REPORT
ON
THE MINERAL EXPLORATION
IN
THE JUNIN AND CUELLAJE AREA
REPUBLIC OF ECUADOR

(PHASE I)

MARCH 1995

JAPAN INTERNATIONAL COOPERATION AGENCY

METAL MINING AGENCY OF JAPAN

PREFACE

In response to request of the Government of the Republic of Ecuador, the Japanese Government decided to conduct a mineral exploration project in the Junin and Cuellaje areas 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 Masahiko Nono from 3rd October 1994 to 15th January 1995.

The team exchanged views with the officials concerned of the Government of the Republic of Ecuador and conducted a field survey in the Junin and Cuellaje areas. After the team returned to Japan, further studies were made and the present report has been prepared. This report includes the survey results of geological, geophysical and drilling survey in Phase I.

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

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

March 1995

Kimio Fujita
President
Japan International Cooperation Agency

Takashi Ishikawa
President
Metal Mining Agency of Japan

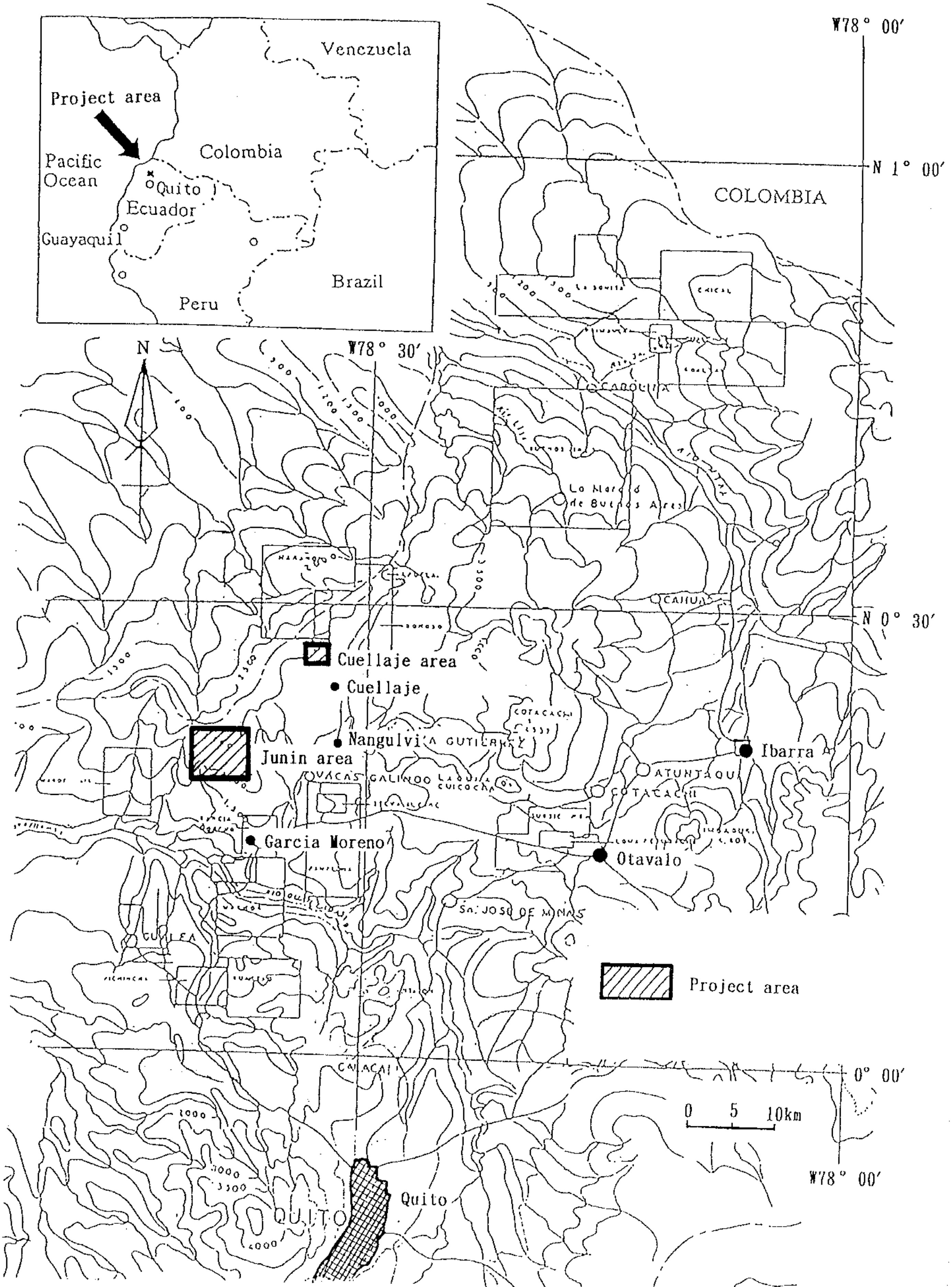


Fig. 1 Location map of project area.

ABSTRACT

The present survey was carried out in the Junin and Cuellaje areas, in conformity with the Scope of Work agreed between the government of the Republic of Ecuador and Japan, on 17th August 1994.

The purpose of the project is to discover ore deposits, to confirm the potential of ore deposits by clarifying the geology and mineralization in the Junin and Cuellaje areas, and to make a suitable transfer of technology to counterparts of ecuadorian organization.

The project area is located about 50 km north of Quito and situated on the western flank of the Andean mountain range in Ecuador. The Junin project, which includes this project area, was carried out from 1991 to 1993. This Project area consists of the Junin area and the Cuellaje area (Fig.1).

In the Junin area, drilling was carried out to clarify the geology and to confirm the extension and intensity of mineralization around the Rio Junin mineralized zone and the Q. Fortuna mineralized zone. In the Cuellaje area, geological, geochemical and geophysical surveys were carried out to clarify the geology and mineralization in the surrounding area of the Rio Magdalena mineralized zone. Drilling was also carried out to confirm the extension and intensity of mineralization in the Rio Magdalena mineralized zone.

Field survey was carried out by a survey team consisting of japanese and ecuadorian members from 3rd October 1994 to 15th January 1995.

The western flank of the Andean mountaine range which includes the project area, has a high possibility of porphyry copper deposits and several other type of ore deposits. The project area consists of Apuela/Nanegal granodiorite batholith and dikes and stock of quartz porphyry and diorite porphyry which intrude into granodiorite. According to the previous survey results, stockwork and dissemination type of copper and molibdenum mineralization has been recognized in the project area, for which the existence of porphyry copper deposits is expected in the project area.

The survey results obtained in Phase I in the Junin area are as follows:

Drilling of two holes (total depth of 601.79m) for the Rio Junin mineralized zone reveal that stockwork veins and disseminations of pyrite, chalcopyrite, chalcocite, bornite in the fractures and molybdenite in quartz veins occur in granodiorite, quartz porphyry and diorite porphyry in the eastern and deeper part of the Rio Junin mineralized zone. The average grade of the mineralized part (from 1.00m to 300.58m) of MJJ-14 is 0.29%Cu and 0.022%Mo. The average grade of the mineralized part (from 0.60m to 301.21m) of MJJ-15 is 0.22%Cu and 0.007%Mo. The results of ore assay show a tendency of increasing copper grade at depth and the mineralized zones extend toward eastern part where the existence of copper rich zone is expected.

Drilling of two holes (total depth of 300.98m) for the Q. Fortuna mineralized zone reveal that stockwork and dissemination of pyrite, chalcopyrite, bornite and chalcocite occur in granodiorite, quartz porphyry and diorite porphyry. The average grade of the mineralized part (core length of 144.60m) of MJJ-16 is 0.15%Cu and 0.0012%Mo. The average grade(from 4.05m to 150.25m) of MJJ-17 is 0.46%Cu and 0.0194% Mo. The core(from 60.00m to 150.25m) shows high grade of 0.62%Cu and 0.0273%Mo.

According to the survey results of the Junin project, phyllic alteration zone and geochemical anomalous zone extend from the Rio Junin to the lower stream of the Q. La Controversia, and reach possibly to the Q. Fortuna. Copper rich zone seems to be located between the Rio Junin and the Q. Fortuna. The Q. Verde area shows the possibility of existence of promissing ore deposits because of many dikes of quartz porphyry, phyllic zone and geochemical anomalous zone are widely recognized.

The survey results obtained in Phase I in the Cuellaje area are as follows:

Geology in the Cuellaje area consists of Apuela/Nanegal granodiorite batholith and dikes of andesite porphyry, quartz porphyry and diorite porphyry which intrude into granodiorite. In the central part of the area, the Rio Magdalena mineralized zone has been observed Geology of the surrounding area of the Rio Magdalena mineralized zone consists mainly of granodiorite, and several dikes of andesite porphyry and diorite porphyry which intrude into granodiorite.

Small veins and weak disseminations of pyrite, chalcopyrite and bornite were recognized in granodiorite.

As the results of geochemical survey, high score zones of factor 3 related to Cu/Mo mineralization were detected in the west of the branch of the Rio Magdalena and in the branch of the Rio Meridiano which is not significant.

As the results of IP survey, zones of high P.F.E. with low resisitivity are limited only in the central (Anomaly B) and in the northeast (Anomaly A) parts in the Cuellaje area. Anomaly B, which is small and trends towards northwest, seems to correspond to a small scale of mineralization.

Drilling surveys of MJC-3 and MJC-4 in the central zone, and MJC-5 and MJC-6 in the south zone, reveal that small veins of pyrite and chalcopyrite occur in granodiorite. Small amount of sulfide minerals was continuously observed. The copper and molibdenum grade of mineralized part of each holes are low.

Based on the survey results, the recommendations for Phase II survey in the Junin area and Cuellaje area are as follows:

1)In the area between the Rio Junin and the Q. Fortuna, and the area of Q. Verde,the possibility of existing significant mineralization seems to be high. Therefore, drilling survey for these areas is recommended to confirm the extension and intensity of mineralization. The recommendation area for drilling survey is shown on Fig.2. The evaluation of ore deposits is also recommended.

2)The possibility of development of mineralized zones in the Junin area seems to be high. As a result of development, effect for natural, social and other environmental concerned are estimated. To evaluate the effect of future development, environmental investigation is recommended to be carried out for the Junin area and surrounding areas.

3)According to the results obtained by the Phase I survey , Cu/Mo mineralization was recognized in the Cuellaje area, however, the possibility of existing promissing ore deposits seems to be low because of low grade of copper and weak continuity of mineralized zone. Therefore, further survey are not considered necessary.

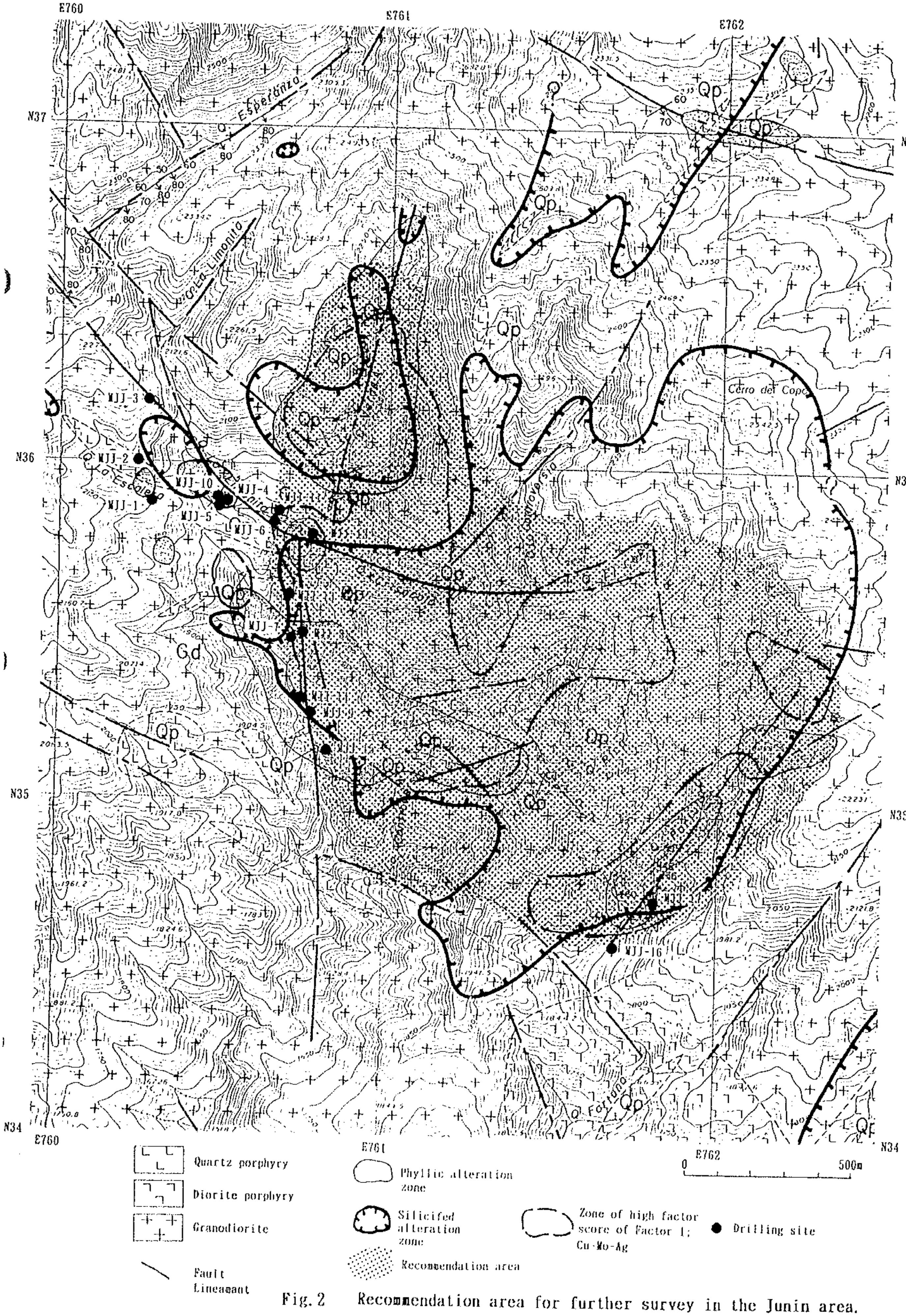


Fig. 2 Recommendation area for further survey in the Junin area.

CONTENTS

PART I GENERAL

Chapter 1 Introduction

1-1 Background of the project

The Junin and Cuellaje Project area lies in the western flank of the Cordillera Occidental of Ecuador, where predominates a porphyry copper belt which is known to run consistently from North to South of America.

The area and its vicinity were surveyed as Junin Project for Mineral Exploration during 1991 to 1993 by the Japanese Government. The survey results recommended promissing areas of porphyry copper type mineralization.

In 1993, the Ecuadorian Government requested to the Japanese Government a cooperative technological assistance in order to carry out continuously the project for mineral exploration in the Junin and Cuellaje areas. In response to such request, in August, 1994 the Japanese Government sent a mission composed of representatives of JICA and MMAJ and as a result, it was agreed the Scope of Work on cooperative mineral exploration with CODIGEM on 17th August, 1994. The survey team was sent to Ecuador from 3rd October, 1994 until 15th January, 1995.

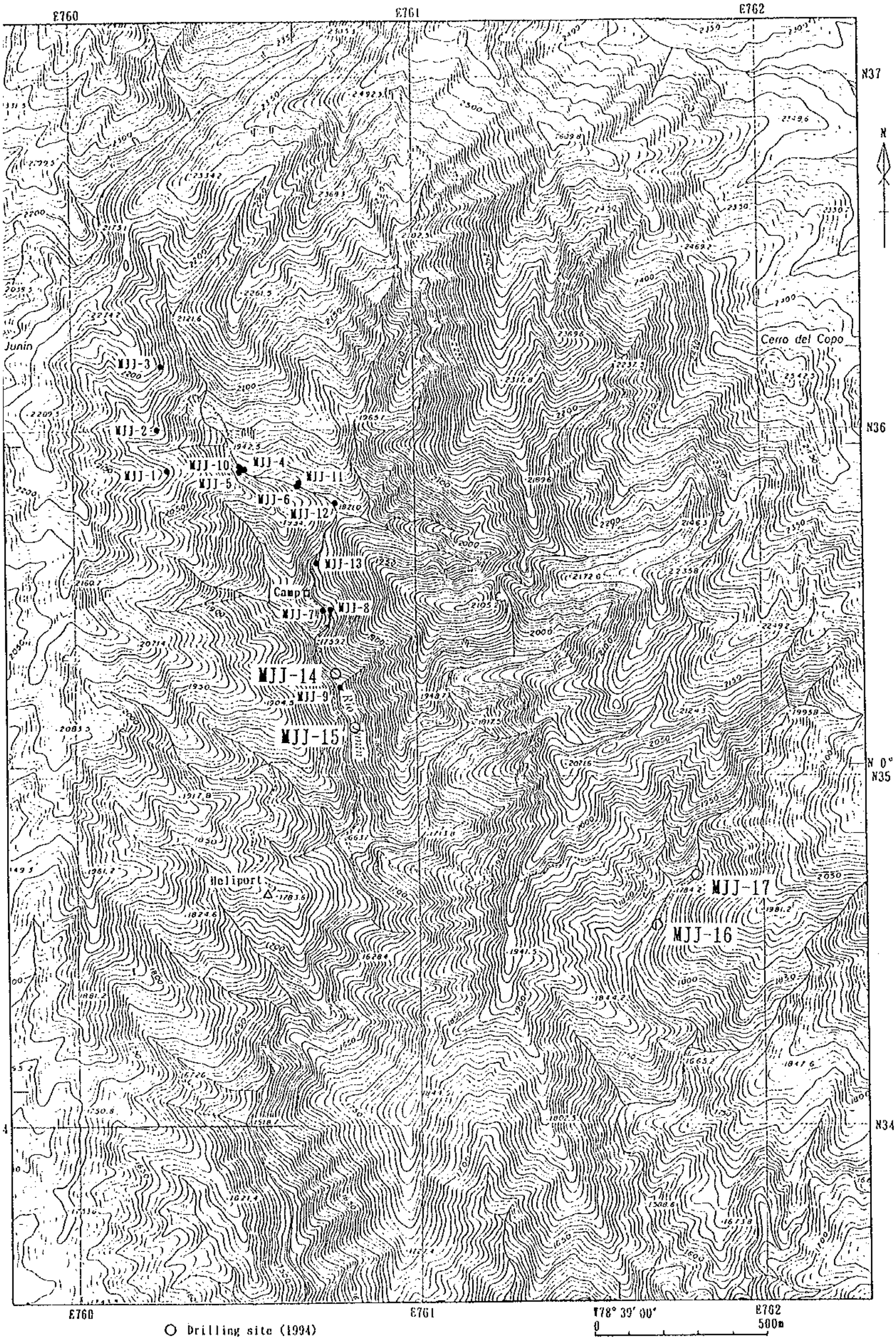
1-2 Outline of Phase I Survey

1-2-1 Location of the Project Area

The project area is located about 50km north of Quito and situated between 1,800m and 2,700m above sea level on the western flank of the Andean mountain range in Ecuador. The survey areas of the Phase I consists of two areas, the Junin area and the Cuellaje area, which were selected based on the survey results of the Junin Project conducted from 1991 to 1993.

1-2-2 Purpose of the Survey

The Purpose of the project is to discover ore deposits, to confirm the potential of ore deposits by clarifying the geology and mineralization in the Junin and Cuellaje areas, and to make a suitable transfer of technology to counterparts of Ecuadorian organization.



○ Drilling site (1994)
● Drilling site (1991-1993)

Fig. I-1-1　Location map of drilling in the Junin area.

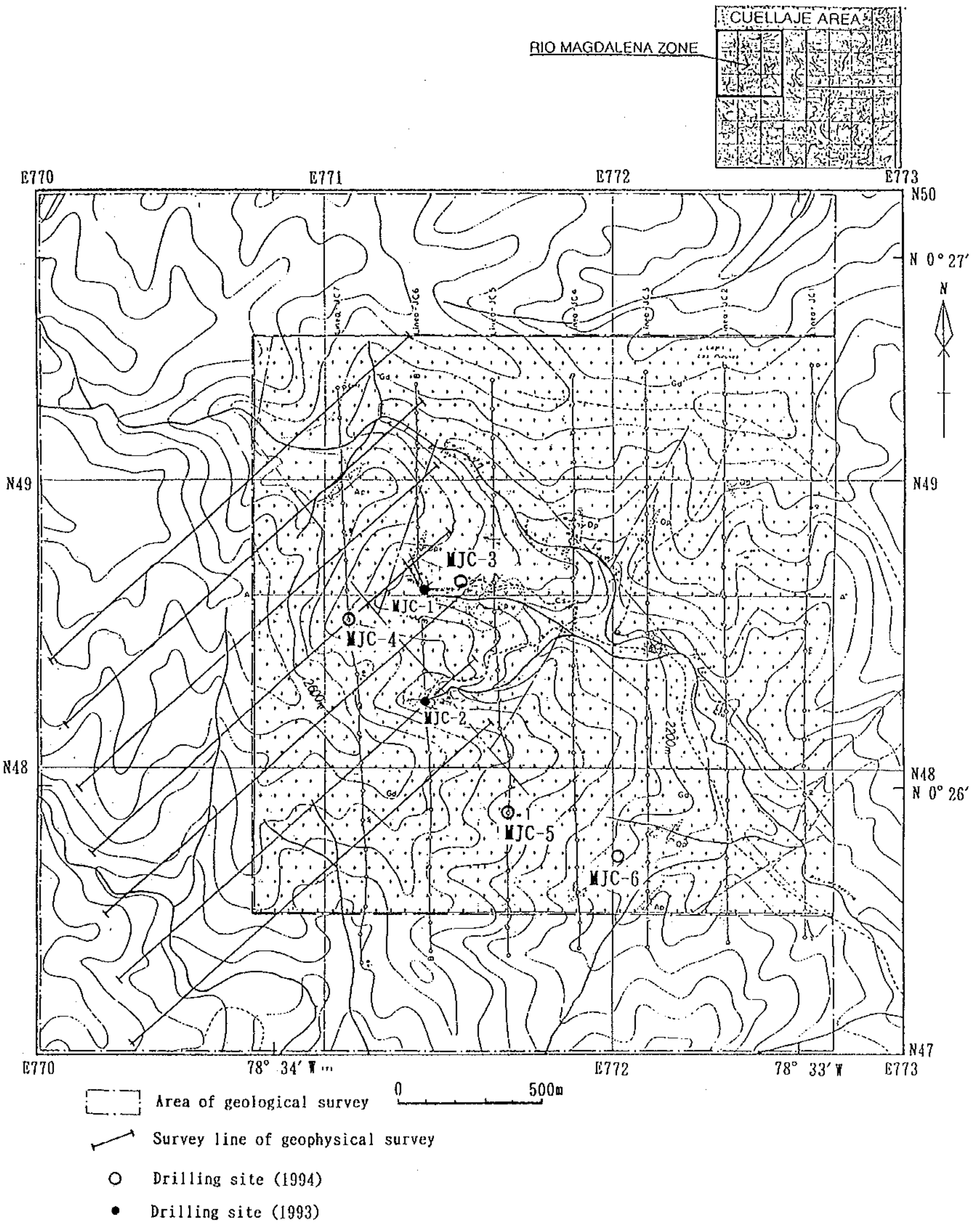


Fig. I-1-2 Location map of geological, geophysical and drilling survey in the Cuellaje area.

1-2-3 Survey Method

In the Junin area, drilling was carried out in order to clarify the geology and to confirm the extension and intensity of mineralization around the Rio Junin mineralized zone and the Q. Fortuna mineralized zone.

In the Cuellaje area, geological, geochemical and geophysical surveys were carried out in order to clarify geology and mineralization in the surrounding area of the Rio Magdalena mineralized zone. Drilling was also carried out to confirm the extension and intensity of mineralization in the Rio Magdalena mineralized zone. The amount of survey and laboratorial studies of the two survey areas are shown on Table I-1-1 and Table I-1-2.

1-2-4 Organization of the Survey

The present survey correspond to the Phase 1 survey of the Project. Personnel who were involved in the Project, as administrators and members of the survey team are shown as follows:

1)Planning and negociation

(Japanese side)		(Ecuadorian side)	
Akira Sato	MMAJ	Jorge Sevilla	CODIGEM
Satoshi Shiokawa	MMAJ	Ramon Vera	CODIGEM
Seiichi Mizusawa	MMAJ	Juan Cevallos	CODIGEM
		Juan Sosa	CODIGEM
		Gabriel Valenzuela	CODIGEM

2)Inspection

Naoki Sato MMAJ

3)Survey team

(Japanese survey team)		(Ecuadorian survey team)	
Masahiko Nono	BEC	Gabriel Valenzuela	CODIGEM
Yutaka Nagoya	BEC	Carlos Ortiz	CODIGEM
Kazutoshi Sugiyama	BEC	Vicente Fiallos	CODIGEM
David Escobar	BEC	Bolivar Revelo	CODIGEM
Kazuto Matsukubo	BEC	Fernando Grijalva	CODIGEM
		Luis de la Torre	CODIGEM

Table I-1-1 Item and amounts of fieldworks.

Junin area

Drilling	Hole No.	Depth (m)	Direction (magnetic north)	Inclination
	MJJ-14	300.58	N90E	-45°
	MJJ-15	301.21	N90E	-45°
	MJJ-16	150.73	-	-90°
	MJJ-17	150.25	-	-90°

Cuellaje area

Geological survey	Area of survey		4	km ^{2}
	Length of survey route		21	km
	Geochemical rock samples		224	samples
Geophysical survey	Length of IP survey line		11.9	km
	Number of line		7	lines
	Number of measurement		455	times
Drilling	Hole No.	Depth (m)	Direction (magnetic north)	Inclination
	MJC-3	300.70	-	-90°
	MJC-4	301.00	-	-90°
	MJC-5	300.50	-	-90°
	MJC-6	301.00	-	-90°

Table I-1-2 Item and and amount of laboratorial studies.

Junin area

Drilling	Hole No.	MJJ-10	MJJ-11	MJJ-12	MJJ-13	MJJ-14	MJJ-15	MJJ-16	MJJ-17	total
	Thin section					9	10	3	4	26
	X-ray diffra	15	15	15	15	42	43	23	18	186
	Inclusion					3	3	1	1	8
	Ore assay	27	32	58	134	314	227	148	144	1,084
Geochemical survey	Rock(Ca, Na, K, Rb, Sr)						85 samples			

Cuellaje area

Geological survey	Thin section					21 samples		
	Polished section					13 samples		
	X-ray diffractive					224 samples		
	Inclusion					10 samples		
	Ore assay					28 samples		
Geochemical survey	Rock(Ag, Au, Ca, Cu, Fe, Mo, Na, K, Pb, Rb, S, Sr, Zn)					224 samples		
	Rock(Ca, Na, K, Rb, Sr)					206 samples		
Geophysical survey	Resistivity measurement					24 samples		
	Polarizability					24 samples		
Drilling	Hole No.	MJC-1	MJC-2	MJC-3	MJC-4	MJC-5	MJC-6	total
	Thin section			7	5	4	5	21
	X-ray diffra	11	9	31	27	21	29	128
	Inclusion				1	1		2
	Ore assay	18	46	76	102	25	25	292

Alfonso Vaca	CODIGEM
Frankline Ortega	CODIGEM
Ricardo Rosales.	CODIGEM

MMAJ;Metal Mining Agency of Japan.

CODIGEM;Corporacion de Desarrollo e Investigacion Geologico Minero Metalurgica.

BEC;Bishimetal Exploration Co., Ltd.

1-2-5 Period of the Survey

1)Planning and negociation.
From 11th August, 1994 to 21st August, 1994.

2)Inspection
From 14th December, 1994 to 25th December, 1994.

3)Geological and geochemical survey.
From 25th October 1994 to 4th December 1994.

4)Geophysical Survey.
From 25th October 1994 to 7th December 1994.

5)Drilling survey.
From 3rd of October 1994 to 15th January, 1995.

6)Data analysis and compilation.
From 5th of December, 1994 to 28th February, 1995

Chapter 2 Geographic Features of the Project Area

2-1 Location and Access

The Project area is located in the Provincia of Imbabura, about 50 to 80 km north of Quito, the capital city of Ecuador. The Phase I survey included two survey areas, Junin area and Cuellaje area (Fig.1, Fig.I-1-1 and Fig.I-1-2).

Base-camp was located at Garcia Moreno for Junin area and Cuellaje for the Cuellaje area, which is about 200km of road distance and five hours drive from Quito via Otavalo (110km of paved road between Quito and Otavalo, and 70km of unpaved road between Otavalo and Garcia Moreno). From Garcia Moreno to Chalguayacu Alto, the entrance of Junin, it take about one hour drive by 20km of unpaved road. From Chalguayacu Alto to "Junin Camp" in the CentralZone of Junin area, it requires half hour drive by 10km and half hour on horseback in dry season. From Nangulvi to the Cuellaje area, it requires fourty minutes of drive through 17km of unpaved road.

2-2 Topography and Hydrography

The project area lies in the western flank of West-Andian mountain range. The topography of the Project area is very steep, elevation range from 1,500m to 3,000m above sea level in Junin area, and from 1,800m to 2,600m above see level in Cuellaje area. The most prominent summit distributed around the Project area is Mt Cotacachi (4,937 m) which is located in the east of 20km of the Cuellaje area. Junin and Cuellaje areas are situated on the southern flank and southeastern flank of the Cordillera de Toisan.

In the Project area, the principal drainage system originates from the Andian mountain range and consists macroscopically of the E-W system represented by the Rio Guayllabamba running to the west in southern area and of the NW-SE system represented by the Rio Mira streaming towards the northwest direction. The survey areas, Junin and Cuellaje, are distributed in an area along a branch of the upper stream of the Rio Guallabamba. Adding to these preferential directions, second degree drainage systems are developed, which are characterized by a N-S system such as the Rio Junin, a NE-SW system such as the Q. Fortuna and a NW-SE system such as the Q. Limonita and the Q. Chrisocola in the Junin area. In the Cuellaje area, main drainage system trends along NE-SW represented by the Rio Magdalena and the Rio San Joaquin.

2-3 Climate and Vegetation

Climate in the survey area is tropical with high humidity in lower altitude area, however, it is temperate and dry in higher altitude areas. The records show that annual humidity ranges from 50% to 75%. Precipitation amounts to 2,000mm to 3,000mm annually. The rain season runs from December to April. In Junin area, it is very common from October to start rain in the afternoon and decresing temperature. From December, it rains through day and night.

Vegetation in the Junin area consists mainly of jungles. Vegetation in the Cuellaje area consists of jungles along the streams and in part of the highl, and plantations of sugar cane existing in the highland and slope.

Chapter 3 Geological Features of the Project Area

Ecuador is situated in the northwestern part of South American Continent and occupies an area between Colombia and Peru geographically. Geotechtonically, Ecuador belongs to so-called mobile belt of the Andian geosyncline, which is formed in a narrow stripe along the western margin of the Guiana-Brazil shield, and which is characterized such geotectonic structure with faults, folds and violent volcanic activities as eugeosyncline is.

The geology of Ecuador consists of rocks from Pre-Cambrians up to Quaternaries. Principal geologic structure shows NNW-SSE trend which reflects upon the distribution of the three geo-tectonic ranges, Coast, Mountains and Orient. Geology of coastal range is composed of Mesozoic marine formation (the Pinon formation), Tertiary formation and Quaternary formations. Geology of Mountain ranges is composed of three geologic zones: the West-Cordillera; the Andian inner valley; and the East-Cordillera. In the West-cordillera volcanic rocks, which are dated to be from Cretaceous to Pareogine (the Macuchi formation), are piled up enormously. In the southern part of this geologic range, Paleozoic and Pre-Cambrian basements are recognized to distribute. In the Andian inner valley, many depositional basins are scattered and are filled with sediments and volcanic detritus. Geology of Orient is composed of sedimental layers from Carboniferous to Quaternary.

Geology around the Project area including the Junin and Cuellaje areas, consists of Cretaceous Macuchi formations which are intruded by acidic to intermediate granitic rocks (MRNE/DGGM, 1982). Furthermore batholith of granodiorite in the Project area was determined to be 13 to 15 Ma; Stocks of porphyritic rocks were to be 6 to 11 Ma with K-Ar method. Principal geologic structure show N-S and NNE-SSW directions which are represented by distributional characteristics of Apuela-Nanegal batholith.

Ecuador has two major Metallogenic Provinces: Oriental and Occidental, each of which is subdivided into three and five Metallogenic Zones respectively (INEMIN, 1988). Classification of these zones is interpreted on Table.I-3-1, and their distribution are shown in Fig.I-3-1. The Junin and Cuellaje areas are situated in the Metallogenic Zone VII, a anticlinorium-synclinorium of Occidental

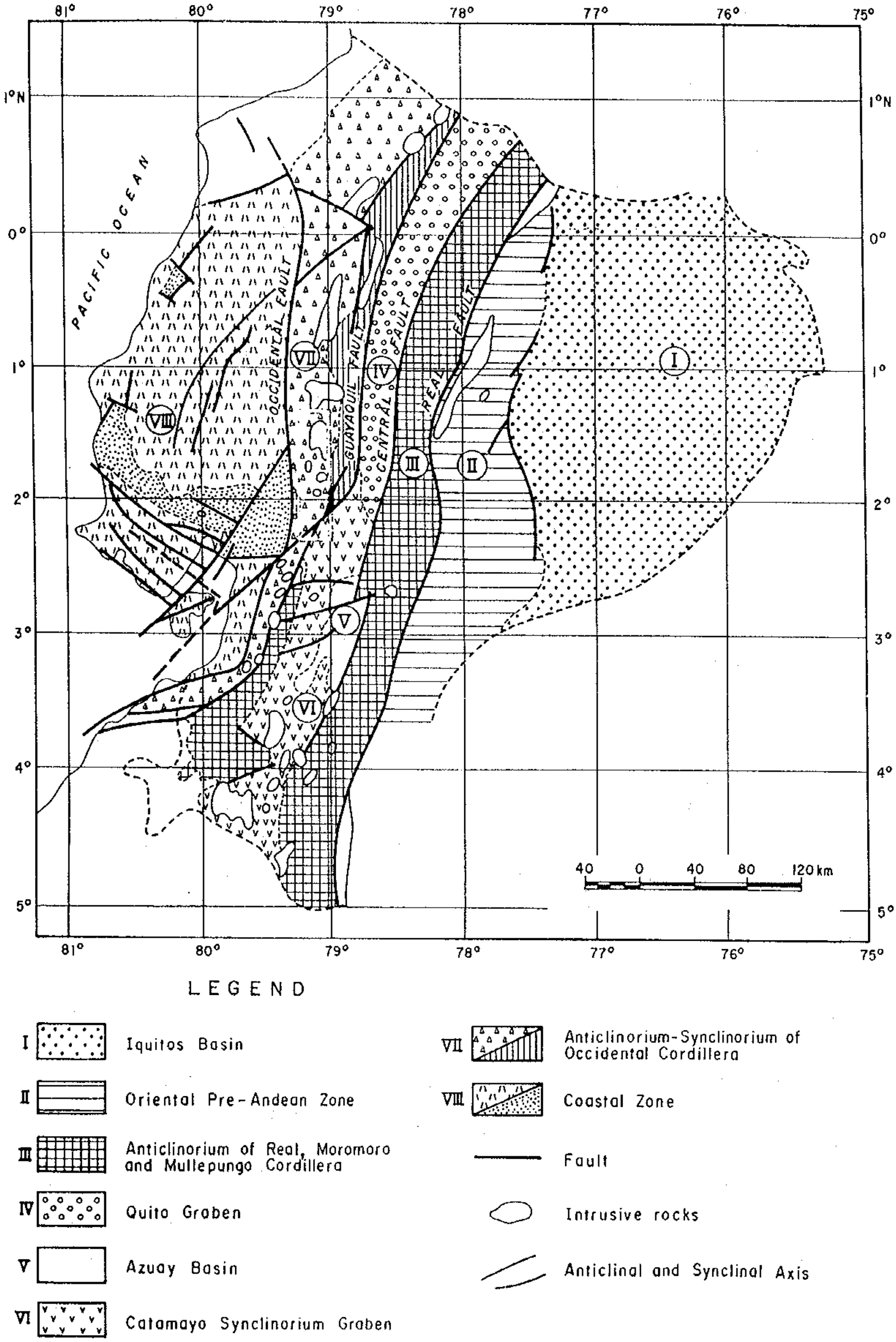


Fig. I-3-1 Geotectonic and metallogenic zones of Ecuador.

Table I-3-1 Geotectonic and metallogenic zones of Ecuador.

<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>

Metallogenic Province. The Zone VII extends north-south: northern most limit may be around the Piedrancha deposits in Colombia ; to the south, El Torneado mineralized zones and Chaucha deposits ; and southern most limit may be around the Michiquillay deposts. In the vicinity of Piedrancha, later stage auriferous mineralization is also recognized. Massive sulfide deposits have been mined at the La Plata mine and the Macuchi mine which are just south of Quito, and polymetallic deposits are being mined at the Portovelo mine in the southern part of Ecuador. Therefore the Zone VII may have a high potential of ore deposits, especially of porphyry copper type deposits.

In the Junin and Cuellaje areas, mineralization of copper and molibudenum is recognized(JICA and MMAJ, 1992)and the exsitence of porphyry copper ore deposits are expected.

Chapter 4 Overall Discussion on the Results

4-1 Junin Area

4-1-1 Geology and Mineralization

Geology around the Rio Junin mineralized zone and the Q. Fortuna mineralized zone consists of granodiorite, quartz porphyry and diorite porphyry. The granodiorite belongs to Apuela/Nanegal batholith. The quartz porphyry and diorite porphyry form dikes and stock, and intrude into the granodiorite. Dikes trend NE-SW and NW-SE directions.

The Rio Junin mineralized zone is composed of small stockwork vein and dissemination of pyrite, chalcopyrite, bornite, chalcocite and molybdenite. Chloritization and epidotization are recognized in granodiorite, quartz porphyry and diorite porphyry. Silicification and sericitization are observed near the veins and fractures. Hole No. MJJ-14 and MJJ-15 penetrated granodiorite, quartz porphyry and diorite porphyry. The mineralization occurs continuously and extends towards east and depth with an extension of more than 300m from the Rio Junin. The average grade of the mineralized part (from 1.00m to 300.58m) of MJJ-14 is 0.29%Cu and 0.0022%Mo(calculated by 314samples). The average grade at depth from 207.00m to 294.00m of MJJ-14 is 0.41%Cu and 0.047%Mo. The copper grade shows a tendency of increasing at depth. The average grade of the mineralized part (from 0.60m to 301.21m) of MJJ-15 is 0.22%Cu and 0.007%Mo (calculated by 227 samples). Near quartz porphyry at depth, the average grade of core length of 118.21m shows 0.41%Cu and0.016%Mo. The Rio Junin mineralized zone is characterized by mineralization occurring near the quartz porphyry and diorite porphyry and abundant bornite and chalcocite observed in the deeper part. Chalcocite at depth seems to be a secondary mineral which indicates that mineralization is controlled by faults and fractures. Near the Rio Junin mineralized zone, faults trending N-S, NW-SE, NE-SW and NNE-SSW are recognized and seeming to be related with the mineralization.

Holes No. MJJ-16 and MJJ-17 clarified the geology around the Q. Fortuna mineralized zone which consists of granodiorite and quartz porphyry containing small stockwork vein and dissemination of pyrite, chalcopyrite, bornite and chalcocite. The mineralization is

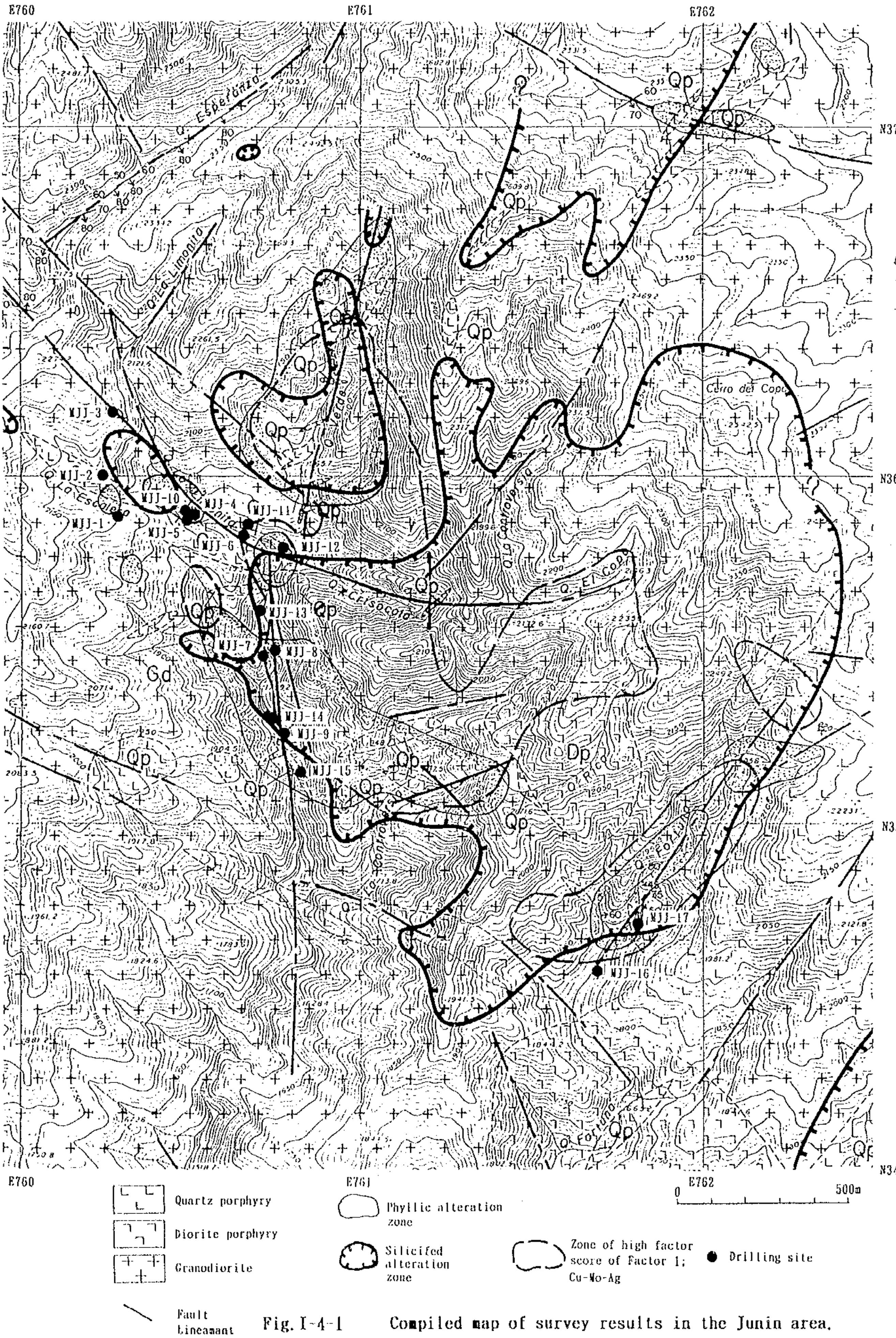


Fig. I-4-1 Compiled map of survey results in the Junin area.

characterized by abundant pyrite which occurs in stockwork vein and dissemination. Silicification and sericitization are observed mainly in quartz porphyry. Chloritization and epidotization are observed mainly in granodiorite. The average grade of core length of 144.60m of MJJ-16 shows 0.15%Cu and 0.0012%Mo (calculated by 148 samples). The average grade of the mineralized part (from 4.05m to 150.25m) of MJJ-17 shows a high grade of 0.46%Cu and 0.0194%Mo (calculated by 144 samples). The grade at depth from 60.00m to 150.25m of MJJ-17 is very high and shows 0.62%Cu and 0.0273%Mo. The Q. Fortuna mineralized zone is characterized by abundant copper minerals recognized in and near the quartz porphyry.

4-1-2 Correlation between Geochemical Anomaly and Mineralization

As the results of rock geochemical analysis of the sampled collected around the Q. Fortuna, geochemical anomalous zones of Au, Ag, Cu and Mo are detected in the middle of Q. Fortuna. High score of the factor 3 relating Cu/Mo mineralization are also distributed in the middle stream of the Q. Fortuna. These geochemical anomalous zones are located in the mineralized zone of granodiorite and quartz porphyry. Geochemical anomalous zones are not distributed in the upper most stream and lower stream of the Q. Fortuna.

4-1-3 Possibility of Existence of Ore Deposits

As the results of drilling survey carried out in the Junin area, the rich zone of Cu mineralization was confirmed in the eastern part of the Rio Junin and in the deeper part of the Q. Fortuna. According to the alteration, phyllic alteration zone is distributed from the Q. Verde through the Rio Junin to the lower stream of the Q. La Controversia and has a possibility of extending to the middle stream of the Q. Fortuna. As the results of rock geochemical survey, high score of factor relating to Cu/Mo mineralization is distributed from the Q. Verde to the eastern part of the Rio Junin, lower stream of Q. La Controversia and Q. Rica. According to the distribution of phyllic zone and geochemical anomalous zone, the rich zone of copper mineralization recognized in the holes of MJJ-14 and MJJ-15 seems to extend to the lower stream of Q. La Controversia and Q. Rica and also seems to have a possibility of extending to the Q. Fortuna (Fig.I-4-1).

Cu/Mo mineralization has been also recognized in the Q. Limonita, Q. Chrisocola, Q. La Controversia, Q. Rica and Q. Copo in addition to the Rio Junin and Q. Fortuna. Among these mineralized zones, the mineralized zone of the Q. Verde seems to have a high possibility for the existence of promissing Cu mineralization because of the intrusion of quartz porphyry accompanied by phyllic zone and geochemical anomalous zone(Fig.I-4-1).

4-2 Cuellaje Area

4-2-1 Geology and Mineralization

Geology in the Cuellaje area consists mainly of granodiorite and small dikes of quartz porphyry and andesite porphyry which intrude into the granodiorite batholith.

In the Rio Magdalena mineralized zone, stockwork veins and dissemination type of pyrite, chalcopyrite and bornite have been recognized (JICA/MMAJ,1992). An occurrence of sulfide minerals and distribution of alteration minerals seems to be similar to the typical porphyry copper deposits (JICA/MMAJ,1992).

As the results of geological survey for the surrounding area of the Rio Magdalena mineralized zone, the geology in the survey area consists mainly of granodiorite and small and few dikes of andesite porphyry, quartz porphyry and diorite porphyry which intrude into the granodiorite. Small veins and dissemination of pyrite and chalcopyrite were recognized in granodiorite located in a branch of the Rio Magdalena, in the upper stream of the Rio Magdalena, in a branch of the Rio San Joaquin and in a branch of the Rio Meridiano. The length of each zone is between 200m and 400m, while the amount of sulfide minerals is small. As the results of ore assay, copper grade of many samples show low value and copper mineralization seems to be weak. However, ore assay results of the samples collected in a branch of the Rio Meridiano show 0.1%Cu to 13.7%Cu. The high grade, 13.7%Cu, resulted from the existence of copper oxide mineral and small bornite vein trending NE-SW.

Drilling survey consisting of MJC-3 and MJC-4 for the central part, and MJC-5 and MJC-6 for the south part, was carried out. Total depth is 1,203.20m. Each hole penetrated granodiorite and encountered small veins of pyrite and chalcopyrite. Mineralization is widely

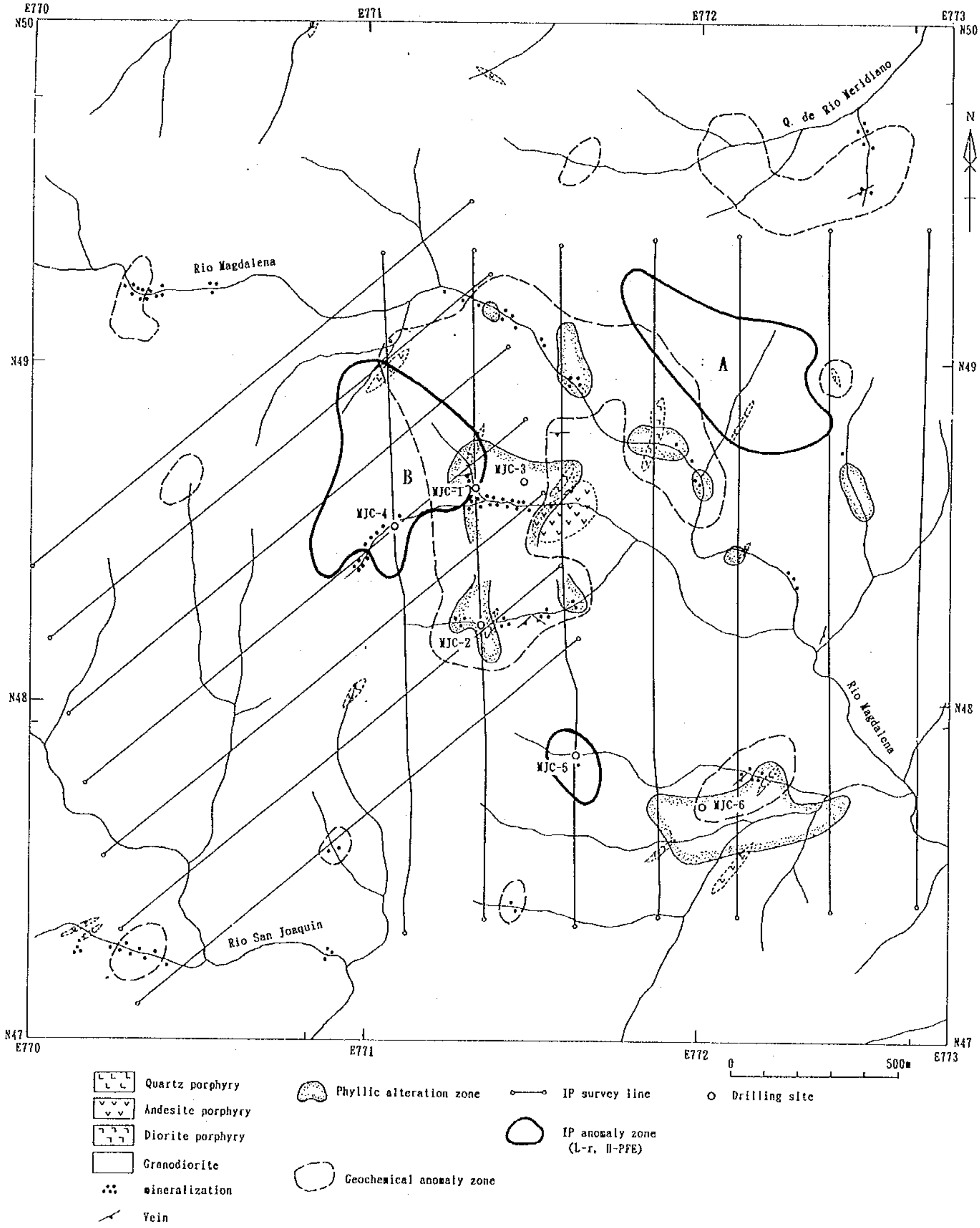


Fig. I-4-2 Compiled map of survey results in the Cuellaje area.

distributed, but amount of sulfide minerals is small. Alteration consists mainly of chloritization and epidotization. Silicification and sericitization are recognized only along small veins. The average grade of core length of 106.70m of MJC-3 shows 0.18%Cu and 0.0065%Mo (calculated by 76 samples). The average grade of core length of 99.50m of MJC-4 shows 0.04%Cu and 0.0002%Mo(calculated by 102 samples). The average grade of core length of 32.00m of MJC-5 shows 0.03%Cu and 0.0001%Mo (calculated by 25 samples). The average grade of core length of 41.00m of MJC-6 shows 0.08%Cu and 0.0015%Mo (calculated by 25 samples). Each mineralized part shows low grade of copper and molybdenum without any continuity and with small scale of mineralization. Based on the results obtained by this survey, Cu/Mo mineralization was recognized, however, it does not seem remarkable (Fig.I-4-2).

4-2-2 Correlation between Geochemical Anomaly and Mineralization

As the results of rock geochemical survey, geochemical anomalies of Cu, Mo, Au and Ag are distributed in the Rio Magdalena mineralized zone. A high score zone of factor 3 related to Cu/Mo mineralization was detected in the west branch of the Rio Magdalena, in the upper part of the Rio Magdalena , in the branch of the Rio Meridiano and in the branch of the Rio San Joaquin. These anomalies zone seem to be affected by the mineral showings existing near the anomalies. Among these anomalies, the anomaly in the west branch of the Rio Magdalena is most promising because of dikes of andesite porphyry and diorite porphyry, and copper showings (Fig.I-4-2).

4-2-3 Correlation between Geophysical Anomaly and Mineralization

As the results of IP survey carried out in the western part of the Rio Magdalena mineralized zone, high F.E. zone is not distributed in the western part, however, it extends from the central to south. The zone of high F.E. with low resistivity which are related to porphyry copper mineralization, are limited only in the central (Anomaly B) and in the northeast (Anomaly A) parts. Anomaly seems to be composed of mainly pyrite (JICA/MMAJ, 1993). Anomaly B, which is better than Anomaly A, is small, trends to northwest and seems to correspond to a small scale of mineralization (Fig.I-4-2).

4-2-4 Possibility of Existence of Ore Deposits

According to the results of the drilling survey, mineralization was recognized at the deeper part in the central and south of the Rio Magdalena mineralized zone. However, the grade of copper and molybdenum is clarified to be low by ore assay. Mineral showings and geochemical anomalies were recognized in the surrounding area of the Rio Magdalena mineralized zone. These showings and anomalies seem to be not significant. IP survey reveals that no anomaly was observed in the west, and high F.E. with low resistivity zones are limited only in the central and northeast parts.

Based on the results obtained by the survey carried out in the Cuellaje area, Cu/Mo mineralization was recognized, however, the possibility of existing promissing ore deposits seems to be low because of a low grade of copper and a weak continuity of high grade ore.

Chapter 5 Conclusions and Recommendations

5-1 Conclusions

5-1-1 Junin Area

(1) The Rio Junin mineralized zone consists of stockwork veins and disseminations of pyrite, chalcopyrite, chalcocite, bornite in the fractures and molybdenite in quartz veins which occur in granodiorite, quartz porphyry and diorite porphyry. Silicification and sericitization are recognized near stockwork and quartz veins. Chloritization and epidotization are widely observed in granodiorite, quartz porphyry and diorite porphyry. Mineralization is related to silicification and sericitization.

(2)Drilling surveys of MJJ-14 and MJJ-15 reveal that porphyries are located in the eastern and deeper part of the Rio Junin, and that chalcopyrite, bornite and chalcocite occur near dikes of porphyries. Mineralization extends toward east and depth with an extension of more than 300m. The average grade of the mineralized part (from 1.00m to 300.58m) of MJJ-14 is 0.29%Cu and 0.022% Mo(calculated by 314 samples). The average grade from 207.00m to 294.00m of MJJ-14 is 0.41%Cu and 0.047%Mo, which show a tendency of increasing grade at depth. The average grade of the mineralized part (from 0.60m to 301.21m) of MJJ-15 is 0.22%Cu and 0.007%Mo (calculated by 227 samples). Near quartz porphyry at depth, the average grade of core length of 118.21m shows 0.41%Cu and 0.016%Mo. According to the results of drilling, rich zone of copper is expected in the eastern part of the Rio Junin mineralizedzone.

(3)Drilling surveys of MJJ-16 and MJJ-17 reveal that quartz porphyry intrudes into granodiorite, and stockwork and dissemination of pyrite, chalcopyrite, bornite and chalcocite occur in granodiorite, quartz porphyry and diorite porphyry. Mineralization is characterized by abundant pyrite. Silicification and sericitization are mainly recognized in quartz porphyry. Chloritization and epidotization are mainly recognized in granodiorite. The average grade of the mineralized part (core length of 144.60m) of MJJ-16 is 0.15%Cu and 0.0012%Mo (calculated by 148 samples). The average grade from 4.05m to 150.25m of MJJ-17 is 0.46%Cu and 0.0194%Mo (calculated by 144 samples). Core (from 60.00m to 150.25m) shows high grade of 0.62%Cu and 0.0273%Mo.

(4)The results of geochemical analysis show that geochemical anomalous zones of Au, Ag, Cu and Mo are distributed in the middle stream of the Q. Fortuna.

(5)Phyllic alteration zone and geochemical anomalous zones extend from the Rio Junin to the lower stream of the Q. La Controversia, and reach possibly to the Q. Fortuna. Abundant copper zone seems to be located between the Rio Junin and the Q. Fortuna.

(6)Around the Q. Verde, many dikes of quartz porphyry are distributed, where phyllic zone and geochemical anomalous zone are widely recognized. The Q. Verde mineralized zone indicates the possibility of existence of promissing ore deposits.

5-1-2 Cuellaje Area

(1)Geology of the surrounding area of the Rio Magdalena mineralized zone consists mainly of granodiorite, and several dikes of andesite porphyry and diorite porphyry which intrude into granodiorite. Small veins and disseminations of pyrite, chalcopyrite and bornite were recognized in granodiorite located in a branch of the Rio Magdalena, in the upper stream of the Rio Magdalena, in a branch of the Rio San Joaquin and in a branch of the Rio Meridiano. The length of each mineralized zone is between 200m to 400m, while the amount of sulfide minerals is small. Small scale of veins observed in the branch of the Rio Meridiano consist of bornite and show 13%Cu in width of 0.1m.

(2)As the results of geochemical survey, high score zone of factor 3 related to Cu/Mo mineralization was detected in the west of the branch of the Rio Magdalena and in the branch of the Rio Meridiano.

(3)As the results of IP survey, zones of high P.F.E. are widely distributed, however, zones of high P.F.E. with low resistivity are limited only in the central (Anomaly B) and in the northeast(Anomaly A) parts in the Cuellaje area. Anomaly B, which is small and trends towards northwest, seems to correspond to a small scale of mineralization.

(4)Drilling surveys of MJC-3 and MJC-4 carried out in the central zone, and MJC-5 and MJC-6 carried out in the south zone, reveal that small veins of pyrite and chalcopyrite occur in granodiorite. Small amount of sulfide minerals are continuously observed. The average grade (core length of 106.70m) of MJC-3 is 0.18%Cu and 0.0065%Mo (calculated by 76 samples). The average grade (core length of 99.50m) of MJC-4 is 0.04%Cu and 0.0002%Mo (calculated by 102 samples). The average grade (core length of 32.00m) of MJC-5 is 0.03%Cu and 0.0001%Mo (calculated by 25 samples). The average grade (core length of 41.00m) of MJC-6 is 0.08%Cu and 0.0015%Mo (calculated by 25 samples). The grades of mineralized part of each holes are low.

(5)Based on the results obtained by this survey, Cu/Mo mineralization was recognized, however, the possibility of existing promissing ore deposits seems to be low because of a low grade of copper and a weak continuity of high grade ore.

5-2 Recommendations for Phase II Survey

5-2-1 Junin Area

Based on the survey results, the recommendations for Phase II survey in the Junin area are as follows:

(1)Between the eastern side of Rio Junin mineralized zone and the Q. Fortuna mineralized zone, a possibility of existing stockwork and dissemination type of abundant copper mineralization seems to be high. Therefore, drilling survey for that zone is recommended to confirm the extension and intensity of mineralization at depth of more than 300m and to evaluate the ore deposits (Fig.2).

(2)For the Q. Verde mineralized zone, drilling survey is also recommended to clarify the mineralization in the Junin area.

(3)The possibility of development of mineralized zones in the Junin area seems to be high. Effect for natural, social and other environmental concerns should be estimated by the development. To evaluate the effect in the development, environmental investigation is recommended to be carried out for the Junin area and surrounding areas.

5-2-2 Cuellaje Area

Based on the survey results, recommendations for Phase II survey in the Cuellaje area are as follows:

According to the results obtained by the survey, Cu/Mo mineralization was recognized, however, the possibility of existing promissing ore deposits seems to be low because of low grade of copper and weak continuity of high grade ore. Therefore, further surveys are not considered necessary.

PART Ⅱ DETAILS

Chapter 1 Junin area

1-1 Drilling survey

1-1-1 Purpose

The purpose of the drilling survey is to confirm the extension and intensity of mineralization in the eastern part of the Rio Junin mineralized zone and the Q. Fortuna mineralized zone.

1-1-2 Details

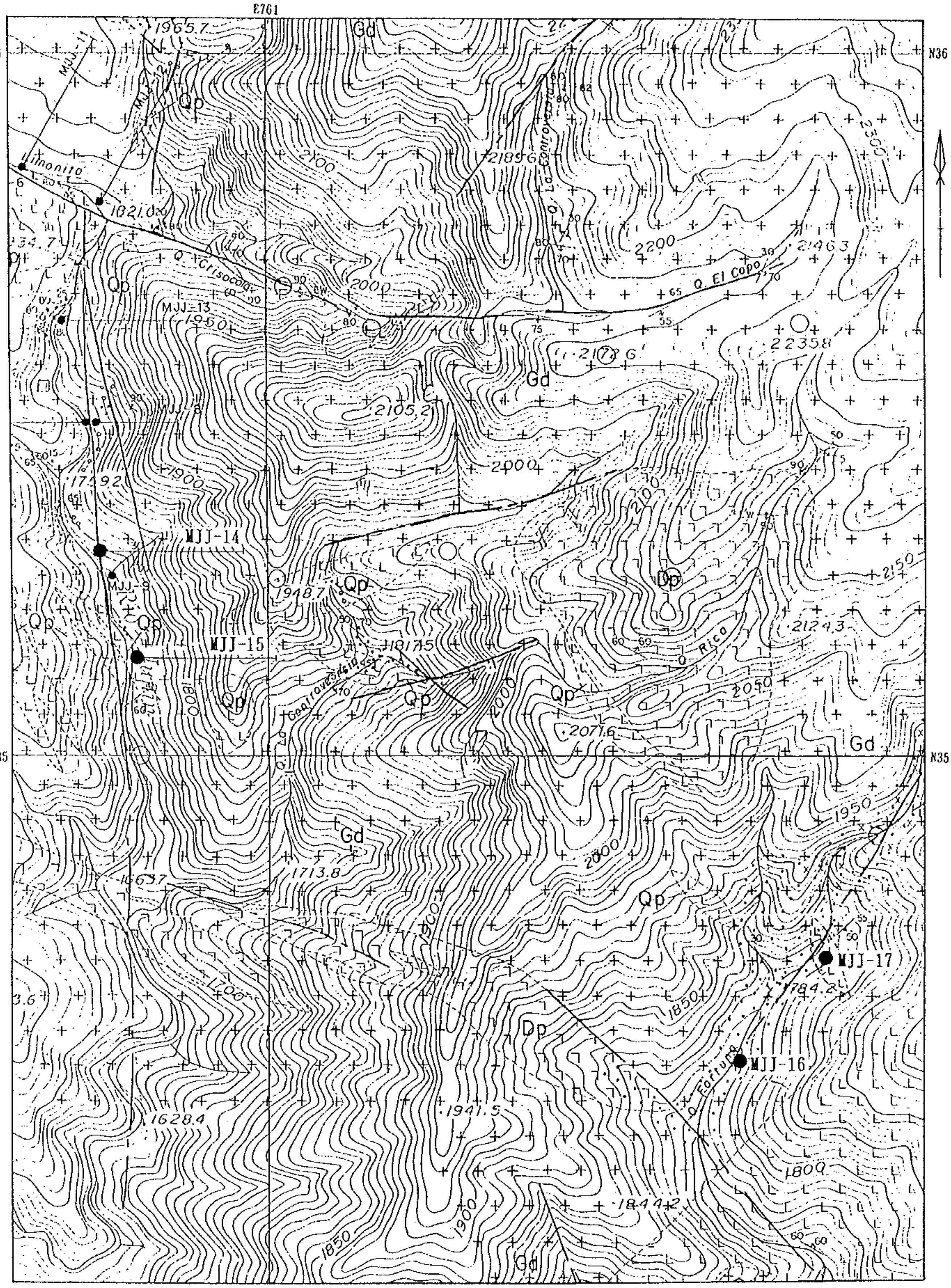
In order to confirm the geology and mineralization at depth, diamond core drilling method was adopted. Two holes (each design depth per hole:300m) were drilled for the Rio Junin mineralized zone and two holes (each design depth per hole: 150m) were drilled for the Q. Fortuna mineralized zone. The location of drill holes are shown on Fig.II-1-1. The details are as follow:

(1) Transportation and preparation of drilling site

All the machines, equipments and materials were transported by truck to the Junin heliport through Garcia Moreno and Chalguayacu Alto. The mobilization from Junin heliport to drilling sites were carried out horseback and man power. Every existing narrow and snaky road was amplified and adjusted completely in order to supply foods and materials for the camp and drilling activities. Drilling water was taken directly from the Rio Junin.

(2) Outline of drilling work

Drilling work was conducted from 23rd October 1994 to 16th December 1994. Drilling work was carried out, as a rule, for 24 hours a day. Drilling method adopted was wire line which would maximize recovery of drill cores and improve the drilling efficiency. The drill machines utilized were L-38 and L-24 which had sufficient drilling capacity for deep drilling. Cementation and casing work were needed to be done repeatedly because the mineralized rock present tremendous fractures and contain underground water which cause some difficulty of drilling. Drilling performance of the holes are shown in Appendix 14, the drilling progress are shown in Appendix 15. Drill machine, equipment and consumed material are listed up on Appendix 16.



● Drilling site (1994)
• Drilling site (1991-1993)

Fig. II-1-1 Location map of drill holes in the Junin area.

(3) Examination of drill cores

The drill core was examined simultaneously with drilling operations at the drilling sites and at the base camp in Garcia Moreno. The results of this examination were compiled in columnar sections on a scale of 1:200 (Appendix 17). Drill cores were split with a diamonde cutter and splitter. One half of the split cores was taken as samples for laboratory studies and the other was reserved in the storage of CODIGEM for future reference.

(4) Drilling work

Specifications of each hole are shown on Table II-1-1.

Table II-1-1 Specification of Holes in the Junin area

Hole No.	Location	Altitude	Direction	Inclination	Depth
MJJ-14	N35.291 E760.755	1,737m	N90°E	-45°	300.58m
MJJ-15	N35.135 E760.805	1,710m	N90°E	-45°	301.21m
MJJ-16	N35.564 E761.687	1,769m	-	-90°	150.73m
MJJ-17	N34.710 E761.815	1,797m	-	-90°	150.25m

1-1-3 Results

The geological colum of the drill cores are shown in Appendix 17. The results of microscopic observations are shown in Appendix 1. The results of X-ray diffractive analysis are shown in Appendix 3. The ore assay results are shown in Appendix 4. The geology and mineralization observed on drill cores are as follows:

(1)MJJ-14

MJJ-14 was drilled in granodiorite, quartz porphyry and diorite porphyry. The boundary between granodiorite and porphyries can be defined, indicating a boundary of 45 degree with respect to the direction of the hole. Chloritization, epidotization and sericitization are recognized in granodiorite, quartz porphyry and diorite porphyry. Silicification and sericitization are observed in and near the mineralized zone.

Pyrite, chalcopyrite and bornite occur in fractures accompanied by the silicification and sericitization. Dissemination of pyrite, chalcopyrite and bornite is observed in the silicified and sericitized

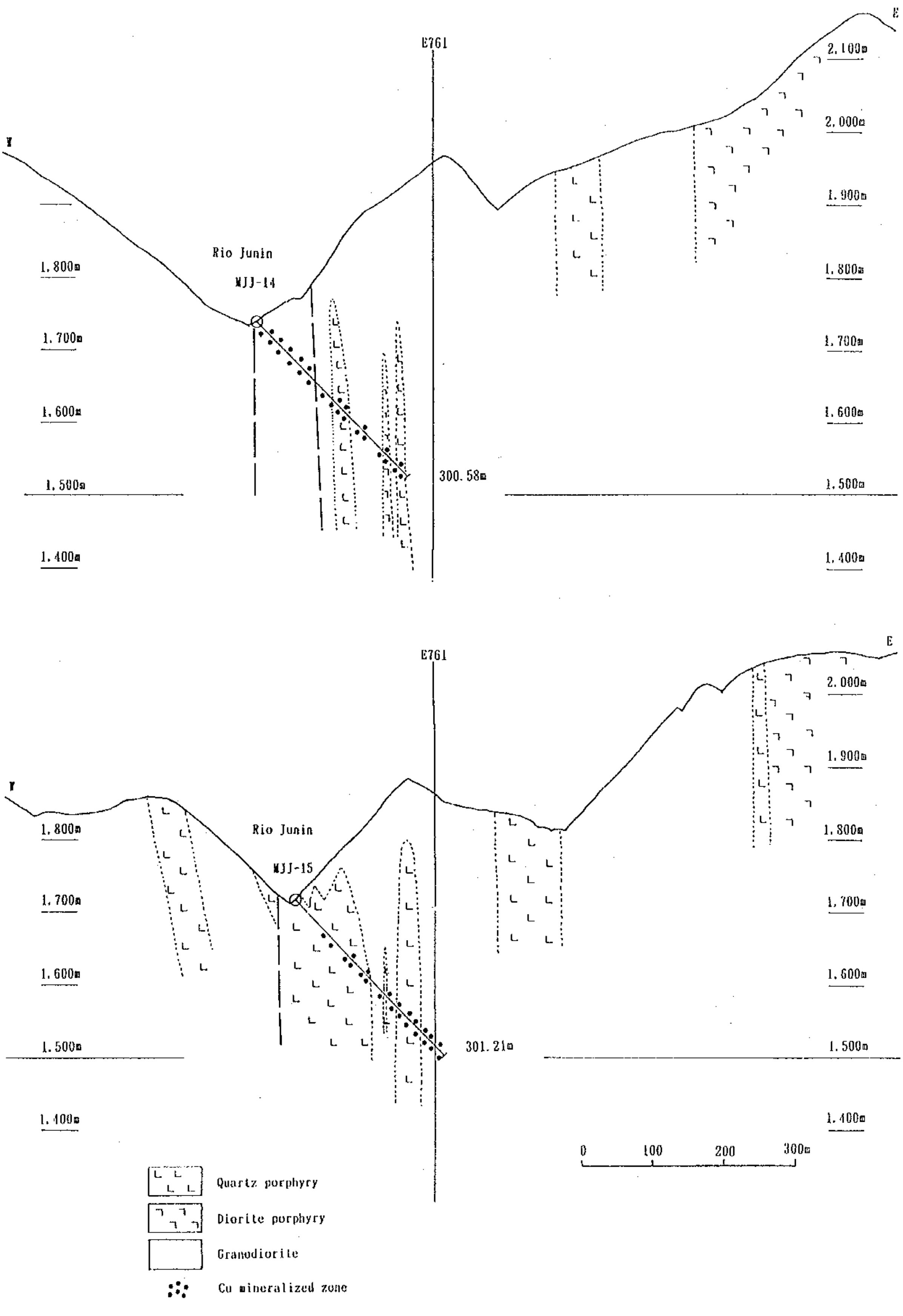


Fig. II-1-2 Geologic profiles around hole No. MJJ-14 and MJJ-15 part. Amount of pyrite is abundant in the shallow part, however, little in the deeper part. Chalcopyrite and bornite widely occur upto the bottom of the holes. Chalcocite and molybdenite are partially observed at depth.

0.00 to 1.00m; Surface soil.
1.00 to 147.70m; Granodiorite with chloritization, epidotization and sericitization. Pyrite, chalcopyrite, bornite and a few chalcocite occur in fractures.
147.70 to 180.55m; Quartz porphyry with chloritization, epidotization and sericitization. Pyrite, chalcopyrite, bornite and a few chalcocite and molybdenite occur in fractures.
180.55 to 250.50m; Granodiorite with chloritization, epidotization and sericitization. Chalcopyrite, bornite and a few chalcocite, molybdenite and specularite are observed in fractures. Small veinlets and dissemination of pyrite, chalcopyrite, bornite and chalcocite occur in the strongly silicified and sericitized part.
250.50 to 269.00m; Diorite porphyry with silicification, sericitization and chloritization. Dissemination and veinlets of bornite are recognized. Quartz vein contains molybdenite.
269.00 to 279.90m; Granodiorite with silicification and sericitization. Chalcopyrite and bornite occur in fractures.
279.90 to 285.24m; Quartz porphyry with chloritization, epidotization and sericitization. Chalcopyrite and bornite occur in fractures.
285.24 to 286.24m; Granodiorite with chloritization, epidotization and sericitization. Chalcopyrite and bornite occur in fractures.
286.24 to 298.50m; Quartz porphyry with chloritization, epidotization and sericitization. Pyrite, chalcopyrite, bornite and occur in fractures.
298.50 to 300.58m; Granodiorite with chloritization, epidotization and sericitization. Chalcopyrite and bornite occur in fractures.

The results of ore assay of 314 samples show that the average grade of copper and molybdenum of whole samples is not high, however, has a tendency of increasing the grade at depth (Fig.II-1-5). The results of ore assay are as follows:

Average grade of whole samples;

0.29%Cu, 0.022%Mo from 1.00m to 300.58m in depth.

Average grade of good mineralized part;

0.31%Cu, 0.005%Mo from 12.00m to 50.00m in depth.

0.33%Cu, 0.018%Mo from 119.00m to 179.00m in depth.

0.41%Cu, 0.047%Mo from 207.00m to 294.00m in depth.

(2)MJJ-15

MJJ-15 was drilled in granodiorite and quartz porphyry. The boundary between granodiorite and quartz porphyry show 45 and 30 degree with the direction of the hole. Chloritization, epidotization and sericitization are recognized in granodiorite and quartz porphyry. Strong silicification and sericitization are observed in the mineralized zone. Pyrite, chalcopyrite and bornite occur in fractures in granodiorite and quartz porphyry. Silicification and sericitization are observed near the mineralized fractures. Mineralization at the depth from 200.50m to 254.72m in quartz porphyry is strong.

0.00 to 0.60m;Surface soil.

0.60 to 1.00m;Granodiorite with chloritization and epidotization.

1.00 to 150.00m;Quartz porphyry with chloritization, epidotization, sericitization and silicification. Pyrite is observed in fractures. Chalcopyrite occur in silicified and sericitized part.

150.00 to 173.55m;Granodiorite with chloritization and epidotization. Pyrite is observed in fractures. Chalcopyrite occur in strongly silicified and sericitized part.

173.55 to 177.80m;Quartz porphyry with sericitization and silicification and chloritization. Pyrite is observed in fractures. Chalcopyrite occur in strongly silicified and sericitized part.

177.80 to 200.50m;Granodiorite with chloritization, epidotization, sericitization and silicification. Pyrite and chalocopyrite occur in fractures.

200.50 to 254.72m;Quartz porphyry with sericitization, silicification and chloritization. Pyrite, chalcopyrite, bornite, chalcocite and molybdenite are observed in fractures.

254.72 to 301.21m;Granodiorite with chloritization, sericitization and silicification. Pyrite, chalcopyrite and bornite are observed in fractures.

The results of ore assay of 227 samples show that the average grade of copper and molybdenum of whole samples is not high, however, the grade near quartz porphyry at depth show high grade (Fig.II-1-5). The results of ore assay are as follows:

Average grade of whole samples;

0.22%Cu, 0.007%Mo from 0.60m to 301.21m in depth.

Average grade of good mineralized part;

0.41%Cu, 0.016%Mo from 183.00m to 301.21m in depth.

(3)MJJ-16

MJJ-16 was drilled in granodiorite and quartz porphyry. Chloritization, epidotization and sericitization are recognized in granodiorite, and chloritization, epidotization, silicification and sericitization are observed in quartz porphyry. Alteration of this hole is characterized by strong epidotization. Chalcopyrite and bornite occur mainly in quartz porphyry. Pyrite occur widely in fractures in granodiorite.

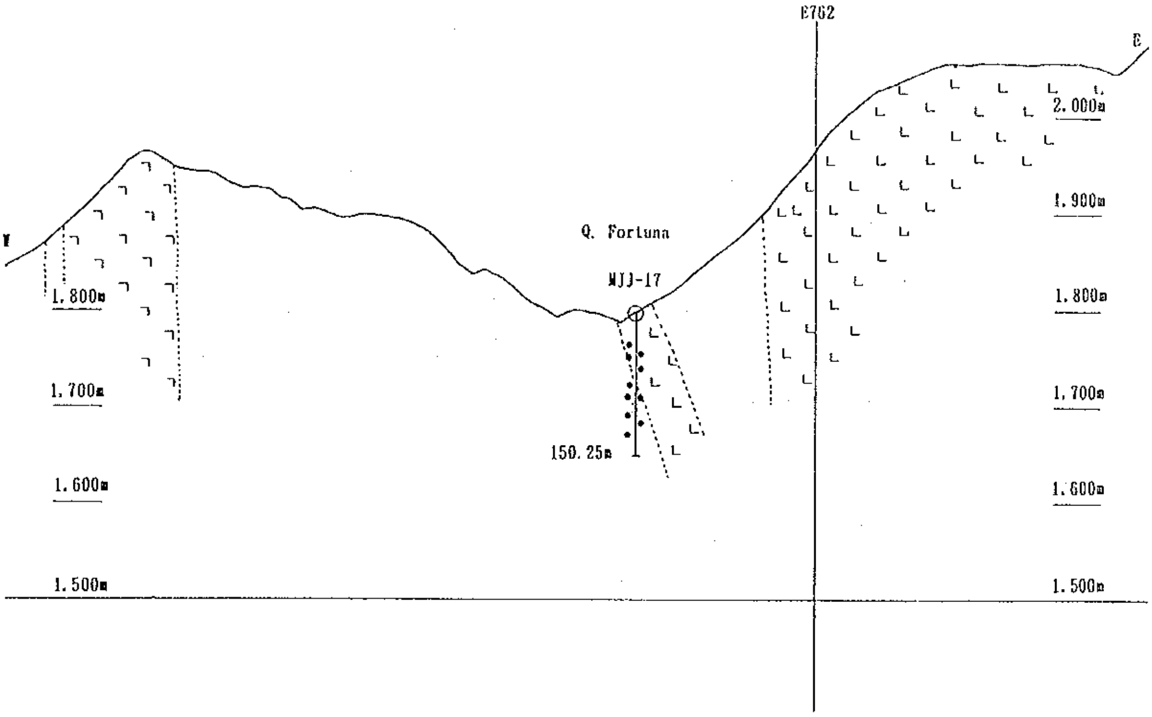
0.00 to 3.29m;Surface soil.

3.29 to 44.70m;Granodiorite with chloritization and epidotization. Pyrite and bornite occur.

44.70 to 63.00m;Quartz porphyry with sericitization and silicification. Pyrite and chalcopyrite are observed in fracturs.

63.00 to 109.30m;Granodiorite with chloritization and epidotization. Pyrite and chalcopyrite are observed in fractures.

109.30 to 150.73m;Quartz porphyry with sericitization and silicification. Pyrite and chalcopyrite are observed



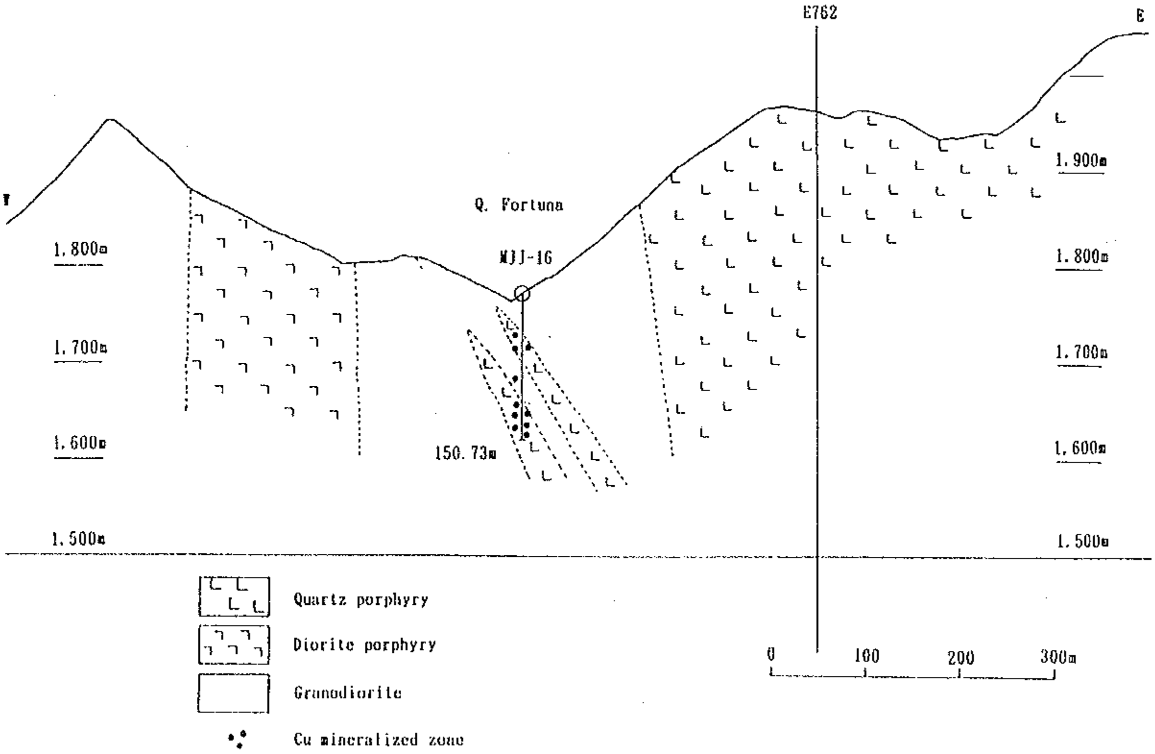


Fig. II-1-3 Geologic profiles around hole No. MJJ-16 and MJJ-17 in fractures.

The results of ore assay of 148 samples show that the average grade of copper and molybdenum of whole samples is low, however, the grade near quartz porphyry at depth show slightly high grade (Fig.II-1-5). The results of ore assay are as follows:

Average grade of whole samples;

0.15%Cu, 0.001%Mo for core length of 144.60m.

Average grade of mineralized part;

0.08%Cu, 0.0005%Mo from 3.00m to 64.90m in depth.

0.20%Cu, 0.0018%Mo from 6803m to 150.73m in depth.

(4)MJJ-17

MJJ-17 was drilled in granodiorite and quartz porphyry. The boundary between granodiorite and quartz porphyry show 20 and 60 degree with the direction of the hole. Chloritization, epidotization and sericitization are recognized in granodiorite. Chloritization, epidotization, silicification and sericitization are recognized in quartz porphyry. Chalcopyrite and bornite occur mainly in fractures of quartz porphyry. Pyrite occur widely in fractures of granodiorite and quartz porphyry.

0.00 to 4.05m;Surface soil.

4.05 to 64.50m;Quartz porphyry with sericitization, silicification, chloritization and epidotization. Pyrite, chalcopyrite and chalcocite are observed in fractures.

64.50 to 150.25m;Granodiorite with chloritization, epidotization and sericitization. Pyrite, chalcopyrite, chalcocite and molybdenite occur in fractures.

The results of ore assay of 144 samples show that the average grade of copper of whole samples is high, and the grade near quartz porphyry at depth show very high grade (Fig.II-1-5). The results of ore assay are as follows:

Average grade of whole samples;

0.46%Cu, 0.019%Mo from 4.05m to 150m in depth.

Average grade of good mineralized part;

0.62%Cu, 0.027%Mo from 60.00m to 150.25m in depth.

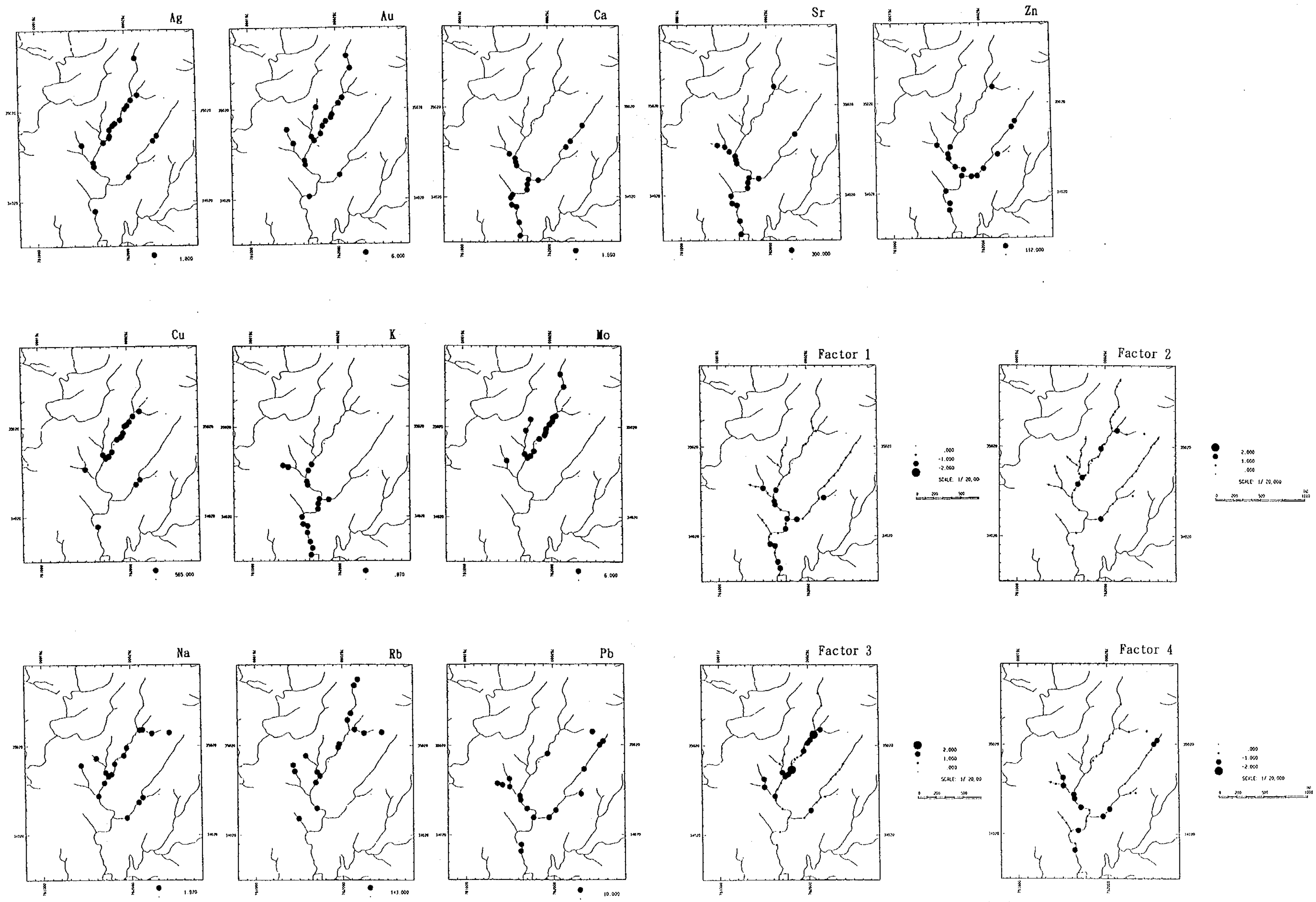
1-2. Results of Laboratorial Studies

1-2-1. Rock Geochemical Analysis

Chemical analysis of 5 additional elements was carried out for 85 rock samples collected around Q. Fortuna in 1992 to clarify the chemical elements related with mineralization and alteration of rocks.Five analytical elements are Ca, Na, K, Rb and Sr. The results of chemical analysis are shown in Appendix 6. Statistical data processing was carried out for 5 additional elements and 6 elements, Ag,Au, Cu, Mo, Pb and Zn which were analysed in 1992. The statisticalresults are shown in Appendix 7. Correlation coefficients were calculated to clarify the relationship among each element. Exploratory data analysis(EDA) method was adopted to decide the threshold value to detect the geochemical anomalies. Histogram and boxplot were made on the data processed for each element. According to the data processing methods, the threshold value was taken as the value of upper whisker. Geochemical anomaly maps shown on Fig.II-1-4 were made by analyzing the distribution of 11 elements by EDA method of univariate analysis. The results obtained by Factor analysis of Varimax rotation method in multivariate analysis are shown on Fig.II-1-4. Anomalous values of Ag, Au, Cu, Na and Rb are distributedaround the middle stream of Q. Fortuna. Anomalous values of Ca, K, Pb,Sr and Zn are distributed around the upper and lower streams of Q. Fortuna. According to the results of Factor analysis, following factors and related elements are obtained:

Factor 1: Ca, K, Sr and Zn
Factor 2: Na and Rb
Factor 3: Ag, Au, Cu and Mo
Factor 4: Pb

High score of Factor 3 related with Cu/Mo mineralization is distributed around the middle stream of the Q. Fortuna. According to the mentioned above, a geochemical anomalous zone was detected around the middle of the Q. Fortuna.



Geochemical Anomaly map of each elements

Results of Factor analysis

Fig. II-1-4 Geochemical anomaly map around Q. Fortuna.

1-2-2 X-ray Diffractive Analysis

X-ray diffractive analysis of the drill core: MJJ-10, MJJ-11, MJJ-12, MJJ-13, MJJ-14, MJJ-15, MJJ-16, MJJ-17 was carried out to clarify the relationship between alteration and mineralization. The results of X-ray diffractive analysis are shown in Appendix 3 and Fig.II-1-5.

(1)MJJ-10

Alteration from 0m to 70m is mainly composed of the assemblage of sericite/quartz indicating the phyllic alteration zone. Alterationat at the depth from 70m to the bottom of the hole is due to the assemblage of chlorite/sericite/quartz/plagioclase.

(2)MJJ-11

Alteration at the depth from 0m to bottom of the hole is mainly composed of the assemblage of sericite/quartz/plagioclase. The phyllic alteration zone is partially recognized at the depth from 0m to 50m.

(3)MJJ-12

Assemblage of sericite/quartz is recognized around the depth of 10m. Assemblage of sericite/quartz/plagioclase/K-feldspar is widely distributed.

(4)MJJ-13

Alteration at the depth from 0m to 50m is composed of the assemblage of sericite/quartz/plagioclase/calcite. At depth, the assemblage of sericite/quartz indicating phyllic alteration zone is mainly recognized.

(5)MJJ-14

The assemblages of sericite/quartz, sericite/quartz/plagioclase and sericite/quartz/plagioclase/potash feldspar are recognized. chlorite and calcite are detected. The assemblage of sericite/quartz occurs in the altered part.

(6)MJJ-15

The assemblages of sericite/quartz, sericite/quartz/plagioclase and sericite/quartz/plagioclase/potash feldspar are recognized. The assemblage of sericite/quartz occurs in the altered part.

(7)MJJ-16

The assemblages of sericite/quartz and sericite/quartz/plagioclase are recognized in the altered part. The assemblage of chlorite/sericite/quartz/plagioclase/potash feldspar is recognized in granodiorite.

(8)MJJ-17

The assemblage of sericite/quartz is mainly recognized. The assemblage of sericite/quartz/plagioclase is partially recognized.

1-2-3 Ore Assay of Drill Cores

Ore assay of 251 samples collected from the drill cores of MJJ-10,MJJ-11, MJJ-12 and MJJ-13 was carried out to clarify the grade of mineralization (Fig.II-1-5). Analytical elements are Au, Ag, Cu, Pb, Zn, Mo and Fe. The results of chemical analysis are shown in Appendix 4.

(1)MJJ-10

As the results of ore assay of 27 samples, the average grade of 0.15%Cu was obtained.

(2)MJJ-11

As the results of ore assay of 32 samples, the average grade of 0.13%Cu was obtained.

(3)MJJ-12

As the results of ore assay of 58 samples, the average grade of 0.23%Cu was obtained.

(4)MJJ-13

As the results of ore assay of 134 samples, the average grade of 0.45%Cu was obtained. The values of more than 0.8%Cu are distributed

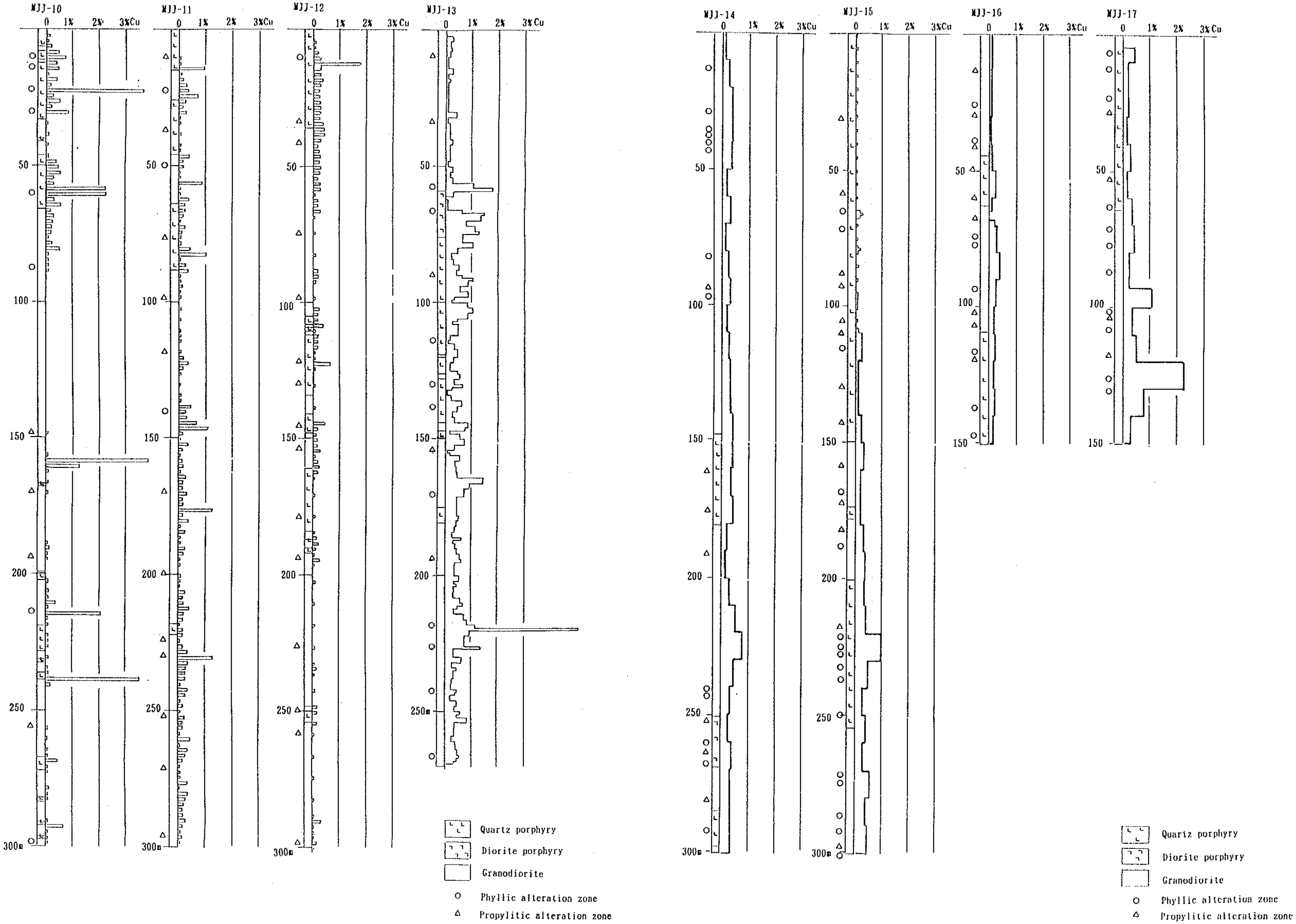


Fig. II-1-5 Results of ore assay and X-ray diffractive analysis of drill holes MJJ-10 to MJJ-17 in the Junin area.

in quartz porphyry and diorite porphyry.

1-2-4 Measurements of Filling Temperature of Fluid Inclusions

The measurements of filling temperature of fluid inclusions were carried out for quartz in veins and rocks in holes of MJJ-14 to MJJ-17. The results of measurements are shown in Appendix 5.

(1)MJJ-14

The measurements of 3 samples collected at the depth of 37.00m, 82.40m and 262.50m respectively, gave filling temperature values from 156°C to 574°C. Temperature increases gradually at the deeper part.

(2)MJJ-15

The measurements of 3 samples collected at the depth of 162.50m, 243.60m and 294.75m respectively, gave filling temperature values from 284°C to 490°C. Temperature increases gradually at the deeper part.

(3)MJJ-16

One sample collected at the depth of 9.00m indicated filling temperature values from 266°C to 436°C. Temperature shows similar as the values obtained at the depth of MJJ-14.

(4)MJJ-17

One sample collected at the depth of 147.00m gave filling temperature values from 269°C to 434°C. Temperature values are similar as the temperature values obtained at the depth of MJJ-14.

1-3 Consideration

1-3-1 Geology and Structure

Geology around the central zone of the Junin area consists of Apuela-Nanegal batholith of granodiorite(Gd) and stock or dikes of quartz porphyry(Qp) and diorite porphyry(Dp), which intrude into granodiorite. Granodiorite shows gray color and medium grained, containing biotite and hornblend as mafic mineral. Quartz porphyry shows a maximum length of 400m and width of 150m, and a maximum diameter of stock of 250m. Distribution density of dikes and stocks tend to be predominant in the central zone of the Junin area. Granodiorite in the project area was determined to range from 13 to 15 Ma, while stock of porphyrytic rocks ranged from 6 to 11 Ma by K-Ar method (JICA/MMAJ,1992).

Principal geological structure shows lineaments along N-S and NNE-SSW directions. In the Rio Junin mineralized zone, N-S and NNE-SSW lineaments were recognized. The fractured zones detected in the hole of MJJ-14 and MJJ-15 confirm the presence of these N-S and NNE-SSW directions.

1-3-2 Mineralization of the Rio Junin and the Q. Fortuna Mineralized Zones

The MJJ-14 and MJJ-15 holes were drilled to clarify the eastern extension and intensity of the Rio Junin mineralized zone. These holes encountered the mineralization which shows that the mineralization extends to the eastern and deeper part of the Rio Junin mineralized zone. The Rio Junin mineralized zone is characterized by stockwork veins and disseminations of pyrite, chalcopyrite, bornite, chalcocite and molybdenite in fractures in mainly quartz porphyry and diorite porphyry. Characteristics of mineralization in MJJ-14 shows abundant pyrite in the upper part of the hole. Chalcopyrite and bornite are developed widely from shallow part to deeper part. Chalcocite observed at the deeper part seems to be secondary mineral which indicates that the mineralization is controlled by faults and fractures. Silicification and sericitization are widely observed in quartz porphyry and diorite porphyry. Alteration in granodiorite is mainly due to chloritization and epidotization. Silicification and sericitization in granodiorite are limited near the fractures.

Mineralization, which is controlled by faults and fractures, seems to be related with the activity of quartz porphyry and diorite porphyry accompanied by silicification and sericitization.

The MJJ-16 and MJJ-17 holes were drilled to clarify the mineralization around the Q. Fortuna. Accordingly, chalcopyrite and bornite are seen developed in/around quartz porphyry. Pyrite is distributed widely from surface to bottom of the hole. In the hole of MJJ-16, it is found that granodiorite and quartz porphyry are strongly epidotized and that alteration of rocks seems to be similar to the prophylitic alteration. The hole of MJJ-16 seems to be located near the prophyritic alteration zone. From the above results, it is suggested a drilling to clarify the mineralization in the upper stream of the hole of MJJ-17. Phyllic alteration zone around the Rio Junin extends toward southeast, around the lower stream of the Q. La Controversia. It is possible that the phyllic alteration zone observed in the Rio Junin reaches the Q. Fortuna. As the results of measurement of the filling temperature of fluid inclusions, temperature values of more than 400°C were obtained. These values are higher than the temperature measured around the phyllic alteration zone of porphyry copper ore deposits.

Chapter 2 Cuellaje Area

2-1 Geological Survey

2-1-1 Purpose

The purpose of survey is to detect promissing mineralized zones in the surrounding area of the Rio Magdalena mineralized zone.

2-1-2 Method

Geological survey was conducted by a survey team consisting of japanese and ecuadorian members. Survey route was set along the stream, ridge and lines of geophysical survey. Total length of survey route was 21km. Outcrops along the survey route were observed in detail and in the mineralized outcrops pictures were taken. The results of observation of the outcrops were described on the route map in a scale of 1:5,000. Rock samples were collected for the laboratorial studies, such as microscopic observation and X-ray diffractive analysis. The samples for ore assay were collected in the mineralized outcrops. The location of these collected samples are shown in Plate II-2-1. The results of laboratorial studies are shown in Appendix 1, Appendix 2, Appendix 3 and Appendix 5. The results of geological survey were compiled on a plan map and sections in a scale of 1:5,000 (Plate II-2-2 and Plate II-2-3).

2-1-3 Results

(1)Geology and structure

The geology of this area consists mainly of granodiorite(Gd) belonging to Apuela/Nanegal batholith and several dikes of andesite porphyry(Ap) and quartz porphyry(Qp) which intrude into granodiorite (Fig.II-2-1, Fig.II-2-2, Plate II-2-2 and Plate II-2-3). Granodiorite shows greyish color, is medium grained, and contains biotite and hornblende as mafic minerals. Granodiorite containing little mafic minerals is distributed around the branch of the Rio Meridiano, in the northeastern part of the survey area. Small dikes of aplite of 1 to 3 cm width were observed in some granodiorite. Age of granodiorite was determined as middle of Miocen by K-Ar method (JICA/MMAJ,1992). Small dikes of andesite porphyry are distributed in the branch of the Rio Magdalena, in the branch of the Rio Meridiano and in the branch of

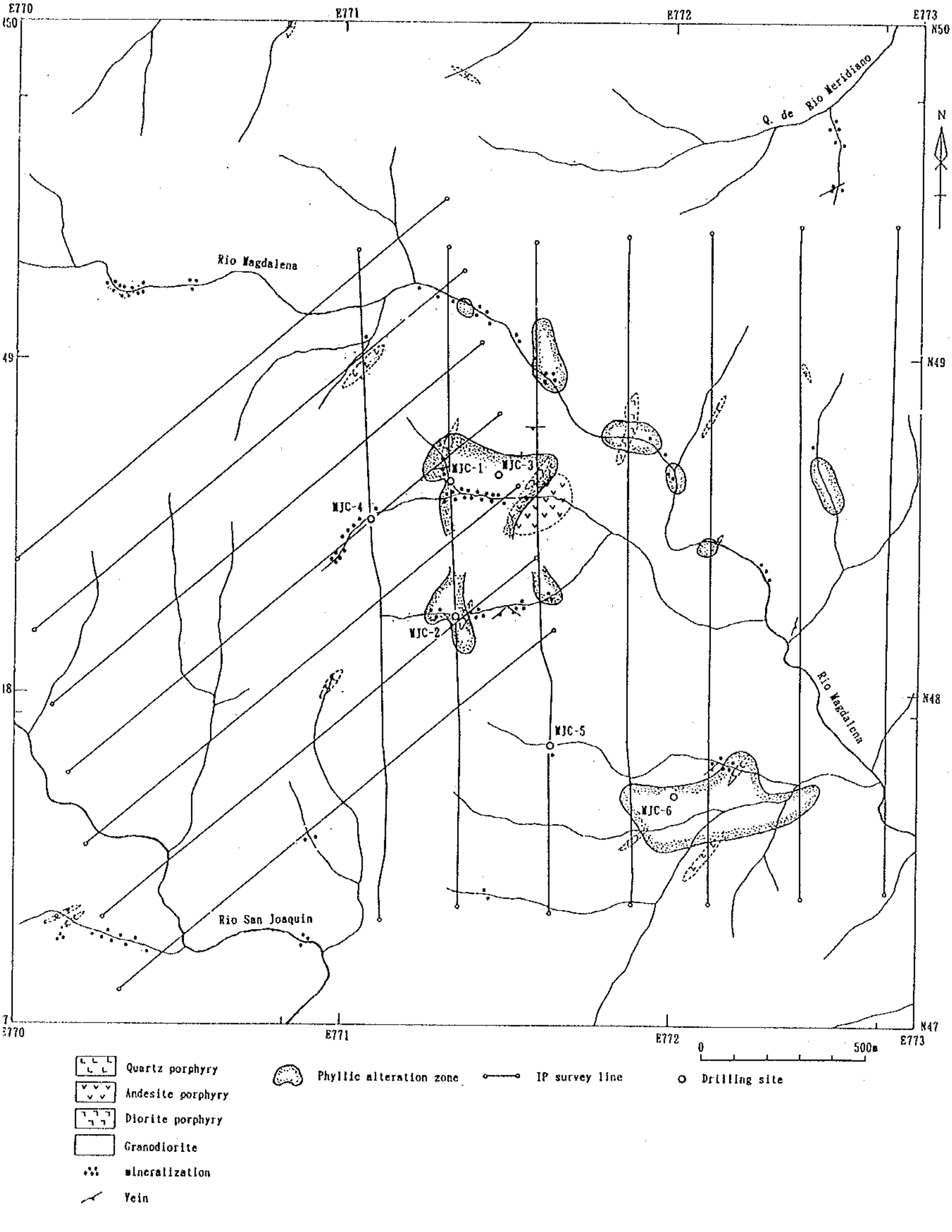


Fig. II-2-1 Geology, alteration and mineralization in the Cuellaje area.

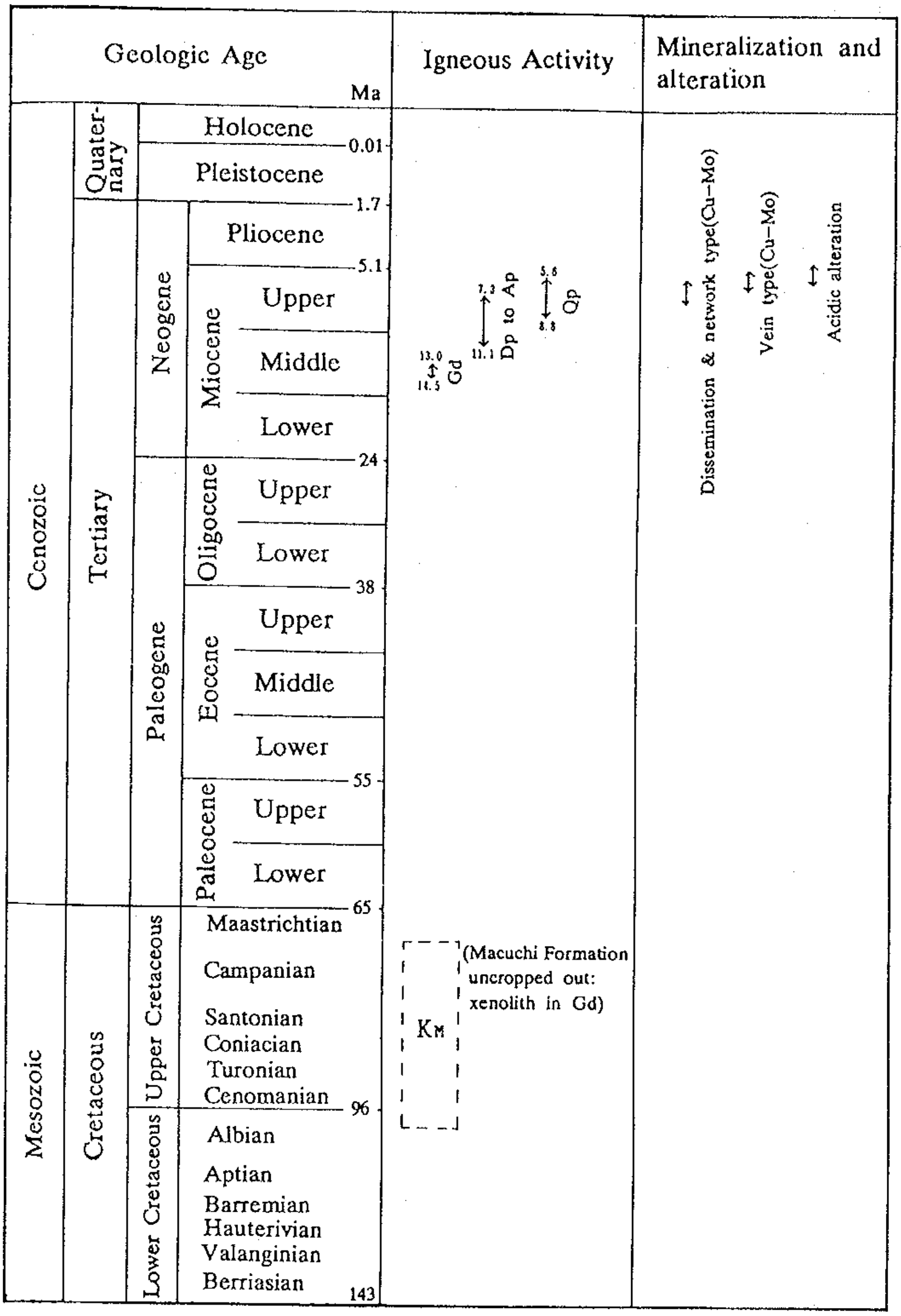


Fig. II-2-2 Generalized columnar section of the Cuellaje area.

the Rio San Joaquin. Andesite porphyry contains plagioclase as phenocryst in the greenish gray groundmass. Small dikes of quartz porphyry are distributed in the branch of the Rio San Joaquin. Quartz porphyry contain phenocryst of quartz in compact groundmass.

Main geological structure consists of lineaments trending NE-SW and NW-SE. Faults trending N-S were recognized in the upper stream of the Rio Magdalena. Faults trending NNE-SSW were also recognized in the Rio San Joaquin.

(2)Mineralization and alteration

As the results of the survey, several mineral showings were newly discovered in the survey area. These are small scale of showings. The results of the ore assay are shown on Table II-2-1 and the results of X-ray diffractive analysis are shown in Appendix 3. The results of observation of the showings are as follows:

1)West of the Rio Magdalena mineralized zone

Dissemination and veins of pyrite and chalcopyrite occur in granodiorite in the upper stream from the hole MJC-4. The results of ore assay show low grade of copper with maximum grade of 0.05%Cu.

2)Upper stream of the Rio Magdalena

Small veins of pyrite, chalcopyrite and bornite occur in fractures in granodiorite. In some places, dissemination of pyrite was recognized. The mineralized zone occupies a length of 200m. The results of ore assay show low grade of copper with maximum grade of 0.14%Cu.

3)Branch of the Rio San Joaquin

Small veins of pyrite and chalcopyrite occur in fractures in granodiorite. In some place, dissemination of pyrite was recognized. Dissemination of chalcopyrite was also recognized in andesite porphyry. The mineralized zone occupies a length of 300m. The results of ore assay show low grade of copper with maximum grade of 0.05%Cu.

Table II-2-1 Results of ore assay in the Cuellaje area.

Ser. No.	Sample NO.	Location N	Location E	Rock name, description	Sampling width(m)	Au g/t	Ag g/t	Cu ppm	Pb ppm	Zn ppm	Mo ppm	Fe %
1	C1301	49.901	772.595	Gd, diss, Py, Cp	0.50	<0.1	<0.1	201	12	32	2	2.19
2	C1302	49.834	772.537	Gd, diss, Py, Cp	0.30	<0.1	<0.1	203	10	10	4	0.87
3	C1304	48.522	771.089	Gd, diss, Py, Cp	1.00	<0.1	<0.1	413	9	29	11	2.06
4	C1305	48.522	771.089	Gd, diss, Py, Cp	1.00	<0.1	<0.1	206	9	20	19	2.39
5	C1309	47.932	770.959	Qv, diss, Py, Cp	0.10	<0.1	4.5	578	31	28	46	6.24
6	C1311	49.693	772.473	Gd, film, Py, Cp	1.00	<0.1	0.6	973	7	38	15	2.17
7	C1312	49.693	772.473	Qv, film, Py, Cp	0.15	<0.1	26.7	12361	11	41	1950	10.74
8	C1313	49.660	772.445	Gd, diss, Py, Cp	1.00	<0.1	0.6	215	8	24	153	2.63
9	C1314	49.660	772.445	Gd, diss, Py, Cp	1.00	<0.1	1.1	519	20	23	17	2.85
10	C1315	49.642	772.467	Gd, film, Lm	1.00	<0.1	2.6	507	13	14	59	2.10
11	C1316	49.539	772.472	Gd, diss, film, Py, Lm, Cp, Cc, Bo, Mc	1.00	<0.1	9.4	21242	11	31	1869	5.20
12	C1317	49.539	772.472	Gd, diss, film, Py, Lm, Cp, Cc, Bo, Mc	1.00	<0.1	9.9	8126	38	59	655	27.67
13	C1318	49.539	772.472	Gd, diss, film, Py, Lm, Cp, Cc, Bo	1.00	<0.1	4.0	1721	11	22	667	2.84
14	C1319	49.539	772.472	V, Py, Lm, Cc, Bo	0.10	<0.1	55.6	137538	36	271	1204	26.66
15	C1320	49.519	772.499	Gd, diss, film, Py, Lm, Cp, Bo	1.00	<0.1	3.3	7085	13	50	361	1.56
16	G1302	47.262	770.884	Gd, diss, Py, Cp	0.50	<0.1	<0.1	312	7	35	2	2.54
17	N1302	47.520	772.305	Gd, QV, film, Lm	0.80	<0.1	0.3	249	7	8	3	1.03
18	N1303	47.389	772.690	Qv, diss, Py, Lm	0.50	<0.1	1.0	1245	11	30	10	2.39
19	N1316	49.215	770.545	Gd, QV, film, Py, Lm, Cp, Bo, Mc	1.20	<0.1	0.2	721	9	24	7	2.60
20	S1301	47.400	771.449	Gd, diss, Py, Cp	0.50	<0.1	1.4	804	11	69	9	3.27
21	S1302	49.201	770.402	Gd, film, Py, Cp Bo	0.50	<0.1	<0.1	472	9	16	5	1.47
22	S1304	49.213	770.305	Gd, diss, Py, Cp Bo	1.00	<0.1	0.1	1459	9	18	13	1.72
23	S1308	49.596	771.584	Gd, film, Py, Cp	0.10	<0.1	<0.1	189	9	13	7	0.97
24	S1311	47.259	770.371	Gd, diss, Py	1.00	<0.1	0.2	436	9	33	47	2.30
25	S1312	47.276	770.312	Gd, diss, Py	1.00	<0.1	0.2	165	35	117	6	2.29
26	S1319	47.265	770.115	Gd, diss, Py, Lm	1.00	<0.1	6.9	519	60	31	179	8.22
27	S1320	47.290	770.776	Ft, diss, Py	0.50	<0.1	2.7	272	28	58	127	7.11
28	S1321	47.240	770.424	Gd, diss, Py, Lm	1.00	<0.1	<0.1	159	14	63	4	1.99

Gd:granodiorite, Qv:quartz vein, Ft:fault, diss:dissemination
Py:pyrite, Cp:chalcopyrite, Lm:limonite, Bo:bornite, Cc:chalcocite, Mc:malachite

4)Branch of the Rio Meridiano

Pyrite, chalcopyrite, bornite and chalcocite were recognized in fractures in an area of 400m length of granodiorite. Dissemination of pyrite was observed in granodiorite in some places. The ore assay of bornite vein 0.1m in width shows high grade of copper, 13.75%Cu. Altered zone of silicification and sericitization were recognized along the bornite vein which contains malachite. The ore assay of samples collected in the altered zone shows 2.12%Cu. The fracture trending NE-SW is dominant.

As the results of X-ray diffractive analysis, assemblages of chlorite/quartz/plagioclase and sericite/quartz/plagioclase were recognized in granodiorite. Assemblage of sericite/quartz was not detected. Kaolinite formed by weathering was detected.

(3)Measurement of filling temperature of fluid inclusion

The measurement of filling temperature of fluid inclusion was carried out for 10 samples of quartz in veins and rocks (Appendix 5).

1)Method

Heating stage of TH600RH and controller made by Linkam Co. were adopted as the equipment for measurement. Several chips of quartz were detected as samples.

2)Results

As the results of temperature measurements, temperature values of quartz in vein gave 166°C to 477°C. The maximum temperature of 477°C was obtained in the upper stream of the hole MJC-4. The second high temperature, 406°C, was obtained in the branch of the Rio Meridiano. According to the results of the measurements, the samples showing high temperature values were located around the main mineralized zone. The temperature values of samples show 110°C to 453°C and many temperature values show more than 400°C.

2-1-4 Consideration

Geology of the surrounding area of the Rio Magdalena mineralized zone consists mainly of granodiorite, and several dikes of andesite porphyry and diorite porphyry which intrude into granodiorite. Alteration of granodiorite is characterized by chloritization.

Mineralization was recognized in: 1)the west of the Rio Magdalena mineralized zone, 2)the upper stream of the Rio Magdalena, 3)the branch of the Rio San Joaquin and 4)the branch of the Rio Meridiano. These mineralized zones have silicification and sericitization recognized only near the fractures. The area of alteration is not wide. As the results of X-ray diffractive analysis, the assemblage of sericite/quartz was not detected. Therefore, these alterations observed in the mineralized zone do not seem related to the large scale of mineralization. In the branch of the Rio Meridiano, mineralization consisting of bornite and chalcocite vein was recognized and showing the high grade of copper, however, the width of vein is small.

The results of the measurement of filling temperature of fluid inclusions show slightly high temperatures around the mineralized zones, and the temperature values correspond to the temperature values obtained in the phyllic alteration zone of porphyry copper deposits.

As the results of the geological survey carried out in the surrounding area of the Rio Magdalena mineralized zone, several mineral showings were recognized, however, these mineralization and alteration are weak. Therefore, the possibility of existing promissing ore deposits in the survey area seems to be low.

2-2. Geochemical Survey

2-2-1. Purpose

The purpose of geochemical survey is to detect a promissing mineralized zone in the surrounding area of the Rio Magdalena mineralized zone.

2-2-2 Method

Rock samples were collected along the geological survey route, and chemical analysis was carried out for 13 chemical elements, Ag, Au,Ca, Cu, Fe, K, Mo, Na, Pb, Rb, S, Sr and Zn to discuss about the geochemical features of the elements. The location of 224 rock samples are shown in Plate II-2-1. One sample was collected from several parts of the outcrop and total weight of sample ranged from 500g to 1kg. After drying, the samples were crushed in iron bowl and were powdered in the laboratory of CODIGEM. Powdered samples sent to Japan to carry out the chemical analysis in the laboratory of Bishimetal Exploration Co.,Ltd. Statistical analysis and processing were carried out for the data obtained from the survey area in 1994 and data obtained from the central part of the Cuellaje area in 1992.

2-2-3 Results

(1)Chemical analysis

Chemical analysis of 13 elements was carried out for 224 rock samples collected in the surrounding area. Chemical analysis of 5 elements, Ca, K, Na, Rb and Sr, was also carried out for 206 rock samples collected in the central area in 1992. The results of chemical analysis are shown in Appendix 8.

(2)Data processing

Statistical processing of chemical data was carried out with computer. The data less than detection limit value are assumed to be a half value of the detection limit. The results of statistical analysis are shown in Appendix 9 and Appendix 10.

(3)Univariate analysis

Exploratory data analysis(EDA) method(Kurzul,H.1988) was adopted to decide the threthold value to detect the geochemical anomalies.

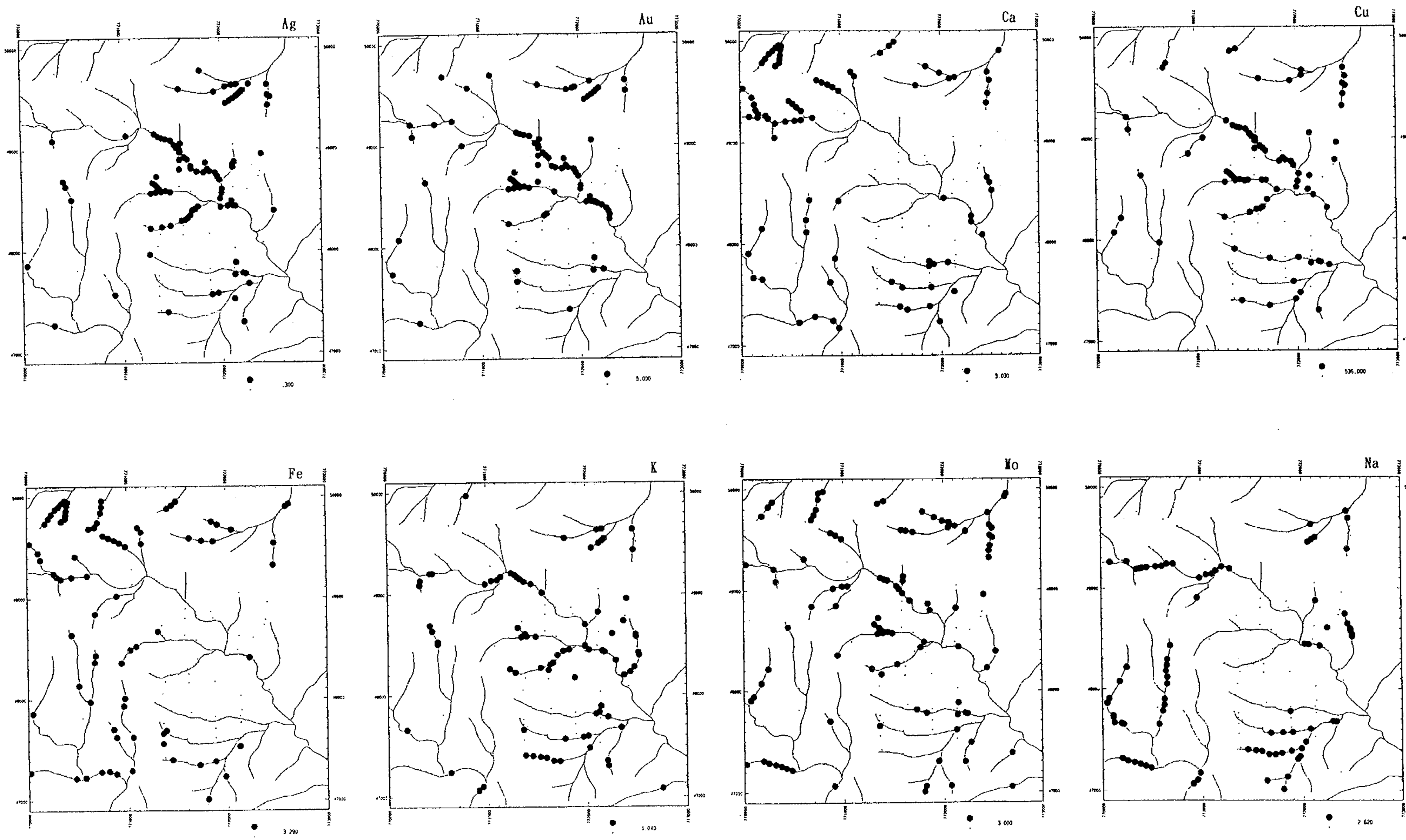


Fig. II-2-3　Geochemical anomaly map in the Cuellaje area.

Histograms of each element are shown in Appendix 10. The threthold value was taken as the value of the upper whisker and the ditribution of anomalous values were detected (Fig.II-2-3). The following characteristics of geochemical feature of each element are as follows:

Ag;The threshold value is 0.3ppm. The anomalous values are distributed in the middle stream of the Rio Magdalena and in the upperstream of the Rio Meridiano.

Au;The threshold value is 5ppb. The anomalous values are distributed in the middle stream of the Rio Magdalena and in the upperstream of the Rio Meridiano.

Ca;The threshold value is 3.03%. The anomalous values are distributed in the surrounding area.

Cu;The threshold value is 536ppm. The anomalous values are distributed in the middle stream of the Rio Magdalena and in the upperstream of the Rio Meridiano.

Fe;The threshold value is 1.04%. The anomalous values are distributed in the middle stream of the Rio Magdalena, in the upper stream of the Rio Meridiano and in the southern part of the area.

Mo;The threshold value is 3ppm. The anomalous values are scattered in the area.

Na:The threshold value is 2.62%. The anomalous values are distributed in the surrounding area. The low value are distributed inthe middle stream of the Rio Magdalena.

Pb;The threshold value is 16ppm. The anomalous values are distributed in the surrounding area.

Rb;The threshold value is 53ppm. The anomalous values are scattered in the area.

S ;The threshold value is 0.034%. The anomalous values are scattered in the area.

Sr;The threshold value is 478ppm. The anomalous values are scattered in the area.

Zn;The threshold value is 60ppm. The anomalous values are distributed in the surrounding area.

(4)Multivariate analysis

Factor analysis method was applied for examination of the relationship among the elements and mineralization or characteristics

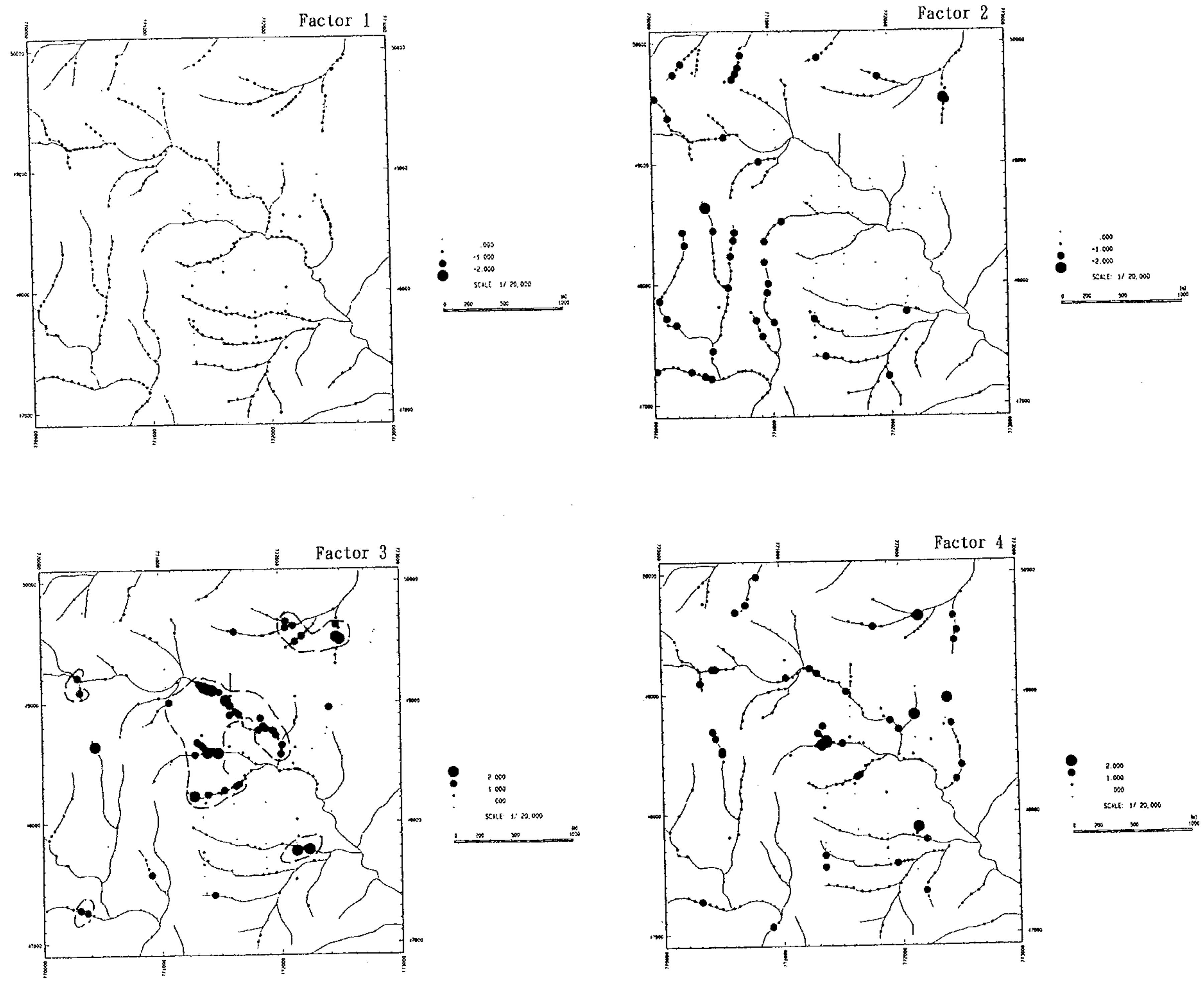


Fig. II-2-4　Results of Factor analysis in the Cuellaje area.

of rocks by the chemical analysis data. Data was processed with computer by Barimax rotation method. Factor score, which indicates how high relationship between mineralization and target elements, was obtained. As the results of Factor analysis, following factors and elements are obtained:

Factor 1: Ca, Na and Sr
Factor 2: Fe,Pb and Zn
Factor 3: Ag, Au, Cu, Mo and S
Factor 4: K and Rb

Factor 1 seems to be a group of elements indicating the alteration of rocks, however, the distribution of factor score does not have a relationship with mineralization and geology. Factor 2 seems to be a group of elements indicating the marginal part of the mineralization. Factor 3 seems to be a group of elements relating with copper and molybdenum mineralization. Factor 4 show a group of elements relating with the potashic alteration. The distribution of factor scores are shown in Fig.II-2-4. High score of Factor 1 are distributed in the middle stream of the Rio Magdalena and in the branch of the Rio Meridiano. High sore of Factor 2 are distributed inthe surrouding area of the Rio Magdalena mineralized zone. According to the Factor analysis, the distribution of high score of Factor 3 is considered to be a anomalous zone related with copper and molybdenum mineralization (Fig.II-2-4).

2-2-4 Consideration

According to the results of geochemical survey and geology, the zone of high score of Factor 3 and anomalous zones of Ag, Au, Cu, Mo and S are distributed in the middle stream of the Rio Magdalena and in the upper part of the Rio Meridiano. In the middle stream of the Rio Magdalena, the Rio Magdalena mineralized zone was recognized. The zone of high score of Factor 3 and anomalous zones of elements indicate the Rio Magdalena mineralized zone. In the surrounding area, a small scale of anomalous zone was only detected in the branch of the Rio Meridiano, therefore, a possibility of existing a promissing ore deposits is low in the surrounding area.

2-3. Geophysical Survey

2-3-1. Purpose

The purpose of geophysical survey is to clarify the continuity of mineraliztion at depth in the western part of the Rio Magdalena mineralized zone and to clarify the relation with mineralized zone and geochemical anomalous zones.

2-3-2 Method

The measurements were done by using the frequency-domain method at the frequencies of 3.0Hz and 0.3Hz, and adopting a dipole-dipole electrode configuration with a separation factor in from 1 to 5.

Based upon the geological structure, seven survey lines (Line-JC8 to Line-JC14) of 1,700m each in length were set along a NE-SW direction with a 200m line spacing. The numbering of the survey points were done every 100m spacing with 100m dipoles. The location of survey lines are illustrated in Fig.II-2-5. Instrument used for the conventional IP survey were manufactured in Japan, their specifications are as follows:

Equipment	Model	Specification	Quantity
IP Transmitter	CH-8104T	2.5A, 800V	1
IP Receiver	CH-8104R		1
IP Checker	522A		1
Engine Generator	GPU-2000	2kw,150v,400Hz	1
Transceiver	ICB-87	0.5W	6

2-3-3 Analysis Method

Fig.II-2-6 shows a flow chart of the procedure used for data analysis.

(1)Calculation of apparent resistivity and percent frequency effect (PFE)

The measurements are taken by supplying an electric current(Iac) at 3.0Hz into the ground through a pair of current electrodes(C1, C2) and detecting the corresponding potential difference(Vac) with a pair of potential electrodes(P1, P2).

The apparent resistivity of the ground is calculated by applying

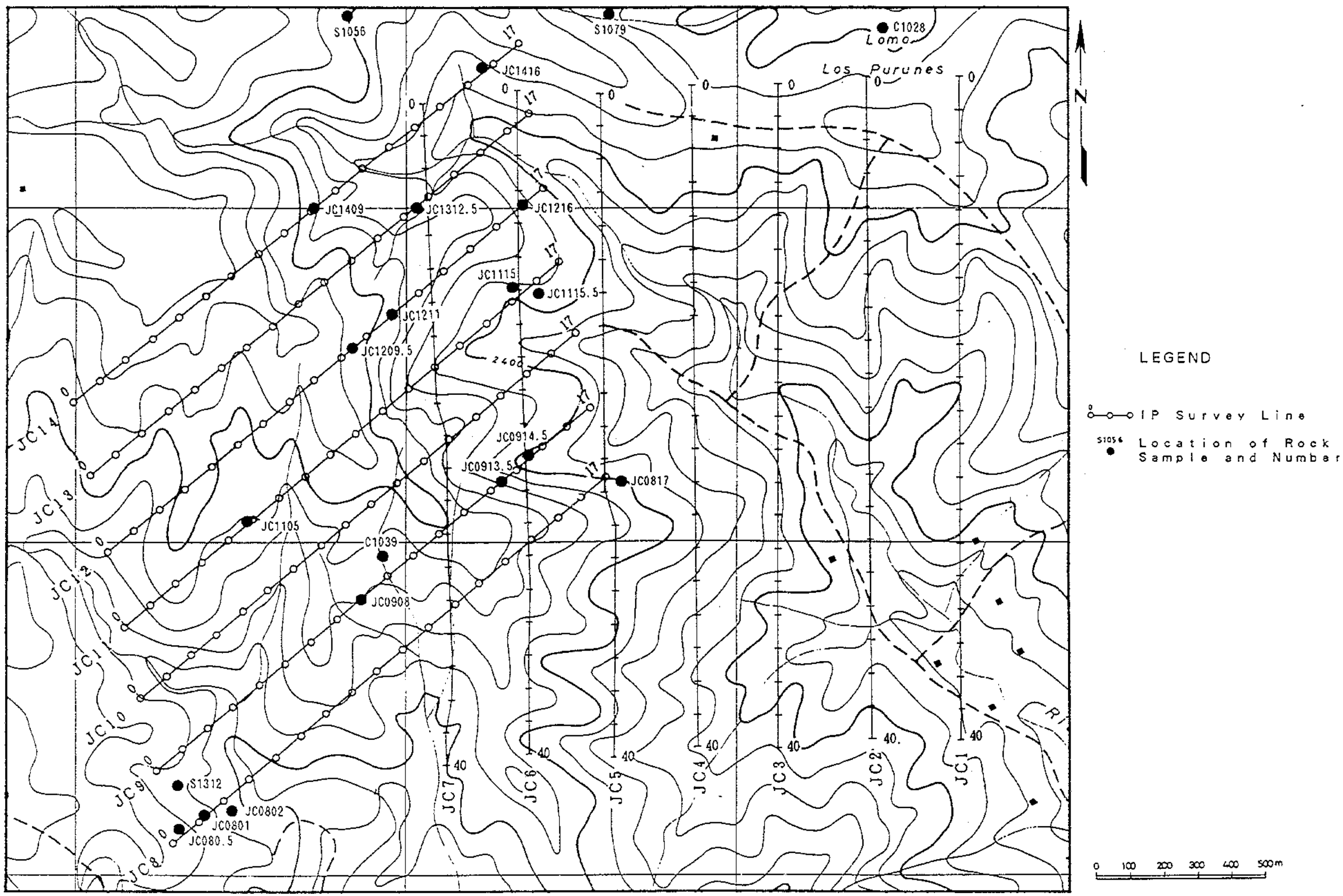


Fig. II-2-5 Location of IP survey lines and rock samples in the Cuellaje area.

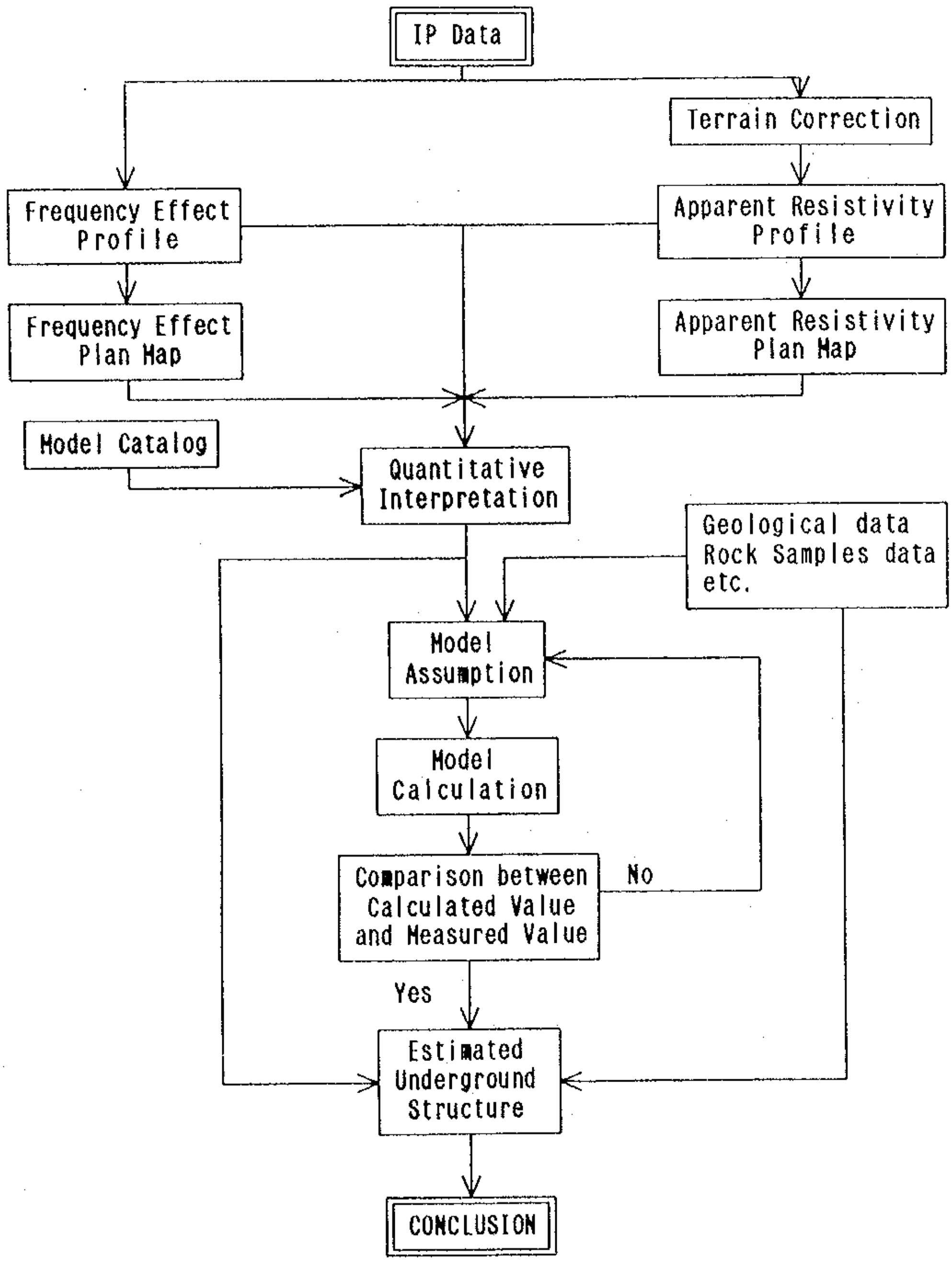


Fig. II-2-6 Flow chart of IP data analysis.

the measured potential difference to the following equation:

$$\rho = K \cdot \frac{V_{ac}}{I_{ac}} (\Omega \cdot m)$$

Where K is a geometric factor which depends on the electrodic configuration utilized.

$$K = \frac{2\pi}{\frac{1}{C_1P_1} - \frac{1}{C_1P_2} - \frac{1}{C_2P_1} + \frac{1}{C_2P_2}}$$

After reading the potential difference Vac at 3.0Hz, the frequency is changed to 0.30Hz while the current is kept constant. The percent frequncy effect (PFE) can then be directly read by a meter of the receiver panel and calculated by the following formula, which is also a function of change in resistivity as the frequency is changed.

$$PFE = \frac{V_{dc} - V_{ac}}{V_{ac}} \times 100 = \frac{\rho_{dc} - \rho_{ac}}{\rho_{ac}} \times 100(\%)$$

The value of apparent resistivity and PFE are plotted at the intersection of lines extending downward at 45 degrees from the transmitter and receiver midpoints. Since the depth of plotting does not represent the physical property with depth, this pseudo-section does not give a true section of the surface distribution of the IP effect.

(2)Terrain correction

Since the geometrical factor K is calculated as a function of the location of the current and potential electrodes on half-infinite plane, is affected by topography depending on the location of electrodes, even if the terrain is homogeneous. For example, for the case of a dipole-dipole configuration, appears to be high beneath a hill and low beneath a valley. On the other hand, PFE is less affected by topography because it is rather proportional to the ratio of resistivity difference at two frequencies.

As the topography of the survey area is comparatively steep and rugged, topographic corrections were carried out for all survey lines by means of a finite element method assuming a two dimentional half space topography.

The pseudo-sections and plan maps were drawn using the above mentioned topographical corrected values.

(3)Electrical measurement of rock samples

Electrical measurements on rock samples were carried out in order to determine the actual electrical properties of rocks distributed on the survey area. The rock collected from the surface were formed into a cubic shape. Their measurements were realized in water saturated condition after the rocks were soaked in water during ten days. As same as for the case of field survey, PFE was calculated by using the resistivity diference at 0.3Hz and 3.0Hz. The resistivities of the rock samples are calculated by the following equation:

$$\rho=\frac{a_1 \times a_2}{l}\times\frac{V}{I}$$

where ℓ : thichness of the sample (cm)
a_1 & a_2 : width of the sample (cm)
V : potential difference (V)
I : electric current (A)

(4)Simulation analysis

For analysis of IP data, there are mainly two method:

One is a qualitative method which correlates the anomaly patterns of profile and plan map in reference to standard anomaly pattern derived from various simple physical structural model. The other one is a quantitative method by using meshes which assumes PFE and resistivity values on the basis of geology, standard models and results of electrical measurement of rock samples. The theoretical values were then calculated by numerical analysis using a two-dimensional finit element technique. Continuous comparisons between the calculated values and observed data permitted to change the various parameters of the model in order to approach efficiently the observed values. By this interative procedure, it was possible to obtain an optimum model of the underground physical structure.

2-3-4 Results and Interpretation

(1)Results of rock sample measurements

Resistivity and PFE values were measured for 24 rock samples collected in the Rio Magdalena zone. The location of the collected samples are shown in Fig.II-2-5, and the corresponding measurement results are indicated in Appendix 11.

The resistivity of rock samples range from 203 to 53,078 Ωm. The resistivity of no or weak altered rocks show more than 10,000 Ωm. The resistivity of the strongly altered rock samples show less than 4,000 Ωm. The PFE value, which are generally indicative of sulfide contents, range from 0.2 to 9.1%. The PFE values are inversely propotional to their resistivity value, i.e., low resistivity rock indicate high PFE and high resistivity rocks indicate low PFE.

Mineralozation and limonitization factors are taken into consideration, the results can be summarized as follow:

Strongly altered and large anount of pyrite bearing rocks show low resistivity with high PFE. Weak mineralized rocks show high resistivity with moderate PFE. No mineralized and limonitized rocks are related to higher resistivity and lower PFE.

In the western part of the Rio Magdalena zone,it is therefore included that the argillization, chloritization and pyritization processes caused a decrease in resistivity and an increase in PFE. On the other hand, highresistivity with low PFE values are found to be due to silicification and limonitization.

(2)Distribution of apparent resistivity and PFE

Based on the apparent resistivity and PFE values in this survey, apparent resistivity and PFE can divided as follows:

Apparent resistivty value;

high apparent resistivty ; more than 650 Ωm
medium apparent resistivty; 250 to 650 Ωm
low apparent resistivty ; less than 250 Ωm

PFE value;

very high PFE; more than 7.0%
high PFE ; 5.0 to 7.0%
medium PFE ; 3.0 to 5.0%
low PFE ; less than 3.0%

1)Distribution of PFE

The zones with more than 5.0% PFE value is ditributed in the north, central and south part. The north anomalies(A and C) have a tendency of extending toward north and northwest and decreases at depth. In the central anomalies(B, D and F), very high PFE is widely distibuted and extend to northwest at depth. In the south anomalies(E and G), high PFE extend to southwest, however, it is not significant. The west anomaly(H) is small and not clear.

2)Distribution of apparent resistivity

High apparent resistivity is ditributed in the south, west and northwest parts and decreases at depth. In the south part, high apparent resistivity is widely distributed and extends to the southwest part and forms the south anomalies(E and G). In the west and northwest, the west anomaly(H) is distributed.

Low apparent resistivity is distributed in the east, central and southwest parts. The east low apparent resistivity is most widely dis tributed and extends to northwest at depth forming the anomaly(A). In the cenral anomaly extends to the deeper part and extends to northwest part forming the anomaly(B). The southwest anomaly is distributed only near the surface.

3)IP anomalies

In this area, eight IP anomalies are seen.

IP Anomaly A;Detected around Lines JC2 and JC3 with No.6 to No.8 as center. Low apparent resistivity. High PFE to very high PFE.

IP Anomaly B;Detected around the intersection of Line JC6, JC7 and JC11. Low apparent resistivity. High PFE to very high PFE.

IP Anomaly C;Detected around the north of Lines JC4. Medium apparent resistivity. High PFE to very high PFE.

IP Anomaly D;Detected around the intersection of Lines JC6, JC7 and JC13. Medium apparent resistivity. High PFE to very high PFE.

IP Anomaly E;Detected around Lines JC3, JC4, JC5, JC6 with No.32. High apparent resistivity. High PFE to very high

PFE.

IP Anomaly F;Detected around the intersection of Line JC6, JC7, JC8 and JC9. Medium apparent resistivity. Very high PFE.

IP Anomaly G;Detected around the Line JC8 with No.1 to No.3 at depth. High apparent resistivity. High PFE to very high PFE.

IP Anomaly H;Detected around the Line JC12 with No.1 to No.3. High apparent resistivity. High PFE.

Anomaly A and Anomaly B is expected the existence of porphyry copper type mineralization because of amount of sulfides and alteration.

(3)Simulation analysis

The results of two dimensional model simulation for Line JC8 to JC14 are shown in Appendix 12 and Fig.II-2-7.

Anomaly B is distributed in the intersection of Lines JC6, JC7, JC11, JC12 and JC13. In the Line JC7 and JC12, anomaly was detected at depth and extend to northwest at depth, however, decrease around Line JC14.

2-3-5 Consideration

As the results of analysis for the survey carried out in 1992 and 1994, Anomaly A to H were detected. Zones of high PFE are widely distributed, however, zones of high PFE with low resistivity are limited only in the central (Anomaly B) and in the northeast (Anomaly A) parts in the Cuellaje area. Anomaly A seems to be affected by abundant pyrite (JICA/MMAJ,1993). Anomaly B seems to be affected by porphyry copper type mineralization because of existing copper mineralized zone near IP anomaly. Anomaly B trends to northwest, however, decreases around Line JC14. Therefore, mineralization affected by Anomaly B seems to correspond to a small scale of mineralization.

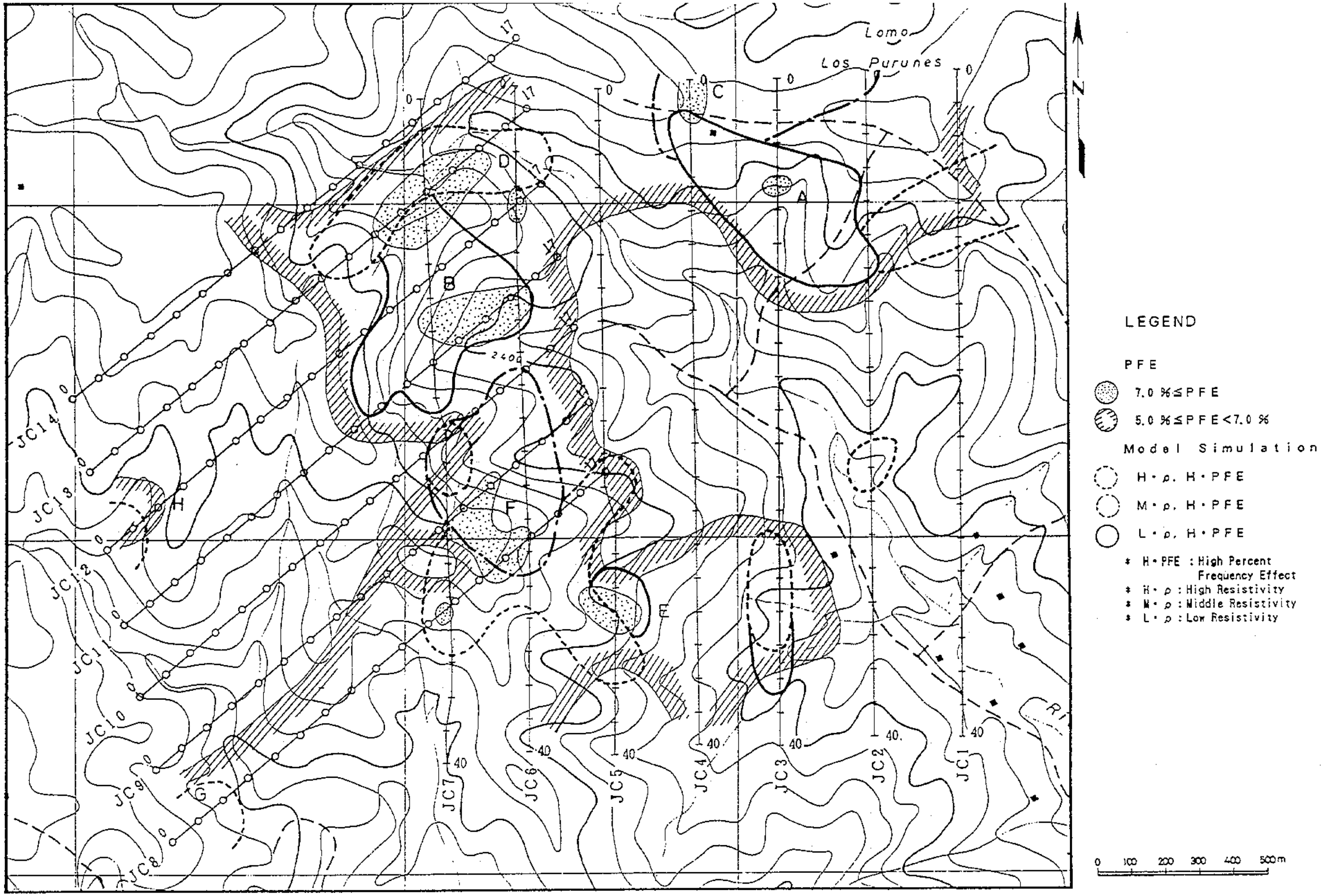


Fig. II-2-7 Plane map of PFE and model simulation.

2-4 Drilling survey

2-4-1 Purpose

The purpose of the drilling survey is to confirm the extension and intensity of mineralization in the central and south parts of the Rio Magdalena mineralized zone.

2-4-2 Details

In order to confirm the geology and mineralization at depth, diamond core drilling method was adopted. Two holes (each design depth per hole:300m) were drilled for the central part of the Rio Magdalena mineralized zone and two holes (each design depth per hole: 300m) were drilled for the south part of the Rio Magdalena mineralized zone. The location of drill holes are shown in Fig.II-2-8. The details are as follow:

(1) Transportation and preparation of drilling site

All the machines, equipments and materials were transported by truck to the Cuellaje camp through village of Cuellaje. The mobilization from Cuellaje camp to drilling sites were carried out horseback and man power. Every existing narrow and snaky road was amplified and adjusted completely in order to supply foods and materials for the camp and drilling activities. Drilling water was taken directly from the branch of the Rio Magdalena.

(2) Outline of drilling work

Drilling work was conducted from 18rd October 1994 to 15th December 1994. Drilling work was carried out, as a rule, for 24 hours a day. Drilling method adopted was wire line and ordinary method. The drill machines utilized were two NEPTUNO-1200 which has sufficient drilling capacity for deep drilling. Cementation and casing work were needed to be done repeatedly because the mineralized rock present tremendous fractures. Drilling performance of the holes are shown in Appendix 14, the drilling progress are shown in Appendix 15. Drill machine, equipment and consumed material are listed up on Appendix 16.

(3) Examination of drill cores

The drill core was examined simultaneously with drilling

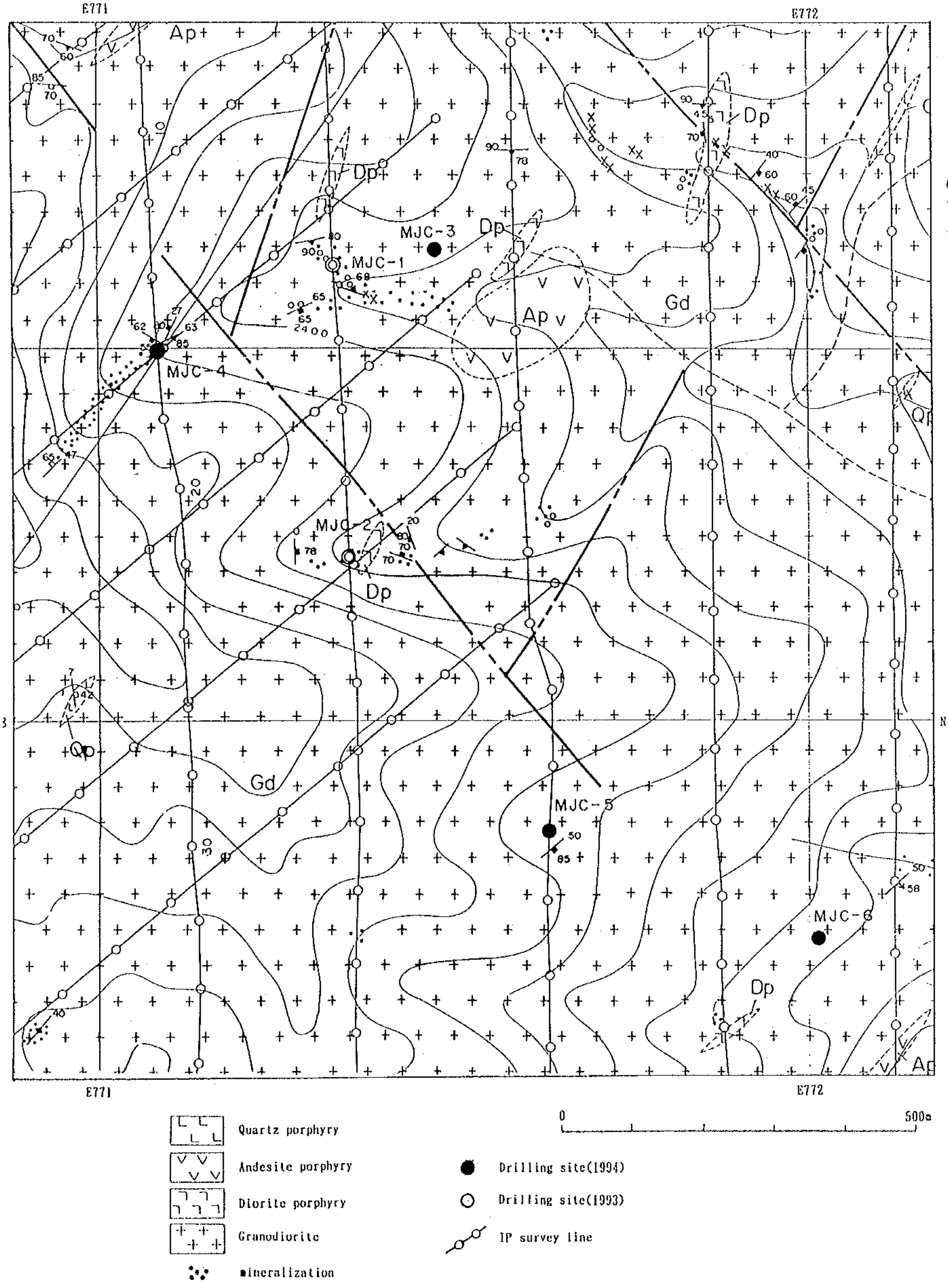


Fig. II-2-8　Location map of drill holes in the Cuellaje area.

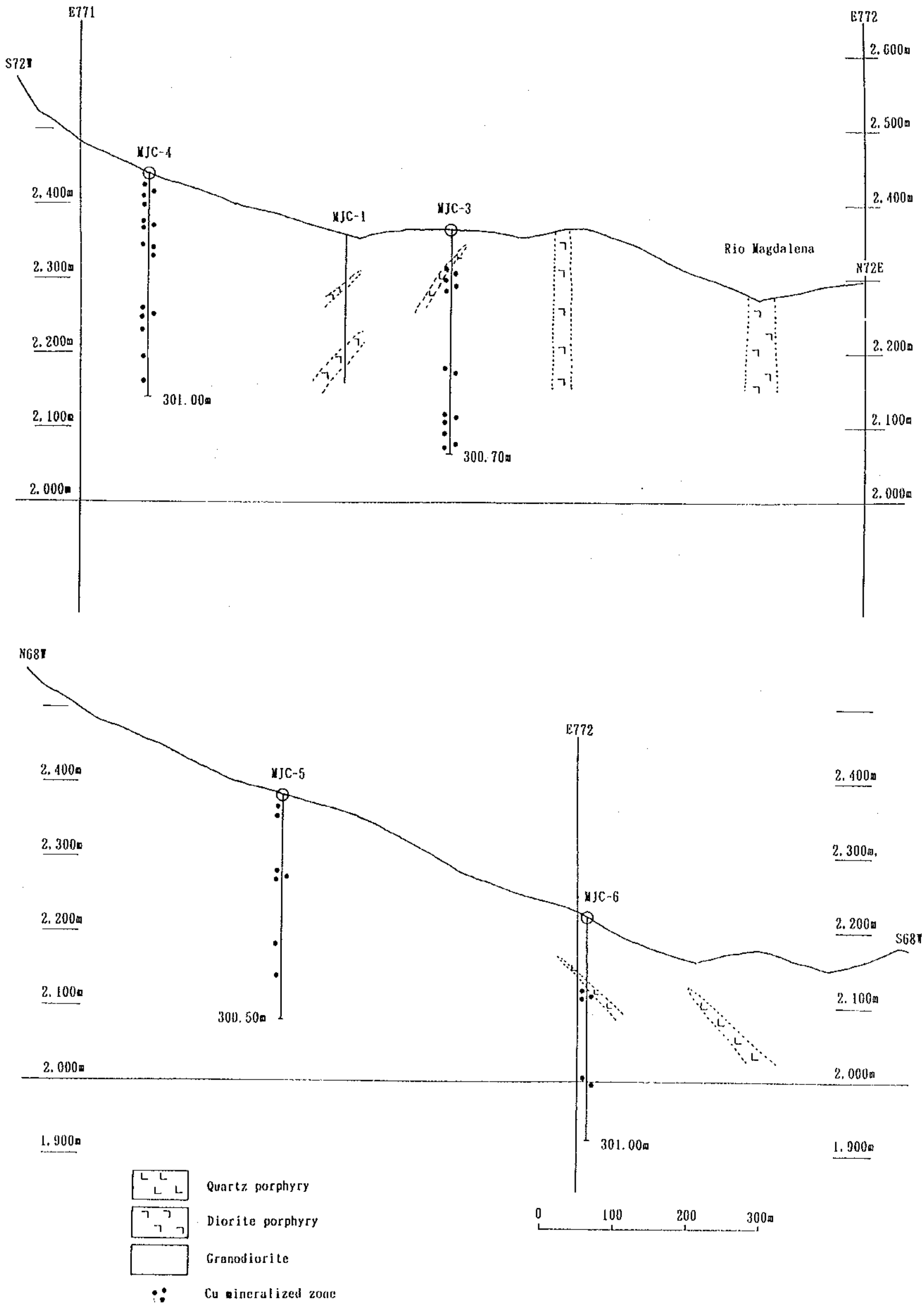


Fig. II-2-9 Geologic profiles around drill hole MJC-3, MJC-4, MJC-5 and MJC-6.

operations at the drilling sites and at the base camp in Garcia Moreno. The results of this examination were compiled in columnar sections on a scale of 1:200 (Appendix 17). Drill cores were split with a diamonde cutter and splitter. One half of the split cores was taken as samples for laboratorial studies and the other was reserved in the storage of CODIGEM for future reference.

(4) Drilling work

Specifications of each hole are shown on Table II-2-2.

Table II-2-2 Specification of Holes in the Cuellaje area

Hole No.	Location	Altitude	Direction	Inclination	Depth
MJC-3	N48.656 E771.475	2,428m	-	-90	300.70m
MJC-4	N48.518 E771.085	2,484m	-	-90	301.00m
MJC-5	N47.848 E761.630	2,408m	-	-90	300.50m
MJC-6	N47.695 E761.014	2,274m	-	-90	301.00m

2-4-3 Results

The geological colum of the drill cores are shown in Appendix 17. The results of microscopic observations are shown in Appendix 1. The results of X-ray diffractive analysis are shown in Appendix 3. The ore assay results are shown in Appendix 4. The geology and mineralization observed on drill cores are as follows:

(1)MJC-3

MJC-3 was drilled in granodiorite and quartz porphyry. Chloritization is generally recognized in granodiorite. Silicification and sericitization are observed near the fractures in the mineralized zone.

0.00 to 0.50m;Surface soil.

0.50 to 49.40m;Granodiorite with chloritization.
Chalcopyrite and bornite occur in fractures.
Pyrite is partially recognized.

49.40 to 49.80m;Quartz porphyry.

49.80 to 197.00m;Granodiorite with chloritization.
Chalcopyrite and bornite are observed in fractures.
Dissemination of pyrite and chalcopyrite occur in

silicified part.

197.00 to 263.00m;Granodiorite with chloritization.
Chalcopyrite is slightly observed in fractures.

263.00 to 270.00m;Granodiorite with chloritization.

270.00 to 300.70m;Granodiorite with silicification and sericitization. Chalcopyrite occur in fractures. Bornite and molybdenite occur slightly in fractures.

The results of ore assay of 76 samples show that the average grade of copper and molybdenum of whole samples is low, however, the grade increaces near quartz porphyry. The results of ore assay are as follows:

Average grade of whole samples;
0.18%Cu, 0.006%Mo for core length of 106.70m.

Average grade of good mineralized part;
0.27%Cu, 0.008%Mo from 47.00m to 80.00m in depth.

(2)MJC-4

MJC-4 was drilled in granodiorite and quartz porphyry. Chloritization is generally recognized in granodiorite. Silicification and sericitization are observed near the fractures in the mineralized zone.

Pyrite, chalcopyrite and bornite occur in fractures accompanied by silicification and sericitization in granodiorite. Mineralization is weak.

0.00 to 0.50m;Surface soil.

0.50 to 8.90m;Granodiorite with chloritization.

8.90 to 10.70m;Quartz porphyry.

10.70 to 21.75m;Granodiorite with chloritization.

21.75 to 22.60m;Quartz porphyry.

22.60 to 301.00m;Granodiorite with chloritization
Pyrite and chalocopyrite occur in fractures.
Bornite occur slightly.

The results of ore assay of 102 samples show that the average grade of copper and molybdenum of whole samples is very low. The results of ore assay are as follows:

Average grade of whole samples;
0.04%Cu, 0.0002%Mo for core length of 99.50m.

(3)MJC-5

MJC-5 was drilled in granodiorite. Chloritization is recognized in granodiorite. Silicification and sericitization are observed in fractures in the mineralized part.

0.00 to 1.50m;Gray sand.
1.50 to 300.50m;Granodiorite with chloritization.
Pyrite and chalcopyrite occur.
Bornite and chalcocite occur slightly.

The results of ore assay of 25 samples show that the average grade of copper and molybdenum of whole samples is very low. The results of ore assay are as follows:

Average grade of whole samples;
0.03%Cu, 0.0001%Mo for core length of 32.00m.

(4)MJC-6

MJC-6 was drilled in granodiorite and quartz porphyry. Chloritization is recognized in granodiorite. Silicification and sericitization are recognized in fractures in the mineralized part. Pyrite and chalcopyrite are observed in fractures in granodiorite.

0.00 to 10.00m;Surface soil.
10.00 to 64.30m;Quartz porphyry.
64.30 to 92.90m;Granodiorite with chloritization.
Pyrite and chalcopyrite occur slightly in fractures.
92.90 to 301.00m;Granodiorite with chloritization.
Pyrite and chalcopyrite occur slightly in fractures.
Bornite occur slightly.

The results of ore assay of 25 samples show that the average grade of copper and molybdenum of whole samples is low. The results of ore assay are as follows:

Average grade of whole samples;
0.08%Cu, 0.0015%Mo for core length of 41.00m.

(5)Results of laboratorial studies

1)X-ray diffractive analysis

X-ray diffractive analysis for the rock samples collected from holes MJC-3 to MJC-6 to clarify the alteration.

MJC-3;Assemblages of sericite/quartz/plagioclase and chlorite/sericite/quartz/plagioclase are mainly observed. Assemblages of sericite/quartz is not detected.

MJC-4;Assemblages of sericite/quartz/plagioclase is mainly observed. Assemblages of sericite/quartz is partialy recognized.

MJC-5;Assemblages of sericite/quartz/plagioclase is mainly observed. Assemblages of sericite/quartz is not detected.

MJC-6;Assemblages of sericite/quartz/plagioclase is mainly observed. Assemblages of sericite/quartz is not detected.

2)Measurement of filling temperature of fluid inclusions

Measurement of filling temperature of fluid inclusions carried out for quartz in vein of holes MJC-4 and MJC-5. One sample collected at the depth of 285.70m of MJC-4 gave filling temperature values from 224°C to 407°C. One sample collected at the depth of 254.70m of MJC-5 gave filling temperature values from 140°C to 399°C. The temperature obtained from the two samples is slightly lower than measurement temperature obtained from the Junin area.

2-4-4 Consideration

As the results of drilling MJC-3 and MJC-4 for the central part of the Rio Magdalena mineralized zone, mineralization was recognized in the two holes. However, the continuity of mineralization is poor and the grades of copper and molybdenum are low. Based on the results of the hole MJC-4, no significant mineralization seems to exist in the western side of the central part of the Rio Magdalena mineralized zone.

As the results of drilling MJC-5 and MJC-6 for the south part of the Rio Magdalena mineralized zone, mineralization was recognized in the two holes. However, the continuity of mineralization is poor and the grades of copper and molybdenum are low. Therefore, no significant mineralization seems to exist in the south part of the Rio Magdalena mineralized zone.

PART Ⅲ CONCLUSION AND RECOMMENDATIONS

Chapter 1 Conclusions

1-1 Junin Area

(1) The Rio Junin mineralized zone consists of stockwork veins and disseminations of pyrite, chalcopyrite, chalcocite, bornite in the fractures and molybdenite in quartz veins which occur in granodiorite, quartz porphyry and diorite porphyry. Silicification and sericitization are recognized near stockwork and quartz veins. Chloritization and epidotization are widely observed in granodiorite, quartz porphyry and diorite porphyry. Mineralization is related to silicification and sericitization.

(2)Drilling surveys of MJJ-14 and MJJ-15 reveal that porphyries are located in the eastern and deeper part of the Rio Junin, and that chalcopyrite, bornite and chalcocite occur near dikes of porphyries. Mineralization extends toward east and depth with an extension of more than 300m. The average grade of the mineralized part (from 1.00m to 300.58m) of MJJ-14 is 0.29%Cu and 0.022% Mo(calculated by 314 samples). The average grade from 207.00m to 294.00m of MJJ-14 is 0.41%Cu and 0.047%Mo, which show a tendency of increasing grade at depth. The average grade of the mineralized part (from 0.60m to 301.21m) of MJJ-15 is 0.22%Cu and 0.007%Mo (calculated by 227 samples). Near quartz porphyry at depth, the average grade of core length of 118.21m shows 0.41%Cu and 0.016%Mo. According to the results of drilling, rich zone of copper is expected in the eastern part of the Rio Junin mineralizedzone.

(3)Drilling surveys of MJJ-16 and MJJ-17 reveal that quartz porphyry intrudes into granodiorite, and stockwork and dissemination of pyrite, chalcopyrite, bornite and chalcocite occur in granodiorite, quartz porphyry and diorite porphyry. Mineralization is characterized by abundant pyrite. Silicification and sericitization are mainly recognized in quartz porphyry. Chloritization and epidotization are mainly recognized in granodiorite. The average grade of the mineralized part (core length of 144.60m) of MJJ-16 is 0.15%Cu and 0.0012%Mo (calculated by 148 samples). The average grade from 4.05m to 150.25m of MJJ-17 is 0.46%Cu and 0.0194%Mo (calculated by 144 samples). Core (from 60.00m to 150.25m) shows high grade of 0.62%Cu and 0.0273%Mo.

(4)The results of geochemical analysis show that geochemical anomalous zones of Au, Ag, Cu and Mo are distributed in the middle stream of the Q. Fortuna.

(5)Phyllic alteration zone and geochemical anomalous zones extend from the Rio Junin to the lower stream of the Q. La Controversia, and reach possibly to the Q. Fortuna. Abundant copper zone seems to be located between the Rio Junin and the Q. Fortuna.

(6)Around the Q. Verde, many dikes of quartz porphyry are distributed, where phyllic zone and geochemical anomalous zone are widely recognized. The Q. Verde mineralized zone indicates the possibility of existence of promissing ore deposits.

1-2 Cuellaje Area

(1)Geology of the surrounding area of the Rio Magdalena mineralized zone consists mainly of granodiorite, and several dikes of andesite porphyry and diorite porphyry which intrude into granodiorite. Small veins and disseminations of pyrite, chalcopyrite and bornite were recognized in granodiorite located in a branch of the Rio Magdalena, in the upper stream of the Rio Magdalena, in a branch of the Rio San Joaquin and in a branch of the Rio Meridiano. The length of each mineralized zone is between 200m to 400m, while the amount of sulfide minerals is small. Small scale of veins observed in the branch of the Rio Meridiano consist of bornite and show 13%Cu in width of 0.1m.

(2)As the results of geochemical survey, high score zone of factor 3 related to Cu/Mo mineralization was detected in the west of the branch of the Rio Magdalena and in the branch of the Rio Meridiano.

(3)As the results of IP survey, zones of high P.F.E. are widely distributed, however, zones of high P.F.E. with low resistivity are limited only in the central (Anomaly B) and in the northeast(Anomaly A) parts in the Cuellaje area. Anomaly B, which is small and trends towards northwest, seems to correspond to a small scale of mineralization.

(4)Drilling surveys of MJC-3 and MJC-4 carried out in the central zone, and MJC-5 and MJC-6 carried out in the south zone, reveal that small veins of pyrite and chalcopyrite occur in granodiorite. Small amount of sulfide minerals are continuously observed. The average grade (core length of 106.70m) of MJC-3 is 0.18%Cu and 0.0065%Mo (calculated by 76 samples). The average grade (core length of 99.50m) of MJC-4 is 0.04%Cu and 0.0002%Mo (calculated by 102 samples). The average grade (core length of 32.00m) of MJC-5 is 0.03%Cu and 0.0001%Mo (calculated by 25 samples). The average grade (core length of 41.00m) of MJC-6 is 0.08%Cu and 0.0015%Mo (calculated by 25 samples). The grades of mineralized part of each holes are low.

(5)Based on the results obtained by this survey, Cu/Mo mineralization was recognized, however, the possibility of existing promissing ore deposits seems to be low because of a low grade of copper and a weak continuity of high grade ore.

Chapter 2 Recommendations

2-1 Junin Area

Based on the survey results, the recommendations for Phase II survey in the Junin area are as follows:

(1)Between the eastern side of Rio Junin mineralized zone and the Q. Fortuna mineralized zone, a possibility of existing stockwork and dissemination type of abundant copper mineralization seems to be high. Therefore, drilling survey for that zone is recommended to confirm the extension and intensity of mineralization at depth of more than 300m and to evaluate the ore deposits (Fig.2).

(2)For the Q. Verde mineralized zone, drilling survey is also recommended to clarify the mineralization in the Junin area.

(3)The possibility of development of mineralized zones in the Junin area seems to be high. Effect for natural, social and other environmental concerns should be estimated by the development. To evaluate the effect in the development, environmental investigation is recommended to be carried out for the Junin area and surrounding areas.

2-2 Cuellaje Area

Based on the survey results, recommendations for Phase II survey in the Cuellaje area are as follows:

According to the results obtained by the survey, Cu/Mo mineralization was recognized, however, the possibility of existing promissing ore deposits seems to be low because of low grade of copper and weak continuity of high grade ore. Therefore, further surveys are not considered necessary.

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LIST OF FIGURES AND TABLES

APENDICES

Appendix 1 Microscopic observation under thin section.

Results of Microscopic Observation of Thin Section (1)

Ser. No.	Sample No.	Location N	Location E	Rock name, Texture	Alteration	Primary mineral Qz	Kf	Pl	Bi	Hb	Px	Ap	Sh	Zr	Alteration mineral Qz	Ab	Bi	Se	Ac	Ep	Ch	Ca	Sm	Le	Lm	etc. Op
1	MJJ14-5.80	35.291	760.755	Granodiorite holocrystalline	Pl→Ser, Or→Ser, Bi→Chl/Epi, Hb→Chl/Epi	○	○	◎	○	△		·		·				○		○	○					△
2	MJJ14-29.30	35.291	760.755	Granodiorite holocrystalline	Pl→Ser, Or→Ser, Bi→Chl/Ser	◎	○	◎	○	·		·	·	·	○		·	◎			△					△
3	MJJ14-98.10	35.291	760.755	Granodiorite holocrystalline	Pl→Ser, Or→Ser, Bi→Chl/Ser	◎	○	◎	○	·		·	·	·	○		·	◎			△					·
4	MJJ14-106.00	35.291	760.755	Granodiorite holocrystalline	Pl→Ser, Or→Ser, Bi→Chl/Ser, Hb→Chl/Ser	○	○	◎	△	·		·	·	·	△			○			·					·
5	MJJ14-161.80	35.291	760.755	Quartz porphyry porphyritic	Pl→Sau/Ser, Hb→Chl	○	○	◎		△				·	○			○		△	△					△
6	MJJ14-247.00	35.291	760.755	Granodiorite holocrystalline	Pl→Ser, Bi→Chl, Hb→Chl	◎	△	◎	○	·		·	·	·				○			△					△
7	MJJ14-252.90	35.291	760.755	Diorite porphyry microcrystalline	Pl→Sau, Hb→Chl			◎		△		·	·			△		○			○					△
8	MJJ14-298.25	35.291	760.755	Quartz porphyry microcrystalline	Pl→Ser, Bi→Chl/Ser, Hb→Chl/Ser	○		◎	·	·					◎			◎			○					△
9	MJJ14-300.10	35.291	760.755	Granodiorite holocrystalline	Pl→Ser	◎	○	◎	○			·	·	·				○		△	△					△
10	MJJ15-59.50	35.135	760.805	Quartz porphyry porphyritic	Bi→Chl/Epi, Pl→Ser	◎		○	△	·			·					△		○	○					○
11	MJJ15-94.70	35.135	760.805	Quartz porphyry porphyritic	Bi→Chl/Epi, Hb→Chl/Epi, Pl→Ser	○		◎	△	△			·	·				△		△	○					·
12	MJJ15-106.00	35.135	760.805	Quartz porphyry porphyritic	Bi→Chl/Epi, Hb→Chl/Epi, Pl→Ser	○		◎	·	△				·				△		△	△					·
13	MJJ15-130.00	35.135	760.805	Quartz porphyry porphyritic	Bi→Chl/Epi, Hb→Chl/Epi	◎		◎	·	△			·	·				△		△	○					·
14	MJJ15-173.70	35.135	760.805	Quartz porphyry porphyritic	Pl→Ser, Hb→Chl/Epi	○		◎	·	○		·	·	·	·		·	○		○	△					○
15	MJJ15-189.95	35.135	760.805	Granodiorite holocrystalline	Pl→Ser, Bi→Chl	◎	○	◎	○	·		·	·	·	◎		·	○		△	○					○

Results of Microscopic Observation of Thin Section (2)

Ser. No.	Sample No.	Location N	Location E	Rock name, Texture	Alteration	Primary mineral Qz	Kf	Pl	Bi	Hb	Px	Ap	Sh	Zr	Alteration mineral Qz	Ab	Bi	Se	Ac	Ep	Ch	Ca	Sm	Le	Lm	etc. Op
16	MJJ15-210.00	35.135	760.805	Quartz porphyry porphyritic	Bi→Chl, Hb→Chl	○		◎	△	△		·	·					○		△	○					△
17	MJJ15-261.00	35.135	760.805	Granodiorite holocrystalline	Pl→Ser, Bi→Chl, Hb→Chl	○		◎	○	·		·	·	·	◎			○		○	○					△
18	MJJ15-300.20	35.135	760.805	Granodiorite holocrystalline	Pl→Ser, Or→Ser, Bi→Chl	◎	○	◎	○			·	·	·				◎			○					·
19	MJJ15-301.00	35.135	760.805	Granodiorite holocrystalline	Pl→Ser, Or→Ser, Bi→Chl	◎	○	◎	○			·	·	·				◎			○					○
20	MJJ16-102.10	34.564	761.687	Granodiorite holocrystalline	Pl→Ser, Or→Ser, Bi→Chl, Hb→Chl	◎	·	◎	○	·		·	·	·				◎		○	○					△
21	MJJ16-119.40	34.564	761.687	Dacite cryptocrystalline	Pl→Sau/Ser, Bi→Chl, Hb→Chl	○		◎	○	·			·					○		○	○					·
22	MJJ16-148.00	34.564	761.687	Quartz porphyry porphyritic	Pl→Ser, Bi→Chl	◎		◎	○						○			◎			△					○
23	MJJ17-33.80	34.710	761.815	Quartz porphyry microcrystalline	Bi→Chl, Hb→Chl	○		◎	△	·				·			·	○		△	△					△
24	MJJ17-64.20	34.710	761.815	Quartz porphyry porphyritic	Pl→Ser, Bi→Chl, Hb→Chl	○		○	·	△					△		.	◎			○					△
25	MJJ17-101.35	34.710	761.815	Granodiorite porphyritic	Pl→Ser	◎	·	○	·			·		·				◎			△					·
26	MJJ17-149.30	34.710	761.815	Granodiorite holocrystalline	Pl→Ser, Or→Ser	◎	○	◎	·	·		·		·				○			△				·	△
27	MJC3-49.60	48.656	771.475	Quartz porphyry porphyritic	Bi→Chl	◎		◎	○	·		·		·	○		·	△			○					△
28	MJC3-106.80	48.656	771.475	Granodiorite porphyritic		○	○	◎	○			·		·	○			△			△					△
29	MJC3-153.70	48.656	771.475	Granodiorite porphyritic		○	·	◎	○			·		·			·	·			△					△
30	MJC3-186.00	48.656	771.475	Granodiorite holocrystalline	Pl→Ab/Ser	◎	◎	○	○			·	·	·		○		◎			○					·

Results of Microscopic Observation of Thin Section (3)

Ser. No.	Sample No.	Location N	Location E	Rock name, Texture	Alteration	Primary mineral QzKfPlBiHbPxApShZr	Alteration mineral QzAbBiSeAcEpChCaSmLeLm	etc. Op
31	MJC3-253.50	48.656	771.475	Granodiorite holocrystalline	Pl→Ser	◎○◎○・ ・・・	○ ◎ ○	△
32	MJC3-275.60	48.656	771.475	Granodiorite holocrystalline	Pl→Ser	◎○◎△	◎ ○ ・	・
33	MJC3-300.00	48.656	771.475	Granodiorite holocrystalline	Pl→Ab	○○◎○ ・・・	○・ ・ ・○	・
34	MJC4-10.00	48.518	771.085	Quartz porphyry porphyritic		○ ◎△・ ・	○ △ △	○
35	MJC4-40.20	48.518	771.085	Granodiorite porphyritic		○ ◎○○ ・・・	・	○
36	MJC4-102.00	48.518	771.085	Granodiorite porphyritic	Hb→Chl/Epi	○ ◎○○ ・・・	△△	○
37	MJC4-209.10	48.518	771.085	Granodiorite porphyritic	Hb→Chl	○ ◎○△ ・・・	△△	○
38	MJJ4-291.00	48.518	771.085	Granodiorite holocrystalline	Pl→Ser, Hb→Chl	○△◎○△ ・・・	△ △△	△
39	MJC5-74.50	47.848	771.630	Granodiorite holocrystalline	Pl→Ser, Bi→Chl	○△◎△○ ・・・	○ △	△
40	MJC5-99.50	47.848	771.630	Granodiorite holocrystalline	Pl→Ser, Bi→Chl	○△◎○ ・ ・	○ ○ △◎	△
41	MJC5-218.00	47.848	771.630	Granodiorite holocrystalline	Pl→Ser, Hb→Chl	◎△◎○△ ・・・	△ △	△
42	MJC5-300.20	47.848	771.630	Granodiorite holocrystalline	Pl→Ser, Hb→Chl	◎△◎○△ ・・・	○ △○△	△
43	MJC6-93.00	47.695	772.014	Quartz porphyry porphyritic	Hb→Chl, Bi→Chl	○ ◎△△ ・ ・	△ △○△	△
44	MJC6-104.40	47.695	772.014	Granodiorite holocrystalline	Pl→Ab	◎△◎○○ ・ ・	・ ・ ・・	△
45	MJC6-220.80	47.695	772.014	Granodiorite holocrystalline	Pl→Ab	◎△◎△○ ・ ・	△ ・ ・○・	△

Results of Microscopic Observation of Thin Section (4)

Ser. No.	Sample No.	Location N	Location E	Rock name, Texture	Alteration	Primary mineral QzKfPlBiHbPxApShZr	Alteration mineral QzAbBiSeAcEpChCaSmLeLm	etc. Op
46	MJC6-239.90	47.695	772.014	Granodiorite holocrystalline	Pl→Ab	◎△◎○△ ・・・	・ △ ○・	△
47	MJC6-299.90	47.695	772.014	Granodiorite holocrystalline	Pl→Ser, Hb→Chl, Bi→Chl	◎△◎○○ ・・・	・ △ △○△	△
48	C1022	49.901	772.595	Granodiorite holocrystalline		◎○◎△ ・・・	△ ・△△	△
49	C1027	49.611	772.494	Granodiorite holocrystalline	Hb→Chl	◎○◎△△ ・ ・	△ △◎	△
50	C1043	48.186	770.938	Granodiorite holocrystalline	Pl→Ab, Bi→Chl	◎△◎△ ・ ・	△ △○	○
51	C1065	49.437	772.473	Granite holocrystalline	Pl→Ser, Bi→Chl	◎◎○△ ・ ・	△ △	△
52	G1025	47.279	770.704	Granodiorite holocrystalline	Pl→Ab, Hb→Chl, Bi→Chl	◎○◎○○ ・・・	△ △ △	△
53	G1026	47.284	770.735	Granodiorite holocrystalline	Pl→Ab	◎・◎○○ ・・・	○ △ △△	△
54	N1018	47.721	770.109	Granodiorite holocrystalline	Hb→Chl	◎ ◎○・ ・・・	△ △○△	△
55	N1025	47.314	770.195	Quartz porphyry porphyritic		○ ◎△ ・・	○ △ △	・
56	N1029	49.215	770.545	Granodiorite holocrystalline	Pl→Ab	○△◎△△ ・ ・	△ △ △△	・
57	N1301	47.011	771.803	Granodiorite holocrystalline	Bi→Chl	◎△◎△ ・ ・	△ △△ ・	・
58	N1305	47.612	770.236	Andesite intersertal	Hb→Chl	◎ ○	△○△	・
59	N1313	49.230	770.630	Granite holocrystalline		◎◎◎△ ・ ・	・ △	・
60	S1007	47.380	771.600	Granodiorite holocrystalline	Pl→Ser	◎・◎○○ ・ ・	△ △・	・

Results of Microscopic Observation of Thin Section (5)

Ser. No.	Sample No.	Location N	Location E	Rock name, Texture	Alteration	Primary mineral Qz	Kf	Pl	Bi	Hb	Px	Ap	Sh	Zr	Alteration mineral Qz	Ab	Bi	Se	Ac	Ep	Ch	Ca	Sm	Le	Lm	etc. Op
61	S1011	49.208	770.452	Granodiorite holocrystalline		◎	○	◎	○	○		•	•	•				△			△					○
62	S1047	49.975	770.803	Quartz porphyry porphyritic		◎	◎	○	△			•		•							△					△
63	S1048	49.959	770.757	Granodiorite holocrystalline		◎	△	◎	○	△		•	•	•				△			△					△
64	S1055	49.614	770.766	Granodiorite holocrystalline	Pl→Ab	○	△	◎	△	△		•		•		○		△			△					•
65	S1057	49.569	770.878	Granodiorite holocrystalline	Pl→Ab	○	△	◎	△	△		•		•		○		△			△				•	△
66	S1089	48.950	770.753	Granodiorite porphyritic	Pl→Ab	◎	△	◎	△	△		•	•	•		○		△			△	△				•
67	S1308	49.596	771.584	Dacite intersertal		△		○		△	△				○					△	△	△				△
68	S1316	47.320	770.150	Dacite intersertal		△		○					•		△			△		△	△	△				△

Pl;plagioclase, Or;orthoclase, Bi;biotite, Hb;hornblend, Ab;albite, Ser;sericite, Chl;chlorite, Epi;epidote, Sau;saussurite
Qz;quartz, Kf;potash feldspar, Px;pyroxene, Ap;apatite, Sh;sphene, Zr;zircon, Se;sericite, Ep;epidote, Ch;chlorite, Ca;calcite,
Sm;smectite, Le;Leucoxene, Lm;limonite, Op;opaque mineral
◎;abundant, ○;common, △;a little, •;rare

Appendix 2 Microscopic observation under polished section.

Results of Microscopic Observation of Polished Section in the Cuellaje Area

Ser. No.	Sample NO.	Location N	Location E	Sample description	mineral assemblage Py	Po	Ht	Ge	Mt	Cp	Bo	Cv	Cc	Mc	Mo	Sp
1	C1302	49.834	772.537	Gd, diss, Py, Cp			d •	d •								
2	C1304	48.522	771.089	Gd, diss, Py, Cp	vd○		d •			vd○						
3	C1309	47.932	770.959	Qv, diss, Py, Cp	d •			vd •								
4	C1312	49.693	772.473	Qv, film, Py, Cp	v◎	•		•		v○		•			d△	•
5	C1316	49.539	772.472	Gd, diss, film, Py, Lm, Cp, Cc, Cv, Mc	v◎	△		•		v○		△			△	
6	C1321	49.539	772.472	V, Py, Lm, Cc, Bo	◎	•				◎	△	•				
7	N1302	47.520	772.305	Gd, QV, film, Lm	d△			•		d△			△	•		
8	N1303	47.389	772.690	Qv, diss, Py, Lm	d△		•	•								
9	S1301	47.400	771.449	Gd, diss, Py, Cp			d •	d •	d •							
10	S1302	49.201	770.402	Gd, film, Py, Cp				d •	d •	d •						
11	S1304	49.213	770.305	Gd, diss, Py, Cp Bo	d△				d△	d△			•			
12	S1319	47.265	770.115	Gd, diss, Py, Lm	d△			d△								
13	S1321	47.240	770.424	Gd, diss, Py, Lm	d△											

◎; abundant ○; common △; a little • ; rare
Py; pyrite Po; pyrrhotite Ht; hematite Ge; geothite
Mt; magnetite Cp; chalcopyrite Bo; bonite Cv; covellite
Cc; chalcocite Mc; malachite Mo; molybdenite Sp; sphalerite
d; dissemination v; vein Gd; granodiorite Qv; quartz vein
diss; dissemination film; film vein

Appendix 3 Results of X-ray diffractive analysis.

Results of X-ray diffractive analysis in the Cuellaje area.

(Cuellaje area)

Ser. No.	Sample No.	Rock Name	Montmorillonite	Ser./Mont. M. L.	Kaolinite	Halloysite	Chlorite	Sericite	Biotite	Quartz	Plagioclase	K-feldspar	Amphibole	Calcite	Epidote	Gypsum	Gibbsite	Goethite	Lepidocrocite	Pyrite	Hematite	Chalcopyrite	Bornite	Ten-tetra	Molybdenite
1	S1001	Gd					·	·		◎	○	○	·												
2	S1002	Gd					·			○	○														
3	S1003	Gd					·			○	○	+	○												
4	S1004	Gd					·			○	○		·												
5	S1005	Gd					·	·		◎	◎		+												
6	S1006	Gd						·		○	○		·												
7	S1007	Gd						○		◎	◎		+												
8	S1008	Gd					·	·		○	○	+	·												
9	S1009	Gd					○	·	·	◎	◎	+			?										
10	S1010	Gd						?	?	○	○	+	·												
11	S1011	Gd					·	○		◎	◎	?	·												
12	S1012	Gd						·		◎	○		·								·				
13	S1013	Gd					·	·		◎	◎		·												
14	S1014	Gd						·		○	○		+								·				
15	S1015	Gd			+		·	○		◎	◎		·												
16	S1016	Gd						+		○	○														
17	S1017	Gd					○	·	·	◎	◎	○													
18	S1018	Gd			·					○	○	+	·												
19	S1019	Gd					·	○		◎	◎														
20	S1020	Gd			·			·		◎	○	·	·												
21	S1021	Apl								◎															
22	S1022	Gd								○	◎		+								·				
23	S1023	Gd								◎	◎		+								+				
24	S1024	Gd								◎	◎		+								·				
25	S1025	Gd,Apl					·	·		◎	◎	○	+												
26	S1026	Gd								○	○		·								·				
27	S1027	Gd					·	○		◎	◎		+												
28	S1028	Gd						·		○	○		·												
29	S1029	Ap					+			○	○	+	+												
30	S1030	Gd						+	·	○	◎		·												
31	S1031	Gd						·		◎	◎		○												
32	S1032	Gd						+	·	○	○		·								·				
33	S1033	Gd								○	○		·								·				
34	S1034	Gd						·		○	○	+	·												
35	S1035	Gd						+		◎	◎	+	+								·				
36	S1036	Gd								○	○	·	·												
37	S1037	Gd						○	·	◎	◎	○	+								·				
38	S1038	Gd						·		○	◎		·												
39	S1039	Gd								◎	◎	○	+												
40	S1040	Gd						·		○	○		·												
41	S1041	Gd						+	·	◎	◎	+	·												
42	S1042	Gd						+		○	◎	+	·												
43	S1043	Gd						+		◎	◎	+	+												
44	S1044	Gd						·	·	○	○	·	·												
45	S1045	Gd						○	·	◎	◎	○	+								?				
46	S1046	Gd								○	○	+	·												
47	S1047	Gd			·					◎	◎	○													
48	S1048	Gd								○	○	+	·												
49	S1049	Gd					+			◎	◎	+	·												
50	S1050	Gd								○	○		·												

Gd: granodiorite, Qp: quartz porphyry, Dp: diorite porphyry,
Ap: andesite porphyry, Apl:aplite
◎ abundant, ○ common, + a little, · rare, ? uncertain

Ser. No.	Sample No.	Rock Name	Montmorillonite	Ser./Mont. M. L.	Kaolinite	Halloysite	Chlorite	Sericite	Biotite	Quartz	Plagioclase	K-feldspar	Amphibole	Calcite	Epidote	Gypsum	Gibbsite	Goethite	Lepidocrocite	Pyrite	Hematite	Chalcopyrite	Bornite	Ten-tetra	Molybdenite
51	S1051	Gd				?	+			○	○	+	+												
52	S1052	Gd			+		·			○	○	+													
53	S1053	Gd			?					◎	◎		·												
54	S1054	Gd		·			·	·		◎	+														
55	S1055	Gd					·	○		◎	◎	+	+												
56	S1056	Gd			·			+		○	○	+	·												
57	S1057	Gd			·			○	·	◎	◎	+	·		?										
58	S1058	Gd			·			+		○	○		·												
59	S1059	Gd			?		?	○	·	◎	◎	○	·												
60	S1060	Gd								◎	◎		·												
61	S1061	Gd								◎	◎	○	·												
62	S1062	Gd			·			○	·	○	◎	+	·												
63	S1063	Gd			·			○		◎	◎	○	+												
64	S1064	Gd						·		○	○		·												
65	S1065	Gd			·			·		◎	◎	+	+								?				
66	S1066	Gd					·			○	○	+	·												
67	S1067	Gd								◎	◎		+												
68	S1068	Gd			·		·			○	○														
69	S1069	Gd			·					◎	◎														
70	S1070	Gd						+		○	○										·				
71	S1071	Gd					·	◎		◎	◎														
72	S1072	Gd						○		○	○		·												
73	S1073	Gd					·			◎	◎	○													
74	S1074	Gd			·			·		○	○														
75	S1075	Gd,Apl						○	·	◎	◎	+	·												
76	S1076	Gd						+		○	○	○	·												
77	S1077	Gd			·					◎	◎	○													
78	S1078	Gd					·			○	○		·												
79	S1079	Gd			·			+		◎	◎	○													
80	S1080	Apl			·			·		○	◎		·												
81	S1081	Gd			+		·	+		◎	◎														
82	S1082	Gd					·	·		○	◎														
83	S1083	Gd			○		+	·		◎	◎														
84	S1084	Gd			·			·		○	◎		·												
85	S1085	Gd					·	+		◎	◎	+	+												
86	S1086	Gd			+		·	·		◎	○														
87	S1087	Gd					○			◎	◎				+										
88	S1088	Gd			·			·		○	○		·												
89	S1089	Gd					·	○		◎	◎		+												
90	S1090	Gd			·			·		○	○	+	·								·				
91	S1091	Gd		·			·	·		◎	◎		·												
92	S1092	Gd								○	○														
93	S1093	Gd					·	+	·	◎	◎		+												
94	S1094	Gd			·			+		○	○		·												
95	S1095	Gd					+	○		◎	◎		+												
96	S1096	Gd								○	○	+	·												
97	S1097	Gd					·			◎	◎		+												
98	S1098	Gd			·		·	·		○	○														
99	S1099	Gd			·			·		○	○	?	·												
100	S1100	Gd					·			◎	○		·												

Gd: granodiorite, Qp: quartz porphyry, Dp: diorite porphyry,
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101	S1101	Gd		·			·	·		◎	○		·												
102	S1102	Gd								○	○	+	·												
103	G1002	Gd					·			◎	◎	+	+												
104	G1009	Gd								○	○	+	·												
105	G1010	Gd					·	·		◎	◎		+												
106	G1011	Gd					·			○	○	+	·												
107	G1012	Gd					·	+		◎	◎		+												
108	G1013	Gd			·					○	○	+	·								·				
109	G1014	Gd					·	+		◎	◎		+												
110	G1015	Gd			·					○	○	+	·												
111	G1016	Gd					·			◎	○	+	·												
112	G1017	Gd			·					◎	○	○													
113	G1018	Gd					·			◎	◎	○													
114	G1019	Gd						○		+	+	·													
115	G1020	Apl								◎	○	○													
116	G1021	Gd			·					○	○		·												
117	G1022	Gd								◎	◎	+	+												
118	G1023	Gd						+		○	○		·								·				
119	G1024	Gd					·		·	◎	◎	○													
120	G1025	Gd			·			·		◎	○	+													
121	G1026	Gd			·		·			◎	◎		+		·						·				
122	G1027	Gd			·					○	○	+	·												
123	G1028	Gd					·	·		◎	◎		+								·				
124	G1029	Gd					·	·		○	○		·												
125	G1030	Gd						·		◎	◎	+	+								+				
126	G1031	Gd					·			○	○		·												
127	G1032	Gd					·	·		◎	◎		+												
128	G1033	Gd			·					○	○		·												
129	G1034	Gd			·		·			◎	◎	○	·								·				
130	C1001	Gd			·					◎	○		·												
131	C1002	Gd								◎	◎		+												
132	C1003	Gd								○	○	·	·												
133	C1004	Gd					+	+		◎	◎														
134	C1005	Gd					·	·		○	○														
135	C1006	Gd					+	+		◎	◎														
136	C1007	Gd					·			○	○														
137	C1008	Gd		+	+		·	·		◎	◎	○	·												
138	C1009	Gd		·			·			○	○	+													
139	C1010	Gd	·	+	○					◎	○	○									?				
140	C1011	Gd			+			+		○	○	+													
141	C1012	Gd					·	+		◎	◎	+	+												
142	C1013	Gd						+		◎	○	+	·												
143	C1014	Gd						+		◎	◎	+	·												
144	C1015	Gd			·			+		◎	◎	+													
145	C1016	Gd								○	○	+													
146	C1020	Gd					·			○	○														
147	C1021	Gd					·	+		◎	◎														
148	C1022	Gd						+		○	○		+								·				
149	C1023	Gd					·	+		◎	◎										·				
150	C1024	Gd					·	·		○	○														

Gd: granodiorite, Qp: quartz porphyry, Dp: diorite porphyry,
Ap: andesite porphyry, Apl:aplite
◎ abundant, ○ common, + a little, · rare, ? uncertain

Ser. No.	Sample No.	Rock Name	Montmorillonite	Ser./Mont. M. L.	Kaolinite	Halloysite	Chlorite	Sericite	Biotite	Quartz	Plagioclase	K-feldspar	Amphibole	Calcite	Epidote	Gypsum	Gibbsite	Goethite	Lepidocrocite	Pyrite	Hematite	Chalcopyrite	Bornite	Ten-tetra	Molybdenite
151	C1025	Gd			·			·		◎	◎				·										
152	C1026	Gd			·			+		◎	+														
153	C1027	Gd					·	·		◎	◎			·											
154	C1028	Gd								+				○						+					
155	C1029	Gd			·			·		◎	◎		·												
156	C1030	Gd						+		◎	○														
157	C1031	Gd					·	+		◎	◎														
158	C1032	Gd						+		○	○														
159	C1033	Gd			·					◎	◎	○	·												
160	C1034	Gd						·		○	○		·								·				
161	C1035	Gd			·			○		◎	◎		·												
162	C1036	Gd					·	·		◎	○														
163	C1037	Gd					+		·	◎	○	○													
164	C1038	Gd					·			○	○	+													
165	C1039	Gd					·	○		◎	◎	+	·								?				
166	C1040	Gd					·	+		○	○														
167	C1041	Gd					·	+	·	◎	◎		·												
168	C1042	Gd					·	·		◎	○														
169	C1043	Gd					·			◎	○				·										
170	C1044	Gd			·		·			○	○	+			·										
171	C1045	Gd		·			○			◎	◎														
172	C1046	Gd			·			·		○	○		·												
173	C1047	Gd					·	·		◎	◎		·												
174	C1048	Gd			·			·		○	○		·												
175	C1049	Gd					·	·		◎	○		·								·				
176	C1050	Gd						·		○	○		·												
177	C1051	Gd			·			○	·	◎	◎	+	·												
178	C1052	Gd					·	·		◎	○														
179	C1053	Gd					·	·	·	◎	◎	+	·												
180	C1054	Gd			·			·		○	○		·												
181	C1055	Gd								◎	◎	○	+												
182	C1056	Gd			·			·		○	○		·												
183	C1057	Gd						+	·	◎	◎	+	+												
184	C1058	Gd			·					○	○	+													
185	C1059	Gd					·	○	·	◎	◎														
186	C1060	Gd						·		○	○		·												
187	C1061	Gd					·	+		◎	◎														
188	C1062	Ap					·		·	+	○	+	·		·										
189	C1063	Gd						+		◎	○	·		+											
190	C1064	Gd						·		○	○		·								·				
191	C1065	Qp			·			·		◎	◎	○													
192	C1066	Gd			·			·		○	○		·												
193	C1067	Gd		·			·			◎	◎						+								
194	N1001	Gd			·					○	○	+	·												
195	N1002	Gd			·			·		◎	◎		·												
196	N1003	Gd			·			·		○	○		·												
197	N1004	Gd			·			○		◎	◎		+												
198	N1005	Gd								○	○	+	·												
199	N1006	Gd			·					◎	◎	○	+												
200	N1007	Gd								○	◎	+	·												

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