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FINAL REPORT OF
MINERAL EXPLORATION IN

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MARCH 1994

JAPAN INTERNATIONAL COOPERATION AGENCY

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A FINAL REPORT OF
MINERAL EXPLORATION IN
CERRO NEGRO
THE REPUBLIC OF CHILE

MARCH 1994

JAPAN INTERNATIONAL COOPERATION AGENCY

METAL MINING AGENCY OF JAPAN

PREFACE

In response to a request from the Government of the Republic of Chile, the Government of Japan carried out a survey of the mineral ore deposits in the Cerro Negro area of northern Chile.

This survey inducted drilling, geophysical prospecting, calculation of ore reserves, metallurgical tests and pre-feasibility study. The Government of Japan assigned the investigation to the Japan International Cooperation Agency (JICA). The JICA entrusted the highly-specialized survey of geology and mineral resources, to the Mineral Mining Agency of Japan(MMAJ). The survey was scheduled as a two year project, commencing in 1992. The MMAJ dispatched 8 experts to survey the area from November 7, 1992 to March 8, 1993. From August 23, 1993 to January 29, 1994, 12 experts on an MMAJ-organized team investigated the region's geology and mineral resources.

The field survey was completed on schedule with the cooperation of the related organization of the Government of Chile and Empresa Nacional de Mineria(ENAMI).

This report is the final report of the two year project.

The authors hope to express deep appreciation to officials at the Government of Chile, the Ministry of Foreign Affairs of Japan, the Ministry of Trade and Industry of Japan, and the Japan Embassy in Chile for their cooperation with this project.

March, 1994

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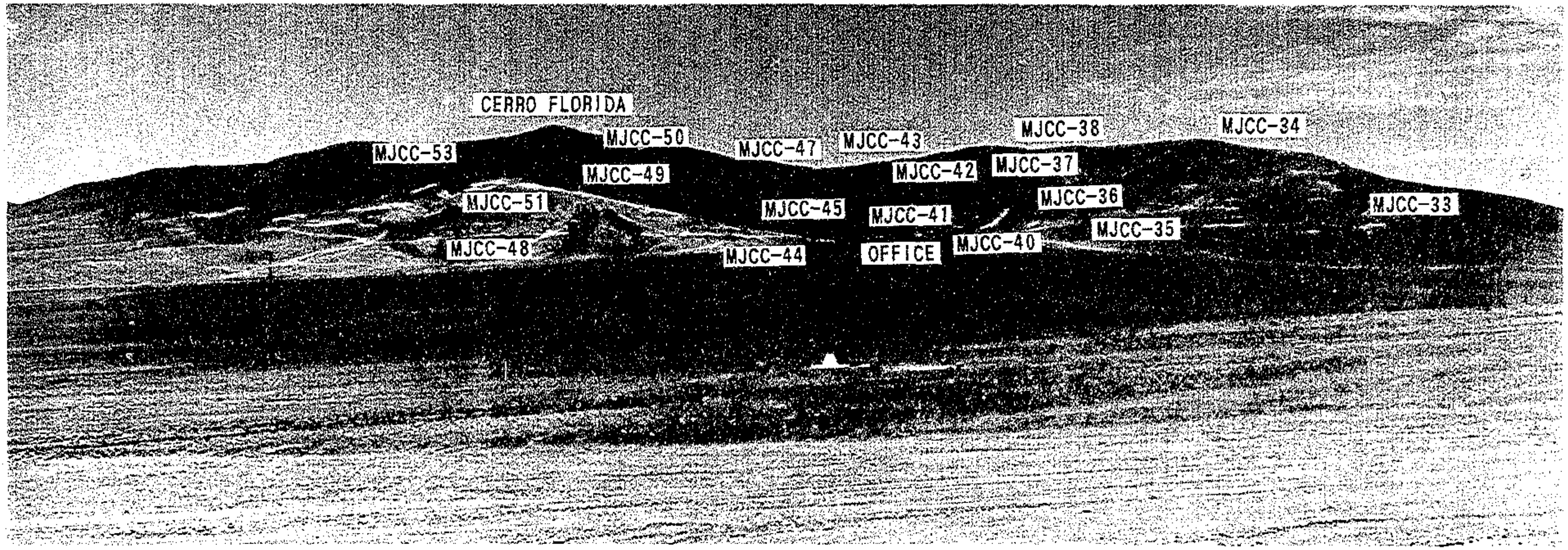
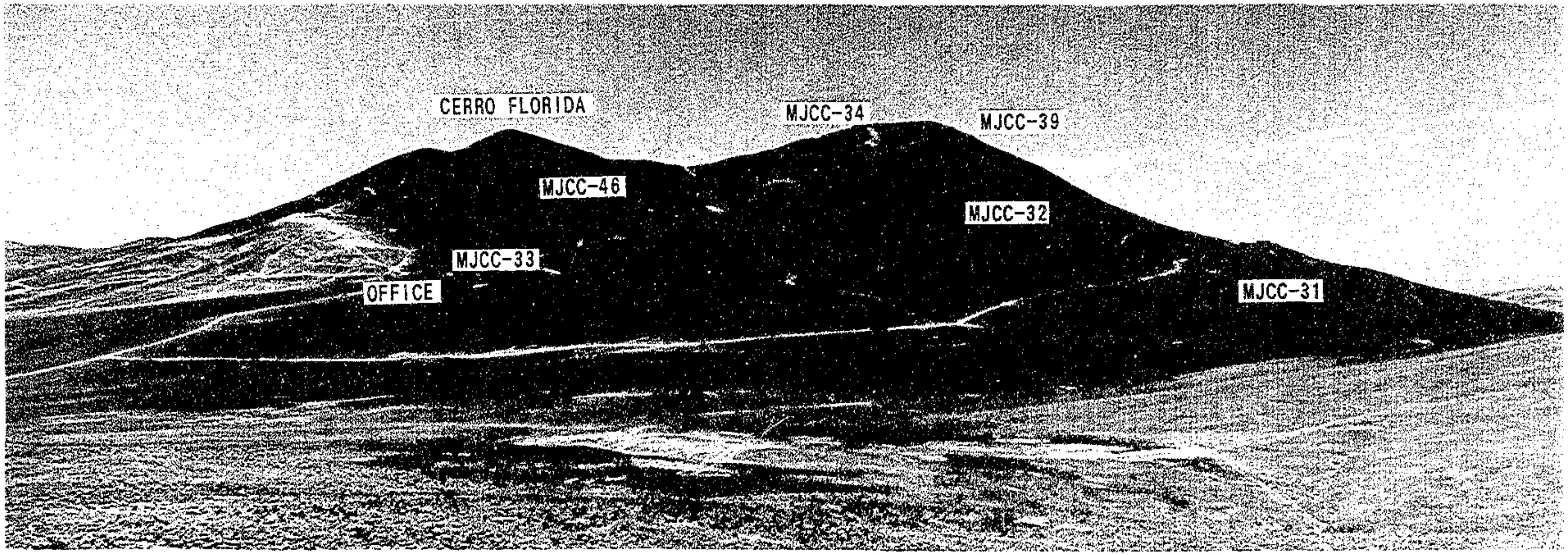
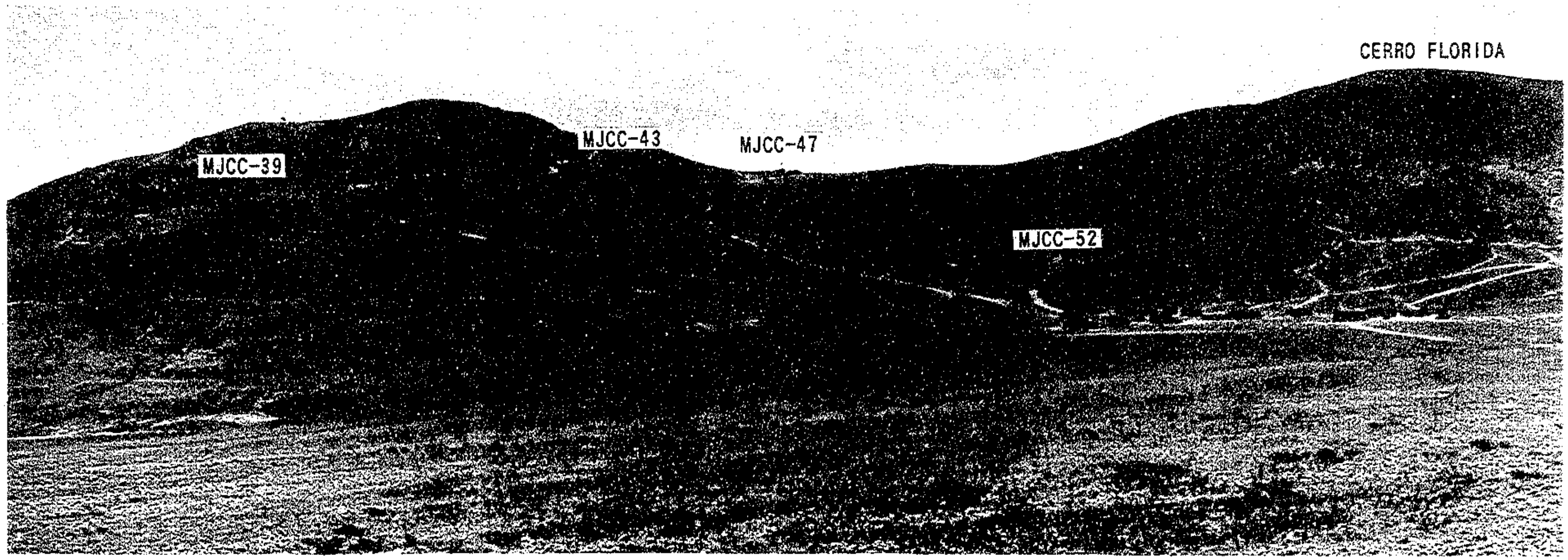
Metal Mining Agency of Japan



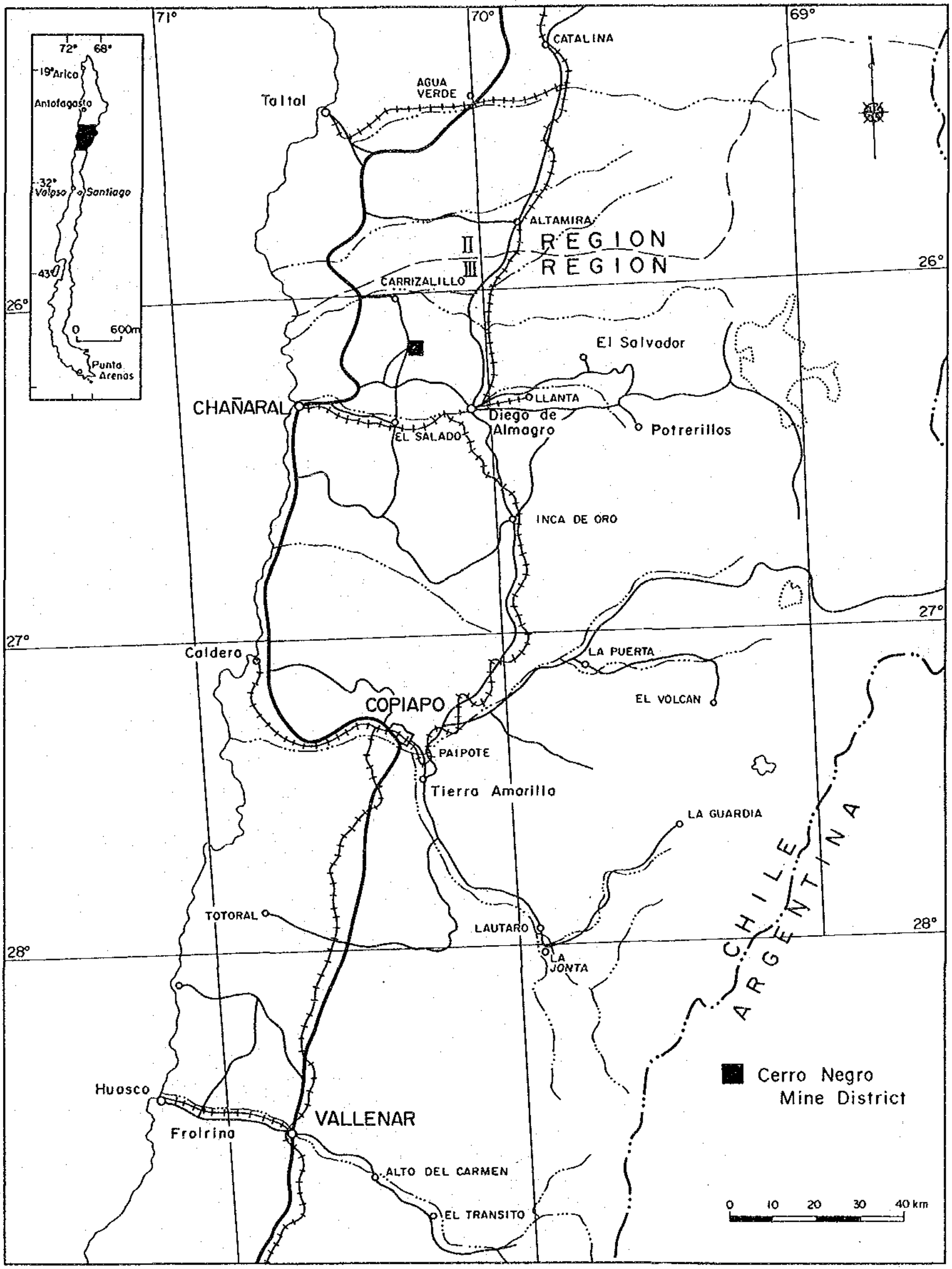
Survey Area (East look)



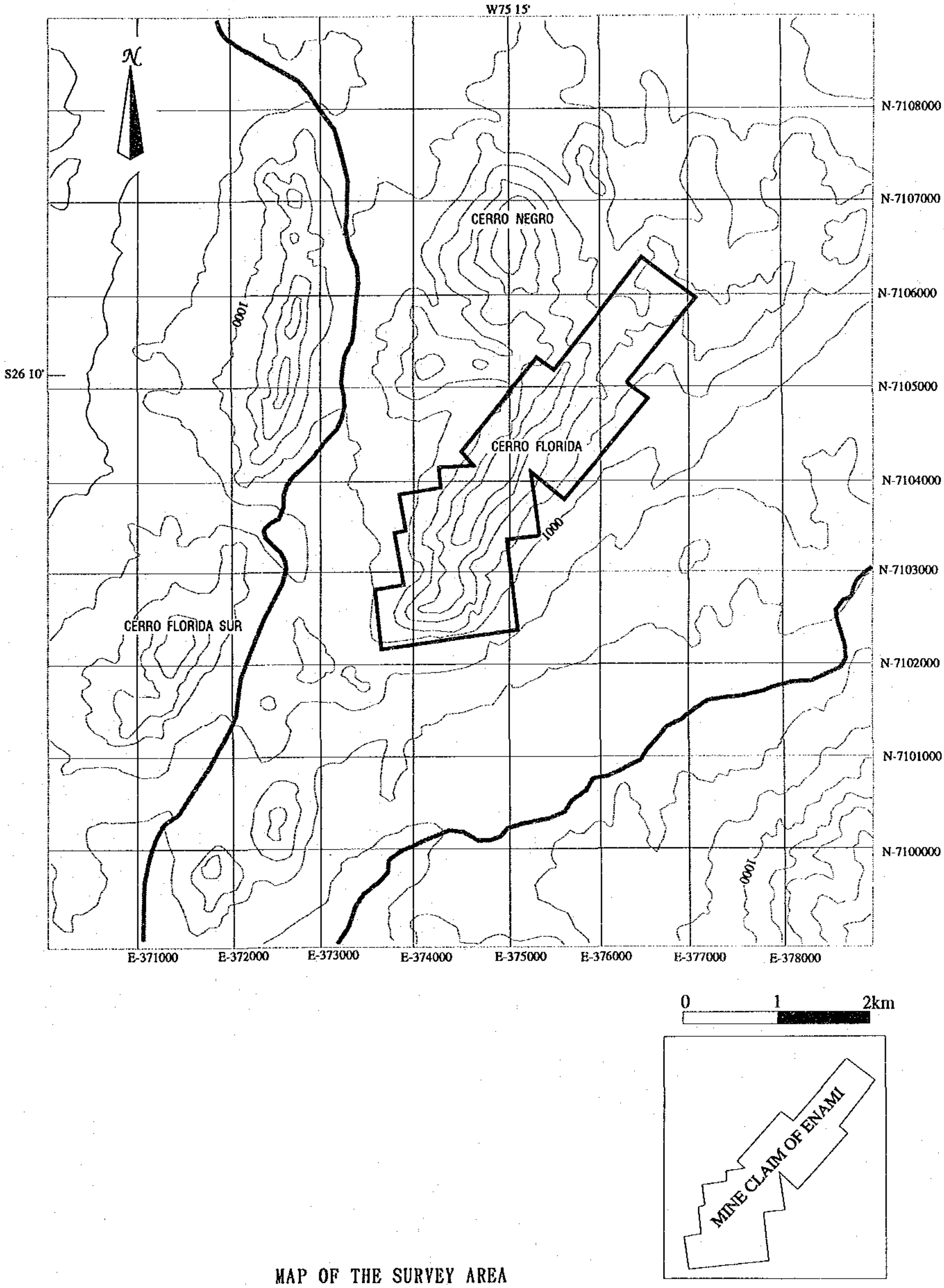
Survey Area (North look)



Survey Area (West look)



MAP OF THE REGION



MAP OF THE SURVEY AREA

ABSTRACT

This survey was performed for two years, that is, 1992 and 1993. Total numbers of drill holes reached to 53 holes and total advance went to 10,028m(80m ~500m/each hole), consequently the outline of upper ore body mainly composed of oxide copper ore was revealed. Furtheremore, parts of ore bodies mainly composed of sulfide copper ore which exist in lower, western and eastern parts in the area were also detected in this survey. But the details of these sulfide ore bodies were not surveyed enough to affect the calculation of ore reserves and pre-feasibility study.

As geophysical prospecting, IP logging in 10 holes, measuring the physical properties of drill cores(IP effect and relative resistivity from 424 samples, and magnetic susceptibility from 458 samples), and re-analysis of the existing surface IP data and surface magnetic data were performed in 1992. Consequently it was shown that high magnetic anomalous zone corresponds well to the distribution of "hydrothermal breccia" which is main country rock of upper oxide ore body, and high IP and low resistivity zone seem to correspond well to the shape of lower sulfide ore body. Therefore the usage of CSAMT method is suggested to be useful for the exploration of lower, western and eastern ore bodies which may be potential.

Metallurgical tests were performed in Chile and Japan. Consequently, leaching-SX-EW method was concluded to be useful for oxide ore and flotation method was done to be useful for sulfide ore, and afterwards the suitable flowsheet of each process was recommended. Which is suitable for mixture of sulfide ore and oxide ore should be decided in accordance with its ratio between solublecopper and total copper.

After getting drilling data, ore reserves was calculated by distance inverse square method, because the variogram from the geo-statistical method was shown unpractical. Accordingly, 87,692,000t with total Cu grade 0.53%(cut-off grade; 0.4%) was estimated as total ore reserves and 33,787,120t with total Cu grade 0.61%(cut-off grade;0.4%) was estimated as economical exploitable ore reserves (ore reserves in designed open pit).

Considering above mentioned survey results and other assumptions, rate of return was calculated by DCF method in the case of development in this mine. Then, -6.411% was indicated as the internal rate of return(Abb. form;IRR)(before interest) with copper price of 90¢. Copper prices were calculated to be 104.3¢ and 165.7¢ so as that IRR(before interest) would be zero and 15%. As low or minus IRR in this estimation should depend on low copper grade, copper grades were reckoned backwards to be 0.70% and 1.13%(total Cu) so as that IRR (before interest) become zero and 15%.

Most of sulfide ores in lower ore body is not contained in minable ore reserves because of its high depth, and it is not suitable to mine in open pit method. The ore reserves of oxide ore decrease largely, if a little higher Cu grade is needed. On the other hand, the sulfide ore reserves decrease slicely, if a little higher Cu grade is needed. Therefore, oxide ore is convenient for small scale mining in high grade part, and it is expected in the near future to explore sulfide ore in lower, western and eastern part of this area.

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Attached samples and documents

(1)Drilling survey

Rock & ore samples, thin sections, polished sections, photographes showing drilling works, photographes showing all of drilling cores, geological columnar sections(1/200), microscopical photographes.

(2)Metallurgical tests

Polished sections, photographes showing metallurgical tests.

(3)Calculation of ore reserves

Output figures and tables.

PART I

GENERAL REMARKS

PART I GENERAL REMARKS

CHAPTER 1 INTRODUCTION

1—1 Process of survey

This survey was carried out to confirm existing ore deposits and to estimate new ore reserves. The survey commenced in 1992 as a two year project, finishing in 1993. The Chilean counterpart of this project is Empresa Nacional de Mineria(ENAMI).

1—2 Results and recommendation of 1st year's survey

1—2—1 Results of 1st year's survey

Geophysical prospecting data clarified the rough distribution of the mineralization zone which is considered to be composed of magnetite and chalcopyrite were detected after IP logging, measurement of physical properties of core samples, and reanalysis of surface IP data and geomagnetic survey data.

6,424 meters of drilling works(160m ~500m depth/hole) reached to 30 holes was carried out, based on results of existing drilling data, the surface geological data and the results of geophysical prospecting. Copper oxide ores and copper sulfide ores in varying degrees were found in almost all the drilling holes.

Most of the country rocks of these copper mineralization zones are andesites and "hydrothermal breccias". These country rocks often bear a high grade copper ore mineralization zone. The high grade copper oxide mineralization zone generally exists near the surface at less than 60m. On the other hand, high grade copper sulfide mineralization zone generally exists at a depth of more than 50m. The transitional zone often exists between the copper oxide zone and copper sulphide zone. Large quantities of iron oxides(magnetite, hematite and specularite) occur in the matrix part of the country rock of copper sulfide ore and sometimes they may be called semi-iron ore.

Regarding metallurgical tests, the survey of capacities of the institute of metallurgy and metallurgical plants of big mines was carried out to decide to which was ordered the metallurgical tests the 1993 program.

Regarding calculation of ore reserves, variogram was drawn in order to use geo-statistic method. However, the range could not be defined. This means the grade varies in narrower ranges than the intervals of each holes. Therefore, the calculation of ore reserves was carried out after setting the grades by the inverse square of distance. As a result, 67 million tons(mean Cu grade;0.43%) in 0.3% of cut-off and 25 million tons(mean Cu grade;0.57%) in 0.4% of cut-off were estimated.

1—2—2 Recommendation of 1st year's survey

The CSAMT method of prospecting is as effective as the geophysical prospecting.

Regarding drilling, the following three points were recommended:

1. Detailed drilling in the area of high grade Cu mineralization zones.
2. Further examination of the distribution of andesites and "hydrothermal breccias" of Los Cerros Floridas formation, and the relationship between Cu mineralization zone and the Atakama fault zone.
3. More than 30 ~40 drilling data are necessary to calculate ore reserves including economical evaluation.
   Regarding metallurgical tests, mineralogical study, fundamental tests of flotation, leaching tests and making flow sheet are necessary.
   Regarding calculation of ore reserves, modelling the distribution of ore grade based on geological structure and features of ore deposit with consideration of anisotropy are necessary. In addition, high capacity computer and various peripheral devices will be necessary.
   Based on the drilling survey, metallurgical tests and calculation of ore reserves, the pre-feasibility study was carried out.

1—3 *Outline of 2nd year's survey*

1—3—1 Location

The survey area is located in the III province, the northern part of Chile. The survey area is about 900km north of Santiago and about 90km in a straight line from Copiapo City, the provincial capital. By road the survey area is about 220km from Copiapo City. The area is the same as that of 1st year's survey. Access from Copiapo City is via Caldera, Chanaral and El Salado. Traffic levels are moderate.

1—3—2 Purpose

The purpose of 2nd year's survey is to find out more ore reserves in ore deposits confirmed by the 1992 survey. In addition, the survey seeks further detailed data by drilling in the Cerro Negro area. Metallurgical tests are also planned. Afterwards calculation of ore reserves and pre-feasibility study are planned.

1—3—3 Method

(1) Drilling

① Subject with overriding priority

Based on the 1992 survey, drilling was carried out in the surrounding area of the presumed mining site to find out potential ore reserves. Some drillings were also carried out within the presumed mining site(surrounding area of MJCC-10 and 29) to obtain detailed data.

② Field survey

The location of drilling site and length of depth are shown in Fig. I-1-3-1 and Table I-1-3-1. Drilling of the 1992 survey was carried out in 30 points (MJCC 01～MJCC 30)and the total length of drilling was 6,424m. 23 points (MJCC 31～MJCC 53)and total length of drilling of 3,604m were carried out in 1993.

The specifications of drilling were as follows;

1) Capacities of drilling machines should be fully satisfied in case the drilling depth get increasing.
2) Casing pipes with minimum caliber should be prepared for more than 60% of scheduled depth.
3) Minimum caliber of drilling core was more than BQ.
4) Collection of drilling core and the rate of collection
   a. Complete collection of the core without surface soil was the goal.
   b. Collection rate of core was to be more than 80% in difficult conditions of collection. All the cores should be recovered in the mineralization zone, the bottom of holes and the boundary area of rocks.
5) Treatment of drilling core
   a. Recovered cores should be kept in core boxes marked on both top and bottom in dry circumstances.
   b. Slime should be kept in core boxes, the same as drilling cores packed with transparent vinyl bags.
   c. The depth of the sampling should be correctly described both inside and outside of the core box.
   d. After finishing the drilling, the cores should be kept in the place designated by the concerned Chilean organization.
6) Identification and analysis of the cores
   a. The cores should be observed in detail. The columner section should be made on a scale of 1:200.
   b. Microscopic observation should be carried out if necessary.
   c. Chemical analysis of the mineralized part of the core should be carried out.
   d. The outcrop survey should be carried out. The field data should be compared to the mineralized part of the core, if necessary.

Number of specimens of laboratory tests is shown in table I-1-3-2(1) and (2).

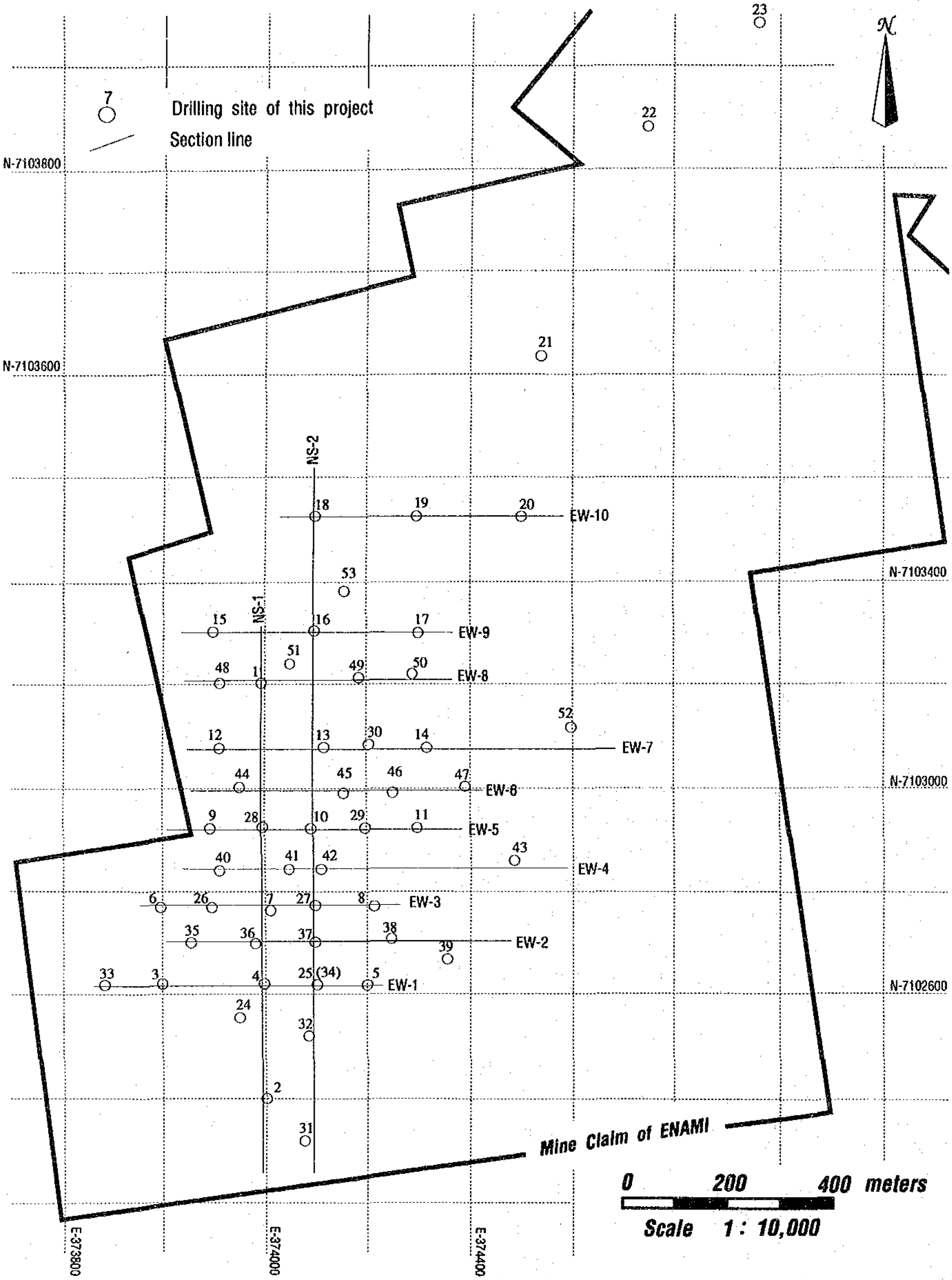


Fig. I-1-3-1 Location Map of Drilling Site

Table I — 1 — 3 — 1   Quantity of Drilling Works

DRILL HOLE	LOCATION		ELEVATION(m)	DIR.(°)	DIP(°)	DEPTH (m)	
NO.	X	Y				Plan	Result
MJCC- 1	E=374,000.010	N=7,103,200.270	1,081.920	0	-90	160.00	222.00
MJCC- 2	373,999.820	7,102,400.810	1,082.923	0	-90	185.00	164.00
MJCC- 3	373,999.970	7,102,620.040	1,081.724	0	-90	180.00	165.00
MJCC- 4	373,999.990	7,102,620.000	1,142.899	0	-90	240.00	191.00
MJCC- 5	374,199.780	7,102,619.680	1,188.662	0	-90	240.00	191.00
MJCC- 6	373,799.280	7,102,770.310	1,057.857	0	-90	160.00	161.00
MJCC- 7	373,995.120	7,102,770.440	1,110.415	0	-90	200.00	200.00
MJCC- 8	374,199.880	7,102,771.620	1,151.261	0	-90	150.00	190.00
MJCC- 9	373,899.990	7,102,920.000	1,056.995	0	-90	160.00	215.00
MJCC-10	374,088.680	7,102,920.690	1,090.641	0	-90	190.00	160.00
MJCC-11	374,298.810	7,102,917.180	1,166.160	0	-90	160.00	192.00
MJCC-12	373,899.450	7,103,070.580	1,052.067	0	-90	150.00	169.00
MJCC-13	374,099.280	7,103,072.740	1,090.695	0	-90	190.00	240.00
MJCC-14	374,309.220	7,103,080.400	1,166.735	0	-90	170.00	205.00
MJCC-15	373,900.000	7,103,300.050	1,060.970	0	-90	160.00	200.00
MJCC-16	374,098.680	7,103,301.680	1,120.487	0	-90	215.00	217.00
MJCC-17	374,294.630	7,103,307.190	1,173.925	0	-90	180.00	160.00
MJCC-18	374,100.290	7,103,520.250	1,101.050	0	-90	200.00	185.00
MJCC-19	374,300.010	7,103,520.000	1,151.730	0	-90	150.00	165.00
MJCC-20	374,501.390	7,103,518.490	1,231.980	0	-90	220.00	188.00
MJCC-21	374,552.310	7,103,831.550	1,195.650	122	-50	250.00	300.00
MJCC-22	374,760.020	7,104,299.980	1,143.930	122	-50	250.00	165.00
MJCC-23	374,984.870	7,104,500.030	1,163.940	122	-60	250.00	165.00
MJCC-24	373,954.150	7,102,538.730	1,113.558	0	-90	210.00	388.00
MJCC-25	374,090.930	7,102,620.000	1,181.415	0	-90	220.00	226.00
MJCC-26	373,910.360	7,102,770.120	1,082.425	0	-90	180.00	184.00
MJCC-27	374,099.985	7,102,770.000	1,126.569	0	-90	280.00	500.00
MJCC-28	374,000.061	7,102,920.000	1,070.737	0	-90	180.00	199.00
MJCC-29	374,199.960	7,102,920.000	1,130.809	0	-90	330.00	230.00
MJCC-30	374,200.100	7,103,075.060	1,144.762	0	-90	340.00	298.00
MJCC-31	374,079.770	7,102,320.648	1,056.597	0	-90	160.00	160.00
MJCC-32	374,095.882	7,102,505.728	1,133.906	0	-90	170.00	160.00
MJCC-33	373,700.767	7,102,619.679	1,053.375	0	-90	130.00	130.00
MJCC-34	374,097.606	7,102,625.744	1,181.105	145	-75	170.00	160.00
MJCC-35	373,860.044	7,102,700.806	1,082.637	110	-80	130.00	141.95
MJCC-36	373,983.598	7,102,699.232	1,114.297	110	-80	150.00	145.00
MJCC-37	374,107.737	7,102,701.826	1,151.558	110	-80	150.00	150.00
MJCC-38	374,249.487	7,102,698.238	1,187.992	150	-80	130.00	130.00
MJCC-39	374,348.851	7,102,667.133	1,192.791	160	-75	180.00	195.15
MJCC-40	373,918.390	7,102,839.820	1,071.604	110	-80	190.00	190.00
MJCC-41	374,056.513	7,102,844.340	1,093.266	110	-80	250.00	250.00
MJCC-42	374,121.915	7,102,838.278	1,127.008	110	-80	150.00	150.00
MJCC-43	374,501.900	7,102,839.588	1,163.186	105	-75	170.00	170.00
MJCC-44	373,960.145	7,102,999.801	1,059.360	125	-65	150.00	165.00
MJCC-45	374,156.646	7,102,999.549	1,128.378	110	-80	140.00	140.00
MJCC-46	374,247.789	7,103,001.136	1,131.684	110	-80	140.00	140.00
MJCC-47	374,398.019	7,102,999.944	1,182.294	95	-80	180.00	175.00
MJCC-48	373,911.740	7,103,199.720	1,060.57	110	-80	170.00	165.00
MJCC-49	374,199.560	7,103,200.280	1,135.175	0	-90	90.00	90.00
MJCC-50	374,301.917	7,103,201.625	1,187.763	0	-90	80.00	80.00
MJCC-51	374,059.946	7,103,229.970	1,103.266	140	-80	150.00	150.00
MJCC-52	374,619.448	7,103,093.336	1,109.301	70	-60	210.00	210.00
MJCC-53	374,170.397	7,103,370.201	1,137.753	140	-75	160.00	156.90

Table I-1-3-2(1) List of Samples for Thin Sections

(TS:Thin section)

Sample No.	Drill No.	Depth(m)	Rock Name
TS- 1	MJCC- 1	28.10	Hb Porphyrite
TS- 2	MJCC- 2	58.20	Sp-Cc-Qz Vein
TS- 3	MJCC- 3	88.00	Sp Ore
TS- 4	MJCC- 4	186.40	Brecciate Andesite
TS- 5	MJCC- 5	64.70	Banded Sp Ore
TS- 6	MJCC- 6	120.70	Mt bearing Hb-Andesite
TS- 7	MJCC- 7	138.70	Cp-Py-Sp-Mt Ore
TS- 8	MJCC- 8	186.50	Mt Andesite
TS- 9	MJCC-10	37.70	Sp-Mtt Ore
TS-10	〃	69.00	Mt-Hm-Cp-Py Ore
TS-11	MJCC-14	90.05	Sp Ore
TS-12	MJCC-15	145.00	Silic.Hornblend Andesite
TS-13	MJCC-19	53.85	Sp-Mtt Ore
TS-14	MJCC-21	137.10	Py-Cv-Qz-Ch Vein
TS-15	〃	268.60	Cp-Py Ore(Mt,Hm)
TS-16	MJCC-24	94.80	Py-Cp-Cv•Cc-Sp Ore
TS-17	〃	280.10	Hornblend Andesite
TS-18	〃	280.10	Mt bearing Andesite
TS-19	MJCC-25	35.40	Mt Andesite
TS-20	〃	211.50	Sp-Mt-Py-Qz assemblage
TS-21	MJCC-26	155.50	Cp-Py, Sp Veinlet
TS-22	MJCC-27	121.70	Sp-Mt-Ge-Qz-Ox Ch Ore
TS-23	〃	234.60	Cp-Py Vein in Sp-Mt Ore
TS-24	MJCC-28	117.40	Mt Andesite
TS-25	MJCC-29	37.75	Sp-Go-To-Qz in Andesite
TS-26	〃	54.30	Py vein in Sp-Ore
TS-27	〃	113.00	Cp-Cv-Py Vein
TS-28	〃	151.00	Cp-Py,Sp vein in Mt Andesite
TS-29	MJCC-30	84.00	Sp-Mtt Ore
TS-30	〃	94.60	Sp-Qz Ore in Mtt Andesite
TS-31	〃	226.30	Py-Cp-Mt in Mt Andesite
TS-32	MJCC-35	132.20	Sp-Mt-Py-Qz Ore in Andesite
TS-33	MJCC-40	6.20	Meta-Andesite
TS-34	MJCC-41	245.50	Mt Ad. with Py-Cp
TS-35	MJCC-42	74.40	Andesitic Tuff
TS-36	MJCC-43	47.55	Hm-Mt Ore in Brecciate Ad.
TS-37	〃	52.00	Meta Ad. with Mt ball
TS-38	MJCC-44	164.40	Py-Mt-Hm Vein in Meta Ad.
TS-39	MJCC-45	10.30	Hm-Qz Ore in Mt Andesite
TS-40	〃	25.90	Sp Ore in Meta Andesite
TS-41	MJCC-47	32.70	Brecciate Meta Andesite
TS-42	〃	122.80	Brecciate Meta Andesite
TS-43	MJCC-53	156.00	Meta Andesite

Table I -1-3-2(2) List of Samples for Polished Sections
(PS:Polish section)

Sample No.	Drill No.	Depth(m)	Rock Name
PS- 1	MJCC- 1	91.55	Cp-Py-Mt Ore
PS- 2	〃	196.80	Sp-Cc-Qz Vein
PS- 3	MJCC- 2	58.20	Sp-Cc-Qz Vein
PS- 4	MJCC- 3	88.00	Sp Ore
PS- 5	MJCC- 4	2.60	Sp Ore
PS- 6	MJCC- 5	64.70	Banded Sp Ore
PS- 7	MJCC- 7	20.50	Sp-Martite Ore
PS- 8	〃	60.90	Stratiform Sp Ore
PS- 9	〃	138.70	Cp-Py-Sp-Mt Ore
PS-10	MJCC- 8	186.50	Mt Andesite
PS-11	MJCC-10	37.70	Sp-Martite Ore
PS-12	〃	69.00	Mt-Hm-Cp-Py Ore
PS-13	MJCC-14	90.05	Sp Ore
PS-14	MCCC-19	53.85	Sp-Martite Ore
PS-15	MJCC-21	137.10	Py-Cv-Qz-Ch Vein
PS-16	〃	268.60	Cp-Py Ore(Mt,Hm)
PS-17	MJCC-24	94.80	Py-Cp-Cv•Cc-Sp Ore
PS-18	MJCC-25	35.40	Mt Andesite
PS-19	〃	211.50	Sp-Mt-Py-Qz assemblage
PS-20	MJCC-26	155.50	Cp-Py, Sp Veinlet
PS-21	MJCC-27	121.70	Sp-Mt-Ge-Qz-Ox Ch Ore
PS-22	〃	234.60	Cp-Py Vein in Sp-Mt Ore
PS-23	MJCC-28	71.30	Mt Ore
PS-24	〃	117.40	Amg-Mt Andesite
PS-25	MJCC-29	37.75	Sp-Go-To-Qz in Andesite frg.
PS-26	〃	54.30	Py vein in Sp-Ore
PS-27	〃	113.00	Cp-Cv-Py Vein
PS-28	〃	136.10	Cp-Py-Sp Ore
PS-29	〃	151.00	Cp-Py,Sp vein in Mt Andesite
PS-30	MJCC-30	84.00	Sp-Mtt Ore
PS-31	〃	94.60	Sp-Qz Ore in Mtt Andesite
PS-32	〃	226.30	Py-Cp-Mt in Mt Andesite
PS-33	MJCC-35	132.20	Sp-Mt-Py-Qz Ore in Andesite
PS-34	〃	79.20	Py-Hm-Cv-Mt Ore in Tuff
PS-35	MJCC-41	153.70	Py-Sp-Mt Ore
PS-36	〃	245.50	Mt Andesite with Py-Cp
PS-37	MJCC-42	43.20	Mt-Sp-Qz Ore in Tuff
PS-38	MJCC-43	47.55	Hm-Mt Ore in Bre. Andesite
PS-39	〃	52.00	Meta Ad. with Mt ball
PS-40	MJCC-44	164.40	Py-Mt-Hm Vein in Meta Ad.
PS-41	〃	25.90	Sp Ore in Meta Andesite
PS-42	MJCC-47	32.70	Brecciate Meta Andesite

(2) Geophysical prospecting

The physical properties of the country rock and ore deposit were studied by physical logging and measurement of physical properties of cores in the 1992 study. The existing data on surface IP prospecting and geomagnetic survey were analyzed again in order to review the survey. Based on the study, detection of sulfide ore expected to exist by the CSAMT method was proposed. However, since ore deposits existing in deeper levels were beyond the scope of this limited two year survey, geophysical prospecting was not carried out in the 1993 survey.

(3) Metallurgical tests

① Subject with overriding priorities

Two subjects were given overriding priority in the 1993 survey. The first was estimation of general metallurgical flowsheet for commercial basis production of the Cerro Negro ore deposits. The second was obtaining data for design of metallurgical plants. The metallurgical tests using drill cores obtained after chemical analysis in 1992 was performed at institute of Chile. At the same time, the flotation test was carried out in Japan to reconfirm the Chilean test.

② Tests in Chile

Metallurgical tests in Chile was carried out in Centro de Investagacion Mineria y Metalurgica(CIMM). At least one(ordinarily two) Japanese expert of metallurgy was dispatched to supervise from the commencement of the test to the end of January,1994, when the test was finished.

Five kinds of specimens were tested: oxide ore mineral(called OX1), sulphide ore mineral(called SC1), mixed ore mineral(MC1) of the upper ore body, sulfide ore mineral(SW2), and mixed ore mineral (MW2) of the western ore body. Test items and schedule are shown in Proposicion de Terabajo DMET 26/93 Modificacion 3, negotiated among the Japanese side, the Chilean counterpart(ENAMI), and CIMM. Floatation test of SC1, MC1, SW2 and MW2, and the test of leaching-solvent extraction(called SX) and electrolysis extraction (called EW) took about 9 months.

③ Test in Japan

Floatation test of large quantities of the specimens of two kinds of sulfide ore minerals(SC1 and SW2) was carried out in Japan as the confirmation of the test in Chile for the purpose of understanding the technical capability of CIMM. The specimens for testing were sent from Chile after treatment in CIMM.

(4) Calculation of ore reserves

① Subject with overriding priority

Calculation of ore reserves were carried out by geo-statistical method whenever possible. If necessary, calculation was carried out by the inverse-square method of distance.

② Work in Japan

1) Calculation of ore reserves

a. Ore grade was set in 25m ×25m(plan) ×10m(depth) as a unit block.

b. Ore grade was set by geo-statistical method. However, when the method was difficult to use, inverse-square method was employed.

c. Three kinds of ore grade, that is, soluble Cu, insoluble Cu and total Cu were treated.

d. Actual calculation of ore reserves was carried out.

2) Design of open pit

a. Designing the open pit should be carried out based on the estimated cost and estimated ore reserves as calculated above.

b. Actual calculation of ore reserves within the pit(reserves of minable ore) should be carried out.

(5) Pre-feasibility study

① Subject with overriding priorities

Probability of commercial basis should be carried out by DCF method.

② Survey in Chile

a. Before the examination by DCF method, the experts of prospecting, mining, mining engineering and administration were dispatched to collect the data in Chile. However, the experts of prospecting and metallurgy were excluded from the pre-feasibility study team, because they had already been dispatched for the drilling and metallurgical tests.

b. Discussion of feasibility after calculation of internal rate of return and sensitivity analysis was made.

1—3—4 Organization of survey team

The member who participated in this project in survey planning and the survey execution is as follows;

Survey planning(Japan side, 1992)

Yasuo NOGUCHI	The Metal Mining Agency of Japan
Ichizo MORIKAWA	ditto
Haruhisa MOROZUMI	ditto
Ken-ichi SATO	ditto

Survey planning(Japan side, 1993)

Toshio SAKASEGAWA	The Metal Mining Agency of Japan
Sho INOKUCHI	The Ministry of International Trade and Industry

Kaoru SUZUKI	The Japan International Cooperation Agency
Haruhisa MOROZUMI	The Metal Mining Agency of Japan

Survey planning(Chile side, 1992)

Gaston Fernanndez M.	Empresa Nacional de Mineria
Silvio Girardi Morales	ditto
Julio Chazarro Ortiz	ditto
Mario Serrano Cavieres	ditto
Pedro Ilabaca Ugarte	ditto

Survey planning(Chile side, 1993)

Julio Chazarro Ortiz	Empresa Nacional de Mineria
Pedro Ilabaca Ugarte	ditto

Field survey team(1992)

Fumio WADA	Dowa Engineering Co, LTD
Hirofumi YOSHIZAWA	ditto
Yutaka KIKUCHI	ditto
Koji UCHIYAMA	ditto
Michio TANAHASHI	ditto
Toshiie TSUBAKITA	ditto
Yoshiaki KARINO	ditto
Masayuki HISATSUNE	ditto

Field survey team(1993)

Taro KAMIYA	Metal Mining Agency of Japan
Jiro DATE	Dowa Engineering co, LTD
HiroFumi YOSHIZAWA	ditto
Toshiaki SUZAKI	ditto
Masayuki HISATSUNE	ditto
Takeo ODAKA	ditto
Hiroshi TANAKA	ditto
Chiaki INOUE	ditto
Yoji MIZUMA	ditto
Munetaka EGUCHI	ditto

1—3—5 Term of survey

1992's survey was carried out as the following;

Preparation in Japan	October 30, 1992～ November 6, 1992

Field survey(drilling)	November 7, 1992～ March 8, 1993
ditto (geophysical prospecting)	November 28, 1992 ～ January 27, 1993
ditto (analysis of the existing data and metallurgical survey)	January 5, 1993 ～ January 24, 1993
Reporting	January 25, 1993～ March 11, 1993
Total term of the survey	October 30, 1992～ March 11, 1993

1993's survey(the second year's survey) was carried out as shown in Table I-1-3-3. Each survey items were carried out as follows;

Preparation in Japan	August 20, 1993 ～ August 22, 1993
Test in Chile(metallurgy)	August 23, 1993 ～ January 29, 1994
Flotation test in Japan	October 18, 1993～ January 15, 1994
Field survey(drilling)	October 1, 1993 ～ December 8, 1993
ditto (pre-feasibility study)	
Calculation of ore reserves	November 1, 1993～ January 25, 1994
Reporting	December 18, 1993 ～ February 25, 1993
Total term of the survey	August 20, 1993 ～ February 25, 1994

Table I-1-3-3 PROCESS OF THE PROJECT IN PHASE II

Items		Members	Amount of Works	August	Srptem.	October	November	December	January	February	March
General Control		Date		08/23				12/08			
I	Drilling	Yoshizawa	3,000 m ± α			10/15		12/03			
		Suzaki				10/15		12/03			
II	Metallurgical Test (in Japan)	A	Work Index			10/18				01/15	
		B	Flotation Test			10/18				01/15	
		C	etc.			10/18				01/15	
	Metallurgical Test (in Chile)	Hisatsune		08/23		10/10					
		Tanaka		08/23		09/25					
		Kodaka	Work Index		10/05			11/20			
		Inoue	Flotation Test		10/05		11/01				
			Leaching Test								
		Hisatsune	etc.			11/15				01/29	
		Tanaka				11/15			12/22		
III	Calculation of Ore Reserves	A				11/01				01/25	
		B				11/01				01/25	
		C				11/01				01/25	
IV	PRE - F/S	Mizuma	Mining Engineer			11/15			12/04		
		Hisatsune	(Metallurgist)								
		Date	(Geologist)								
		Eguchi	Economist			11/15			12/04		

Note;Each date means the date of departure from Japan and the date of arrival in Japan.

CHAPTER 2 GEOGRAPHY OF SURVEY AREA

2—1 Topography and river system

This survey area is located in the Ⅲ province in the northern part of the Republic of Chile. The area is about 900km north of Chile's capital, Santiago, and about 90km in a straight line from Copiapo City, the capital of this province(refer to location maps of the region and the area at the beginning of this report).

The topography(from west[coastal side]to east) of the northern part of the Ⅲ province and the Ⅱ province which surrounds this survey area is as follows:

① La Cordillera de la Costa(the coastal mountain range)

② La Depresion Central(central lowland)

③ La Cordillera de Domeyko(the Domeyko mountains)

The topography shows characteristic belt-like features in the NS direction.

The mountain system surrounding the Cerro Negro mine is called Los Cerros Floridas and is located in the coastal mountain range described above in ①. The general trend of this mountain range is NNE-SSW and oblique to the geological structure of this region in the NS direction. These mountains are mainly composed of andesitic tuff and form comparatively steep topography. The summits of the mountains are 950m to 1,250m above sea level. In the northern part of the survey area, Mt.Cerro Negro with 1,316m elevation is mainly composed of granite.

The river system of the survey area is strongly influenced by the belt-like topography and mountain system as described above. The direction of the upper stream(the eastern part) is generally NNE-SSW. The direction of the middle and lower streams changes to west and the rivers flow into the Pacific. Ordinarily no water flows in the rivers. Water in the rivers is observed only once in every several years, but underground waterflow is observed under the large rivers.

2—2 Climate and vegetation

The climate of this survey area is a typical coastal desert climate. The climate is affected by the Fumboldt current which flows up from Antarctica along the Pacific coast of South America. The characteristics of the climate are as follows;

① Throughout the year fine almost everyday.
Extremely scarce precipitation throughout the year.
Low humidity. However, thick fog in the night and the early morning.

② Strong land and sea breeze.
Big temperature differences within a day.

The maximum and minimum temperatures in the summer season(December to February) are about 27° C and 20° C, respectively. The summer season is comfortable. On the other hand, the minimum temperature in the winter season is 2 ° C to 5° C. Although rainfall occurs only once in every several years(about 20mm), moisture is supplied by coastal fog. This fog is an important factor for vegetation.

Regarding vegetation, cactuses and 20cm to 30cm tall herbs grow only in the rivers and skirts of mountains.

Animals do not inhabit this area, except for the lizzard and scorpion. Even these animals are seldom seen. However, approaching the Domeyco mountains, vegetation becomes thick. A small number of herbivorous guanaco(which eat plants) and fox inhabit the region. These animals are sometimes seen.

CHAPTER 3 GENERAL GEOLOGY

3—1 Geological structure of the Andes mountains

This survey area is situated in the Andes mountains which run from north to south along the Pacific coast of the South American continent. The Andes mountains(Andean Cordillera) are roughly divided into the following three mountain ranges from the Pacific coast(the west) to the east;

① Cordillera de la costa
② Cordillera de los Andes
③ Precordillera

The Cerro Negro ore deposit is located within ① Cordillera de la costa.

The Andes Mountains continue in the western margin of the South American continent. The mountains run approximately 9,500km from north to south and 300 to 500km from west to east. The mountains are considered to be formed by upheaval. The highest mountain, Aconcagua, is located in ② Cordillera de los Andes with a summit elevation of 7,021m.

The common view of the history of geological structure of the Andes is comparatively simple. The Andes Mountains were formed by at least two orogenic movements after the Palaeozonic era. The summary is as follows;

① The pre-Andes submergence zone was formed on the eastern side of the present Andes mountains from the end of the Cambrian to the middle of the Devonian period. Marine deposits with 10km thickness had been sedimented in the submergence zone. The sediments rose to be land in the middle of the Permean period.

② The Andes depression zone with active volcanic activity was formed on the western side of the marine deposits zone after the Triassic period. This geosyncline was intruded by the Andes batholith. The Andes batholith is mainly composed of grano-diorite and was formed during the Cretaceous and Paleogene periods. Geosyncline has rapidly risen to be land since Pliocene.

③ On the other hand, Cordillera de la costa are low mountains which originated by horst-garven. These mountains were affected by two orogenic movements in the Palaeozonic era. The basement is mainly Pre-Cambrian to Palaeozonic strata.

④ The igneous activity of calc-alkaline rocks with hornblende andesite has occurred over the entire Andes range from Pliocene to present.

Further detailed studies have energetically been carried out to clarify a more detailed history of the geological structure. For example, Mpodozis and

Ramos(1989) try to express the geologic history of the Andes using the recent theories such as plate tectonics, subduction zone, additional prism zone, activity of magma and strike-slip fault.

3—2 Geology of the Cerro Negro ore deposit area

The strata of Palaeozoic to Quarternary are distributed in the Cerro Negro ore deposit area. The outline of distribution is as follows(refer Fig. I-3-2-1 and Table I-3-2-1).

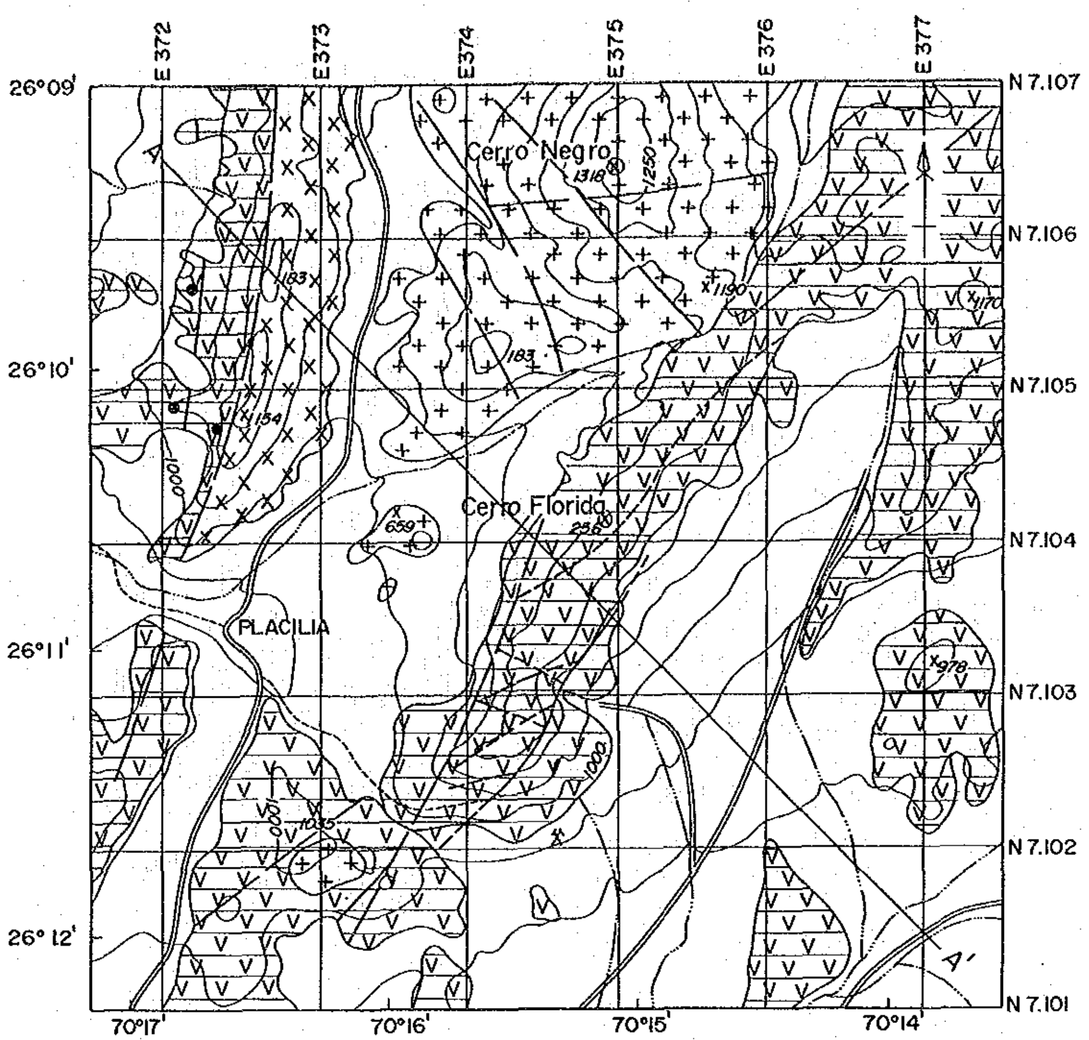
① Alluvium (Quarternary) mud-flow deposits, talus deposits
② Atacama gravel formation
(Neogene) talus deposits, gravels, sand
③ Los Cerros Floridas formation
④ La Negra formation(Early Cretaceous) andeste, pyroclastic rock
⑤ Pan de Azucar formation(Late Jurrasic) andesite, continental sediments
⑥ basement mata-sediments
(Ordovician to Devonian)
calcite, conglomerate

In addition to the above rock facies, the following three composit intrusive rocks are observed.

① Sierra Pastenes Batholith (Early Cretaceous)
intruded into Los Cerros Floridas formation as grano-dioritic, gabbroic, monzonite dioritic and tonalitic rocks.
② Sierra Minillas Batholith (Jurassic to Cretaceous)
Intruded into La Negra formation as dioritic, grano-dioritic and tonalitic rocks.
③ Cerros del Vetado Batholith (Permian)
Mainly composed of granite, intruded into basement metamorphic rocks as tonalitic and adamellitic rocks.

The strata described above widely composed Cordillera de la Costa. Within Cordellera de la Costa, igneous activity of andesitic rocks is considered to be closely related to the formation of ore deposits. These are recognized within the La Negra formation and the Los Cerros Floridas formation. The outline of the relashonship is as follows;

① The La Negra formation has the strike of generally N-S direction and inclines to the east.
La Negra formation is composed of andesite and andesitic pyroclastic rocks and sandstone within the former two rocks.



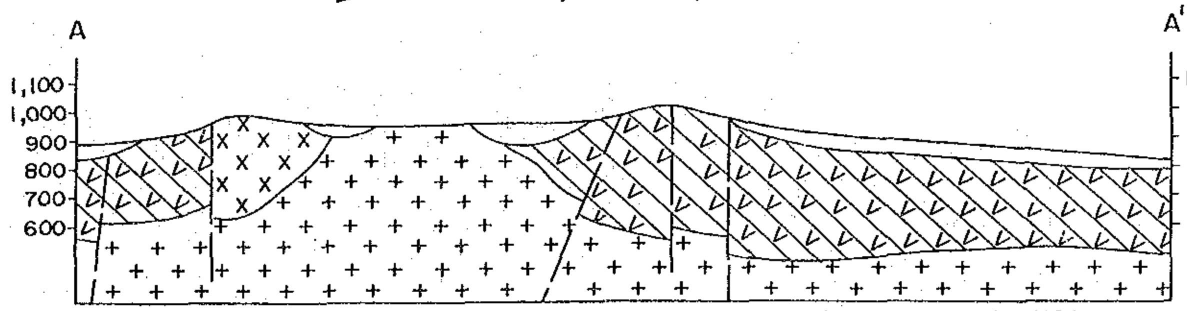
Regional Geologic Map

Legend

	Quaternary		Alluvial Deposit
Neocomian	Hauterivian	+ + +	Sierra Pastenes Batholith (Pegmatitic monzogranite with tourmaline)
	Valanginian	V V V	Los Cerros Floridas Formation (Andesite with intercalation of limestone)
Upper Paleozoic	Permian	X X X	Cerros del Vetado Batholith (Pegmatitic monzogranite with tourmaline)

Symboles

Structural system of the Atacama fault, indicating sunken blocks



After Naranjo (1978)

FIg. I -3-2-1 Geological Map of the Region

Table I -3-2-1 Stratigraphy of the Region

AGE	FORMATION	INTRUSIVES	EVENT
CENOZOIC Quaternary	ALLUVIAL DEPOSITS(Qal) Mud flow & terrace deposits		Uplift of Cordillera Mountains
Tertiary	TERRACE DEPOSITS(TTt) Terrace deposits with 15-20m thickness		Cordillera Mountains building
MESOZOIC Cretaceous	LOS CERROS FLORIDAS FORMATION(Kcf) Principally andesitic lava and volcanic sediments	SIERRA PASTENES BATHOLITH(Jksp) Diorite-gabbro and granodiorite	Volcanism(=Granitic) (Andes batholith) Volcanism(=Andesitic)
Jurassic	LA NEGRA FORMATION(Jim) Principally andesitic lava and continental sediments in its lowest part	SIERRA MINELLAS BATHOLITH(Jksm) Diorite,granodiorite, monzonite and tonalite	Volcanism(=Granitic) Volcanism(=Andesitic)
Triassic	PAN DE AZUCAR FORMATION (Jap) Principally fossiferous limestone, conglomerate in its lowest part		Sedimentary basin (Andes geosyncline)
PALEOZOIC	BASEMENTS(Pzms) Principally quarzite, phyllite and slate	CERRO DEL VETADO BATHOLITH(Pzsv) Granite	Volcanism(=Granitic)

After Carta Geologia de Chile Zona(1978)

Andesite shows porphyritic and dark brownish to dark reddish color. Their occurrence is massive and they cannot be recognized as lava flow from the texture.

Plagioclase is generally argillizated and sericitizated, and mafic minerals altered opaque minerals.

Sandstone shows brownish to reddish color. Sandstone is composed of strata 5cm to 20cm thick.

The thickness of the formation is 3,000m and covers Pan de Azucar concordantly.

② Los Cerros Floridas formation is the country rock of the Cerro Negro ore deposit.

The strike and dip are almost the same as lower strata and show monoclinic structure of 20 ° E.

They are composed of greenish to grayish porphyritic andesite and brecciated andesite.

Limestone of 5cm to 10cm thick is distributed in southeast Los Cerros Floridas. Regarding general alteration, plagioclase is sericitized and mafic minerals altered opaque minerals.

The thickness of the formation is considered to be 2,000m and covers, with unconformity, La Negra formation.

One of the characteristics of the area of the Cerros Negro ore deposit is that it is located within the fault zone of Falla Atacama(Atacama fault). This Falla Atacama continues for more than 700km from north to east. It is considered to be the great tectonic line which reaches the deep into the crust. The line starts in Antofagasa(S24 °) and continues via the Copiapo area before reaching Coquimbo(S30 °). The tectonic line generally shows left strike-slip. However, it also shows throw or right strike-slip in the secondary faults or in part. Although the width of the fault zone varies extremely, the average width is 3km to 4km. The activity began in the early Cretaceos period and many faults have been made by the activity. The activity also displaces La Negra formation, Los Cerros Floridas formation, and batholith in the area of the Cerro Negro ore deposit. Many strike-slip faults and gliding planes are observed in this area. This great tectonic line is presumed to have contributed to the formation of the Cerro Negro ore deposit and related igneous rocks.

3—3 Metallic ore deposits in the survey area

In the survey area, there are many mines, including some whose work has been suspended. Almost all the ore deposits are copper, iron and copper-iron ore. This ore was deposited in country rock of volcanics of Los Cerrws Floridas and

La Negra formation. The ore deposits, including the Cerro Negro ore deposit, are located within 925km of Carta Gelogica de Chile and are shown in Table I-3-3-1.

The Carrizalillo de las Bonbas ore deposit ys the most important ore deposit in this area. It has been mined on a small scale(about 10men/) since the 1950s. The potential ore reserves are estimated at about 20,000 to 200,000 tons of copper. However, there are no reliable records about the amount of ore production. Regarding production records, since almost all mines work on a small scale, there are no records. Therefore, details of the scale of ore reserves, mining terms, past production, and so on, are unknown.

Small scale mining by petty miners(pirquinero) has continued intermittently. Oxide copper minerals on the surface of the Cerro Negro ore deposit are the parts of the target area of this survey. Mining of sulfide minerals has also been carried out. Underground sulfide mining at scores of meters to several hundred meters has worked partially in the recent past. However, no reports about actual production have been made.

Table I − 3 − 3 − 1 List of Mines around Cerro Negro Area

NAME OF MINE	LOCATION	FORM/ORIENTATION	COUNTRY ROCK	TYPE OF ORE MINERALS
ROSARIO	26° 01.0′ 70° 15.5′	vein /20° E/90°	diorite	Cu oxides
CARRZALILLO DE LA BOMBAS	26° 01.6′ 70° 19.0′	brecciated chimny	monzonite	Cu sulphides Cu/Fe oxides
TONA	26° 05.7′ 70° 24.6′	vein /20° W/90°	metaandesite	Fe oxides
ELIANA	26° 05.8′ 70° 15.5′	vein /20° E/80° E	metaandesite -granite	Cu sulphides Fe oxides
LA SUERTE	26° 10.0′ 70° 15.5′	vein /65° E/90°	metaandesite	Cu oxides/sulphides
DISTRITO MINERO CERRO NEGRO	26° 10.0′ 70° 15.2′	veins with various orientation	andesite	Cu oxides/sulphides Fe oxides
DANNY SUR	26° 10.5′ 70° 15.5′	irregular form with extension to N/E	metaandesite	Fe oxides
ESPANOLITA	26° 10.7′ 70° 18.0′	irregular form with extension to N/S	andesite	Fe oxides
FRESIA	26° 13.5′ 70° 17.2′	irregular form	limestone/ andesite	Cu/Fe oxides
COMPADRE	26° 18.3′ 70° 16.5′	irregular form	andesite	Fe oxides

CHAPTER 4 OVERRALL DISCUSSION ABOUT THE SURVEY RESULTS

4—1 Geological structure and mineralization

(Geology in the survey area)

The Los Cerros Floridas formation of early Cretaceous are widely distributed in this area. The general rock facies are calcite, peritic rock, andesitic pyroclastic rock and andesite lava flow, in descending order. Four flow units of andesite are observed. Since peritic rocks and andesitic pyroclastic rocks are caught in the upper two units, the upper two units of andesite lava flows are given the name, "upper Los Cerros Floridas formation," and the lower two units of andesite lava flow are given the name, "lower Los Cerros Floridas formation." The Atacama fault was formed after formation of the Los Cerros Floridas formation. The other faults with NNE-SSW direction are arranged parallel to the former fault in this area. These faults are NNE-SSW(Los Cerros Floridas-W. Fault & Los Cerros Floridas-E. Fault). At the same time, or just after, the faults were formed, secondary faults with two directions, NW-SE and NE-SW, were formed. Although the activity of fault formation begins before iron and copper mineralization, the activity is presumed to be finished comparatively late. This is because the mineralization zones might be moved by these fault activities. Fault fracture zones were affected by the western fault with the direction NNE-SSW.

Brecciation which is the origin of "hydrothermal breccia" is considered to begin at the same time or after the commencement of the fault activities. This is because the distribution of the "hydrothermal breccia" is controlled by the fault and develops where many faults gather in complex formation. The original rock of the "hydrothermal breccia" is mainly andesite of the upper Los Cerros Floridas formation. The "hydrothermal breccia" is distributed widely in the shallower part at less than 150m. However, the shape is irregular and obliquely crosses the bedding plane. Very few "hydrothermal breccia" are observed in sheet or vein-like shapes in the lower Los Cerros Floridas formation which lies deep underground.

Iron mineralization which is mainly mieralized magnetite and specularite occurred at the same time or later than "hydrothermal breccia" formation. The iron minerals fill the matrix of breccias in the central part of the hydrothermal breccia. On the other hand, the iron minerals occur as a vein of iron minerals within andesite in the marginal area.

After the mineralization of iron minerals, copper mineralization which mainly mineralized chalcopyrite and pyrite began. Paragenesis of iron minerals and copper minerals is not observed. The part composed mainly of iron minerals is not cut by sulfide minerals like veins. Instead, the reverse phenomena is

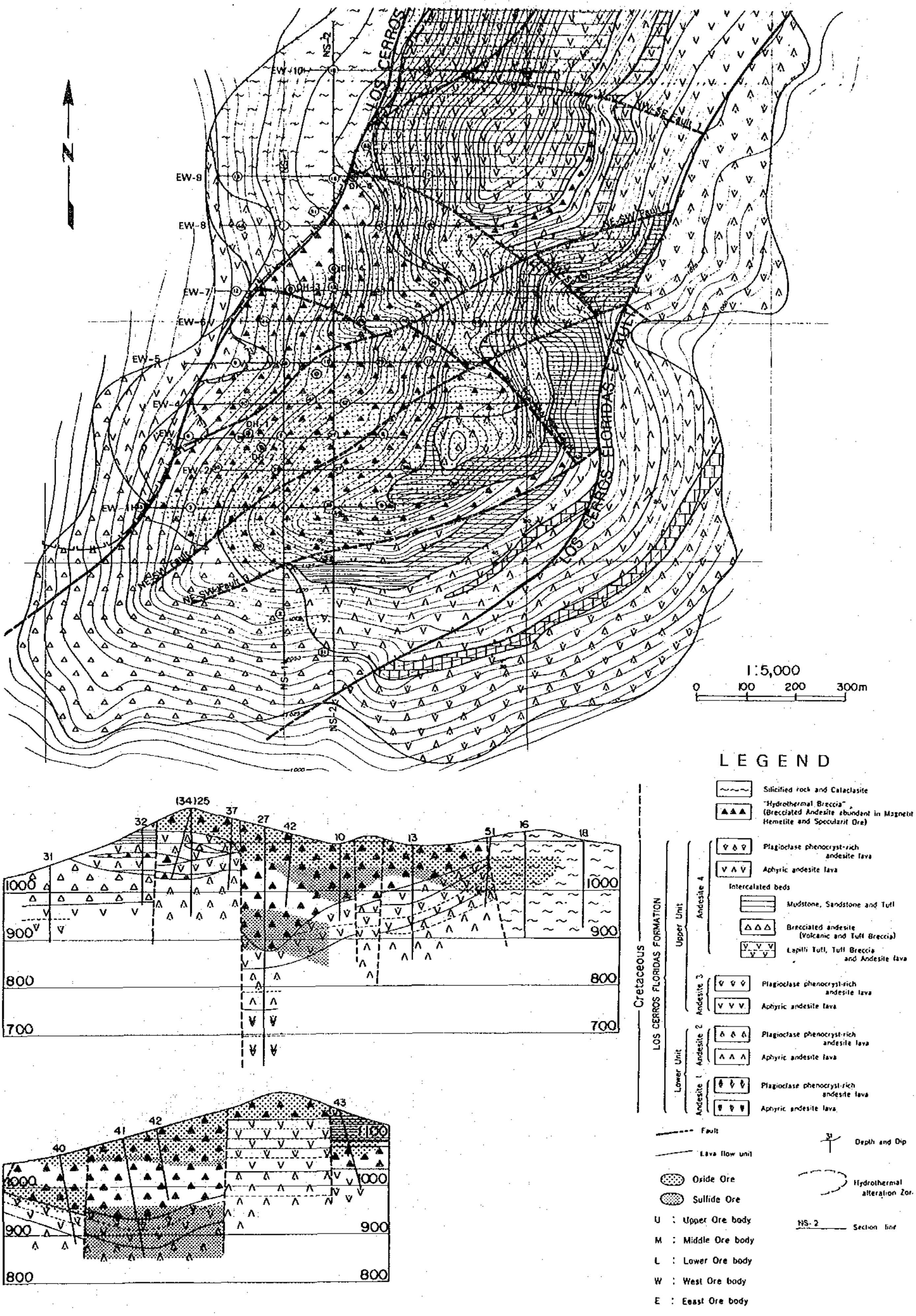


Fig. I-4-1-1 Geological Map of the Area

observed. Therefore, copper mineralization is considered to occur after iron mineralization. After the iron and copper mineralization, iron and copper minerals were oxidized to form an copper oxide ore deposit. The process mentioned above is shown in Fig. I-4-1-1(Geologic map and section of the survey area).

(Geological Structure)

The fault with the NNE-SSW called Los Cerros Floridas fault was formed at the same time as formation of the Atakama fault. This was in the late Cretaceous period mentioned above. The fracture zone with more than 200m of the maximum width was formed in the surrounding area of Los Cerres Floridas-W. fault. This fracture zone looks white in color. This results from calcite, gypsum, a small amount of sericite, and kaolinite. The throw of the fault is about 100m with a sinking east side. The heave of the fault is presumed to be comparatively large, but the detail is unknown. The eastern side also sank in Los Cerros Floridas fault, which has a throw of more than 100m. The heave of this fault is unknown. Only Los Cerros Floridas fault is accompanied with a fracture zone where altered mineral is observed. The reason is that granitic rock, slightly younger than Los Cerros Floridas formation, intruded in the western part of the fault.

Secondary faults with the direction of NE-SW were formed at the same time or just after the formation of the NNE-SSW direction's fault. Almost all eastern sides of the NE-SW faults sank. This detail is shown in the cross section of the Appendix. Many of the western sides of the NW-SE faults sank. The throw of the secondary fault is less than 10m. Details of the heave along the strike is unknown because of the complicated arrangement of the faults.

The geological structure in this area can be summarized as follows:

Two Los Cerros Floridas faults with the direction of NNE-SSW lie in the eastern and western sides of both areas. The eastern sides sank in both faults. There are two kinds of faults with a NE-SW and NW-SE direction between the two former Los Cerros Floridas faults.

(The relationship between "hydrothermal breccia" and iron mineralization)

"Hydrothermal breccia" is distributed mainly in complicated fault areas. It is also distributed widely in shallow places. The distribution area is about 700m from east to west, and about 800m from north to south. Over the region the thickness is about 150m. The breccia cuts the bedding plane of strata. The shape of distribution is complicated. Magnetite, specularite, and a small amount of quartz occur filling up in the matrix among andesite breccias. These breccias have diameters of several cm to ten cm. The occurrence of iron minerals shows the textural characteristics of the "hydrothermal breccia". The marginal part of andesite breccia are surrounded by magnetite and specularite. Those are altered and change color to white at several mm thick. Those phenomena are often observed. The distribution area of the "hydrothermal breccia" roughly coincides with the distribution of iron mineralization. In the marginal part of the distribution, there is a tendency that the amounts of iron minerals decrease and amounts of quartz increase. The cause of brecciation of the "hydrothermal breccia" is not distinct. However, the cause is presumed to be the emission of volatile materials before iron mineralization. After the emission of volatile materials, iron mineralization of magnetite and specularite may occur by hydrothermal process.

(Copper mineralization)

Copper mineralization is considered to occur after iron mineralization. This is because paragenesis of copper minerals and iron minerals are not observed.

Ore body in copper minerals appears to exist within two or three horizons. However, the period of formation is considered to be later than that of the country rock. Therefore, copper mineralization which occurred after the formation of country rock is considered to be selectively precipitated in the country rock to form the ore bodies within two or three horizons.

4 — 2 Ore deposits

(Distribution of ore bodies)

Copper mineralization is observed within the upper ore bodies which are widely covers the upper part of the survey area and the lower ore bodies. The barren part whose thichness is 20m～80m lies between the upper ore bodies and lower ore bodies. The ore bodies which are located in the northwestern part between two Los Cerros Floridas faults and in the lower part of the upper ore bodies are distinguished from the lower ore bodies, because their horizon and mineral components of the ore bodies are different from those of the lower ore bodies. They are given the name the middle ore bodies. There are two ore bodies in the eastern and western parts of Los Cerros Floridas fault. The eastern ore bodies lies in the deep underground of MJCC-52 drilling hole. They are resemble to the lower ore bodies in horizon and mineral components. However, since the locations of both deposits from the lower deposits, they are distinguish from the lower ore bodies as the west ore bodies and the east ore bodies. The locations of these ore bodies are shown in Fig. I-4-2-1.

The country rocks of these upper ore bodies are mostly "hydrothermal breccia, except a part of Los Cerros floridas formation. The main country rocks of the middle and lower ore bodies are "hydrothermal breccia" and the andesite

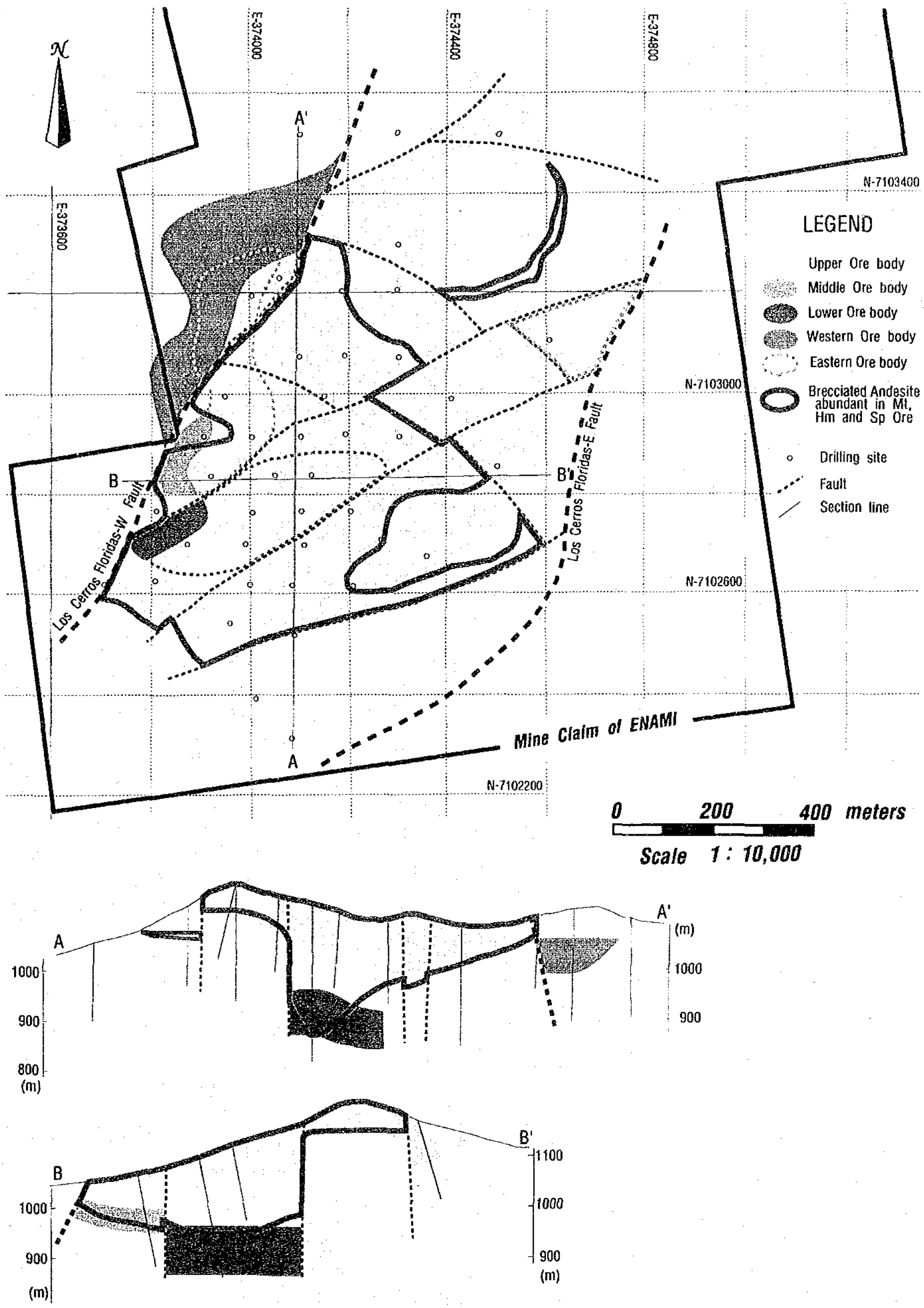


Fig. I -4-2-1 Distribution Map of Ore Bodies

of the lower horizon of the upper Los Cerros Floridas formation. Since the middle and lower ore deposits lie slightly different horizons each other as shown in the cross section of appendices, they are distinguished from each other. In addition, the mineral components of them are also different from each other. Since the east ore bodies is distant from the lower ore bodies, they are also distinguished from the lower ore bodies. However, they are considered to be the same of the lower ore bodies in horizon and mineral component. The west ore bodies are also considered to be the same of the lower and east ore bodies. However, the country rock of the west ore bodies is fracture zone which is accompanied with Los Cerros Floridas-W fault. Although the original rock of the fracture zone is indistinct, the rock is probably considered to be Los Cerros Floridas formation.

No distinct relationship between the pattern of faults and distribution features of the ore deposits. However, prominant ore deposits in quantity and ore grade are concentrated in the central part of this area which is complicated faults zone. Therefore, the mineralization in this area is considered to be controlled by fault structure. Altough the fault formation occurred before the formation of ore deposit, dislocation of the ore deposits by fault movement is observed in the cross section. It suggests that the fault movement intermittently continued for a long time.

(Occurrences of ore minerals)

The upper ore bodies are widely distributed in the shallower part of this area. The oxide mineralization zones which are composed of oxidized sulfide minerals in the upper part of the upper ore bodies. In the lower part of the oxide mineralization zones, mixed mineralization zones in which copper oxide minerals and sulfide minerals coexist, and sulfide mineralization zones in which are composed of much sulfide minerals are distributed.

The middle, lower, west and east ore bodies are generally composed of sulfide mineral dominant zones. Oxide mineralization zones are sometimes observed near the crossing points of these ore bodies and faults. Therefore, oxide mineralization zones are divided into two types. One is oxide mineralization zones due to structural movement. The other is common oxide mineralization zones which are affected from the surface. The middle ore bodies are rich in sulfide minerals. However, they often catch mixed mineralization zones and oxide mineralization zones. Their features are slightly different from the lower, west and east ore bodies.

The summarized ore grade list in each drilling hole is shown in Table I-4-2-1(1) & (2).

The major copper minerals in oxide zones are atacamite, malachite,

Table I—4—2—1(1) Mineralized Zones and Cu Grade(Phase I)

MJCC No.	Mineralized Zone	Depth(m)	Thick. (m)	T-Cu (%)	S-Cu (%)	I-Cu (%)	S/I	Type of Mineralization	Ore bodies
1	A	84 ～ 98	15	0.66	0.11	0.55	0.20	Sulfide Zone	Upper C.
〃	B	171 ～ 198	28	0.85	0.00	0.85	0.00	Sulfide Zone	Middle C.
2	A	4 ～ 13	10	0.46	0.19	0.27	0.70	Mixed Zone	Upper C.
〃	B	25 ～ 35	11	0.50	0.18	0.32	0.56	Mixed Zone	〃
3	A	15 ～ 28	14	0.68	0.24	0.44	0.55	Mixed Zone	Upper C.
〃	B	55 ～ 95	41	0.84	0.63	0.21	3.00	Oxide Zone	〃
〃	C	116 ～ 125	10	0.53	0.16	0.37	0.43	Sulfide Zone	〃
4	A	1 ～ 10	10	0.49	0.35	0.14	2.50	Oxide Zone	Upper C.
〃	B	50 ～ 59	10	0.76	0.45	0.31	1.45	Mixed Zone	〃
5	A	27 ～ 36	10	0.45	0.36	0.09	4.00	Oxide Zone	Upper C.
〃	B	42 ～ 52	11	1.84	1.73	0.11	15.73	Oxide Zone	〃
〃	C	63 ～ 72	10	0.68	0.57	0.11	5.18	Oxide Zone	〃
〃	D	159 ～ 168	10	0.64	0.02	0.62	0.03	Sulfide Zone	Other(Lower C. ?)
7	A	1 ～ 38	38	0.89	0.77	0.12	6.42	Oxide Zone	Upper C.
〃	B	47 ～ 59	13	0.54	0.37	0.17	2.18	Oxide Zone	〃
〃	C	77 ～ 86	10	0.53	0.13	0.40	0.33	Sulfide Zone	Lower C.
〃	D	127 ～ 152	26	1.09	0.05	1.04	0.05	Sulfide Zone	〃
10	A	1 ～ 11	11	0.59	0.40	0.19	2.11	Oxide Zone	Upper C.
〃	B	17 ～ 33	17	0.86	0.49	0.37	1.32	Mixed Zone	〃
〃	C	37 ～ 50	14	1.09	0.81	0.28	2.89	Oxide Zone	〃
〃	D	54 ～ 102	49	0.72	0.04	0.68	0.06	Sulfide Zone	〃
12	A	80 ～ 89	10	0.61	0.03	0.58	0.05	Sulfide Zone	West. W.
〃	B	116 ～ 148	33	0.71	0.01	0.70	0.01	Sulfide Zone	Middle C.
16	A	50 ～ 59	10	0.93	0.45	0.48	0.94	Mixed Zone	Middle C.
〃	B	85 ～ 94	10	0.67	0.35	0.32	1.09	Mixed Zone	〃
〃	C	101 ～ 111	11	0.46	0.01	0.45	0.02	Sulfide Zone	〃
17	A	12 ～ 21	10	0.54	0.27	0.27	1.00	Mixed Zone	Upper C.
〃	B	41 ～ 55	15	0.89	0.56	0.33	1.70	Oxide Zone	〃
19	A	12 ～ 22	11	0.50	0.20	0.30	0.67	Mixed Zone	Upper C.
〃	B	27 ～ 38	12	0.49	0.22	0.27	0.81	Mixed Zone	〃
〃	C	54 ～ 70	17	1.00	0.59	0.41	1.44	Mixed Zone	〃
20	A	1 ～ 18	18	0.59	0.36	0.23	1.57	Oxide Zone	Upper C.
〃	B	117 ～ 126	10	0.60	0.43	0.17	2.53	Oxide Zone	〃
21	A	185 ～ 194	10	0.61	0.10	0.51	0.20	Sulfide Zone	Other(Lower C. ?)
24	A	31 ～ 40	10	0.84	0.60	0.24	2.50	Oxide Zone	Upper C.
25	A	3 ～ 21	19	0.52	0.30	0.22	1.36	Mixed Zone	Upper C.
26	A	110 ～ 119	10	1.24	0.04	1.20	0.03	Sulfide Zone	Lower C.
27	A	11 ～ 20	10	0.47	0.16	0.31	0.52	Mixed Zone	Upper C.
〃	B	32 ～ 45	14	0.93	0.73	0.20	3.65	Oxide Zone	〃
〃	C	51 ～ 72	22	0.57	0.26	0.31	0.84	Mixed Zone	〃
〃	D	195 ～ 210	16	0.53	0.04	0.49	0.08	Sulfide Zone	Lower C.
〃	E	231 ～ 242	12	1.60	0.08	1.52	0.05	Sulfide Zone	〃
28	A	44 ～ 53	10	0.51	0.26	0.25	1.04	Mixed Zone	Upper C.
〃	B	69 ～ 78	10	0.61	0.39	0.22	1.77	Oxide Zone	〃
29	A	3 ～ 12	10	0.73	0.46	0.27	1.70	Oxide Zone	Upper C.
〃	B	38 ～ 64	27	0.85	0.49	0.36	1.36	Mixed Zone	〃
〃	C	84 ～ 101	18	0.59	0.05	0.54	0.09	Sulfide Zone	〃
〃	D	110 ～ 119	10	3.13	0.26	2.87	0.09	Sulfide Zone	〃
〃	E	133 ～ 156	24	3.80	0.04	3.76	0.01	Sulfide Zone	〃
30	A	32 ～ 42	11	0.54	0.26	0.28	0.93	Mixed Zone	Upper C.
〃	B	56 ～ 66	11	0.67	0.04	0.63	0.06	Sulfide Zone	〃
〃	C	70 ～ 96	27	0.65	0.30	0.35	0.86	Mixed Zone	〃

Upper C. : Upper Ore bodies in the Central block
Middle C. : Middle Ore bodies in the Central block
Lower C. : Lower Ore bodies in the Central block
East. C. : Eastern Ore bodies in the Central block
West. W. : Western Ore bodies in the Western block

Table I—4—2—1(2) Mineralized Zones and Cu Grade(Phase II)

MJCO No.	Mineralized Zone	Depth(m)	Thick. (m)	T-Cu (%)	S-Cu (%)	I-Cu (%)	S/I	Type of Mineralization	Ore bodies
34	A	7 ~ 34	28	0.75	0.45	0.30	1.50	Oxide Zone	Upper C.
35	A	1 ~ 10	10	1.54	1.33	0.21	6.33	Oxide Zone	Upper C.
〃	B	66 ~ 80	15	1.68	1.49	0.19	7.84	Oxide Zone	Middle C.
〃	C	107 ~ 122	16	0.73	0.51	0.22	2.32	Oxide Zone	〃
〃	D	126 ~ 139	14	0.55	0.15	0.40	0.37	Sulfide Zone	〃
36	A	31 ~ 44	14	0.60	0.26	0.34	0.76	Mixed Zone	Upper C.
〃	B	118 ~ 127	10	0.64	0.27	0.37	0.73	Mixed Zone	Middle C.
37	A	1 ~ 10	10	0.84	0.43	0.41	1.05	Mixed Zone	Upper C.
〃	B	19 ~ 38	20	0.76	0.50	0.26	1.92	Oxide Zone	〃
〃	C	61 ~ 70	10	0.69	0.32	0.37	0.86	Mixed Zone	〃
38	A	25 ~ 34	10	1.01	0.86	0.15	5.73	Oxide Zone	Upper C.
〃	B	41 ~ 52	12	0.71	0.50	0.21	2.38	Oxide Zone	〃
39	A	29 ~ 57	29	0.55	0.21	0.34	0.62	Mixed Zone	Upper C.
〃	B	98 ~ 109	12	0.44	0.20	0.24	0.83	Mixed Zone	〃
40	A	1 ~ 10	10	0.99	0.59	0.40	1.48	Mixed Zone	Upper C.
〃	B	33 ~ 42	10	0.44	0.09	0.35	0.26	Sulfide Zone	Other(Upper C. ?)
〃	C	74 ~ 84	11	0.69	0.30	0.39	0.77	Mixed Zone	Middle C.
〃	D	120 ~ 129	10	0.43	0.03	0.40	0.08	Sulfide Zone	〃
41	A	13 ~ 26	14	0.66	0.48	0.18	2.67	Oxide Zone	Upper C.
〃	B	151 ~ 160	10	2.03	0.14	1.89	0.07	Sulfide Zone	Lower C.
〃	C	172 ~ 190	19	0.50	0.01	0.49	0.02	Sulfide Zone	〃
〃	D	220 ~ 229	10	1.07	0.01	1.06	0.01	Sulfide Zone	〃
〃	E	239 ~ 250	12	1.55	0.03	1.52	0.02	Sulfide Zone	〃
42	A	1 ~ 13	13	0.65	0.43	0.22	1.95	Oxide Zone	Upper C.
〃	B	21 ~ 38	18	0.77	0.56	0.21	2.67	Oxide Zone	〃
〃	C	52 ~ 67	16	0.94	0.49	0.45	1.09	Mixed Zone	〃
〃	D	80 ~ 89	10	0.47	0.11	0.36	0.31	Sulfide Zone	〃
43	A	2 ~ 19	18	0.45	0.42	0.03	14.00	Oxide Zone	Upper C.
〃	B	34 ~ 51	18	0.81	0.62	0.19	3.26	Oxide Zone	〃
〃	C	66 ~ 81	16	0.44	0.22	0.22	1.00	Mixed Zone	〃
44	A	63 ~ 72	10	0.60	0.07	0.53	0.13	Sulfide Zone	Middle C.
〃	B	153 ~ 162	10	0.65	0.15	0.50	0.30	Sulfide Zone	〃
45	A	1 ~ 11	11	0.79	0.59	0.20	2.95	Oxide Zone	Upper C.
〃	B	50 ~ 60	11	0.65	0.05	0.60	0.08	Sulfide Zone	〃
46	A	14 ~ 24	11	0.80	0.55	0.25	2.20	Oxide Zone	Upper C.
〃	B	55 ~ 70	16	0.61	0.16	0.45	0.36	Sulfide Zone	〃
47	A	26 ~ 35	10	0.92	0.68	0.24	2.83	Oxide Zone	Upper C.
〃	B	79 ~ 88	10	2.22	1.92	0.30	6.40	Oxide Zone	〃
48	A	119 ~ 147	29	0.57	0.00	0.57	0.00	Sulfide Zone	Middle C.
49	A	11 ~ 31	21	0.82	0.46	0.36	1.28	Mixed Zone	Upper C.
〃	B	34 ~ 45	12	0.47	0.18	0.29	0.62	Mixed Zone	〃
〃	C	51 ~ 61	11	0.60	0.40	0.20	2.00	Oxide Zone	〃
50	A	2 ~ 31	30	0.52	0.26	0.26	1.00	Mixed Zone	Upper C.
〃	B	39 ~ 49	11	0.64	0.39	0.25	1.56	Oxide Zone	〃
〃	C	70 ~ 79	10	0.59	0.48	0.11	4.36	Oxide Zone	〃
51	A	113 ~ 122	10	0.34	0.02	0.32	0.06	Sulfide Zone	Upper C.
52	A	7 ~ 36	30	0.56	0.33	0.23	1.43	Mixed Zone	Upper C.
〃	B	54 ~ 63	10	0.46	0.14	0.32	0.44	Sulfide Zone	Other(Upper C. ?)
〃	C	140 ~ 151	12	1.48	0.06	1.42	0.04	Sulfide Zone	East. C.
〃	D	190 ~ 199	10	0.97	0.16	0.81	0.20	Sulfide Zone	〃
53	A	17 ~ 28	12	1.58	1.21	0.37	3.27	Oxide Zone	Upper C.

Upper C. : Upper Ore bodies in the Central block
Middle C. : Middle Ore bodies in the Central block
Lower C. : Lower Ore bodies in the Central block
East. C. : Eastern Ore bodies in the Central block
West. W. : Western Ore bodies in the Western block

chalcanthite. In addittion to those major minerals, there are small quantities of chrysocolla, azurite, chalcocite and covelline. They generally occur as menbrane. Atacamite and chalcanthite sometimes occur as euhedral crystals. Coexisting iron minerals are generally hemetite and limonite due to oxidation. Specularite and magnetite often remain.

Pyrite and chalcopyrite in sulfide zones occur as dissemination~networks features, and sometimes occur as veins with width of 30cm in country rocks. They sometimes occur with chalcocite. Coexisting iron minerals are specularite and magnetite. These oxide minerals and sulfide minerals closely coexist in mixed mineralization zone. However, since mixed mineralization zone complicatedly exists with oxide mineralization zone, mixed mineralization zone is not indicated as in dividual zone. Quartz is main gangue mineral. Calcite is sometimes observed as gangue mineral.

4—3 Results of geophysical prospecting

IP logging in the drilling holes, measurement of physical properties of drilling cores(IP characteristics, resistivity and magnetic susceptibility) and re-analysis of the existing IP prospecting data and geomagnetic survey data were carried out in 1992. The following points were clarified:

① High IP/low resistivity is caused by the mineralization zone of chalcopyrite and pyrite concentration around the MJCC-7 drilling hole.

② High magnetic anomaly is caused by magnetite concentration. The high anomalous zone coincides to the iron mineralization zones around the MJCC-10 and 13 drilling holes. The high anomalous zones are distributed outside of above copper mineralization zone. Existance of sulfide minerals within iron mineralization zone is judged by resistivity measurement. Resistivity decreases by existance of sulfide minerals within iron mineralization zone.

The prospecting to the deeper part and the area of both side of the 1992 survey area was proposed as the 1993 program. Geophysical prospecting was not carried out in 1993 by the above reasons.

4 — 4 Results of metallurgical tests

Metallurgical tests were entrusted to Centro de Investigacion Mineria y Metalurgica (CIMM) of the Republic of Chile, for the development of the most suitable flowsheet in the productive operation, for the estimation of metallurgical results and for obtaining detailed data to be used in the plant design. In these tests, boring cores obtained in the year of 1992 were used as test samples. Various metallurgical tests including flotation and heap leaching—SX/EW were performed with five kinds of ore samples, that is, one oxide ore from the upper ore body(OX-1), two types of mixed ores from the upper and western ore bodies(MC-1, MW-2) and two types of sulfide ores from the upper and western ore bodies(SC-1, SW-2). As a result of the tests, heap leaching (including bacteria leaching) −SX/EW method proved suitable for the treatment of the oxide ore from the upper ore body and the mixed ore from the western ore body(the ratio, soluble Cu/total Cu isabout 50% in either ore) with about 76% of estimated extraction rate. On the other hand, for the treatment of the mixed ore from the upper ore body(sol.Cu/total Cu is under 20%) and for all the sulfide ores, flotation is suitable with about 90% of recovery (around 77% in case of the mixed ore). As a result of analytical and other investigations on copper concentrates, tailings and also on cathode copper, any impurities that may cause troubles in commercial or environmental aspects were not detected.

As for the two types of mixed ores from the upper and western ore bodies, which are classified as geologically identical, treatment method depends upon the ratio of soluble Cu/total Cu. For ores, of which ratio is under 20%, flotation is suitable, while for those, of which ratio is above 50%, leaching−SX/EW method is better. Accordingly, particular classification of mixed ore is unnecessary in the point of mineral processing. It is recommended that ores are classified in terms of the ratio, soluble Cu/total Cu, simply into oxide or sulfide for the production program and discussion. In economical discussion, however, it should be noted that treatment of these mixed ores may bring somewhat lower metallurgical results and increased operation costs.

Fig. I-4-4-1 shows the flowsheet of metallurgical tests. The results and informations obtained from these tests are summarized in Table I-4-4-1. Fig. I-4-4-2 shows the flowsheet of ore treatment of Cerro Negro deposit based on the above metallurgical results.

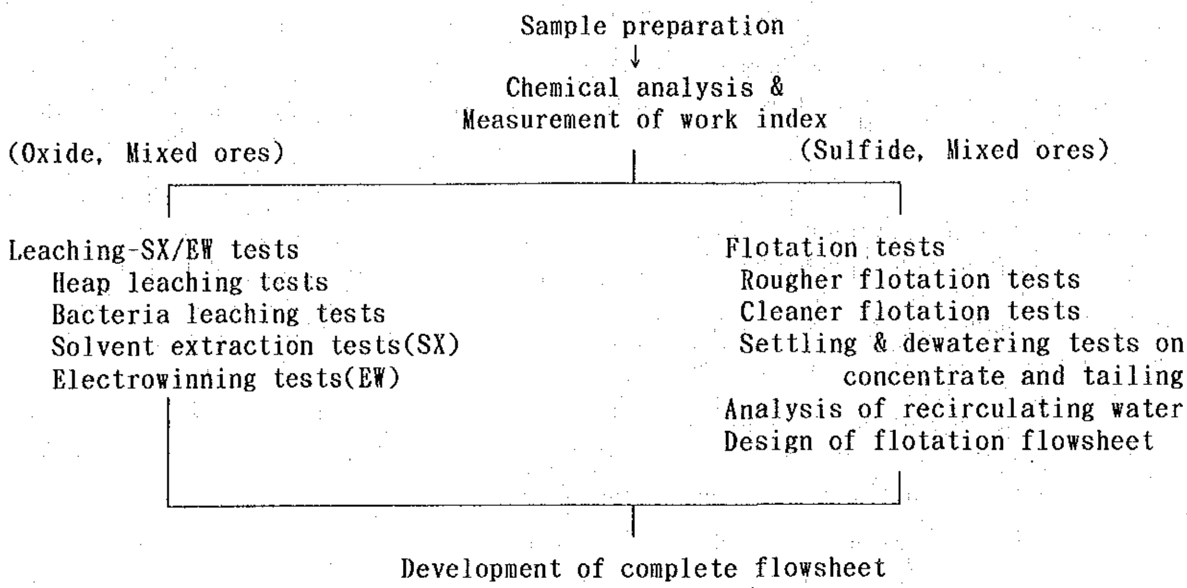


Fig. I — 4 — 4 — 1 Flowsheet of Metallurgical Tests

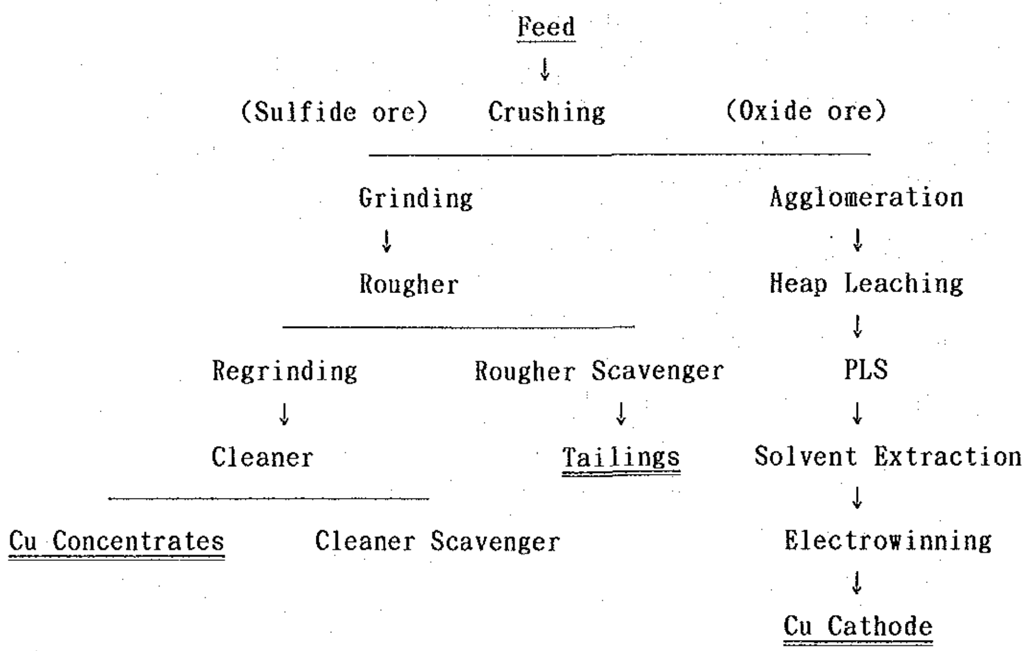


Fig. I — 4 — 4 — 2 Flowsheet of Ore Treatment

Table I — 4 — 4 — 1 Summary of the Metallurgical Results

Sample	SC-1	SW-2	OX-1	MC-1	MW-2
Bond's Work Index (kWh/st)	13.62	17.65	14.45	13.90	16.90
Recovery by Flotation (%)	93.05	87.12	NA	76.60	55.53
Cu Grade of Cu Concentrates (%)	38.75	32.87	NA	33.40	26.63
Extraction by Leaching (%)	NA	NA	75.5	51.8	80.8
Consumption of Sulfuric Acid kg H2SO4/t ore)	NA	NA	30.3	51.9	124.2
kg H2SO4/kg Cu)	NA	NA	5.10	10.8	14.0
Unit Area of Conc. Thickener (m^2/tpd)	0.177	0.202	NA	0.108	0.614
Unit Area of Tail. Thickener (m^2/tpd)	0.106	1.084	NA	0.541	1.490
Unit Area of Conc. Filter (m^2/tpd)	0.028	0.047	NA	0.032	0.099

4—5 Results of calculation of ore reserves

The method of calculation of ore reserve is as follows;

① At first, ore deposits are divided into following five ore bodies, those are the upper, lower, middle, east and west ore bodies.

② Mean Cu grades of each 10m in depth was calculated by the chemical analysis of each 1m in drilling cores. The mean values of Cu grades were assigned as the grade of each 10m of ore body.

③ All the grades were assigned as a unit block which is 25m x 25m(plan) x 25m (depth) in all the ore bodies. The assigning method was distance inverse-square method, because variogram was impractical by geo-statistics method.

④ The actual range of data assignment was a sphere with 400m radius. The reason was that the range of influence in the variogram of the NE-SW direction on the plane. However, it is necessary to further examination about the range of 400m.

⑤ Assigned grades are total Cu, soluble Cu and insoluble Cu. The example of assigned grades and ore body are shown in Fig. II-3-1-3(1) & (2), and average assignment in each block is shown in Fig. II-3-1-4. Specific gravity varies from 2.7 to 3.3, the value of 2.7 is adopted as specific gravity for safety. As the result, 87,692,000tons of ore reserves and To-Cu 0.54%(Cut-off grade 0.4%) were estimated. The lowest level including ore reserves is 820mL above sea level. Refer to the colored figure of grades of blocks on plan about assigned grades in all the blocks(attached document).

In addition to the calculation, designing of open pit was carried out by Moving Cone Method under the following supposition;

① Cut-off grade is 0.4%(Total Cu).

② Total mining recovery is 80%.

③ Copper price is US$1.05/Pound. Though this price is fairly higher than actual price, it is considered to be better that setting up of open pit is fairly larger.

④ Total expenses of mining, dressing, smelting shipping and sales, etc are US$6.91/ton of ore.

⑤ Pit slope is 45 ° , road width within pit is 20m and road slope is 45 . °

The ore reserves within the open pit is estimated to be minable reserves 33,787,120tons(To-Cu grade is 0.61%) is estimated. In this case, the lowest level is 960mL above sea level.

The summary of ore reserves and minable ore reserves is shown in TableI-4-5-1.

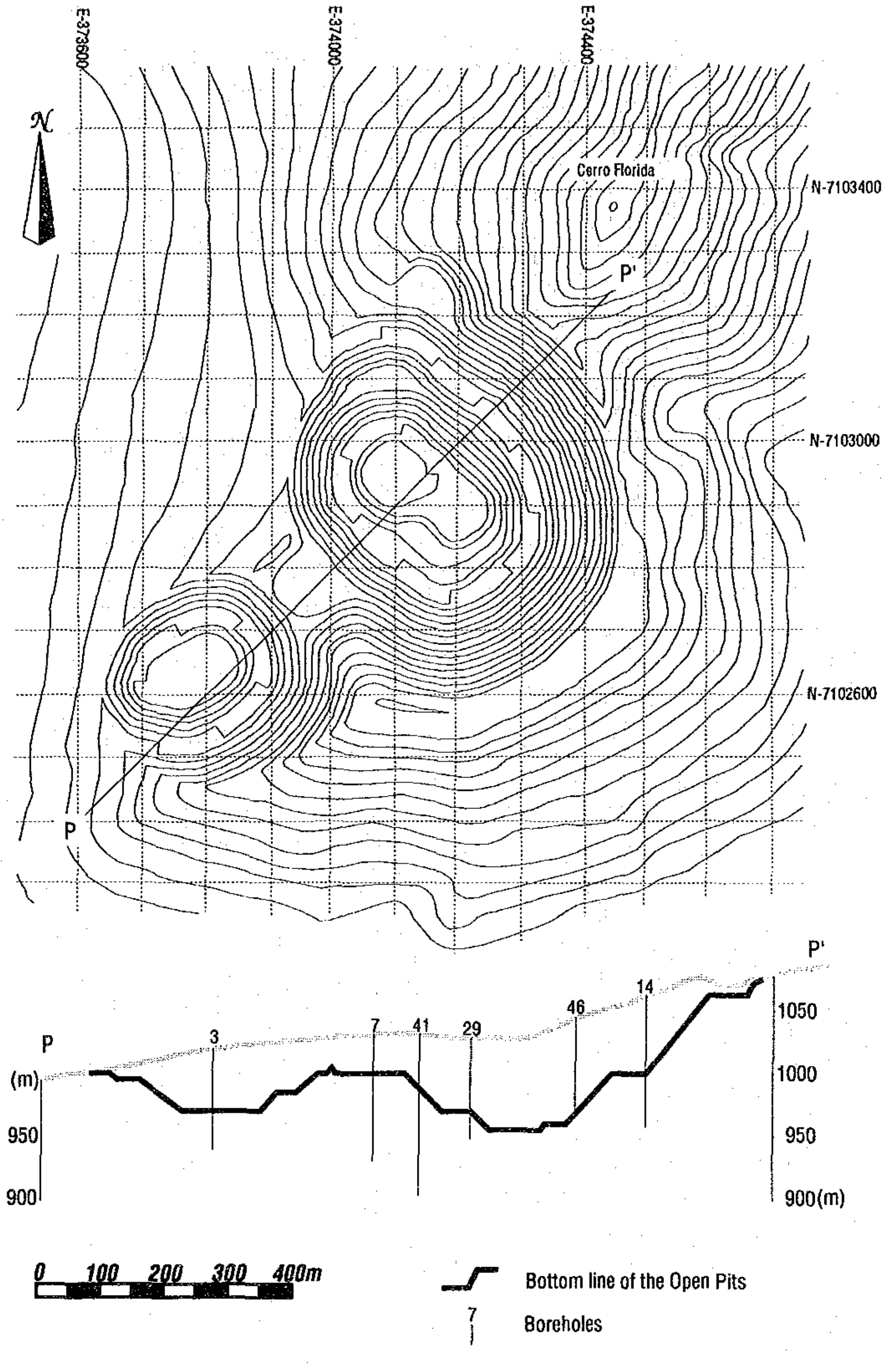


Fig. I-4-5-1 Design Map of Open Pit

Table I-4-5-1 Summary of Calculation of Ore Reserves

Ore Reserves

Cut-off grade (To-Cu %)	0.200	0.400	0.600	0.800	1.000
Ores (×1,000t)	175,572	87,258	18,588	5,298	3,578
Average grade (To-Cu %)	0.428	0.541	0.820	1.199	1.350

Minable Ore Reserves (Ore Reserves in the proposed open pits)

Cut-off grade (To-Cu %)	0.0000	0.2000	0.3000	0.4000	0.5000	0.6000	0.7000	0.8000
Ores (t)	75,062,304	56,607,024	45,413,876	33,787,120	19,763,740	9,438,694	5,479,144	4,556,588
Volume (cubic meters)	27,800,856	20,965,564	16,819,954	12,513,749	7,319,904	3,495,812	2,029,312	1,687,625
Average grade (To-Cu %)	0.374	0.487	0.545	0.613	0.729	0.932	1.145	1.228

4—6 Results of pre-feasibility study

The experts were dispatched to collect necessary information about production of commercial basis in order to examine the possibility of exploitation of the deposits in 1993. After design of open pit, calculation of minable ore reserves and flow sheet making of ore treatment was proposed, the examination about the development by DCF method was carried out with the results of testing and collected information.

Major presupposition is the following:

① Minable ore reserves; 33,787,000tons, To-Cu 0.613%(Cut-off grade 0.4%)
breakdown; oxide ore 24,170,000tons, To-Cu 0.522%
sulfide ore 9,611,000tons, To-Cu 0.842%
(waste 41,280,000tons)

The ore is mined by open cut mining. Mining term is 10 years.

② production;

Copper oxide ore minerals(recovery 72%)
-->cathode copper 9,110tons/year(Cu 99.99%), Copper amount 9,109tons

Copper sulfide ore minerals(recovery 93%)
-->Copper concentrates 21,500tons/year(Cu 35.0%), Copper amount 7,525tons

Flow sheet of ore treatment is shown in Fig. I-4-4-2 and Fig. II-4-3-2. The SX-EW method is selected in treatment of oxide ore.

③ Term of production

Since the longest term of special depreciation as the tax privilage is eight years, a term of production activity is ten years. Besides the term, term of production preparation is three years.

④ Sales condition

The condition adjusts the standard sales condition in the dressing plant of Japan.

⑤ Copper price

The standard is 90¢/lb, however, the cases of 110¢ and 130¢ are considered.

Under the above conditions, internal rate of return(abbreviation form;IRR) (before interest) was calculated by the DCF method. As a result, in cases of 90¢, *110¢ and 130¢ of copper price, IRR were -6.411%, 1.937% and 7.357%, respectively.* The copper price which was calculated back to zero IRR was 104.3¢. The IRR before interest is generally considered to be necessary more than 15%. The copper price which was calculate back to IRR of 15% was 167.5¢.

Total Cu grade 0.70%(breakdown;oxide Cu ore grde 0.61%, sulfide Cu ore grade 0.97%) is necessary in the copper price of 90¢ without any condition change in order to meet zero IRR without interest. 15% of IRR in the same conditions need the crude ore grade of 1.13% in total Cu(breakdown;oxide Cu ore grade 0.97%, sulfide Cu ore grade 1.54%).

The result of calculation by the DCF method is shown in Table II-4-4-1(1), (2)&(3).

CHAPTER 5 CONCLUSION AND RECOMMENDATION

5—1 Conclusion

Calculation of ore reserves based on the result of drilling survey was carried out. The proccess is as follows; At first, calculation of ore reserves was carried out. Next, design of open pit was carried out by the Moving Cone Method. Finally, ore reserves within open pit was calculated as minable ore reserves. In case of 0.4% of Cut-off grade, 87,692,000tons(To-Cu 0.54%) and 33,787,000tons(To-Cu 0.61%) were estimated, as ore reserves and minable ore reserves respectively. The details are shown in Table I-4-5-1 and Table I-4-5-2.

IP logging in the drilling holes, measurement of physical properties of drilling cores(IP characteristics, resistivity and magnetic susceptibility) and re-analysis of the existing IP prospecting data and geomagnetic survey data were carried out in 1992. As a result, the following points were clarified: High magnetic anomaly zone coincides "hydrothermal breccia(generally the country rock of oxide ore bodies)" which is located in shallow part. High IP/low resistivity zone coincides sulfide ore body which is located deep part.

Regarding metallurgical tests, flotation, heap leaching and SX-EW tests were carried out for five types ore minerals, those are oxide ore minerals, sulfide ore minerals and mixed ore minerals of the upper and west ore bodies(except oxide ore minerals of the west ore body because of their small amounts), and flow sheet of optimum ore mineral treatment in this mine was completed. The flow sheet is shown in Fig. I-4-4-2, Fig. II-2-3-1 and Fig. II-2-5-1.

Based on the calculation of ore reserves and metallurgical tests, IRR was tried to calculate by the DCF method. As a result, in cases of 90¢, 110¢ and 130¢ of Copper price, IRR values were -6.411%, 1.937% and 7.357%, respectively. The copper price which was calculated back to zero IRR was 104.3¢. IRR without interest of more than 15% is generally considered to be necessary. The copper price which was calculate back to IRR of 15% was 167.5¢. In order to develop this mine, unrearistically high copper price must be expected. It is caused by low grade of ore. The grade of ore to realize production on commercial basis was tried to calculate.

As a result, total Cu grade 0.70% of crude ore(breakdown;oxide Cu ore grade 0.61%, sulfide Cu ore grade 0.97%) is necessary in the copper price of 90¢ without any condition change in order to meet zero IRR before interest. 15% of IRR in the same conditions is necessary crude ore grade of total Cu 1.13%(breakdown;oxide Cu ore grade 0.97%, sulfide Cu ore grade 1.54%).

5—2 Recommendation for future

The target deposits of the survey was the upper ore deposits which are composed of oxide copper ore minerals. The grade of oxide ore minerals makes higher, the ore reserves markedly decline. Therefore, small scale mining must be necessary in the high grade parts of oxide ore. Regarding locations of high grade part of ore, refer to the ore grade distribution map in attached document.

Since the lower ore bodies were not the target in this project, the details of the deposit are indistinct. Almost all the ore reserves of the lower ore bodies are not included in the minable ore reserves. It was recognizedin this survey that the minable ore reserves of the sulfide ore deposits slightly decrease when the grade of ore becomes higher. The prospecting plan including underground mining should be examined for the lower, west and east ore bodies, and their extension parts in near future. The prospecting area should be enlarge for the lower part and both side(particularly to the west and east) with field geological survey, geochemical prospecting(to be necessary to examine index elements and minerals), structural drilling and geophysical prospecting (mainly CSAMT method). Practical exploitation planning should be planned with the pilot tests of metallurgy and investigations about water supply, electric supply and logistics of necessary materials while prospecting will be carried out.

PART II

DETAILS OF SURVEY

PART 2 DETAILS OF SURVEY

CHAPTER 1 DRILLING SURVEY

1—1 Purpose

The 1992 drilling survey was carried out in a possible mineralized area by outcrop survey. In addition, in IP anomalous areas deep underground in the western skirt of Mt.Cerros Floridas physical prospecting was employed. From the survey, copper oxide ore bodies near the surface and copper sulfide ore bodies deep underground were confirmed.

The purpose of the 1993 survey is to study the continuity, scale, grades and geological structure of copper oxide and copper sulfide ore deposits. This information will be used to calculate the ore reserves and to plan a feasibility study by core drilling in the probable areas of ore deposits. These areas will be decided by the overall analyses of the 1992 drilling and other existing data.

The drilling points of the 1992 survey, 1993 survey and ENAMI's survey are shown in Fig.I-1-3-1. Details of the drilling, such as location, direction, inclination and depth, are shown in Table I-1-3-1.

1—2 Drilling works

The term of the drilling survey was October 1 to November 26, 1993. The actual drilling term was October 1 to November 18, 1993. The progress of drilling work and the result are shown in Table II-1-2-1 and Table II-1-2-2, respectively.

Drilling work with NX caliber was conducted. 92.33% to 100% of cores were recovered including surface soil and talus deposits. Efficiency of drilling varied by geology. Particularly in fracture zone, the drilling efficiency remarkably declined because of water leaking and core blocking. The efficiency of each drilling was 11.82m to 28.00m/work, and the average efficiency of total drilling was 18.58m/work.

1—3 Results of survey

The recovery of cores in drilling was markedly satisfied as mentiond in "Drilling work." Taking color pictures, measurment of recovery rate, RQD(Rock Quality Designation) and by the naked eye determination of all the collected cores were carried out. These cores were finally prepared as specimens for chemical analysis. The remains of cores(semi-crashed) which were sampled for chemical analysis were kept in wooden boxes with lids in every 4m(3m in case of HW size) and stored in a storehouse in Chile.

Table Ⅱ — 1 — 2 — 1　Process Table of Drilling and List of Equipment

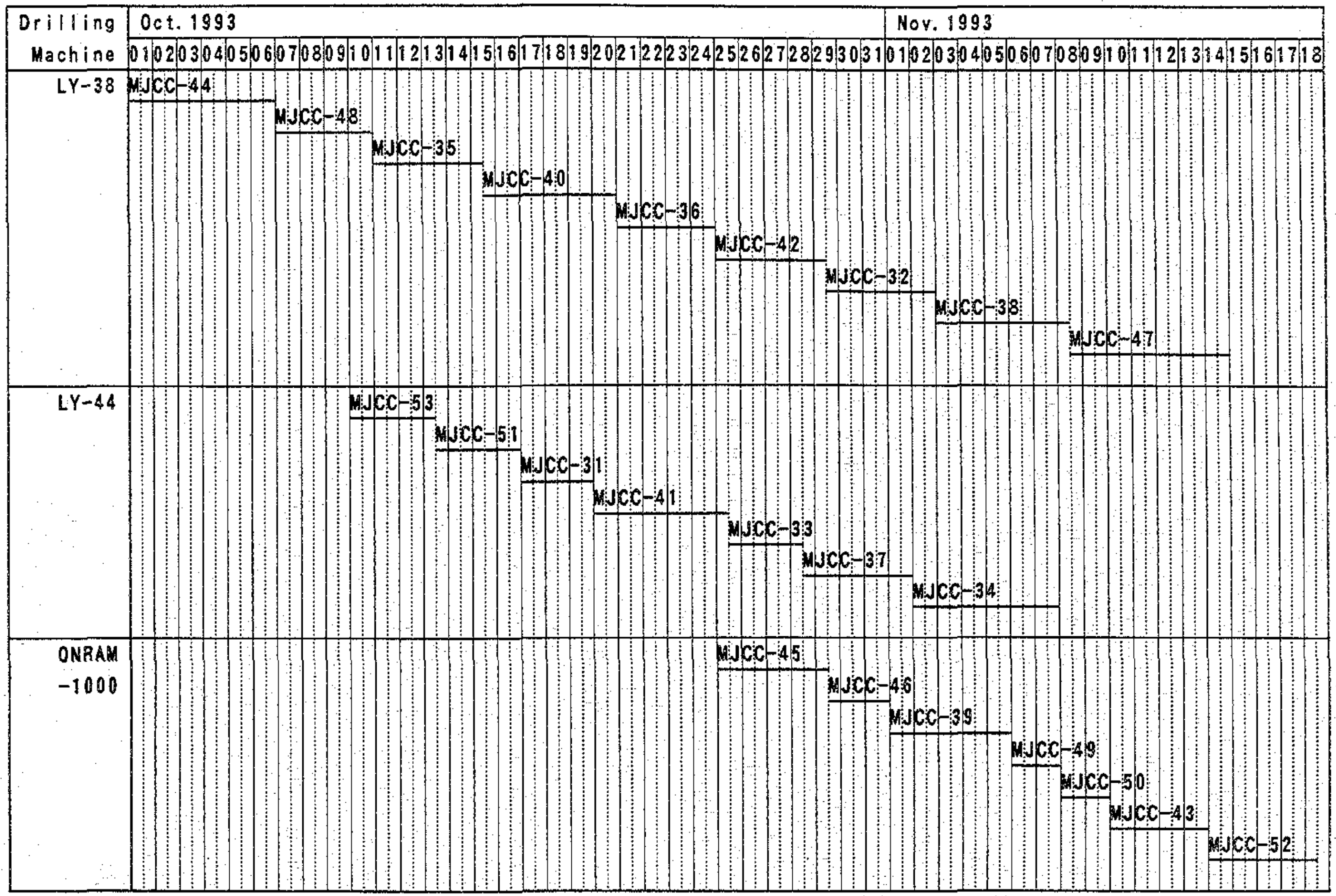


Table I — 1 — 2 — 2 Results of Drilling Works

Drill Hole Number	Drilling Period				No. of Days		No. of Workers	Depth of Drilling		Over Burden	Core Length	Core Recov.	Drilling Speed
	Start Date	Turn	Finish Date	Turn	Total Days	Working Days	man*turn	Planned (meter)	Drilled (meter)	(meter)	(meter)	(meter)	(m/turn)
MJCC-31	93/10/17	1	93/10/19	2	3.0	3.0	18	160	160.00	3.85	156.15	97.59	26.67
MJCC-32	93/10/29	2	93/11/02	2	4.5	4.5	27	170	160.00	0.00	155.15	96.97	17.78
MJCC-33	93/10/25	2	93/10/28	1	3.0	3.0	18	130	130.00	1.00	128.30	98.69	21.67
MJCC-34	93/11/02	1	93/11/07	2	5.5	5.5	36	170	160.00	0.00	159.85	99.91	14.55
MJCC-35	93/10/11	1	93/10/15	1	4.5	4.5	27	130	141.95	0.00	139.65	98.38	15.77
MJCC-36	93/10/21	1	93/10/24	2	4.0	4.0	24	150	145.00	0.00	139.85	96.45	18.13
MJCC-37	93/10/28	2	93/11/01	2	4.5	4.5	27	150	150.00	0.00	149.40	99.60	16.67
MJCC-38	93/11/03	1	93/11/08	1	5.5	5.5	34	130	130.00	0.00	124.80	96.00	11.82
MJCC-39	93/11/01	1	93/11/05	2	5.0	5.0	20	180	195.15	1.25	193.90	99.36	19.52
MJCC-40	93/10/15	2	93/10/20	2	5.5	5.5	33	190	190.00	0.00	187.65	98.76	17.27
MJCC-41	93/10/20	1	93/10/25	1	5.5	5.5	33	250	250.00	0.00	249.25	99.70	22.73
MJCC-42	93/10/25	1	93/10/29	1	4.5	4.5	27	150	150.00	0.00	138.50	92.33	16.67
MJCC-43	93/11/10	1	93/11/13	2	4.0	4.0	16	170	170.00	0.00	170.00	100.00	21.25
MJCC-44	93/10/01	1	93/10/06	2	6.0	6.0	40	150	165.00	3.05	155.77	94.41	13.75
MJCC-45	93/10/25	1	93/10/29	1	4.5	3.5	16	140	140.00	0.00	139.15	99.39	20.00
MJCC-46	93/10/29	2	93/10/31	2	2.5	2.5	10	140	140.00	1.05	137.90	98.50	28.00
MJCC-47	93/11/08	2	93/11/14	2	6.5	6.5	39	180	175.00	0.00	174.35	99.63	13.46
MJCC-48	93/10/07	1	93/10/10	2	4.0	4.0	27	170	165.00	0.00	164.05	99.42	20.63
MJCC-49	93/11/06	1	93/11/07	2	2.0	2.0	8	90	90.00	0.00	89.25	99.17	22.50
MJCC-50	93/11/08	1	93/11/09	2	2.0	2.0	8	80	80.00	0.00	79.00	98.75	20.00
MJCC-51	93/10/13	2	93/10/16	2	3.5	3.5	21	150	150.00	0.00	148.40	98.93	21.43
MJCC-52	93/11/14	1	93/11/18	1	4.5	4.5	18	210	210.00	0.00	208.20	99.14	23.33
MJCC-53	93/10/10	1	93/10/13	1	3.5	3.5	20	160	156.90	2.15	152.90	97.45	22.41
Total	93/10/01	1	93/11/18	1	98.0	97.0	547	3600	3604.00	12.35	3541.42	98.26	18.58

Columnar sections on a scale of 1:200 were made by naked eye observation of drilling cores. The summarized columnar section were made on a scale of 1:1,000(Appendix A). The details of the geological situation and mineralization/ alteration are mentioned in the section on the description of drilling holes.

The specimens of ore minerals and rocks considered necessary were sampled. The thin sections and polished specimens were treated for microscopic observation in order to confirm the columnar section and drilling section (Appendix D). Close-up photographs of representative ore minerals and rocks were taken to record their occurrence.

During chemical analysis of specimens, the specimens were crashed at every 1cm(vertical direction). Half was supplied for chemical analysis and the other half was kept as the sample. The result of the analysis with RQD measurement results are shown in the Table and an listed according to the sampled depth of drilling holes. In addition to the table, the results are illustrated as graphs (Apendix B and C).

Regarding the position of remarkable copper mineralization in the drilling holes, the grades in all the drilling holes are shown in the table of mineralization zones of the drilling cores(Table I -4-2-1).

1 — 3 — 1 Geology and stratigraphy

The rock facies observed in field survey and drilling are fundamentally classified into Quarternary deposits, Cretaceous Los Cerros Floridas formation (andesitic volcanic rocks and partly limestone), dykes, mineralized/altered rocks and fractuated rocks by tectonic movement. The outline of characteristic occurrences of their rock facies are mentioned below.

A detailed geological description of each drilling hole is shown in the section of geological description of drilling cores and the columnar section of drilling holes(Fig. I -4-1-1 and Appendix A).

1) Quarternary deposits

① Talus deposits

The deposits are distributed on the gentle slopes of mountains, and with a thickness of 5m to 10m. The deposits include many small granule of hematite and magnetite. The quantities of hematite granules are more than those of magnetite granules.

2) Cretaceous Los Cerros Floridas formation

This formation is mainly composed of andesite lava flows and andesitic pyroclastic rocks. The four andesite lava flows are confirmed by the analysis of the lava flow units. The lava flows are given names from the fourth andesite lava flow(hereafter called Ad.4) to first andesite lava flow(hereafter called Ad.1), in descending order. The Ad.4 and Ad.3 are aphylic, and sometimes include tuffs or limestones. The Ad.2 and Ad.1 are mostly in plagioclase porphyritic andesite. They seldom include tuff or other rocks.

① Andesitic tuffs

This rock is distributed in the summit part of Mt.Los Cerros Floridas and is remarkably distributed in the upper horizon of Los Cerros Floridas formation. It shows greenish gray to grayish and reddish brown color. The rock facies is composed of medium to fine-grained tuff, tuffaceous sandston and lappilli tuff which partly shows foliation or graded bedding. Although the magnetism of tuffaceous rocks is very weak, sandy and massive part show similar features to aphylic andesitic lava flow,.

Lappilli within tuff is blackish in color. The characteristics of the lappilli is large quantities of magnetite within the groundmass. This is considered to be juvenile. A part of fine-grained tuff includes large quantities of specularite, and shows graded bedding due to different specularite content. Euhedral chalcopyrite and limonited pyrite are observed in the parts in which oxidation dissolution by meteor water were not progressing.

② Aphylic andesite

This rock is aphylic andesite lava which shows grayish to dark grayish color. It is distributed on the Los Cerros Floridas formation. Although it is not generally dense and massive, amygdaloidal structure or autobrecciation is sometimes observed in the boundary part of each lava flow unit, and the structures are key to analysis of the geological structure. Total iron content (as ferric oxide) is less than 10%, although no iron mineralization part is included. Bleach and de-magnetization progress by argillization in the hydrothermal alteration part, and sometimes are difficult to distinguish from massive tuff by the naked eye. There are many fine veins of specularite in the neighboring area of "hydrothermal breccia" zone. The rock is affected by hydrothermal alteration in the surrounding part of vesicles which were paths of hydrothermal solution.

③ Plagioclase porphyritic basaltic andesite

This rock is dark grayish massive lava associated with many plagioclase phenocrysts(1mm x 3mm to 2mm x 4mm). It is generally massive in the central part of unit lava flow. On the other hand, amygdaloidal structure is often observed in the boundary area of lava flows. Autobrecciation is also sometimes observed in the marginal part. The features gradually change from phenocrystic to aphyric and are often observed within a flow unit. These rock bodies generally occur in the lower horizon of Los Cerros Floridas formation. Plagioclase phenocryst shows long columnar. However, preferred orientation of the elongated direction is not observed. Strong magnetism due to large quantities of magnetite in the groundmass is one of its characteristics. Magnetism is not detected near the vesicules which are considered to be the paths of hydrothermal solution. As total iron content(as ferric oxide) is more than 15%, even in non-iron mineralization part, the rock should be classified as basalt.

④ Tuff breccia

This rock facies is composed of tuff and breccias of plagioclase porphyritic andesite, and often occurs as altered rock. This rock facies is considered to be included in the strongly alterated rocks which are classified as "hydrothermal breccia".

⑤ Hyaloclastite

This rock occurs as thin layers of about 1m whose color is blackish to greenish gray in the boundary part of lava flows. It sometimes changes gradually to autobrecciated lava. Magnetism is markedly weak, contrary, to that of lavas which are strong. The quantity of this rock is not so much that the rock does not express a geologic map and geological section.

⑥ Calcaleous rocks

Although this rock is not confirmed by drilling, it is distributed with outcrops as a thin layer in the southeastern part of Mt.Los Cerros Floridas. The general rock facies is that of blackish calcaleous rocks with many tuffaceous inpurities. However, it partly occurs as white colored holocrystalline limestone.

3) Dykes

① Diorite porphyritic dykes

This rock occurs in MJCC-12 and MJCC-18 drilling holes, and often intermingled with andesites by milonitization of a strike-slip fault. The rock facies is widely varied and occurs as medium-grained to fine-grained and white rocks. This rock is often accompanied with felsitic rocks which originate in the same magma as the rock.

② Andesitic dykes

This rock is grayish aphylic andesite or andsite with plagioclase phenocryst. Weak magnetism is one of its characteristics.

4) Others

① "Hydrothermal breccias"

The lithic breccias originated from various rocks which are composed of Los Cerros Floridas formation and iron oxide minerals. These fill up among the breccias as reticulated veins or fine veins. This rock was called "hydrothermal breccia" as the field name of a past survey. This past field name follows in this report for convenience.

This rock was observed at almost all the drilling holes except the holes located in the western margin of the survey area. The distribution of this rock is not concordant with the andesites. Lithic breccias are composed of the fragment of aphylic andesite, plagioclase porphyritic andesite and tuff. There are two cases in the composition of the breccias. One case is that the breccias are composed of only a kind of andesite, and another case is the breccias are composed of more than two kind of andesites. The grain size of lithic breccias varies from boulder to granule. The lithic breccia looks like a jig-saw puzzle, and the fractuated faces of scattered fragments in some areas are often combined with each other.

Iron oxide minerals forming this rock are foliated hematite(specularite), massive hematite, magnetite and maghemite. The quantity ratio of iron oxide minerals and lithic breccias vary from the compact iron ore to the fine vein zone of iron oxide minerals.

② Shear cataclasites

These rocks are cataclastic rocks whose origin is unknown. These occur in the strike-slip fault zone. The textures of original rocks sometimes remain. However, the texture generally shows that of cataclasite. This rock is successively observed in the drilling holes(MJCC-1, 6, 9, 12, 16, 48, 51) in the survey area. Iron content of this rock is low and total iron content(as ferric iron) in this rock is generally less than 7%.

By the overall examination of the distribution situation of these rocks, the general stratigraphy of the survey area follows this description in descending order. However, detailed description of the stratigraphy is difficult since the geology of the survey area was disturbed by fault movement and "hydrothermal brecciation".

Quarternary; Talus deposit

Cretaceous(Los Cerros Floridas formation);

Tuff～tuffaceous sandstone dominant with layers of calcaleous rocks (including "hydrothermal breccia").

Aphylic andesitic lava/tuff breccia dominant(including "hydrothermal breccia") correspond to andesite on the Ad.4 and Ad.3 described later.

Plagioclase porphyritic basaltic andesitic lava dominant(including small quantities of "hydrothermal breccia") correspond to Ad.2 and Ad.1 described later.

1－3－2 Geological structure

Several fault systems were confirmed or presumed by existence of fracture zones and rapid changes of rock facies in the drilling and field survey. These fault systems divide the survey area into several geologic blocks. The blocks are one of the important factors to analyse the shapes of ore deposits and grades of copper ore deposits.

On the other hand, so-called "hydrothermal breccia" is widely distributed in the drilling survey area. This is the country rock of copper ore mineralization. The distribution situation and mineral components are also important factors to analyse of the formation of copper ore deposits and grades of copper.

The representative structures are as follows. The representative geologic map and geological section are shown in Part I and at the end of this report (Fig. I-4-1-1 and the Plate-II).

① Strike and dip

As the variation of rock facies is scarce and the juvenile structures are destroyed by "hydrothermal brecciation" in many places, confirmation of general direction of strike and dip by stratigraphic study was not satisfactorily carried out.

The general inclination of dip is presumed to be 20 ~30° to the north-west. By the shape and quantities of plagioclase, the amygdaloidal structure of andesite lavas is presumed to be the general inclination. The moderate inclination of 20 ~30° to the northwest is presumed by the foliation of tuffs. Those are slightly distributed near the summit of the mountain. Almost vertical inclination to the southeast was found on south and east of the mountain.

② The fracture zone of Los Cerros Floridas-W fault

Cataclasite by fault is observed in the drilling holes(MJCC-1, 6, 9, 12, 16, 18, 48, 51) in the western marginal part of the drilling survey area. This cataclasite is considered an extension of strike-slip fault observed at the surface near the drilling hole MJCC-19. The cataclasite shows the strike and dip of about N30° E and 50° NW, respectively. This is considered to be a strike-slip fault with a fracture zone of 50m~100m in width. This is determined by the occurrence and depth of the cataclasite and the drilling holes.

③ Los Cerros Floridas-E fault

This fault is presumed by field survey to lie in the eastern part of the mountain. The fault most likely lies parallel to the former Los Cerros Floridas-W fault.

④ Fault with the direction of NE

The existence of four faults with a direction of NE is presumed by the rapid change of rock facies in neighboring drilling holes. The NE-1 fault is considered to lie near the MJCC-19 drilling hole, the NE-2 fault near the MJCC-6, 40, 10 and 46 drilling holes, the NE-3 fault near the MJCC-24, 37 and 8 drilling holes, and the NE-4 fault near the MJCC-32, respectively. All the directions of strike show about N60 ° E and all their dips are considered to be steep. Particularly, the NE-2 and the NE-3 faults lie crossing the survey area. They are important for the analysis of geological texture.

⑤ Fault with the direction of NW

The existence of two faults with the direction of NW is presumed by the examination of rock facies in the drilling holes and analysis of valley topography. The NW-1 fault near the MJCC-50 and 52 driling holes and the NW-2 fault near the MJCC-19 drilling hole are presumed to lie with strike of about N55 ° W and steep dip. Particularly in the NW-1 fault, the left lateral slip of valley topography is observed, and the fault is presumed to be cut by the NE-2 fault.

Six valleys in the topography with parallel directions of NW are recognized between the NW-1 fault and the NW-2 fault. These valleys are considered to be small faults or fractures with the same direction.

⑥ "hydrothermal breccia"

The "hydrothermal breccia" is observed in the drilling holes like the surface. Their occurrences vary and the distributions are complicated in drilling cores. The deepest occurrence of 850mL is observed in the MJCC-41 drilling hole. The occurrence is observed in less than 900mL in the surrounding area. General tendency of occurrence is deeper in the southwestern part. However, the tendency is cut by the NE-3 fault which was described before. In addition, no occurrence of a deep part is observed in the southern part of the NW-3 fault. The rough shape of this rock is presumed to be pipe or funnel-like. It widens to the upper part deep underground, and spreads widely in harmony with strata in the shallow part.

1—3—3 Copper ore deposits

The copper deposits in the survey area are divided into five ore bodies by their three dimensional distribution. They are the upper body, middle body, lower body, east body and west body. Their distribution is shown in Fig. I-4-2-1. Although the upper ore body is mainly composed of oxide minerals, there are mixed ore parts coexisting with sulfide and oxide minerals, and sulfide minerals in the lower part of the ore body. The other bodies are mainly composed of sulfide minerals. In addition, the dominant oxide mineral parts and mixed ore dominant parts are observed. The characteristics of these minerals are as follows;

Copper oxide ore zone:

associated with malachite, atacamite, chalcanthite with chrysocolla, azurite and chalcocite.

Mixed zone(Intermediate zone):

the mixed part of copper oxide mineral zone and sulfide ore mineral zone.

Copper sulfide mineral zone:
copper sulfide minerals are mainly composed of chalcopyrite.

The spacial distribution of each copper mineralized zone and the distribution of grades are closely confirmed by the 1993 drilling survey. The mineralization zones observed by the drilling survey are summarized according to their ore minerals in Table I-4-2-1.

The characteristics of each mineralization zone are summarized below.

1) Copper oxide mineralization zone

A copper oxide mineralization zone is observed in almost all the drilling holes except the holes located in the western margin of the survey area. This mineralization zone is generally distributed over the shallower underground at less than 50m～100m. The high Cu grade parts of more than 1%SCu repeat at intervals of about 10m～15m. The high grade part of more than 10%SCu is partly observed(for example, under about 50m of MJCC-55 drilling hole). However, continuity of the high grade part is not good. The main copper oxide minerals are atacamite and malachite with small quantities of chrysocolla, azurite and chalcanthite.

This mineralized zone can be divided further considering to the origin of copper oxide minerals. The occurrence and distribution of the copper oxide minerals are as follows;

① Oxides[1]:(exotic ore)

This kind of minerals is oxidized in the present place after the removing from other places by some reason. The main minerals are malachite, atacamite and chalcanthite. The mineralization zone is not accompanied with related copper sulfide minerals in this survey area. The representative occurrence is observed in the shallow part of the MJCC-7 drilling hole.

② Oxides[2]:(in situ type)

This kind of mineralization zone is accompanied with mixed and copper sulfide mineralization zones. The oxide minerals are considered to be formed that copper sulfide ore mineral oxidized by meteor water and precipiteted in neighboring place. This zone is generally accompanied with small quantities of a non-oxidized remnant of copper sulfide minerals. The large part of the upper ore bodies are classified into this type.

③ Oxides[3]:(tectonic type)

This type of ore is copper oxide ore mineral which occurs harmonizing with fracture zone(fault), and the tectonic movement is considered to have close relationship to the origin of copper oxide minerals. The grade of copper ore is generally low, and the oxidation is presumed to be limited within fracture zone. The representative occurrence of this type is observed in the underground of about 120m under the MJCC-20 drilling hole.

2) Mixed zone(Intermediate zone)

Copper sulfide minerals sometimes remained within the copper oxide mineral zone. This particular section is called the mixed zone(intermediate zone). The high grade part of the copper oxide mineral ore zone which was described before is mostly composed of copper oxide minerals. However, much of the less than total Cu1% within the high grade part is composed of nearly the same quantities of copper oxide mineral and remnant copper sulfide minerals. The mixed zone sometimes occurs as the transitional zone between the copper oxide mineral ore zone in the upper part and the copper sulfide mineral zone in the lower part. However, the distribution features of the above three zones are too complicated to define as individual zones.

This mineralized zone can be divided further detailed by considering the origin of copper minerals. The characterisrics of distribution and the occurrence of copper minerals are as follows;

① Transition[1]:(exotic type)

Although the mixed zone in which juvenile copper sulfide minerals and the oxide[1] mentioned above occurs in theory, the study has not been carried out in this survey area.

② Transition[2]:(in situ type)

The characteristic of this type is that the copper sulfide mineralization zone continues in the lower part of the body. Both copper oxide ore minerals and copper sulfide ore minerals occur. The origin of copper oxide minerals is copper sulfide minerals occurring in their neighborhood. Those were formed by meteor water in situ. However, some copper sulfide minerals remain as a result of incomplete oxidation. The representative occurrences are observed 50m underground near the MJCC-29 and 50m underground near the MJCC-42. This type is generally observed in the central part of the upper body and the upper part of the other bodies.

③ Transition[3]:(tectonic type)

Although this type is fundamentally the same oxide[3], copper oxide minerals occur in addition to copper oxide minerals. The copper sulfide minerals are considered to remain by incomplete copper oxidation. These occur regardless of the depth. This is in harmony with the fact that the survey area is divided into many tectonic blocks as a result of the tectonic movement of many faults. The representative occurrence is observed under 120m near the MJCC-20 drilling hole.

3) Copper sulfide mineralization zone

Copper sulfide mineralized zones are observed in many drilling holes in this survey area. A high grade copper sulfide mineralization zone is observed in the drilling hole near the center of this survey area. The copper sulfide zone generally occurs underground deeper than 50m ~100m. The parts of more than 20%ICu are observed in a limited place(for example, 135m in the depth of MJCC-29 drilling hole). The continuity of the above high grade part is not good. The main copper sulfide mineral is chalcopyrite, with small quantities of chalcocite and covelline also present.

This type of mineralization zone can be divided by the origin, the characteristics of occurrences, and the distribution features. Those characteristics follow;

① Sulfides[1]:(exotic type)

This type of mineralization zone is the exotic origin of copper sulfide. These types of zones are not observed in this survey area.

② Sulfides[2]:(in situ type)

This type of mineralization zone includes only the juvenile copper sulfide minerals by copper mineralization. It is divided into the following four sub-classes by the nature of the country rock.

・Sulfides[2-1]:(in situ HTB type)

This type of mineralization zone forms the main mineralization zone in which the occurrence of copper sulfide has a close relationship with the existence of "hydrothermal breccia" in this survey area. The shape of the mineralization zone is presumed to be like "stock" in the central part of "hydrothermal breccia" and like widely-spreading "manto" in the marginal part of the survey area. Copper sulfide minerals of the copper mineralization zone are disseminated ore and fine veins which are mainly composed of chalcopyrite. The chalcopyrite coexists with iron oxide minerals(specularite and magnetite) and iron sulfide(pyrite). These kinds of minerals are the main ore minerals of sulfide ores. The representative occurrence is observed about 40m underground near the MJCC-40 drilling hole and about 80m underground near the MJCC-42 drilling hole.

・Sulfides[2-2]:(in situ vertical type)

This type copper sulfide mineralization zone is born in andesite as the country rock. As the horizontal distribution, it is in harmony with lava which is originally amygdaloidal in structure. The shape is considered to be a kind of mantle which is horizontally spreading. Copper sulfide minerals of the mineralization zone includes chalcopyrite and pyrite dissemination. This type of mineralization zone is distributed comparatively widely. It is distributed with horizontal extension within andesite under "hydrothermal breccia." The representative occurrences of this type are observed 200m underground near the MJCC-27 drilling hole and 150m underground near the MJCC- 41 drilling hole.

・Sulfides[2-3]:(in situ fault type)

This is the copper sulfide mineralization zone. The country rock is mylonite andesites within the fracture zone of Los Cerros Floridas fault(the direction of NNE-SSW). Although occurrence of chalcopyrite and pyrite occur less quantities than that of chalcopyrite as composite sulfide minerals and mineralization/alteration process is not developed, copper grade remainds in middle class(the occurrence is observed in the MJCC-12, 16, etc).

・Sulfides[2-4]:(in situ vein type)

This type of mineralization zone can be regarded as ore veins on a small scale. The veins occur under the mineralization zone with manto shaped described above. This zone under the mantle shaped mineralization zone is also considered to be the supplied paths of ore solution and the extension of the lower parts of [2-1] and [2-2] types mentioned above. The occurrence is observed in the MJCC-29 drilling hole(about 135m), MJCC-41 hole(about 250m), MJCC-52 hole(about 145m) and working place of the mine which is located in the southern part of the MJCC-39 hole. However, the occurrence of the elongated direction of the ore deposit is not observed except in the mine. As the copper grade is high, commercial mining is considered to be probable if the other conditions are prepared.

③ Sulfides[3]:(tectonic type)

Copper sulfide mineralization zone is considered to be formed and controlled by the tectonic movement theoretically. However, this type of zone is considered not to be existed in this survey area.

1—3—4 Review of 1st year's survey results

In total, 30 holes and a length of drilling of 6,420.00m were carried out in the high probability area of copper ore deposits. This was performed by the examination of the existing data in 1992. Decision of the drilling points was made after consideration of the following points:

① Ore deposit and mineralization/alteration zone was observed by surface survey.
② High anomalous area by geophysical prospecting(IP method).
③ Low resistivity area by geophysical prospecting(IP method).
④ Medium to high magnetic anomalous area by geophysical prospecting (geomagnetic prospecting).
⑤ Mineralization zone by existing drilling data.

A copper oxide mineralization zone and a copper sulfide mineralization zone were detected in almost all the drilling holes in more or less quantities. The many country rocks are andesites of Los Cerros Floridas formation and "hydrothermal breccias," and they often bear high grade copper mineralization zones. The high grade copper oxide mineralization zone generally occurs near the surface at less than 60m underground. On the other hand, high grade copper sulfide mineralization zones generally occur in a deeper place at more than 50m. An intermediate zone(mixed mineralized zone) often occurs between the copper oxide mineralization zone and the copper sulfide mineralization zone. The shape of this mixed mineralization zone is too complicated to define as an individual mineralization zone.

The detailed data were obtained by drilling 12 holes within the 30 holes of total drilling. A detailed description and examination of the remaining holes are given in the 1993 report.

The main mineralization zones observed in the 12 holes described in detail are as follows; Within the mineralization zones, the biggest copper oxide mineralization zone is 25m deep(average grade is 1.023%Cu), and the biggest copper sulfide mineralization zone is 29m deep(average 1.021%Cu).

Drilling hole	depth(range)	TCu%	SCu%	ICu%	TFe%	Type of Mineralization
MJCC-07	0m- 15m(15m)	0.673	0.538	0.137	32.23	Oxide Mineral. zone
MJCC-07	15m- 40m(25m)	1.023	0.917	0.106	29.23	Oxide Mineral. zone
MJCC-07	46m- 54m(8m)	0.692	0.492	0.200	31.93	Oxide Mineral. zone
MJCC-07	125m-154m(29m)	1.021	0.046	0.975	34.07	Intermediate Mineral. zone
MJCC-08	0m- 21m(21m)	0.458	0.208	0.250	27.12	Sulfide Mineral. zone
MJCC-10	0m- 45m(45m)	0.750	0.532	0.218	30.01	Oxide Mineral. zone
MJCC-10	45m- 50m(5m)	0.748	0.218	0.530	38.06	Sulfide Mineral. zone
MJCC-10	50m-105m(55m)	0.689	0.037	0.652	36.13	Intermediate Mineral. zone
MJCC-11	30m- 32m(2m)	1.030	0.945	0.079	32.42	Oxide Mineral. zone
MJCC-11	38m- 39m(1m)	0.910	0.800	0.110	28.44	Oxide Mineral. zone
MJCC-11	57m- 59m(2m)	0.740	0.580	0.160	51.21	Intermediate Mineral. zone
MJCC-11	163m-164m(1m)	1.750	0.150	1.600	24.63	Oxide Mineral. zone
MJCC-12	38m- 40m(2m)	0.875	0.810	0.065	7.70	Oxide Mineral. zone
MJCC-12	57m- 68m(11m)	0.409	0.294	0.115	7.43	Intermediate Mineral. zone
MJCC-12	79m-107m(28m)	0.409	0.065	0.344	6.43	Sulfide Mineral. zone
MJCC-12	115m-148m(41m)	0.697	0.014	0.683	12.12	Sulfide Mineral. zone
MJCC-13	9m- 17m(8m)	1.089	0.848	0.241	23.68	Oxide Mineral, zone
MJCC-13	20m- 37m(17m)	0.744	0.335	0.408	24.13	Intermediate Mineral. zone
MJCC-13	45m- 51m(6m)	1.168	0.538	0.312	38.10	Intermediate Mineral. zone
MJCC-13	59m- 74m(15m)	0.472	0.014	0.458	28.78	Sulfide Mineral. zone
MJCC-16	50m- 93m(43m)	0.548	0.249	0.299	15.58	Intermediate Mineral. zone
MJCC-16	93m-111m(18m)	0.451	0.008	0.443	11.83	Sulfide Mneral. zone