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

(PHASE Ⅱ)

MARCH 1990

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

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 from July 2 to November 16, 1989.

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.

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.

January 1990

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

Gen-ichi Fukuhara
President
Metal Mining Agency of Japan

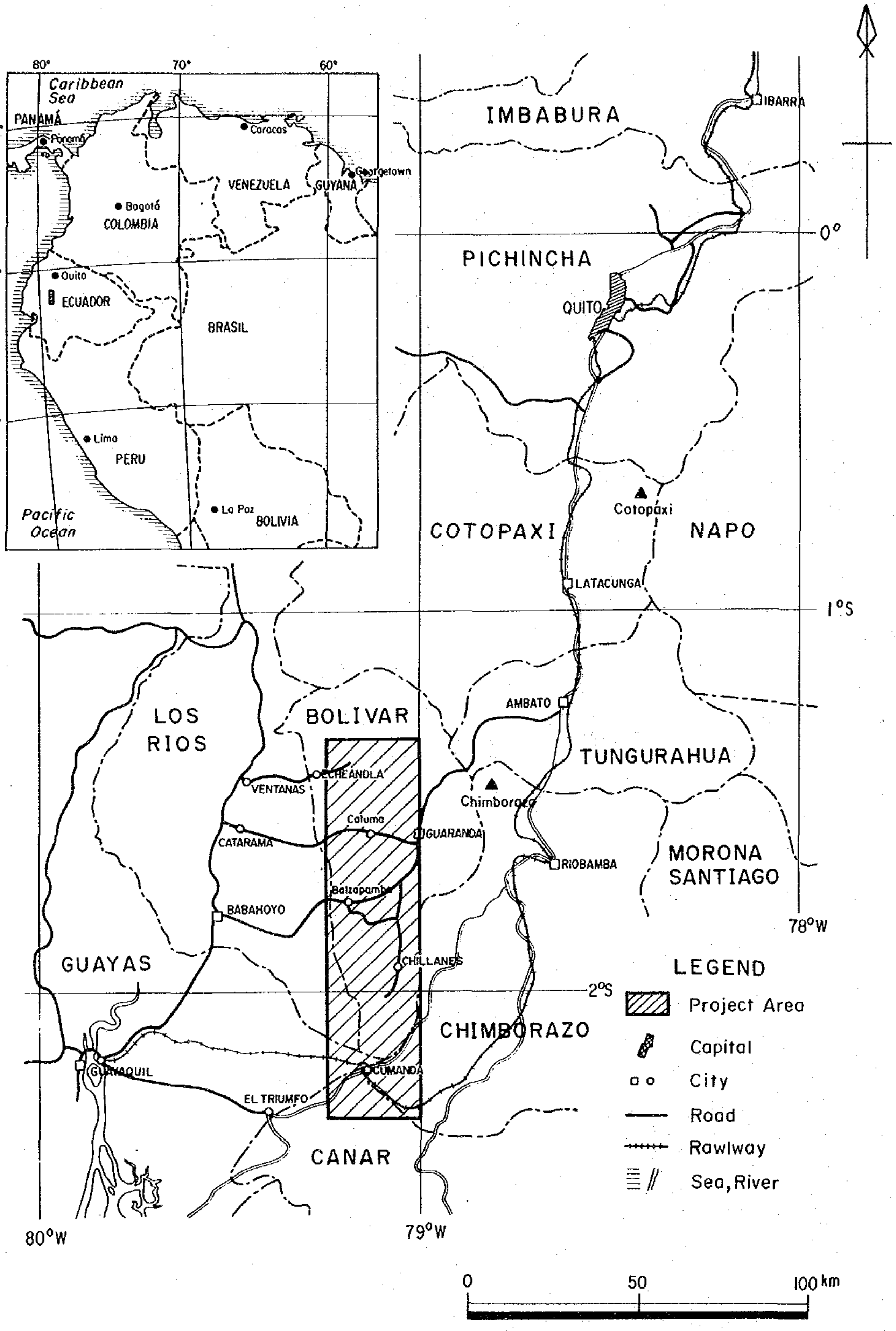


Fig. 1 Location map of the project area

ABSTRACT

The second year survey of the Bolivar Project, in the Republic of Ecuador, was carried out for the purpose of delineating mineral deposits by clarifying surrounding geology in the following five areas: Geophysical survey (bore hole IP method) and drillings were proceeded in the El Torneado zone, Balzapamba area; geophysical survey (IP method) in the Osohuayco zone, Balzapamba area; detailed geological survey and geophysical survey (IP method) in the Chaso Juan area; detailed geological survey in the Telimbela and Las Guardias areas; and detailed geological and geochemical surveys in the La Industria-Yatubi area. The results of surveys are as follows:

(1) El Torneado zone, Balzapamba area

The porphyry copper mineralized zone in the El Torneado zone is divided into a "dissemination" zone and a "network" vein zone on the basis of their modes of occurrence. The former extends over an area of 400 m x 400 m, and the latter is distributed in the direction of NNE-SSW at a scale of 40 to 70 meters in width and 70 to 350 meters in length. Ore grades are generally low. The Phase II geophysical surveys revealed the conditions of occurrence of sulfide minerals in the lower part of the both mineralized zones, "dissemination" and "network". Since the Phase II drilling penetrated the lower limit of the "network", moreover, disclosed that the "dissemination" zone be about reaching the lower part of the mineralization. Consequently, it may be assumed that the center of mineralization in the El Torneado have been subjected to erosion, and that the lower most part of mineralization be exposed at the present ground surface. Therefore, the mineralized zone of the area has been proved to be low grade, and may not be a target for future mining based on tne results of the Phase I and II survey.

(2) Osohuayco zone, Balzapamba area

The mineralized zone in granodiorite over an area of 100 m x 200 m, and the two stripes of mineralization distributed at a width of about 10 meters in the Macuchi Formation, are considered to extend to a further depth with a dip toward southeast. In the northeastern part of the Osohuayco zone, a wide zone of anomaly with low resistivity and high FE (more than 8 %) was detected, suggesting the existence of a concealed mineralized zone in the lower part.

(3) Chaso Juan area

The porphyry copper mineralization in the Chaso Juan area is recognized at four zones. They are, however, distributed discontinuously at a small scale. Geophysical exploration conducted in this area revealed the existence of IP anomalous zones between the Central and South zones, and at and to the south and north of the West zone. The former anomalous zone reflects the extent of the South zone and the latter reflects the West zone. In terms of mineral exploration, the former anomalous zone is more important than the latter.

(4) Telimbela area

In this area, the porphyry copper mineralization is recognized at seven zones. The scale of mineralization is the largest in the entire Bolivar area, and its strong mineralization extends to the Macuchi Formation. Pyrite dissemination and veinlets are widely distributed in granitic rocks,centering around each of the seven mineralized zones. Macroscopically, the mineralized zones in this area are generally distributed in the direction of NE-SW. The largest one is the North zone, where exist Zone V extending over an area of 400 m x 1,200 m, and Zone VI over a length of about 400 m. Maximum Cu contents are 0.8 % in Zone V and 1.65 % in Zone VI.

(5) La Industria-Yatubi area

Outcrops, similar to the hot-spring type Au mineralization, were identified in the vicinities of two mountaintops (Cerro Barranco Amarillo and Caimito South). To find mineralized outcrops is the significant target of the Phase II survey. The scale of the outcrops mineralized are approximate 100 m in length. The assay result shows the Maximum Au content of 0.3 g/t. These outcrops are recognized to be silicified strongly, and the silicified part turns to a white alteration zone which is just below the mountaintops. Since the silicified zone was largely eroded, the silicified rocks remained at the mountaintops are assumed to be the relics of the silicified part formed near the lower limit of mineralization.

(6) Las guardias area

In this area, the major porphyry copper mineralization are distributed along melanocratic diorite intrusive rocks and faults in the direction of NW-SE. This direction is in a marked contrast to the NE-SW direction of the mineralized zones and of intrusive rocks in other areas.

Mineral showings, which are sporadic and small in scale compared with the other area, are recognized at 12 loca-tions. Most of which are distributed over a length of less than 100 meters. Maximum Cu content is 0.47 %.

Based on the consideration of work results mentioned above, the following are recommended for the Phase III survey:

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

It is recommended to conduct further geological exploration, including pit and trench survey, and geophysical surveys (IP method) along additional two survey lines, in order to grasp the full details of the geophysical anomalous zone which was detected in the northeastern part of the Osohuayco zone. Drilling is also recommended to disclose the geophysical anomalous zone in the northeastern part and to clarify more precisely the features and conditions of the mineralized zones in the Macuchi Formation in the southern area. The data analyzed thereby will support exploration as guidelines for future survey work in the Macuchi Formation within the Republic of Ecuador.

(2) Telimbela area (Fig.III-2-2)

It is recommended to conduct further geological investigation, including pit and trench survey, in order to grasp the full details of the mineralized zones in the northeastern part of the Telimbela area, where mineralization and alteration were confirmed. Geophysical exploration (IP method) and drilling are also recommended to disclose the condition and extent of mineralization in the lower part.

CONTENTS

PART II DETAILS

PART III CONCLUSIONS AND RECOMMENDATIONS

PART I GENERAL

Chapter 1 Introduction

1-1 Background of survey

The Bolivar project area lies in the western flank of Occidental Cordillera of Ecuador, where traverses a porphyry copper belt which is known to run continuously from North America to South America.

The Ecuadorian Government has given a top priority politically to develop metallic mineral resources for reconstructing the nation's economy through promotion of exports of those commodities, and has requested the Japanese Government in 1984 to provide technical cooperation for conducting mineral exploration in the Bolivar area.

In response to this request, the Japanese Government sent a mission to Ecuador from May 15 to 24, 1988, which composed representatives of the Japan International Cooperation Agency (JICA), the Metal Mining Agency of Japan (MMAJ), the Ministry of Foreign Affairs, and the Ministry of International Trade and Industry.

The mission concluded a SCOPE OF WORK agreement with INEMIN for mineral exploration in the Bolivar area.

The survey of this year is conducted for Phase II.

1-2 Conclusions and recommendations of Phase I survey

1-2-1 Conclusions of Phase I survey

(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) Other areas

The geology of other 11 areas consists of the Macuchi formation of Late cretaceous, with intrusion of granitic rocks in Oligocene to Miocene.

Macroscopically, mineralization in these areas can be classified into three types that are porphyry copper type, vein type, and hot spring type. Porphyry copper type mineralization occurs mainly in peripheral zone of granitic rocks and surrounding Macuchi formation, vein type in Lourdes volcanic rocks, and hot spring type in granitic rocks and/or Lourdes volcanic rocks.

Porphyry copper type mineralization is observed in Chaso Juan, Telimbela and Las Guardias areas, vein type is in San Miguel area, and hot spring type is in La Industria-Yatubi and San Miguel areas.

Extension of mineralized zone is comparatively large in Chaso Juan, Telimbela and Las Guardias areas. In chaso Juan area, ten mineral showings are recognized and grouped into three mineralized zones, North mineralized zone, East mineralized zone, and South mineralized zone, extension of which vary from 10 to 300 m. Average grade of ore samples is 1.2 to 1.8 g/t Ag and 0.24 to 0.44 % Cu, furthermore the highest grade is 1.5 g/t Au, 160.9 g/t Ag, and 9.03 % Cu.

In Telimbela area, mineralized zones are confirmed at four places, scale of which vary from 500 m x 350 m to 400 m x 200 m, and 150 m wide. Grades of ores gave maximum content of 1.60 % Cu.

In Las Guardias area, mineralized zones are located at three places, scale of which vary from 400 m x 100 m to 350 m x 50 m, and 50 m wide. Maximum contents of ores are 0.6 g/t Ag, 0.09 % Cu and 0.01 % W.

Mineralization in Chaso Juan area may be characterized by a high ratio of chalcopyrite/pyrite, and by occurrence of scheelite. General trends of ;mineralized zones are N-S direction in Chaso Juan area, NE-SW in Telimbela area, NW-SE in Las Guardias area, and NNW-SSE in San Miguel area.

Data analysis of magnetic susceptibility showed a close relation between demagnetization and mineralization, and delineated anomalous zones of low magnetic susceptivility. One is in Chaso Juan area, extension of which is about 1 km x 1 km, and the other in Telimbela, extension of which is about 2 km x 750 m. Adding those, two other magnetic anomalous zones were picked up in La Industria-Yatubi and San Miguel areas, scale of which are 500m x 200 m and 2.5 km x 500 m with NNW-SSE direction, respectively.

As a result of geochemical survey, several factors were selected as indicators for Cu and Mo mineralization. High to moderate score zones of these factors were obtained in Chaso Juan, Telimbela and Las Guardias areas. In La Industria-Yatubi and San Miguel areas, different factors, which were thought to indicate hot spring type mineralization of another stage, were also detected.

1-2-2 Recommendations for Phase II survey

(1) Balzapamba area

1) Borehole geophysical survey (IP) and drilling to clarify the detailed occurrence of El Torneado mineralized zone.

2) Geophysical survey (IP or SIP) to clarify bonanza of mineralized zone related to low resistivity zones at the lower part of Osohuayco mineralized zone.

(2) Other areas

1) Detailed geological survey and geophysical survey (IP or SIP) to define the detailed occurrence of mineralized zone in the Chaso Juan, Telimbela and Las Guardias areas where porphyry copper type deposits can be expected.

2) Soil geochemical survey in the southwestern part of the La Industria-Yatubi area where the occurrence of hot spring type gold deposits may be expected.

3) Geophysical survey (SIP) in the San Miguel area to clarify the detailed occurrence of mineralized zone of copper vein type and detailed geological survey in the San Miguel area to follow up the mineralized zone where hot spring type gold deposit may be expected.

1-3 Outline of the Phase II survey

1-3-1 Survey area

The Phase II work covered following five areas: the Balzapamba; Chaso Juan; Telimbela; La Industria-Yatubi and Las Guardias areas. These areas were recommended on the result of the Phase I survey (Fig.I and Fig.I-1-1).

1-3-2 Purpose of the survey

The purpose of the survey is to determine the possible occurrence of ore deposits through careful clarification of geology and geological structure in the Bolivar area.

The objectives of the geological and geochemical surveys were to clarify the relationship between mineralization, and geological structures and volcanic activities in order to delineate promising mineralized zones.

The geophysical survey was planned to pursue lateral and vertical extension of mineralization. In the Balzapamba area, the geophysical survey aimed to collect essential information in order to make selection of drilling sites.

The purpose of drilling was to clarify geological structure and to confirm intensity and characteristics of mineralization.

1-3-3 Method of the survey

The Balzapamba area consists of two working areas, El Torneado zone and Osohuayco zone.

In El Torneado zone, the Bore Hole IP Method and diamond core drilling were taken place to confirm extension of mineralized zone. In Osohuayco zone, IP method was adopted to follow up the results of the Phase I survey and to clarify both the mineralized zone found through geological survey and the sub-surface distribution of low-resistivity anomaly detected by CSAMT survey.

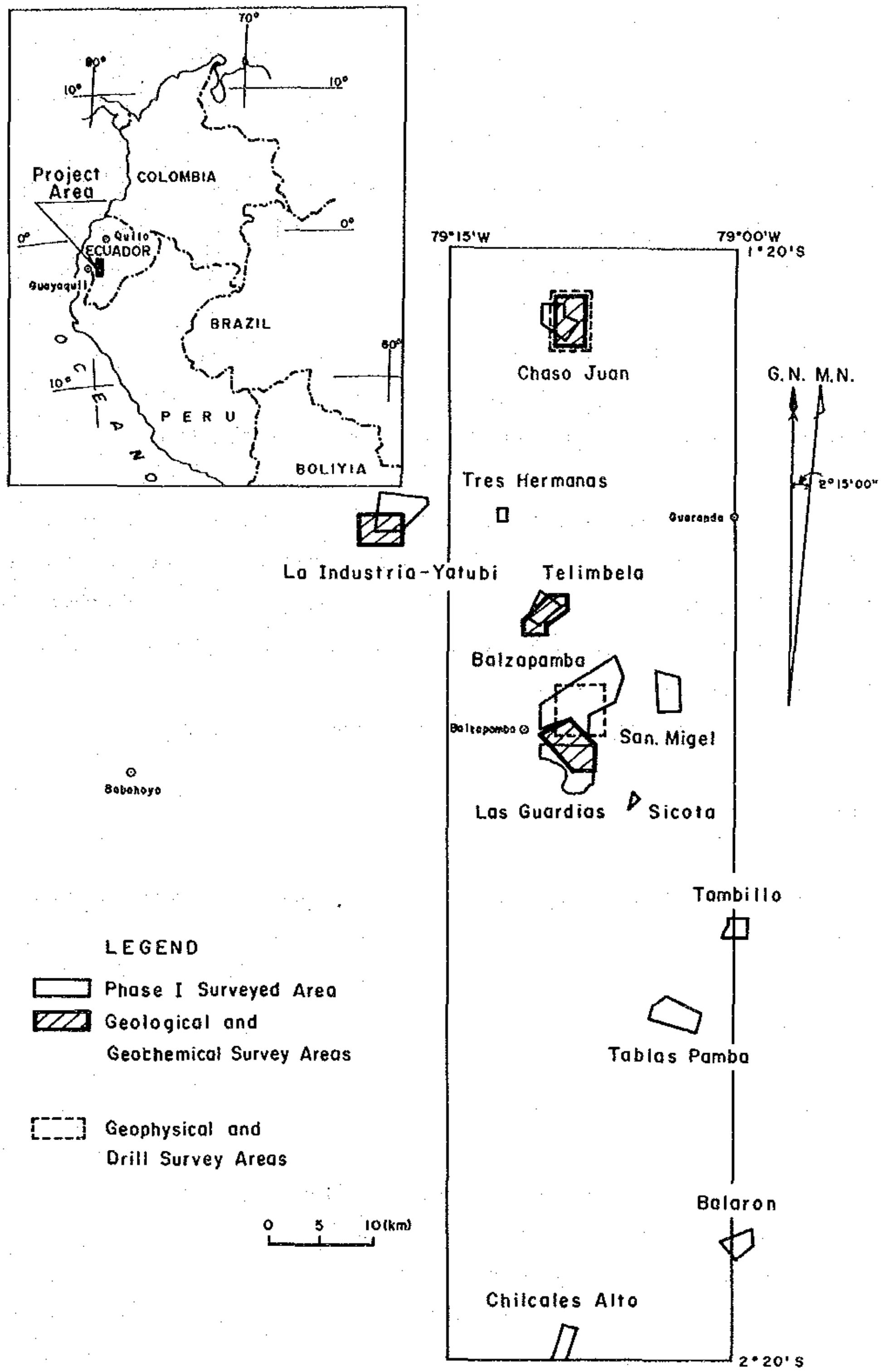


Fig. I–1–1 Location map of the surveyed area

In the Chaso Juan area, detailed geological survey was taken place to confirm extension and characteristics of mineralized zones found through the Phase I survey and IP method was adopted to clarify lateral extension and sub-surface continuation between the Central mineralized zone and the South mineralized zone.

In the Telimbela area, detailed geological survey was taken place in order to confirm lateral extension and mineralogical characteristics of mineralized Zone I, Zone II, Zone III and Zone IV, and to clarify relationship between intrusive rocks and mineralization-alteration.

In the La Industria-Yatubi area, a number of ore-floats were observed within a limited area through the Phase I survey. Therefore, geochemical exploration and detailed geological survey were taken place to delineate center-parts of mineralization and/or alteration.

According to the results of the Phase I survey, two systems of geological structure, NW-SE and NE-SW, may cross in the Las Guardias area. On the other hand , mineralization was observed along NW-SE geological structure. Detailed geological survey, therefore, was taken place to clarify the extension and characteristics of mineralized zones in and around intersection of geological structures.

Survey amounts and laboratory works are listed on Table I-1-1 and Table I-1-2.

1-3-4 Organization of survey team

Following tables list the members who participated in planning and administrating the survey (Table I-1-3), and who proceeded field survey (Table I-1-4).

1-3-5 Survey period

Field survey:

From July 2 to November 16, 1989

Geological and geochemical survey: From July 2 to August 20, 1989

Geophysical survey : From July 2 to October 6, 1989

Drilling : From August 22 to November 16, 1989

Data analysis and documentaion:

From August 21, 1989 to January 31, 1990

Table I–1–1 List of survey amounts

Items	Quantity		
1. Geological and geochemical survey	Area (km^2)	Survey length (km)	Geochemical samples
(1) Chaso Juan	15	36.0	0
(2) Telimbela	9	26.9	0
(3) La Industria-Yatubi	8	21.9	205
(4) Las Guardias	13	33.0	0
2. Geophysical survey	Area (km^2)	Survey length (km)	
(1) Balzapamba			
1) El Torneado	0.26	6.9	
2) Osohuayco	2.0	9.6	
(2) Chaso Juan	2.4	9.6	
3. Drilling	Depth (m)	Dip (°)	
(1) Balzapamba			
1) MJE–4	305.30	–90	
2) MJE–5	305.20	–90	
3) MJE–6	353.00	–90	

Table I–1–2 List of laboratory works

Method / Area	Thin section	Polished section	Dating (K-Ar)	Chemical Analyses			X-ray diffractive analysis	Resistivity
				Whole rock	Ore (Au, Ag, Cu, Pb, Zn, Mo)	Soil (Au, Ag, Cu, Pb, Zn, Mo, As, Hg)		
Balzapamba	0	0	0	0	0	0	0	6
Drill core	5	11	0	0	54	0	41	16
Chaso Juan	1	4	1	1	10	0	4	10
Telimbela	5	4	2	2	22	0	9	0
La Industria-yatubi	0	0	0	0	11	205	6	0
Las Guardias	4	2	2	2	8	0	1	0
Total	15	21	5	5	105	205	61	32

Table I-1-3 Member list of project administration

Japanese counterparts		Ecuadorian counterparts	
Yoshio Matsukawa	MMAJ	Leonardo Elizalde	INEMIN
Kyoichi Koyama	MMAJ	Wilson Santamaria	INEMIN
Hiroyasu Kainuma	JICA	Marco Marin	INEMIN
Hideya Metsugi	MMAJ	Edgar Lopez	INEMIN
		Luis Quevedo	INEMIN

Table I-1-4 Member list of survey team

Japanese counterparts			Ecuadorian counterparts		
Hideo Kuroda	Leader Geological and geo-chemical survey	BEC	Vicente Fiallos	Geological and geochemical survey	INEMIN
Hiroshi Kusaka	Geological and geo-chemical survey	BEC	Alfredo Zamara	Geological and geochemical survey	INEMIN
Norio Ikeda	Geological and geo-chemical survey	BEC	Xavier Bermudez	Geological and geochemical survey	INEMIN
Toshimasa Tajima	Geophysical survey	BEC	Gabriel Unda	Geological and geochemical survey	INEMIN
Manabu Kaku	Geophysical survey	BEC	Edgar Lopez	Geophysical survey	INEMIN
Nobuyuki Sasaki	Drilling	BEC	Cesar Cardenas	Drilling	INEMIN
Takashi Matsuoka	Drilling	BEC	Luis de ls Torre	Drilling	INEMIN
Tsukasa Anbo	Drilling	BEC	Alfonso Vaca	Drilling	INEMIN

BEC: Bishimetal Exploration Co., Ltd.

Chapter 2 Geography of survey area

2-1 Location and access

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 Baba hoyo).

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)
Telimbela	Car (135 km, 3.0 hours)
La Industria-Yatubi	Car (125 km, 3.0 hours)
Las Guardias	Car (5 km, 0.5 hours)

2-2 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.

2-3 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-2-1.

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-2-1 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

Chapter 3 General geology

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 to intermediate plutonic rocks.

Stratigraphic 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$\pm$2.5 Ma (early Eocene). Furthermore, K-Ar isotopic ages were determined to be 19.2$\pm$3 Ma to 30.8$\pm$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.

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).

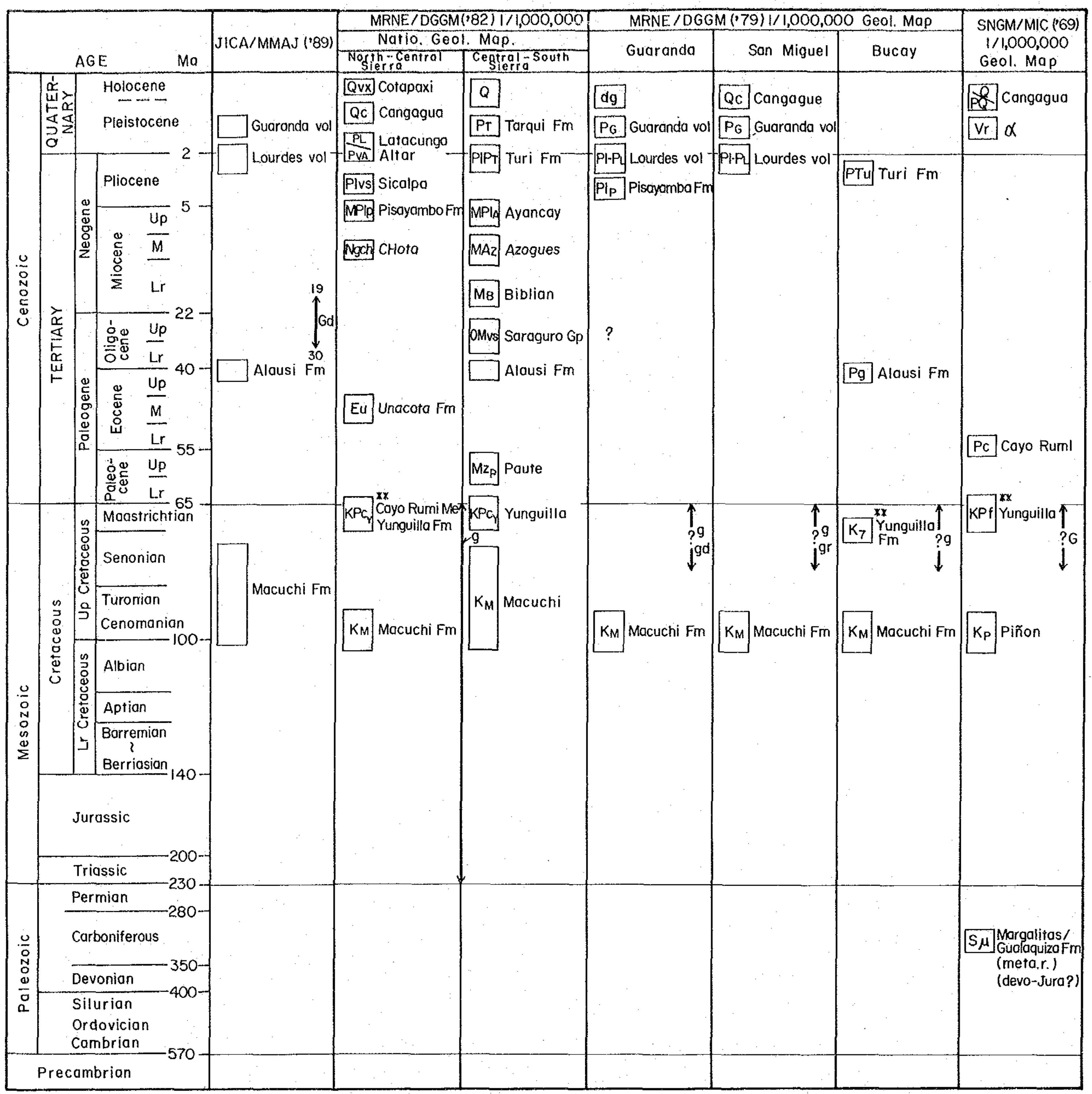


Fig. I-3-1 Stratigraphic correlation around the project area

Table I–3–1 Classification of metallogenic zones

<table>
<tr><th colspan="2">Topography</th><th>Geology</th><th>Metallo-genic Province</th><th>Metallogenic Zone</th><th>Metallogenic Sub-Province</th></tr>
<tr><td colspan="2">Galapagos Islands</td><td>Pliocene ~ Quaternary</td><td></td><td></td><td>Cu-Ni-Co Sub-Province of Ocean Floor (Quaternary)</td></tr>
<tr><td colspan="2">Coast</td><td>Pre-Cretaceous ~ Pleistocene (Pinion Formation)</td><td rowspan="5">Occidental (Ocean Crust, Eugeosyncline)</td><td>VIII. Coastal Zone</td><td>Fe-Ti-Pt Sub-Province of Coast (Jura ~ Early Cretaceous)</td></tr>
<tr><td rowspan="5">Mountain Range</td><td>Occidental Cordillera</td><td>Cretaceous ~ Paleocene (flysh) (Macuchi Formation)</td><td>VII. Anticlinorium-Synclinorium of Occidental Cordillera</td><td>Cu Sub-Province of Occidental Cordillera (Cretaceous ~ Miocene)</td></tr>
<tr><td rowspan="3">Interandean Depression</td><td rowspan="3">Neogene ~ Holocene</td><td>VI. Catamayo Synclinorium Graben</td><td rowspan="3">Polymetalic Sub-Province of High Plateau (Paleocene ~ Quaternary)</td></tr>
<tr><td>V. Azuay Basin</td></tr>
<tr><td>IV. Quito Graben</td></tr>
<tr><td>Real Cordillera</td><td>Metamorphic Rocks of Paleozoic and Mesozoic</td><td rowspan="3">Oriental (Continental Crust, Miogeosyncline)</td><td>III. Anticlinorium of Real, Moromoro and Mullepungo Cordillera</td><td>Sn-W-U Sub-Province of Real Cordillela (Later Paleozoic)</td></tr>
<tr><td colspan="2" rowspan="2">Orient</td><td>Carboniferous ~ Cretaceous</td><td>II. Oriental Pre-Andean Zone</td><td rowspan="2">Au Sub-Province of Orient Basin (Mesozoic ~ Cenozoic)</td></tr>
<tr><td>Tertiary ~ Quaternary</td><td>I. Iquitos Basin</td></tr>
</table>

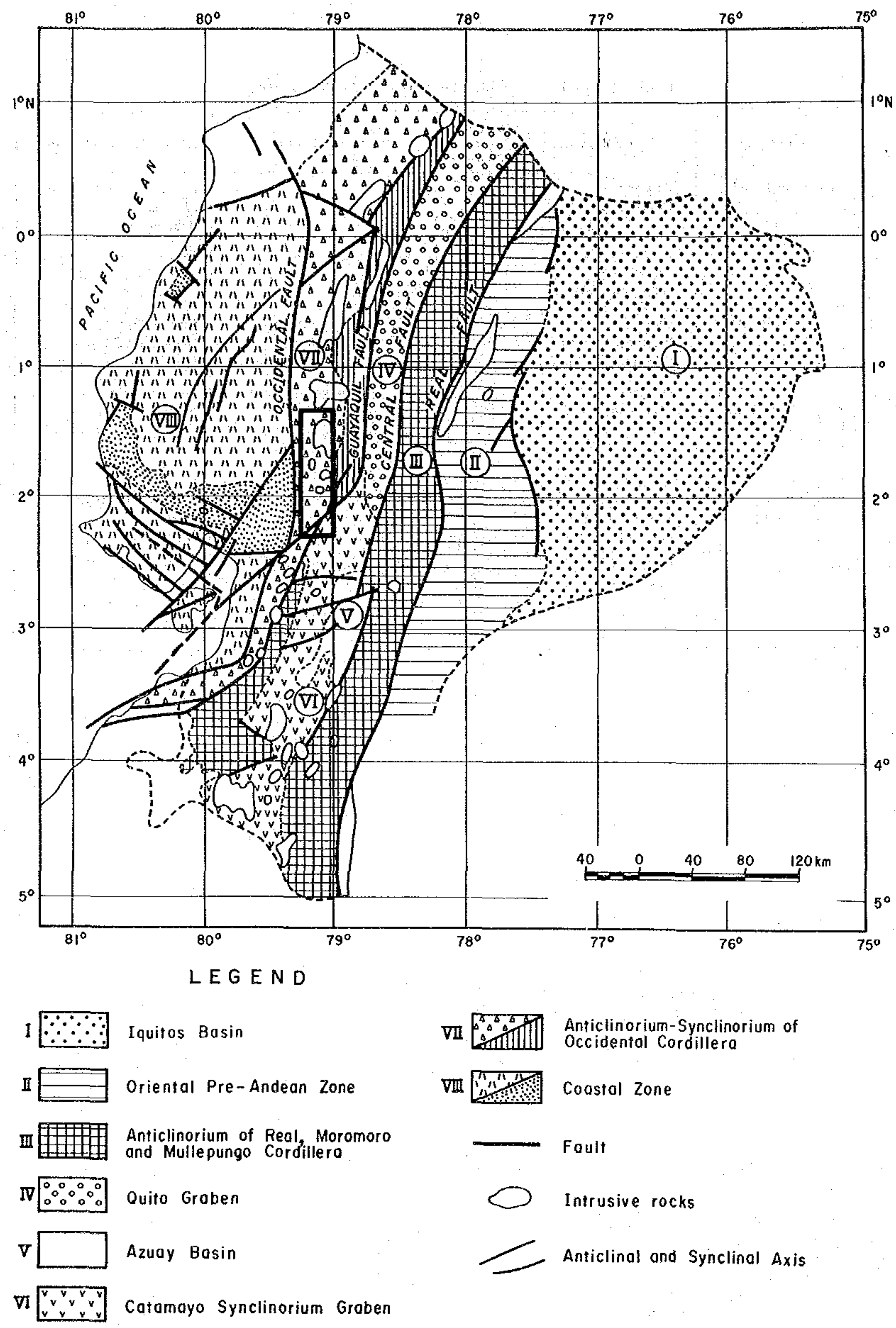


Fig. I–3–2 Geotectonic and metallogenic zone map of Ecuador

Chapter 4 General discussion on the survey results

4-1 Survey results in each survey area

The Phase II survey was conducted to clarify the conditions of mineral occurrence in the following five areas: Balzapamba, Chaso Juan, Telimbela, La Industria-Yatubi, and Las Guardias.

In the Balzapamba area, geophysical (Bore hole IP method) and drilling surveys were conducted for the El Torneado zone. Geophysical survey (IP method) was conducted for the Osohuayco zone in the same area. In the Chaso Juan area, geophysical (IP method) and detailed geological surveys were conducted. In the Telimbela and Las Guardias areas, detailed geological investigations were carried out. In the La Industria-Yatubi area, geochemical (soil) and detailed geological surveys were conducted. The following are the major findings of these surveys.

4-1-1 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.

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.

4-1-2 Osohuayco zone, Balzapamba area

There are two known mineralized zones of different types: one in the northwest and the other in the south. The former is a chalcopyrite-pyrite dissemination and thin vein zone occurring in granodiorite, extending over an area of 100 m x 200 m. Maximum Cu content of the samples taken from the disseminated part is 0.08 %. The latter is a chalcopyrite-pyrite dissemination and small vein zone impregnated in silicified and partly skarnized altered rocks in the tuff bed of the Macuchi Formation. This mineralized zone is primarily distributed in two stripes with a general strike in the direction of NE-SW and a dip of 30°SE. Mineral contents of the samples taken from a lower vein in the northwestern part of the zone are 0.4 g/t in Au, 27.8 g/t in Ag and 2.65 % in Cu. Since the geophysical exploration detected a continuation of high apparent resistivity and high FE (more than 5 %) values with a general dip toward southeast, it is considered that this mineralization extends to a further depth.

The geophysical survey also detected low apparent resistivity and high FE (more than 8 %) values in the northeastern part of the Zone. Although details are yet unknown as this area is covered with weathered soil, this suggests possible existence of an additional concealed mineralized zone in the lower part.

4-1-3 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.

4-1-4 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.

4-1-5 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.

4-1-6 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.

4-2 General discussion

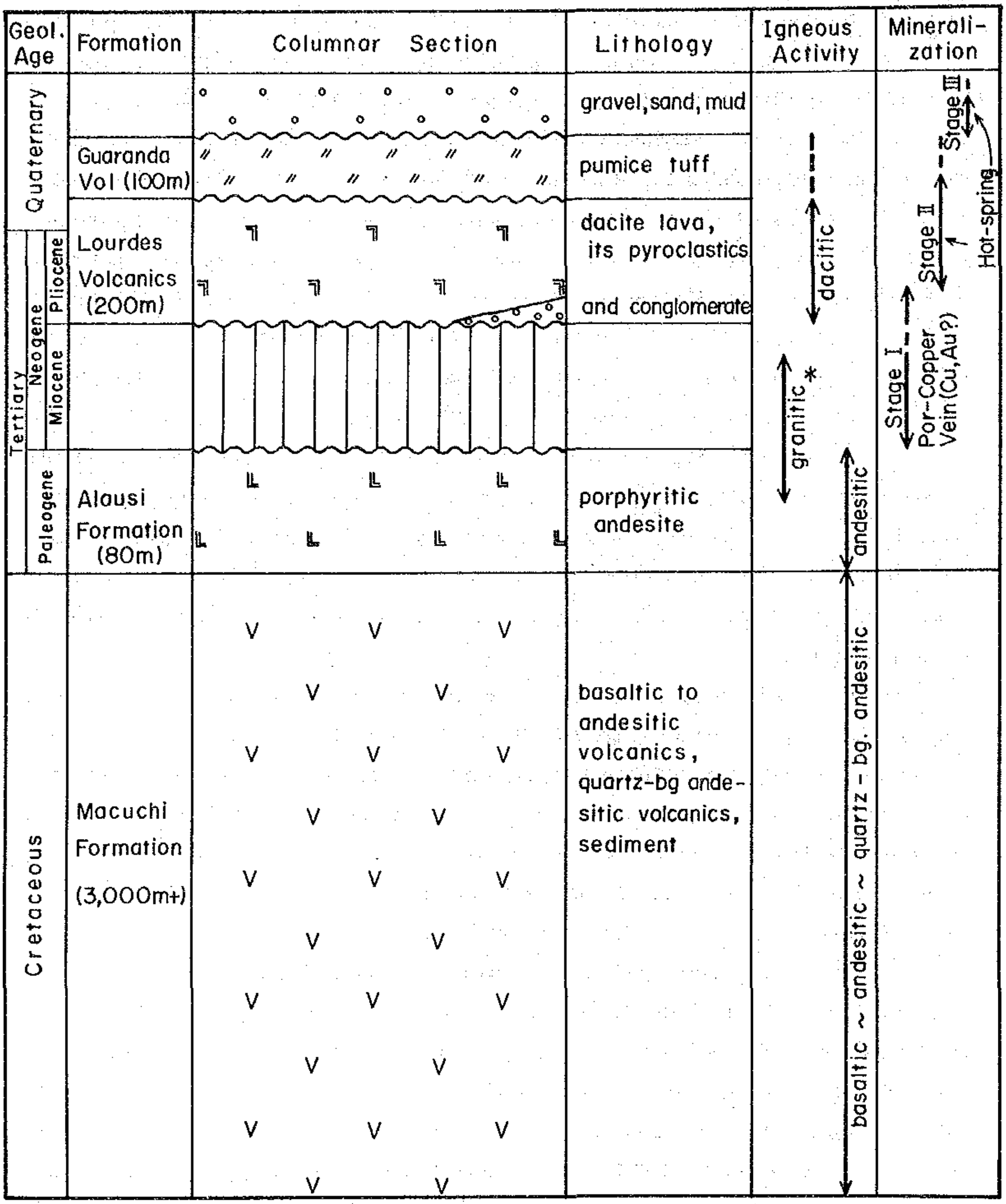
4-2-1 Characteristics of igneous activities and mineralization

This section summarizes the characteristics of and the relationships between the tectonic, and igneous and hydrothermal activities in the Bolivar area.

The Macuchi Formation, which is marine in origin and formed during Late Cretaceous, was subjected to Andean orogeny in the Eocene to Oligocene period. Orogeny in Ecuador is characterized by faults, mainly of lateral slip, of an NNE-SSW to NE-SW system, and by folds of the same system, as well as intrusion of plutonic rocks (MRNE/CGGM,1982). The intrusion of which is, in turn, characterized by granitic rocks intruded in the N-S direction during Oligocene to Miocene in the survey area. Whether this N-S system structure was initiated by a comparatively new tectonics after Neogene, or whether it was due to other internal processes including reactivation of the basement complex, is yet to be known. These events were followed by hydrothermal activities in the Miocene to Pleistocene period. The major tectonic structures after Pliocene are characterized by faults and folds of NNW-SSE and NNE-SSW to NE-SW systems, exhibiting vertical dislocation. Mineralization observed in the Bolivar area can be grouped into three types: the porphyry copper type, the vein type and the hot spring type. Hydrothermal activities in this area took place in three stages: Stage I in Miocene to Pliocene; stage II in Pliocene to Pleistocene and Stage III in Holocene. Stage I hydrothermal activities are accompanied by precipitation of sulfide minerals. The hydrothermal activities in Stage II are characterized by acidic alteration with hematite, while those in Stage III accompanied metal-free acidic alteration. The porphyry copper type and the vein type mineralizations correspond to Stage I, and the hot spring type Au mineralization corresponds to Stage II (JICA/MMAJ, 1989).

The mineralized zones and the dikes and stocks in the Balzapamba and Telimbela areas are arranged and developed along the NNE-SSW to NE-SW system, corresponding to the direction of the tectonic line. This fact suggests that the tectonic line and the intrusion of dikes and stocks, as well as the mineralization, are closely related and, therefore, indicates the importance of further exploration along this direction. Those of faults, dikes and mineralized zones in the Las Guardias area, which trend toward NW-SE direction, may be a conjugate set of the principal tectonic line.

The isotopic age of the granodiorite and quartz diorite batholith embedded sporadically in the N-S direction in the Macuchi Formation in Ecuador, is 30 to 19 Ma, while 15 to 18 Ma are the melanocratic diorite, hornblende quartz diorite and porphyritic quartz diorite intruded as dikes and stocks in the direction of NNE-SSW to NE-SW. This may suggest that the activities of granitic rocks in this area were closely related to the reactivation of the N-S basement complex in the early stage, and to the tectonic movement of the NNE-SSW to NE-SW system in the later stage. Generalized geologic stratigraphy of the Bolivar area is shown in Fig.I-4-1. Table I-4-1 is a list of mineral showings, excluding those in the Balzapamba area.



* 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–4–1 Generalized stratigraphy in the project area

Table I–4–1 Summary of survey results with mineral showings

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 Geological Survey	Chaso Juan	15	Macuchi Formation: hornfels, andesites & tuff breccias	Central part	Vlet and/or diss (Por-Cu)	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 discussed in the first phase report, has been also proved to be limited in the central part of the survey area. Geophysical investigation (IP method) will be required to test mineral extension horizontally and vertically.
									sil	A2015	0.2	1.1	0.33	0.00	0.01	0.00	
									chl.	A2017	0.1	4.2	1.41	0.00	0.01	0.05	
										B2002	0.1	1.7	0.24	0.00	0.01	0.00	
			Intrussive rocks: (1) Bi-Ho granodiorite	Southern part	Vlet and/or diss (Por-Cu)	800 x 300m	Cp, Mo, Py	Gd	sil	C2006	Tr	Tr	0.04	0.00	0.00	0.00	
									chl.	C2009	Tr	1.0	0.24	0.00	0.00	0.00	
										C2010	Tr	Tr	0.02	0.00	0.00	0.00	
			(2) Melamocratic diorite	Western part	do.	(?) x 200m	Cp, Mo, Py	Gd	sil	C2011	Tr	Tr	0.01	0.00	0.00	0.00	
										D2008	Tr	Tr	0.01	0.00	0.00	0.00	
Detailed Geological Survey	Telimbela	9	Macuchi Formation: hornfels & basaltic andesite	Zone I	Vlet and/or diss (Por-Cu)	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 extended area. (NE-SW direction)
				Zone II		400 x 200m	Cp, Py, Mo	Qd & Horn	sil chl	A2026	0.2	1.6	0.16	0.00	0.01	0.00	
				Zone III		900 x 400m	Py	Qd	sil chl	A2030	0.1	0.9	0.12	0.01	0.01	0.00	
				Zone IV		(?) x 400m	Cp-Py-Mo	Qd	sil chl	A2033	0.1	9.5	0.80	0.01	0.03	0.08	
			Intrusive rocks:							A2035	0.2	5.6	0.47	0.00	0.02	0.00	– Three zones of mineralization are picked up in 1989. Two of three are significant mineralization.
			(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	
			(2) (Bi)-Ho							A2043	0.2	2.7	0.53	0.00	0.01	0.01	
			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 diorite	Zone VII		(?) x 100m	Cp, Py	Qd	sil chl	B2020	Tr	Tr	0.09	0.00	0.01	0.00	
										B2021	Tr	Tr	0.08	0.00	0.01	0.00	
			(5) Porphyritic q-diorite							B2022	Tr	Tr	0.08	0.00	0.01	0.02	
			(6) Q porpyry														
Detailed Geological & Geochemical Survey	La Industria-Yatubi	8	Macuchi Formation: none	C. B. Amarillos	Goss (Hot Spring)	L W 500 x 300m	Hm-Q-day	Qd	sil arg	A2068	Tr	Tr	0.00	0.00	0.00	0.01	– Further investigation.
										A2071	Tr	Tr	0.02	0.01	0.00	0.00	
										A2072	Tr	Tr	0.01	0.00	0.00	0.00	
			Intrusive rocks: (1) q-diorite	Caimito South	Goss (Hot Spring)	400 x 200m	Hm-Q	Qd	sil arg	C2029	Tr	Tr	0.00	0.00	0.00	0.02	
										C2033	Tr	Tr	0.00	0.00	0.00	0.01	
			(2) melanocratic diorite							E2027	Tr	Tr	0.01	0.01	0.00	0.00	
										E2028	Tr	Tr	0.01	0.00	0.00	0.00	
Detailed Geological Survey	Las Guardias	13	Macuchi Formation: hornfels,	Northern part	Vlet and/or diss (Por-Cu)	L W 400 x 100m	Cp, Py, Mo	Melano Dio Ande. or Horn	st. sil	A2080	0.2	2.1	0.47	0.00	0.01	0.00	– No further investigation.
										A2091	Tr	Tr	0.04	0.00	0.01	0.00	
			q-andesite,							C2037	Tr	Tr	0.05	0.00	0.00	0.00	
			andesite & pyroclastics	Center part		350 x 50m	Cp, Py	Gd	sil	C2041	Tr	Tr	0.08	0.00	0.01	0.00	
									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: (1) granodiorite	Southern part		400 x 10^m	(Cp, Py)	Gd & melano Dio	st. sil	D2035	Tr	Tr	0.00	0.00	0.02	0.00	
			(2) melamocratic diorite							D2043	Tr	Tr	0.02	0.00	0.00	0.00	
			(3) porphyritic q-diorite	Angas-north		500 x 250m	Cp, Py	Gd & melano Dio	sil								

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

4-2-2 Possibilities of locating ore deposits

Mineralization in the five areas covered in the Phase II survey is recognized in two different types: porphyry copper type mineralization and hot-spring type Au mineralization.

Au mineralization of the hot spring type is found in the La Industria-Yatubi area. Although Au is partly contained in this mineralized zone. Which zone was largely eroded, relics in the ground surface may be the silicified part near the lower limit of the mineralization.

Mineralization of the porphyry copper type is found in all of the five areas, and the detail discussion is now available on the mineralizations located in the El Torneado zone in the Balzapamba area. This zone was subjected to erosion to such an extent where the lower part of mineralization is exhibited on the ground surface. Therefore the lower limit of mineralization is recognized to be at a shallow part.

Among other areas, mineralized zones of the Telimbela area and the Osohuayco zone are particularly important, as they are not only large in scale but also are expected to extend toward northeast beyond the area boundaries. In the Osohuayco zone, mineralization is found in the Macuchi Formation and in granitic rocks.

It is necessary to undertake further investigation into the mineralization embedded in the Macuchi Formation, in order to clarify the conditions of mineral occurrence and thereby collect data which may prove useful for future exploration of similar mineralization in other areas. It is also necessary to understand more precisely the characteristics of geophysical anomalies detected in the northeastern part of the Osohuayco zone.

In the La Industria-Yatubi area, only recognized was an alteration zone with a small amount of pyrite. Mineralized zones in the Chaso Juan and Las Guardias areas were small in scale and sporadic though ore grade was high locally.

4-2-3 Evaluation of survey methods

(1) Magnetic susceptibility measurement

The magnetic susceptibility measurement undertaken through survey proved the range of magnetic susceptibility for each rock types, consequently revealed the existence of demagnetization halo, which exceeded the measured differences in magnetic susceptibility due to the types of mineralization and the kinds of rocks. In other words, magnetic susceptibilities are 20 to 60 x 10^{-3} SI units for granodiorite, 40 to 156 x 10^{-3} SI units for melanocratic diorite, 50 to 70 x 10^{-3} SI units for andesite in the Macuchi Formation, and less than 10 x 10^{-3} SI units for tuff and sedimentary rocks, while those of the mineralized zones are in the ranges of less than 0.1 to 20 x 10^{-3} SI units in the most susceptible parts and less than 10 to 40 x 10^{-3} SI units in the least susceptible parts. Although it is difficult to differentiate demagnetization haloes associated with particular mineralization when and where there are more than one type of mineralization as in the La Industria-Yatubi area, they are clearly distinguishable from the overall background. The magnetic susceptibility measurement makes it possible to understand the extent of demagnetization effect in quantitative terms and, therefore, is quite useful in making a selection of promising mineralized zones during field work.

(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 eléctric potential become inevitably small, making the data obtained thereby less reliable.

(4) IP method electric exploration

Electric exploration with the IP method was conducted in the Osohuayco, Balzapamba area and the Chaso Juan area. The mineralized zones under strong silicification were expressed as the zones of high apparent resistivity and high FE, while the mineralized zones under strong argillization were expressed as the zones of low apparent resistivity and high FE. These results combined made it possible to estimate the conditions of sulfide mineral occurrence and the extent of their alteration below the ground surface.

In both areas, apparent resistivity values reflected the influence of steep topography thereof. However, since survey lines were placed in perpendicular to the direction of topographic inclination, it was possible to make the necessary corrections of measured resistivity values on a two-dimensional model for proper analysis.

Chapter 5 Conclusions and recommendations

5-1 Conclusions

(1) El Torneado zone, Balzapamba area

The porphyry copper mineralized zone in the El Torneado zone is divided into a "dissemination" zone and a "network" vein zone on the basis of their modes of occurrence. The former extends over an area of 400 m x 400 m, and the latter is distributed in the direction of NNE-SSW at a scale of 40 m to 70 m in width and 70 m to 350 m in length. Ore grades are generally low. The Phase II geophysical surveys revealed the conditions of occurrence of sulfide minerals in the lower part of the both mineralized zones, "dissemination" and "network". Since the Phase II drilling penetrated the lower limit of the "network", moreover, disclosed that the "dissemination" zone be about reaching the lower part of the mineralization. Consequently, it may be assumed that the center of mineralization in the El Torneado have been subjected to erosion, and that the lower most part of mineralization be exposed at the present ground surface. Therefore, the mineralized zone of the area has been proved to be low grade, and may not be a target for future mining based on the results of the Phase I and II survey.

(2) Osohuayco zone, Balzapamba area

The mineralized zone in granodiorite over an area of 100 m x 200 m, and the two stripes of mineralization distributed at a width of about 10 meters in the Macuchi Formation, are considered to extend to a further depth with a dip toward southeast. In the northeastern part of the Osohuayco zone, a wide zone of anomaly with low resistivity and high FE (more than 8 %) was detected, suggesting the existence of a concealed mineralized zone in the lower part.

(3) Chaso Juan area

The porphyry copper mineralization in the Chaso Juan area is recognized at four zones. They are, however, distributed discontinuously at a small scale. Geophysical exploration conducted in this area revealed the existence of IP anomalous zones between the Central and South zones, and at and to the south and north of the West zone. The former anomalous zone reflects the extent of the South zone and the latter reflects the West zone. In terms of mineral exploration, the former anomalous zone is more important than the latter.

(4) Telimbala area

In this area, the porphyry copper mineralization is recognized at seven zones. The scale of mineralization is the largest in the entire Bolivar area, and its strong mineralization extends to the Macuchi Formation. Pyrite dissemination and veinlets are widely distributed in granitic rocks, centering around each of the seven mineralized zones. Macroscopically, the mineralized zones in this area are generally distributed in the direction of NE-SW. The largest one is the North zone, where exist Zone V extending over an area of 400 m x 1,200 m, and Zone VI over a length of about 400 m. Maximum Cu contents are 0.8 % in Zone V and 1.65 % in Zone VI.

(5) La Industria-Yatubi area

Outcrops, similar to the hot-spring type Au mineralization, were identified in the vicinities of two mountaintops (Cerro Barranco Amarillo and Caimito South). To find mineralized outcrops is the significant target of the Phase II survey. The scale of the outcrops mineralized are approximate 100 m in length. The assay result shows the Maximum Au content of 0.3 g/t. These outcrops are recognized to be silicified strongly, and the silicified part turns to a white alteration zone which is just below the mountaintops. Since the silicified zone was largely eroded, the silicified rocks remained at the mountaintops are assumed to be the relics of the silicified part formed near the lower limit of mineralization.

(6) Las guardias area

In this area, the major porphyry copper mineralization are distributed along melanocratic diorite intrusive rocks and faults in the direction of NW-SE. This direction is in a marked contrast to the NE-SW direction of the mineralized zones and of intrusive rocks in other areas.

Mineral showings, which are sporadic and small in scale compared with the other areas, are recognized at 12 locations. Most of which are distributed over a length of less than 100 meters. Maximum Cu content is 0.47 %.

5-2 Recommendations for Phase III survey

(1) Osohuayco zone, Balzapamba area

It is recommended to conduct further geological exploration, including pit and trench survey, and geophysical surveys (IP method) along additional two survey lines, in order to grasp the full details of the geophysical anomalous zone which was detected in the northeastern part of the Osohuayco zone. Drilling is also recommended to disclose the geophysical anomalous zone in the northeastern part and to clarify more precisely the features and conditions of the mineralized zones in the Macuchi Formation in the southern area. The data analyzed thereby will support exploration as guidelines for future survey work in the Macuchi Formation within the Republic of Ecuador.

(2) Telimbela area

It is recommended to conduct further geological investigation, including pit and trench survey, in order to grasp the full details of the mineralized zones in the northeastern part of the Telimbela area, where mineralization and alteration were confirmed. Geophysical exploration (IP method) and drilling are also recommended to disclose the condition and extent of mineralization in the lower part.

PART Ⅱ DETAILS

Chapter 1 El Torneado zone, Balzapamba area

1-1 Geology and mineralization

1-1-1 Geology

The geology of Balzapamba area consists of pyroclastics of the Macuchi formation (late Cretaceous) and granitic rocks and trachyandesite which intruded into the former formation.

generally, the Macuchi Formation comprises six members named A through F in ascending order, and lower most menber A is distributed in the area. Member A comprises dark green, massive and compact pyroxene andesite lava and green, andesitic fine tuff. In addition, thin and rhythmic alternation layers of dark gray siliceous and calcareous beds are intercalated in andesitic pyrocrastics locally. These rocks are affected by hornfelsation along the margin of granitic rocks. Origin of which is not confirmed yet, becouse rock forming minerals and texture are obscure. Those currently observed are compact and hard rock with fine grained biotite-hornblende-pyroxene-quartz assemblage.

Granitic rocks in this area comprise hornblende-biotite granodiorite batholith, intrusive melanocratic diorite, and trachyandesite dikes. The first and former rocks are distributed widely in this area in NE-SW direction, and dated as 25 Ma by K-Ar method (JICA/MMAJ, 1989). The melanocratic diorite contains fine grained biotite and crops out 20 to 50 m wide in NE-SW direction, and shows porphyritic texture locally. The trachyandesite and aplite dikes are recogneized as small rock bodies, widths of which show only several meters. The former shows greenish gray in color, contains small amounts of phoenocrysts including feldspars, and directs in NE-SW or E-W. While the latter contains transparent minerals mainly with minor amounts of biotite and directs in NE-SW or NW-SE.

1-1-2 Mineralization and alteration

Mineralization in this area is porphyry copper type, macroscopically, and distributed in northeastern margin of granodiorite batholith. The minralized zones are recognized in an area of 400 m x 400 m. Principal ore zones consist of 5 stripes which trend toward NNW-SSE direction. These zones are divided into two characteristic parts based on minerallogical occurrence: "dissemination" zone and "network" vein zone. The former mineralization is cut by the latter.

The "dissemination" zone spreads through the El Torneado mineralized zone, which is composed of sulfide minerals dotted and scattered in granodiorite. Sulfide minerals fill thin cracks as a form of film-like, locally. Mineralized Zone B, which crops out for about 20 m along a branch river Rio Esperanza, belongs to this dissemination zone where chalcopyrite increase in proportion to pyrite abundance. The assay results of representative ore samples show 0.03 % in Cu. Sulfide minerals tends to dominate in and around mafic portion of host rocks. Host rocks are affected by chloritization, biotization and epidotization. Chlorite is observed through the mineralized zone while biotite and epidote tend to abound in the center part of the mineralization.

"Network" vein zone occurs in fracture zones of granodiorite, where irregular intersticies or opennings between breccias are filled with ore and gangue minerals. Ore comprises large quantity of pyrite, small quantity of chalcopyrite, minor amount of chalcocite and molibdenite, and also contains magnetite, scheelite and pyrrhotite locally. Gangue contains quartz, chlorite, secondary biotite and epidote (locally). Lenticular ores are observed locally in network vein zone: for instance, chalcopyrite lens more than 1 cm in diameter; pyrite lens mone than 5 cm in diameter; molybdenite lens more than 1 cm in diameter. The "network" vein zones are limited an area of 40 to 70 m wide and 70 to 350 m long directing in NNE-SSW, while "dissemination" zones spred through mineralized zone (Fig.-II-1-1).

Mineralized Zone A, C and D, which crop out along a branch river Rio Esperanza, belong to this "network" vein zones. They are affected by sericitization and silicification completely. The assay results of representative ore samples show 0.66 % in Cu for Zone A and 0.03 % in Cu for Zone D. Mineralized zone E, which crops out at the boundary between grandiorite and the Macuchi Formation, belongs to "network" vein zones of Pyrite-chlorite-quartz veins. Chloritization and silicification are recognized in the vicinity of veins.

Detailed geological survey, geophysical survey (CSAMT) and Drilling survey were carried out for the Phase I survey. Drilling survey was concentrated on the mineralized Zone A based on the results of geological and geophysical survey which were preceded to drilling survey. As a result of drilling survey, mineralized Zone A was proved to continue downward with inclination of 60°SE, and to expand more in scale at underground than surface (outcrops). Furthermore, drill holes confirmed a concealed mineralized zone at 150 to 200 m below the mineralized Zone A, which belongs to "network" vein zone. The assay results of ore samples from this concealed mineralized Zone A showed 0.01 to 0.36 % in Cu.

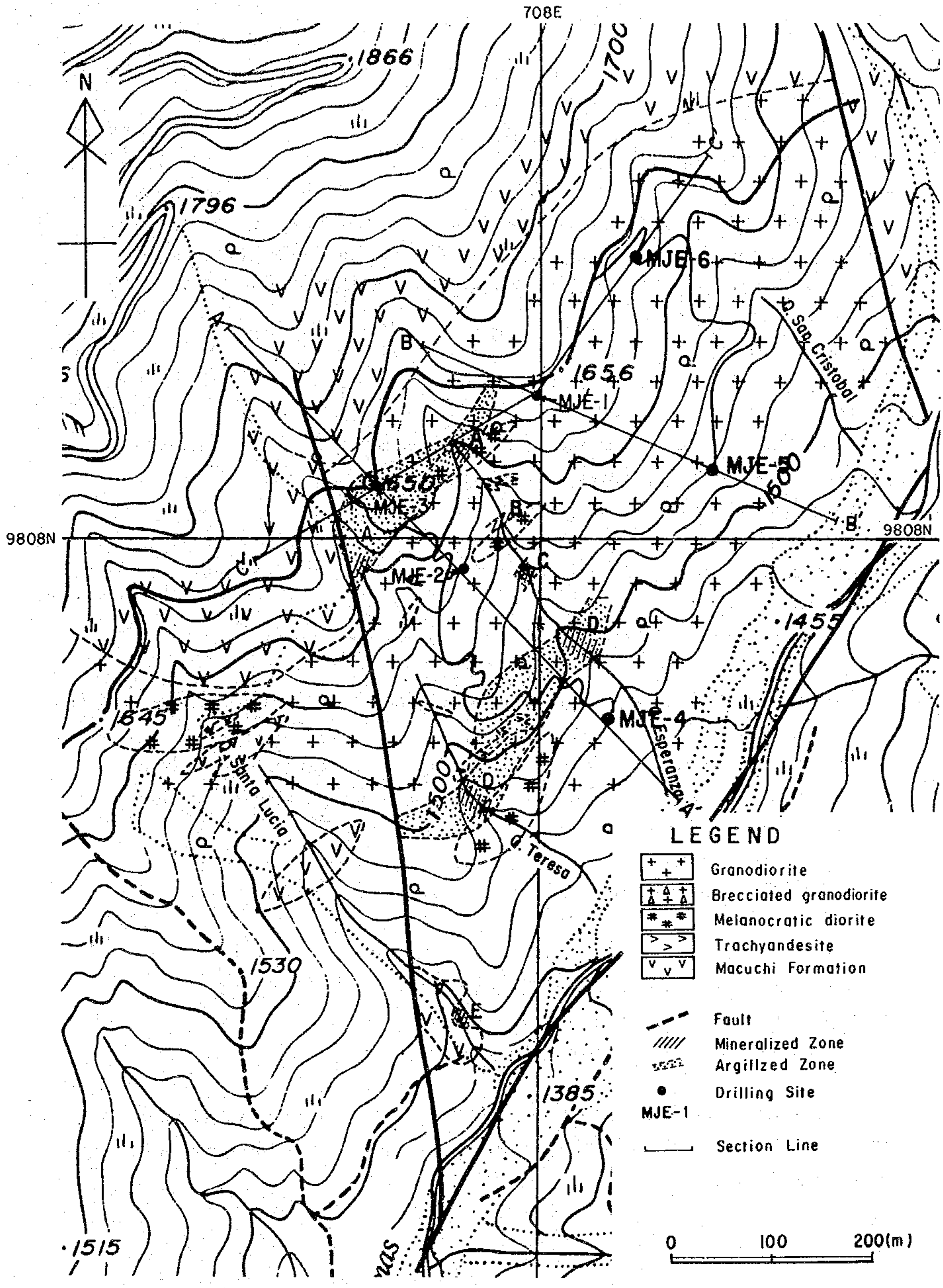


Fig. II–1–1 Geological map of the El Torneado, Balzapamba area

1-2 Geophysical survey

1-2-1 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.

1-2-2 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 Fig.II-1-2.

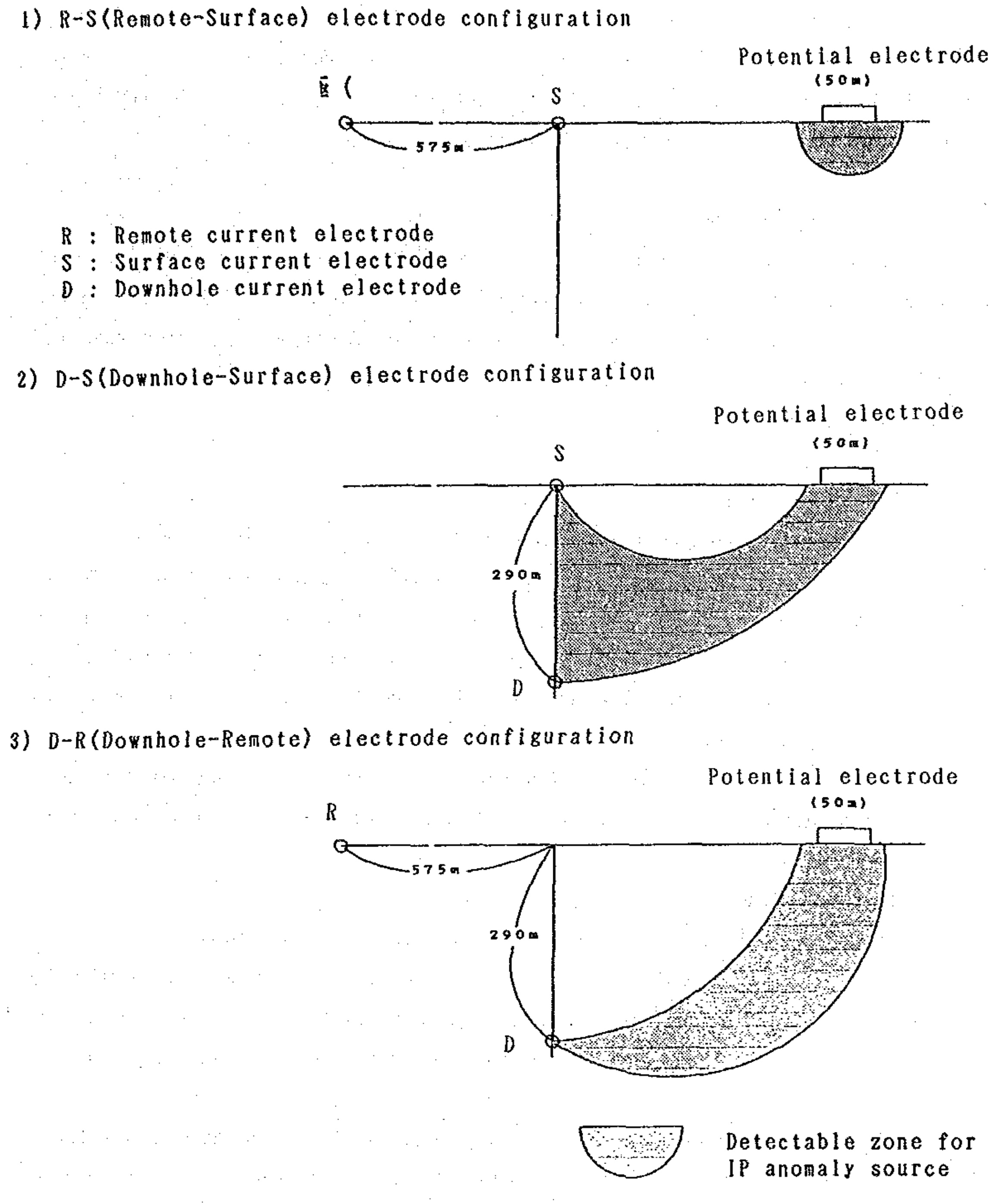


Fig. II-1-2 Detected zone by each electrode configuration

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.

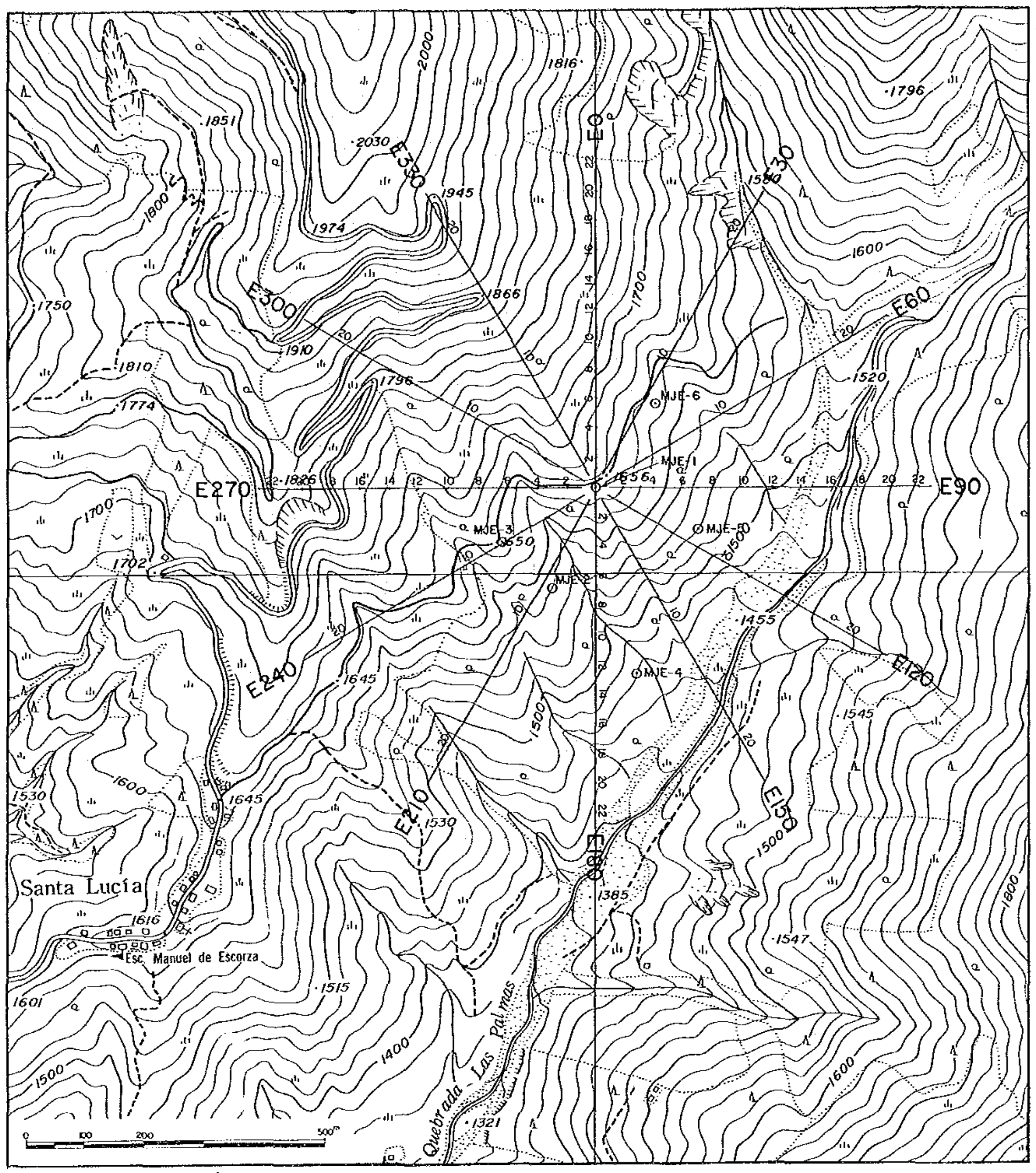


Fig. II–1–3 Location map of borehole-IP survey lines in the El Torneado, Balzapamba area

Name of Line	Length	Direction	Name of Line	Length	Direction
E0	575m	N0°	E180	575m	S0°
E30	575m	N30° E	E210	575m	S30° W
E60	575m	N60° E	E240	575m	S60° W
E90	575m	N90° E	E270	575m	N90° W
E120	575m	S60° E	E300	575m	N60° W
E150	575m	S30° E	E330	575m	N30° W

(3) Survey instruments

Instruments used for the borehole IP survey were manufactured in Japan except for an engine generator which was manufactured in Canada, as shown below.

Name of Equipment	Model	Specification	Quantity
IP Transmitter	CH-T7802	2.5A, 800V	1
IP Receiver	CH-R7802		1
IP Checker	522A		1
Engine Generator	GPU-2000	2kw, 150V, 400Hz	1
Transceiver	ICB-660	0.5W	6

1-2-3 Analysis method

Fig.II-1-4 shows a flow-chart for data analysis.

(1) Calculation of apparent resistivity and frequency effect

The measurement is conducted by supplying a current (Iac) at 3.0Hz into the ground through a pair of current electrodes (C1,C2) and detecting its potential difference (Vac) with a pair of potential electrodes (P1,P2).

The apparent resistivity (APR) of the ground is calculated by using the measured potential difference into the following equation:

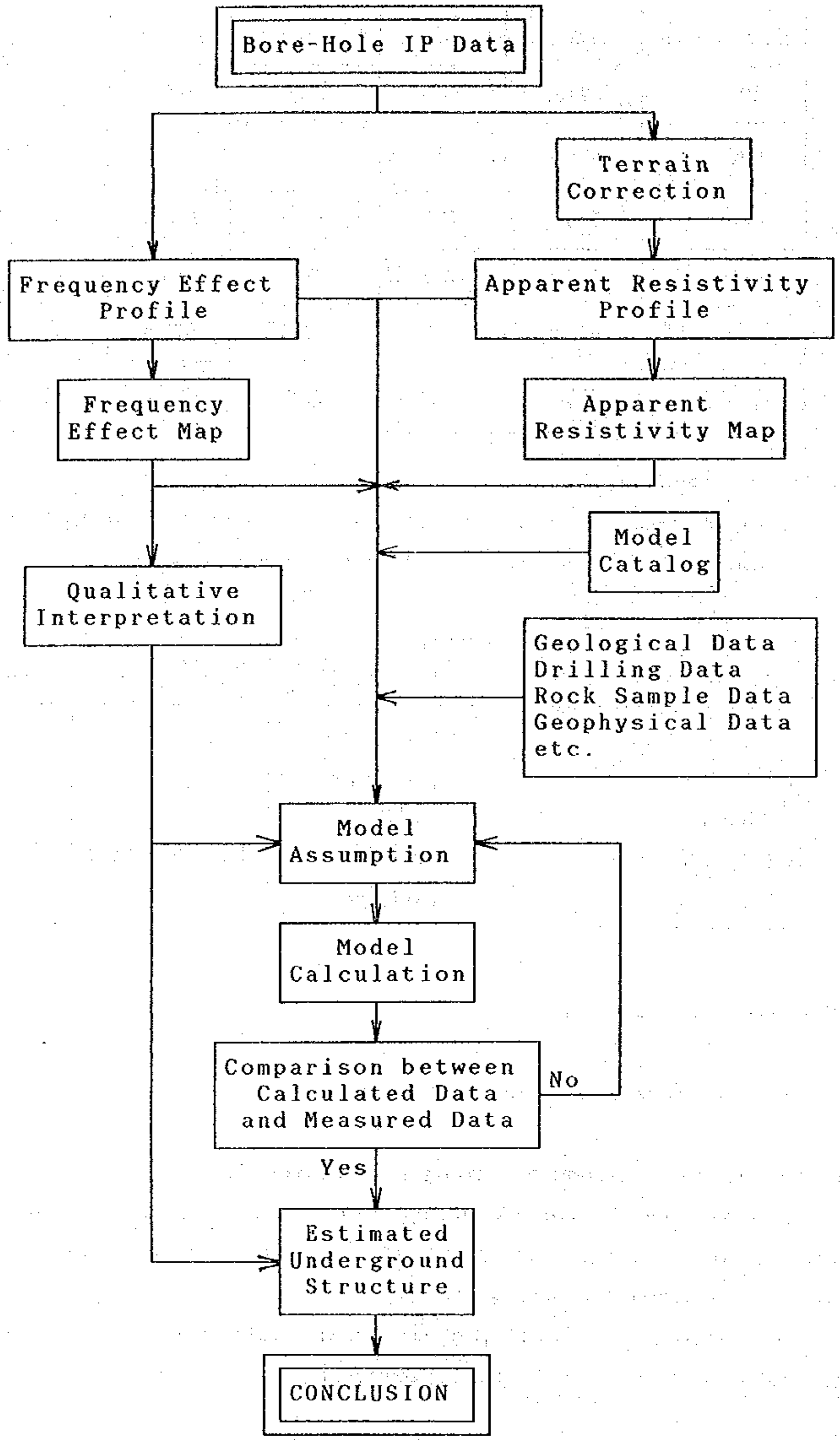


Fig. II–1–4 Flow chart of borehole-IP data analysis

$$\rho_{AC}=K\cdot\frac{V_{AC}}{I_{AC}}\quad(\Omega\cdot m)$$

K is called a geometric factor and depends on the electrode configuration utilized. The factors K_{RS}, K_{SD} and K_{RD}, which correspond to the electrode configurations R-S, D-S and D-R respectively, are defined as follows:

$$K_{RS}=2\pi/\left(\frac{1}{SP_1}-\frac{1}{SP_2}-\frac{1}{RP_1}+\frac{1}{RP_2}\right)$$

$$K_{DS}=2\pi/\left(\frac{1}{SP_1}-\frac{1}{SP_2}\right)-4\pi/\left(\frac{1}{DP_1}-\frac{1}{DP_2}\right)$$

$$K_{DR}=4\pi/\left(\frac{1}{DP_1}-\frac{1}{DP_2}\right)-2\pi/\left(\frac{1}{RP_1}-\frac{1}{RP_2}\right)$$

After reading the potential difference Vac at 3.0 Hz, the frequency effect (FE) is directly read by a meter on a receiver panel by changing the frequency to 0.3 Hz and keeping constant the applied current. The FE is calculated by the following formula which is a function of the change in the apparent resistivity as the frequency is changed.

$$FE=\frac{V_{DC}-V_{AC}}{V_{AC}}\times 100=\frac{\rho_{DC}-\rho_{AC}}{\rho_{AC}}\times 100\ (\%)$$

The value of APR and FE are plotted at the intersection of lines extending downward at 45^{o} angles from the transmitter and receiver midpoints. For example, the values are plotted below No.2 in case of a pair being set on No.1 and No.3.

(2) Terrain correction

Since a geometrical factor K is calculated as a function of the location of the current and potential electrodes on a half-infinite plane, APR is affected by topography depending on the location of electrodes, even if the terrain was homogeneous. For example, as compared with a flat topography, APR is detected higher beneath a hill and lower beneath a valley, behaving as same as that of a dipole-dipole configuration. Especially, D-S and D-R electrode configurations are highly effected by topography.

On the other hand, as FE is proportional to a ratio of resistivity differences at two frequencies, it is less affected by topography.

As the topography of the survey area is comparatively steep and rugged, the correction was performed for all survey lines by means of a finite element method assuming a 2-dimensional half space topography.

The pseudo-section and plan maps were drawn using the topographically corrected values.

(3) Electrical measurement of rock samples

FE and APR measured on the surface do not necessarily show the real physical properties of rocks or ore deposits because of the fact that they are somewhat disturbed by overburden, weathered layer, underground water, etc. Therefore, the actual physical properties of rocks exposed in the survey area were investigated in the Laboratory in order to interpret the underground structure as close as possible.

The rocks collected from the drill holes were used and their measurements were carried out in water saturated condition after the rocks were soaked in water for ten days.

The resistivities of the rock samples are calculated by the following equation:

$$\rho = \frac{2\pi r_{1}}{\ell} \times \frac{V}{I} \quad (\Omega \cdot m)$$

l: length of sample (m)

r: radius of the sample (m)

V: potential difference (V)

I: electric current (A)

FE is defined by their resistivity differences at 0.3Hz and 3.0Hz as same as in the field survey.

(4) Simulation analysis

For analysis of IP data, there are mainly two simulation methods:

One is a quantitative method which correlates the anomaly patterns of profile and plan maps in reference to standard anomaly patterns derived from various simple physical structural models.

The other is a qualitative method which compares the observed data with theoretical values calculated from the simulated physical structure.

These two methods were combined to perform better simulations.

Pseudosections were modeled by meshes having the assumed FE and resistivity values on the basis of geology, standard models and results of electrical measurement in the rock samples. The theoretical values were then calculated by numerical analysis using computer techniques.

Thereafter, comparisons between the calculated values and observed data permitted to change the various parameters of the model in order to approach the observed value. By this iteractive procedure, it was possible to obtain the optimum underground physical structure, which is illustrated in Figure A-3.

Two dimensional finite element method was applied for simulation analysis in this survey.

1-2-4 Results of survey and analysis

(1) Results of electric measurement of rocks

In this phase, sixteen samples were collected from the borehole MJE-4 and examined for resistivity and FE. These results are listed on Table II-1-1 along with the results of laboratory measurements carried on seven samples during the Phase I survey.

Table II－1－1 Resistivity and FE of Rock Samples of the El Torneado,Balzapamba Area

Sample No.	Location	Occurrence	ρ (Ω・m)	FE (%)
1	MJE-4 22.7 m	py weakly dissemination	838	0.2
2	MJE-4 31.6 m	cp-py thin vein/dissemination	4,850	4.0
3	MJE-4 60.5 m	py thin vein/dissemination	934	3.9
4	MJE-4 72.0 m	py film/dissemination	655	4.9
5	MJE-4 86.4 m	py thin vein/dissemination	518	6.0
6	MJE-4 104.8 m	cp-py thin vein/dissemination	5,370	9.5
7	MJE-4 120.0 m	bt-chl-qtz vlts	425	0.2
8	MJE-4 138.0 m	bt-chl-qtz vlts	874	0.9
9	MJE-4 152.4 m	bt-chl-qtz vlts	2,740	0.0
10	MJE-4 174.5 m	mo-cp-py vlts/dissemination	4,580	9.2
11	MJE-4 200.6 m	cp-py thin vein/dissemination	3,390	6.1
12	MJE-4 223.5 m	cp-py dissemination	3,980	5.7
13	MJE-4 247.5 m	py thin vein dissemination	3,640	9.1
14	MJE-4 268.5 m	cp-py dissemination	2,880	5.5
15	MJE-4 289.0 m	py dissemination	1,250	2.0
16	MJE-4 303.5 m	py dissemination	8,090	3.2
	MJE-1 200.0 m	cp-py dissemination	5,320	2.9
	MJE-1 300.0 m	cp-py thin vein/dissemination	2,270	5.4
	MJE-2 100.4 m	cp-py weakly dissemination	896	1.8
	MJE-2 190.0 m	py weakly dissemination	1,500	4.6
	MJE-2 300.0 m	py weakly dissemination	13,170	0.6
	MJE-3 273.5 m	cp-py thin vein/dissemination	1,060	7.3
	MJE-3 291.0 m	cp-py dissemination	3,830	5.4

The resistivities of the rocks varied from 425 Ohm-m to 13,170 ohm and their average was 2,140 Ohm-m. The resistivity values present a tendency to be low at depths shallower than 150m and high at deeper than 150m.

The silicified rocks seem to give a high resistivity, while altered rocks, a low resistivity. For FE values, they range from 0.0 to 9.5% and tend to increase in proportion to the contents of sulphide. Furthermore, the FE of the rocks containing film-like sulphide appear to be higher in FE as compared with those containing disseminated sulphide.

(2) Plan maps

1) R-S (Fig.II-1-5 and Fig.II-1-6)

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 (Fig.II-1-7 and Fig.II-1-8)

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 (Fig.II-1-9 and Fig.II-1-10)

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.

(3) IP pseudo-sections

The observed apparent resistivities in a D-R electrode configuration show about ten times higher values than those in the other electrode configuration, but the feature of the resistivity change is nearly similar among the configurations. In the interpretation that follows, the corrected values are mainly referred in the analysis.

In case that the resistivity change in each electrode configuration is small and consistent between each other, the characteristics of an uniform earth is inferred from the surface to the depth. A big change in resistivity or FE indicates a geological change at the shallow part. A separation and change of the sole R-S curve indicate a geological change in the middle depth and the change of only the D-R curve indicates the change in the depth.

1) Line E0 (Fig.II-1-11)

Although the distributions presented by the curves are similar, the resistivity shown by a D-R curve is generally high, indicating the existence of resistive rocks at the depth. There is a resistivity change at No.13 and the north side shows high value in resistivity.

The magnitude of FE is nearly constant between No.8 and No.22 and a high FE indicating mineralization at the bottom of borehole MJE-1 is detected between No.2 and No.6. A low FE is observed at the surface of No.10.

2) Line E30 (Fig.II-1-12)

The resistivity distribution of R-S and D-S is same, but some differences can be seen in D-R between No.16 and No.22. The high resistivity at No.2 and between 6 and 14 suggest the existence of resistive rocks at the depth. The low resistivities at No.16 in all electrode configurations reflect the conductive layer near the surface. Low resistivity at No.4 in D-R configuration is seen as a conductive layer in the middle depth.

The FE distribution caused by R-S and D-S are same, but The FE in D-R configuration are high in general with a Tendency of increasing FE towards depth. FE anomalous body at The high FE values detected between stations No.2 and 6 in D-R configuration reflect mineralization at the bottom of MJE-1. Other high FE values are seen at No.14 and between No.14 and No.20.

3) Line E60 (Fig.II-1-13)

The resistivity gives a similar distribution except between No.2 and No.8 in D-R configuration. Although the existence of resistive rocks are assumed at the depth of No.4 and near the surface of No.10, they are probably affected by topography. The comparative high resistivities between No.12 and No.22 should be also induced by topographic effect.

For FE distribution values, high FE anomalies are recognized between No.2 and No.6 and at the depth between No.8 and No.14. As same as in the line E30, these anomalies are induced by mineralization at the bottom of MJE-1. Another high FE is observed at the surface of No.10.

4) Line E90 (Fig.II-1-14)

The resistivity distribution in this line, shows a similar pattern except for the values detected in No.2 to No.6 in D-R configuration and No.12 to No.22 in D-S configuration. The resistivity at the east of No.7 is high and at the west is low. The remarkable low resistivity at No.4 in D-R configuration may be due to topographic effect as well as that between No.12 and No.22 in D-S configuration.

For the FE, the high FE indicating a mineralization near the bottom of MJE-1 is seen at the west of No.8 in D-R configuration and there is no FE anomaly at the depth of east of No.12, because the FE values are almost same in this place. A high FE at the east of No.14 in D-S configuration is not reliable because of a very weak signal level was obtained.

5) Line E120 (Fig.II-1-15)

High resistivities are seen at the surface of No.10. Changes of resistivity at No.4 and No.12 seem to be due to topographic effect.

FE in D-S configuration is high at the east of No.14. High contrast in FE value at the west of No.8 reflect mineralization near the bottom of the borehole MJE-1.

6) Line E150 (Fig.II-1-16)

There seems to be topographic effect at No.6 in D-R configuration and at the south of No.12 in D-S configuration, but no resistivity variation at the depth is found and only partial resistivity change is seen near the surface.

The distribution of FE is the same as that in Line E120 where extremely low FE values are seen at the south of No.12 and which might be affected by noise.

7) Line E180 (Fig.II-1-11)

In D-S configuration, low resistivities are seen between No.10 and NO.14, and high FE values are also seen between No.10 and No.18. This low resistivity/high FE is inferred to correspond to the mineralization D. A negative FE anomaly at No.6 in D-R configuration may be induced by the mineralization near the bottom of the borehole. As the resistivity in R-S configuration is as a whole higher than that in D-R configuration, resistive rocks should exist at the depth.

8) Line E210 (Fig.II-1-12)

Also in this line, negative FE values detected at No.4 in D-R configuration may reflect mineralization near the bottom of the borehole. Low resistivity and high FE is located at No.8. Resistivity contrast is seen in boundary with No.19 while FE contrast is also seen at No.17. These boundaries correspond to the location of geological boundaries between Macuchi Formation and granitic rocks.

9) Line E240 (Fig.II-1-13)

Relatively low resistivity at No.8 and high FE at No.10 correspond to the fault passing on these points. There remains topographic effect at the west of No.12. High FE which might be induced by the mineralization near the bottom of the borehole are seen at the east of No.8 in D-R configuration. As resistivity in D-R configuration is entirely high, resistive rocks should exist at the depth.

10) Line E270 (Fig.II-1-14)

A FE distribution shows a similar pattern independent of the electrode configuration. High FE at No.10 also corresponds to the fault. Regarding the resistivity distribution resistivity in D-S configuration is low, in D-R is high and in R-S is middle. This distribution indicates that rocks at the depth are resistive and rocks near the surface are conductive.

11) Line E300 (Fig.II-1-15)

Resistivity feature is as same as that in Line E270. High FE probably induced by mineralization near the bottom of the borehole is recognized in D-R configuration.

12) Line E330 (Fig.II-1-16)

Resistivity distribution is similar to that in Line E0 and E300, and FE distribution is similar to that in Line 0.

(4) Simulation analysis

Simulation analysis were made for the section E210-E30 that runs parallel to the mineralization strike, as well as for the section E300-E120 that runs perpendicular to the mineralization zone.

Apparent resistivity curves for both sections indicate in general, middle resistivity for shallow depth, low resistivity for the middle depth and high resistivity toward the depths. As FE values are about 5 to 6% in average, a three layer structure can be then assumed as a basic model in where to fit the anomalous bodies.

The mineralization zone, confirmed by drilling, was added into this model so that a mineralization model was made by interpreting the FE anomaly pattern detected by borehole IP.

The apparent resistivity values were so strongly affected by the local topography that could not be modelled by our 2-D analytical model, therefore in the final simulations the matching of FE values were mainly taking into consideration.

1) Section E210-E30 (Fig.II-1-17)

Block No.4 placed at about 50m depth and having 100m in thickness, is placed parallel to the topography but tending to become thinner towards east. This block corresponds to mineralization A.

Block No.5, located at about 250m and with a thickness of about 100m indicates a blind mineralization slightly dipping west. This mineralization seems stronger (higher FE) than the one of Block A.

These mineralized blocks were assumed by comparing the low FE values around MJE-1 (measured by R-S and D-S configurations) and the prominent high FE anomaly accompanied by negatives FE values near MJE-1 drill hole measured by D-R configuration.

2) Section E300-E120 (Fig.II-1-18)

Block No.5, that correspond to mineralization A, shows a tendency to be thicker towards north and thinner towards south but dipping sharply to the south.

Block No.6 which represents a blind mineralization, is interpreted as having its origin in the south of the area and dipping along the topography in the north of drill hole MJE-1.

Block No.7 correspond to mineralization B or C deeping steeply to the south. This mineralization yields strong anomalies in the south of station 10 by the D-S configuration. On the other hand, prominent high FE together with negative FE are detected between MJE-1 and MJE-5 by D-R configuration and considered to be due to the superposition of the Block Nos.6 and 7.

1-2-5 Discussion

(1) Interpretation

Based on the analysis and interpretation of the data obtained during this survey, a general consolidated map is illustrated in Fig.II-1-19. By taking also into consideration the mineralization of the area, the following discussion was ellaborated:

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.

(2) Discussion on Borehole IP

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 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

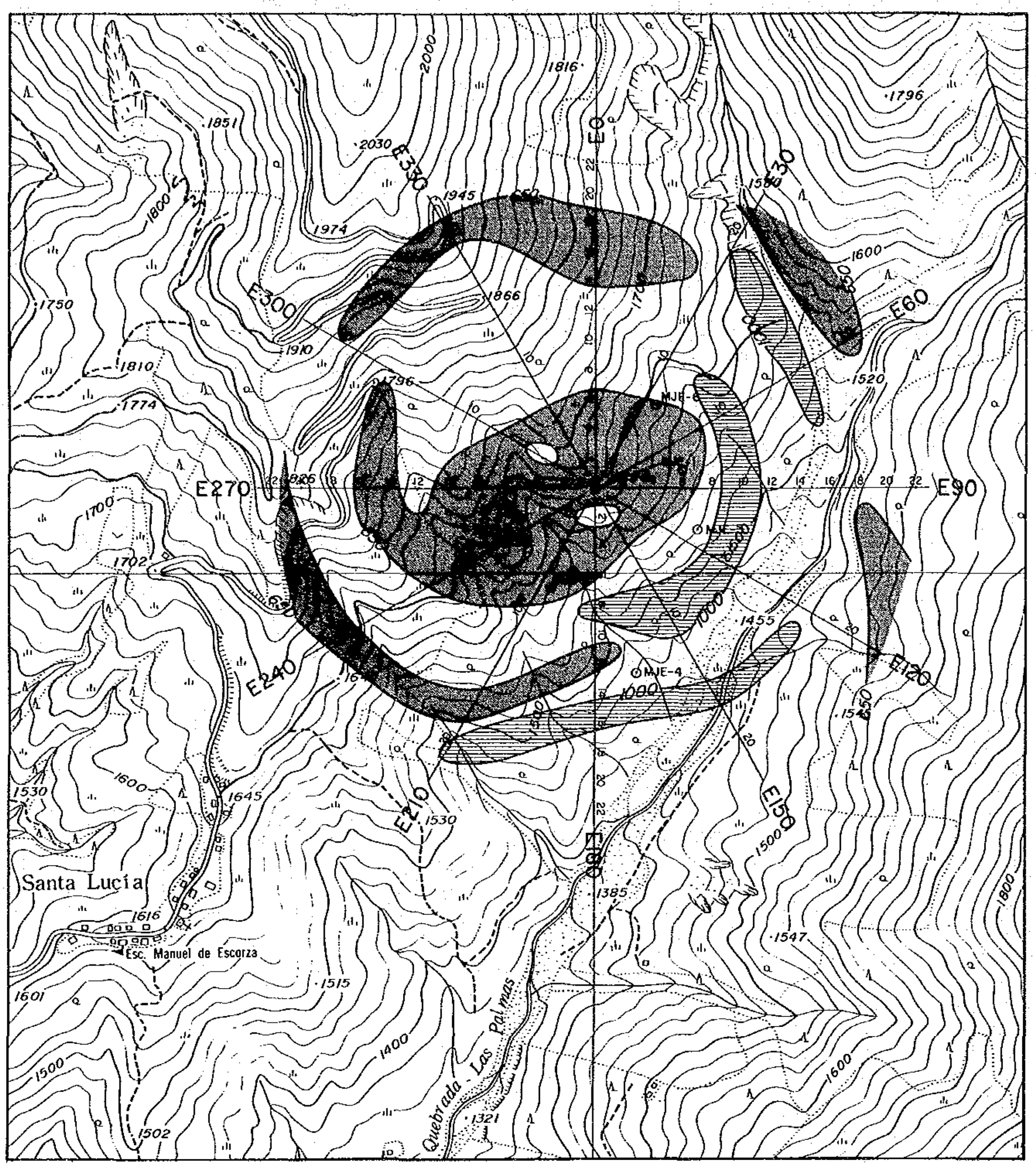
E210. These cases were especially observed when no potential difference can be read between the electrodes since they are both located on the same equipotential line.

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 occurr 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.



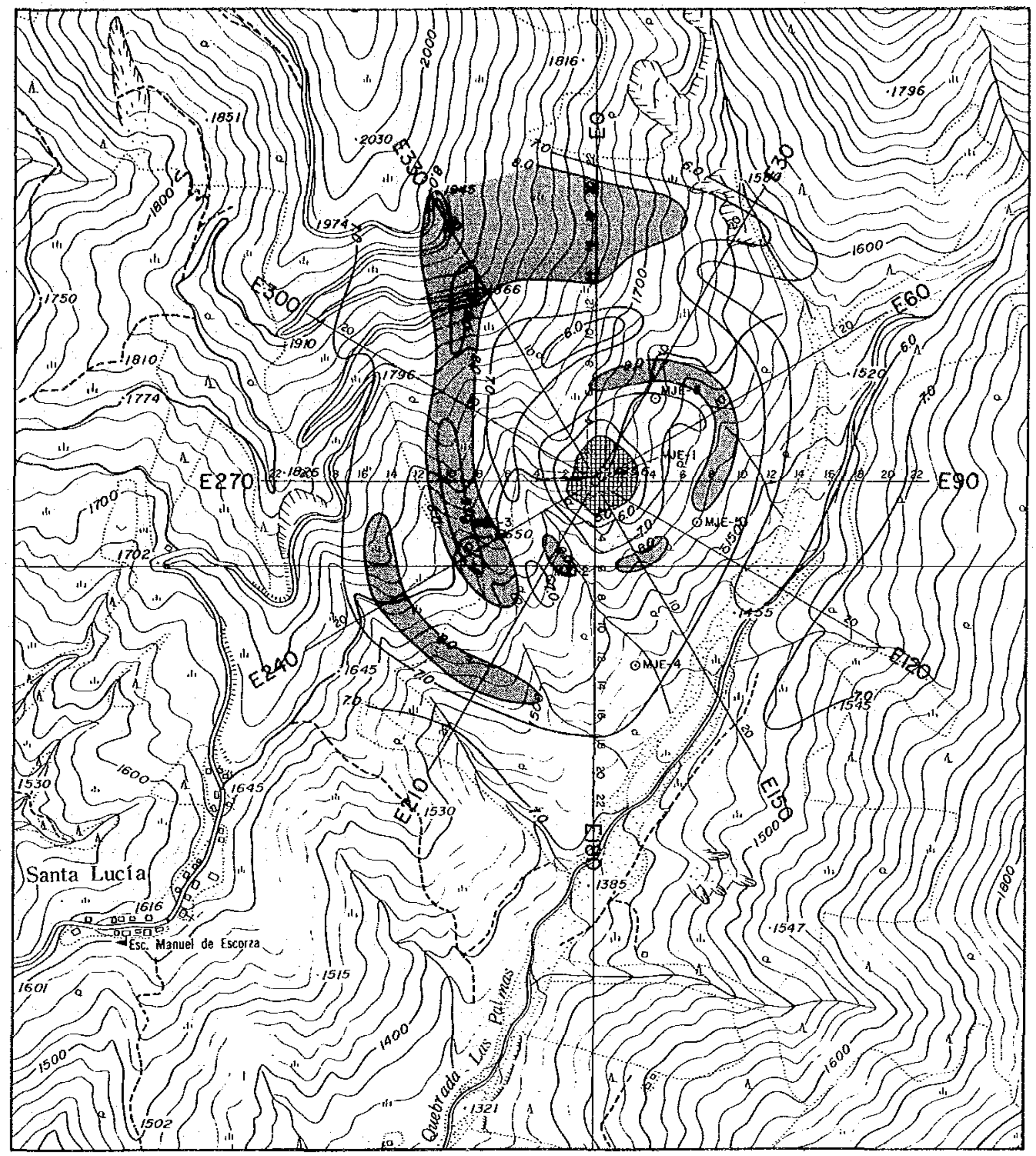
0 100 200 500m

LEGEND

(shaded)	$\rho < 650\ \Omega \cdot m$
(blank)	$650\ \Omega \cdot m \leqq \rho < 1{,}000\ \Omega \cdot m$
(hatched)	$1{,}000\ \Omega \cdot m \leqq \rho$

UNIT : Ω·m

Fig. II–1–5 Apparent resistivity plan map (electrode configuration R-S) of the El Torneado, Balzapamba area



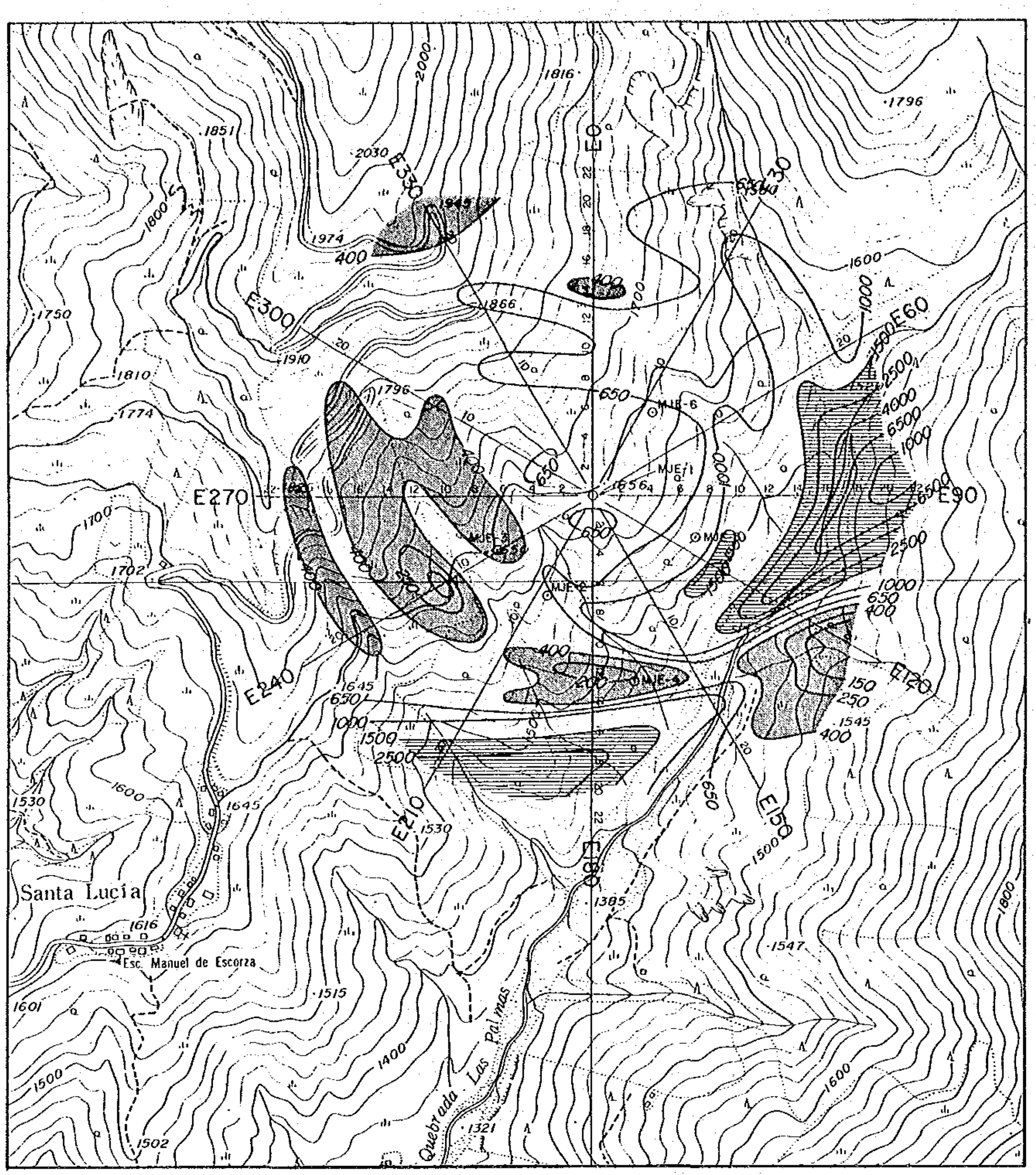
0 100 200 500m

LEGEND

(black)	10.0 % ≦ FE
(shaded)	8.0 % ≦ FE < 10.0 %
(blank)	5.0 % ≦ FE < 8.0 %
(cross-hatched)	FE < 5.0 %

UNIT : %

Fig. II–1–6 PFE plan map (electrode configuration R-S) of the El Torneado, Balzapamba area

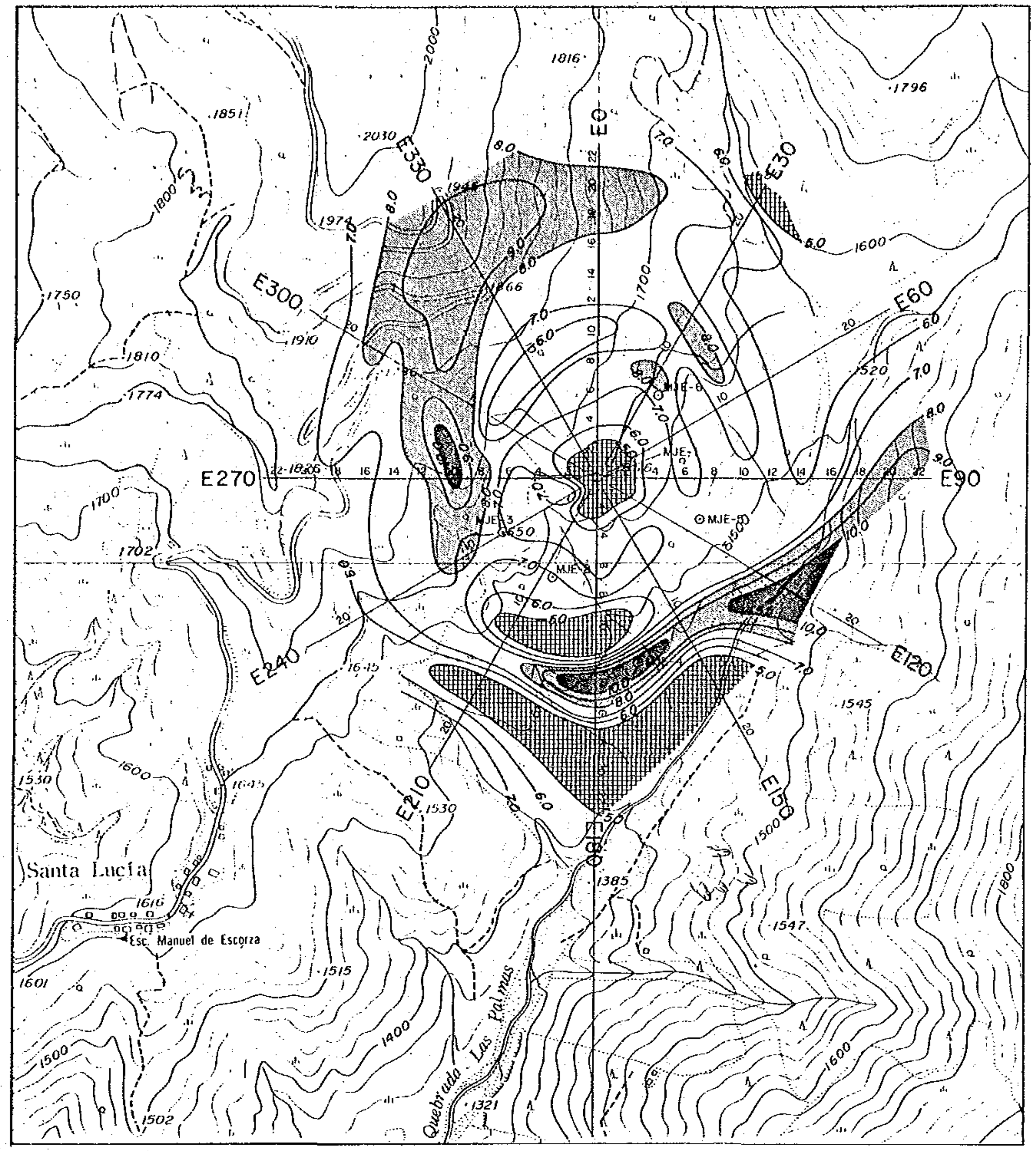


LEGEND

(shaded)	$\rho < 400\ \Omega\cdot m$
(blank)	$400\ \Omega\cdot m \leq \rho < 1{,}500\ \Omega\cdot m$
(hatched)	$1{,}500\ \Omega\cdot m \leq \rho$

UNIT : Ω·m

Fig. II–1–7 Apparent resistivity plan map (electrode configuration D-S) of the El Torneado, Balzapamba area

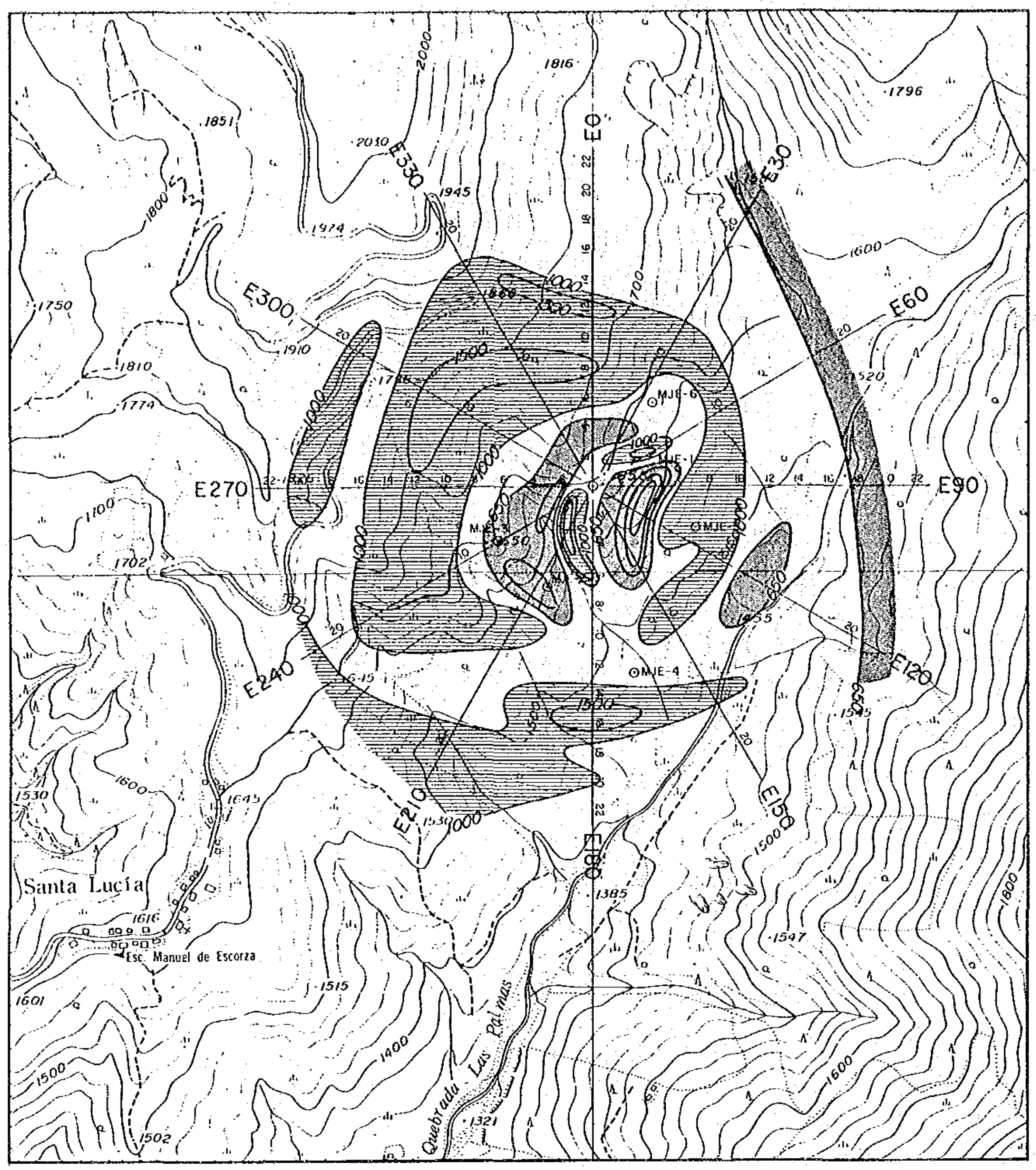


LEGEND

(black)	10.0 % ≦ FE
(shaded)	8.0 % ≦ FE < 10.0 %
(blank)	5.0 % ≦ FE < 8.0 %
(cross-hatched)	FE < 5.0 %

UNIT : %

Fig. II–1–8 PFE plan map (electrode configuration D-S) of the El Torneado, Balzapamba area



0 100 200 500m

LEGEND

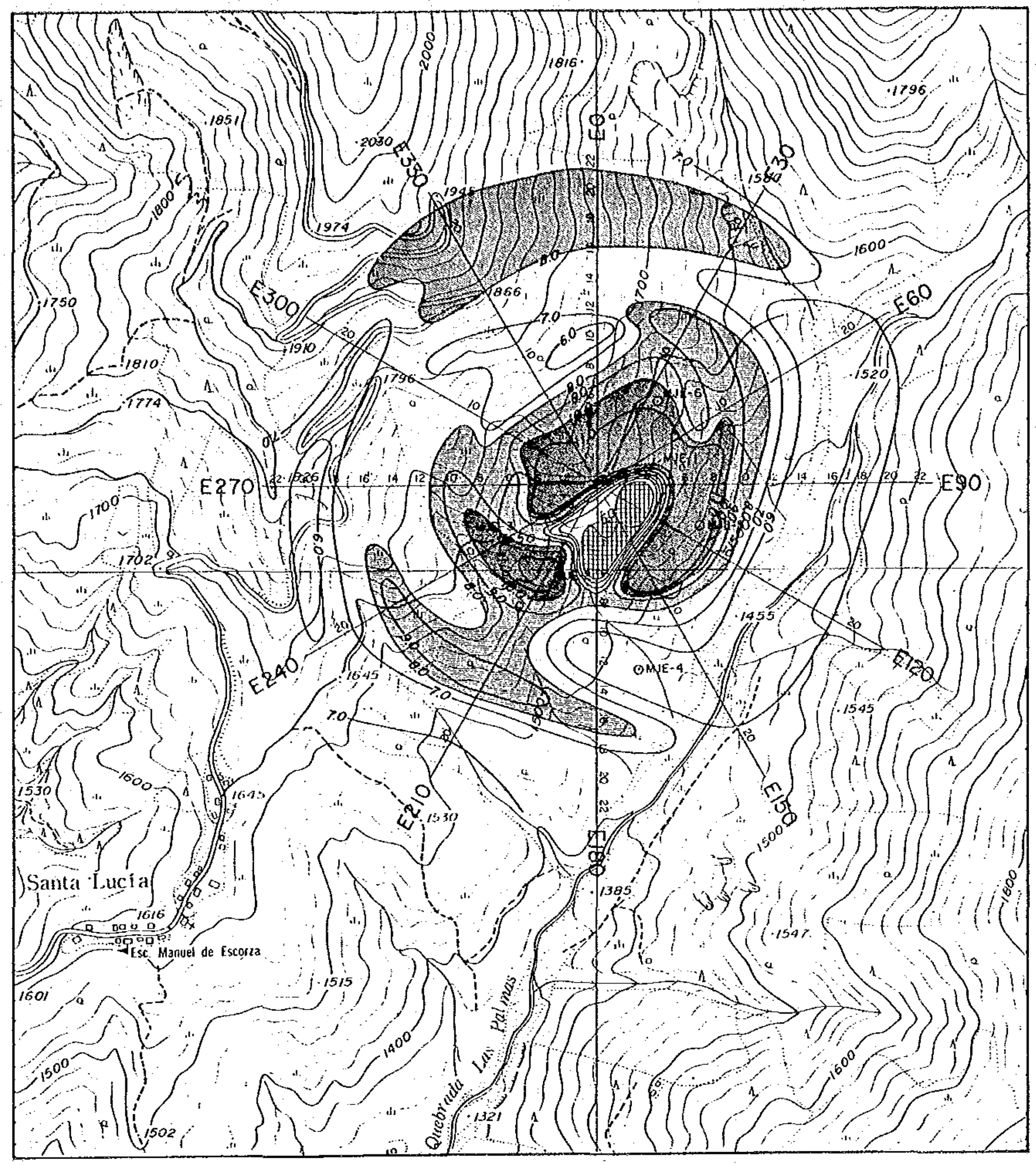
ρ < 650 Ω · m

650 Ω · m ≦ ρ < 1,000 Ω · m

1,000 Ω · m ≦ ρ

UNIT : Ω · m

Fig. II–1–9 Apparent resistivity plan map (electrode configuration D-R) of the El Torneado, Balzapamba area



0 100 200 500m

LEGEND

10.0 % ≦ FE

8.0 % ≦ FE < 10.0 %

5.0 % ≦ FE < 8.0 %

FE < 5.0 %

UNIT : %

Fig. II–1–10 PFE plan map (electrode configuration D-R) of the El Torneado, Balzapamba area

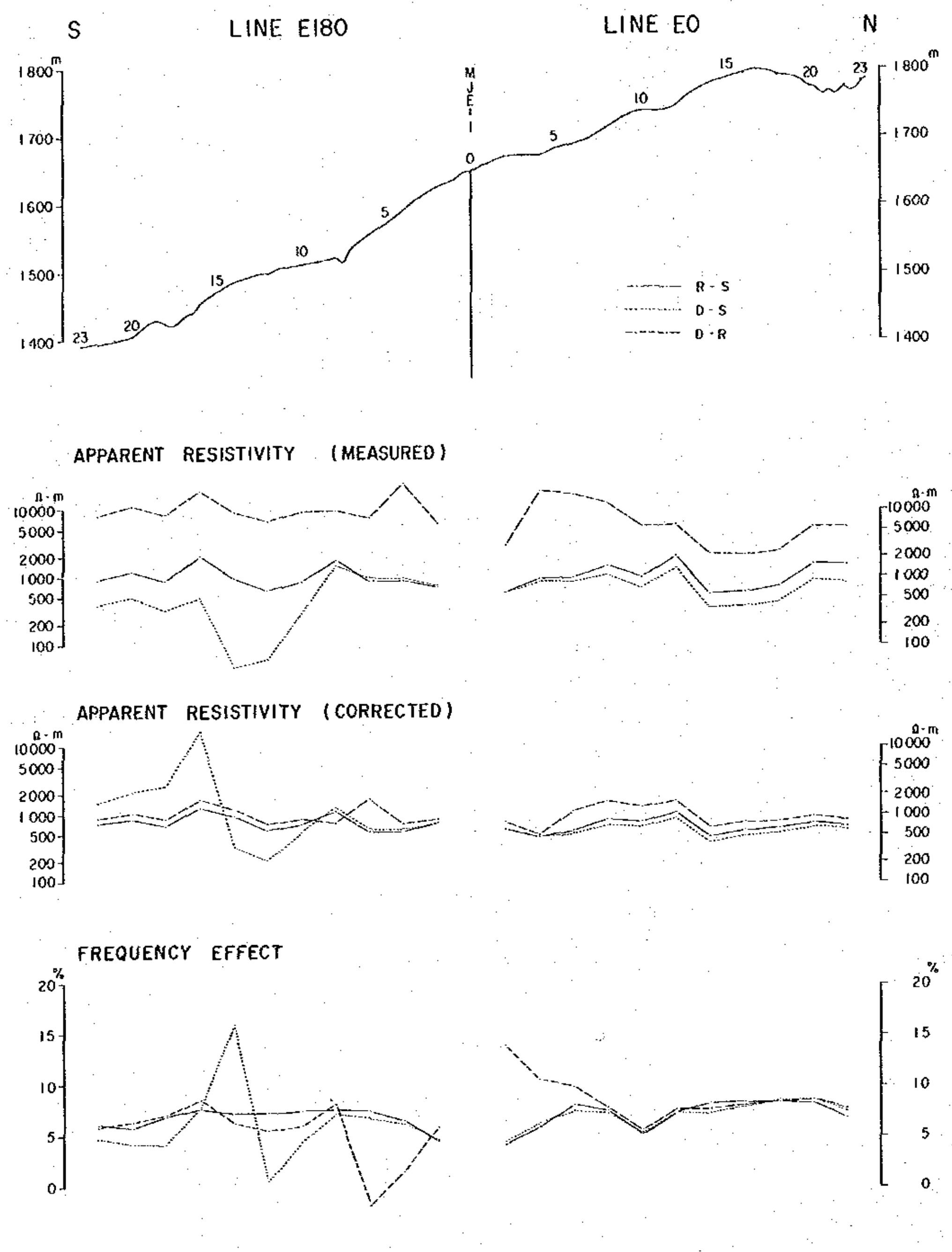


Fig. II–1–11 Sections of apparent resistivity and PFE (line E-0 and E-180) of the El Torneado, Balzapamba area

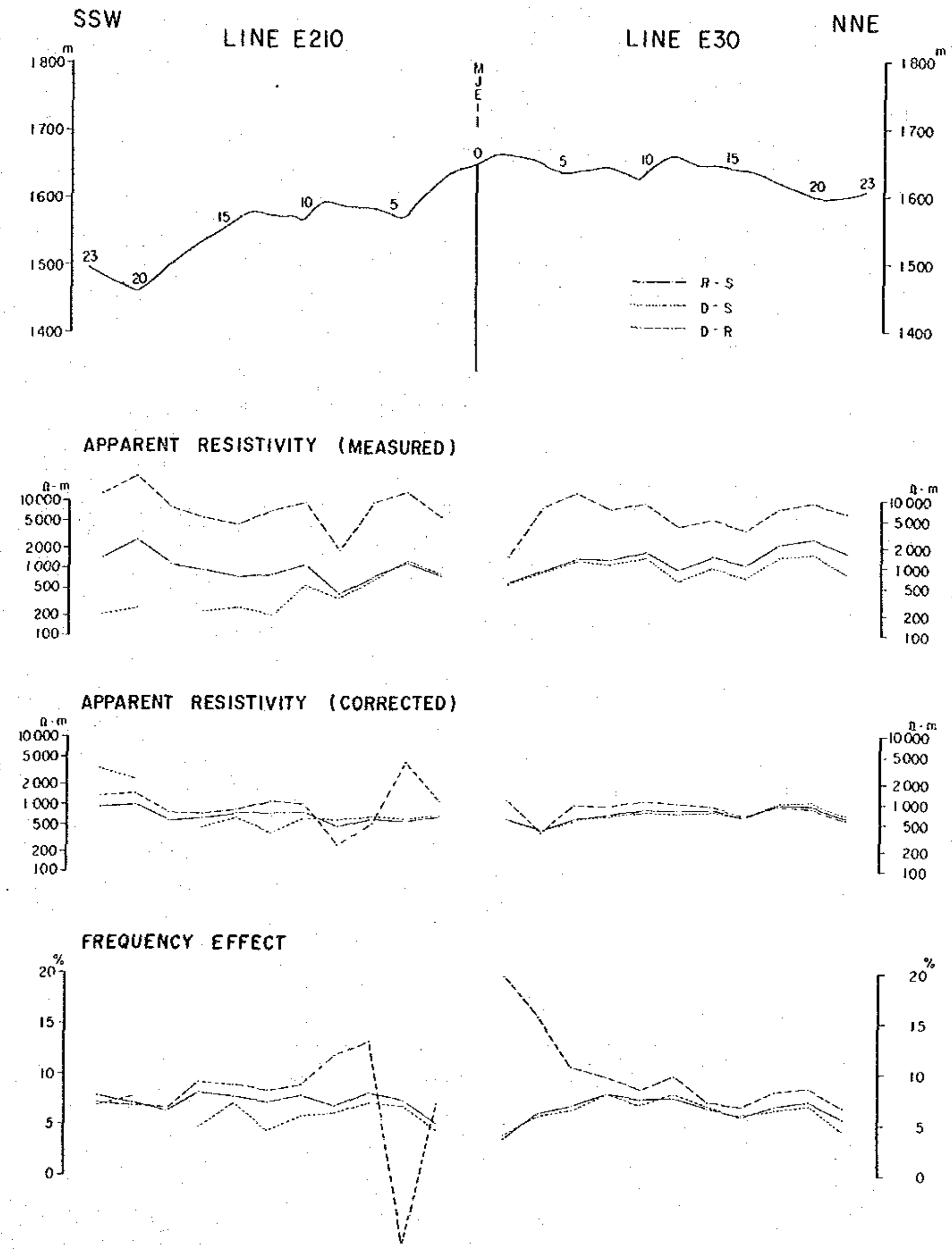


Fig. II–1–12 Sections of apparent resistivity and PFE (line E-30 and E-210) of the El Torneado, Balzapamba area

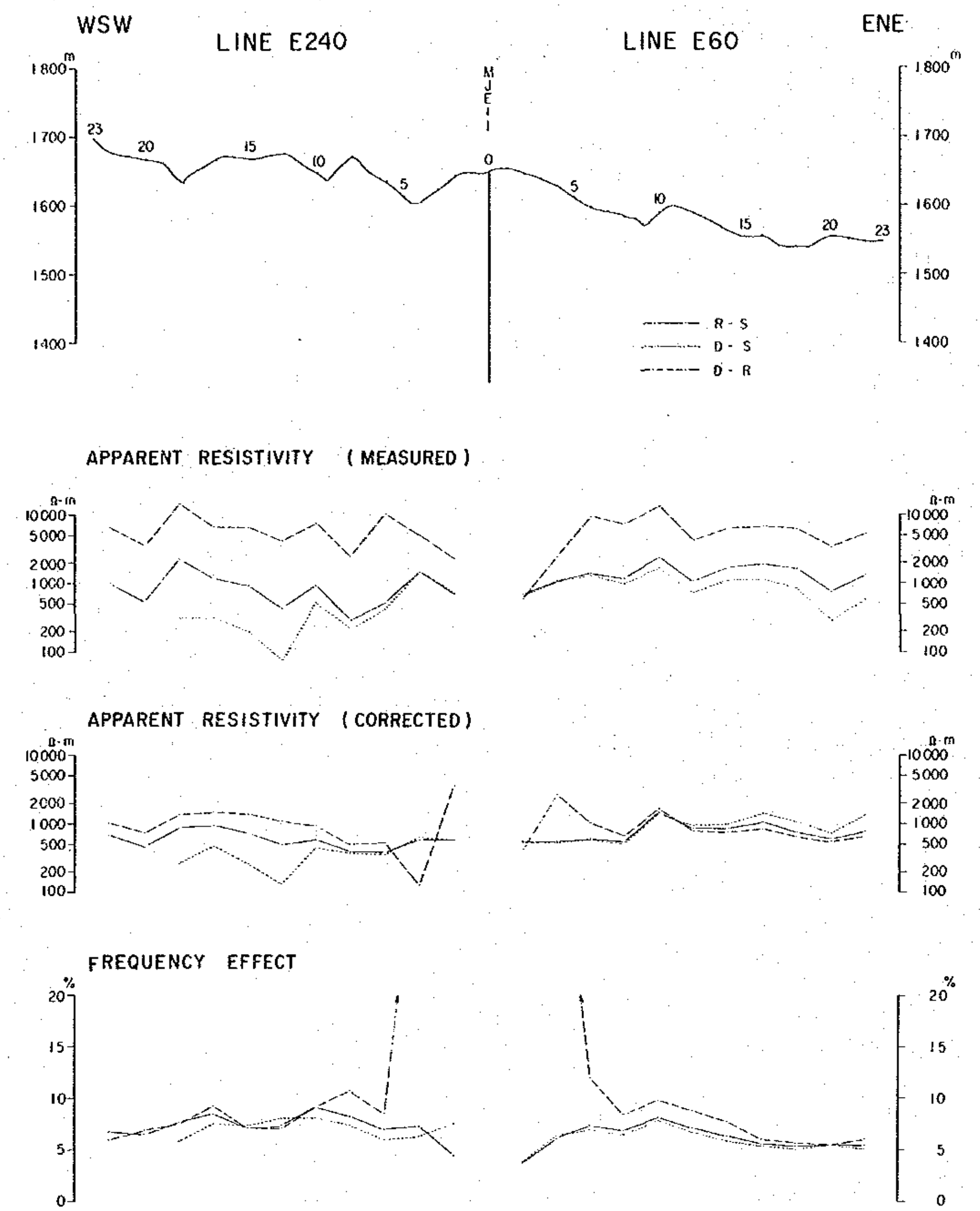


Fig. II–1–13 Sections of apparent resistivity and PFE (line E-60 and E-240) of the El Torneado, Balzapamba area

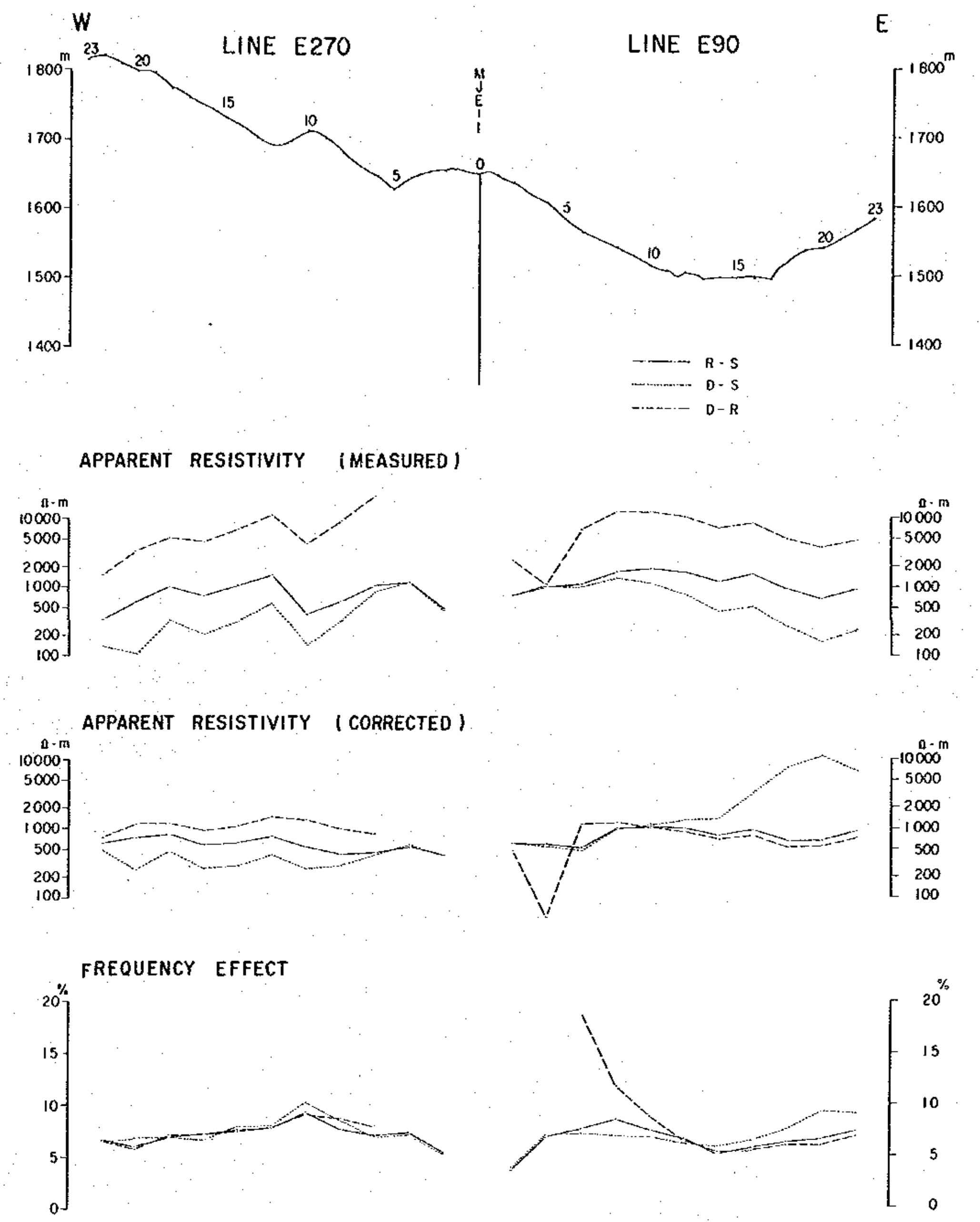


Fig. II–1–14 Sections of apparent resistivity and PFE (line E-90 and E-270) of the El Torneado, Balzapamba area

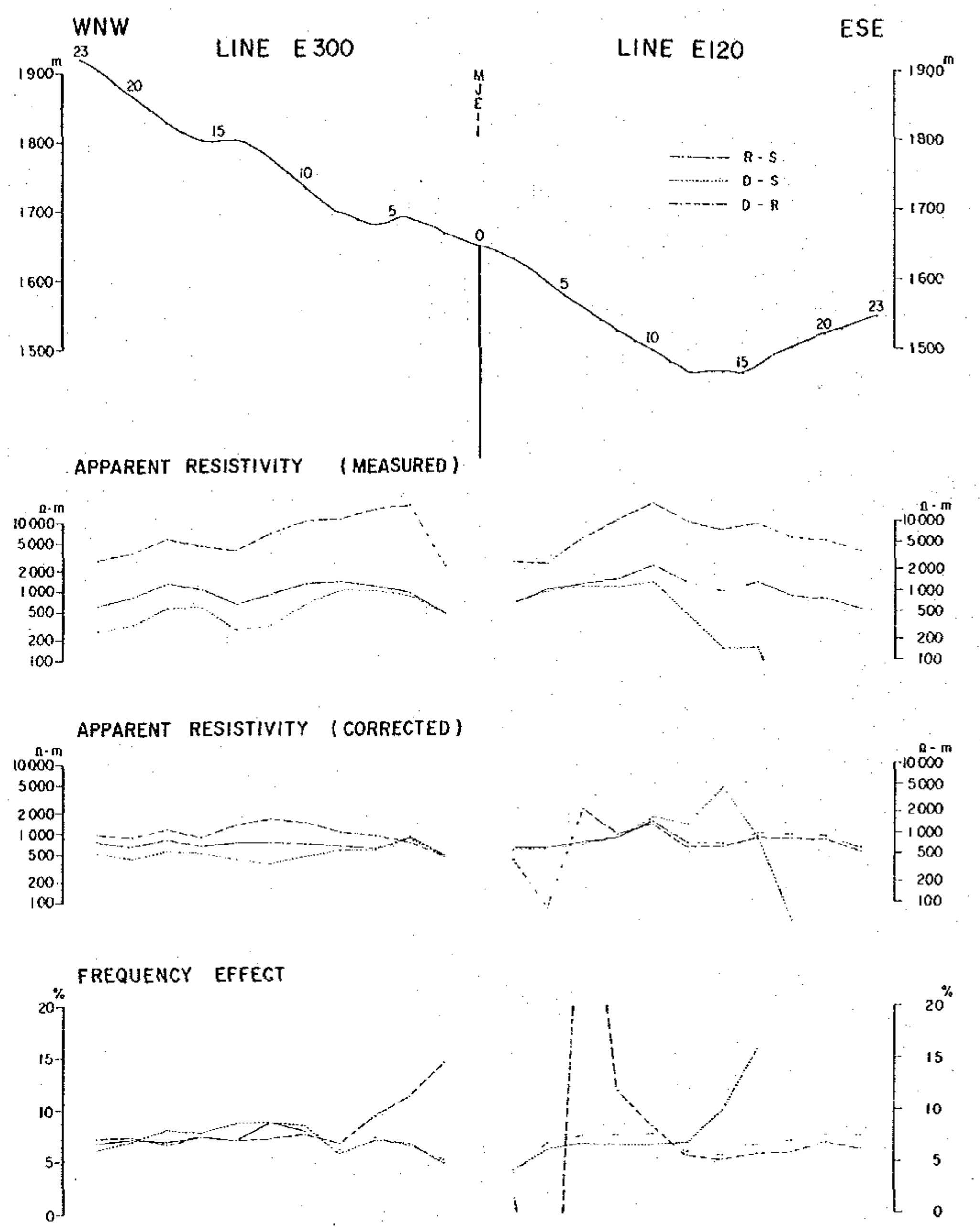


Fig. II–1–15 Sections of apparent resistivity and PFE (line E-120 and E-300) of the El Torneado, Balzapamba area

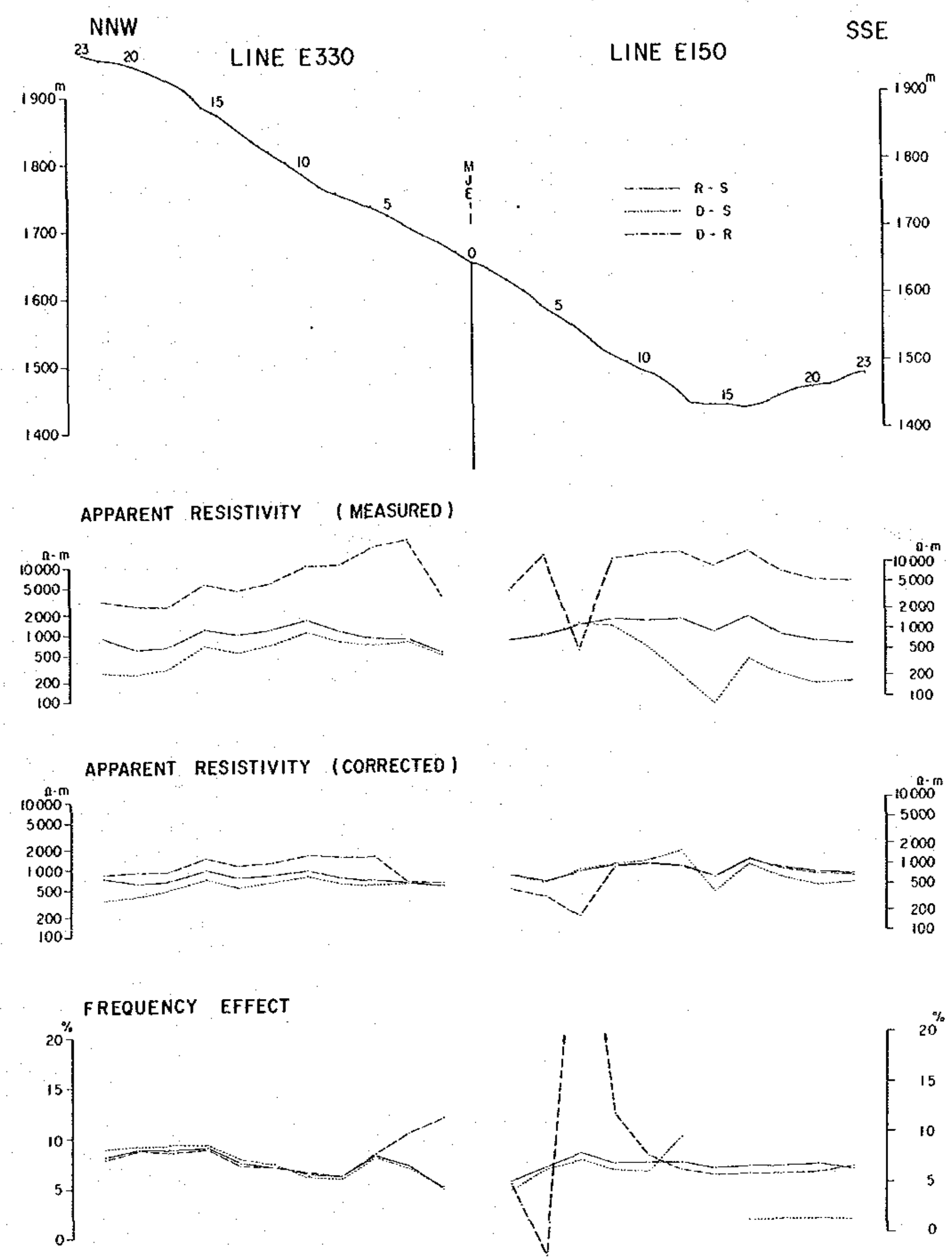
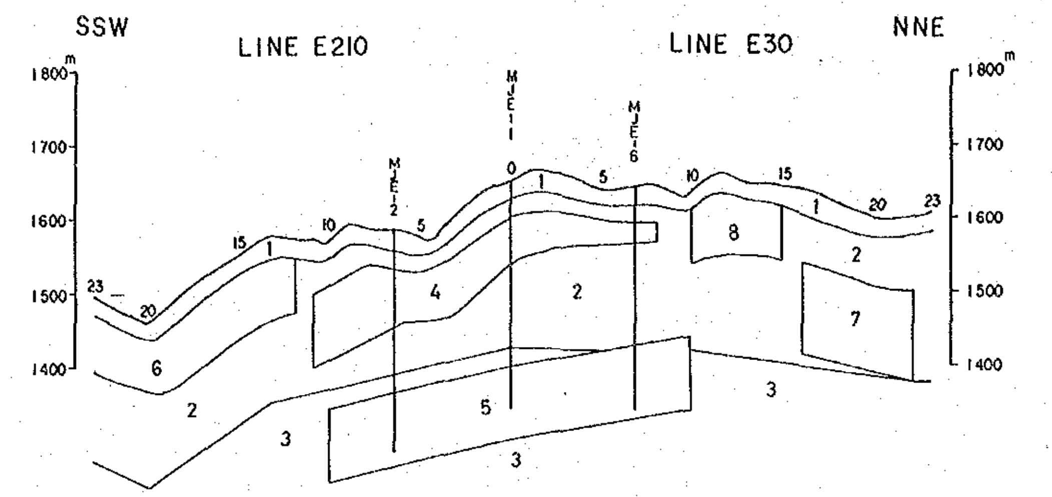


Fig. II–1–16 Sections of apparent resistivity and PFE (line E-150 and E-330) of the El Torneado, Balzapamba area



BLOCK NUMBER :	1	2	3	4	5	6	7	8	9	10
RESISTIVITY(ohm-m):	700.0	500.0	400.0	2000.	1000.	1500.	1300.	1300.	700.0	2000.
P.F.E. (%) :	4.00	4.50	6.00	6.00	13.0	20.0	15.0	15.0	10.0	9.00

BLOCK NUMBER :	11
RESISTIVITY(ohm-m):	700.0
P.F.E. (%) :	7.00

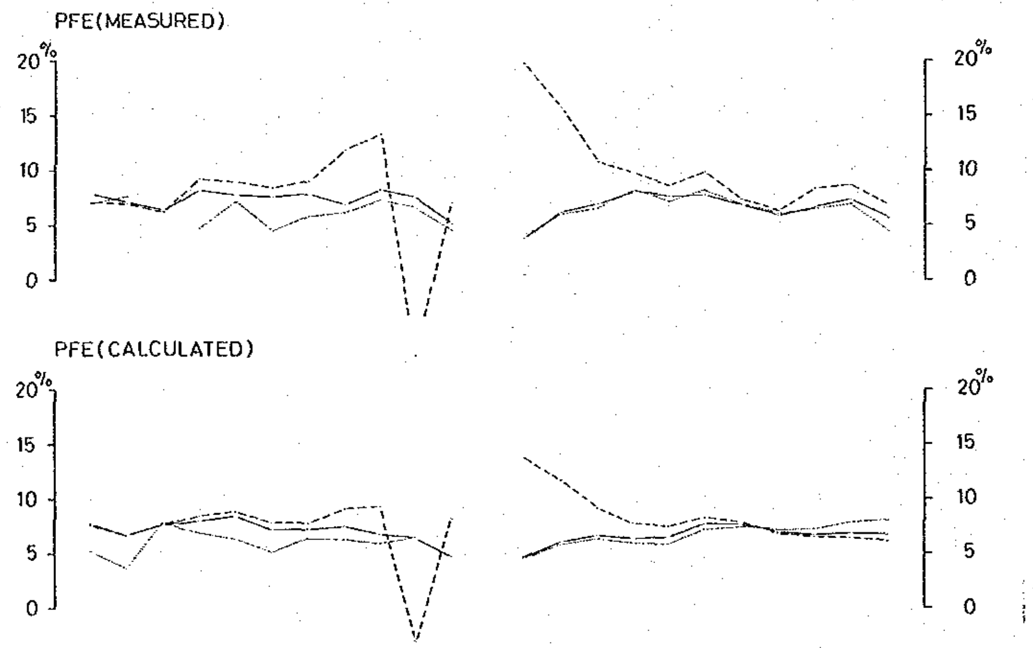
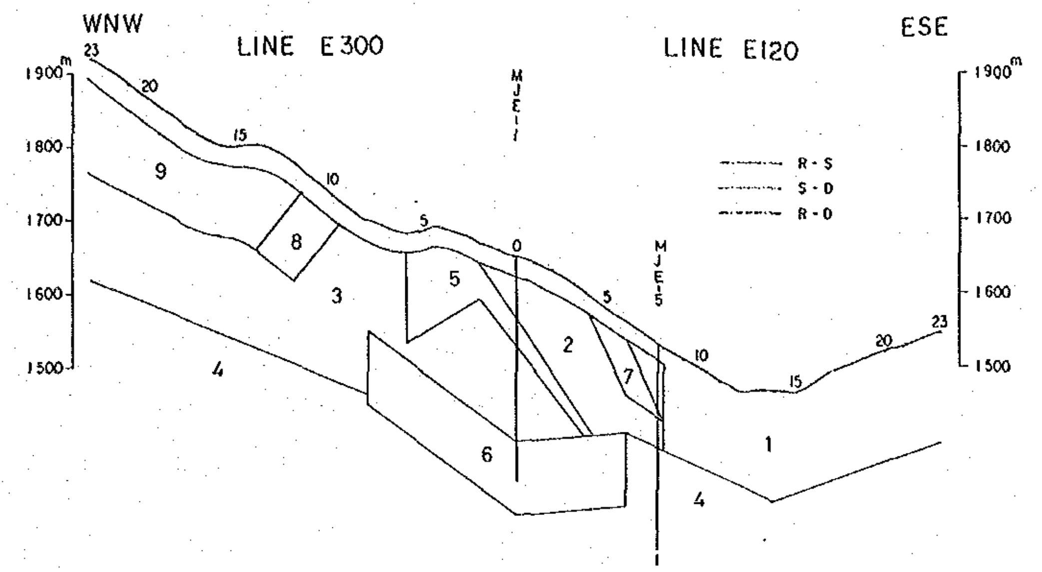


Fig. II–1–17 Analyzed section (line E-30 and E-210) of the El Torneado, Balzapamba area



BLOCK NUMBER :	1	2	3	4	5	6	7	8
RESISTIVITY(ohm-m):	700.0	500.0	2000.	500.0	2000.	1000.	1500.	700.0
P.F.E. (%) :	4.00	4.50	5.00	10.0	20.0	12.0	10.0	8.00

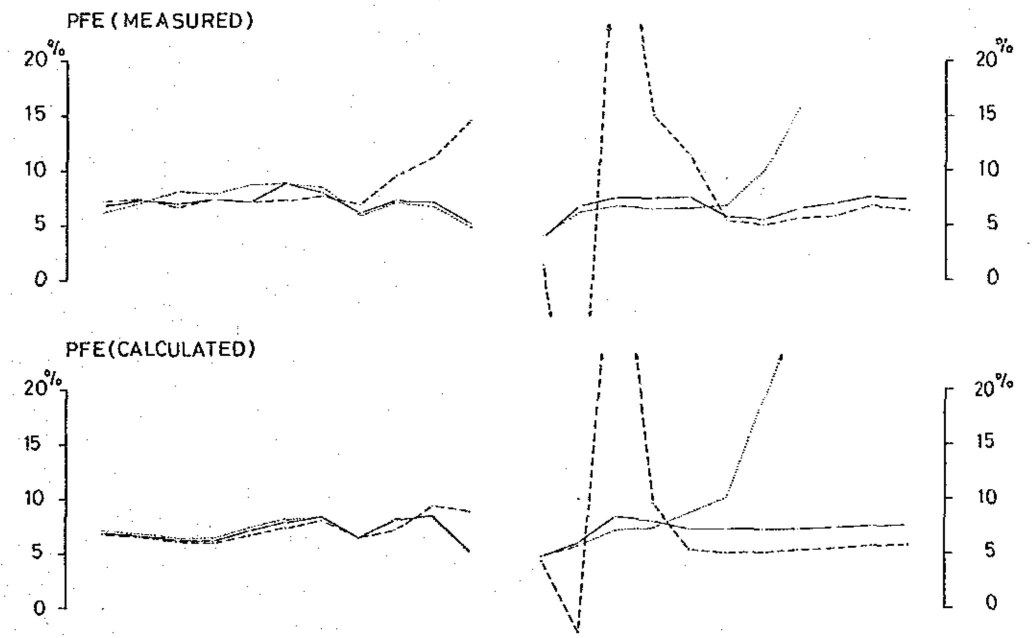


Fig. II–1–18 Analyzed section (line E-120 and E-300) of the El Torneado, Balzapamba area

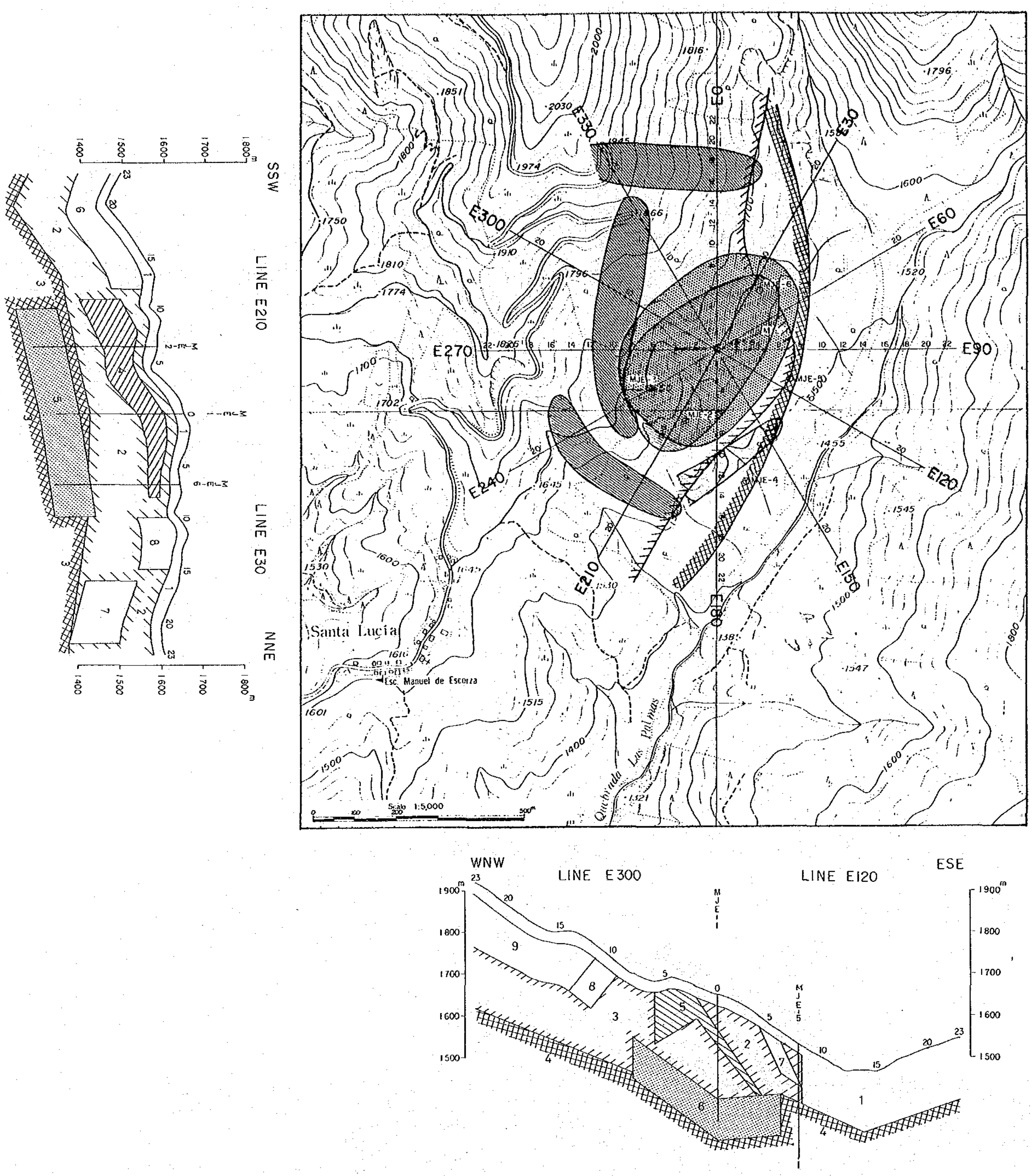


Fig. II–1–19 Interpretation map of the El Torneado, Balzapamba area

1-3 Drilling

1-3-1 purpose of drilling

The purpose of this drilling is to clarify the occurrence and property of the El Torneado mineralized zone, and to evaluate the ore deposits.

1-3-2 Details of drilling

(1) Area for drilling

The El Torneado mineralized zone, where drilling was conducted, is situated about 1 km northeast of Santa Lucia settlement which is nearly the center of the Balzapamba area. The drilling sites were located on a steep slope of about 1,450 m above sea level.

The drilling sites were decided based on result of Bore Hole IP survey which preceded the drilling using MJE-1 hole as a electrode station, considering results of detailed geological and drilling surveys. The locations of all these holes are shown in Fig.II-1-20.

(2) Outline of drilling work

For this work, drilling equipment and machine were donated from Japan, and drilling tools, bits, rods and mud materials were brought in from Japan, and pumps, machines and other supplemental materials from INEMIN. Drilling work was conducted through a period from September to October, 1989. The drilling machine used was the Longyear model L-38. Work for site preparations, equipment dismantling and relocation was performed on a daytime shift only. Drilling work was carried out as a rule for 24 hours a day. Wire line process was used for improved core recovery and other work efficiency.

Drilling performance of each hole is listed on Table.II-1-2.

(3) Delivery of Materials and Equipments, and site preparation work

Materials and equipments supplied from Japan and INEMIN were delivered to the base in Santa Lucia by trucks. Delivery to the drilling site from the base, dismantling at sites, and relocation from one drilling site to another were carried out all with manpower, except drilling machine which has a self-propelling function for transportation. The main access road for delivery of materials and equipments was secured by repairing

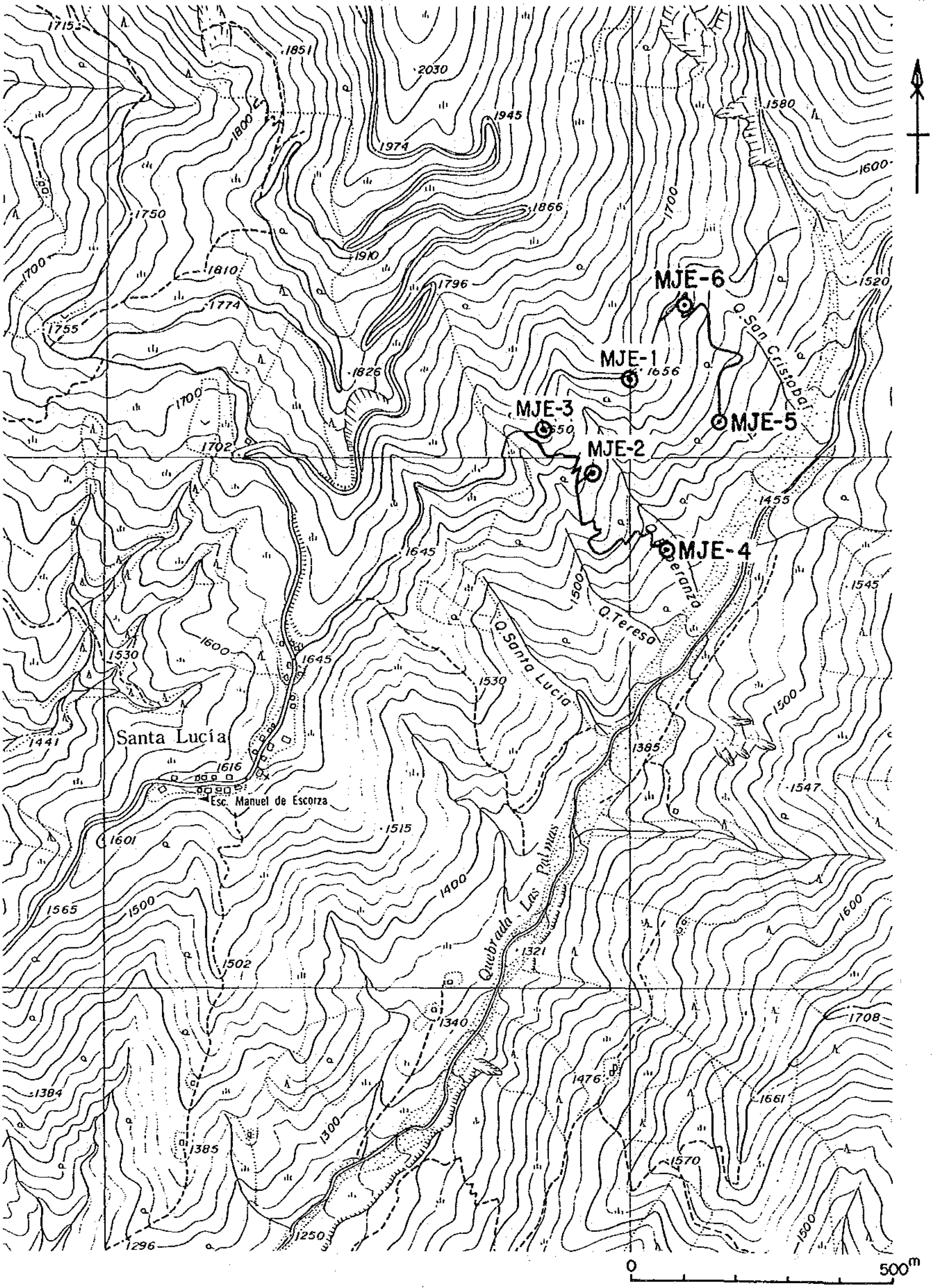


Fig. II–1–20 Location map of drill holes

Table II−1−2 Generalized drilling results

Drill Hole NO	Machine Type	Drilling Period	Drilled Length	Core		Number of Drilling Shift			Drilling speed		Remarks
				Length	Recovery	Drilling	Preparation & Removing	Total	m/shift*	m/shift**	
MJE-4	L38	Sep. 6, 1989 ~ Sep. 16, 1989	305.30 m	292.90 m	99.7 %	31	11	42	7.27	9.85	
MJE-6	L38	Sep. 26, 1989 ~ Oct. 12, 1989	353.00 m	342.40 m	99.2 %	49	10	59	5.98	7.20	
MJE-5	L38	Oct. 18, 1989 ~ Oct. 31, 1989	305.20 m	291.00 m	98.9 %	40	13	53	5.76	7.63	
Total	-	-	963.50 m	926.30 m	99.3 %	120	34	154	6.26	8.03	

Note * Drilled Length per one shift covering total works operated

** Drilled Length per one shift covering net drilling operation

MJE-4,5,6 were drilled by 3 shift/day (8 hours/shift) an existing road which was constructed last year, and new branch roads were constructed from main access road to sites.

Water for drilling work was supplied with water pipeline (1 to 1/2 inch polyethylene pipe): for MJE-4 hole by natural flowing from an reservoir dam in Esperanza valley; and for MJE-5 and MJE-6 holes by operating a lift pump from Teresa valley.

(4) Drilling work

Actual drilling works are shown in Table A-2. The progress of drilling work for each hole is shown in Figs.II-1-21 to 23.

Detail works of each hole are as follows:

1) MJE-4 hole

0 to 11.5 m (hole diameter 101 mm, with NQ-NU casing 11.50 m)

To drill surface soil and gravel layers, 101 mm metal bits were used with bentonite mud water. After reaching rock at 11.50 m, NQ-NU casing was inserted.

11.50 to 203.20 m (hole diameter 75.7 mm of NQWL, with BW casing 203.20 m)

Under BQWL process, the hole was drilled with use of fresh water with TK60. The lithology was hard coarse granodiorite. Chalcopyrite-pyrite-quartz thin veinlets were partly observed in this rock. At 203.20 m, BW casing was inserted.

203.30 to 305.30 m (hole diameter 60.0 mm of BQWL)

Under BQWL process, the hole was drilled with use of fresh water with TK60B. The lithology was coarse granodiorite. This rock showed thin veinlets of chalcopyrite-pyrite-quartz. Drilling was completed at 305.30 m.

2) MJE-5 hole

0 to 26.40 m (hole diameter 101.0 mm, with NQ-NU casing 26.40 m)

Surface soil and gravel layers were drilled with 101.0 mm metal crown. Surface soil and gravel layers continued until 10.90 m. Under the depth, the lithology was coarse granodiorite containing limonite thin veinlets. After reaching rock at 26.40 m, NQ-NU casing was inserted.

26.40 m to 196.00 m (hole diameter 75.70 mm of NQWL, with BW casing 196.00 m)

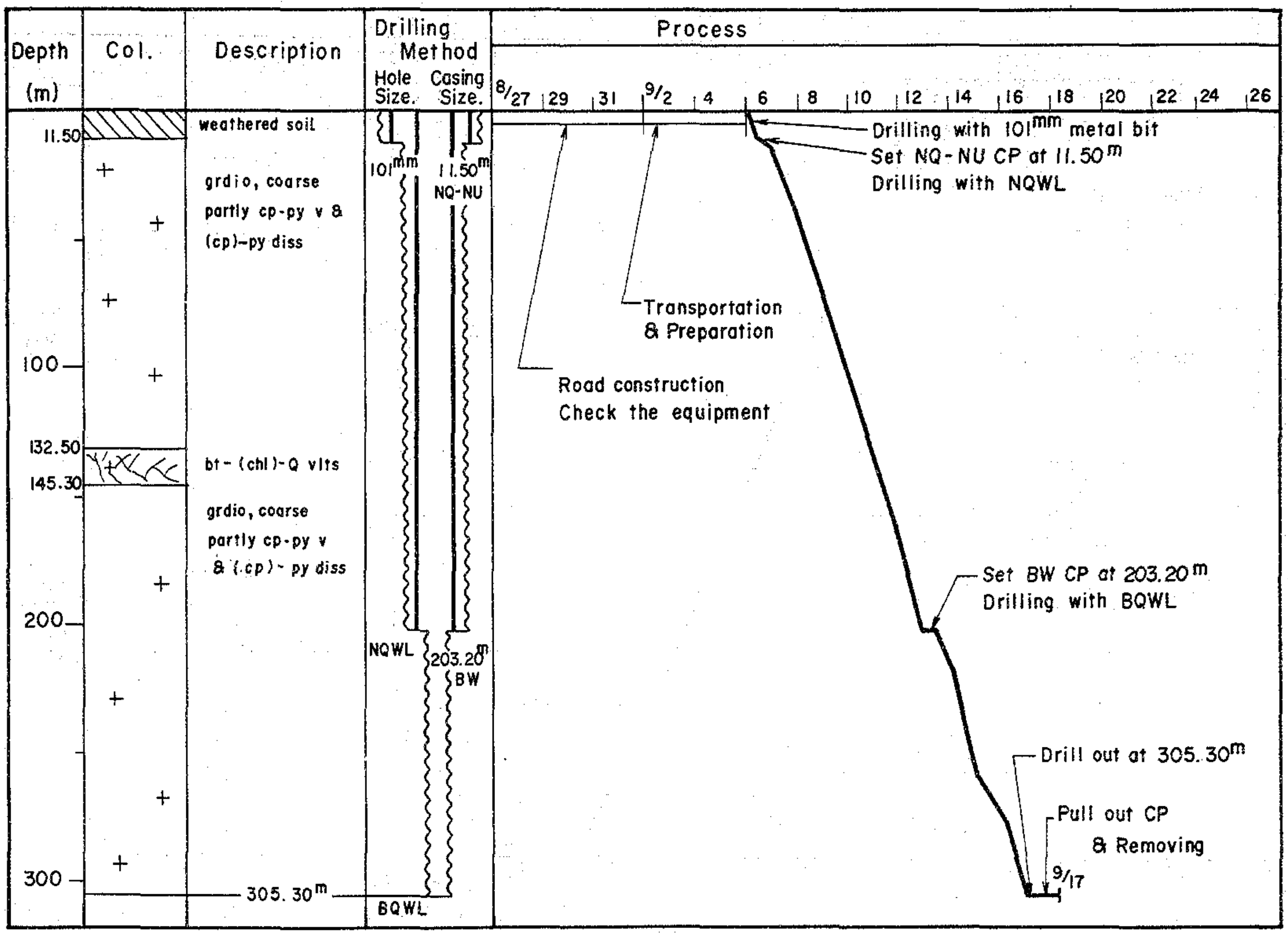


Fig. II–1–21 Progress record of hole MJE-4

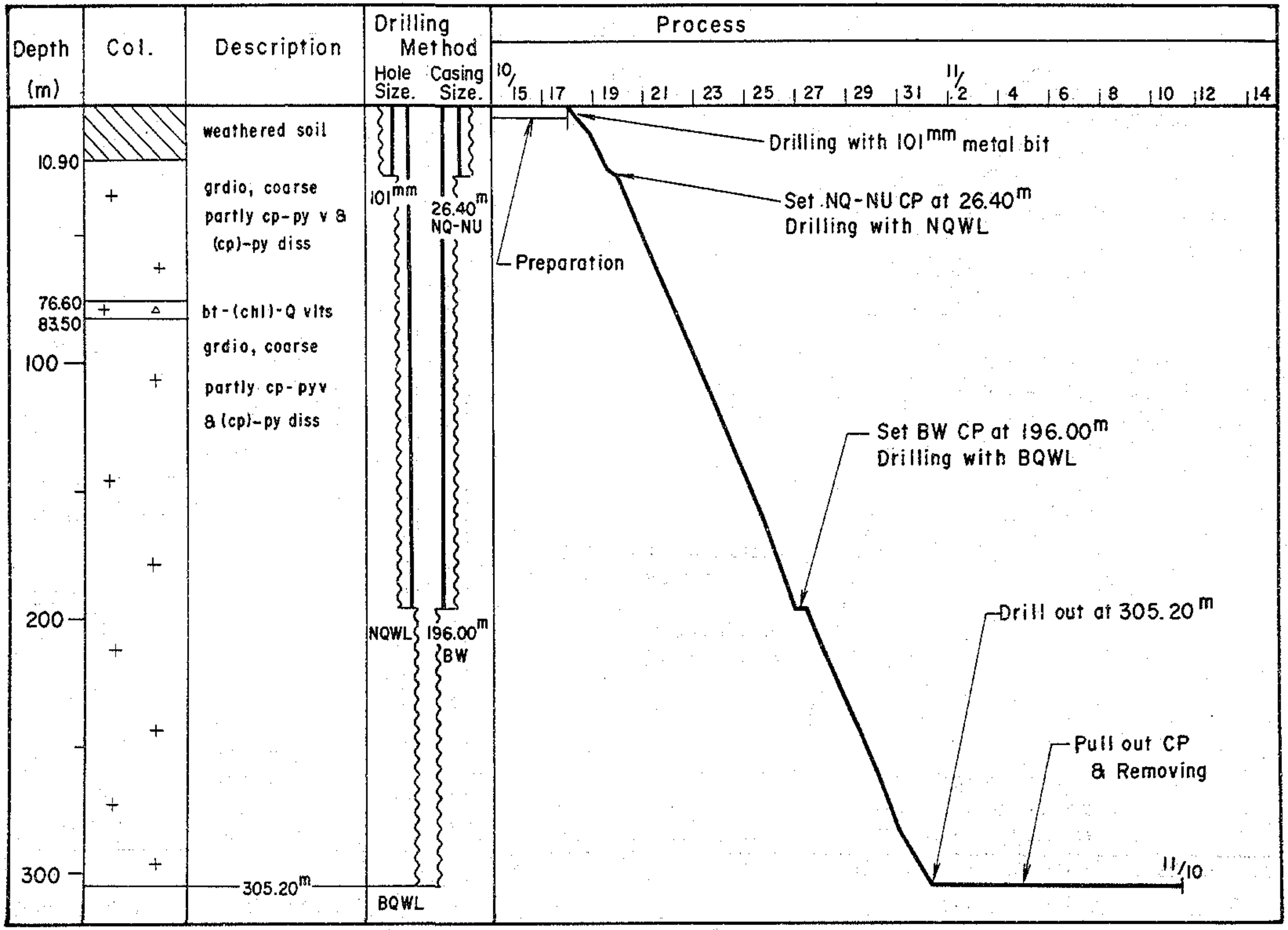


Fig. II–1–22 Progress record of hole MJE-5

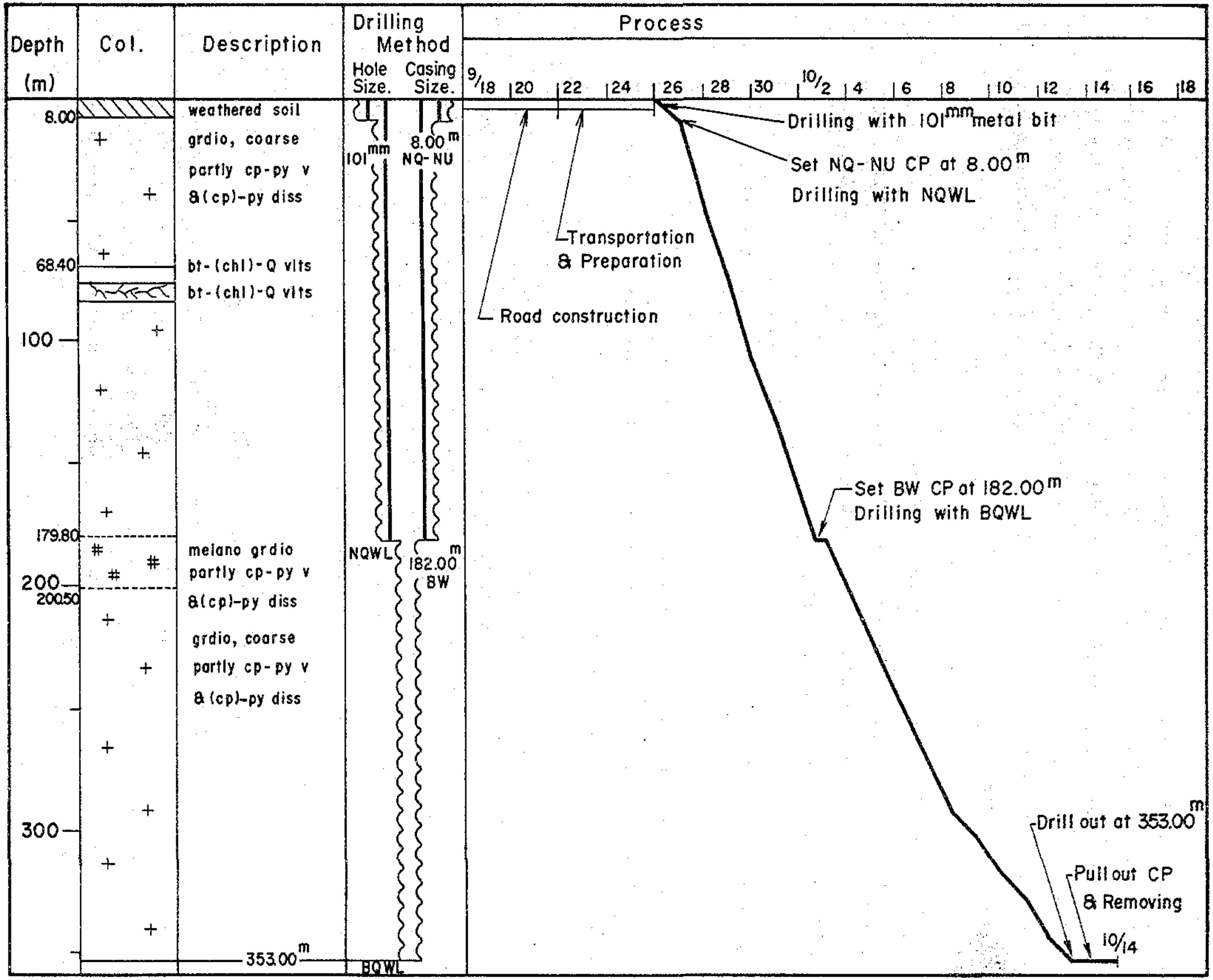


Fig. II–1–23 Progress record of hole MJE-6

Under NQWL process, drilling was conducted with use of bentonite mud and TK60B. The lithology was coarse granodiorite, in which sheared zones containing partly veins existed. Chalcopyrite-pyrite-quartz thin veins were observed partly in this rock. At 98.60 m, complete loss of circulation mud occurred and this was overcome with sealing by Telstop. Subsequently, at 100.90 m, the circulation was lost again. Although sealing by Telstop was applied as a measure against the loss of circulation, it was never recovered. Under the condition of complete loss, drilling had to be continued until 196.00 m where BW casing was inserted.

196.00 to 305.20 m (hole diameter 60.0 mm of BQWL)

Under BQWL process, drilling was made with use of bentonite mud and TK60B. The lithology was coarse granodiorite in which chalcopyrite-pyrite thin veins were partly observed. At 305.20 m, drilling was completed.

3) **MJE-6 hole**

0 to 8.00 m (hole diameter 101.0 mm, with NQ-NU casing 8.00 m)

Surface soil and gravel layers were drilled with 101.0 mm metal crown. After reaching rock at 8.00 m, NQ-NU casing was inserted.

8.00 to 182.00 m (hole diameter 75.7 mm of NQWL, with BW casing 182.00 m)

Under NQWL process, the hole was drilled with use of TK70B. The lithology was mainly coarse granodiorite in which chalcopyrite-pyrite thin veins were observed. At 22.00 m, circulation mud was completely lost. Telstop was applied as a measure against this loss of circulation, and the loss repeated at the depths of 28.90 m, 39.40 m and 42.50 m. Under the condition of complete loss, drilling was continued until 182.00 m where BW casing was inserted.

182.00 to 353.00 m (hole diameter 60.0 mm of BQWL)

Under BQWL process, drilling was made with use of TK60B. The lithology was coarse granodiorite and melanocratic granodiorite in which chalcopyrite and pyrite thin veins were partly observed. At 184.90 m, circulation was completely lost. Although this was overcome with sealing, this situation was never recovered. Drilling was continued in this condition until completed at 353.00 m.

(5) Examination of drill cores

For each hole, drill core examination were proceeded with drilling simultaneously at the drilling site and Santa Lucia work station. Result of this examination were compiled into columnar section of a scale of 1:200. Drill cores were split into halves with diamond cutter after completing each drill hole. One half was taken for test samples and the other for duplicates.

1-3-3 Results of survey (Fig.II-1-24 and Fig.II-1-25)

(1) Outline of geology, mineral deposite and geophysical survey

In selecting the drilling site, the results of Bore Hole IP survey (MJE-1 hole used) were utilized comprehensively, considering the results of geological and drilling surveys of the previous year.

MJE-4 hole was drilled on the southern side of outcrops of mineralized Zone D. The mineralized Zone D at its outcrop is "network" veins about 50 m wide and 350 m long trending toward the NNE-SSW. The networked metalliferous veins coexist of chalocopyrite-pyrite-(molybdenite)-secondary biotite-chlorite-quartz, which fill the cracks or opennings of granodiorite breccias. The breccias of host rock are entirely affected by sericitization and silicification. According to the results of Bore Hole IP method electric exploration, middle-deep IP anomalous zone more than 8 % in FE value was detected below the mineralized Zone D, the extension of which was estimated to be 500 m + * in NE direction. Deep Ip anomalous zone, however, does not exist here while it spread widely in the northeastern part of the mineralized zone.

The state of mineralization is uncertain in the vicinities of MJE-5 and 6 holes, for soil covers all of the ground surface. It was considered, however, that the Mineralized Zones A through D continue to the drilling sites, because Bore Hole IP survey detected a deep IP anomalous zone more than 8 % around these holes, and because the sites located on the northeastern extension of Zone A through D which are exposed in river Rio Esperanza.

(2) MJE-4 Hole

1) Location, Inclination and Depth

Location: Latitude 9808.83N, longitude 708.07E, altitude +1,461 m
Inclination: -90°

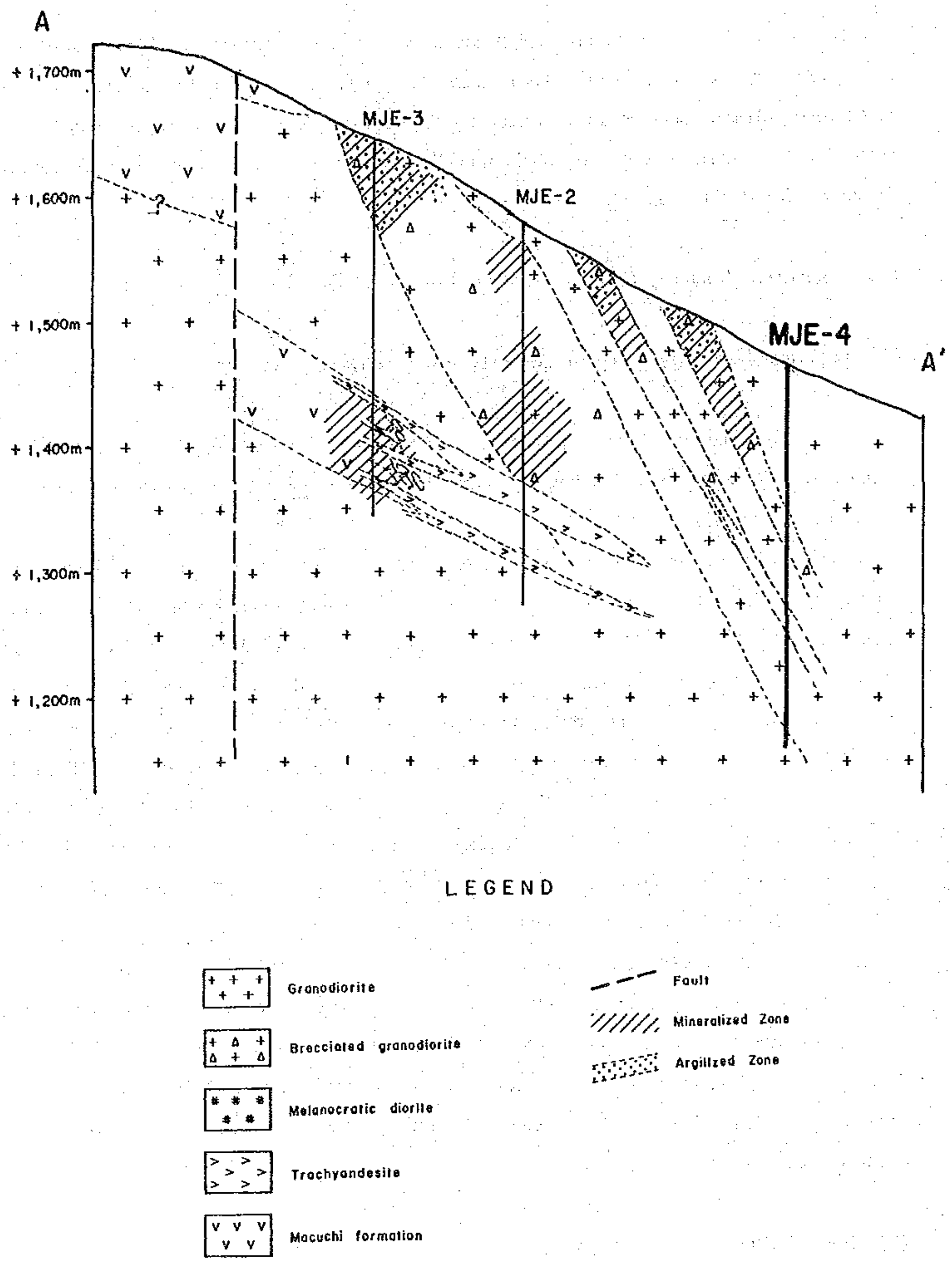


Fig. II–1–24 Geological section of drill hole MJE-4 and MJE-5

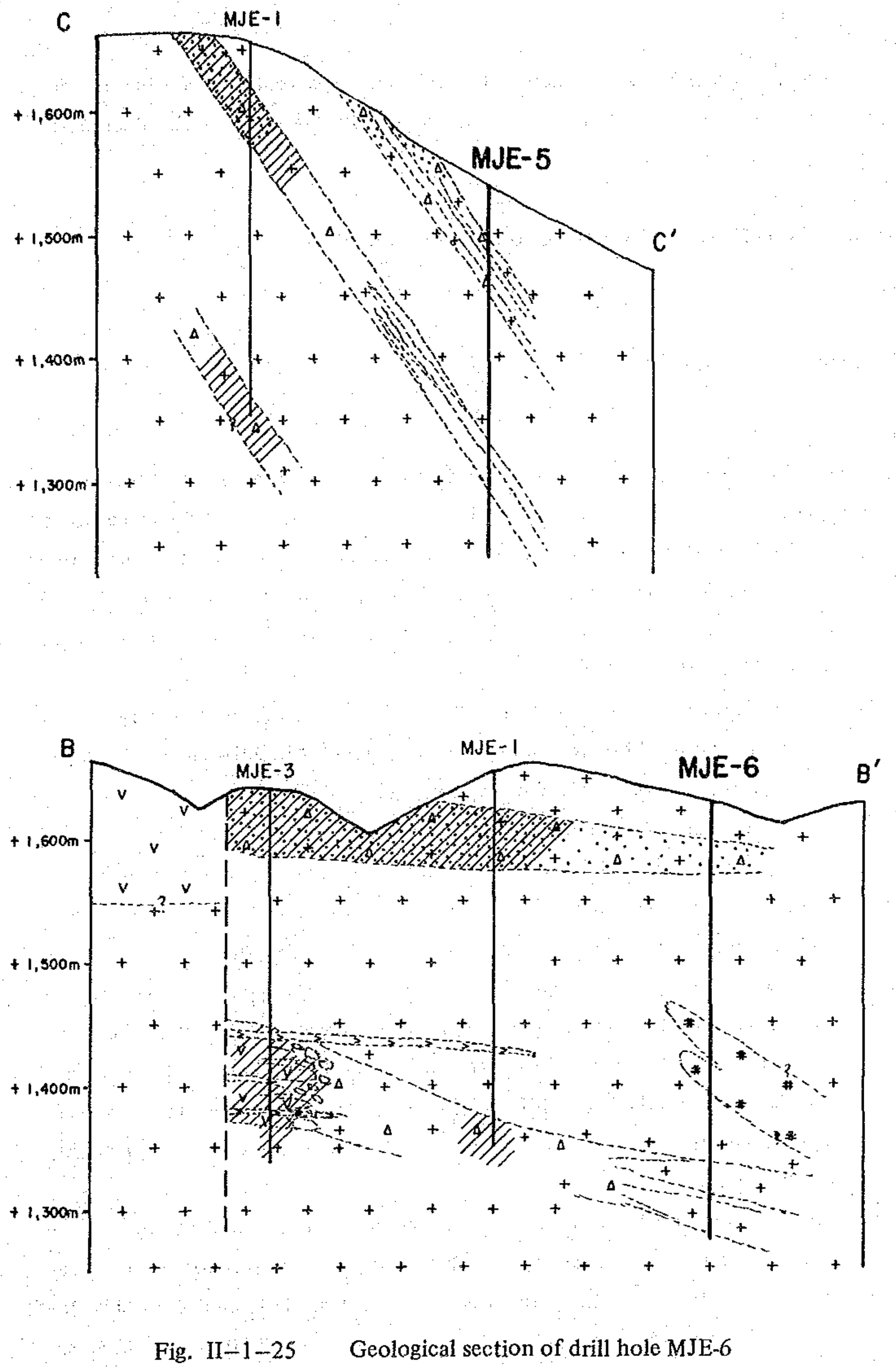


Fig. II–1–25 Geological section of drill hole MJE-6

Depth: 305.30 m

2) Purpose

This drilling was conducted to clarify the occurrence and features of mineral deposit in the southern extension of the mineralized Zone D in the El Torneado mineralized zones.

3) Geology and mineralization of drilling hole (Plate II-1-9)

0 to 11.50 m :

Masa of coarse-grained granodiorite

11.50 to 114.50 m :

Lithology is coarse-grained hornblende-biotite granodiorite (hereinafter called "coarse-grained granodiorite"). A small quantity of fine-grained pyrite and a very small quantity of fine-grained chalcopyrite were observed entirely as scattered dissemination and film-like form. Pyrite and chalcopyrite mainly occur in the portion of mafic minerals of host rock, and pyrite-(chlorite)-(epidote)-(secondary biotite)-quartz veins exist locally. The vein widths of the former, which bears chalcopyrite, is a 3 cm at maximum, and is mostly less than 1 cm. Cracks of host rock are mostly filled with veins 1 to 2 mm in width. The vein widths of the latter, which bears no chalcopyrite, vary up to 10 cm (depth 112.70 m). Comparatively large quantity of pyrite were observed as large lens and lump (2 to 5 mm long) in this vein. Two other types of vein were also observed, which differed from above two veins in mineral occurrence and paragenesis. One is pyrite (fine-grained)-secondary biotite-quartz vein and the other is barren quartz vein with white-transparent chabazite in druse. The Chalcopyrite-pyrite-(molybdenite)-chlorite-secondary biotite-(epidote)-quartz veins shows the same occurrence as veins existing in the section 114.50 to 145.30 m as mentioned later, and fills the fractures of host rock. These quartz veins were mostly compact. However, those in the sections 84.50 to 85.20 m and 101.80 to 101.95 m (depth) were vesicular and granulated like-sugar, and observed in the opennings between breccias of host rock in comparatively long distances of the cores.

The occurrence of sulfide minerals in this section is as follows. Chalcopyrite exists in a very small quantity in veins and host rock to a depth of around 100 m, but very rarely in host rock, and exists only in veins deeper than 100 m. Molybdenite is only locally found in veins 2 to 3 cm wide at a depth of 30.30 m, 31.50 m, 48.00 m, and 56.50 m.

For alteration, the host rock is entirely affected by weak chloritization.

Secondary biotite occurs locally. Weak sericitization is locally observed in short intervals ranging from 1 to 2 m at a depth of 20 m, 30 m, 35 m.

Further at the contact of the above metalliferous veins, some alteration corresponding to the gangue minerals are observed.

Analytical results of ore samples obtained from this area show 0.02 % in Cu (average of seven samples).

114.50 to 145.30 m :

Lithology is coarse-grained granodiorite. Fine-grained pyrite-secondary biotite-chlorite-quartz veinlets exist as a whole in the form of networks, stripes or twigs in fracture zone. The vein width ranges from 1 mm to 10 cm, and is mostly about 5 mm. The fabric of veins is irregular and complicated, and changes with change of the fracture zones. Pyrite in the veins is very fine, black and muddy.

These portions abundant in veins are affected by mylonitization. Rock forming minerals are elongated. The width of which is 2.3 cm to 20 cm. Pyrite-quartz veins (about 5 mm in vein width) are cut by the above mentioned veins in the fracture zone, and dislocation is about 3 cm. At the non-altered host rock off milonitized part, observed are pyrite dissemination in the form of spotted and film-like, and are weak chloritization.

145.30 to 305.30 m :

Lithology is coarse-grained granodiorite. Fine-grained pyrite is disseminated and scattered with a small quantity, mainly in the portion of mafic minerals. This section is entirely affected by weak chloritization. Epidote and secondary biotite locally occur.

Chalcopyrite-pyrite-epidote-(secondary biotite)-quartz veins and pyrite-chlorite-(secondary biotite)-quartz veins locally exist in thin cracks of host rock. The vein width is 1 mm to 3 cm. In chalcopyrite-bearing veins, paragenesis change is observed at a depth of 230 m. Above this depth most veins are chlorite-quartz gangue, while below this depth epidote appears and coexists in most veins.

Secondary biotite-quartz networked veins exist locally in fracture zone. In this veins fine-grained pyrite occur generally at the depth shallower than 200 m, but its quantity decreases extremely in section deeper than 200 m.

Molybdenite is rarely observed in sulfide bearing veins. Weakly sericitized zone locally occurs. The width of this alteration zone is less than 1 m in core length.

Analytical results of ore samples obtained from this section show 0.03 % in Cu (average of seven samples).

4) Consideration

The mineralized Zone D of "network" vein zone corresponds to networked veinlets portions formed in fracture zone between 114.50 and 145.30 m in depth of this hole. Though comparatively coarse-grained chalcopyrite, pyrite, molybdenite, etc. are observed in large quantities in outcrops of Zone D, only fine-grained (muddy) pyrite are observed on the core. This hole is considered to penetrate the lower limit of the mineralized Zone D, because geological evidence of lower most portion of hydrothermal deposits is observed: the manner of brecciation in fracture zone; and the change of pyrite grain size.

In the "dissemination" zone, on the other hand, chalcopyrite is also disseminated with pyrite in the section 11.50 to 114.50 m. (The "dissemination" zone: mineralized prior to "network" vein zone ; and chalcopyrite-pyrite are disseminated in the form of dissemination and veinlets in intrusive rocks; and widely spreads in this entire zone.) In the section deeper than 114.50 m, however, chalcopyrite is not recognized in the form of dissemination, but in the form of veinlets of mm order in small quantities. Only fine-grained pyrite is observed as dissemination in this section in small quantities. These evidences coincide with the tendency of the occurrence change from the center part to the outer of the porphyry copper type mineralization, which is recognized through the geological survey in the Bolivar area for two years.

As regards the relationship between the results of geophysical survey and drill hole MJE-4, the middle-deep IP anomalous zone shows that sulfide minerals continue between the outcrop of Mineralized Done D and the networked veinlets in fracture zone in this hole. The deep IP anomalous zone, which is detected in northeast of this hole, are not confirmed at this hole.

(3) MJE-5 Hole

1) Location, Inclination and Depth

Location: Latitude 9808.08N, longitude 708.17E, altitude +1,537 m

Inclination: -90°

Depth: 305.20 m

2) Purpose

This drilling was conducted to clarify the occurrence of mineral deposit in the northeastern extension of the mineralized zones B, C and D in the east of the El Torneado mineralized zone.

3) Geology and mineralization in drilling hole (Plate II-1-10)

0 to 10.90 m :

Masa of coarse-grained granodiorite

10.90 to 26.40 m :

Lithology is biotite-hornblende coarse-grained granodiorite (hereinafter called "coarse-grained granodiorite"), and abounds in secondary biotite. Fine-grained chalcopyrite is slightly disseminated. In this entire area, limonite-(pyrite) thin veins exist in cracks of host rock. The vein width is 1 to 5 mm. Analytical results of ore samples obtained from the 15.50 to 16.00 m section show 0.02 % in Cu and 0.02 % in W.

26.40 to 30.00 m :

Lithology is melanocratic medium-grained granodiorite, and abounds in secondary biotite. Pyrite is slightly disseminated. Veinlets such as pyrite-sericite-quartz veins and (chalcopyrite)-pyrite-chlorite veins are observed in comparatively large quantities. The vein width is 1 to 7 mm.

30.00 to 70.00 m :

Lithology is coarse-grained granodiorite, and abounds in secondary biotite. Pyrite is slightly disseminated. Pyrite-sericite-quartz veinlets (5 mm to 3 cm in vein width) and chalcopyrite-pyrite-(chlorite)-(quartz) thin veins (1 mm in vein width) in cracks of host rock locally. Toward 70 m in depth, the dissemination and a number of thin veins increase. Analytical results of ore samples obtained from this area show 0.01 % in Cu and 0.03 % in W (average of two samples). Also in the 35.40 to 36.20 m, 38.00 to 39.10 m, 42.90 to 43.20 m, 54.90 to 55.00 m, 62.20 to 63.70 m and 65.60 to 65.70 m sections, the fracture zone is filled with extreamely fine-grained (muddy) pyrite-secondary biotite-(chlorite)-quartz veinlets. Results of X-ray diffractive analysis show that chabazite and stilbite, which are considered to be the end formation of a hydrothermal activity, are observed in the veins in the 38.00 to 39.10 m section.

70.00 to 85.00 m :

Lithology is coarse-grained granodiorite, and abounds in secondary biotite, Chalcopyrite and pyrite are scattered as a film. Chalcopyrite-pyrite-chlorite thin veins (about 1 mm in vein width) mostly exist along the cracks in host rock of this hole. Analytical results of ore samples obtained from this section show 0.03 % Cu and 0.03 % W.

The interstices of brecciated host rock are filled with secondary biotite-quartz networked veins in the 76.60 to 83.50 m section.

85.00 to 155.00 m :

Lithology is coarse-grained granodiorite, and abounds in secondary biotite. Pyrite is disseminated. The 90 to 120 m section is dotted with comparatively large lens (about 5 cm long) of pyrite. Chalcopyrite-pyrite-(chlorite) thin veins (about 1 mm in vein width) locally exist. The dissemination of sulfide minerals and quantity of secondary biotite start to decrease gradually in the vicinity of 130 m in depth. Analytical results of ore samples obtained from this area show 0.01 % in Cu and 0.04 % in W (average of three samples).

Also secondary biotite-quartz veins 1 cm in vein width exist along the fracture zone in a depth of 89.90 m.

155.00 to 305.20 m :

Lithology is coarse-grained granodiorite, and is affected by weak chloritization. The secondary biotite of host rock found in the upper portion is hardly observed. Fine-grained pyrite is slightly disseminated. Chalcopyrite-pyrite is slightly disseminated. Chalcopyrite-pyrite-chlorite thin veins (about 1 mm in vein width) locally occur. Fine-grained molybdenite is locally observed in the thin veins. Analytical results of ore samples obtained from this area show 0.01 % in Cu (average of nine samples).

In this area, both the quantity of sulfide minerals and number of veins are much fewer than those in the upper portion. Also veinlets of barren quartz veins (1 to 2 cm in vein width) are observed.

Also in the 210.90 to 221.30 m sections and at 221.35 m, secondary biotite-quartz networked veinlets occur. In these veins, druses have developed, in which chalcedony quartz is precipitated in a colloform texture. Results of X-ray diffractive analysis show that stilbite also exists in the druses.

4) Consideration

The same mineralization as in the mineralized zones C and D consisting of "networked" vein mineralized zone was confirmed as secondary biotite-quartz veinlet zone containing extremely fine-grained pyrite in fracture zones in the following sections of this hole: 35.40 to 36.20 m, 38.00 to 39.10 m, 42.90 to 43.20 m, 54.90 to 55.00 m, 62.20 to 63.70 m, 65.60 to 65.70 m, 76.60 to 83.50 m, and 89.90 to 89.91 m in depth. The mineralized Zone C is considered to continue toward veinlet zones in the 76.60 to 83.50 m and 89.90 to 89.91 m sections, and the mineralized Zone D to continue toward areas shallower than these areas.

The outcrops of the mineralized zones C and D are both chalcopyrite-pyrite-(molybdenite)-chlorite-quartz networked vein mineralized zones, with which filled are the interstices of breccias of host rock that is affected by sericitization. Chloritization is observed along the veins, and the quantity of sulfide minerals is also large. In this hole, however, these mineralized zones branch into veins in the fracture zone, and sulfide minerals exist only as extermely fine-grained pyrite in addition to small quantity of fine-grained molybdenite observed in the 76.60 to 83.50 m section. Also a very small quantity of chlorite is only observed in the veins, and no alteration around veins. From these facts, it is consiered that this hole entered the lower part or lower limit of the mineralized Zones C and D.

In addition, the extremely fine-grained pyrite-secondary biotite-quartz veinlets, with which filled are interstices of the fracture zone existing in the 209.30 to 252.25 m section, are considered to be an extension of the mineralized zone A.

Further more, the northeastern extension of "dissemination" zone of the mineralized zone B corresponds to the dissemination which mainly exists in the 70 to 85 m section reaching the lower limit at about 155 m. In outcrops of the mineralized zone B, chalcopyrite and pyrite occur as scattered dissemination and veinlets, and large quantities of secondary biotite are observed in host rock. This hole shows the same occurrence at the 70 to 85 m section. However, chalcopyrite is dotted in small quantities in this area. In the 90 to 130 m section, several centimeter lens also exist locally. Secondary biotite is observed to a depth of about 155 m, and only chloritization is recognized below 155 m.

The dissemination of sulfide minerals in the drill core is weaker than that of the outcrops of Esperanza valley, chalcopyrite/pyrite ratio is low in this area, and the chalcopyrite is limitted in thin veins. These facts imply that this hole presents at the peripheral portion of "dissemination" zone extending in the entire El Torneado mineralized zone.

According to the results of the geophysical survey, the deep IP anomalous zone extending in NE-SW direction in vicinities of this hole seems to indicate that the "dissemination" zone continues toward the southeastern part, where pyrite mainly occurs in the 70 to 130 m section.

(4) MJE-6 Hole

1) Location, Inclination and Depth

Location: Latitude 9808.29 N, longitude 708.10 E, altitude +1,625 m

Inclination: -90°

Depth: 353.00 m

2) Purpose

This drilling was conducted to clarify the occurrence and features of mineral deposits at the northeastern extension of the mineralized zone A and the concealed mineralized zone, in the northeast of the El Torneado mineralized zone.

3) Geology and mineralization in drilling hole (Plate II-1-11)

0 to 8.00 m :

Masa of coarse-grained granodiorite

8.00 to 29.20 m :

Lithology is biotite-hornblende coarse-grained granodiorite (hereinafter called "coarse-grained granodiorite"). Pyrite is slightly scattered entirely and mainly in the portion of mafic minerals. This area is characterized by the fact that large quantities of limonite-(pyrite)-(chlorite)-(quartz) thin veins are present in cracks of rock in the 8 to 22 m section. Two origin of limonite are recognized: One is limonite which originates from sulfide minerals by oxidation; and the other is limonite precipitated from underground water in which iron element has been eluted. The host rock is entirely affected by weak chloritization, and sericitized zone is locally present. Chalcopyrite-pyrite-chlorite-secondary biotite-quartz veinlets with a core length of 40 cm exist in a depth of 23.90 m. Analytical results of ore samples obtained from this section show 0.01 % in Cu.

29.20 to 57.80 m

Lithology is coarse-grained granodiorite, and pyrite is entirely disseminated. Veinlets such as chalcopyrite-pyrite-chlorite-(secondary biotite)-quartz veins and pyrite-chlorite-(secondary biotite)-quartz veins exist in comparatively large quantities. The vein width is 0.5 to 5 cm. Chalcopyrite in the veins is fine-grained, and mostly less than 1 mm wide. Comparatively coarse grain pyrite are observed in large quantities, locally in lenticular form more than 5 cm in length. Analytical results of ore samples obtained from this section show 0.02 % in Cu.

The host rock is entirely affected by weak chloritization. This section is more affected by sericitization than any other section of this hole. Chalcedony quartz veinlet zone where druses exist in the 52.00 to 53.00 m section. In this section, epidote and sericite are also observed.

57.80 to 179.80 m

Lithology is coarse-grained granodiorite. Fine-grained pyrite is slightly disseminated. The entire area is affected by weak chloritization. Veinlets such as pyrite-sericite-quartz veins and chalcopyrite-quartz veins locally exist and local chalcopyrite-pyrite-chlorite-secondary biotite quartz veinlets exist. The vein width is 1 to 5 cm. A number of these veins are distributed between 160 m and 179.80 m in depth. Also chalcopyrite-pyrite-chlorite-(quartz) thin veins locally exist in a film like form in narrow cracks of host rock. The width is 1 to 3 mm, and mostly about 1 mm. Analytical results of ore samples obtained from this section show 0.01 % in Cu (average).

The quantity of chalcopyrite increases in proportion to the depth: very few in the 55 to 115 m section; and much are observed in the film-like thin veins in narrow cracks of host rock: deeper than 115 m, and the quantity increases moreover. However, only pyrite is disseminated in host rock, but chalcopyrite.

In the 59.80 to 60.90 m section, chalcedony quartz veinlets are accompanied with druses. Stilbite has crystallized in druses. Also in the 68.40 to 76.00 m section, secondary biotite-quartz veins exist in the fracture zone. In voids of these veins, chalcedony quartz and epidote are locally observed.

Sericitization is only observed discontinuously around pyrite-sericite-quartz veins. Secondary biotite is recognized in veins.

179.80 to 200.50 m :

Lithology is melanocratic biotite-hornblende medium-grained to coarse-grained granodiorite, and abounds in secondary biotite. Fine-grained pyrite is slightly disseminated. Chalcopyrite-pyrite-chlorite-(quartz) thin veins are locally present in small cracks of host rock. The vein width is about 1 mm. Sericitization is locally observed in and around pyrite-sericite-quartz veins. The width of the alteration zone is about 50 cm. Analytical results of ore samples obtained from this section show 0.02 % in Cu (average of two samples).

200.50 to 209.30 m :

Lithology is coarse-grained granodiorite. Pyrite is slightly disseminated. Pyrite-chlorite-secondary biotite-(sericite)-quartz veins are locally present. The vein width is 4 to 5 cm. Analytical results of ore samples obtained from this section show 0.02 % Cu.

209.30 to 232.20 m :

Lithology is melanocratic biotite-hornblende medium-grained granodiorite, and is affected by weak chloritization. Pyrite is slightly disseminated. Chalcopyrite-pyrite-chlorite veins with a vein width of about 1 mm are locally observed in marrow cracks of host rock body. This tends to increase toward the peripheral portion (near 232.20 m in depth) of this rock. In a depth of 231.20 m, molybdenite is locally observed in chalcopyrite-pyrite-(epidote)-quartz veins with vein width of 7 cm. Analytical results of ore samples obtained from this section show 0.01 % in Cu and 0.05 % in W.

232.20 to 270.00 m :

Lithology is coarse-grained granodiorite. Pyrite is slightly disseminated, and is affected by weak chloritization. Chalcopyrite-pyrite-chlorite-(secondary biotite)-quartz veins are locally present. The vein width is 1 mm to 2 cm. Dissemination of sulfide minerals increases downwards from 270 m in depth.

Analytical results of ore samples obtained from this section show 0.02 % in Cu and 0.07 % in W (average of two samples).

270.00 to 340.00 m :

Chalcopyrite and pyrite are scattered in a film-like. Chalcopyrite-pyrite-chlorite-(quartz) thin veins (about 1 mm in width) are locally present in veinlets (1 to 10 cm and mostly 1 to 2 cm in vein width) such as chalcopyrite-pyrite-chlorite-secondary biotite-quartz veins and pyrite-sericite-quartz veins, and in narrow cracks of host rock. Analytical results of ore samples obtained at a depth of 273.10 cm (length: 10 cm) show 0.1 g/t in Au,3.8 g/t in Ag, 0.02 % in Cu, 0.26 % in Pb, 1.59 % in Zn, and 0.20 % in W. A number of veins and large quantities of sulfide mineral dissemination are distributed in this section, which are superior to any other section shallower or deeper, especially in vicinities of 310 to 320 m in depth where dissemination of chalcopyrite is observed in comparatively large quantities in host rock. Analytical results of ore samples obtained from this section show 0.02 % in Cu and 0.06 % in W (average of five samples).

The host rock is affected by weak chloritization, and epidote is observed comparatively more intensely in this section than that in any other section.

In addition, in the 289.10 to 290.10 m, 312.90 to 312.91 m, 315.30 to 315.35 m, 319.80 to 320.80 m sections, extremely fine-grained (muddy) to fine-grained pyrite-(chalcopyrite)-(chlorite)-secondary biotite-quartz veinlets are present along the cracks of fracture zones. The vein width is mostly 0.2 to 1 cm, though it widens and narrows locally.

340.00 to 353.00 m

Lithology is coarse-grained granodiorite. Fine-grained pyrite is disseminated in small quantities. Veinlets (1 to 3 cm in vein width) such as (chalcopyrite)-pyrite-chlorite-secondary biotite-epidote-quartz and pyrite-quartz-sericite are locally observed. As a whole. the quantity of sulfide minerals is exceedingly lower than that in the upper portion.

Also in the 349.00 to 349.40 m, and 350.30 to 351.20 m sections, extremely fine-grained pyrite-secondary biotite-quartz veinlets are present in the fracture zones. In these porous veinlets, druses have developed, and colloform chalcedony quartz is observed in these druses. This host rock has been leached and locally changed into loosen vesicular rock.

4) Consideration

The northeastern extension of mineralized Zone A of "network" vein zone continues toward veinlet zone in the 29.20 to 57.80 m section. At the outcrops and dril-ling cores of MJE-1 and MJE-3 holes which were drilled last year, the mineralized Zone A is networked veins where the interstices in brecciation zone were filled with chalcopyrite-pyrite-molybdenite-chlorite-secondary biotite-quartz. This zone abounded comparatively in sulfide minerals, and pyrrhotite and scheelite also were recognized. Contrary in this hole (MJE-6), host rock is scarcely brecciated, a small quantity of sulfide minerals exist, and pyrrhotite is not observed. These facts show that this hole has penetrated the lower part of the mineralized Zone A. The sericitization, which has been noticeably observed at