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ON

THE [illegible] MINERAL [illegible]

IN

THE [illegible] AREA, [illegible]

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PART I

[illegible]

[illegible] INTERNATIONAL [illegible]
METAL MINES [illegible]

REPORT
ON
THE COOPERATIVE MINERAL EXPLORATION
IN
THE VERAGUAS·PROGRESO AREA,
THE REPUBLIC OF CHILE

PHASE I

MARCH 1994

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

PREFACE

In response to the request of the Government of the Republic of Chile, the Japanese Government decided to conduct a Mineral Exploration in the Veraguas-Progreso Area Project 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 Chile a survey team headed by Mr. Yoshikatsu Ichige from 17 October, 1993 to 31 December, 1993.

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

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

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

February 1994

Kensuke Yanagiya

President

Japan International Cooperation Agency

Takashi Ishikawa

President

Metal Mining Agency of Japan

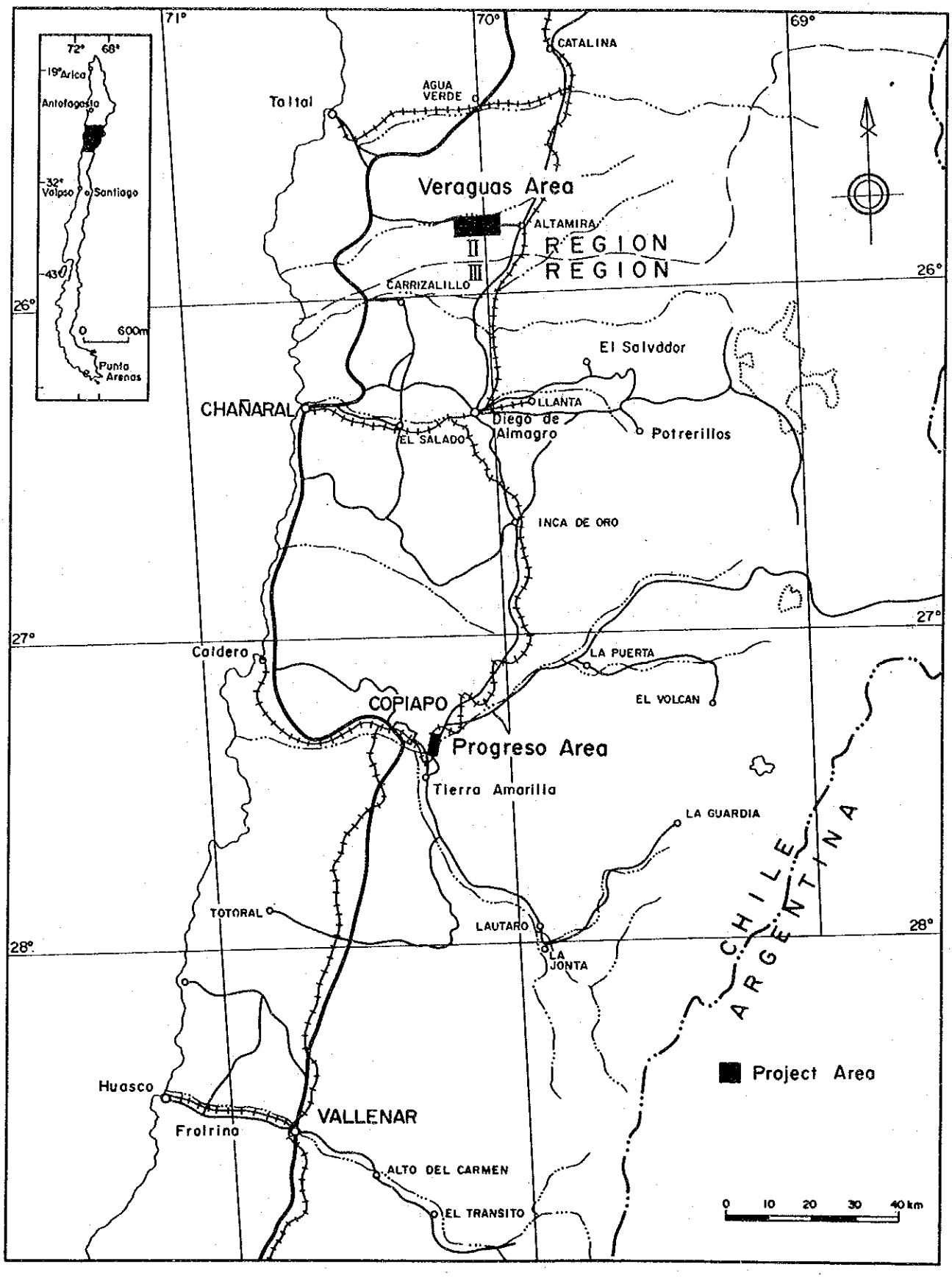

Fig. 1 Location of the Project Area

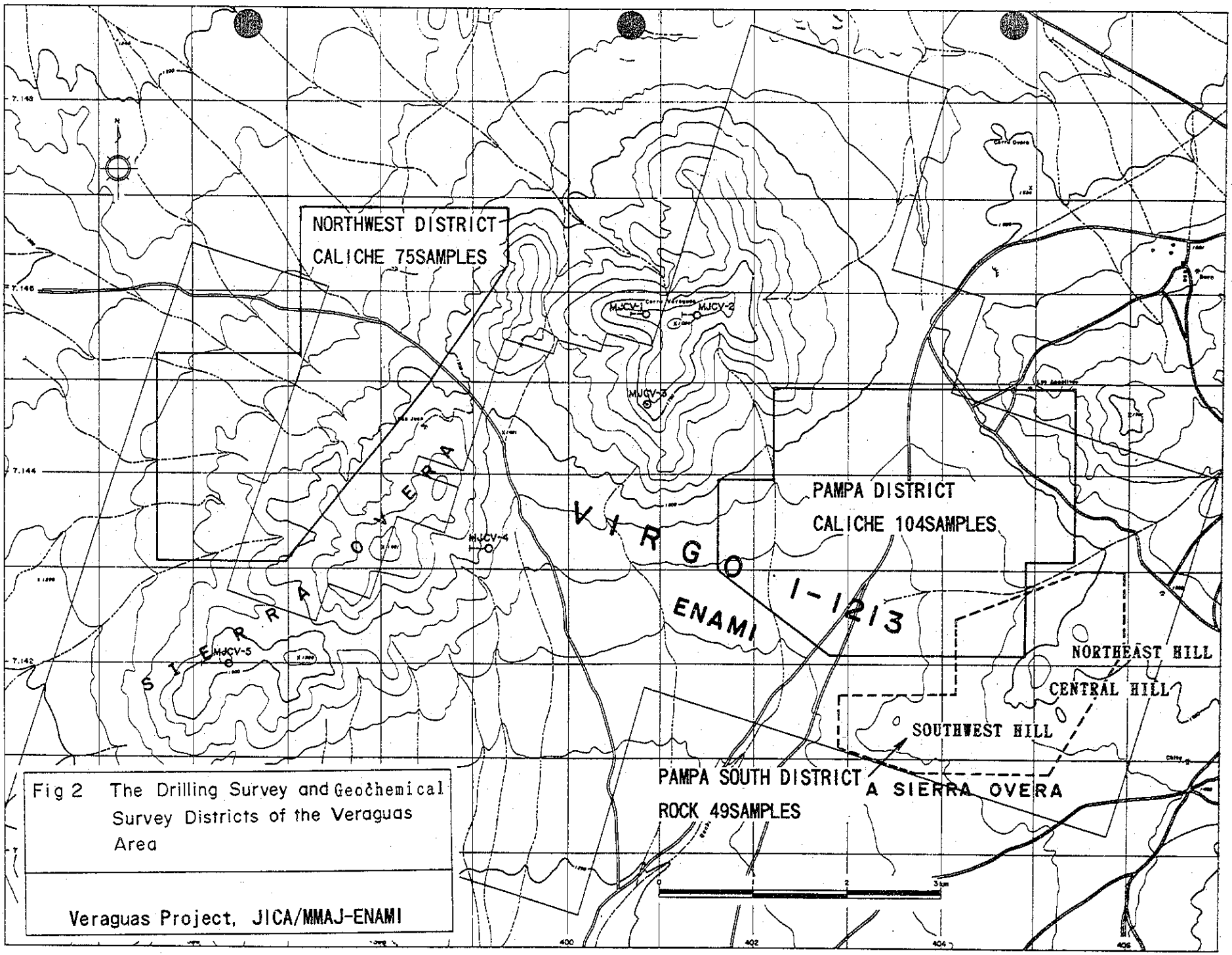

Fig 2 The Drilling Survey and Geochemical Survey Districts of the Veraguas Area

Veraguas Project, JICA/MMAJ-ENAMI

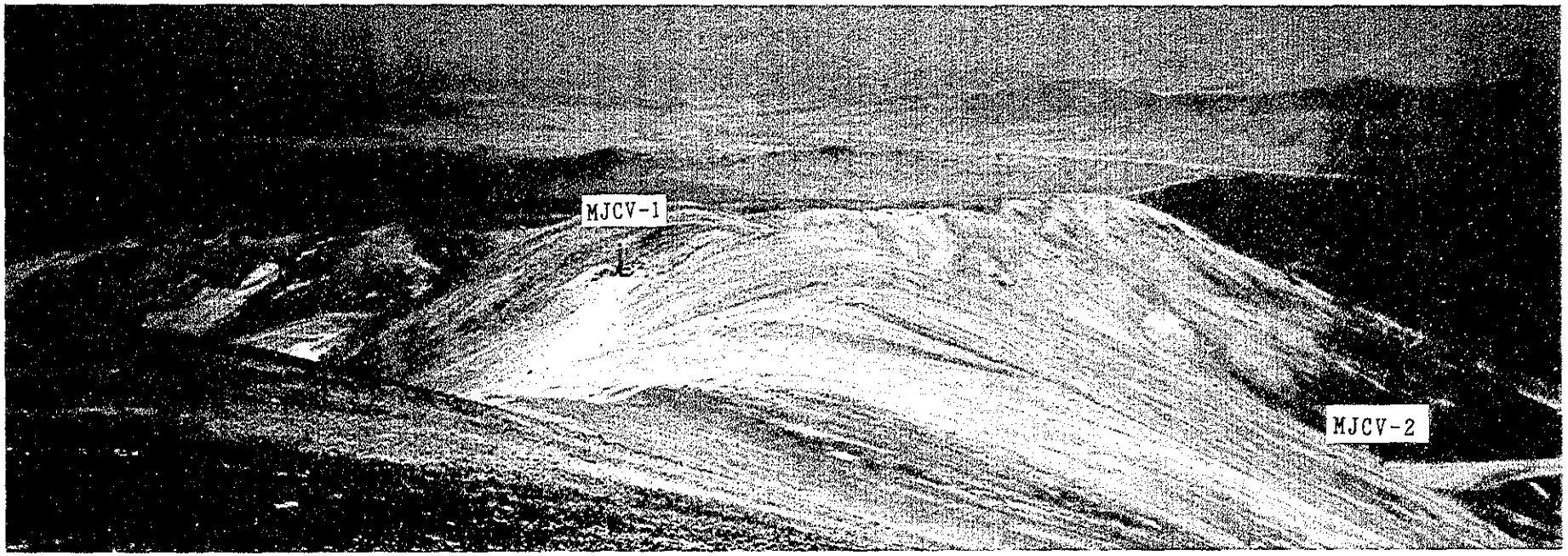

Photo 1 A view of northern hillside of Cerro Veraguas from the peak (Veraguas Area)

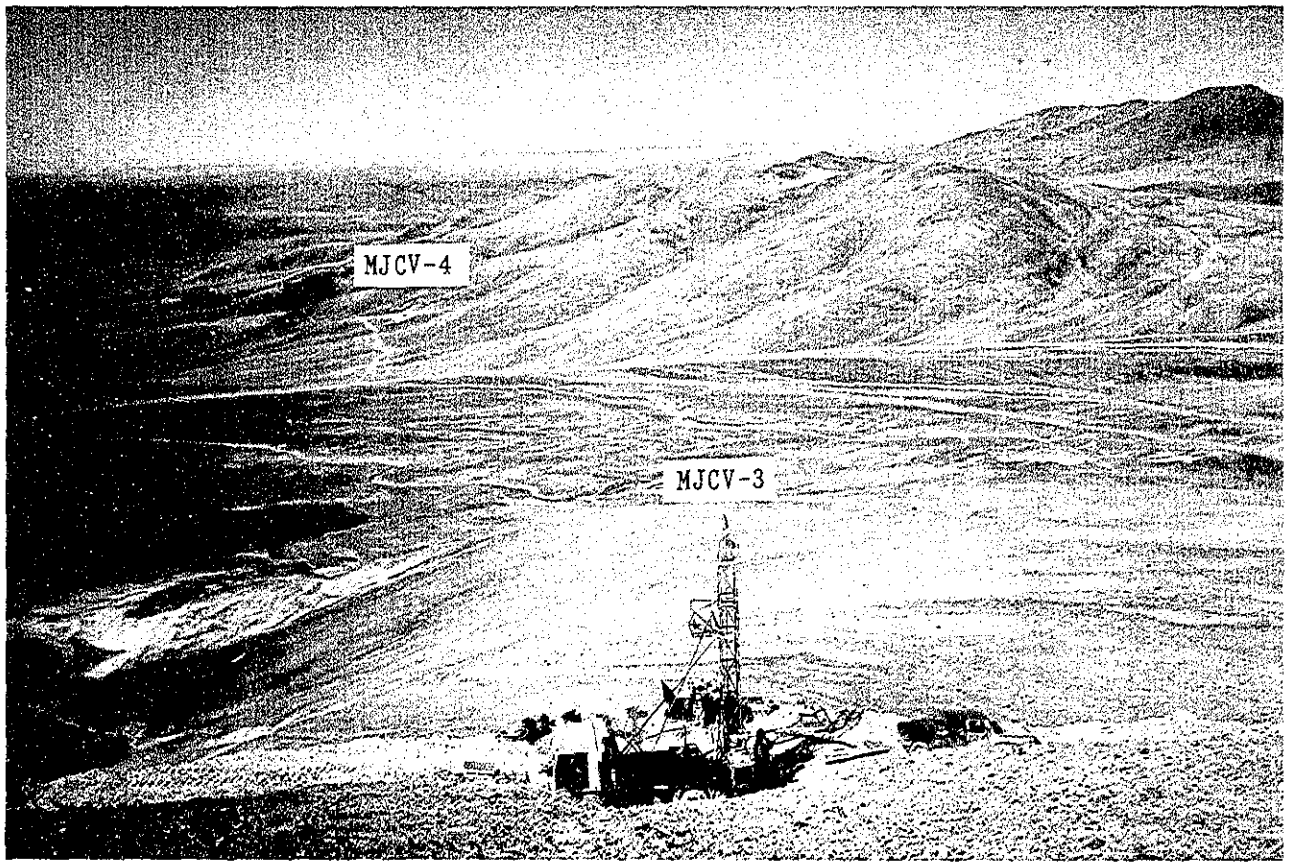

Photo 2 A view of Sierra Overa from Cerro Veraguas (Veraguas Area)

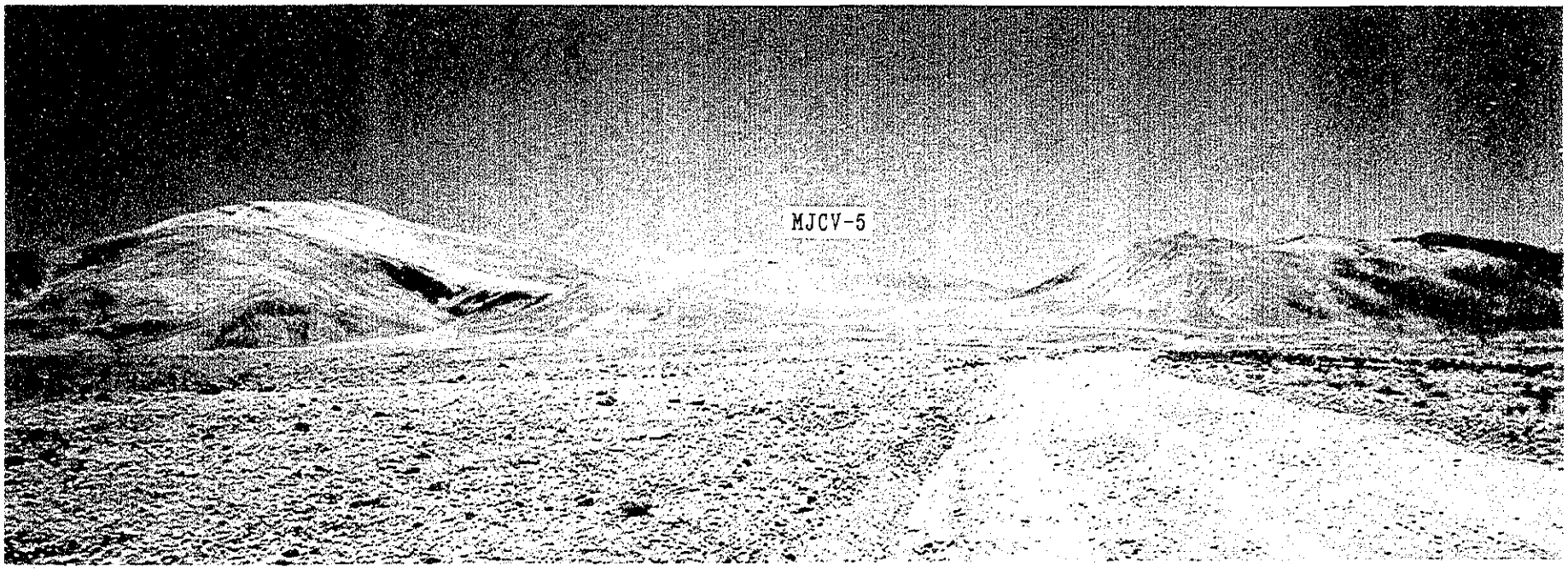

Photo 3 A view of southern part of Sierra Overa (Veraguas Area)

Photo 4 Caliche sampling work (Veraguas Area)

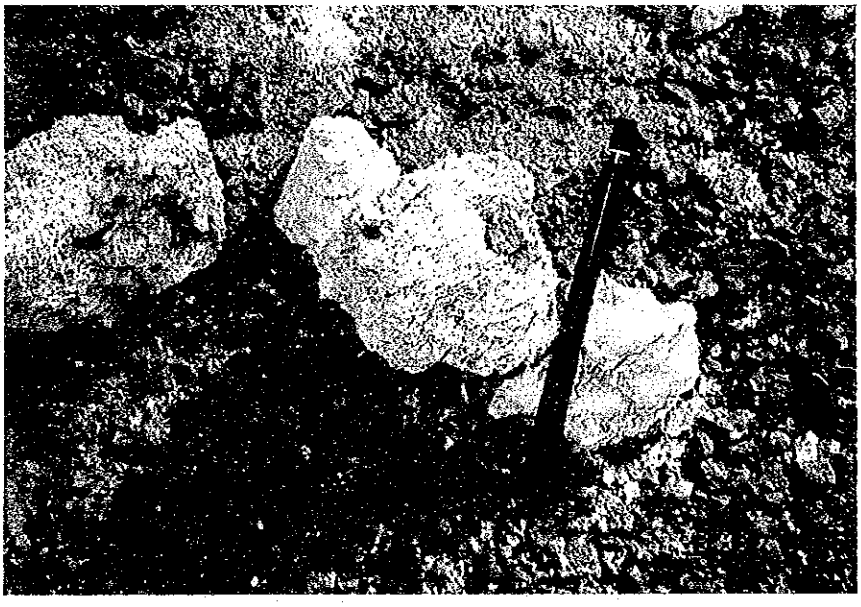

Photo 5 Fibrous type caliche sample (Veraguas Area)

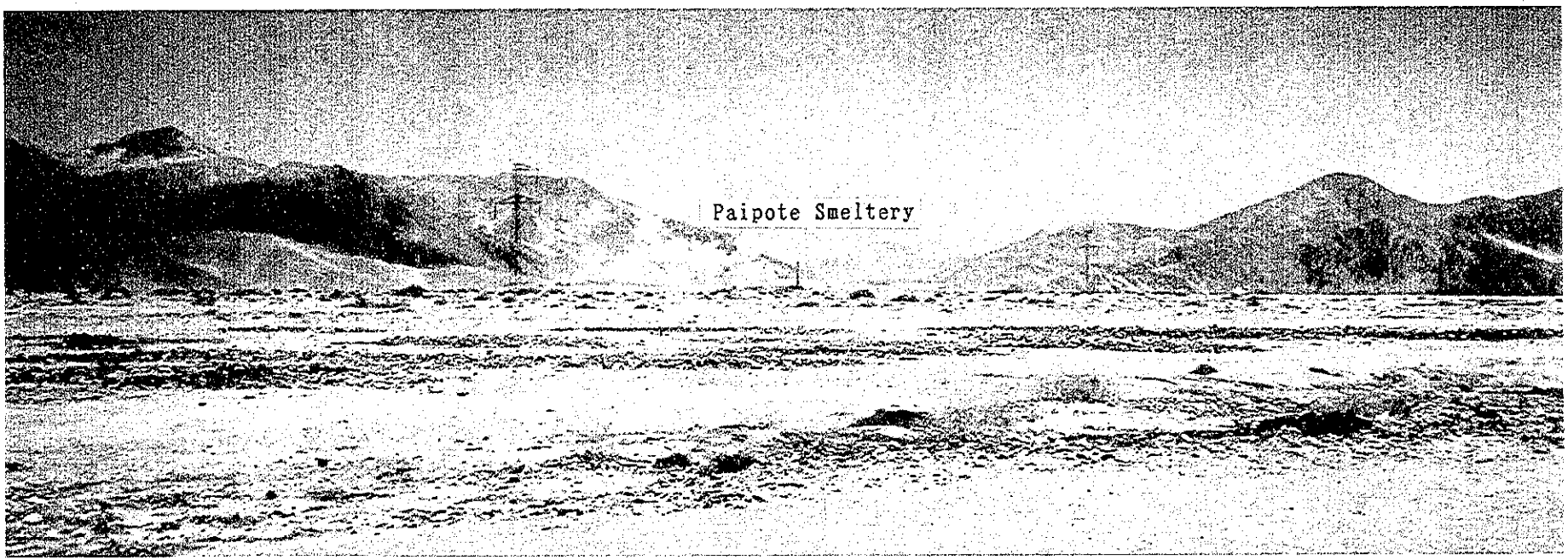

Photo 6 A view of Progreso Area from Paipote river

Abstract

The present survey was carried out as Phase I of the cooperation mineral exploration in the Veraguas - Progreso area, the Republic of Chile. The aim of the survey is to discover new ore deposits through clarification of the geological and mineralogical conditions in the two regions.

The survey began with an analysis of existing data on the Veraguas and Progreso Districts; once the knowledge needed to conduct the survey had been assembled and analyzed, drilling survey and geochemical survey in the Veraguas area were conducted. The major themes of these two surveys are as follows.

Drilling survey:

To clarify the geological structure of the Veraguas area and ascertain the existence of porphyry copper deposits.

Geochemical survey:

To ascertain the effectiveness of geochemical investigations taking as the medium caliche and rocks in the Veraguas area, and to pick out new areas of potential deposits.

1. Results of survey

(1) Drilling survey in the Veraguas district

Operations in the drilling survey covered a total of 5 holes, with a total drilling length of 2,053 m. The locations for the drilling holes were selected with the following points in mind, determined from the results of the analysis of the existing data.

1 Areas where ground surface surveys confirmed zones of mineralizing alteration and geochemical anomalies.

2 Areas shown by geophysical survey (CSAMT method) to be of low to medium resistivity, thought to correspond to zones of mineralizing alteration.

Results of the survey were as follows.

The Cerro Veraguas and Sierra Overa where the drilling surveys were carried out, are made up of Cretaceous Aeropuerto formation andesitic volcanics and porphyry thought to have intruded in age from the late Cretaceous to Palaeogene.

Both rocks have undergone marked hydrothermal alteration, and are classified, from the top down, into intensely silicified, quartz-sericified, siliceous argillized and chloritized zones. The lower part of the siliceous argillized zone and the chloritized zone are made up of quartz, sericite, gypsum, anhydrite and pyrite, as well as kaolinite and chlorite, and correspond to the phillic zone of the hydrothermal alteration classification of porphyry copper deposits according to Lowell and Guilbert (1970). In addition, the chloritized zone between 448.15-467.5m and between 478.9-493.5m at the MJCV-4 hole is rich in albite and potassium feldspar, corresponding to the potassic zone of the same classification. Each zone of alter-

ation possesses a brecciated or pseudobrecciated structure, the matrix has undergone strong kaolination and sericitization, and hematite, jarosite and limonite are developed in stockwork form, from which it may be considered that the brecciation effect was brought about at the time of hydrothermal activity.

In the lower part of the siliceous argillized zone and the chloritized zone where the original rocks are porphyry and surrounding andesitic volcanics, pyrite dissemination is prominent and is accompanied by sphalerite and galena as well as copper minerals such as chalcopyrite, chalcocite, covelline and cuprite. Mineralization discovered in each area was as follows.

Cerro Veraguas summit district (MJCV-1 & MJCV-2):

Copper mineralization is found in the porphyry of the lower part of the siliceous argillized zone and in the chloritized zone, particularly in the border area with the andesitic volcanics and along the fracture zone within the porphyry; but T.Cu is slight, at only 500-1100ppm.

Cerro Veraguas southern district (MJCV-3):

Copper mineralization is found in the porphyry of the chloritized zone below 300m at the MJCV-3 hole, in particular in and around the border area with the andesitic volcanics; and 10 points, a total of 14m, had 500-7000ppm T.Cu. At these points the molybdenum grade is also high, with an average of 52.4ppm between 300-375 m and a maximum of 213ppm.

Sierra Overa eastern district (MJCV-4):

Copper mineralization is found in the lower part of the siliceous argillized zone and in and around the border area between the porphyry and andesitic volcanics of the chloritized zone below 206m at the MJCV-4 hole and around the potassic zone below 400m; and 7 points, a total of 13m, had 500-3200ppm T.Cu.

Sierra Overa southwest district (MJCV-5):

Between 280-292m at the MJCV-5 hole, where the porphyry and N-S fracture zone intersect, measured 540ppm T.Cu, and between 364-367m, the border area of the chloritized and siliceous argillized zones within the porphyry, 1,041ppm T.Cu.

(2) Geochemical survey in the Veraguas area

The present survey is a geochemical survey taking as the medium caliche and rocks. The geochemical survey of caliche was carried out in the alluvium / colluvium distribution areas at the northwest foot and eastern side of the Cerro Veraguas and the Sierra Overa. Close to the former are located the San Juan deposits, and close to the latter, the Pampa deposits. The geochemical survey of rock was carried out in the southeast part of the area.

In the area where the geochemical survey of caliche was carried out, anomalies in T.Cu and S.Cu were obtained 1.3 km west of the San Juan Deposits and at the Pampa deposits. Since the former is characteristically accompanied by anomalies in FeO, Fe_2O_3 and SiO_2, and the latter by anomaly in S,

there is a possibility that the two geochemical anomalies reflect mineralization of a different character.

In the area where the geochemical survey of rock was carried out, geochemical anomaly of T.Cu in accordance with the existence of hematite was found. Since it may be considered that magnetite was replaced into hematite due to acidic hydrothermal activity, the anomalies in T.Cu may be understood to be caused by small amounts of copper accompanying the magnetite that was formed at the time of plutonic activity and there was no mineralization accompanying the hydrothermal activity.

2. Recommendation for Phase II

The drilling survey did not lead directly to the discovery of mineral deposits, but it was discovered that there was copper and molybdenum mineralization below 300m at the MJCV-3 hole in the Cerro Veraguas southern district, and copper and gold mineralization below 400m at the MJCV-4 hole in the Sierra Overa eastern district. In addition, some 1,500 m northwest of the MJCV-4 hole, on the northern side of the Sierra Overa, are the San Juan deposits.

Since it may be considered highly potential that porphyry copper deposits would be embedded in the environs of these districts of mineralization, it is proposed that in Phase II drilling survey be carried out in the district from southern hill side of the Cerro Veraguas to the east and north sides of the Sierra Overa.

In order to clarify the connection between mineralization and the geochemical anomalies discovered approximately 1.3 km west of the San Juan deposits as a result of the geochemical survey of the caliche, it is proposed that a trench survey be conducted from the zone of geochemical anomaly to the northwest mountainside of the Sierra Overa.

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Part III CONCLUSION AND RECOMMENDATION

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sary to make efforts at collecting all cores, especially from mineralized rocks, the bottom of holes and ore boundaries.

6) Handling of cores

a) Collected cores should be placed in a core box with the top and bottom clearly marked, and stored in a dry place.

b) Slime collected in place of a core should be put into a transparent vinyl bag and placed in a core box in the same way as a core.

c) The depth at which the core or slime was collected should be indicated accurately on the inside and outside of the core box.

d) When drilling is completed the cores should be stored at the place specified by organization concerned in Chile.

7) Appraisal and analysis of cores

a) Cores should be appraised in detail, and a geologic columnar section drawn up on a scale of 1:200.

b) Cores should be observed microscopically as necessary.

c) Each part of a core containing minerals should be analyzed.

d) Where necessary mineral outcrops should be investigated and compared closely with the part of the core containing minerals.

e) Table I-1-1 shows the numbers and quantities of samples for laboratory tests.

8) While the drilling survey is being conducted the chief geologist should remain on site and carry out core appraisal and other connected on-site work such as comparisons with the surface geology.

1-2-3 Geochemical Survey

1. Purpose

To confirm the validity of a geochemical survey of the caliche and rocks in the Veraguas area and also to identify areas of prospective new mineral deposits.

2. Site Investigation

1) Table I-1-2 shows the content of the survey and its quantities.

2) For the geochemical survey of the caliche, sampling lines running east to west should be drawn up at intervals of 400m to 500m, and samples collected as a general rule at 200m intervals along the lines. Each sample should be approximately 200g in weight, and any pieces of rock should be removed.

3) For the geochemical survey of rock, samples should as a general rule be collected at 100m to 400m intervals so as to provide an even distribution of sampling points. Each sample should

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Part I GENERAL REMARKS

CHAPTER 1 INTRODUCTION

1-1 Object of the Investigation

The object of this investigation is to confirm the existing of new mineral deposits in the Veraguas-Progreso areas of the Republic of Chile through elucidation of the geology of the area and the distribution of mineral deposits.

1-2 Methods of Survey

1-2-1 Analysis of Existing Data

1. Purpose

To collect and analyze existing data from geological, geochemical and geophysical surveys conducted in the Veraguas and Progreso areas by "the Empresa Nacional de Mineria (ENAMI)", thus accumulating data necessary for the conducting of the present survey.

2. Site Investigation

To be carried out over a period of 7 days at the facilities of ENAMI.

1-2-2 Drilling Survey

1. Purpose

To elucidate the geological structure of the Veraguas area, and to confirm the existence of porphyry copper deposits.

2. Site Investigation

1) Table I-1-1 lists the contents of the drilling survey.
2) As the depth of bores may be increased, drilling machines should have sufficient drilling capacity with regard to the planned bore depth.
3) Casing pipes with the minimum diameter should be prepared to reach to 60% or more of the planned bore depth.
4) The minimum diameter of cores should be BQ or larger.
5) Collection of cores and core recovery
   a) As a general rule the whole core should be collected, with the exception of the surface soil.
   b) Core recovery should be 80% or more even if it is difficult to collect all cores. It is neces-

LIST OF TABLES

Table I-1-1 Amounts of field works and laboratory tests of Drilling Survey

	Planned Survey			Actual Survey		
Drill Hole	Direction	Inclination	Depth	Direction	Inclination	Depth
MJCV-1	N90° W	-65°	400m	N90° W	-65°	402m
MJCV-2	N90° W	-60°	350m	N90° W	-60°	350m
MJCV-3	---	-90°	400m	---	-90°	401m
MJCV-4	N90° W	-35°	500m	N90° W	-35°	500m
MJCV-5	N90° W	-55°	400m	N90° W	-55°	400m
Total			2,050m			2,053m
Laboratory tests						
①Polished thin section			30pcs			31pcs
②X-ray diffractin analysis			50pcs			50pcs
③Homogenization temperature measurement of fluid inclusion			10pcs			14pcs
④Chemical analysis T.Cu,S.Cu,Au,Ag,Mo,Fe			2,050pcs (12,300elements)			2,052pcs (12,312elements)

Table I-1-2 Amounts of field works and laboratory tests of Geochemical Survey

	Planned Survey	Actual Survey
Samples to be collected	Caliche 150pcs	Caliche 179pcs Northwest district 75pcs Pampa district 104pcs
	Alteration rock 50pcs	Alteration rock 51pcs Sun Juan mine 2pcs Pampa south district 49pcs
Laboratory tests ①Thin section 20pcs ②X-ray diffractin analysis 60pcs ③Chemical analysis 200pcs T.Cu,S.Cu,FeO,Fe203, (1,800elements) S04, S, Cl,C02,Si02		21pcs 61pcs Total 230pcs Caliche 179pcs Alteration rock 51pcs (2,070elements)

be approximately 200g in weight, and any pieces of weathered rock should be removed.

1-3 Composition of Survey Team and Period of Investigation

1-3-1 Composition of Survey Team

The survey team, comprising survey planners, agreement negotiators and those participating in the investigation group, was made up as follows:

First phase	
Japanese side	Chilean side
Planning of the investigation and its negociation	Planning of the investigation and its negociation
Mr.Toshio Sakasegawa Metal Mining Agency of Japan Mr.Sho Inokuchi Ministry of International Trade and Industry Mr.Kaoru Suzuki Japan International Cooperation Agency Mr.Haruhisa Morozumi Metal Mining Agency of Japan Mr.Seiichi Mizusawa Metal Mining Agency of Japan	Mr.Silvio Girardi Morales Empresa National de Mineria Mr.Juan Tello Ortiz Empreza National de Mineria Mr.Julio Chazarro Ortiz Empreza National de Mineria Mr.Pedro Ilabaca Ugarte Empreza National de Mineria Mr.Mario Serrana Cavieres Empreza National de Mineria
Site investigation group	Site investigation group
Drilling survey and analysis of existing data Mr.Yoshikatsu Ichige(head of the group) Nittetsu Mining Consultants Co.,Ltd. Mr.Masatoshi Tsuzuki Nittetsu Mining Consultants Co.,Ltd. Geochemical Survey Mr.Haruhisa Morozumi Metal Mining Agency of Japan Mr.Syuuichi Miyatake Metal Mining Agency of Japan Mr.Kunihito Yamamoto Metal Mining Agency of Japan	Mr.Pedro Ilabaca Ugarte Empreza National de Mineria Mr.Ernest Garcia Fuentes Empreza National de Mineria

1-3-2 Period of Investigation

The period of investigation allotted to Phase I of the survey was as follows:

1) Planing and Scope of Work: 14th August 1993 to 27th August 1993

2) Site investigation (Geochemical survey): 17th October 1993 to 5th November 1993

3) Site investigation (Boring survey and analysis of existing data): 29th October 1993 to 31st December 1993

4) Drawing up of analytical report: 6th November 1993 to 24th February 1994

CHAPTER 2 GEOGRAPHICAL FEATURES OF THE SURVEY AREA

2-1 Location and Access

The area covered by the survey is comprised of the Veraguas and Progreso areas. The Veraguas area is located approximately 850 km north of Santiago, the capital of Chile, some 80 km east of the Pacific coast, in the southern part of the II Region. The range covers a total land area of 80 km2 in ENAMI's Virgo 1-1213 mining field and the Chatal 3001-3400 mining field of Taltal Chanaral S. A., a local private company with which ENAMI has a prospecting contract. The site is 350 km by road from either Antofagasta, capital of the II Region, or Copiapo, capital of the III Region; a 4-hour journey by car.

The Progreso area is located approximately 660 km directly north of Santiago, 70 km east of the Pacific coast, in the center of the III Region. The range covers a total land area of approximately 10 km^2 of ENAMI's Progreso 1-211 mining field including the grounds of the Paipote Smelter. The area is 10 km by road from Copiapo, and can be reached in 10 minutes by car.

2-2 Topography and Water System

The topography of northern Chile reflects the geological distribution and composition, and may be divided into three belts running north-south, from the west;

Coastal Cordillera
Central Depression
Domeyko Cordillera

The Veraguas area is located in the eastern edge of the coastal cordillera, bordering on the central depression.

In the central part of the area, the peaks Cerro Veraguas (1,864m) and Sierra Overa (1,681) have a relative height of 200 to 300 m and form a mountainous area stretching roughly 10 km NE to SW, with an average width of 3 km. To the SW of the saddle of the two peaks lies the San Juan Mine. In the south-east part of the area are low mountains (1,597 m) with a relative height of about 100m, running NE to SW. These mountains, over 1,400 m in height, display steep geographical features, while the base of the mountains forms an area of gently-sloping hills 1,200 to 1,450 m above sea level.

With regard to the water system, dry river beds can be seen running NW and SE along the edge of the NE-SW mountains, turning west in the lower reaches to empty into the Pacific Ocean. However, these water courses were formed in the historical past when there was rainfall, and it is extremely rarely that any water actually flows here.

2-3 Climate and Vegetation

The Veraguas area has a typical desert climate, with hardly any rainfall and continual clear skies.

Temperatures are between 25°C and 30°C during the day, dropping drastically at night to 10'C to 15'C in summer (December to February), 5°C to 10°C in winter (June to August). Mist often forms in the coastal areas, but very rarely covers by the area.

Thus vegetation is extremely limited; only cacti are to be found.

CHAPTER 3 EXISTING GEOLOGICAL DATA FOR THE SURVEY AREA

3-1 Outline of Previous Surveys

The hydrothermal alteration zones of the Veraguas area have been mentioned by Kents. P (1962), Ruge, H (1977) and Naranjo, J.A. et al. (1984), and their existence has been noted, but no prospecting has been carried out in earnest. However, since 1987 ENAMI has turned its attention to the hydrothermal alteration zones in the area, and has carried out the geological, geochemical and geophysical surveys listed in the table below.

Dates of submitting reports	Contents of investigations	Title of reports and investigators(*)
Oct.1987	Analysis of topography by aerial photographs (1:60,000) Preliminary geological survey 12.5×14km 180km² (1:50,000) Preliminary geochemical survey 15km² (1:10,000)	ENAMI(1987):ESTUDIO GEOLCGICO-ECONOMICO PRELIMINAR DEL AREA DE LAS PERTENENCIAS MINERAS VIRGO1-1213 DEL DISTRITO MINERO DE SIERRA OVERA *MAGMA GEOLOGOS CONSULTORES ASOCIADOS
Apr.1993	Detailed geological & geochemical survey 6districts 4.3km² (1: 5,000)	ENAMI(1993):EVALUACION GEOLOGICA PROSPECTO CERRO VERAGUAS *EGM SERVICIOS LTDA.
Jun.1993	CSAMT electorode spacing 100m 13profile lines, a total of 30,600m	ENAMI(1993):ESTUDIO GEOFISICO MEDIANTE CSAMT SECTOR SIERRA OVERA *GEODATOS

3-2 Geological Situation of the Survey Area

Mercade, M.W. (1978), Naranjo, J.A and Puig, A (1984), Ulriksen, C.G (1990), Boric, P.R, Diaz, F.F and Maksaev, J.V (1990), etc., have reported on the regional geology of northern Chile, in which the Veraguas district is located. In addition, the International Mineral Resource Development Cooperation Association (JMEC, 1993) has on the basis of these data carried out satellite-image analysis of the region centered on this area, synthesizing the regional geological map, comprehensive geological columnar section and ore deposit & mineral-alteration zone distribution map shown in Fig. I-3-1, -2, -3.

According to this information, the regional geology around this area is clearly related to the topography, and the area may be divided into three zones: from the west, the Coastal Cordillera, Central Depression and Domeyko Cordillera.

The Coastal Cordillera has a distribution on the west of rocks of the Paleozoic group and Triassic-Jurassic System, and on the east, underlying Cretaceous System. On the border between the two runs the

Atacama Fault, which is a normal fault belt on a N-S axis, which suggests that the western land mass has risen in relation to the rest. The Central Depression has underlying Cretaceous System, while in the Domeyko Cordillera Jurassic to Cretaceous System is overlained by Tertiary and Quaternary Systems. In addition in the Domeyko Cordillera, the West Fault (Falla Oeste) and Domeyko Fault (Falla de Domeyko) on a N-S axis, are clearly developed.

The area covered by the present survey is located on the border of the Coastal Cordillera and the Central Depression, and in the western part of this area porphyritic and aphanitic andesite lava and pyroclastics of the Aeropueruto Formation dominate. In the eastern part the Aeropueruto formation is in many places covered by andesitic lava and pyroclastics of the Palaeogene Chile-Alemania Formation and Neogene Atacama conglomerate.

These volcanic rocks are penetrated by batholith so called "the Cerro de Pingo Group" composed of diorite, tonalite and granite and small rock bodies of dioritic or andesitic porphyry, thought to have been active from the later Cretaceous Period to the Paleogene Period.

Within the area are located the Pampa Copper Mine (small-scale, at present unworked, irregular form, chrysocolla, hematite, specularite, calcite) 3 km east of the peak of the Cerro Veraguas, and the San Juan Copper Mine (small-scale, at present unworked, veined, chrysocolla, hematite) 2.5 km to the southwest. In addition, 8 km to the east, outside the area are distributed the Sierra Overa group of copper and gold mines, at present unworked or worked on a small scale. Thus it may be considered that the potential for copper and gold deposits in this area is high.

3-3 General Geology in the Survey Area

3-3-1 Drilling survey area

The area is composed of the Aeropuerto formations of the Cretaceous period and intrusive rocks. These rocks had been altered in the Tertiary period, forming the Cerro Veraguas and the Sierra Overa. The flat or gently sloping areas surrounding the hills are covered in alluvium, colluvium and river deposits of the Pliocene to the Quaternary periods.

The Aeropuerto formations are composed mainly of dacitic or andesitic volcanic rock and are accompanied with subordinate sedimentary rocks. The intrusive rocks are composed of quartz diorite, tonalite, quartz andesite and porphyry. The type of alteration is seemed to be derived from lava or pyroclastics. According to ENAMI (1987), the alteration is classified into intensely silicified zone, quartz-sericitized zone, siliceous-argillized zone and propylitized zone. In the intensely silicified and quartz-sericitized zones, there are strong concentrations of sulfide cercilla relics, limonite, hematite, jarosite, etc., controlled by the fracture zone.

In the quartz-sericitized zone northeast of the Sierra Overa, is the San Juan Copper Mine (small-scale, containing chrysocolla, at present unworked).

3-3-2 Geochemical survey area

The Northwest District to the NW of the Sierra Overa, and the Pampa District to the SE of the Cerro Veraguas, i.e. the areas from which samples of caliche were collected, are composed of alluvium and colluvium, with river deposit in parts. In the flat land in the eastern part of the Pampa District is located the Pampa Copper Mine (small-scale, malachite, chrysocolla, atacamite, hematite, specularite, calcite, irregular form, at present unworked). ENAMI (1993) has carried out trench surveys of the Pampa Mine, and has announced ore analysis results showing 0.004% - 4.3% copper.

The Pampa South District in the southeast of the area, where samples of rock were gathered, is composed of altered rock that was originally lava and volcano clastics. The altered rock is classified in the field as silicified rock, silicified-and-argillized rock, and propylite. Quartz porphyry is also present as an intrusive rock.

The silicified rock is distributed in the greater part of this district, and shows colors of light gray, red-grey and purplish red. The texture of the original rock has been almost disappeared by the alteration, but in some parts layered tuff or lapilli tuff structure can be seen to remain. Compared with silicified rock, the silicified-and-argillized rock is a rather weak silicified rock, due to its containing of white clay. It displays a light gray color, and shows small-scale distribution inside the alluvium in the central north part of the district. Propylite displays a light green color, and its distribution is most notable in the northeastern part of the district. Quartz-porphyry is distributed in the central south part of the district as unaltered rock, phenocrysts of amphibole and plagioclase are manifest, and the grondmass shows cryptocrystalline texture.

It is also observed that there was intrusion in N65°W direction where small dikes of about 10 m width, thought to be subsidiary dike.

In the altered rock, hematite dissemination is frequently observed. In some places strong concentrations of hematite, black in parts, run in veins in a N30°-40°E direction; the veins were 1 to 5 metres in width, and show an almost vertical inclination. In the chloritized zone, dissemination of oxide copper is observed.

3-3-3 Occurrence of caliche

The caliche is not formed on all flat to gently sloping areas; it is formed in places where the alluvial to colluvial deposits are relatively thin, such as area around the hills of calich. Distribution is spread over relatively large areas. Meanwhile, the places where caliche is not formed are dry river beds, floodplains with large rocks, and places where alluvial to colluvial deposits are well developed.

However, there are cases of caliche being formed on the walls of the remains of small water courses, and this is thought to be formed after water flowed here in the past.

The caliche mainly shows massive or porous and flaky or comb-like appearance, and in some cases

contains pieces of rock fragment. There are also some caliche in crystal form, and some in powder form. There are also some sandy caliche, made up for large amount of sand, and caliche which cements with sand grains. Massive, porous and powder-type caliche display white color; the crystal type displays light to dark brown color, depending on the amount of limonite present, and caliche tinged with yellow may contain slight quantity of jarosite.

The depth of formation is 30 cm from the surface, but there is also cases of caliche being formed at the bottom of pits dug 2 to 3 metres deep, called Cata ; and it is possible that in places where the alluvium is thickly developed, there may be caliche formed deep down even though there is none formed near the surface.

3-4 Brief History of Mining in the Area

Boric et al. (1990) classified the mineral deposits of the Coastal Cordillera as a Coastal Cordillera Metalogenic Province, and those of the Central Depression and the Domeyko Cordillera as the Domeyko Metalogenic Province.

In the Coastal Cordillera Metalogenic Province, many vein and/or bedded (manto-type) copper ore deposits are found, with some veins of gold/silver in parts. The Domeyko Cordillera Metalogenic Province are characterized as gold/silver vein deposits and vein, irregular, bedded and stockwork (porphyry copper ore deposits) copper ore deposits.

As shown in Table I-3-1 and Fig. 1-3-4, known deposits in and around this area are mainly Cu-Au-Ag vein deposits in a ground of Aeropuerto formation and intrusive rock, with some bedded-vein copper deposits in places.

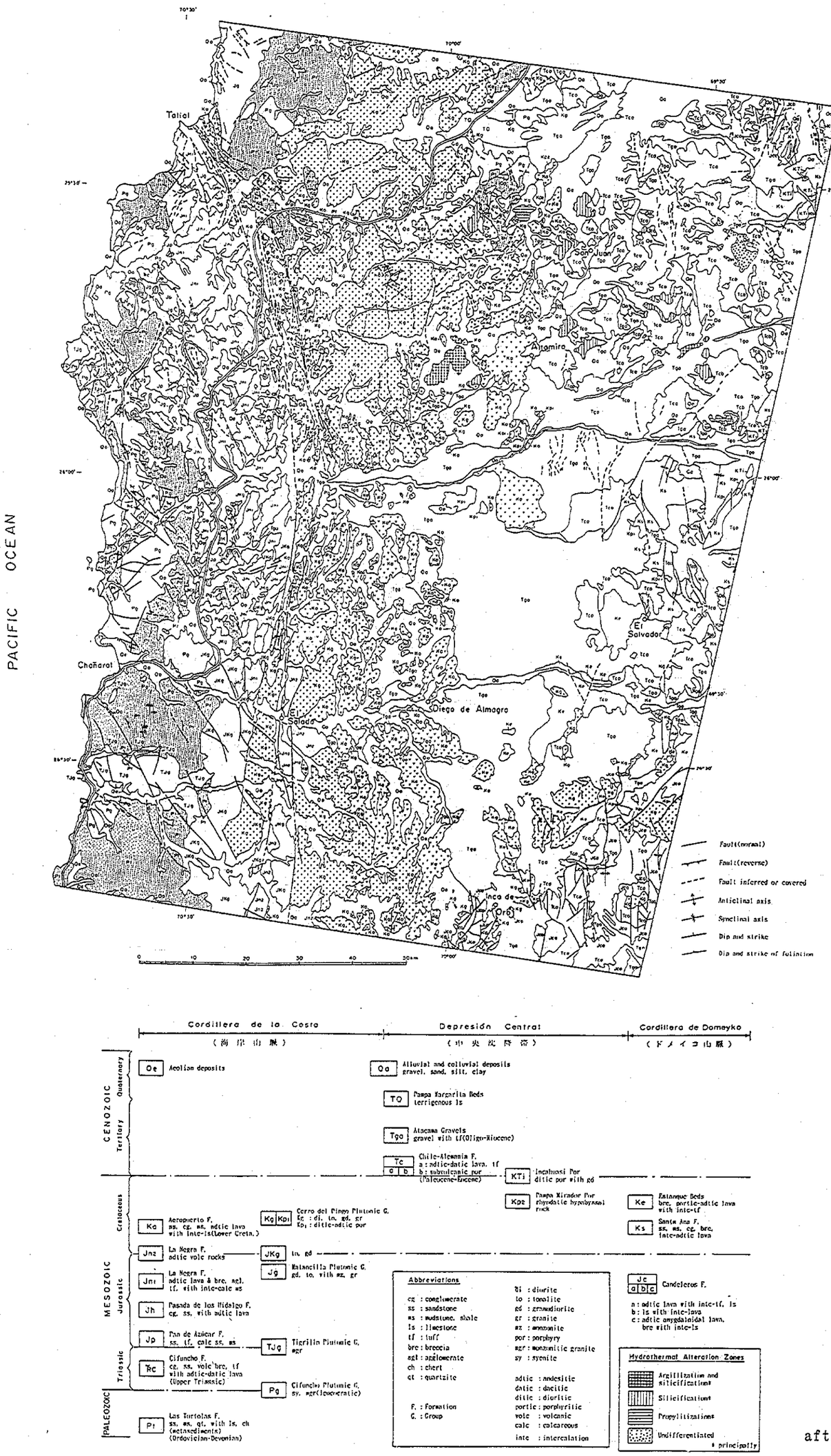
Vein deposits are in most cases mined for the ores yielded from oxidized belts of malachite, chrysocolla, atacamite, covelline etc., or the chalcocite yielded from belts of secondary enrichment, but in either case mining activities amount to no more than very small-scale workings, and there are no reliable records regarding production quantities.

The Frankenstein deposits, 13 km east of the peak of the Cerro Veraguas, are bedded-vein deposits in a ground of andesitic breccia Aeropuerto formation. The main ore minerals are chrysocolla, malachite, cuprite and chalcocite, with small amounts of chalcopyrite, covelline and silver ore. The scale of the mine is a strike extension of 200m, thickness of 1.5-2m, depth 120m; the grade is 2.5% Cu, 100g/t Ag, estimated amount of deposits 670,000 tons (1984).

Table1-3-1 Mines around the Veraguas area

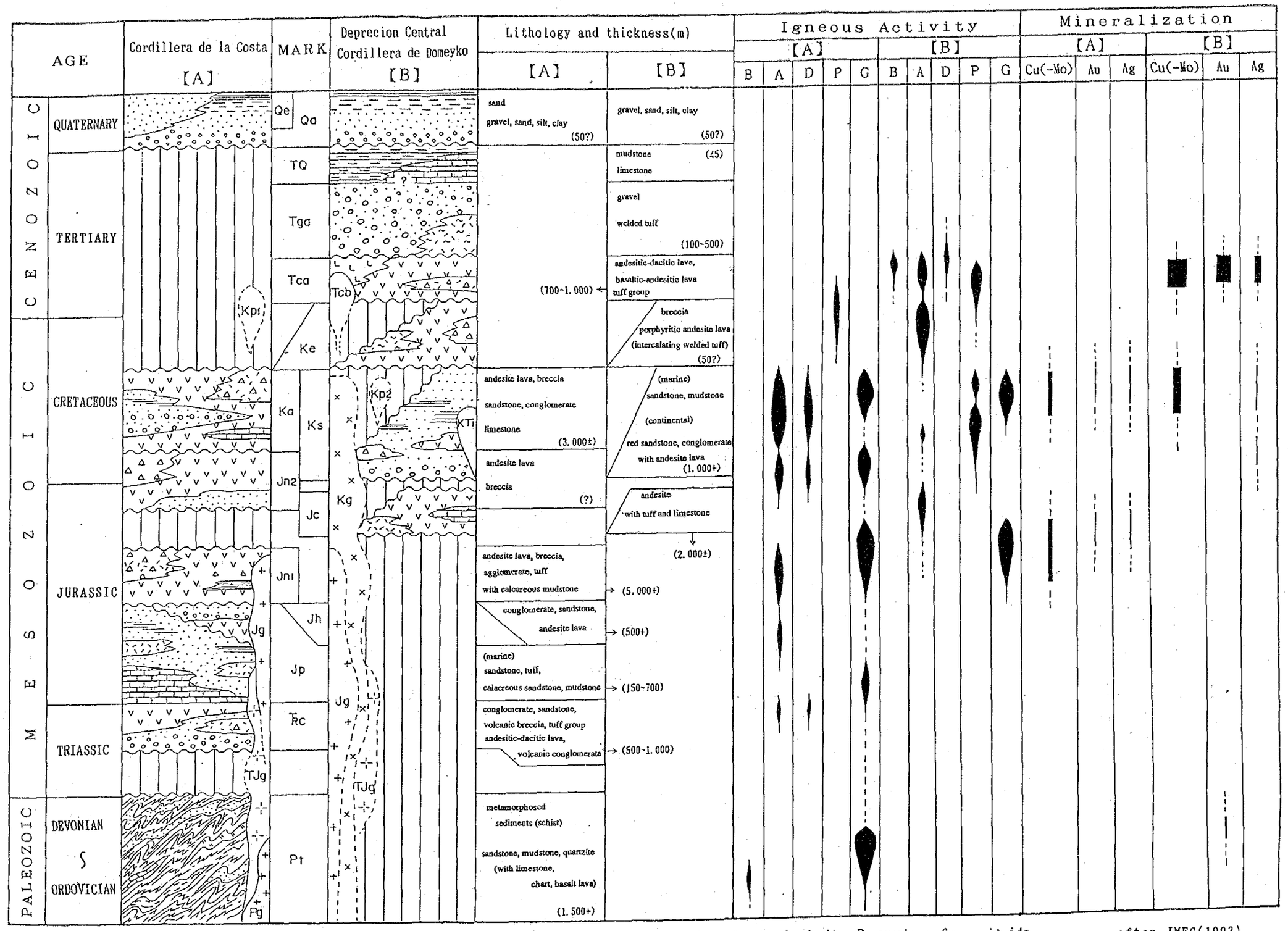
No.	Name of mine	Location	Metalic elements
69	Los Maritos	25° 38′ 53″ 70° 02′ 15″	Cu
75	Corea	25° 44′ 33″ 69° 58′ 03″	Cu
76	Gladys Candelaia	25° 46′ 46″ 69° 56′ 24″	Au
77	Overa	25° 46′ 29″ 69° 54′ 47″	Au,Cu
78	Aguilucho	25° 46′ 11″ 69° 51′ 07″	Cu
79	Los Angelitos	25° 48′ 54″ 69° 56′ 59″	Cu
80	La Gloria	25° 48′ 52″ 69° 55′ 09″	Cu,Au
81	Frankenstein o Francke	25° 49′ 07″ 69° 51′ 31″	Cu,Ag
82	San Juan	25° 48′ 27″ 70° 00′ 41″	Cu
98	Teresa de Colmo Chica -Julia	25° 57′ 05″ 70° 03′ 35″	Cu,Fe
99	Teresa de Colomo	25° 54′ 54″ 70° 02′ 30″	Cu,Mn
100	Chatal,Mateo	25° 50′ 13″ 70° 04′ 32″	Cu,Fe
111	Aguada La Brea	25° 54′ 00″ 69° 49′ 30″	Cu
112	Mantos de PÉrez Sur	25° 54′ 00″ 69° 52′ 20″	Cu
113	Mantos de PÉrez Norte	25° 51′ 00″ 69° 51′ 00″	Cu
114	La Picot	25° 53′ 57″ 69° 58′ 30″	Cu
115	Chita	25° 50′ 03″ 69° 55′ 42″	Cu, Ag, Au
117	Frankestein	25° 49′ 39″ 69° 51′ 40″	Ag,Cu

JMEC(1993)



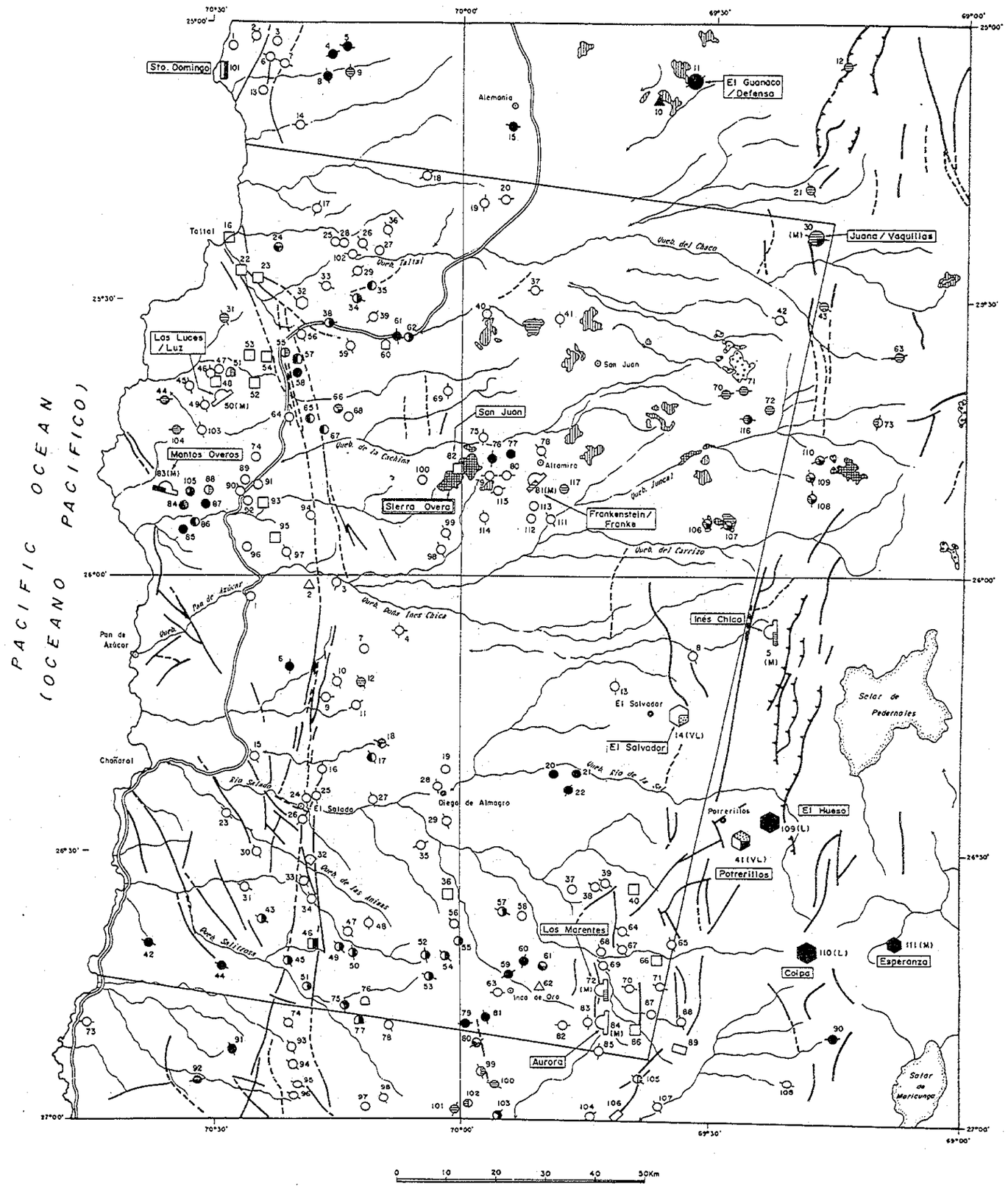
after JMEC(1993)

Fig. I-3-1 Regional geology of the Veraguas area



* B : basalt, A : andesite, D : dacite, P : porphyry, G : granitoids after JMEC(1993)

Fig. I-3-2 Synthetic geologic column



Metallic Element

- Cu
- Au
- Ag
- Mo

82 San Juan — Number and name of ore deposit

Relative Importance of Elements

- 2 principals
- 2 principals, 1 subordinate
- 1 principal, 1 subordinate

Occurrence of Ore Deposit	
Simple	Composite
Vein(with indication of strike)	Vein-irregular
Irregular, bunch	Stratiform-vein
Stockwork (including porphyry copper)	
Breccia pipe	
Stratiform (oriented by strike)	

Hydrothermal Alteration Zone

- Argillization and silicification*
- Silicification*
- Propylitization*
- Undifferentiated

* principally

Category of Ore Deposit

VL : Very large
L : Large
M : Medium
(Others are categorized into small deposits)

	Small	Medium	Large	Very large
Cu	<10.000	10.000 – 1.000.000	1.000.000 – 10.000.000	>10.000.000
Au	<2	2 – 200	>200	>10.000.000
Ag	<60	60 – 6.000	>6.000	

(metal content: t)

- Major fault
- Reverse fault

after JMEC(1993)

Fig. I-3-3 Distribution of ore deposits and hydrothermal zones

CHAPTER 4 DISCUSSION OF THE SURVEY RESULTS

4-1 Characteristics and Structural Control of the Mineralizing Alteration

An examination of the mineralizing alteration effect and structural control in the region in question was carried out as follows, on the basis of the results of the drilling survey and existing data.

1. Cerro Veraguas summit district(MJCV-1 & MJCV-2)

The district is made up of andesitic volcanics and porphyry that have undergone hydrothermal alteration, and conjugate fracture zones with a NE-SW and NW-SE direction are developed.

Hydrothermal alteration is zonalized, from the top down, into a intensely silicified / quartz-sericified transition zone, siliceous argillized zone and chloritized zone. In the lower part of the siliceous argillized zone and in the chloritized zone, quartz, sericite and pyrite are found universally, as well as kaolinite and chlorite, corresponding to the phillic zone of the hydrothermal alteration classification of porphyry copper deposits according to Lowell and Guilbert (1970). Each zone possesses a brecciated or pseudobrecciated structure, the matrix has undergone kaolination and sericitization, and hematite, limonite and jarosite are developed in stockwork form; from which it may be considered that the brecciation effect occurred at the time of hydrothermal activity.

Copper mineralization is found in the border area between the porphyry and andesitic volcanics in the lower part of the siliceous argillized and the chloritized zone and along the fracture zone within the porphyry, but since the copper grade at T.Cu 500-1100ppm is low, and is accompanied as shown at the MJCV-2 hole by the mineralization effect of small amounts of lead and zinc, it is supposed that the area is some distance from the center of the mineralization.

2. Cerro Veraguas southern district (MJCV-3)

The district is made up of andesitic volcanics and porphyry that have undergone hydrothermal alteration, and conjugate fracture zones with a NE-SW and NW-SE direction are developed.

Like the Cerro Veraguas summit district, hydrothermal alteration is zonalized, from the top down, into intense silicified / quartz-sericified transition zone, siliceous argillized zone and chloritized zone. In the lower part of the siliceous argillized zone and in the chloritized zone, quartz, sericite and pyrite are found universally, as well as kaolinite and chlorite, corresponding to the phillic zone of the hydrothermal alteration classification of porphyry copper deposits according to Lowell and Guilbert (1970). Each zone possesses a brecciated or pseudobrecciated structure, the matrix has undergone kaolination and sericitization, and hematite, limonite and jarosite are developed in stockwork form, from which it may be considered that the brecciation effect occurred at the time of hydrothermal activity.

Also, from the CSAMT results, the fact that on both the east and west sides of the MJCV-3 hole the

high resistivity band corresponding to the intensely-silicified zone displays a form that hangs down deep suggests that this point is the center of the hydrothermal alteration and that the strongly silicified zone is developed downwards.

Copper mineralization was discovered in the porphyry of the chloritized zone below 300m at the MJCV-3 hole, in particular in the border area with the andesitic volcanics, and 10 points a total, 14m, had a T.Cu reading of 500-7000ppm. At these points the molybdenum grade is also high, with an average of 52.4ppm between 300-375 m and a maximum of 213ppm, indicating the special features of porphyry copper deposits.

3. Sierra Overa eastern district (MJCV-4)

The district is made up of andesitic volcanics and porphyry that have undergone hydrothermal alteration, and a fracture zone is developed in a N-S direction. From the fact that porphyry cuts the andesitic volcanics like a dike in shape at altitudes below 1,350 m above sea level, it is assumed that it split from the surrounding stock-form porphyry to intrude.

The hydrothermal alteration is zonalized, from the top down, into a quartz-sericified zone, siliceous argillized zone and chloritized zone. The lower part of the siliceous argillized zone and the chloritized zone 206 m at the MJCV-4 hole are made up of quartz, sericite, gypsum, anhydrite and pyrite, as well as kaolinite and chlorite, and within this the chloritized zone between 448.15-467.5m and between 478.9-493.5m is rich in albite and potassium feldspar. Thus the former corresponds to the phillic, and the latter to the potassic, zone of the hydrothermal alteration classification of porphyry copper deposits according to Lowell and Guilbert (1970). Each zone possesses a brecciated or pseudobrecciated structure, the matrix has undergone silicification, kaolination and sericitization, and hematite, jarosite and limonite are developed in stockwork form, from which it may be considered that the brecciation effect was brought about at the time of hydrothermal activity. In addition, the fracture zone between 62.9-171.5m shows marked kaolinization, with concentrations of hematite, jarosite and limonite; from this it is possible that the fracture zone in a N-S direction may have been a passage for hydrothermal solution.

Copper mineralization was found in the lower part of the siliceous argillized zone and chloritized zone, especially in and around the border area between the porphyry and andesitic volcanics below 206m at the MJCV-4 hole, and in the potassic zone mentioned above; and 7 points a total, 13m, had a T.Cu reading of 500-3200ppm. Around the potassic zone below 490 m, gold mineralization (Au 0.6-4.8ppm) was also discovered.

From the fact that to the north and east of the Sierra Overa lie the San Juan deposits, and that anomalies in Cu and Mo are distributed controlled by the fracture zone in a N-S to NNW-SSE direction, it may be considered that the mineralizing alteration in this area is affected by N-S structural control.

4. Sierra Overa southwest district (MJCV-5)

The district is made up of andesitic volcanics and porphyry that have undergone hydrothermal alteration, and a fracture zone is developed in a N-S direction. From the fact that the porphyry is continuous below 1,300m above sea level, the existence of a stock-form porphyry may be presumed.

The fact that a intensely silicified zone continues for 206.9 m from the mouth of the MJCV-5 hole and a CSAMT high resistivity band corresponding to the intensely-silicified zone displays a form that hangs down, suggests that the strongly silicified zone is developed downward. The siliceous argillized zone and chloritized zone below 206.9 m are made up of quartz, sericite, gypsum, anhydrite and pyrite as well as kaolinite and chlorite, corresponding to the phillic zone of the hydrothermal alteration classification of porphyry copper deposits according to Lowell and Guilbert (1970). These zones of alteration are compact and massive, with few places displaying a brecciated structure; but the fracture zone between 219.1-321.4m shows marked kaolinization with concentrations of hematite, jarosite and limonite; from which it is possible that the fracture zone in a N-S direction may have been a passage for hydrothermal water.

Between 280-292m, where the porphyry and N-S fracture zone intersect, T.Cu gave an average reading of 540ppm, and between 364-367m, the border area of the chloritized and siliceous argillized zones within the porphyry, an average of 1,041ppm; from this it is surmised that the copper mineralization was controlled by changes in the alteration environment within the porphyry, and by the N-S fracture zone which was a passage for hydrothermal water.

4-2 Relationship between the CSAMT Results and Mineralizing Alteration

Study of the results of the present drilling survey and the CSAMT results (ENAMI, 1993), showed clearly that the following correspondences between the geological conditions and areas of resistivity.

1) High resistivity band (>300 ohm.m):

Intensely silicified zone or fresh rock. The deep hanging-down of the high resistivity band seen in and around the MJCV-3 and MJCV-5 holes are predicted to indicate the downwards development of the intensely-silicified zone.

Also, it is predicted that the high resistivity areas of the depth indicate the occurrence of a weakly-altered intrusive rocks.

2) Medium resistivity band (100-300 ohm.m):

The lower part of a siliceous argillized zone that has undergone weak kaolination, and andesite and porphyry accompanied by pyrite-dissemination in the chloritized zone.

3) Low resistivity area (<100 ohm.m):

Siliceous argillized zone. In particular, fracture zones with marked argillization correspond to a range below 20 ohm.m.

CHAPTER 5 CONCLUSION AND RECOMMENDATION

5-1 Conclusion

The conclusions reached from the first phase survey are as follows.

5-1-1 Drilling Survey in the Veraguas Area

The survey was carried out 5 holes, with a total length of 2,053 m. The locations for the drilling holes were selected with the following points in mind.

1) Areas where ground surface surveys confirmed zones of mineralizing alteration and geochemical anomalies.
2) Areas shown by physical survey (CSAMT method) to be of low to medium resistivity, thought to correspond to zones of mineralizing alteration.

Results of the survey were as follows.

1. Geology and alteration

The rocks observed at each of the holes were made up of andesitic volcanics of the Cretaceous Aeropuerto formation, porphyry intrusive rocks and altered rocks originating from these rocks.

The andesitic volcanics are made up of porphyritic and aphanitic andesitic lava, autobrecciated lava, tuff and lapilli tuff, and form the basement of the region. These rocks have undergone silicification, kaolinization, sericitization and chloritization and the initial minerals have altered; in many places the texture of the original rock is indistinct.

The porphyry intrusive rocks are comprised of andesite- or diorite- porphyry penetrating the andesitic volcanics in dike or stock-form; to the naked eye they display sub-volcanic texture like tuff and lava, and there are places where the border with andesitic volcanics is indistinct. These rocks have phenocryst of quartz and plagioclase, but the initial minerals have altered through undergoing silicification, kaolinization, sericitization, chloritization, potassium addition and albitization.

The altered rocks were originally the rocks described above that have undergone hydrothermal alteration; they form the mass of the Cerro Veraguas and the Sierra Overa. Based on the classification of alteration zones by ENAMI (1987), they are divided into 4 zones, from the top down, intensely silicified zone, quartz-sericitized zone, siliceous argillized zone and chloritized zone.

Of these, the siliceous argillized zone and the chloritized zone are made up of quartz, sericite, gypsum, anhydrite and pyrite, as well as kaolinite and chlorite, and correspond to the phillic zone of the hydrothermal alteration classification of porphyry copper deposits according to Lowell and Guilbert (1970). In addition, the chloritized zone between 448.15-467.5m and between 478.9-493.5m at the MJCV-4 hole is rich in albite and potassium feldspar, corresponding to the potassic zone of the same

classification.

Each zone of alteration possesses a brecciated or pseudobrecciated structure, the matrix has undergone strong kaolinization and sericitization, and hematite, jarosite and limonite are developed in stockwork form, from which it may be considered that the brecciation effect was brought about at the time of hydrothermal activity.

2. Mineralization effect

The lower part of the siliceous argillized zone and the chloritized zone which were originally porphyry and part of the andesitic volcanics, correspond to the phillic zone of alteration of porphyry copper deposits; pyrite dissemination is prominent and is accompanied by sphalerite and galena as well as copper minerals such as chalcopyrite, chalcocite, covelline and cuprite.

The special features of copper mineralization understood as a result of the drilling survey are as follows.

(1) Cerro Veraguas summit district (MJCV-1 & MJCV-2):

Copper mineralization is found in the porphyry of the lower part of the siliceous argillized zone and in the chloritized zone, particularly in the border area with the andesitic volcanics and along the fracture zone within the porphyry; but since the copper grade at T.Cu 500-1100ppm is low, and is accompanied as shown in the MJCV-2 hole by the mineralization effect of small amounts of lead and zinc, it is supposed that the region is some distance from the center of the mineralization.

(2) Cerro Veraguas southern district (MJCV-3):

Copper mineralization is found in the porphyry of the chloritized zone below 300m at the MJCV-3 hole, in particular in and around the border area with the andesitic volcanics; and 10 points a total, 14m, had a T.Cu reading of 500-7000ppm. At these points the molybdenum grade is also high, with an average of 52.4ppm between 300-375 m and a maximum of 213ppm, indicating the special features of porphyry copper deposits.

(3) Sierra Overa eastern district (MJCV-4):

Copper mineralization is found in the lower part of the siliceous argillized zone and in and around the border area between the porphyry and andesitic volcanics of the chloritized zone below 206m at the MJCV-4 hole and around the potassic zone below 400m; and 7 points a total, 13m, had a T.Cu reading of 500-3200ppm. Around the potassic zone below 490 m, gold mineralization (Au 0.6-4.8ppm) is also discovered. The discovery of copper and gold mineralization in the potassic zone shows the special features of porphyry copper deposits.

(4) Sierra Overa southwest district (MJCV-5):

Between 280-292m at the MJCV-5 hole, where the porphyry and N-S fracture zone intersect, T.Cu measured 540ppm, and between 364-367m, the border area of the chloritized and siliceous argillized

zones within the porphyry, 1,041ppm; from this it is surmised that the copper mineralization was controlled by changes in the alteration environment within the porphyry, and by the N-S fracture zone, a passage for hydrothermal water.

The results of the ore analysis showed the copper grade to be 7000ppm maximum, and did not lead directly to the discovery of deposits; but it was discovered that there was copper and molybdenum mineralization below 300m at the MJCV-3 hole in the Cerro Veraguas south district, and copper and gold mineralization below 400m at the MJCV-4 hole in the Sierra Overa eastern district. These instances of mineralization indicate the special features of porphyry copper deposits, and it may be expected that such deposits do exist nearby.

5-1-2 Geochemical Survey

179 samples of caliche were collected in the Pampa and Northwest Districts where caliche is present in the alluvium/colluvium distribution areas. In addition, 49 samples of rock were collected from the hills in the Pampa South District where altered rocks are distributed. On these samples chemical analysis for 9 components was carried out and the geochemical anomalies obtained were examined.

With regard to the caliche, in the area around the Pampa Mine deposits, which are the only known mineral deposits in the area under investigation, results showing geochemical anomaly area of T.Cu and S.Cu were obtained. This is considered a clear reflection of the presence of mineral deposits below the alluvium/colluvium. Except the area around the Pampa Mine, a geochemical anomaly area of T.Cu and S.Cu was obtained at the east end of sampling line W in the Northwest District, and the presence of copper deposits below the alluvium/colluvium is expected here too. However, this zone of geochemical anomaly lies along the course of a dry river, and it is possible that the copper deposits exist upstream side.

While geochemical anomalies of S occur in around the Pampa Mine, on the eastern end of sampling line W geochemical anomaly area of FeO, Fe_2O_3 and SiO_2 occur, and it is possible that the copper deposits which may be expected to lie on the eastern end of sampling line W are of a different type to the Pampa Mine deposits.

With regard to the rock, geochemical anomaly of T.Cu is accordant with the existence of hematite, and since the hematite is considered to have been replaced from magnetite through the action of acidic hydrothermal activity, the geochemical anomaly of T.Cu is expected as being attributable to the presence of some amount of Cu in the igneous magnetite. In addition, from the fact that the acidic hydrothermal alteration in this district is different from the type of the potassium type alteration or phyllic type alteration that characterize the hydrothermal alteration of porphyry copper deposits, and neither pyrite nor its secondary mineral jarosite is present at all, the conclusion is reached that there was no mineralization accompanying the hydrothermal activity in this district.

5-2 Recommendation for the Phase II

On the basis of the results of the Phase I surveys the following recommendations are made for Phase II. The survey district for Phase II is shown in Fig. I-5-1.

5-2-1 Drilling Survey

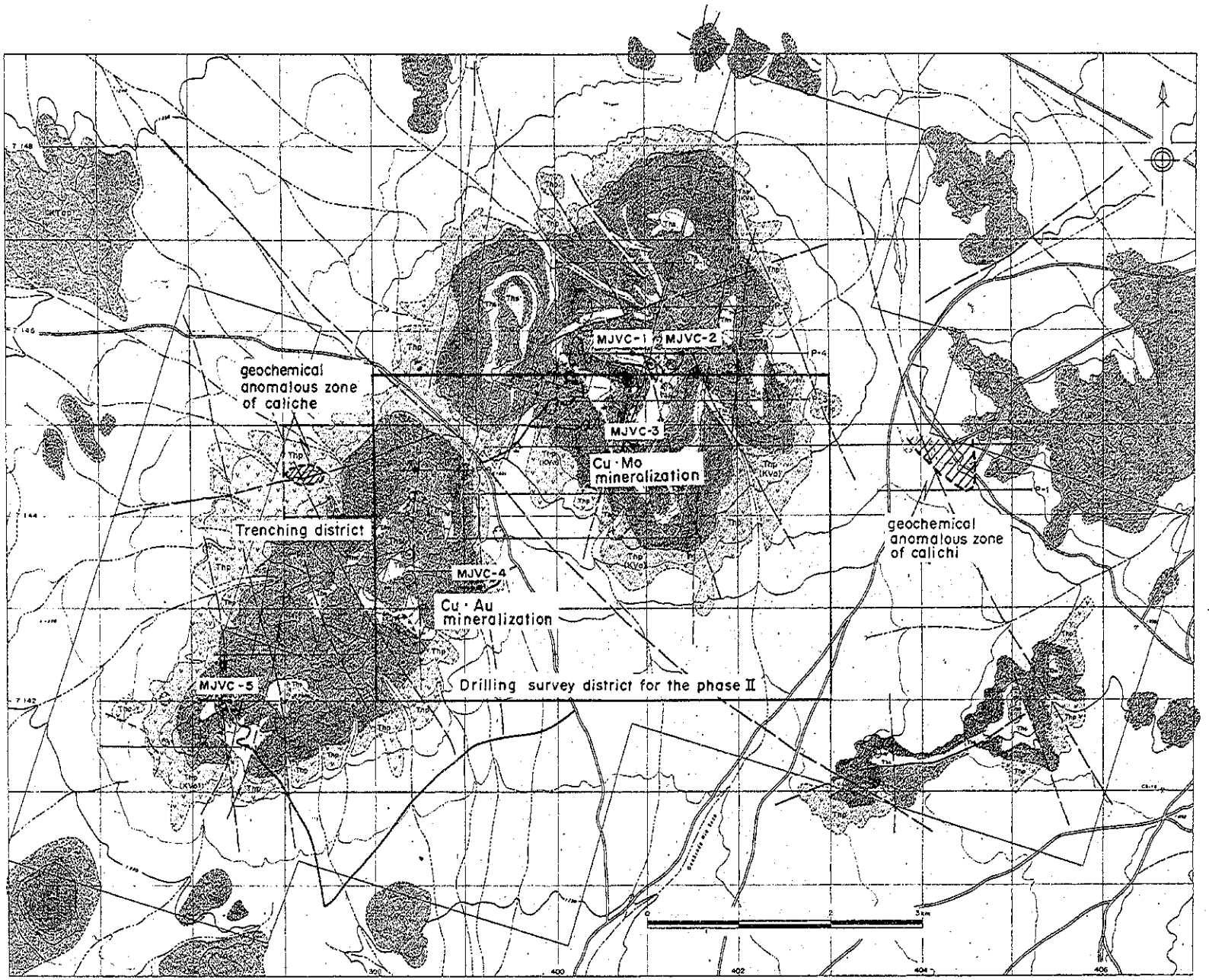
The present survey did not lead directly to the discovery of deposits, but it was discovered that there was copper and molybdenum mineralization below 300m at the MJCV-3 hole in the Cerro Veraguas southern district, and copper and gold mineralization below 400m at the MJCV-4 hole in the Sierra Overa eastern district. These instances of mineralization indicate the special features of porphyry copper deposits, and it may be expected that such deposits do exist nearby. On the northern side of the Sierra Overa, some 1,500 m northwest of the MJCV-4 hole, are the San Juan deposits.

It follows that in Phase II, it would be desirable for drilling survey to be carried out in the district reaching from southern hillside of the Cerro Veraguas to the east and north of the Sierra Overa.

5-2-2 Geochemical Survey

With regard to the eastern end of sampling line W in the Northwest District where geochemical survey of the caliche showed geochemical anomaly area of Cu, it is advisable that a trench survey be carried out to ascertain the presence of the expected copper deposits beneath the alluvium/colluvium. However, since this geochemical anomaly lies along a dry river and the possibility exists that the copper deposits lie upstream side, it is desirable that the trench survey be carried out from the geochemical anomaly area toward its southeast part.

It is judged that there is no need to continue the survey in the area where the geochemical survey of rock was conducted.



Legend

Lithology

- Alluvial, colluvial and fluviatile deposits

Aeropuerto formation

- KVo — Andesitic volcanics with intercalated beds of sandstone and breccia
- KVo1 — Trachyandesitic volcanics with intercalated beds of sandstone and breccia

Intrusion

- KTp — Dioritic ~ andesitic porphyry
- KTqp — Tonalite ~ quartz ionite
- Kqsp — Quartz diorite

Hydrothermal Alteration zone

- Ths — Intensely silicified zone
- Thsr — Quartz sericitized zone
- Tha — Siliceous argillized zone
- Thp — Chloritized zone (Propylitized zone)
- Limonite ~ Jorosite rich zone
- Sulfide Cercillas relic zone (principally pyrite)
- Fault (broken line shows inferred fault)
- Gelogic contact
- Access road
- P-1 Geophysical survey line

Geochemical anomalous zone
- >30ppm
- > 90ppm Cu
- > 30ppm Mo
- >100ppm As
- >100ppm Pb

Geophysical anomalous zone of 1,400meters level
- < 20Ω·m
- 100Ω·m
- >300Ω·m

- Drilling site
- * and —·— Direction of drilling
- MJCV-1 No. of drillhole

Fig. I-5-1

Survey result and recommendation for the phase II

(1 : 60,000)

Analysis of Existing Data, Phase I

Veraguas Project, JICA/MMAJ-ENAMI

PART II DETAILS OF SURVEY

PART II DETAILS OF SURVEY

CHAPTER 1 ANALYSIS OF EXISTING DATA

1-1 Veraguas Area

1-1-1 Outline of previous surveys

The hydrothermal alteration zones of the Veraguas area have been mentioned by Kents. P (1962), Ruge, H (1977) and Naranjo, J.A. et al. (1984), and their existence has been noted, but no prospecting has been carried out in earnest. However, since 1987 ENAMI has turned its attention to the hydrothermal alteration zones in the area, and has carried out the geological, geochemical and geophysical surveys listed in the table below. The results of these surveys are shown in Fig. II-1-1.

Dates of submitting reports	Contents of investigations	Title of reports and investigators(*)
Oct.1987	Analysis of topography by aerial photographs (1:60,000) Preliminary geological survey 12.5×14km 180km² (1:50,000) Preliminary geochemical survey 15km² (1:10,000)	ENAMI(1987):ESTUDIO GEOLOGICO-ECONOMICO PRELIMINAR DEL AREA DE LAS PERTENENCIAS MINERAS VIRGO1-1213 DEL DISTRITO MINERO DE SIERRA OVERA *MAGMA GEOLOGOS CONSULTORES ASOCIADOS
Apr.1993	Detailed geological & geochemical survey 6districts 4.3km² (1: 5,000)	ENAMI(1993):EVALUACION GEOLOGICA PROSPECTO CERRO VERAGUAS *EGM SERVICIOS LTDA.
Jun.1993	CSAMT electorode spacing 100m 13profile lines, a total of 30,600m	ENAMI(1993):ESTUDIO GEOFISICO MEDIANTE CSAMT SECTOR SIERRA OVERA *GEODATOS

1-1-2 ENAMI (1987): ESTUDIO GEOLOGICO-ECONOMICO PRELIMINAR DEL AREA DE LAS PERTENENCIAS MINERAS VIRGO 1-1213 DEL DISTRITO MINERO DE SIERRA OVERA

A preliminary geological & geochemical survey was conducted in the Sierra Overa area, in particular the Virgo 1-1213 mining field; the characteristics of the alteration and mineralization of the Cretaceous andesitic to latitic volcanics and the Tertiary silicified hypabyssal rock were clarified, and it was suggested that detailed geological, geochemical and geoelectrical surveys should be conducted.

A summary of the results of this survey follows.

1. Cerro Veraguas District

Hydrothermal alteration in the district is of the epithermal type, and intensely-silicified, quartz-sericitized, siliceous argillized and propylitized zones are distributed in strata form.

The intensely silicified zone has silica-cinter characteristics, and is found at the peak of the Cerro Veraguas. Below that is a horizontal quartz-sericitized zone, which in the lower parts shifts to a siliceous argillized zone. At the foot of the mountain is distributed propylitized country rocks, covered by a Quaternary stratum.

In addition to stockwork hematite, strong concentrations of pyrite cerdillas relics, and jarosite and limonite are found controlled by the fracture zone.

At the west to southwest foot of the Cerro Veraguas there are geochemical anomalies in Au, Ag, Cu and Mo, indicating a volcanic vent or a passage for hydrothermal solution.

2. Sierra Overa District

Hydrothermal alteration in the district is characterized by porphyry copper deposits with silicic veins in chimney-form breccia pipes. The intensely-silicified and quartz-sericitized zones lie on the central mountainside and natural high ground in an egg-shape pointing NE-SW and measuring 1.5km x 0.8km, and a siliceous argillized zone has a wide distribution in the surrounding area. At the foot of the mountain are distributed propylitized country rocks, covered by a Quaternary stratum.

No primary ore minerals are to be found with the exception of disseminated hematite and stockwork specularite. However, in the center of the intensely silicified and quartz-sericitized zones strong concentrations of pyrite cerdillas relics, jarosite and limonite are found controlled by the fracture zone. Geochemical anomalies in Mo were found at a spot 1,781 m above sea level at the foot of the mountain on the southeast side.

In the San Juan ore deposit located to the NE of the area, secondary oxides of copper (atacamite, chalcanthite, chenevixite) lie in strata and controlled by the NE-SW veins. This mineralization may be considered to have percolated out from the primary minerals that it is expected originate deep within the Sierra Overa.

3. Pampa Sierra Overa Area

The Pampa Sierra Overa mountainside is located on the eastern edge of the survey area, and extends for 4 km. In this area, in the border zone between the intrusive rocks comprised of tonalite and quartz-diorite near the 1,781 m summit and the andesitic volcanics of the Aeropuerto formations, copper oxide minerals (atacamite, chenevixite, chrysocolla) are disseminated in irregular veins with a maximum width of 1m consisting of hematite, calcite, quartz and epidote. These minerals display in parts a massive or stockwork formation, and the spot copper grade is 10% in places. The scale and depth of the mineralization is unclear, and it is necessary to carry out an economic evaluation through test drills and trenching. Also in this area, geochemical anomalies are found in Au(0.1-0.7g/t) and Mo.

1-1-3 ENAMI (1993):ESTUDIO GEOFISICO MEDIANTE CSAMT SECTOR SIERRA OVERA

A CSAMT survey was carried out in this area, to study the potential for porphyry copper type mineralization or mineralization accompanying silicification.

A summary of the results of this survey follows.

1. Bands with high resistitivity

Bands with high resistitivity of >300 ohm.m correspond to intrusive rocks or silicified zones; it may be considered that high resistitivity distributed vertically near the surface indicates silicified rocks, and that high resistitivity distributed deep down over a wide area indicates intrusive rock.

2. Bands with medium resistitivity

Bands with medium resistitivity of 100-300 ohm.m correspond to volcanic rocks and sedimentary rocks, and are distributed over the whole area.

3. Bands with low resistitivity

Bands with low resistitivity of 30-100 ohm.m correspond to conglomerate or zones of alteration of intrusive or volcanic rock.

4. Bands with very low resistitivity

Bands with very low resistitivity of <30 ohm.m correspond to mineral-alteration or water-saturated clay zones.

5. Selected places

The following district with a distribution of very low resistitivity bands are selected as places with a high potential for mineralization.

Central part of the Cerro Veraguas
Eastern part of the San Juan Mine
Southwest part of the Sierra Overa

It may also be considered that there is a possibility of mineralization around the intrusive rock masses and silicified zones that show high resistitivity.

1-1-4 ENAMI (1993): EVALUACION GEOLOGICA PROSPECTO CERRO VERAGUAS

Detailed geological and geochemical surveys were carried out in six areas picked out from the hydrothermal alteration zones forming the Cerro Veraguas and the Sierra Overa.

On the basis of the results obtained and the results of the above-mentioned geophysical survey, targets of exploration were picked out and it was suggested that drilling survey be carried out as the next stage.

A summary of the results of this survey follows.

1. Cerro Veraguas District

(1) Results of geological survey

On the ground surface of the Cerro Veraguas andesitic volcanics, mainly tuff, are prominent, while in the southern part there is a 150m x 70m intrusion of quartz feldspar porphyry. The greater part of the mountain mass has undergone alteration, divided into intensely-silicified, quartz-sericitized and siliceous argillized zones in descending order. The geological structure of the area is marked by a fracture zone running on the west side of the mountain summit in a N30°W direction, and a fracture zone crossing that in a N30°W direction.

(2) Results of geophysical survey

The low resistitivity band has a directionality of N30°E, and displays a formation spread out over the southwest side of the Cerro Veraguas; from this it may be considered that there is some connection between the geological structure mentioned above and the distribution of quartz feldspar porphyry.

(3) Results of geochemical survey

1) The copper grade is very low. However, anomaly in Cu(>30ppm) is distributed in the porphyry on the southern edge, along the N30°W fracture zone and at the foot of the mountain on the eastern side.
2) Anomaly in Mo(>45ppm) occurs along the N30°E fracture zone and corresponds to the places where porphyry, a low resistitivity band and leached pyrite exist. There is also a weak anomaly of >30ppm in the silicified zone at the foot of the mountain on the eastern side.
3) Anomaly in As is distributed in the border area between the intensely-silicified and quartz-sericitized zones.

2. Overa / San Juan District

(1) Results of geological survey

In the district from the Sierra Overa to the San Juan mine tuff is prominent, with some volcanic clastics in parts.

On the southwestern edge of the district, there is quartz feldspar porphyry, which observation under the microscope shows to be extremely similar to tuff, displaying a subvolcanic texture.

Like the Cerro Veraguas, the great part of the district has undergone alteration; the intensely silicified and quartz-sericitized zones on the southwest side of the mountain form strata, while on the southeast side near the San Juan mine the bands are vertical.

As for the geological structure, the fracture zones on a EW-WNW system and a N45W system are prominent, and at the location 7,141,250N/397,250E there is an intrusion of quartz feldspar porphyry controlled by the structure in an E/W-WNW direction. Structures in the same direction are also developed near the San Juan mine.

(2) Results of Physical Survey

Bands of low resistitivity are distributed on the southwest edge of the area and in the northeast. In both cases the occurrence of porphyry deep down may be expected. Also, since the band of low resistitivity in the northeast, near the San Juan mine, has a NW-SE directionality, it may be considered that there is some connection with the fracture zone.

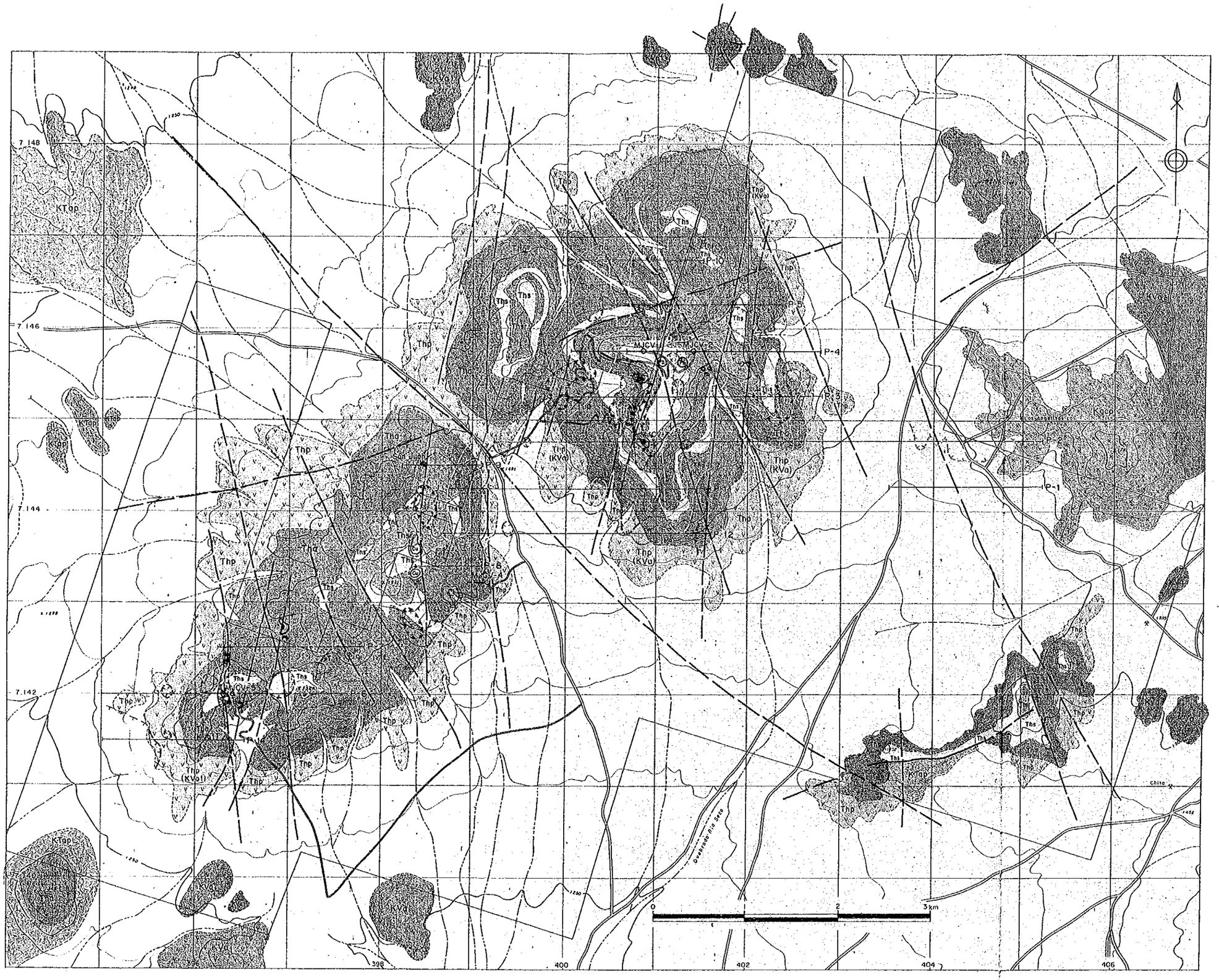
(3) Results of geochemical survey

1) In the San Juan mine, anomaly in copper is found on the west side and on the south side. The former is controlled by a N-S fracture zone, the latter by a NNW-SSE fracture zone.
2) Anomaly in Mo can be found on a small scale around the edges of the intensely silicified zone. The anomaly in Mo to the southeast of the San Juan mine is distributed more or less in parallel with low resistitivity band.
3) Anomaly in As is generally low, but the distribution more or less corresponds to anomaly in Pb. They both have a NW-SE directionality running parallel to the low resistitivity band from the geophysical survey.
4) Anomaly in Pb is found on the northern side of the Overa area, but no geological connection can be found. There is a small anomaly in a N-S direction on the western side of the San Juan mine, but this may be considered to be controlled by a fracture zone in the same direction.

3. Targets of Exploration

On the basis of the above data, ENAMI (1993) picked out the 7 areas listed below as targets of exploration, and suggested that boring surveys be carried out.

District	Location	Remarks
Cerro Veraguas district	① Southern hillside	Porphyry is associated with jarosite and geothite. Low resistivity band overlaps with Mo & Pb anomalous zones
	② Y:7,144,500N X: 401,250E	There is Mo weakly anomalous zone. Cu oxide minerals occur.
	③ Northern redge	Low resistivity band and Mo weakly anomalous zone distribute along the N30° E fracture zone.
	④ Y:7,146,000N X: 400,500E	Intensely silicified zone distributes along the NW-SE fracture zone. Mo weakly anomalous zone is in the brecciated area rich in hematite.
Overa· San Juan district	⑤SE side of San Juan mine	Low resistivity band overlaps with Cu,Pb,Mo,As anomalous zones.
	⑥San Juan mine district	Pb,As,Cu,Mo anomalous zones distribute along the N-S fracture zone
	⑦South western district	Low resistivity band corresponds to the porphyry stock. Pyrite celdillas relics distributs along the fracture zone. Not recognized geochemical anomalous zone.



Legend

Lithology

- Alluvial, colluvial and fluviatile deposits

Aeropuerto formation

- KVa — Andesitic volcanics with intercalated beds of sandstone and breccia
- KVa1 — Trachyandesitic volcanics with intercalated beds of sandstone and breccia

Intrusion

- KTp — Dioritic - andesitic porphyry
- KTop — Tonalite - quartz latite
- Kgcp — Quartz diorite

Hydrothermal Alteration zone

- Ths — Intensely silicified zone
- Thsr — Quartz sericitized zone
- Tha — Siliceous argillized zone
- Thp — Chloritized zone (Propylitized zone)
- Limonite - Jarosite rich zone
- Sulfide Cercillas relic zone (principally pyrite)
- Fault (broken line shows inferred fault)
- Gelogic contact
- Access road
- P-1 Geophysical survey line

Geochemical anomalous zone
- > 30ppm
- > 90ppm Cu
- > 30ppm Mo
- > 100ppm As
- > 100ppm Pb

Geophysical anomlous zone of 1,400meters level
- < 20Ωm
- 100Ωm
- > 300Ωm

- O Drilling site
- • and ---- Direction of drilling
- MJCV-1 No of drillhole

Fig. II-1-1

Synthetic map of the Veraguas area

(1 : 50,000)

Analysis of Existing Data, Phase I

Veraguas Project, JICA/MMAJ-ENAMI

1-2 Progreso Area

1-2-1 Outline of previous surveys

In the environs of the Progreso area many manto-type mines have been developed and are being worked, such as the Punta de Cobre Mine and the La Canderaria Mine.

The geology of Copiapo, which includes the Progreso area, has been investigated by Segerstrom and Parker (1959), K. Segerstrom (1962), Francisco Ortiz (1966) and others, and since the area contains a stratum of Punta de Cobre formation which is the country rock of manto-type deposits, ENAMI has, since 1992, conducted the geological, geochemical and geophysical surveys listed below. The results of these surveys are shown in Fig. II-1-2.

Dates of submitting reports	Contents of investigations	Title of reports and investigators(*)
Oct.1992	Analysis of topography by aerial photographs (1:10,000～30,000) Geological & geochemical survey 9.52km² (1:5,000)	ENAMI(1992):INFORME GEOLOGICO FINAL PROYECTO DE ESTUDIOS PROGRESO PERTENENCIAS PROGRESO 1-211 COPIAPO,IIIREGION,CHILE *ALISTE ECHEVERRIA Y CIA. LTDA
Jun.1993	CSAMT electorode spacing 50m 7profile lines, a total of 8,150m SIP electorode spacing 50m 1profile line , a total of 1,900m SIP electorode spacing 100m 3profile lines, a total of 2,700m	ENAMI(1993):ESTUDIO GEOFISICO MEDIANTE CSAMT Y POLARIZACION INDUCIDA ESPECTRAL PROYECTO PROGRESO,COPIAPO IIIREGION SECTOR PAN, PROGRESO SUR INTERMEDIO Y PROGRESO SUR *GEODATOS
Jul.1993	CSAMT electorode spacing 50m 8profile lines, a total of11,350m SIP electorode spacing 100m 1profile line , a total of 1,900m	ENAMI(1993):ESTUDIO GEOFISICO MEDIANTE CSAMT Y POLARIZACION INDUCIDA ESPECTRAL PROYECTO PROGRESO,COPIAPO IIIREGION PROGRESO NORTE *GEODATOS