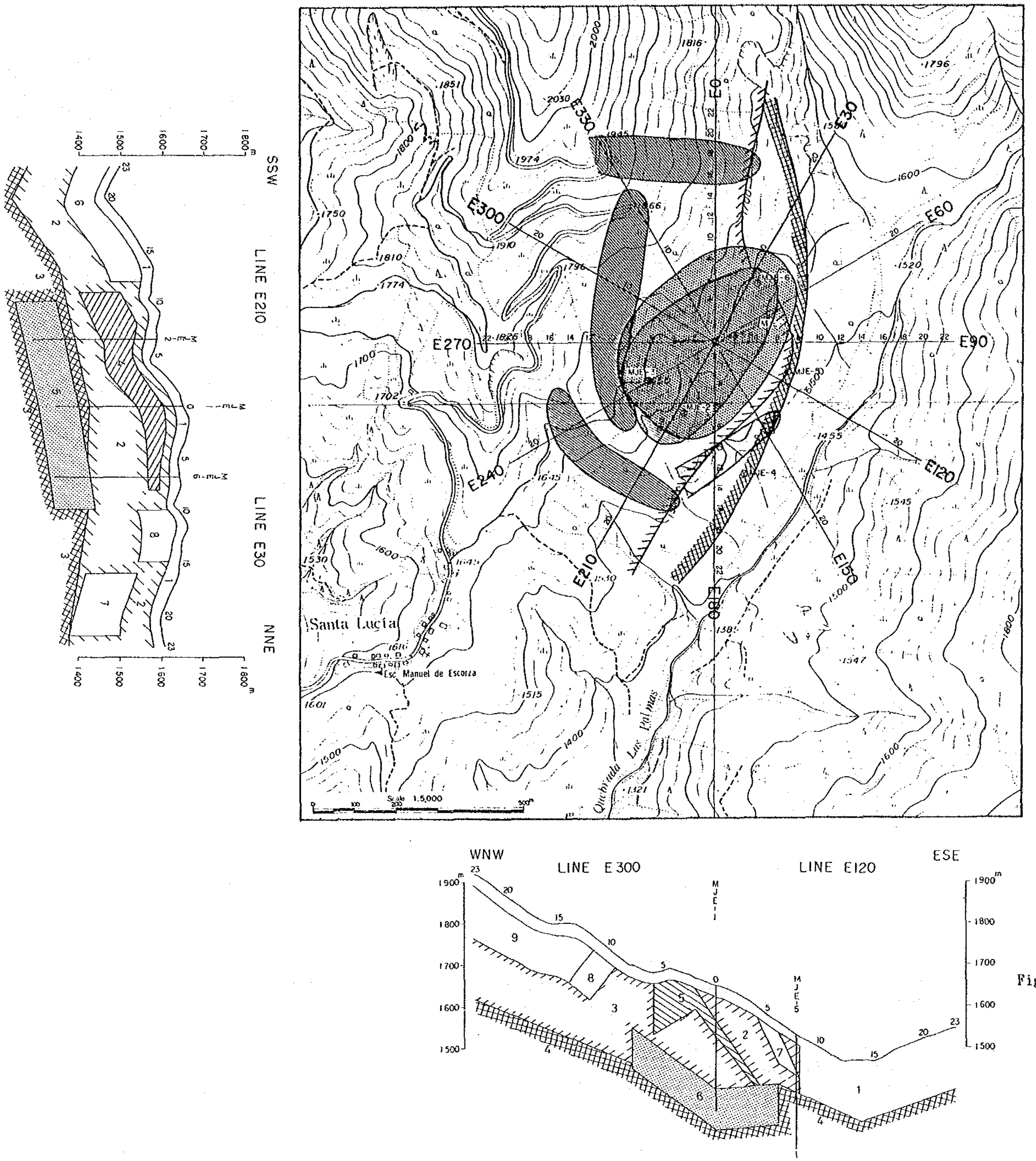


Fig. Ⅱ-1-5 Interpretation map of the of the El Tornead Balzapamba area

Borehole IP would be more effective for ore deposits having relatively high resistivity.

In this survey area, the Borehole IP was conducted due to the reason described in previous chapter 1-2-1. As a result, a concealed mineralized zone which may not be detectable by a conventional IP, has been actually detected at deep portions by Borehole IP.

In spite of the comments made by J. Bertin and J. Loeb (1976) regarding the applicability of this method, this survey revealed some questionable term as follows.

For the case of the D-S configuration, either several unclear low resistivity anomalies or non-measurable values were encountered on the lines E90, E120, E150, E180 and E210. These cases were especially observed when no potential difference can be read between the electrodes since they are both located on the same equipotential line.

Under such circumstances, the topographic correction factor is too large that the apparent resistivity value after topographic correction becomes unreliable. On the other hand, extremely small potential difference values observed between the potential electrodes caused a distortion on the FE value.

For the case of the D-R configuration with the electrodes placed on 3-5 or 5-7, a sudden drop in potential difference were frequently observed. This case is actually same as the encountered in the above configuration, where the potential electrodes coincide with equipotential lines.

These phenomena that can not occur on a flat topography, can be seen on a inclined topography, when observed points are situated in a lower level than the borehole site.

Hence, in order to carry out Borehole IP method properly blind zones caused by electrode configuration and topographic effects should be taken into account. To overcome this situation that can not be solved by a single drill hole, application of the method on several boreholes permit to effectively cover the mentioned blind zone.

1) R-S

This map reflects IP anomaly sources down to about 100m depth from the surface.

Observed resistivity values are ranging from 372 to 1,440 Ohm-m and FE values ranging from 3.6% to 9.1%.

Although a distinct resistivity anomaly is not seen, the low resistivity of less than 650 Ohm-m may reflect an alteration associated with clay minerals and the high resistivity seems to reflect weakly silicified rocks.

A low resistivity zone is widely distributed in the central part, especially the resistivities around the borehole MJE-3 show lower values than 400 Ohm-m. This low suggest that relatively shallower portions around the borehole are subject to alteration. A resistivity change is recognized in the boundaries with Line E30-E31 causing a high resistivity in the southeastern part and a low in the northwestern.

A high FE zone of more than 8% is detected in a N-S direction at the west of MJE-1. It corresponds mainly with the existence of a fault trending in the same direction and seems also consistent with the southwest of a mineralization A at the south end of the zone.

Another FE anomalous zone of more than 8% distributed in the north of MJE-1 seems to indicate a fault along an E-W direction.

High FE zones of about 8%, which are found distributed in a circular pattern around the borehole MJE-1, are presumed to indicate an existent mineralization, however they are not so distinctive.

2) D-S

This map reflects IP anomalous sources down to about 200m depth from the surface.

Observed resistivity values are widely ranging from 53 to 17,500 Ohm-m. This wide variation should be due to a topographic effect and its effect is likely to induce false high resistivity and also low resistivity Generally, the resistivity distribution is low in the northwestern part and high in the southeastern part in the boundary along Line E30-E210. This distribution is seen here more clear than that in R-S (Fig.II-1-5).

Observed FE values are ranging from 0.5% to 16.0% (Fig.II-1-6). The distribution pattern is similar with that of above figure, however the contrast of high and low is rather strong.

High FE zones of more than 8% detected in the west and north seem to correspond to the above-mentioned fault, while an evident anomaly zone having a ENE-WSW direction is located from the south of MJE-1 to the southeast and showing a distinctive feature abruptly changing from 0.5% to 16% on Line E180. This zone on Line E180 corresponds to a mineralization D and the extension to ENE-WSW indicate the continuity of a mineralization D to the depth along the same direction.

3) D-R

This map reflects IP anomalous sources down to about 300m depth from the surface.

Observed resistivity values are ranging from 50 to 4,200 Ohm-m, but a high resistivity of more than 600 Ohm-m is dominant in this map, indicating the existence of resistive rocks at the depth.

Observed FE values are widely ranging from -20% to 42%.

A negative FE zone surrounded by a high FE anomalous zone of more than 9% is detected at the southeast of MJE-1. In this high-negative anomalous zone, the anomaly in the northwest of MJE-1 may reflect the existence of blind mineralization at the depth while that in the southeast correspond to the mineralizated Zone A.

A low resistivity zone of less than 650 Ohm-m is detected around MJE-2, MJE-3 and east of MJE-1. This zone suggests alteration associated with mineralization because of the zone is being located in the mentioned negative or high FE zone.