Mineralization zones at four places were captured according to Cu grade. The depth, average grade and mineralization type of these ranges are as follows.

Mineralization zone	Depth (range)	TCu%	SCu%	ICu%	TFe%	Mineralization type
A	9.00～ 17.00m(8.00m)	1.089	0.848	0.241	23.68	Oxidation zone
B	20.00～ 37.00m(17.00m)	0.744	0.335	0.408	24.13	Intermediate zone
C	45.00～ 51.00m(6.00m)	1.168	0.312	0.857	38.10	Intermediate zone
D	59.00～ 74.00m(15.00m)	0.472	0.014	0.458	28.78	Sulfurization zone
Total of mineralization zone	(46.00m)	0.770	0.317	0.454	27.39	
Total of the upper section	0.00～ 74.00m(74.00m)	0.616	0.252	0.363	27.11	
Total of the deep section	115.00～172.00m(57.00m)	0.114	0.002	0.111	18.64	Sulfide dissemination zone

1-3-8 MJCC-14

1. GENERAL

(1) Reason of the implementation of this survey

This hole is located in the middle of the mineralization zones 1, 2 and 4 (ENAMI, 1991) and "hydrothermal breccia" accompanied with a small amount of hematite and magnetite is distributed on the surrounding surface. Surface physical survey (Geodatos, 1991) found that this was located at the east edge of low resistivity, high IP zone and high magnetism abnormal zone. Thus this survey was intended to recognize the distribution condition of secondary enrichment copper oxide zone and copper sulfide zone.

(2) Outline of the result

This hole is composed of andesite pyroclastic rock (depth: 0m – 25m), andesite "hydrothermal breccia" (depth: 25m – 106m), nonporphyritic andesite lava (depth: 106m – 148m) and basaltic andesite lava (depth: 148m – 205m) and in the entire range, weak copper mineralization (grade: 0.86%Cu max.) is noticed. The coordinate and drilling result of this hole are as follows.

	Coordinate	Drilling result	
N:	7,103,080.40	Direction:	---
E:	374,309.22	Dip:	-90°
H:	1,166.74	Depth:	204.90m

2. GEOLOGICAL FEATURE

(1) Rock face and stratigraphy

1) Andesite pyroclastic rock (depth: 0m – 25m)

This rock is composed of tuff breccia and tuff. The tuff breccia is accompanied with plagioclase porphyritic andesite and tuff breccias and partially shows small scale hydrothermal brecciated structure. The tuff presents banded structure of medium to fine grain and is partially accompanied with hematite fine vein.

2) Andesite "hydrothermal breccia" (depth: 25m – 106m)

This rock is of lithic breccia of andesite and andesite tuff and shows the rock face that the cracks of breccia are filled with hematite (specularite) in netted vein. In the center (depth: 92m ±), compact iron ore condition is presented and lithic breccia fragment increases toward the edge. The lithic breccia is discolored in pale green to reddish brown and its original rock structure is almost difficult to identify. The section upper from the center is accompanied with traces of leached sulfide.

3) Nonporphyritic andesite lava (depth: 106m – 148m)

This is gray or dark gray lava, accompanied with small scale "hydrothermal breccia", magnetite, hematite fine vein and magnetite dissemination. Amygdal structure and self crushed structure are noticed on the border of lava flow.

4) Basaltic andesite lave (depth: 148m - 205m)

This rock is composed of repeated thin layers of dark gray lave flows and features a large amount of fine grain magnetite contained in the ground mass. Amygdal structure and self crushed structure are presented on the border of the lave flow. This rock is accompanied with plagioclase phenocryst in the upper and lower sections.

(2) Decomposition and deformation

Leached sulfide due to oxidation from the surface reaches about 80m deep. No remarkable deformation after mineralization is recognized.

3.MINERALIZATION

(1) General

Copper and iron mineralizations are observed continuously from the surface to the hole bottom. The characteristics are as follows.

Depth	Copper oxide ore	Copper sulfide ore	Hematite	Magnetite	Pyrite
0.00~ 80.00m	△ Crack		○ Network vein		• Dissemination
80.00~105.00m	△ Crack		◎ Network vein		
105.00~125.00m	• Crack	• Dissemination	△ Micro vein	△ Micro vein	△ Dissemination
125.00~150.00m		• Dissemination		△ Micro vein	△ Dissemination
150.00~205.00m		△ Dissemination		○ Dissemination	△ Dissemination

(2) Particulars

1) Oxidation zone

A small amount of copper oxide ore composed of mainly malachite exists in the range from the surface to the depth of 125m (1040mL). Malachite is disseminated in the cracks of andesite breccias in fine vein, coexists with hematite (specularite) but it is not disseminated inside of lithic breccia.

2) Sulfurization zone

Very weak chalcopyrite exists continuously in the depth of 106m (1060mL) or more. Chalcopyrite coexists with pyrite and quartz and is produced in amygdal structure and fine vein of quartz or green mud stone.

4. RESULT OF ORE ANALYSIS

The average grade of the upper and lower sections are as follows.

Mineralization zone	Depth (range)	TCu%	SCu%	ICu%	TFc%	Mineralization type
A	0.00~125.00m(125.00m)	0.227	0.089	0.138	26.95	Oxidation zone
B	125.00~199.00m(74.00m)	0.148	0.012	0.137	19.14	Sulfurization zone
Total of mineralization zone	0.00~199.00m(199.00m)	0.198	0.061	0.137	24.04	

1-3-9 MJCC-16

1. GENERAL

(1) Reason of the implementation of this survey

This hole is located in the distribution area of white decomposed zone and in the north of the low resistivity, high IP zone captured by surface physical survey (Geodatos, 1991). This survey was intended to recognize the development condition of the "hydrothermal breccia" estimated from this and the distribution condition of copper sulfide ore expected in the lower section.

(2) Outline of the result

The rocks composed of this hole are decomposed rock on the surface (originated from supergene, depth: 0.00m – 15.00m), nonporphyritic andesite lava (depth: 15.00m – 84.80m) and mylonitized andesite (depth: 84.80m – 216.75m) and characterized by the development of this mylonitized andesite. The intermediate zone (grade: 0.548%Cu) where copper oxide ore and copper sulfide ore were mixed was recognized in nonporphyritic andesite (depth: 50.00m – 93.00m) and on the other hand, copper sulfide zone (grade: 0.451%Cu) was recognized in mylonitized andesite (depth: 84.80m – 216.75m). The coordinate and drilling result of this hole are as follows.

Coordinate		Drilling result	
N:	7,103,282.50	Direction:	---
E:	374,088.00	Dip:	-90°
H:	1,123.45	Depth:	216.75m

2. GEOLOGICAL FEATURE

(1) Rock face and stratigraphy

1) Decomposed rock (depth: 0.00m – 15.00m)

This is a greenish gray decomposed rock. Although this original rock is andesite, any structure of the original rock is not recognized due to strong decomposition. The decomposition action consists of argillization, silicification and creation of gypsum by supergene. In this hole, visually, any trace of copper mineralization is not recognized.

2) Nonporphyritic andesite (depth: 15.00m – 84.80m)

This rock is greenish gray, lump fine grain nonporphyritic andesite lava and medium level argillization and creation of gypsum along cracks are recognized. The deposit of hematite is recognized at several points and oxidation occurs partially along cracks.

3) Mylonitized andesite (depth: 84.80m – 216.75m)

This rock is dark greenish gray, lump fine grain mylonitized andesite (however, weak rearrangement structure of ore considered to be due to mylonitization is partially recognized). The rock face is equal from the top to the bottom and nonporphyritic andesite lava is estimated to be its original rock because plagioclase phenocryst is recognized little and nonporphyritic andesite is residual. Grayish brown fine grain andesite tuff exists in the middle and lowest section.

(2) Decomposition and deformation

Although oxidation by supergene and creation of gypsum are recognized in the range from the surface to the depth of 80m, visually the degree of decomposition is estimated to be the extent of propylitization in the deeper section. Deformation after mineralization and decomposition requiring no special attention is not recognized.

3. MINERALIZATION

(1) General

The intermediate zone where copper oxide ore and copper sulfide ore are mixed and the copper sulfide zone continuing in the lower section are recognized. The condition of mineralization at each depth is as follows.

Depth	Copper oxide ore	Copper sulfide ore	Hematite	Magnetite	Pyrite
0.00～ 50.00m			△ Network vein		
50.00～ 93.00m	△ Crack	△ Dissemination	○ Network vein		
93.00～111.00m		○ Dissemination	· Network vein	○ Network vein	· Dissemination
111.00～154.00m		△ Dissemination		○ Network vein	· Dissemination
154.00～202.00m		· Dissemination		○ Network vein	· Dissemination
202.00～216.00m		△ Dissemination ～Network vein		○ Network vein	· Dissemination

(2) Particulars

1) Oxidation zone

Mineralization is recognized little in the range from the surface to the depth of 50m (1,120m – 1,070mL) and oxidation zone is not present in this hole.

2) Intermediate zone

The range of 50m to 93m (1,070m – 1,030mL) can be considered to be the intermediate zone where copper oxide ore and copper sulfide ore are mixed. Most of it is contained in nonporphyritic andesite while copper oxide ore is malachite and copper sulfide ore is fine grain chalcopyrite. The former fills cracks and the latter shows dissemination.

3) Sulfurization zone

Copper sulfide zone composed of mainly chalcopyrite is present in the range of 93.00m to 111.00m (1,030m – 1,030mL). Chalcopyrite coexists with pyrite and contained in mylonitized andesite in dissemination (netted vein). The quality level of component ore is mostly chalcopyrite>pyrite and magnetite is the component ore of the ground mass of mylonitized andesite which is the host rock.

4. RESULT OF ORE ANALYSIS

Two mineralization zones were captured. The depth, average grade and mineralization type of each range are as follows.

Mineralization zone	Depth (range)	TCu%	SCu%	ICu%	TFe%	Mineralization type
A	50.00～ 93.00m(44.00m)	0.548	0.249	0.299	15.58	Intermediate zone
B	93.00～111.00m(18.00m)	0.451	0.008	0.443	11.83	Sulfurization zone
Total of mineralization zone	(62.00m)	0.520	0.179	0.341	14.49	
Total of the whole hole	0.00～216.75m(216.75m)	0.197	0.053	0.144	10.02	

1-3-10 MJCC-17

1. GENERAL

(1) Reason of the implementation of this survey

This hole is located in the mineralization zone 1 (ENAMI, 1992) and "hydrothermal breccias" accompanied with hematite are distributed on the surface. Surface physical survey (Geodatos, 1991) found that this belonged to high resistivity, high IP zone and high magnetism abnormal zone. Thus this survey was intended to recognize the distribution condition of copper oxide zone.

(2) Outline of the result

This hole is composed of andesite pyroclastic rocks (depth: 0m - 30m), nonporphyritic andesite lava (depth: 30m - 130m) and basaltic andesite lava (depth: 130m - 160m), and copper mineralization (grade: 1.59%Cu max.) is recognized in the depth of 65m or less.

The coordinate and drilling result of this hole are as follows.

	Coordinate	Drilling result	
N:	7,103,5 .	Direction:	---
E:	374,200.	Dip:	-90°
H:	1,178.85	Depth:	160.05m

2. GEOLOGICAL FEATURE

(1) Rock face and stratigraphy

1) Andesite pyroclastic rocks (depth: 0m - 30m)

These rocks are composed of self crushed lava and tuff. The lava is gray nonporphyritic or plagioclase phenocryst andesite. The tuff shows medium grain to fine grain banded structure and is accompanied with fine veins of hematite (specularite) and magnetite and dissemination of magnetite.

2) Nonporphyritic andesite lava (depth: 30m - 130m)

This rock is dark gray nonporphyritic lava, presenting the condition of "hydrothermal breccia" in the depth of 40m to 50m, accompanied with fine vein of magnetite or dissemination. Amygdal structure and self crushed structure are observed on the border of lava flow. Additionally, the cavities considered to be the path of hot water are also observed (depth: 75m ±).

"Hydrothermal breccia" is composed of mainly netted vein of hematite (specularite) and changes to hematite fine vein, magnetite fine vein and dissemination toward the edge. In the range higher than the center, this is accompanied with traces of leached sulfide.

3) Basaltic andesite lava (depth: 130m - 160m)

This rock is composed of repeated thin layers of dark gray lump lava flows and characterized by a large amount of magnetite contained in the ground mass. This presents amygdal structure and underwater self crushed tuff (dip: about 10 degrees) on the border of lava flow. This is accompanied with plagioclase phenocryst except the lowest range.

(2) Decomposition and deformation

The leaching of sulfide ore from the surface due to oxidation reaches about 50m deep. Any deformation after mineralization requiring a special attention is not recognized.

3. MINERALIZATION

(1) General

Copper mineralization is noticed continuously from the surface to the depth of 68m around the hydrothermal breccia and the mineralization zone is classified to five zones according to the characteristic of ore and mineral.The condition of mineralization at each depth is as follows.

Depth	Copper oxide ore	Copper sulfide ore	Hematite	Magnetite	Pyrite
0.00～ 17.00m	△ Crack		○ Micro vein		
17.00～ 40.00m			・ Micro vein	○ Dissemination	
40.00～ 50.00m	◎ Micro vein		◎ Network vein		・ Dissemination
50.00～ 68.00m	・ Crack		△ Micro vein	○ Dissemination	
68.00～160.00m		・ Dissemination		○ Dissemination	・ Dissemination

(2) Particulars

1) Oxidation zone

In the range from the surface to the depth of 68m (1110mL), a small amount of copper oxide ore composed of mainly malachite and chrysocolla is disseminated in cracks in fine vein, coexists with hematite (specularite), however not disseminated inside of the lithic section.

2) Sulfurization zone

Although visually a very small amount of chalcopyrite exists in the depth of 100m (1075mL) or more, any ore body worthy of mineral deposit is not formed. Chalcopyrite coexists with pyrite and quartz and is produced in amygdal structure and fine veins of quartz and green mud stone.

4. RESULT OF ORE ANALYSIS

The mineralization zone is classified to the following four types according to Cu grade. The depth, average grade and mineralization type of each range are as follows.

Mineralization zone	Depth (range)	TCu%	SCu%	ICu%	TFe%	Mineralization type
A	0.00～ 8.00m(8.00m)	0.464	0.201	0.263	13.69	Oxidation zone
B	11.00～ 22.00m(11.00m)	0.531	0.253	0.278	20.53	Oxidation zone
C	33.00～ 41.00m(8.00m)	0.464	0.258	0.206	20.21	Oxidation zone
D	41.00～ 55.00m(14.00m)	0.911	0.573	0.338	22.81	Oxidation zone
Total of mineralization zone	(41.00m)	0.635	0.353	0.282	19.91	
Total of the whole hole	0.00～ 68.00m(68.00m)	0.479	0.240	0.240	19.00	

1-3-11 MJCC-18

1. GENERAL

(1) Reason of the implementation of this survey

Argillization to white clay is widely recognized on the surface around this hole (ENAMI, 1992). This survey was intended to recognize the decomposition by mineralization in the deep range.

(2) Outline of the result

In this hole, plagioclase porphyritic andesite, nonporphyritic andesite, diorite porphyrite and porphyrite are mixed with complicated penetration. Although copper mineralization is recognized in the depth of 60m (1040mL) or more, this is very weak. The coordinate and drilling result of this hole are as follows.

	Coordinate	Drilling result	
N:	7,103,5 .	Direction:	---
E:	374,200.	Dip:	-90°
H:	1, .	Depth:	184.35m

2. GEOLOGICAL FEATURE

(1) Rock face and stratigraphy

1) Upper range (depth: 0m - 45m)

The upper range is composed of greenish gray plagioclase porphyritic andesite, accompanied with quartz calcite vein and white clay vein decomposed hydrothermally.

2) Medium upper range (depth: 45.0m - 64.5m)

The medium upper range is composed of mainly grayish green nonporphyritic andesite, accompanied with porphyrite vein and felsitic netted vein.

3) Medium lower range (depth: 64.5m - 161.0m)

In the medium lower range, nonporphyritic andesite and plagioclase porphyritic andesite are mixed in the relation of penetration and capturing and accompanied with a large amount of white to orange felsitic vein.

4) Lower range (depth: 161m - 184m)

The lower range is composed of greenish gray nonporphyritic andesite, accompanied with a large amount of white to orange felsitic veins.

(2) Decomposition and deformation

In this hole, decomposition by argillization and argillized vein are recognized on the surface and in the depth of 35m. Felsitic veins and netted veins are recognized at the depths of 45m, 60m ±, 100m ±, 140m ±, 160m ± and 180m ± and fine veins originated from this expand up and down.

3. MINERALIZATION

Weak copper mineralization was recognized in this hole. The copper ores are chalcopyrite, malachite and chrysocolla and appear in the relation with felsitic vein. On the other hand, no iron ore appear. The condition of mineralization at each depth is as follows.

Depth	Copper oxide ore	Copper sulfide ore	Hematite	Magnetite	Pyrite
0.00～ 58.00m					
58.00～ 80.00m	· Dissemination	· Dissemination			
80.00～161.00m	· Dissemination				
161.00～184.00m					

4. RESULT OF ORE ANALYSIS

Weak mineralization was recognized according to Cu grade.

The depth and average grade of that range is as follows.

Mineralization zone	Depth (range)	TCu%	SCu%	ICu%	TFe%	Mineralization type
A	57.00～185.00m(128.00m)	0.060	0.021	0.039	8.72	Oxidation zone

1-3-12 MJCC-20

1. GENERAL

(1) Reason of the implementation of this survey

This hole is located in the north east of the mineralization zone 1 (ENAMI, 1992) and "hydrothermal breccias" accompanied with hematite are distributed on the surrounding surface. Moreover, this is classified to high IP zone and high magnetism abnormal zone by surface physical survey (Geodatos, 1991). This survey was intended to recognize the distribution condition of secondary enrichment copper oxide zone and copper sulfide zone.

(2) Outline of the result

The rocks composed of this hole are andesite lava/tuff zone (depth: 0m – 61m), andesite "hydrothermal breccia" (depth: 61m – 124m) and andesite lava (depth: 124m – 188m). Copper oxide zone (grade: 1.84%Cu max.) was recognized near the surface and copper sulfide zone (grade: 1.84%Cu max.) was recognized in the hydrothermal breccias.

The coordinate and drilling result of this hole are as follows.

2. GEOLOGICAL FEATURE

(1) Rock face and stratigraphy

1) Andesite lava and tuff zone (depth: 0m – 61m)

This rock is composed of mainly andesite lava and andesite tuff, partially accompanied with small scale hydrothermal breccia section and hematite (specularite) fine vein. The andesite lava is gray to reddish brown while the upper section is accompanied with plagioclase phenocryst and the lower section is nonporphyritic. The tuff is medium to fine grained and greenish gray, gray or reddish brown. In the depth of 25m or more, this underwent strong crush, so that most cores are of crushed sand.

2) Andesite "hydrothermal breccia" (depth: 61m – 124m)

This rock is breccia with nonporphyritic andesite as lithic breccia and the cracks are filled with hematite (specularite) in netted vein or fine vein. The most considerable hematite mineralization is noticed at the lower section (depth: 105m – 124m) in particular. Near the depth of 93m, amygdal structure indicating the top end of lava is observed. This zone is in crushed sand state except the depth of 95m ±.

Coordinate		Drilling result	
N:	7,103,5 .	Direction:	---
E:	374,200.	Dip:	-90°
H:	1, .	Depth:	187.65m

3) Andesite lava (depth: 124m – 188m)

This rock is composed of mainly andesite lava, partially accompanied with self crushed lava and underwater crushed tuff. Andesite lava is dark gray lump nonporphyritic lava in the medium and upper section and near the small cavities considered to be a path of hot water in the depth of 145m ±, this presents brownish gray color due to decomposition by hot water. Near the depth of 140m, amygdal structure indicating the bottom end of lava is observed. The lower section is dark gray lump, accompanied with plagioclase phenocryst. This zone entirely has amygdal structure, accompanied with quartz and pyrite.

(2) Decomposition and deformation

The range from 25m to 124m in depth underwent strong crushing action at a low angle, so that most cores are in crushed sand state. The shearing fracture at 30 to 40 degrees are observed in many places.

3. MINERALIZATION

(1) General

Although copper and iron mineralizations continue from the surface to the hole bottom, visually copper mineralization cannot be observed in the crushed sand section. The condition of mineralization at each depth is as follows.

Depth	Copper oxide ore	Copper sulfide ore	Hematite	Magnetite	Pyrite
0.00～ 39.00m	○ Crack	?	○ Network vein		?
39.00～115.00m		?	◎ Network vein		?
115.00～124.00m	○ Crack	?	◎ Network vein		?
124.00～188.00m	· Crack	· Dissemination		△ Dissemination	· Dissemination

(2) Particulars

1) Oxidation zone

Copper oxide body composed of mainly malachite exists in the range from the surface to the depth of 39m (1185mL). Malachite is disseminated in the cracks of andesite breccias in fine veins and tuff breccias. Coexisting iron ore is specularite. The dissemination of malachite is also noticed in the depth of 115m to 124m.

2) Sulfurization zone

Visually, no sulfide can be recognized in the depth of 39m to 115m. This reason is considered to be that the surface of sulfide ore is oxidized in the crushed zone so that it is difficult to identify from crushed host rocks. In the depth of 124m to 188m, a very small amount of chalcopyrite and pyrite, coexisting with quartz, is recognized in amygdal and fine vein of quartz and specularite.

4. RESULT OF ORE ANALYSIS

The mineralization zone is classified to the following five zones according to the distribution of Cu grade. The depth and average grade of each range are as follows.

Mineralization zone	Depth (range)	TCu%	SCu%	ICu%	TFe%	Mineralization type
A	0.00～ 3.00m(3.00m)	1.170	0.887	0.283	26.67	Oxidation zone
B	6.00～ 38.00m(32.00m)	0.454	0.208	0.246	21.63	Intermediate zone
C	55.00～126.00m(71.00m)	0.407	0.127	0.281	30.35	Sulfurization zone
D	136.00～142.00m(6.00m)	0.238	0.045	0.194	16.25	Sulfurization zone
E	154.00～188.00m(34.00m)	0.149	0.030	0.120	15.39	Sulfurization zone
Total of mineralization zone	(146.00m)	0.366	0.134	0.232	24.30	
Total of the whole hole	0.00～126.00m(126.00m)	0.392	0.146	0.246	26.61	

1-3-13 Other drill holes

In the present drilling investigation 30 holes (MJCC-1 ~ MJCC-30) were bored. The detailed description about the drilling except 12 drill holes described above will be made in the Phase II report.

1-3-14 Summary of investigation results

The rock observed in each drill hole mentioned above is basically classified into the following: the andesitic volcanic rocks called the Cerros Florida formation of the Cretaceous period in the Quaternary period formation, dikes, mineralized and altered rock, and cataclastic rock caused by the tectogenesis. The outline of characteristics of each lithofacies is described below.

(1) Quaternary period formation

1) Falling-in formation

This formation is distributed on light slopes of the mountainside and is 5 m to 10 m thick on the surface of the earth.

This formation includes a large amount of hematite and magnetite gravel originating from steep slopes of the mountainside, and generally hematite gravel is conspicuous.

(2) Cretaceous period Los Cerros Florida formation

1) Andesitic tuff

This rock is observed near the surface of the earth of the drilling executed near the top of the mount Los Cerros Florida. They are composed of tuff of medium grain to fine grain which partially present a compositional banding and graded structure. The hematite dissemination, banded metasomatic texture caused by specularite, idiomorphic pyrite dissemination, etc. are observed near the "hydrothermal breccia" zone.

2) Non-porphyritic andesite

This rock is gray - dark gray non-porphyritic andesitic lava, and may present an amygdaloidal texture or autobrecciated texture near the border of lava. It contains a lot of veinlets of hematite (specularite) near the "hydrothermal breccia" zone. Also, this rock is affected by the hydrothermal alteration near small holes which are considered to be a passage of hot water.

3) Plagioclase porphyritic basaltic andesite

This rock is dark gray massive lava and is accompanied by a large amount of plagioclase phenocryst (1 x 3 mm - 2 x 4 mm). Generally, it often contains an amygdaloidal texture near the border of lava flow. A transition from porphyritic to non-porphyritic may occur in the same lava flow. This rock is characterized by the accompaniment of a large amount of magnetite as matrix and strong magnetism. However, it does not present magnetism near small holes which are considered to be a passage of hot water.

4) Tuff breccia

This rock is composed of tuff and plagioclase porphyritic andesitic breccia. It is seldom produced as unaltered rock and it is considered that a large amount of this rock is included in the rock classified as "hydrothermal breccia" caused by iron mineralization.

5) Hyaloclastite

This rock exists as a thin stratum of about 1 m thick on the border of lava flow and may make a transition to autobrecciated lava. The magnetism of this rock is very week unlike lava.

(3) Dike

1) Diorite porphyritic dike

This rock is produced at MJCC-12 and MJCC-18, and is mixed with andesite due to mylonitization caused by the strike-slip fault. Its lithofacies is full of variety and it presents the production condition of medium grain - fine grain and medium - predominant white. Also, it is often accompanied by the felsitic vein which is considered to originate in magma of the same quality as this rock.

2) Andesitic dike

This rock is non-porphyritic gray andesite or that accompanied by feldspar phenocryst and is characterized by a weak magnetism.

(4) Others

1) "Hydrothermal breccia"

This rock has various types of rock of the Los Cerros Florida formation as lithic breccia and presents production condition where breccia gaps are filled with iron ore oxide in the form of reticulated vein - veinlet. In the present investigation area it is called "Hydrothermal Breccia" as a field rock name put through the past investigation. In this report this name is also used for convenience' sake according to the past report, but it does not indicate property related to the origin of the rock. The iron oxide ore composing this rock is foliated hematite (specularite), massive hematite and magnetite. The lithic breccia is brecciated rock fragment of non-porphyritic andesite, plagioclase porphyritic andesite, tuff, etc.. The grain size of lithic breccia is full of variety and there are mixed breccia from boulders to granules. Also, it presents a jigsaw puzzle form and the fracture face of breccia nearby often corresponds.

The proportion of quantity between iron oxide ore and lithic breccia of these rocks is full of variety and make a transition from compact iron ore-like rock to iron oxide ore veinlet zone.

2) Shear cataclastic rock

This rock is cataclastic rock which is produced in the strike-slip fault zone and its source rock is unknown. Partially a source rock texture remains, but generally it presents a mylonitic rock-like texture.

1-4 Considerations

(1) Preface

We prepared drilling profiles using data of 12 drill holes (MJCC-6, 7, 8, 10, 11, 12, 13, 14, 16, 17, 18, and 20) described in this report, studied the geological structure and extent of mineralization, and their relationship. Since we cannot cover all the drilling data in this report, note that we only give you an outline of the study. Furthermore, in studying, we gave some interpretations about the geological structure and the form of mineralization zone, and they are a work hypothesis at the middle stage. Therefore, we refrain from giving a conclusion at this stage of this report and reserve the synthetic study and conclusion for the final report.

(2) Establishing drilling profiles

We paid careful attention so that the drill holes are arranged continuously from east to west as well as from north to south on the drilling geological profiles to represent as many drill holes as possible. That is, there are 7 east-west profile sections (EW-1 - EW-7) and 6 north-south profile sections (NS-1 - NS-6) as shown in the profile location diagram (Fig. 2-1-1), and the drill holes shown in these profiles are as follows:

However, since data of the drill holes in parentheses have not arrived yet, it was not entered in this report.1) EW-1 profile section: MJCC-2

2) EW-2 profile section: (MJCC-3, 4, 5, 24, and 25)

3) EW-3 profile section: MJCC-6,7 and 8 (MJCC-26 and 27)

4) EW-4 profile section: MJCC-10 and 11 (MJCC-9, 28 and 29)

5) EW-5 profile section: MJCC-12, 13 and 14 (MJCC-30)

6) EW-6 profile section: MJCC-16 and 17 (MJCC-15)

7) EW-7 profile section: MJCC-18 and 20 (MJCC-19)

8) NS-1 profile section: MJCC-6 (MJCC-3)

9) NS-2 profile section: MJCC-12 (MJCC-9, 15, 24 and 26)

10) NS-3 profile section: MJCC-7 (MJCC-1, 2, 4 and 28)

11) NS-4 profile section: MJCC-10, 13, 16 and 18 (MJCC-25 and 27)

12) NS-5 profile section: MJCC-8 (MJCC-5, 29 and 30)

13) NS-6 profile section: MJCC-11, 14 and 17 (MJCC-19)

In this report we studies only 5 east-west profiles (EW-3, 4, 5, 6, and 7) and 2 north-south profiles (NS-4 and 6) in which data of 2 or more drill holes can be used. (appendix C, attached drawing PL. II-2)

(3) Geological structure of Los Cerros Florida formation

The copper ore deposit in this investigation area is Cretaceous period Los Cerros Florida formation, copper sulfide ore deposit which exists in the "hydrothermal breccia" accompanied by a large amount of iron oxide ore and copper sulfide ore deposit. Based on the existing investigation data, the form of existence of ore deposit is restricted by the lithofacies and texture of the country rock and is considered to be a so-called "manto type" copper ore deposit. Therefore, it is very important to grasp the geological structure of the Los Cerros Florida formation which is a country rock. We describe the outcome of investigation about the geological structure of the Los Cerros Florida formation using the results of this drilling investigation and the existing investigation results. We think it necessary to take the following points into consideration in clarifying the geological structure in the present investigation area.

1) Tectogenesis caused by Atacama fault

* The Atacama fault is a fault zone of an average 3 to 4 km wide left transversal dislocation which runs north and south through the Chilean coastal mountain range for several hundred kilometers and is considered to be a big tectonic line which reaches a depth of the earth crust (Instituto de Investigaciones Geologias, 1976).

* The present investigation area is located at the east end of this Atacama fault zone and it is supposed that the main fault structure of the NE- SW system and the secondary fault structure of the ES system and EW system exist (ENAMI, 1992).

2) Diorite porphyrites

* The Cretaceous period Sierra Pastenes batholith which is mainly composed of diorite porphyrite - granodiorite is adjacent to the northwest of the present investigation area, and is affected by a displacement caused by the above-mentioned Atacama fault zone (Instituto de Investigaciones Geologias, 1976).

3) "Hydrothermal breccia" action

* The distribution of the "hydrothermal breccia" and iron oxide ore on the surface of the earth is mainly restricted by the main structure of the above-mentioned NE-SW system (ENAMI, 1992).

It is supposed that the structure of the Los Cerros Florida formation which is a country rock of the copper ore deposit existence in the present investigation area is affected by an extremely complicated deformation, block action, and alteration because of these activities of tectogenesis, batholith intrusion, and "hydrothermal breccia" action.

As a result of studying the geological profile considering each point mentioned above as a precondition, it is possible to summarize the geological structure of the present investigation area as shown below.

1) Los Cerros Florida fault fracture zone

The broken rocks caused by a fault are observed at MJCC-12 and MJCC-16, and it is considered to be an extended part of the strike-slip fault observed on the surface of the earth near the MJCC-19. This fault branches to the southwest from the Los Cerros Florida fault indicated in the results of the existing investigation (ENAMI, 1992), and it is considered to be the biggest tectonic line which restricts the geological structure of the present investigation area.

Considering the observation of the fractured face on the surface of the earth and the distribution of lithofacies in each drill hole, it is supposed that this fault is a strike-slip fault with a westward dip having a 50 m - 100 m long fracture zone branched from the Atacama fault.

2) Other faults

Based on the existing investigation results (ENAMI, 1992), many faults or estimated faults other than the above-mentioned exist in the present investigation area. Some faults, as shown between MJCC-11 and MJCC-14 of the profile section NS-6, have an extremely different lithofacies with the fault as the border, and greatly contribute to the formation of the geological structure of the present investigation area. In particular, the east and west lithofacies sharply changes with the estimated fault (here called the Central branch fault) branched to the north from the Central fault (ENAMI, 1992) as the border.

3) Block structure

It is considered that the geological structure of the present investigation area is divided into small blocks by each fault mentioned above. Among all these blocks it can be classified into 3 big ones, which are called the central block, west block and east block.

4) Central block

This block is a long and narrow structural block extending in the NE- SW direction in the central part of the present investigation area. It is divided from the west block by the Los Cerros Florida fault fracture zone, and abuts on the east block caused by the Central branch fault. It is sup-posed that the inner part of the block is sub-blocked by small faults, which was not confirmed by this investigation. This block includes MJCC-6, 7, 10, 13, 14, 17 and 20.

5) West block

This block is situated in the northwest of the Los Cerros Florida fault and abuts on the central block, sandwiching the fault fracture zone. Here the fault fracture zone is included in this block. Therefore, this block includes MJCC-12, 16 and 18.

6) East block

It is considered that this block is distributed in the southwest of the central block, having the Central branch fault as a border, and abuts on the southwest part of the central block caused by the Central fault. It is supposed that the inner part of the block is sub-blocked by small faults. This block includes MJCC-8 and 11.

7) Geological structure in the blocks

The relatively continuous correlation of lithofacies is possible in the central block. For example, as shown in the EW-5 and NS-6 profile sections, the massive basaltic andesite lava appearing at MJCC-13, 14, and 17 was successfully correlated because the amygdaloidal texture characteristic of lava flow and the plagioclase porphyritic texture served as a clue. Since the similar lithofacies can be observed in the lower part of the MJCC-20 as the north extension as well as in the lower part of the MJCC-6 and 7 as the south extension, it is supposed that the basaltic andesite lava is distributed extensively in the lower part of the central block. Furthermore, since the andesitic tuff exists near the surface of the earth at MJCC-14, 17 and 20, it is supposed that the said tuff is distributed continuously at 1,100 m or more of the mount Los Cerros Florida above sea level and ascends toward north with a light dip.

Based on the lithofacies correlation results mentioned above, supposing that the basaltic andesite lava exists continuously without any displacement caused by a fault between MJCC13/14 and 17, it has a strike dip of approximately N25W15SW. However, practically it should be considered that the basaltic andesite lava is affected by various slips and tiltings due to many small faults as shown in the existing investigation results (ENAMI, 1992).On the contrary, the correlation of lithofacies in the west block is very difficult. One reason is that the MJCC-12 and 16 are the fault fracture zone itself and there are few cores retaining a source rock structure. The correlation is much more difficult because andesite and diorite porphyrite are produced with a complicated intrusion in the MJCC-18 away westward from the fracture zone.

The lithofacies of both MJCC-8 and 11 in the east block is full of variety and the correlation of lithofacies shown in the central block cannot be made. This may be attributable to the slip and tilting accompanied by sub-blocking.

(4) "Hydrothermal breccia"

As shown in the existing investigation results (ENAMI, 1992), a great number of "hydrothermal breccia" and iron oxide ore (specularite, massive hematite and magnetite) is distributed on the surface of the earth in the present investigation area. The distribution area is continuous in the NE - SW direction and may be restricted by the fault structure mentioned above.

1) Form of "hydrothermal breccia"

The "hydrothermal breccia" is observed in the drilling core as on the surface of the earth, but the "hydrothermal breccia" in the drilling core presents various forms of production as mentioned in the "summary of investigation results" and its distribution form is complicated. At MJCC-7 and 10 the "hydrothermal breccia" exists continuously from the surface of the earth to the lower part of the drill holes and reaches a depth of approximately 155 m and 115 m, respectively. On the other hand, at MJCC-13 and 14 it produces 10 m - 25 m deep or more below the surface of the earth up to 70 m - 80 m. In other drill holes (MJCC-6, 8, 11, 17 and 20) the "hydrothermal breccia" is observed, but its amount of production is small and the proportion of quantity of the iron oxide ore is low. After considering all the factors mentioned above, it can be interpreted that the "hydrothermal breccia" is generally distributed mainly at MJCC7 and 10 and in the peripheral part it exists in the form harmonic with the stratum near the surface of the earth, that is, in the funnel shape.

However, at this point the location of the neck of the funnel-shaped "hydrothermal breccia" is unknown.

Furthermore, it is supposed that the vicinity of MJCC-17 and 20 indicates the form of vein-shaped "hydrothermal breccia" harmonic with the fault structure near the MJCC-17 and 20 in the north part.

On the other hand, morphologically different from the "hydrothermal breccia", the basaltic andesite lava often contains a large amount of magnetite. The magnetite dis-semination is observed conspicuously in the part indicating the amygdaloidal texture particularly near the "hydrothermal breccia". This fact suggests that the iron dissemination action occurred in an area with a relatively high permeability which has an amygdaloidal texture owing to the activities accompanied by the "hydrothermal breccia" action.

2) Mineral composition of iron oxide ore

The iron ore oxide existing in the "hydrothermal breccia" and its neighboring country rock produces as hematite (specularite), magnetite or their combinations depending on the condition of oxidation. Based on the drilling core observation obtained so far, the distribution of iron ore in each drill hole is roughly classified as shown below.

1. Drilling core 2. Lower part 3. Middle part 4. Upper part 5. Surface of the earth

The "hydrothermal breccia zone" has a variety of scales in each drill hole mentioned above, and the following common points can be found in the distribution of the iron oxide ore in the "hydrothermal breccia" and its neighboring country rock.

Central part of the "hydrothermal breccia" (compact iron ore): Hematite (specularite) vein Peripheral part of the "hydrothermal breccia" (accompanied by the lithic breccia): Magnetite + hematite vein or magnetite vein Neighboring country rock (basaltic andesite lave): Magnetite dissemination Neighboring country rock (andesitic tuff): Hematite dissemination Based on the common points mentioned above, the "hydrothermal breccia" is exposed on the surface of the earth at MJCC-7, 10, 11, and 14 and the distribution of iron oxide ore in its upper part is unknown. However, judging from the common point, it is supposed that magnetite and hematite are distributed in the upper part. Therefore, practically it is considered that generally the central part of the "hydrothermal breccia zone" mentioned above has less ore than the peripheral part.

The distribution form of the iron oxide ore shown above is very important when we think of the copper sulfide zone.

That is, as mentioned above, it is considered that the mineral composition of iron oxide ore has a strong influence on the oxidation condition in the peripheral rock and is closely connected with both oxygen and sulfur activity when sulfide is generated. Consequently, the distribution of iron oxide ore is one of the important factors that restrict the generation of chalcopyrite and pyrite which are the main component ore mineral of the copper sulfide zone.

(5) Copper mineralization

In the present investigation area we confirmed the copper sulfide zone represented by the copper oxide zone and chalcopyrite mainly composed of malachite. On the other hand, as mentioned above, in this area the "hydrothermal breccia" accompanied by a large amount of iron oxide ore is extensive distributed and it is considered that this is one of the important factors when we think of the distribution form and origin of the copper mineralization. However, at the present stage we have not obtained yet detailed analysis results about the form of the "hydrothermal breccia" and distribute of iron oxide ore so that we cannot conduct a detailed study about the relationship between the copper deposit and the "hydrothermal breccia". We will study this problem in the Phase II.

We have classified the copper mineralization zone taking into consideration the combination of copper ore and its origin (juvenile or epigenetic). The characteristics are described below.

The copper mineralization zone can be classified into the following 3 types depending on the type and combination of the component copper ore.

Copper oxide mineralization zone: Mainly composed of malachite and accompanied by atacamite, chrysocolla and azurite .

Mixed zone (middle zone): Mixture of copper oxide mineralization zone and copper sulfide ore body Copper sulfide mineralization zone: Chalcopyrite Considering the origin of copper ore, it can be further subdivided, and the production condition and form of distribution indicate the following characteristics.

1) Copper oxide mineralization zone

Oxides [1]: (exotic type)

This zone is accompanied by copper oxide ore mainly composed of malachite and lacks in copper sulfide ore. Also, the copper oxide ore is precipitated exotically due to the action of meteoric water and extensively produces near the surface of the earth without choosing germinal country rock. (MJCC-7 and 17)

Oxides [2]: (in situ type)

This zone is accompanied by the mixed zone and copper sulfide mineralization zone in the lower part. It is considered that the copper sulfide mineral in the copper sulfide ore is oxidized by the action of meteoric water and is precipitated on the spot or in situ. (MJCC-10 and 13)

Oxides[3]: (tectonic type)

In this zone the copper oxide ore appears harmonically with the fracture zone and it is considered that the tectogenesis has an influence on the generation of copper oxide ore.

Generally, the grade of copper oxide ore is low and it is supposed that local oxidation occurred in the inner part of the fracture zone. (MJCC-8, etc.)

2) Mixed zone (middle zone)

transition [1]: (exotic type)

Theoretically, it is possible to think of the mixed zone producing both juvenile copper sulfide mineral and oxides [1] above, but it is difficult to differentiate transition [1] from [2] describe below. This has not been confirmed yet so far in the present investigation area.

transition [2]: (in situ type)

This zone is characterized by the fact that the copper sulfide mineralization zone continues in the lower position, and both copper oxide and copper sulfide produce. The copper oxide ore originates in neighboring copper sulfide ore and is generated in situ due to action of meteoric water. However, it is considered that copper sulfide ore remains because of insufficient oxidation. Also, this zone is characterized by the fact that copper oxide ore which requires surface condition for the generation like atacamite does not appear, and in the present investigation area the ore produces only in the narrow area between oxides [2] relatively near the surface of the earth and the copper sulfide mineralization zone. (MJCC-6 and 7)

transition [3]: (tectonic type)

Basically, it is the same as oxides [3], but in addition to copper oxide ore copper sulfide ore appears. This is because copper sulfide ore remains due to insufficient mineralization of copper oxide. The ore produces universally regardless of depth in the present investigation area. The above is harmonic with the fact that the present investigation area is affected by the tectogenesis due to many faults and is divided into many structural blocks. (MJCC08, 11, etc.)

3) Copper sulfide mineralization zone

sulfides [1]: (exotic type)

This zone means a mineralization zone containing copper sulfide mineral of exotic origin and is often observed as a secondary enrichment zone in a general copper ore deposit.

To date this zone has not been confirmed yet in the present investigation area.

sulfides [2]: (in situ type)

This is a mineralization zone containing only juvenile copper sulfide mineral caused by mineralization as copper mineral and can be classified into 3 types according to nature of germinal country rock.

sulfides [2-1]: (in situ HTB type)

This zone is a mineralization zone where production condition of copper sulfide ore is closely connected with existence of the "hydrothermal breccia" and forms a main mineralization zone of the present investigation area.

It is supposed that the mineralization zone presents a stock type form in the central part and a manteau type form with a horizontal extent in the peripheral part. The copper sulfide ore constituting a copper mineralization zone is a dissemination type ore and veinlet type ore mainly composed of chalcopyrite, and coexist with iron oxide mineral (hematite and magnetite) and iron sulfide (pyrite) of the "hydrothermal breccia". This is the most promising as an exploitation object from the economic point of view. (MJCC- 7, 10, etc.)

sulfides [2-2]:(in situ VR type)

This zone is a copper sulfide mineralization zone which has andesite as a country rock. Since it has a horizontal extent harmonically with the source rock texture such as amygdaloidal lava, etc., it is considered that a kind of manteau type deposit is formed. The copper sulfide ore constituting a mineralization zone is a dissemination type ore in which chalcopyrite and pyrite coexist, and there are two cases concerning the proportion of quantity: there is more chalcopyrite than pyrite or there is more pyrite than chalcopyrite. Generally, copper mineral is distributed extensively with a horizontal extent in the lower peripheral part of the "hydrothermal breccia" while its condensation is low. Therefore, from the economic point of view, it is difficult to regard this zone as an exploitation object.(MJCC-6, 8, etc.)

sulfides [2-3]: (in situ fault type)

This is a copper sulfide mineralization zone which has mylonitic andesite in the Los Cerros Florida fault fracture zone (NE - SW system) as a country rock. More chalcopyrite produces than pyrite as component mineral sulfide, but the scale of mineralization and alteration is weak and copper grade is medium. (MJCC-12, 16, etc.)

sulfides [3]:(tectonic type)

It is considered that theoretically the formation of the copper sulfide mineralization zone is governed by tectogenesis but at this stage it does not exist in the present investigation area.

As describe above, we classified the copper mineralization zone. We will study the distribution and origin of the mineralization zone including other factors separately in the final report of Phase II.

CHAPTER 2 CALCULATION OF ORE RESERVES

2-1 Criteria of Calculation of Ore Reserves

2-1-1 Documents and data used for calculation

Drilling data:	Analysis data of total 12 drill holes executed in the first year.
Drilling position measurement data:	(Among them the coordinate of 3 drill holes is read from the position diagram.)

2-1-2 Calculator and software used

Calculator

VAX6310 system

Peripheral output devices including a color electrostatic plotter, graphic display, etc.

SUN4 work station

Software

UNIRAS (Image and graphic processing software)

Medsystem (Mine evaluation system, American application software)

MES (Mine evaluation system, software developed by our company)

2-1-3 Criteria of calculation of ore reserves

Scope:	1.2 km east and west (373,600 – 374,800)
	1.6 km north and south (7,102,200 – 7,103,800)
Area:	1.92 square kilometers
Mine image:	50 m (north and south) x 50 m (east and west) x20 m (depth)
Copper grade:	Total Cu grade
Specific gravity:	2.7
Technique:	After the mine image block is established and the mine image grade is allocated by means of the inverse-square law of distance, the ore reserve is calculated.

2-2 Calculation of Ore Reserves

The size of mine image of 50 m each for both east – west and north – south was adopted considering the drilling density and target area. Considering the bench height (10 – 20 m) and the size of mine image in the east – west and north – south direction in the case of open pit mining, that of 20 m is adopted in the direction of depth.

The composite grade (Total Cu) at every 20 m level was calculated for each drilling in order to allocate the Cu grade to mine image. The analyzed grade (in interval of 1 m) and the calculated composite grade for each drilling are shown in Fig. II– 2 – 1 Fig. II – 2 – 2 as profile section for east– west and north – south.

For the allocation technique, the distance inverse-square law was adopted, and data fetch for two cases with a radius of 150 m and 200 m is performed using an ellipsoid of revolution. Also, the fetch range in the direction of depth is set to 10 m so that only horizontal data can be fetched. At this time, a grade distribution diagram was prepared for each level in order to study the fetch range and direction. The data to study directivity, etc. in detail could not be obtained because the drilling interval was wide for the target area and there is little data (2 or 3 pieces) for some levels.

Since a range value of variogram can be used as a standard of the fetch range, several types of variogram are calculated and studied concerning the drilling data in the depth direction as well as the horizontal drilling data.

# DRILL	Total Cu		Solb. Cu		Insolb. Cu	
MJCC- 6	20m	0.015	cns	<.001	20m	0.012
MJCC- 7	20m	0.300	10m	0.130	25m	0.180
MJCC- 8	inc	0.020	inc	0.050	inc	0.050
MJCC-10	25m	0.400	25m	0.330	60m	0.180
MJCC-11	cns	0.045	cns	0.023	cns	0.015
MJCC-12	10m	0.140	cns	0.020	10m	0.120
MJCC-13	rsm	0.050	rsm	0.020	30m	0.040
MJCC-14	5m	0.020	5m	0.008	5m	0.008
MJCC-16	ins	0.100	inc	0.060	inc	0.030
MJCC-17	25m	0.080	15m	0.050	ins	0.020
MJCC-18	inc	0.003	cns	<.001	cns	0.002
MJCC-20	50m	0.070	inc	0.040	60m	0.020

inc:incleasing cns:constant rsm:rhysmic

Generally, a valid variogram (nugget and range) can be obtained because continuous data is available in the drilling direction (generally, vertical), but it is not possible to obtain a valid horizontal variogram if the drilling interval is 100 – 200 m. As the second best measure, the vertical variogram is used for the horizontal nugget and supposing that as for the horizontal range the major axis/minor axis/vertical scale of the ore body is proportionate to the range of each level, the horizontal variogram may be obtained from the vertical range. As the result of trial calculation, the results from which the range can be estimated could not be obtained concerning the horizontal variogram. It is supposed that the target ore body of this investigation is of so-called manto type and it is clear that the extent of ore body and grade trend are horizontal.

Therefore, it cannot be considered that the variogram in the direction of depth represents that of the whole ore body.

There is not sufficient data to deduce the geology, alteration, structure, etc.. Furthermore, in fetching data, the geology or ore grade trend are not taken into consideration along with the study results of the variogram mentioned above. The fetching range of 200 m and 150 m was adopted based on the drilling interval (little less than 200 m), and only a composite of the analyzed data was used to make the calculation above.

Next, the digital terrain model (DTM) was prepared using the altitude values of the position data in each drill hole (measurement results) and interpolating the whole target area. The ore reserves were calculated taking this terrain into consideration. As for the altitude value data there are only 12 points within the target area so that it is difficult to say that the interpolation results obtained from the data correctly reflect the terrain of this area.

The DTM is indispensable to calculate the ore reserve, and in particular if the ore grade is allocated to the mine image up to the surface of the earth, the DTM plays an important role to calculate the proportion of reserve of a block based on the relationship between the central position of the mine image and the altitude value. In this calculation, the terrain data was prepared for convenience's sake as described above, but it is necessary to prepare a more detailed DTM in order to obtain more accurate results.

2-3 Calculation Results

As for the ore grade distribution of each block after calculation of the ore grade allocation, the plans and profile sections were shown in Fig.II – 2 – 5 – Fig.II 2 – 6 as the mine image allocation ore grade distribution diagram. The data fetch range on all the plans and profile sections is 200 m. Taking a general view of the mine image allocation ore grade distribution diagram and profile section, it seems that the horizontal extension is conspicuous. This is because the fetch range was established horizontally on each level, and the ore grade trend of the drilling data was not necessarily represented.

Looking at the plan, there are a lot of parts where blocks with the same allocated ore grade value continue. This tendency is conspicuous particularly in the peripheral parts and indicates that there are many cases where only one piece of drilling data exists within the fetch range. At the same time this tendency suggests that some measures must be taken in handling the blocks of the peripheral parts.

As for the fetch range of 150 m and 200 m, the calculation results of the ore reserve are indicated in the ore reserve calculation table.

According to the calculation results, in the case of the fetch range of 200 m the ore reserves are much larger than that in the case of 150 m. This is because the ore grade is allocated extensively to the mine image of the peripheral parts. This is one of the characteristics when the fetch range and direction is made constant for all the mine images.

Next, the drilling data density and drilling interval have a great influence on the calculation accuracy for the ore reserve calculation which is made systematically such as the distance square law, KRIGING method, trend surface method, etc.. Since in this calculation the drilling data is obtained in only 12 drill holes within the target area of about 2 square kilometers and its interval is a little less than 200 m, we cannot help saying that this is a very sparse distribution to make a ore reserve calculation by the technique represented above. In fact, as mentioned above, the characteristic reflecting the scarcity of drilling data is notably observed in the allocated ore grade distribution results. Usually, the low drilling density is compensated by inserting dummy data taking into consideration the geological structure, ore grade distribution, form of deposits, etc., and by conducting a detailed study about the data fetch direction. However, in order to do it, little data about the geology and geological structure is available, and the calculation technique including trend is not studied well. Therefore, we state clearly that these ore reserve calculation results only serve as a reference from the viewpoint of methodology as well as accuracy and that they are not directly connected with the economic evaluation of the deposit.

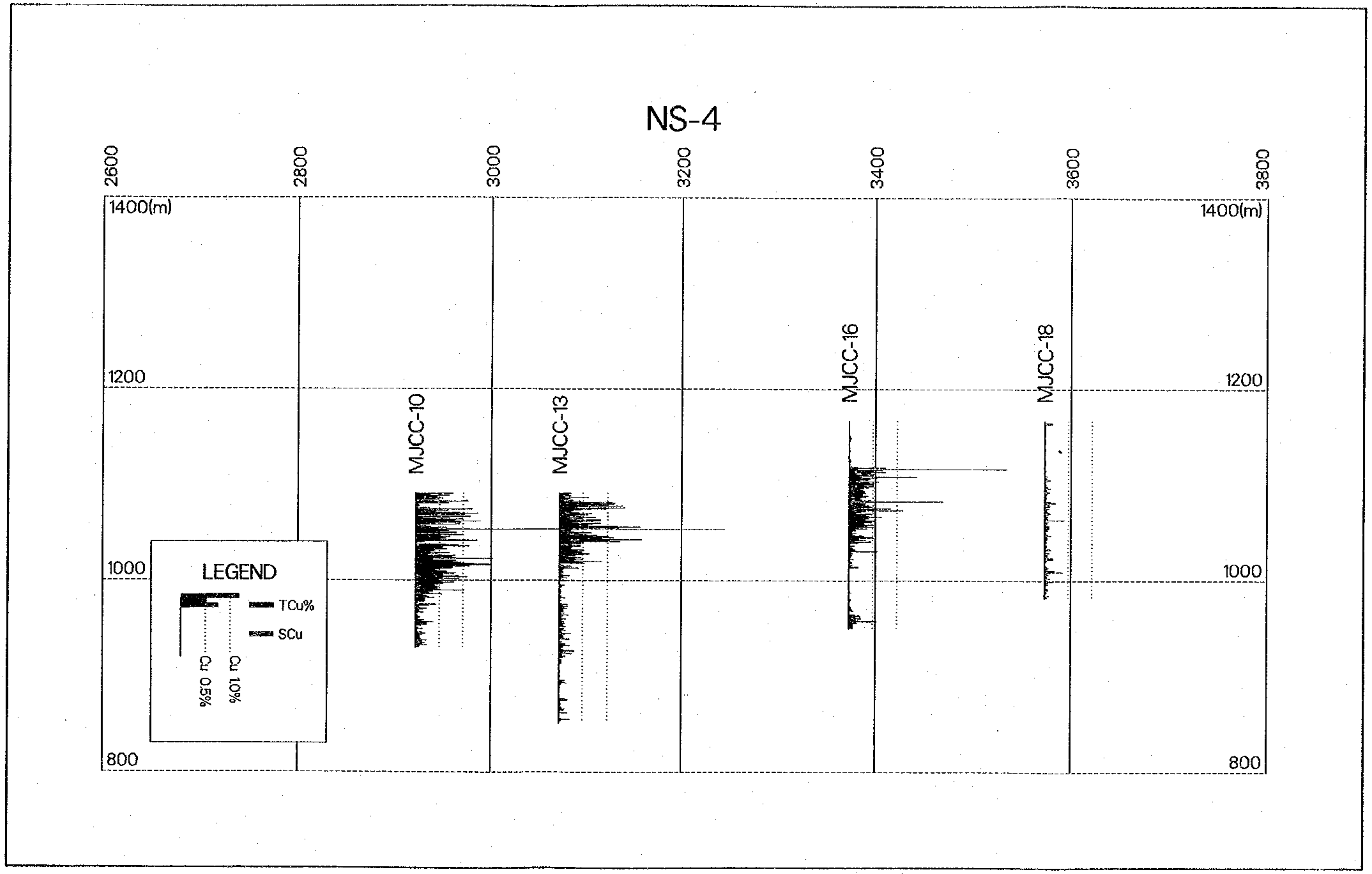

Fig.II-2- 1 A Cross Section of Cu Assay (NS-4)

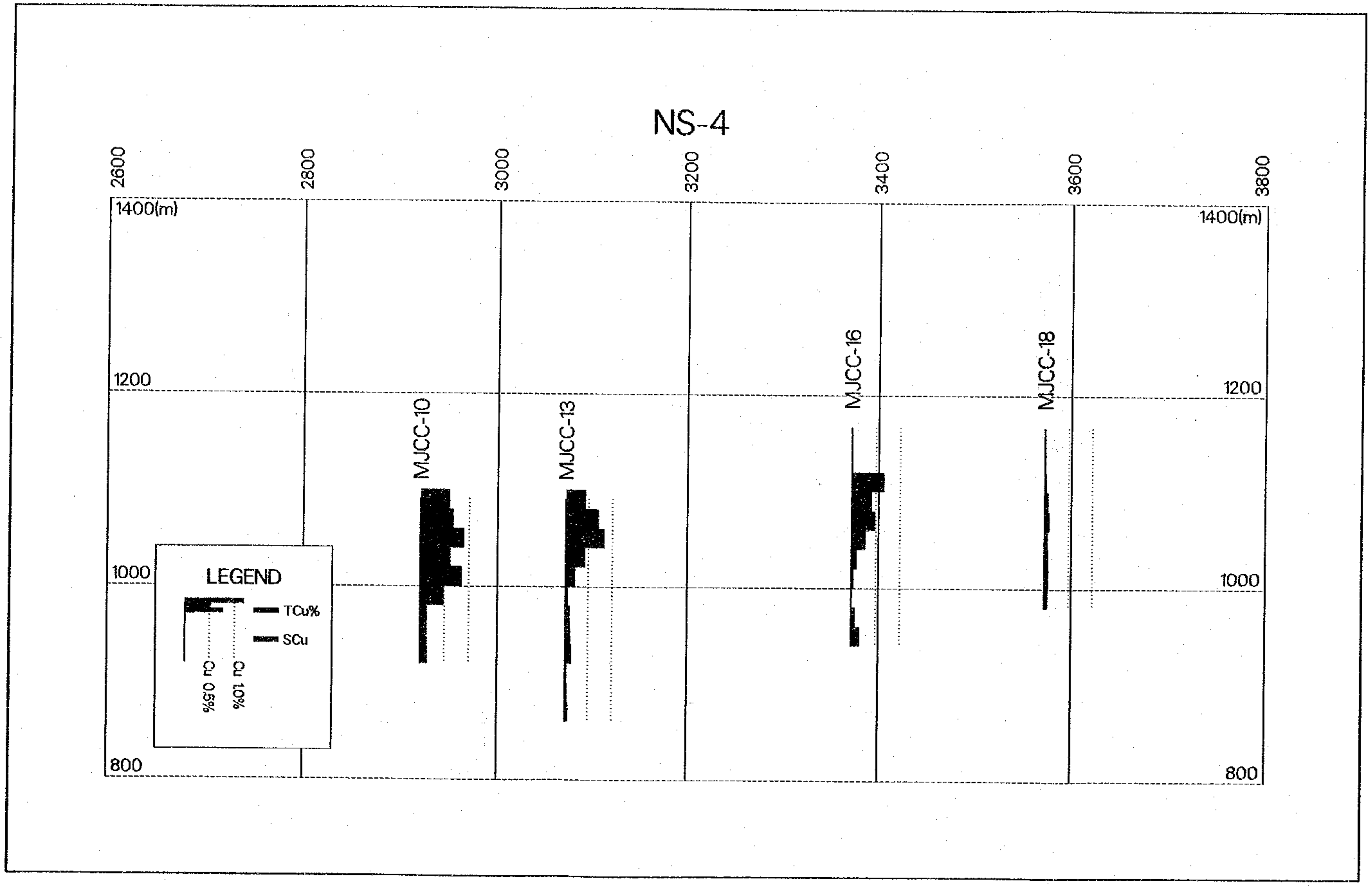

Fig.II-2- 2 A Cross Section of Composited Cu Grade (NS-4)

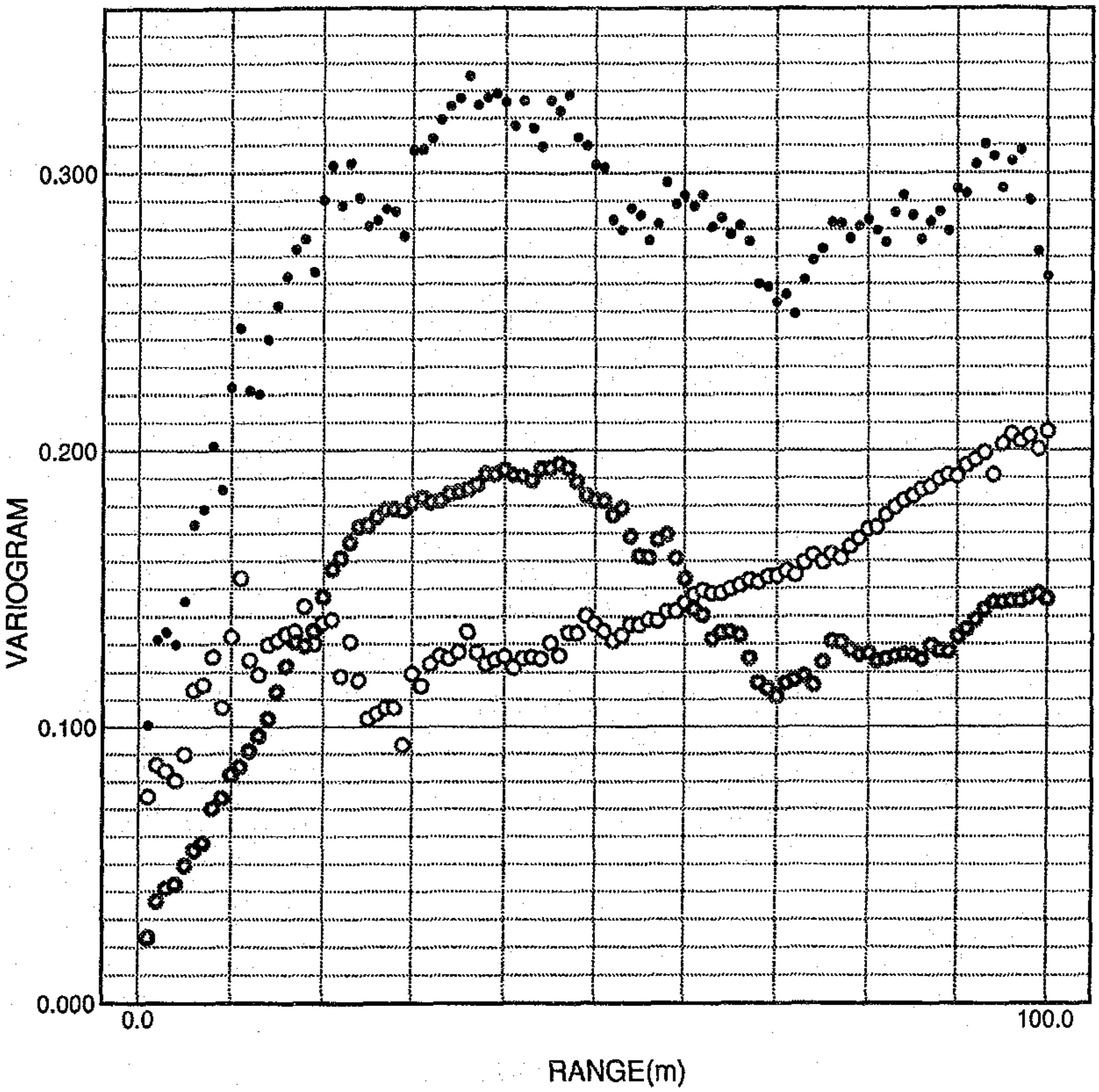

Fig. II-2- 3　Variograms of Cu Grades (MJCC- 7)

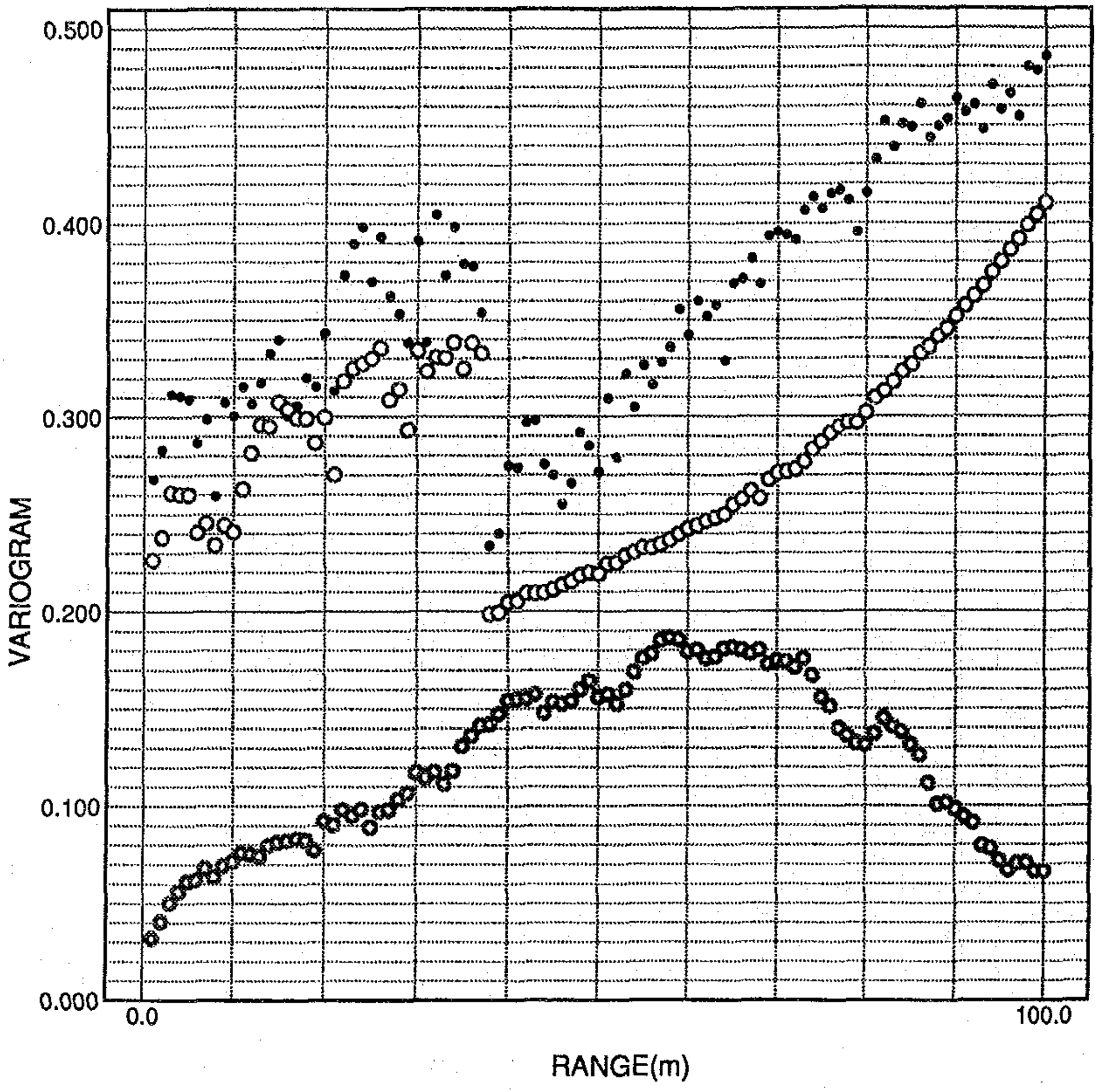

Fig. II-2- 4　　Variograms of Cu Grades (MJCC-10)

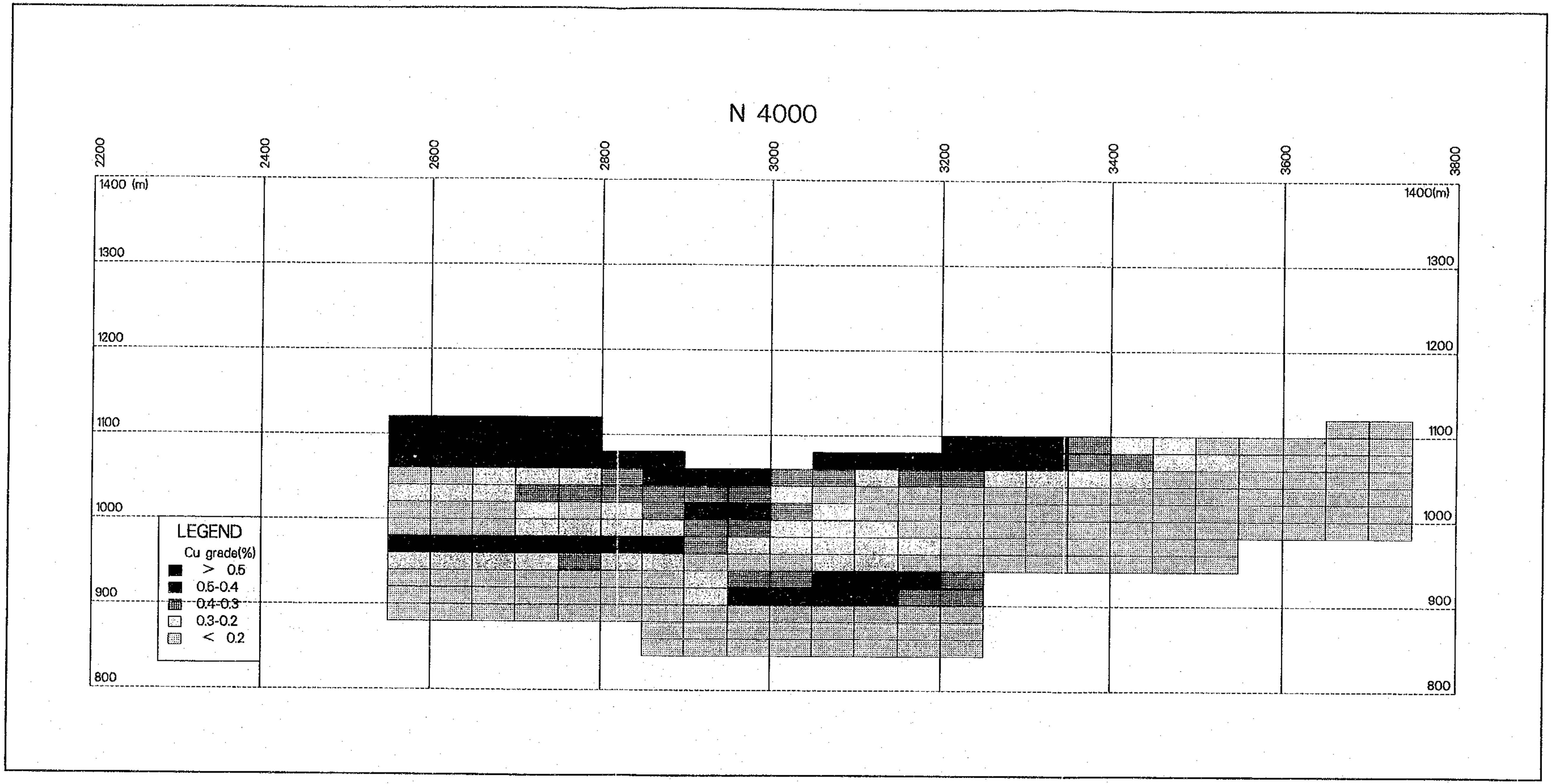

Fig.II-2- 5 A Cross Section of Blocks Assigned with TCu Grade (N4000)

1100m Level

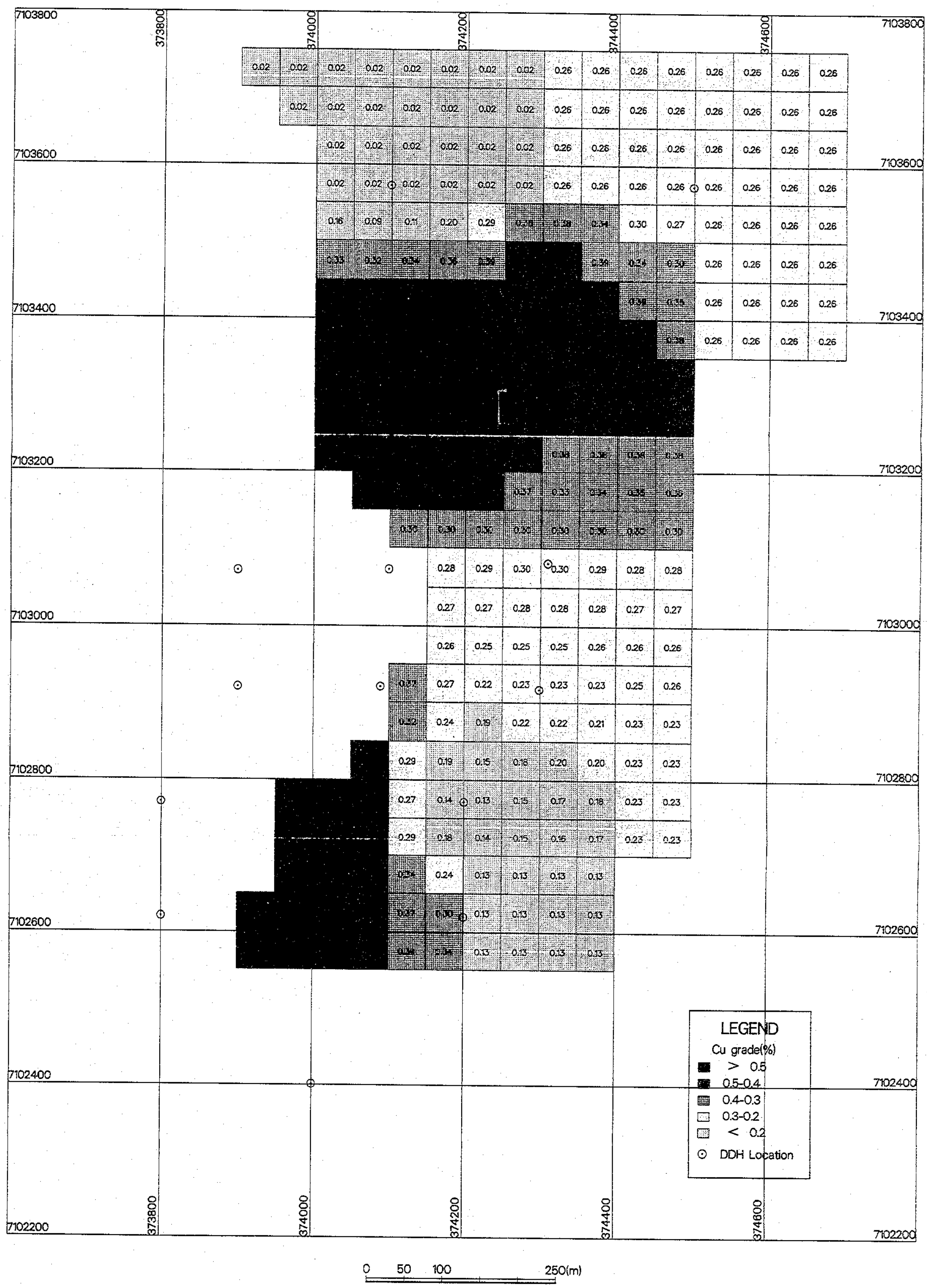

Fig.II-2- 6 A Level Section of Blocks Assigned with TCu Grade (1100m Level)

CHAPTER 3 ANALYSIS OF EXISTING DATA

3-1 Status of Copper Dressing and Smelting in the Republic of Chile

In Chile, the mining industry has played a very important role so far: its history has been virtually equal to the history of the Chilean economy. Copper metal and copper ore are still important sources of foreign currency. Minerals (copper, iron, molybdenum, gold, silver, niter, iodonuium compound, so on.) accounted for 55.2% (US $4.59 billion) of the total export sales of products in 1990 for example. Especially among them, the export sales of copper metal and copper ore which was equivalent to 45.7% of the total export sales.

There are four main copper mines named Andina, El Teniente, El Salvador and Chuquicamata, which are run by a national company, CODELCO Chile (Corporacion Nacional del Cobre de Chile). In their economic policy, the development of copper mines other than the four main ones has been determined to be dependent on private companies including foreign capital.According to the Chilean Mining Industry Association(SONAMI), the amount of investment in the mining industry is expected to reach about US $3.0 billion until 1992. Most investment have been made by foreign capital, and their major projects consist of copper mines such as La Escondida (with an investment of $850 million, to be put into operation in 1991) and Los Bronces (with an investment of $300 million, to be put into operation in 1991).

Table II-3-1 Copper Reserves, Production and Consumption in the World

Names of Countries	Reserves : Million MT	Copper Ore Production: kMTPY	Electrolytic Copper Production: kMTPY	Electrolytic Coppe Consumption:
Chile	120(21.2%)	1609.3(17.6%)	1071.0(9.8%)	ND
U.S.A.	90	1498.2	1953.5	2211.8
Ex-Soviet Union	54	950.0	1355.0	1140.0
Australia	41	295.0	ND	ND
Zambia	34	510.2	470.1	ND
Peru	32	364.1	224.3	ND
Zaire	30	440.6	203.8	ND
Canada	23	731.6	511.2	ND
Philippine	18	193.1	132.2	ND
Poland	15	385.0	390.3	232.8
Japan	ND	ND	989.6	2446.6
Ex-West Germany	ND	ND	475.2	854.7
Others, Total	109	2163.9	3101.3	4094.8
Total	566	9141.0	10877.5	10980.7

Table II-3-2 Main Copper Mines in Chile

Names of Mines	Names of Companies *1	Production Capacity (kMTPY)	Kinds of Ore *2	Mining and Processing Methods *3
CHUQUICAMATA	CODELCO	750	PY, CC, BOR, CP, EN	O/P FLOAT., HEAP LEACH SMELTER
EL TENIENTE	CODELCO	369	Porphyry	U/G FLOATATION
LA ESCONDIDA	ESCONDIDA	320	CC, CP, BOR, COV	O/P FLOAT., LEACH
EL SALVADOR	CODELCO	130	Porphyry	U/G FLOATATION
ANDINA	CODELCO	126	Porphyry	O/P, U/G FLOATATION
LOS BRONCES	DISPUTADA	120	CP, BOR, PY, EN	O/P, U/G FLOATATION
MANTOS BLANCOS	BLANCOS	100	CC, COV, BOR, CHRY AT	O/P, U/G FLOAT., LEACH
EL SOLDAD	DISPUTADA	75	BOR, CP, PY	U/G FLOATATION
LA CASCADA	PUDAHUEL	23*4	CHRY	O/P LEACHING
CAROLINA DE MICHILLA	CAROLINA	20	OXIDE ORE	O/P, U/G LEACH
PAPOSO	CODELCO	20		O/P
OJOS DEL SALADO	OJOS	18		O/P, U/G FLOATATION
CERRO NEGRO	GEOMETAL	8	CC, BOR, CP, PY	
OJANCOS	HOCHSCHILD	6.6	PY, CP, BOR	TO ENAMI
MINA JULIA	PUNTA GRANDE	6	CP, BOR	U/G FLOATATION
TUINA	NORTH LILY	6	CP, BOR, CC, OXIDE	O/P LEACH
CALETA DEL COBRE	PUNTA GRANDE	6		U/G

*1 CODELCO:CORPORACION NACIONAL DEL COBRE DE CHILE
DISPUTADA:CIA. MINERA DISPUTADA DE LAS CONDES SA
BLANCOS: EMPRESA MINERA DE MANTOS BLANCOS SA
PUDAHUEL:SOCIEDAD MINERA PUDAHUEL
HOCHSCHILD: SALI HOCHSCHILD, PUNTA
GRANDE: EMPRESA MINERA PUNTA GRANDE
CAROLINA: CIA. MINERA CAROLINA DE MICHILLA
NORTH LILY: NORTH LILY MINING & INTERNATIONAL MAHOGANY
ESCONDIDA : MINERA ESCONDIDA LTD
GEOMETAL: GEOMETAL EXP. A.G. & ANTOFAGASTA HOLDINGS
OJOS: CIA MINERA OJOS DEL SALADO
*2 PY:Pyrite, CC:Chalcocite, BOR:Bornite, CP:Chlcopyrite, EN:Enargite,
COV: Covellite, CHRY:Chrysocolla, AT:Atacamite
*3 O/P:Open Pit, U/G:Underground, Float.:Floatation, Leach:Leaching
*4: Actual Production

The production of copper mines in Chile in 1989 was 1,609 thousand tones. As listed in Table II-3-1, the production ranks first in the world. The production of copper mines in Chile is expected to reach 1,960 thousand tons in 1994 while the capacity of copper smelting is expected to become 1,483 thousand tons. Japan imported copper concentrates equivalent to 63 thousand tons in copper metal and 142 thousand tons of copper metal from Chile in 1989. The amount of copper consentrates, which was imported to Japan from Chile, ranked sixth after Canada, the United State, Indonesia, Papua New Guinea and the Philippines. The amount of copper metal, which was imported to Japan from Chile, ranked second after Zambia.

Table II-3-2 lists the production capacity of main copper mines in Chile, the kinds of ore and their mining and processing methods. There are a limited number of large-scale copper mines such as Chuquicamata, El Salvador, Andina, El Teniente owned by CODELCO, and newly-developed La Escondida owned by a private company. CODELCO is a leading national copper mining company in Chile while another national mining company, ENAMI, is an organization which is specially operated in the Chilean own way.

ENAMI purchases ore from small-sized or ultra-small-sized mining sectors, converts it into concentrates at their regional central mills and finally converts it into metal at their two smelters. Since ENAMI has a sufficient smelting capacity, it sometimes smelts ore by commission from CODELCO.

Table II-3-3 lists the annual electrolyte capacity of main copper smelters in Chile.

Table II-3-3 Main Copper Smelters in Chile and their Processing Capacity

Names of Smelters	Names of Companies	Annual Electrolyte Capacity (1000MT)
LAS VENTANAS	ENAMI*1	550
CHUQUICAMATA	CODELCO	370
CALETONES	CODELCO	130
POTRERILLOS	CODELCO	85
PAIPOTE	ENAMI	72
MANTOS BLANCOS	BLANCOS	28 (Fire Refining)
SANTIAGO	PUDAHUEL	15

*1 EMPRESA NACIONAL DE MINERIA

ENAMI is also giving financial and technical aid to small-sized or ultra-small-sized mines. ENAMI itself prospects for ore deposits and exploits mines to some extent, but often puts these mines up at auction inside or outside this country without operating them at present after the stage of prospecting is over.

There are main private companies such as Escondida, Mantos Blancos, Disputada de Las Condes, and Pudahuel. They are not technologically inferior to CODELCO.

3-2 Methods of Ore Dressing Expected to be Appliedt to Cerro Negro Ore

The methods of copper ore dressing are as follows:

(1) Direct transport of high grade copper ore to a smelter,

(2) Leaching of low grade copper ore mainly consisting of soluble copper mineral and its precipitation (solvent extraction and electrolyte winning <SX/EW),

(3) Ore dressing by mainly floating low grade ore such as copper sulfide ore, native copper, cuprite and copper carbonate ore,

(4) Combination of leaching and floating, and so on.

According to existing information, Cerro Negro deposit is a random ore deposit consisting of copper oxide ore (malachite, chrysocolla, azurite, atacamite) and copper sulfide ore (chalcopyrite, chalcocite, covelline). The combination of leaching and SX/EW for copper oxide or dressing and floating for copper sulfide ore dressing can therefore be imagined. Copper oxide ore is believed to have a soluble copper oxide grade of 0.8%. Therefore, if the copper deposit is confirmed to contain a small amount of both pyrite and alkali host rock which consumes acid, it becomes possible to economically leach copper away from copper ore by using sulfuric acid. It also seems possible to select the best method from dump leaching, heap leachig and butt leaching by studying the relationship between the grindability of copper ore and the leach rate of copper in consideration of the situation of basic rock and underground water near the mine.

Dump leaching can be applied when it is possible to leach copper away from large grains of copper ore and to find a suitable dump area. Heap leaching is applied by leaching copper away from relatively-large grains of copper ore in an artificially-made heap site. It is characterisc of butt leaching that the final leach rate is high since copper is leached away from fine grains of high grade copper ore in a container after those grains are ground down.

In any one of the leaching methods, leached copper is recovered in the existing iron replacement precipitation process or in the SX/EW process. Since the product becomes cement copper with a copper grade of 70% in the precipitation process, it is further smelted and refined to obtain electrolytic copper. In the SX/EW process, electrolytic copper with a Cu grade of 99.99% can be obtained, and this method can therefore be said to be superior to existing methods from the viewpoint of costs.

Fig. II-3-1 shows the flowsheet of a general heap leaching SW/EW process. If host rock contains a sufficient amount of pyrite, sulfuric acid is generated by the function of bacterium. In this case, it is necessary to add only water in place of sulfuric acid (bacteria leaching).

Since copper sulfide ore is believed to consist of copper minerals such as chalcopyrite, chalcocite and covelline, it is suitable to produce copper concentrates in general floatation ore dressing. As for parts of copper sulfide ore mixed with copper oxide ore, it seems suitable to recover copper in floatation ore dressing after the surface of ore is vulcanized.

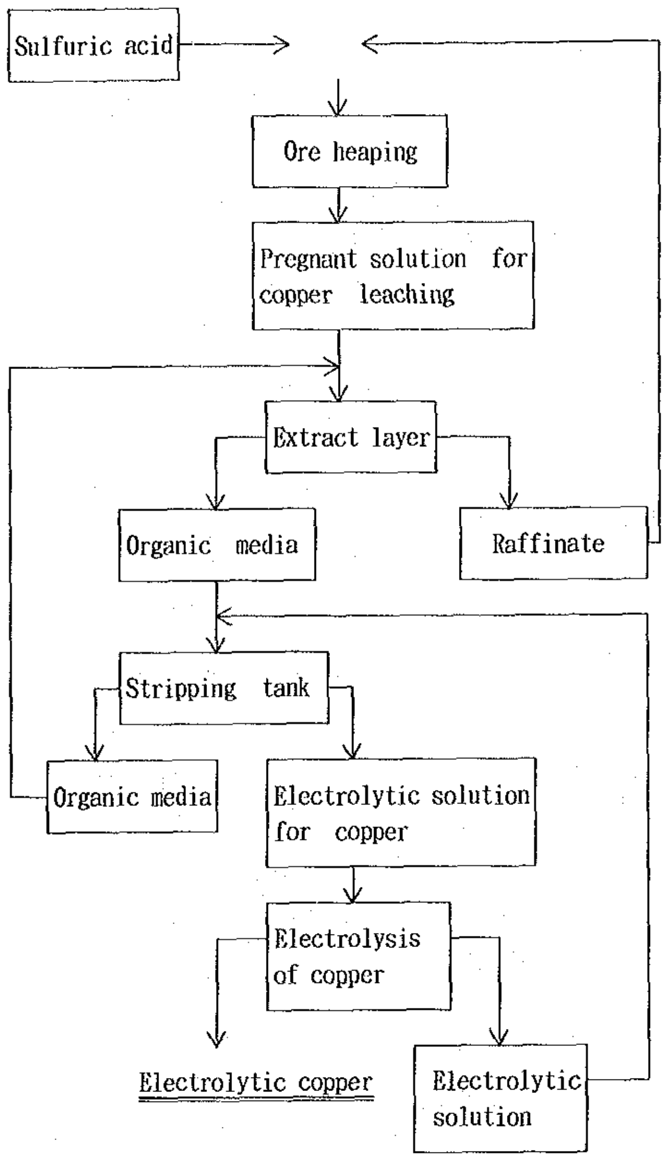

Fig. II-3-1 Flowsheet of Heap Leaching

The items of general ore dressing tests, which should be studied for designing a mill, consist of the identification of minerals, the selection of separation methods, the selection of flowsheets, the selection of grindability, the selection of the kinds of reagents, the selection of the amount of reagents, the selection of floating time, the analysis of tailings and shipping or for each grain size, the complete analysis of concentrates, the measurement of work indexes, settling tests for failings and concentrates, dehydrate tests, the examination of waste water, and so on.

Fig.II-3-2 shows the flowsheet of general floatation ore dressing.

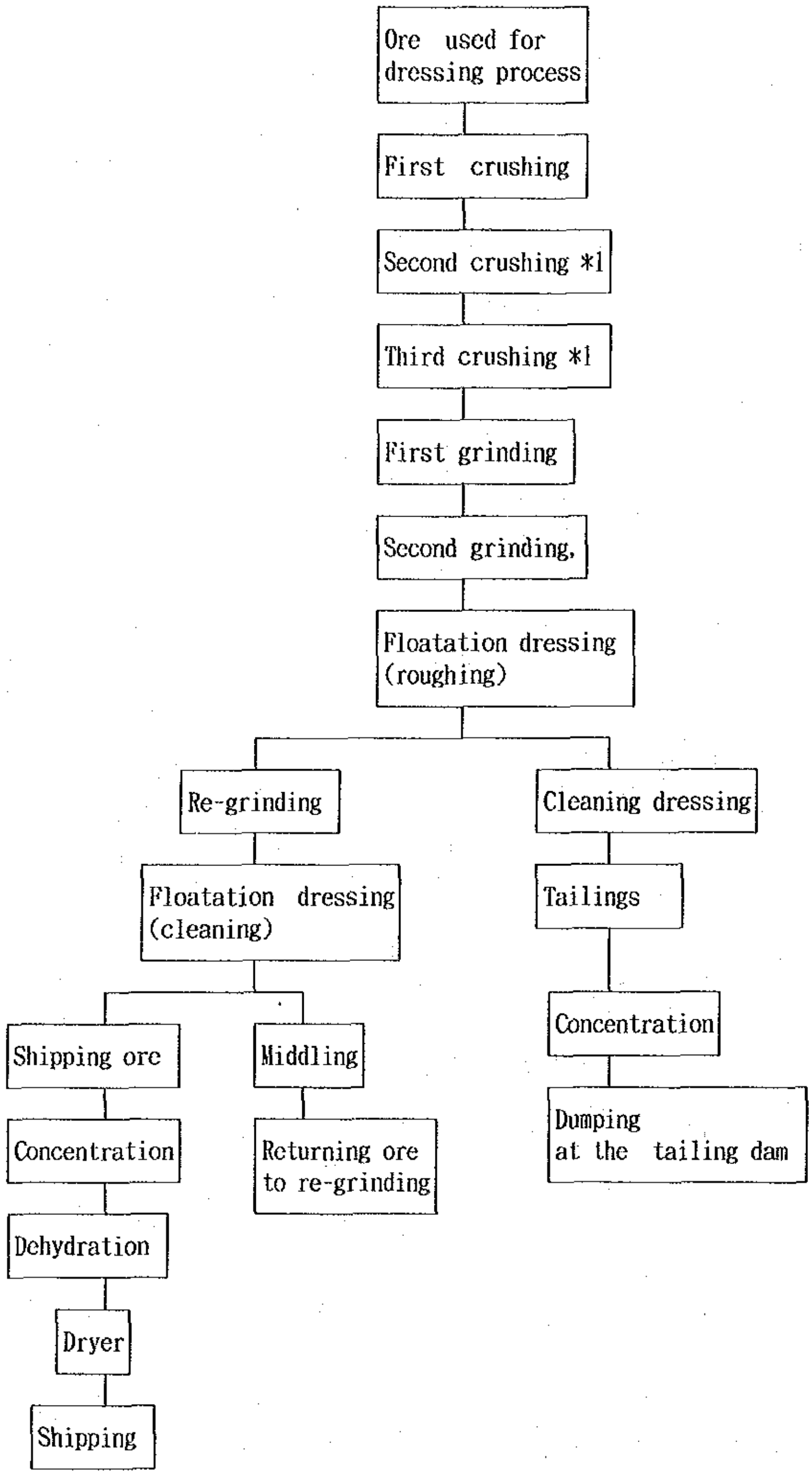

Fig. II-3-2 Flowsheet of Floatation Dressing

＊1: A semi-automatic grinding mill is often used in place of the second and third crushers.

3-3 Problems Expected to Take place and their Measures

The following items of problems, which are expected to take place in drawing up the mine development project in the future, can be considered. The problems are described and their measures are mentioned below.

(1) Floatation recovery percentage; The floatation recovery percentage has a great economical influence on the project. If the recovery rate is not sufficient, a wide range of ore dressing reagents should be examined. Other conditions of floatation ore dressing, including the grindability of copper ore, should also be considered as important subjects. In this regard, it is very important to decide what kind of organization should be used for ore dressing tests.

(2) Leaching recovery percentage; The leaching recovery percentage also has a great economical impact on the project since the ratio of copper oxide ore to copper sulfide ore is high and the copper grade of copper oxide ore is relatively high. If the recovery percentage is low, it is important to clarify the relationship between the grindability of copper ore and the leach rate of copper and to obtain information on contained minerals.

(3) Behavior of gold and silver; The recovery percentage of gold and silver has a great economical influence on the project since gold and silver with a relatively-high grade are contained in the ore. It is necessary to improve the recovery rate of gold and silver by selecting floating ore dressing reagents.

(4) Impurity and the grade of concentrates; Impurity contained in concentrates and the grade of concentrates sometimes have a great influence on the sales conditions of concentrates. If a lot of impurity is contained in concentrates, it becomes necessary to investigate its causes through mineral tests and others and then to take measures for improving the conditions of floatation ore dressing based on the results of the tests.

(5) Adoption of new technologies such as SAG mills, column sell ceramic filters, and so on.; It is necessary to study these new technologies in consideration of their adoption since they contribute to reduction in the costs of construction work and operation. As for the SAG mills, it is necessary to make its own tests for ore evaluation.

(6) Environmental issues and rehabilitation; It is now impossible to develop mines without paying attention to these measures. It is necessary to make the plans of pre-general environmental assessment, regular monitoring and rehabilitation.

(7) Site conditions of the mill and SX/EW plant as well as the tailing dam; Based on site on site investigation, their development plant should be precisely designed.

(8) Infrastructure (water, electricity, transport of concentrates); This seems to be included in the project in the second year. It is impossible to ignore infrastructure in considering the construction of ore dressing facilities.

(9) Blending, oxidation speed; If the ore deposit consists of small ore bodies, it is important to blend these bodies to stabilize the operation of ore dressing. If the speed of ore oxidation is very high as the nature of ore, it becomes necessary to process ore in a short period of time after it is mined or to cope with oxidized ore by using reagents.

(10) Possibility of the expansion and utilization of existing plants; The construction of a new mill is basically considered. However, it may be possible to expand the existing mills based on the results of investigations expected be made in order to cope with the project.

3-4 Results of Investigations on the Status of Copper Dressing and Smelting Technology in the Republic of Chile

In order to cope with the problems mentioned above, four research institutes, nine mines, mills and smelters, and Cerro Negro deposit were visited and information on them was obtained from January 5 to 24, 1993.

The target research institutes were selected to confirm whether they are capable of making ore dressing tests in the next year. Fig. II-3-3(1) shows the locations through their numbers.

(1) Ore Dressing and Smelting Research Center

(2) University of Atacama

(3) Industrial Technology Research Institute

(4) Department of Mine Engineering at the University of Chile

The target mines, mills and smelters listed below were selected to refer to them for information required for developing Cerro Negro as a mine. The status of technology owned by them was investigated. Fig. II-3-3 (2) shows the locations through their numbers.

(5) Manto Verde Mine

(6) El Salvador Mine Mill

(7) ENAMI, El Salado Mill

(8) La Florida Plant

(9) ENAMI, Matta Mill

(10) ENAMI, Pipote Smelter

(11) ENAMI, Vallenar Mill

(12) La Candelaria Mine

(13) Pudahuel Plant

Drilling cores were observed at Cerro Negro deposit which was being prospected. Preliminary investigations on the nature of ore were made.

The result of these investigations are mentioned below.

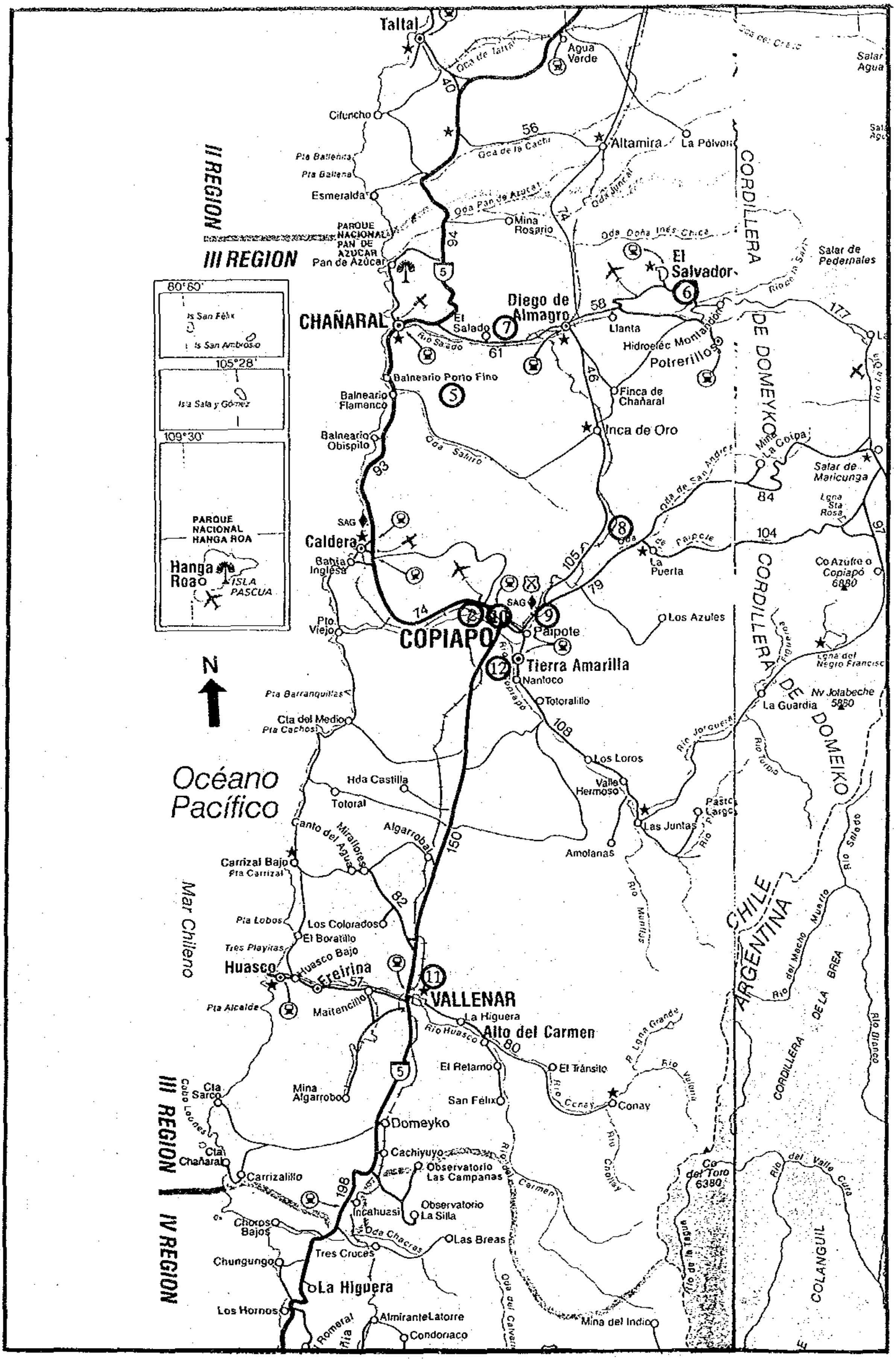

Fig. II-3- 3(1) Location of Research Facilities

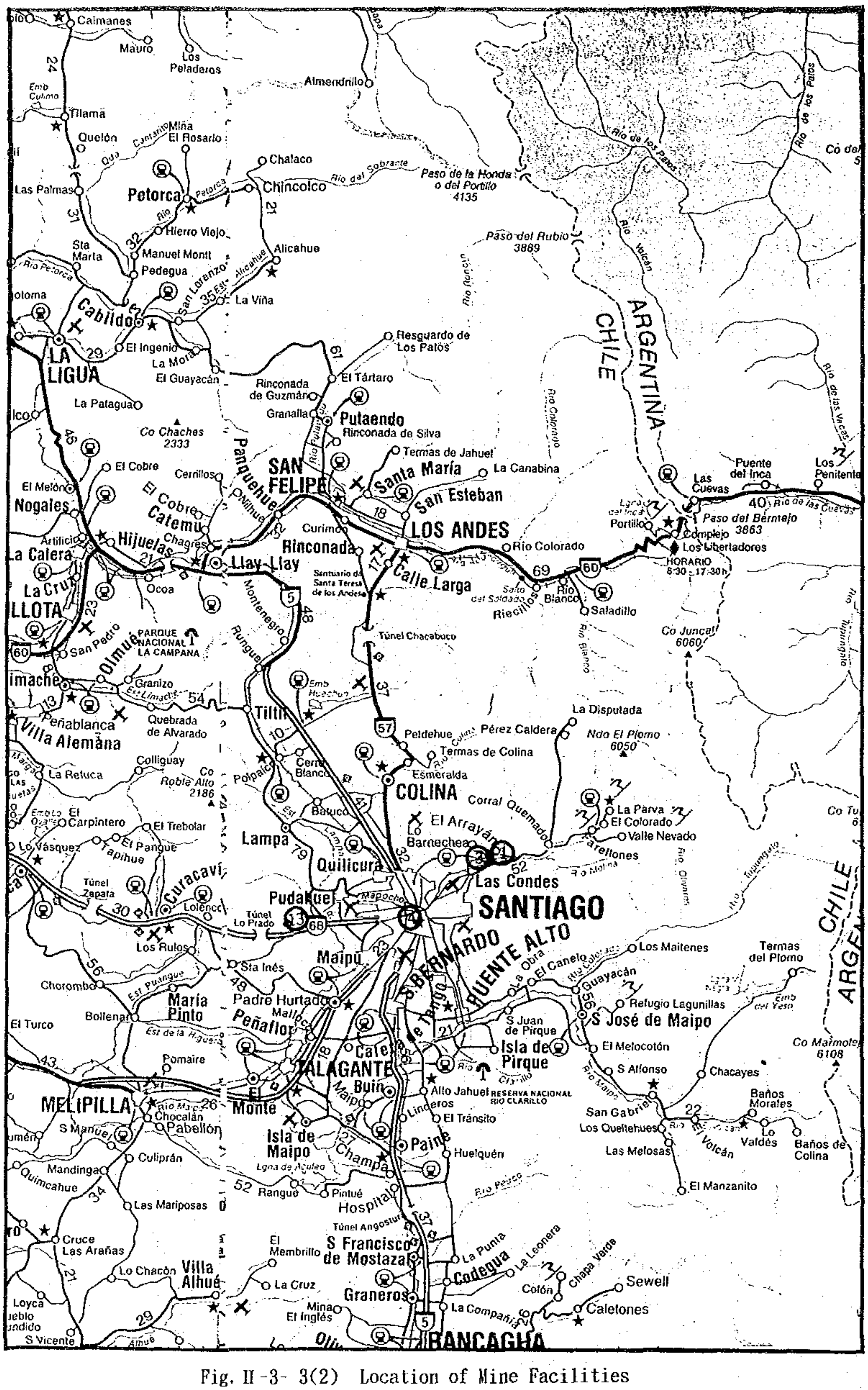

Fig. II-3- 3(2) Location of Mine Facilities

3-4-1 (Ore Dressing and Smelting Research Center)

Results of Investigation

Destination for visit:**Centro de Investigacion Minera y Metalurgica**

Fifteen minutes from Santiago City by car

Date: From 15:00 to 18:00, January 8, 1993

Interviewees:

Dr.Hector LEIVA S.	**Head Extractive Emtallurgy Division**
Luis GUARACHI PEREZ	**Ingeniero Civil de Minas Division Metalurgia Extractiva**
Hernan BRICENO L.	**Jefe de Proyectos Division Metalurgia Extractiva**
Alejandro JARA	**Comercializacion y Desarrollo**
Rodrigo HERNANDEZ C.	**Jefe de Proyecto Division Metalurgia Extractiva**
Juan M. Reyes PINOCHET	**Strategic Manager**
Raul SOUYRIS	
Pablo SOTO LANDA	**Ingeniero Civil Metalurgico, Investigador Asociado**
Alberto TELLO R.	**Head of Projects DCM (Chmical Lab. & Mineralogy)**

Co-visitors:

Julio CHAZARRO ORTIZ	**Gerente de Fomento, ENAMI**

Contents:

1) Outline of CIMM

CIMM is an exploitation, ore dressing and smelting research center, which was established twenty three years ago as a self-support non-profit making research institute. The funds used for its establishment consisted of capital invested by Chuquicamata, El Salvador and El Teniente mines (the ownership of these mines was shifted to CODELCO later) and contributions made by ENAMI, UNDP (the United Nations Development Plans), UNIDO (the United Nations Industrial Development Organization) and the government of Belgium.

The center is aiming for three main policies. The first, second and third policies are adopted towards strategic research for CODELCO, the transfer of technology and the provision of technological services respectively. There are the Exploitation Division, the Mineralogy Division, the Metallurgy Division, the Instrumentation and Automatic Control Division, the Material Division and the Environmental Division, which were established for the transfer of technology and the provision of technological services. As for regional services, the center also has branch offices in La Serena, Antofagasta (technological services such as geology, chemical analysis and ore dressing have started being provided) and Calama (Chuquicamata). About four hundred people and are working at the head office in Santiago and at the branch offices respectively. There are a total of 120 people including 20 doctors and 70 engineers at the Mineralogy Division and the Metallurgy Division.

Its relationship with JICA is long, and several Japanese people have worked for the center (one Japanese may be working at present). There are various research styles: they sometimes provide all equipment and people to their client or conduct cooperative research with their client's staff members as a team.

Generally, the center submits a proposal first based on their client's basic information, makes a general plan according to the budget for a project and the period of time and finally starts conducting research. The same is also true of INTEC we visited later.

2) Capability and Experience of the Mineralogy Division and the Metallurgy Division.

* In the hydrometallurgy field, they have carried out 4,000 projects for Quebrada Blanca, Cerro Colorado, Punta Del Cobre, Manto Verde, Saldivar and others as well as foreign countries such as Argentina and Peru. They can conduct research in 30 to 40 projects at the same time, and are capable of conducting research in 6 to 8 projects per engineer.

Columns with a diameter of 15cm to 60cm and a height of 2m to 10m are used for leaching tests and these tests are repeatedly made for 6 to 12 months to observe the accumulation of impurity. Research continues to be carried out by observing acid consumption and leach rates. It takes two months to prepare and make a report. The amount of required samples is 2 to 6 tons.

* They have 15 years of experience in the ore dressing (comminution, physical concentration) field, and owns characteristic technology related to SAG mills (semi-automatic grinding mills), gold smelting, the transport of slurry, and so on.

As for SAG mills, they have carried out 200 projects for 12 years for Los Bronces, Chuquicamata, Andina, El Teniente, La Escondida, Quebrada Blanca, Alumbrera (Argentina) and Peru as well.

As for gold smelting, they carried out a project by making a mixed team of members from El Indio and St. JOE Company (five engineers were dispatched from the center) and letting them use an entire plant.

As for the transport of slurry, research on abrasion and pressure loss in the case of El Teniente was conducted in cooperation with Bechtel company.

As for batch tests, there are eight testing machines for flotation ore dressing (Denver, Agitair,Outokumpu).

In the pilot plant, there are the first jaw crusher, the second cone crusher, the third roll crusher (a total of 2 to 4t/h), a 20t/h SAG mill (6ft. in diameter x 2ft.), a ball mill (2ft. in diameter x 3ft.), a re-grinding mill, flotation machines (Denver No.5, No. 8, Agitair). The planis operated for 12 hours in two shifts (with a maximum of 20 people/shift) and has the capacity to process 250kg of ore/h, and the structure suitable for revising its worksheet easily.

There are column flotation machines with a height of 2ft. and 3 inches to 3ft. No tower mill (it existed before) and no ceramic filter exist either.If you ask them for the development of an initial flowsheet, it takes two months to complete the flowsheet.

Besides the orders of these tests by commission, research on the measurement of grain size distribution caused in crushers by image analysis equipment, on air sparger cyclone flotation machines, and on others is conducted as strategic research development themes.

3) Outline of the Chemical Analysis & Mineralogy Division

Samples are adjusted by three people in two shifts. Six people are working on assay analysis.

As for analyzers, there are a Philips PW-1400 fluorescent X-ray analyzer, a Philips X-ray diffraction unit (4-80°), atomic absorption analyzers (3 Perkin-Elmer units, 1 Shimazu unit), and an IPC analyzer (ten years old). The gravimetric and colorimetric methods are used here.

Samples used for water quality control are processed in the water quality sample room and their water quality is measured by atomic absorption analyzers.

Care is given to environment: all instruments are cleaned in the cleaning room and completely-stainless hoods are used for example.

As for facilities related to mineralogy and physical characteristics, there are a JEOL-made EPMA as well as three presses (1 Marumoto-made unit) and three polishing machines used for microscopes. The microscopes themselves are old.

4) Impressions and Comments

* This center has sufficient facilities and staff members in both ore dressing and hydrometallurgy as a whole and is judged to be a research institute with a lot of experience.

* There are some weak points such as no existence of pilot plant for SX/EW and the existence of many old analyzers and old mineralogy-related devices.

* CIMM's research facilities and capability seem to be sufficient enough since the composition of minerals at Cerro Negro is expected to be simple and the ordinary conditions of leaching and flotation ore dressing seem to be required.

* The scale and level of the facilities at Antofagasta have not been disclosed yet, and they may be used since they are located near Cero Negro.

3-4-2 Results of Investigation (the University of Atacama)

Destination for visit: Inside Copiapo City

Date: 9:00 to 14:30, January 13, 1993

Interviewees:

Dr.Jose PALACIOS GUZMAN	**Director Depto. Metalurgia**
Dr.German CACERES ARENAS	**Profesor Titular Depto.Ingenieria Metalurgica Facaltad de Ingenieria**

Contents;

1) Organizations

This university was founded in 1857 as the first mining school in Chile. There are two faculties for human study and engineering. The engineering faculty consists of the metallurgical department and the mining department. This research institute conducts chemical analysis and various tests as a service-providing organization attached to the metallurgical department.

2) Capability and Experience of the Institute (including the Mining Department)

The contents of services, which they can provide, consist of flotation ore dressing tests (copper, gold, silver), grinding work indexes, standard flotation ore dressing tests, microscopic tests, copper leaching, and solvent extraction and electrolyte winning (SX/EW) (there is no equipment for SX/EW at present, tests for them can be made in cooperation with ENAMI or El Salado). According to them, the SX/EW pilot plant at Punta Del Cobre (Farah) can be used.

As for ore dressing testing facilities, there are a jaw crusher and a double-roll crusher (-10meh) to process 1 ton of samples/batch. Analytical samples are crushed and a vibration mill. The institute also has a ball mill(with 122 one-inch balls, 10kg or 7.6kg-balls with a diameter of 15mm), Denver and Agitair testing machines for flotation ore dressing, an amalgamation tester, a leaching column (made of glass and plastics), a set of four SX pilot machines (a 4-gallon mixer).

Pilot tests for flotation ore dressing can be made in the three series of Chilean type mills wit a capacity of 300-400kg/h and flotation machines. This plant can be used by lease. And ore is sometimes processed by receiving nine U.S. dollars/ton of ore from ENAMI. This plant has two regular operators and is operated by temporally employing some people. The entire plant can be used on lease by paying 2000 pesos/hour + 18% tax.

As for analytical methods, the assay analysis of gold and silver is often made while the gravimetric method and titration are mainly used in the wet type. There is an atomic absorption analyzer, but the machine seems to be in a bad condition. In this connection, the definition of OXIDE Cu (Sol. Cu) indicates the amount of copper obtained by generally dissolving 5g of sample ore in 50ml of 1-mole-citric acid for two hours. In certain circumstances, the amount of copper obtained by dissolving 5g of sample ore in 50ml of 1-normal sulfuric acid for 12 hours is sometimes used.

In the petro-dynamics field, two professors and seven students came from Munster University in Germany, and these students are writing graduation theses by making field tests. They are extesiometer (0.0001mm measurement) field tests.

In the mineralogy field, a German scholar is staying, and foil producing technology has therefore been improved. They are capable of making about four foils a day by hand polishing as well as and of 10 to 15 foils a day by a made polishing machine by using epoxy resin as hones. In February, a new U.S. made cutter and a new polishing machine will be obtained. Their technology is expected to be further improved.

Dr. J. Palacios, who guided us in the university, had once studied at the ore dressing and smelting research institute of Tohoku University, and speaks Japanese. He got a doctorate from a university in Indiana, the United States.

Dr. G. Caceres is an expert at SX/EW, and was involved in plant construction at Pudahuel. He is giving advice on SX/EW pilot tests at Punta Del Cobre as a consultant. He said he had started application study of bacteria leaching, but he has just obtained a room for that in reality. There are one director, one professor and six technicians.

3) Impressions and Comments

* As a whole, old facilities and old ideas are recognized.

* May people among technicians are very experienced. The fact that Dr. G. Caceres is an expert at SX/EW can be appraised.

* They are enthusiastic about business and their relationship with ENAMI can also be appraised.

* They have experience in small-scale projects, but seem to have little experience in large-scale projects.

3-4-3 Industrial Technology Research Institute

Destination for visit: Instituto Tecnologico (INTEC) Fifteen minutes from Santiago City by car

Date: 16:00 to 17:30, January 18, 1993

Interviewees:

Carlos MOLINA VERA	**Ingeniero Civil de Minas, Jefe Area Metalurgia Extractiva**
Patricio GONZALEZ B.	**Ingeniero Civil de Minas (U. de Chile)** **Area Metalurgia Extractiva**

Co-visitors:

Juilo CHAZARRO ORTIZ

Contents;

1) Outline of the Organization

The institute was established twenty five years ago by CORFO (National Development Corporation) of the Ministry of Economy. This is a non-profit making research institute which provides technological services. The object of the institute is to make technological development required for improving the competitive power of Chilean companies and to contribute to their modernization.

This is a national organization, but earns money equivalent to 70 to 80% of its annual budget of U.S. $3 million from orders, and the rest of the budget comes from the national budget.

Among 220 people, 70 to 80% of them are technology-related people including 100 engineers.

There are various departments such as Extractive Metallurgy (ore dressing and smelting: 50 people), Environmental Technology (20 to 30 people) as well as Automation, TQM (Total Quality Management), Agro-industry, Chemical Industry (including coal), Micro-biology, Food Industry, Electronics, the Library, the Information Center and Chemical Analysis. Many people at engineering companies and consultant companies outside the institute are using them.

2) Experience of the Extractive Metallurgy Department

(1) Anadacollo Gold project (Minera Daytom Company)

The ore grade was 1.1g of Au/t. Tests were repeatedly made for 16 months. Gold was dissolved by leap cyanogen leaching, and gold was recovered in the zinc powder reduction method. 400 basic tests and 35 column tests and pilot plant tests were made. After that, Bechtel Company conduced. F/R. The plant will be put into operation in 1993 to process 10,000 tons of ore/day and produce 3.5 tons of gold/year (this plan has been postponed in reality).

(2) Collahuasi Copper Project (Falconbridge, Noranda, Shell, Chevron, Anglo, American)

This is a large ore deposit with 1 to 2 billion tons of ore reserves whose grade of Cu is 0.94%, and located at an altitude of 4,000m near Iquique in the northern part of Chile. Copper mineral mainly consisted of chalcocite, and the flotation recovery percentage was achieved to be more than 90%. Bacteria leaching tests are being made in fifty columns. Since this ore deposit is located at a high altitude,temperature will be an important factor in smooth leaching. As for the size of this mine, it is expected to process 30,000 to 60,000 tons of ore/day.

(3) Vilacolla Gold Project (Shell)

The cyanogen leaching of gold is considered here. Tests for 8 to 9 tons of ore/day are expected to be made. As for the size of this mine, it is expected to process 5,000 tons of ore/day.

3) Outline of the Extractive Metallurgy Department

Two people working on mineralogy (microscopy). They have technology required for processing ore from the stage of ore crushing to the stage of ore smelting. However, they pay almost no attention to SX/EW.

If you ask them for tests now, they will have time to start making tests around May. It may be necessary to pay 1,000 to 500,000 U.S. dollars/test. The procedures should be carried out in order of discussion with their client, the submittal of a proposal for tests and the execution of tests (It is necessary to make basic tests for 3 months. The amount of samples required for leaching and flotation ore dressing is expected to be 1 ton and 4 tons respectively).

They have testing machines for flotation ore dressing, such as two Agitair machines, three Denver machines and a WEMCO machine. As for gravity concentration machines, there are new machines such as a table (made in Germany), a ore dressing machine, a spiral ore dressing machine, BRCM jigs (made in France) and a KNUDSEN cone.

Besides these machines, new technology from the United States is used: there are forty leaching columns, a kiln for reactivation of activated carbon and equipment for electrolysis of gold.

As for column flotation machines and German-made pneumatic flotation machines, they are waiting for them to be delivered (EKOF, BAHR, DOR and FER-made machines). There is no SAG mill, and they ask CIMM to make tests related to SAG-mills. There is a Larox-made pressure dehydrator.

There is a pilot plant for flotation ore dressing, and the plant is capable of processing 3 to 6 tons of ore/day. The plant consists of a ball mill with dimensions of 2ft. in diameter x 3ft., a re-grinding ball mill with dimensions of 1ft. in diameter x 2ft., six Agitair flotation cells with dimensions of $1ft.^3$ and four Denver flotation cells with dimensions of $0.5ft.^3$ and two banks.

As for supplementary facilities, there are sufficient gold leaching facilities and equipment such as a cyanogen leaching room, an atomic absorption analyzer (PE 3100) for plant (leaching is regarded as main) control, a mercury porosity meter, a colorimeter for analysis of Fe^{2+}, a dissolved oxygen meter (lower limit: 0.2mg of O^2/l) and an ion meter (CN^-, Ag^+, SCN^-). There are also a humidity cell tester and a lysometer which are used for environmental tests. As for analyzers, there are a PE 5000 atomic absorption analyzer and a chromatographic analyzer. As for machines related to metallurgy, there are a press, a cutter, four Polimet, and Leitz-made and Orthol-made microscopes. There is no EPMA, and if it is necessary to make EPMA related tests, they ask other organizations to make these tests.

4) Comments and Impressions

* It is characteristic of the institute that they give importance to gold ore processing technology. Their technology of flotation ore dressing is not so bad, but their technology of SW/EW seems to be very weak.

* Compared with CIMM, they give importance to entire industries and new technology and new-type machines have been introduced.

* The institute's size, integrativeness and experience are inferior to those of CIMM from the viewpoint of mine development.

* They recommended us to bring samples used for microscopic tests to the institute anyway.

3-4-4 Mining Department at the University of Chile

Destination for visit: Universidad de Chile : Departamento de Ingenieria de Minas

Inside Santiago City. Ten minutes from its downtown by car.

Date: 10:00 to 11:30, January 19, 1993

Interviewees:

Augusto MILLAN URZUA	**Director Departamento de Ingenieria de Minas**
E.ALMENDRAS de SIEGEL	**Ingeniero Civil de Minas**
	Characterizacion de Minerales,D. de I. de M.
Peter SIEGEL	**Profesor Aldo C. Casali B. I. C. de Minas**
	M. S. in Metalurgy
	(U of Utah) Procesamiento de Minerales, D. de. I. de M
Gerardo E. FUENTES C.	**Profesor Aso.**

Co-visitors:

H.TRASLAVINA A.	**ENAMI**

Contents

1) Outline of the Department

This department is one of the thirteen departments at the university. There are 46 who received doctorates (14 of them are full-time workers). People at this department can use equipment (EPMA in geology, X-ray diffraction in physical engineering and others) in other departments.

Their catchphrase is that "We have plenty of people with much experience. The prices are also reasonable. A lot of young people are working since our salaries are higher than those in other research institutes."

It takes a long time (four or five days) to make tests since the laboratory is busy. They are asking CIMM and SGO to make tests.

There is no pilot plant. As for their experience in mine development, they have been involved in the development of small-sized mines in the northern part of Chile and some parts of tests for engineering companies.

Buildings and facilities at the university were destroyed by an earthquake in 1985. They had a hard time of the reconstruction of these things.

2) Contents of Facilities and Research (including students' ones)

(1) As for mineral testing equipment, there a cutter, two polishing machines, and six microscopes (including Nicon's)

(2) Various testing machines for petro-dynamics

(3) In the chemical analysis room, there are a PE-atomic absorption analyzer, a LECO-S analyzer, and others. They are used for ten hours a day.

(4) As for testing machines for ore dressing, there are three jaw crushers, a roll crusher pulverizer, sieve, ball mills (including abrasion tests and work indexes), a vibration mill (Humbolt), a flotation machine (Denver-made four-cell type), a cyclone testing machine, a filter testing machine, and so on. There is no SAG mill, and they employ experts as consultants to make tests related to SAG mills. Besides these testing machines, there are jigs, a table, six testing machines (Denver) for flotation ore dressing, various reagents, a magnetic ore separator, an electrostatic ore separator and a column flotation ore dressing cell (self-made).

(5) In the hydrometerology field, they were making tests for the roasting/leaching/electrowinning (REL) processes of shipping copper ore. After ore was roasted on the fluidized bed of a roaster at 800°C, copper and iron were leached away from ore by water and sulfuric acid at a rate of 70% and at a rate of 20% respectively. They are also making tests for the leaching process of shipping copper ore at 60°C by HNO_3 obtained from $NaNO_3$. Both copper and iron can be leached at a rate of 100%, and sulfur is deposited as an element. NO_2 and NO_3 can be absorbed by H_2O_2 and then they can be recovered as HNO_3. They are also making tests for the leaching of chalcopyrite in an autoclave (120 to 150°C, 100 PSI, 6h) by using sulfuric acid as well as tests for Sherrit Gordon's method (planned to be used at La Escondida) by using NH_4OH.

3) Comments and Impressions

* Basic facilities related to flotation ore dressing are sufficient, but there is almost no facilities for SW/EW.

* Their system is basically ready for the orders of tests. After all, this is a university and it is unstable for us to ask them for mine development.

* One of the persons, who guided us in the university, recommended us to visit the University of Santiago on the next occasion, saying that the university is capable of helping the project.

3-4-5 Manto Verde Mine

Destination for visit: Manto Verde (Anglo American Company): Located southeast of Chanaral, and forty minutes from there by car.

Date: From 15:00 to 16:00, January 10, 1993

Interviewees:

Leonardo HERELLA Manager of The Mine

Co-visitors:

Fumio WADA Head of The Investigation Group

Contents

1) Outline of the Mine

Their heap leaching and SX/EW pilot plant is now in operation to make mine development. The plant is capable of processing 80kg of Cu/day, and will be operated from May, 1992 to the end of 1993. The amount of ore with a Cu grade of 0.8%, which is possible to be mined, is said to be 5,000 to 100 million tons.

2) Outline of the Test Plant

The headway has been excavated to obtain samples in tens of kinds. 100 tons of ore per kind has been mined from places with a depth of 0m to 50m and then piled up. Samples have been mixed and a composite with a C content of 0.9% is fed as a test plant.

Ore is crushed into stones of ore with a diameter of 3/8 to 1/2 inches (their final diameter seems to be 3/4 inches) in two-stages of crushing through a jaw crusher and a cone crusher. Sulfuric acid and sea water are added to ore in a drum agglomerater to produce ore briquettes.

There are two kinds of test heaps such as eighteen heaps with dimensions of 1.5m x 1.5m x 6mH (25 tons) and four heaps with dimensions of 4m x 4m x 6mH (125 tons), both kinds of them are surrounded with iron walls and wooden columns, and ore is put into the heaps by gradually piling up wooden columns from the bottom to prevent its consolidation. Spray is controlled at 10 to 15l/h/m^T2^T, but no spray is provided for the first 24 hours for aging, ore is washed by only sea water for the final 3 das, and the liquid s then drained.

Since there is no water source, a pipe is planned to be installed to the seacoast, Flamenco located 40km away from the plant to transport sea water, and sea water is today brought by tank car.

Leaching speed is getting higher by agglomeration, 45% of all copper is leached away from ore in the first 6 days, and the total leach rate of copper for 45 days stands at 85%. However, copper will be leached in the 125-ton leaps for four months.

Leached pregnant solution is recovered through plastic pipes installed at the bottoms of the heaps, and it is discharged into the pregnant solution pond or the intermediate solution pond.

The concentration of Cu in pregnant solution, intermediate solution and raffinate (SX waste liquid) is 6g/l, 1. 5– 2g/l and 0.1 to 0.2g/l respectively.

Tests are being made by sending pregnant solution to the SX (solvent extraction) plant and changing the mixed ratios of pregnant solution to organic solvents, electrolytic solution and drinking water. Fig. II-3-4 shows the flowsheet of ore processing.

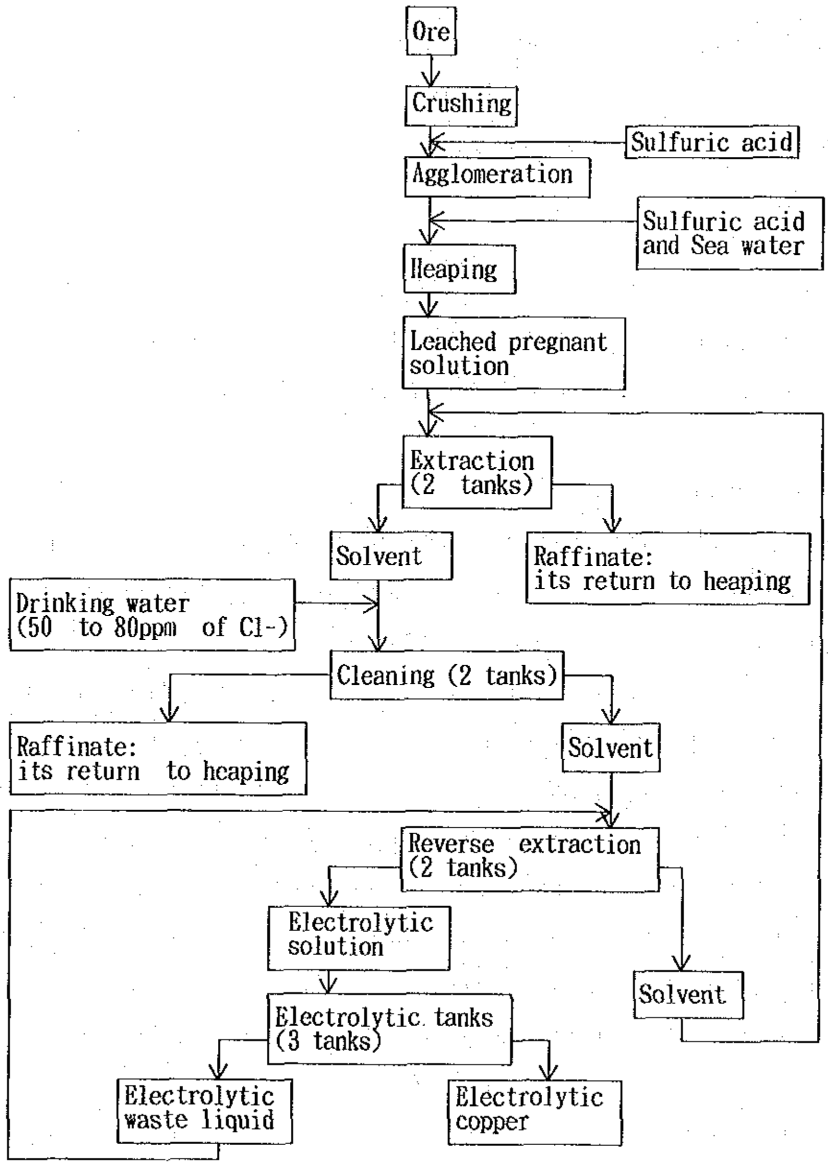

Fig. II-3-4 Flowsheet of Ore Processing at Manto Verde

Sea water is used in the ore cleaning process required for decreasing the concentration of chlorine in copper cathodes produced as products.

The concentration of copper in electrolyte solution, which is sent to the electrolyte process, is 45g/l. One of the three electrolytic tanks was in operation when we visited the plant. Four electrodes with a respective area of about $1m^2$ were installed in each tank, and anodes consisted of Pb. Electric power is used at 3V and 1250A. It takes 4 to 6 days to complete a cycle of electrolysis and the weight of cathodes is 80 Kg. The copper grade of cathodes is 96% to 99%, and S, O and Pb are contained as impurity. It coasted them 800,000 U.S. dollars to construct the plant. 30 to 40 people are working for the plant in two shifts.

3) Comments and impressions

* It is characteristic of technology at this mine that they use sea water and the heaps are very high.

* They do not seem to be good at electrolytic technology, and initial products were separately stored since the quality of them was bad.

* According to people other than employees at the plant, the quality of cathodes does not seem to be sufficient, their copper grade is good enough, but they seem to have a high chorine content.

* The test plant was operated sufficiently by giving consideration to the easy control of various conditions (the grain size of crushed ore, the height of heaps, the amount of spray, various SX conditions): copper was leached away from ore in column(s) for example.

* Although we visited the plant without notice, they kindly guided us in the plant.

3-4-6 El Salvador Mine Mill

Destination for visit: El Salvador Mine Mill

Five minutes from El Salvador City by car,

and fifteen minutes to its tailing reprocessing plant from the city by car.

Date: January 11, 1993

Interviewees:

Mario ARREDONDO ZUNIGA	**Superintendente Concentradora**
CHRISTIAN	**Jefe de Operacion**
Guillermo CHAVES	**Chief of DAM, Drying & Retreatment Plant (Los Amarillos)**

Contents:

1) Outline of Ore Dressing

The ore grade of Cu is 0.9 to 1.3%, and the mill is processing 33,000 to 34,000 tons of ore/day. 80% of ore is produced from underground mining while 20% of ore is produced from open pit mining. One of the most main copper minerals is chalcocite and there is also much pyrite.

Crushers are divided into three sections, Sections 2 and 3 were installed in 1959, and Section 1 was newly installed in 1989. Each section consists of a Simon-made 7-foot standard cone crusher and a short head cone crusher.

Among five sections of grinding circuits, four sections were installed in 1959, and another section was newly installed in 1981. The grinding circuits consist of rod mills, ball mills and closed-circuit cyclones. The new grinding circuit with a capacity of 10,000 tons of ore/d consists of a rod mill (13.5ft. in diameter x 18ft., 3000HP) and a ball mill (16.5ft. in diameter x 19ft., 4000HP) while each one of the old grinding circuits with a respective capacity of 6,000 tons of ore/d consists of a rod mill (10ft. in diameter x 14ft.) and two ball mills (10ft. in diameter x 14ft.).

The processes of the flotation ore dressing circuit consist of roughing, re-grinding, two-stage cleaning, cleaning ore dressing of cleaned tailings and sand flotation of roughed tailings after classification by using two hundred fifty 400-cubic-foot agitators. Since flotation machines are old, small and inefficient, they will be replaced with large-sized machines by using $12 million. Therefore, Dololiver-made 1550-cubic-foot flotation machines are now being tested in using them in the cleaning ore dressing and sand flotation processes. Two short column flotation machines with dimensions of 2m x 8m are used for cleaning.

As for flotation bulk ore dressing, shipping molybdenum ore is obtained in flotation ore dressing by using 7kg of ANAMOL D (As_2O_3 + NA_2S)/t. The ore grade of molybdenum in ore dressing and feeding is 0.011% MO while the ore grade of molybdenum in bulk ore dressing is 0.4% MO.

After final shipping copper ore (27% Cu, 27 to 28% Fe) is enriched in a thickener, it is sent to solar drying facilities through a pipe with a length of 27km, and after it is dried there, it is loaded into freight cars by a loader and then transported to Potrerillos smelter.

They are planning to introduce two ceramic filters as new drying equipment for replacement.

The number of people working for the mine including those working for the smelter is about 3,800 consisting of 1,500 people in the mining field, 1,000 people in the management field including those for hospitals and schools, 275 people (6 people for management and office work, 18 people for technology, 106 people for maintenance, 140 people for operation) at the mill, and so on. The population of El Salvador is about 10,000.

Fig. II-3-5 shows the flowsheet of ore dressing at the mill.

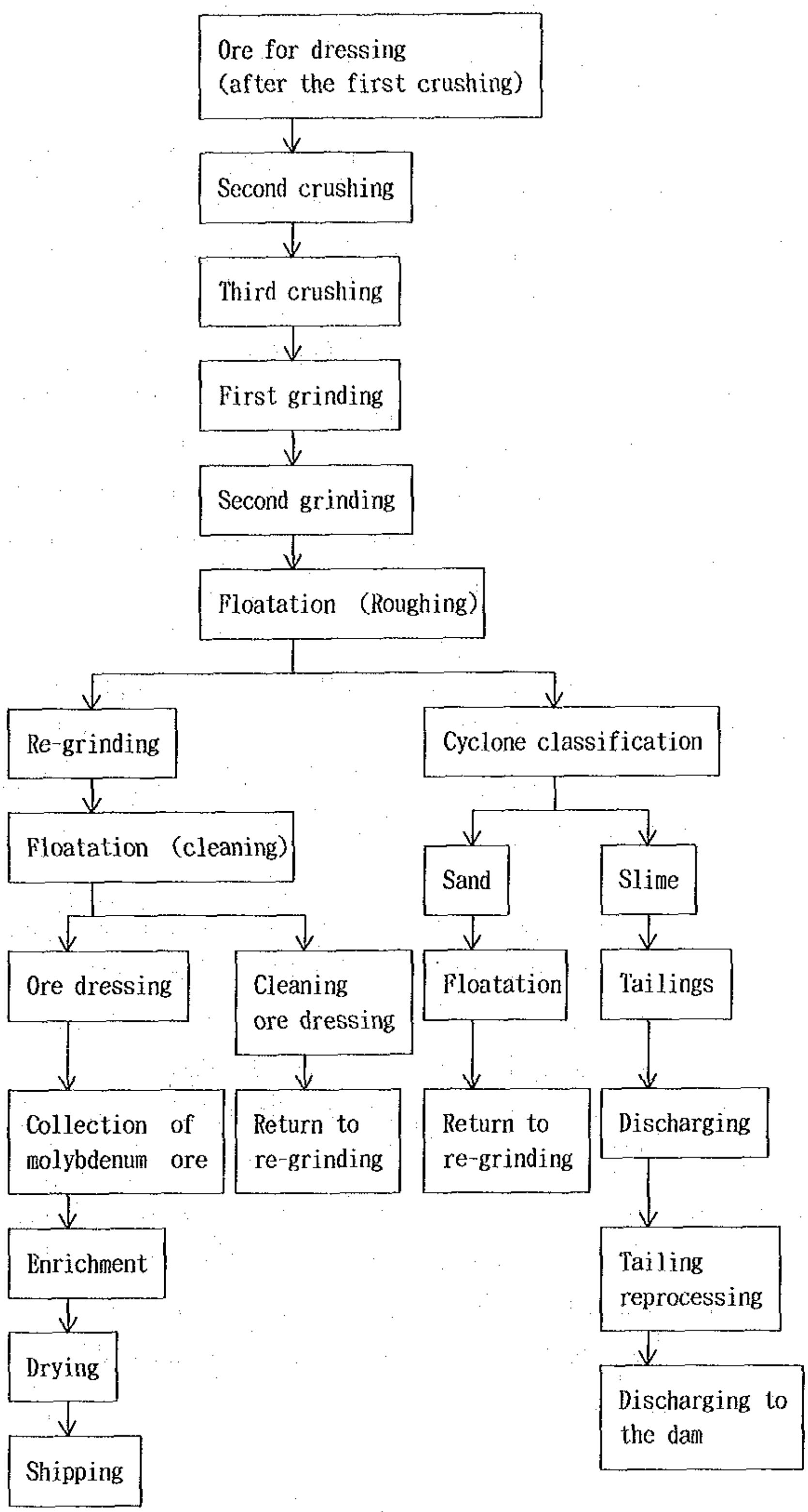

Fig. II-3-5 FlowSheet of Ore Dressing at El Salvador Mill

2) Conditions of Flotation

The length of flotation time consists of 14 minutes for roughing, 12 minutes for sand flotation, a total of 25 minutes for cleaning ore dressing, and so on.

China-made xanthate and SF-323 (Shell) are used at 20g/t and 10g/t as main scavengers respectively, MIBC and calcium hydroxide are used at 22g/t and 3kg/t as foaming agents respectively, and the Ph value of ore in roughing and cleaning is 11.4 and 12.3 respectively.

3) Flotation Tailing Reprocessing Plant

Flotation tailings used to be discharged into the ocean from El Salvador mill through a waterway.A reprocessing plant started to be operated in April, 1990 at a place about 10km downstream from the mill to collect copper while environmental issues were absorbing public attention. The total number of people working for the plant is 43. Fifty tons of copper ore with a Cu concentration of 22% a day is produced by using 62 cascade type flotation machines, newly-installed general flotation machines (which started to be operated on Thursday, a week before we visited) and column flotation machines (whose recovery rate is 66%). Flotation tailings running in the waterway and froth collected in cascade type machines have a Cu content of 0.22% and 0.7% respectively, and their grade is improved to 3% in roughing and 22% in the final concentrates grade. The total recovery rate accounts for 2 to 3% of that in ore feeding at El Salvador mill. Tailings are discharged into the ocean from the plant through the 45km-long waterway.

4) Impressions and Comments

* The chief of the ore dressing section as well as the head of the workshop, a person who guided us in the plant, came to this plant from Mantos Blancos one year ago. Both of them were positively working on the introduction of new technology related to flotation machines, filters, and so on.

* There are a lot of old facilities at the mill, and they should be improved.

* The tailing reprocessing plant does not seem to contribute greatly to environmental improvement, but seems to have a big economical effect.

* Poisonous-looking green mineral was seen along both banks of a river running in El Salado. According to them, it was not caused by tailings from this plant, but waste water from Potrerillos smelter. However, people are not allowed to swim at Chanaral where its river mouth is located since their health may be badly affected. Environmental problems seem to have been very serious in the past.

3-4-7 PLANTA DE OSVALDO MARTINEZ (ENAMI) (Enami, El Salado Mill)

Destination for visit: Enami's Osvaldo Martinez mill in El Salado

Date: 9:00–13:00, January 12, 1993

Interviewees:

Roland URQUIZA **Adminster**

Manuel CARMONA **Jefe de Operacion**

Content:

1) Outline of the plant

This is an old plant built in 1935, which is operated by purchasing ores from 300 small-sized miners.

This plant has sulfide ore processing capacity of 10,000ton/month, worrying about insufficient ore grinding capacity and low efficiency. The availability of the ore grinding circuit is 90%, the quality level of processed ore is 1.4 to 1.7%Cu and Cu collection rate is 91 to 94%.

Oxide ore is processed by heap leaching method and precipitation copper collection method and totally 18,000 ton is processed monthly. While the quality level of processed ore is 3%Cu, the collection rate is 78%. Several years before, SX/EW (3l/min.) pilotplant test was implemented and currently also, that equipment is possessed. That is under consideration now.

Although chemical analysis, simple flotation test and column leaching test are possible in the laboratory, it is now used for operation control and outside tests are impossible. Mr. Carmona recommended CIMM which he had worked before.

Of purchased ore, high quality ore having more than 12% Cu is transferred directly to the refinery.

The total number of workers in the plant is 105, of which 6 persons work in the laboratory.

2) Outline of processing of sulfide ore

Upon receiving, the ore is weighed by the truck scale (60t Cap) and piled for every type of ore. According to a schedule, it is processed by the crusher (3 stages), sampled and the cost is paid for according to the analysis value. The grain size of crushed product is 1/4 inches.

The ball mill consists of four mills of almost the same size (100 kw motor each). The replacement of these with a large mill (280 kw) is now under consideration.

Flotation is performed by Denver Sub A#24 and divided to rough separation and two stages fine separations. The collector used is P3 xanthate and the foaming agent is MIBC pine oil. The final dressing is 26%Cu, 10gAu/t and 40gAg/t and water content after drying under daylight is 8–9%. On the other hand, tailing after flotation (0.2% Cu) is pumped to the dam. The tailing dam some kilometers downstream was built in 1991 (before that, it is discharged to the river) and can be used for coming 10 years. The bank is made of cyclone underflow and overflow is discharged to the river after precipitated in the dam. Used water is not reused. The water quality of drain is checked about once a month by SERNAGEOMIN. Fig.II-3-6 shows the flowsheet of sulfide ore processing.

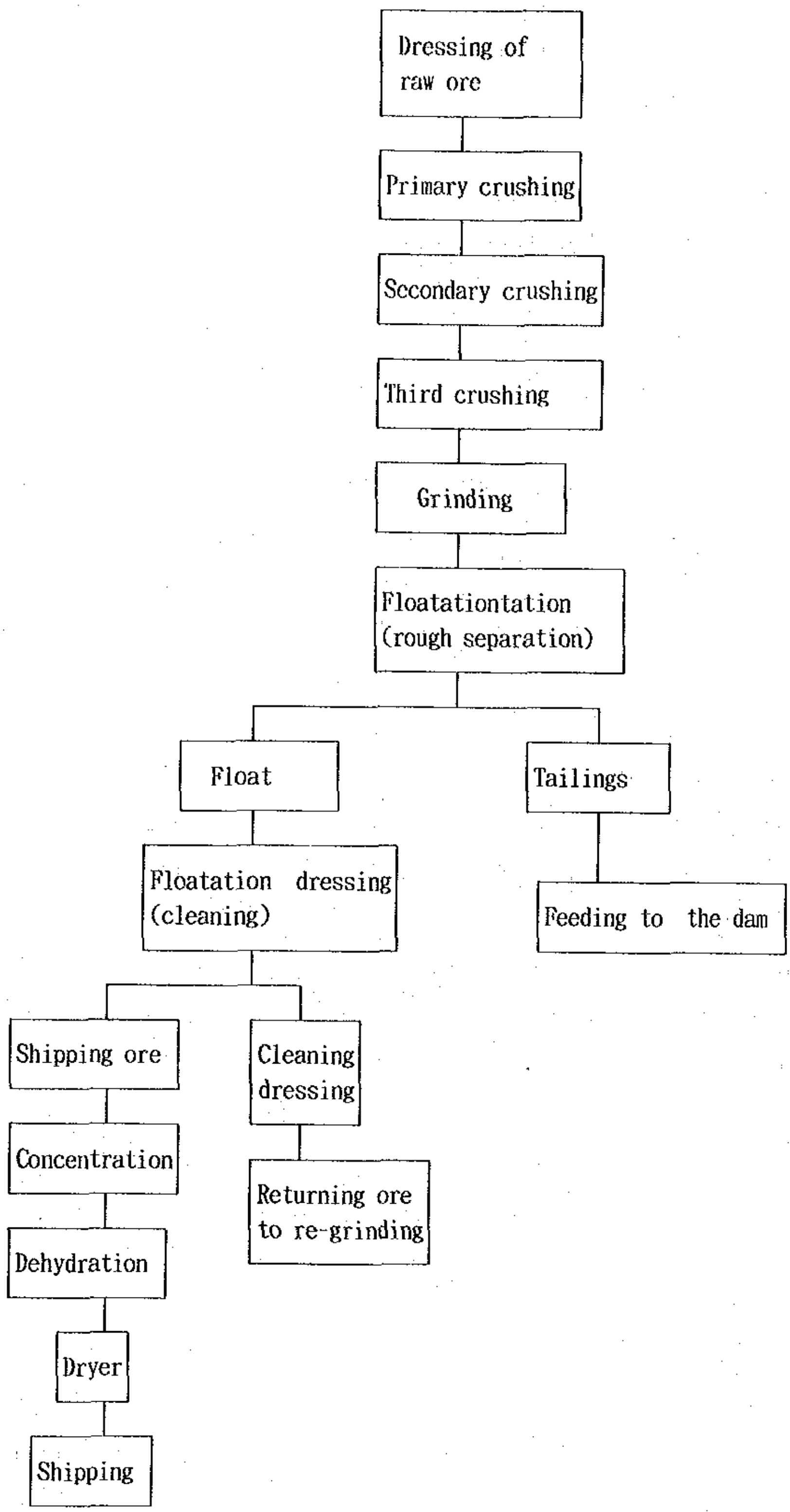

Fig. II-3-6 Flowsheet of Sulfide Ore Processing in OSVALDO

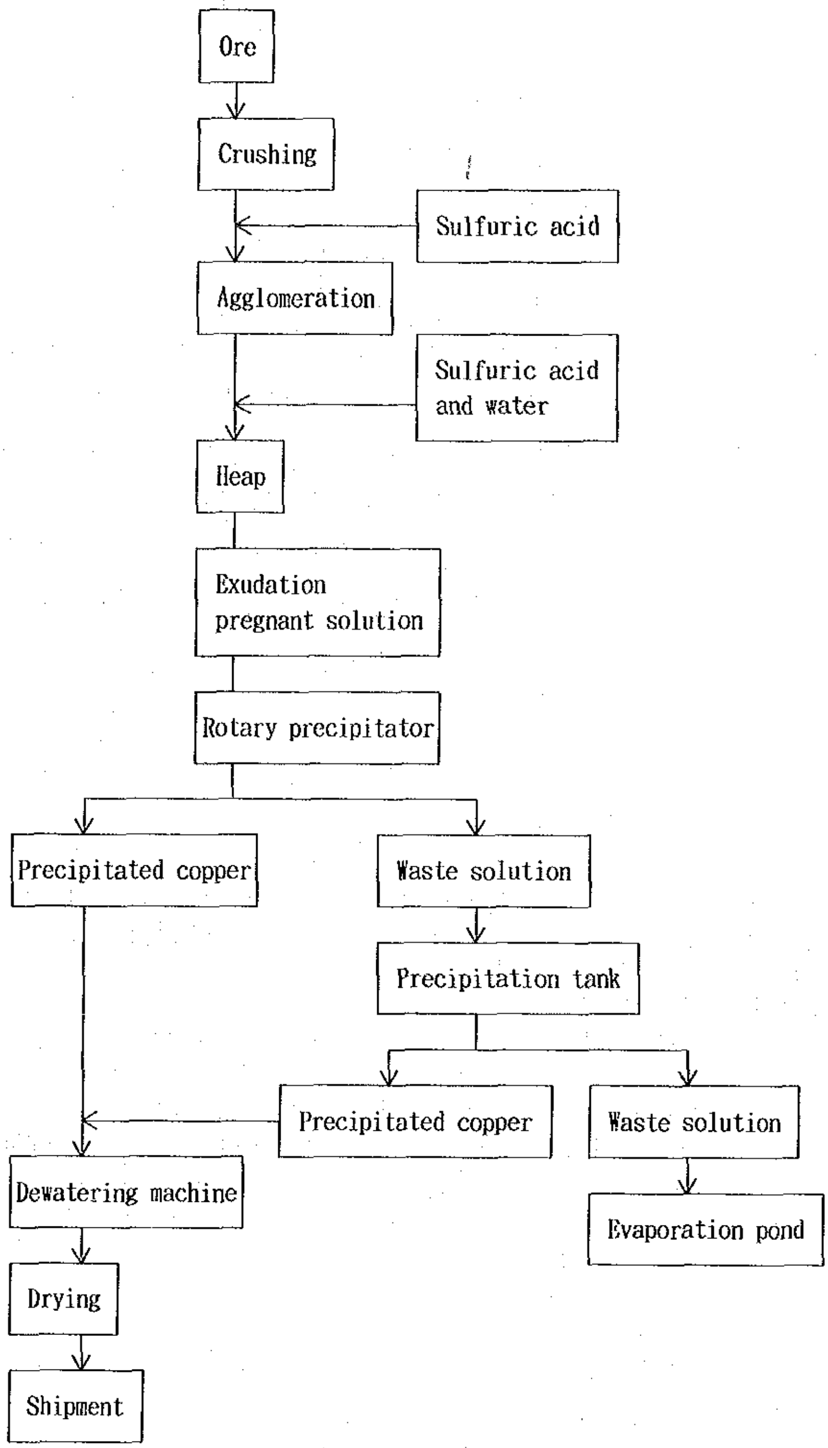

Fig. II-3-7 Flowsheet of Oxide Ore Processing in OSVALDO MARTINEZ

3) **Outline of oxide ore processing**

The processing in receiving, crushing and up to sampling is common to sulfide ore and it is charged from the oxide ore stock pile to the hopper for agglomeration by a truck. Sulfuric acid (60%) of 60kg/t and river water (60g/l Cl) in El Salado are added to the ore while checking the condition to make a lump. The capacity of the agglomerator is 100 ton/h. The ore is carried by a truck and loaded on a heap 1.5m high (fiber reinforced plastic and drain pipes are laid on the floor). With leaching for 30 days as a cycle, the consumption of sulfuric acid is 4.5kg/kg–Cu.

Exudation solution (PLS) is divided to two types, pregnant solution and medium solution and handled separately, and the final dressing is raised to 25 to 30 g–Cu/l. The final pregnant solution is processed by four drum type precipitators and after that, by the replacement precipitating tank so that precipitated copper is collected through replacement reaction by iron scrap.

Iron scrap is loaded on the drum by 12–hour cycle and the total consumption is 1.25Kg–Fe/kg–Cu. Precipitated copper is processed by the gravity filter (25% water content) and drying with daylight (10% water content) and shipped as 70% Cu to the refinery at Paipote. Waste solution is treated in an evaporation pond near the tailing dam.

4) Comment and impression

* Although some people said that dressing test of Cerro Negro in this El Salado mill was possible, this is actually impossible.

* SX/EW pilot plant can probably be implemented if the personnel required can be secured because SX/EW pilot plant is available. In this case, cooperation with other organization is premised.
There is a slight doubt about the analytic ability.

* The equipment in the mill is old and out of date. They were not optimistic about the realization of investment project.

* There are a large number of points which can be improved concerning the grinding in sulfide ore processing, flotation, dewatering, reuse of water and application of SX/EW.

3-4-8 PLANTA DE MINERA LA PLORIDA (S.L.M "LA FLORIDA")

Destination for visit: PLANTA DE MINERA LA FLORIDA

40 minutes from Copiapo city by car

Date: 16:00-18:00, January 12, 1993

Interviewees:

Juan Guerra Jefe Planta

Content:

1) Outline of the plant

This plant processes ores from its own mines (15 km distant and underground) and purchased ores by crushing, heap leaching and SX/EW to produce copper cathode of 100 to 120 ton/month. The total number of workers is 58, of which three engineers are included. This plant was started in 1989 and is blessed with a plenty of excellent water (70m depth, 300m x 2km) which comes from underflow from Andes. They have a project to extend the crusher and SX/EW to increase the plant capacity 2.5 times. The product of this plant is grade A (99.95--99.987% Cu) copper cathode. As for electricity, four diesel generators are employed to generate 1,050KVA. As the analytic method, copper weighing method is applied and fluorescent X-ray analysis is applied for other impurities. Upon purchasing, Cu.Sol, Cu and acid consumption are analyzed to determine the price.

2) Flowsheet of the plant

Received ores are crushed through the primary (16x24inch, JAW: Feed 8 inch, product 2.5-4 inch) and secondary (SYMON 3FT CONE:product 1/2 inch) and their sizes are arranged with a closed circuit with a screen (1/2 x 5/8 inch opening).

Next, 60% sulfuric acid and water (0.8l/sec) are used to produce a lump.

The lump is loaded on the plastic lining as a 107m2x2.2mH heap, left for maturing for a day and sprayed with raffinate (containing sulfuric acid) with 33-day cycle. For the last two days of the cycle, watering is performed, followed by draining in a day. The ore is abandoned after leaching. After removing solids from exudation pregnant solution with a filter, extraction of

solution and inverse extraction are carried out with four tanks (49 m2 each) equipped with plastic lining to obtain electrolytic solution. At this time, the concentration of the pregnant solution is 7g-Cu/l, 5g-H2SO4/l and the concentration of raffinate is 0.3g-Cu/l, 15g-H2SO4/l and the collection rate of copper is 98-99%. They explained that the concentration control of copper in the solution and sulfuric acid in this process is important. In the following electrolytic process, a lead or calcium lead (5%Ca) anode is used in electrolytic solution to obtain copper cathode. The collection rate in this process is 96 to 97%. The master plate for the cathode is produced of a stainless plate.

The electrolytic cycle is 7 days and the unit of the power supply is 4.3kWh/kg-Cu. The cathode area is 1.835 m2, the anode interval is 110 mm, the primary side of the rectifier is 400V, 380A and the secondary side is 25V, 7800A. To secure a high quality, the cathode weighs as low as 47.52kg/piece. Fig.II-3-8 shows the flowsheet of the plant.

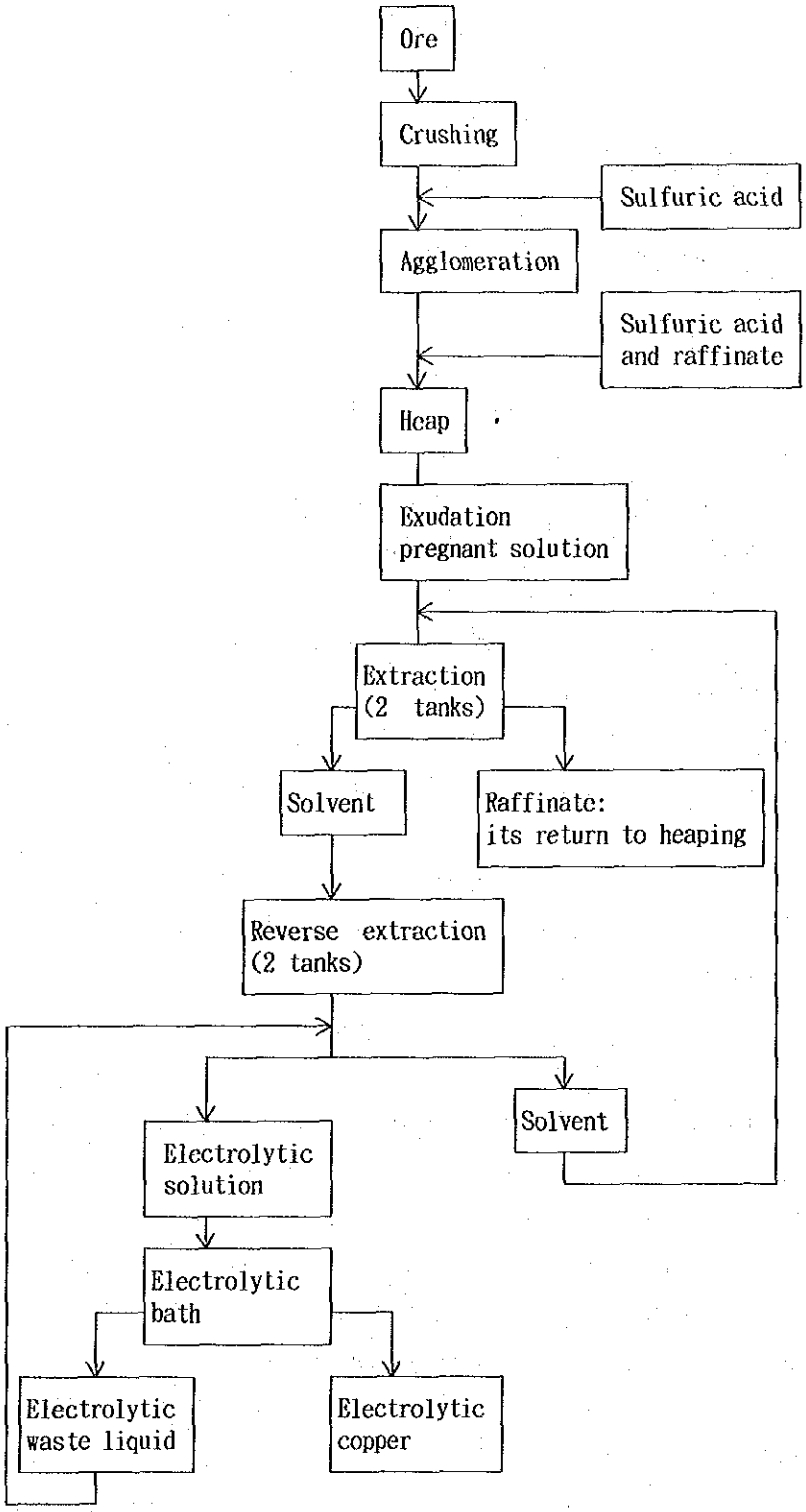

Fig. II-3-8 Flowsheet of Ore Processing in PLANTA DE MINERA LA Mill

3) Impression and comment

* This is a new plant, well controlled.

* The copper collection rate and product quality are both high and the person who guided us seemed confident of their technology.

* This plant location is good and blessed with a plenty of water, which is a rare case in this region.

3-4-9 PLANTA DE MANUEL ANTONIO MATTA (ENAMI)

Destination for visit: PLANTA DE MANUEL ANTONIO MATTA

10 minutes from Copiapo city by car

Date: 11:00 - 13:00, January 14, 1993

Interviewees:

Ortemio HARO Administrator

Content:

1) Outline of the plant

This plant was established with expected production capacity of 6,500 ton/month in 1965. It purchased ores from PEDRO AGUIRRE CERDA (OJOS DEL SALADO) first. Every year after that, this was intensified as shown in Table 4, currently having the capacity of 77,105 ton/month. In 1968, the equipment for purchasing ores was installed and in 1978, the purchase of gold and silver ore started. The number of the employees is now 160 (of who three metallurgists and one mechanic are included).

The miners from which this plant purchases currently total 50 for sulfide ore and 39 for oxide ore as shown in Tables II-3-5 and II-3-6.

The leaching and processing of precipitated copper collection were started just in June 1992 and they are now investigating about the supply capacity of surrounding miners.

Table II-3-4 Extension of MANUEL ANTONIO MATTA Mill

Year	Capacity (ton/month)	Number of mills
1965	6,500	1
66	13,000	2
67	19,500	3
71	35,000	4
80	44,000	5
85	50,000	5
87	55,000	5
89	61,500	6
90	77,105	7

Table II-3-5 Miners for Purchase of Sulfide Ore

Miner	Purchase amount (ton/month)	%	Ore type	Quality level (%Cu)	Distance /gold quality level	Number on map
PUNTA DEL COBRE	61,600	85.6	2	1.9	5km	1
LAS PINTADAS	1,500	2.1	2	2.3	25km	2
GALLEGUILLOS	1,100	1.5	1	3.1	4.5g/t(Au)	3
OJANCOS	700	1.0	3			4
CHECO DE COBRE	600	0.8	3	2.5	<1 g/t(Au)	5
others	6,500	9.0	39			
Total	72,000	100.0	50			

Table II-3-6 Miners for Purchase of Oxide Ore

Miner	Purchase amount (ton/month)	%	Ore type	Quality level (%Cu)	Number on map
SAN MARCOS	150	7.9	1		6
PUNTA DEL COBRE	125	6.6	1		1
ESTANCILLA	100	5.3	1	3.4	7
OJANCOS	80	4.2	1		4
others	1,445	76.1	35		
Total	1,900	100.0	39		

2) Flowsheet of sulfide ore processing

Upon receiving, sulfide ore and oxide ore are weighed by a truck scale and the values are processed by the computer. Crushing is divided to No.1 for small miners and No.2 for large miners. No.1 consists of 18x36 inch jaw crusher, 4&1/4FT STD and 4&1/4FT SHD Simon corn crusher and crushes supplied ore 10 inches to 1/4 inch by 80%. No.2 consists of 30x55 inch crusher, 5&1/2 SHD, 4&1/4 SHD Simon corn crusher and 6x16mm grid screen and crushes supplied 24 inch ores to 4mm. During crushing, each type of ore is sampled and the purchase price is determined by chemical analysis.

Grinding and flotation are both divided to two systems. Grinding for small miner is performed by combination with No.1&2 (MARCAVEDA 7X7FT),No.7(ALLIS-CHALMERS 7X9FT) and cyclone, and grinding for large miner is performed by combination with No.3 (MARCAVEDA 7X7FT), No.4&6 (PECSON 9X9FT), No.5 (PECSON MARCY 8&1/2 x 9FT) and cyclone (KREBAS type 20) to crush ore up to 45%-200 mesh. As the feeder, seven speed variable belt feeders are used.

Flotation for small mine is performed with No.1 flotation circuit (45Cub.FT Denver, ROUGHER 4, CLEANER 2, SCAVENGER 22), and as flotation for large mine, fine separation is performed with No.2 flotation circuit (50 Cub.FT Denver, 4 systems x 16 cells and 300 Cub.FT Dorr-Oliver 4 systems) and the column flotation machine (CONTROL INTERNATIONAL, 8 in dia. x 45FT H) installed in July 1992, so that final separation of 26% Cu, 60g-Au/t is achieved with copper collection rate of 90%. The major reagents are A-208(ACC), SF-115, MIBC, pine oil and slaked lime (pH12-13). They said that application of the column flotation machine dropped the collection rate by 2% (column supplied ore: 18%Cu, tailing: 8-9% Cu). We recommended that column tailing should be reprocessed through cleaning separation. Using DORR-OLIVER 6x8 disk filter, water content is adjusted to 15% and further 10% by daylight drying, and then the ore is carried to the refinery at PAIPOTE or VENTANAS.

The tailing is sent to a dam 1500m away and 40% used water is reused water. In September 1992, computer control system was introduced and currently it controls grinding and flotation machine. For future, control for pH, lubricant and trunnion temperature is under consideration. Fig.II-3-9 shows the flowsheet of sulfide ore processing.

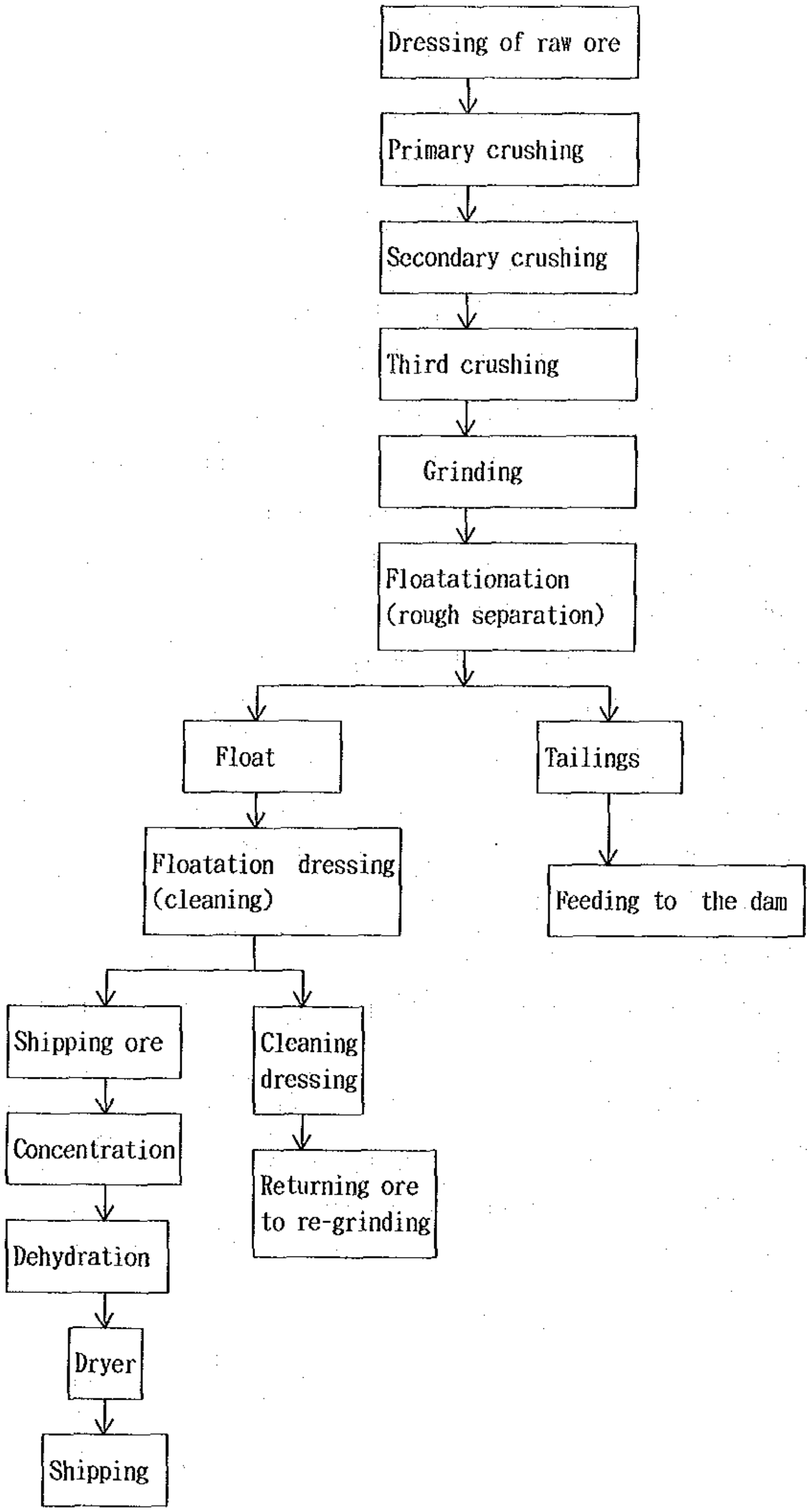

Fig. II-3-9 Flowsheet of Sulfide Ore Processing in MANUEL ANTONIO MATTA Mill

3) **Flowsheet of oxide ore processing**

Oxide ore is processed by leaching and precipitated copper collection method and the maximum capacity is 200 ton/day. After
crushing, 3.4% Cu is agglomerated and loaded on heap 28x155mx1.2mH. After left for 48 hours first, it is sprayed for 20 days and washed for last 16 hours. The current processing volume is 3,000 ton/month. Precipitated copper is collected from pregnant solution (40g-Cu/l) in the rotary precipitated copper collection unit and precipitation pond and the product is finished by a gravity type dewatering machine and daylight drying. The actual copper collection rate is 76%. Fig.II-3-10 shows the flowsheet of oxide ore processing.

4) **Impression and comment**

* Because the capacity was expanded successively, there are many points that machine and equipment do not match each other.

* They don't make the best use of a newly introduced column flotation machine and computer.

* They have little experience and no high technology in leaching processing on oxide ore.

* Because a refinery is located just nearby, this plant is estimated to be likely to be affected by its operating policy.^]

3-4-10 HERNAN VIDELA LIRA FUNDACION (ENAMI) (Enami, Pipote mill)

Destination for visit: HERNAN VIDELA LIRA FUNDACION (ENAMI) (Enami, Pipote mill)

10 minutes from Copiapo city by car

Date: 15:00 - 17:00, January 14, 1993

Interviewees:

Don GUILLERMO TABILO Engineer

Content:

1) **Outline of the plant**

The number of workers in this plant is 715 and the refining amount is 190,000 ton/year. This plant has no electrolytic workshop, purchases cathode coppers and sends the products to LAS VENTANAS or CHUQUICAMATA (TOLL). The actual production of 1992 is 144,000 tons of copper refining (32%Cu), 41,000 tons of precipitated copper (65%Cu), 6,000 tons of high quality ore (12%Cu), 50,000 tons of coal, 8,000 tons of calcite (caldera powder), oil and silica. The final product of this plant is 66,000 tons of 99.96% Cu anode copper (gold content of 5 tons).

The purchased ore has low As (0.07%) and Sb (0.02%). The purchase condition is T/C 100US/t, R/C32US/t and the actual collection rate is 94% for gold, 95% for silver and 94% for copper. Because the contract with OJOS DEL SALADO was canceled last year, currently ANTONIO MATTA is the greatest supplier. To expand the capacity, currently El Teniente process is being tested
(started in December 28, 1992) and scheduled to be completed in November 1993 with the enhancement of its sulfuric acid plant. Sulfuric acid is sold to the mines in the neighborhood at 50-60U$/t and this demand is estimated to be strong until 1995.

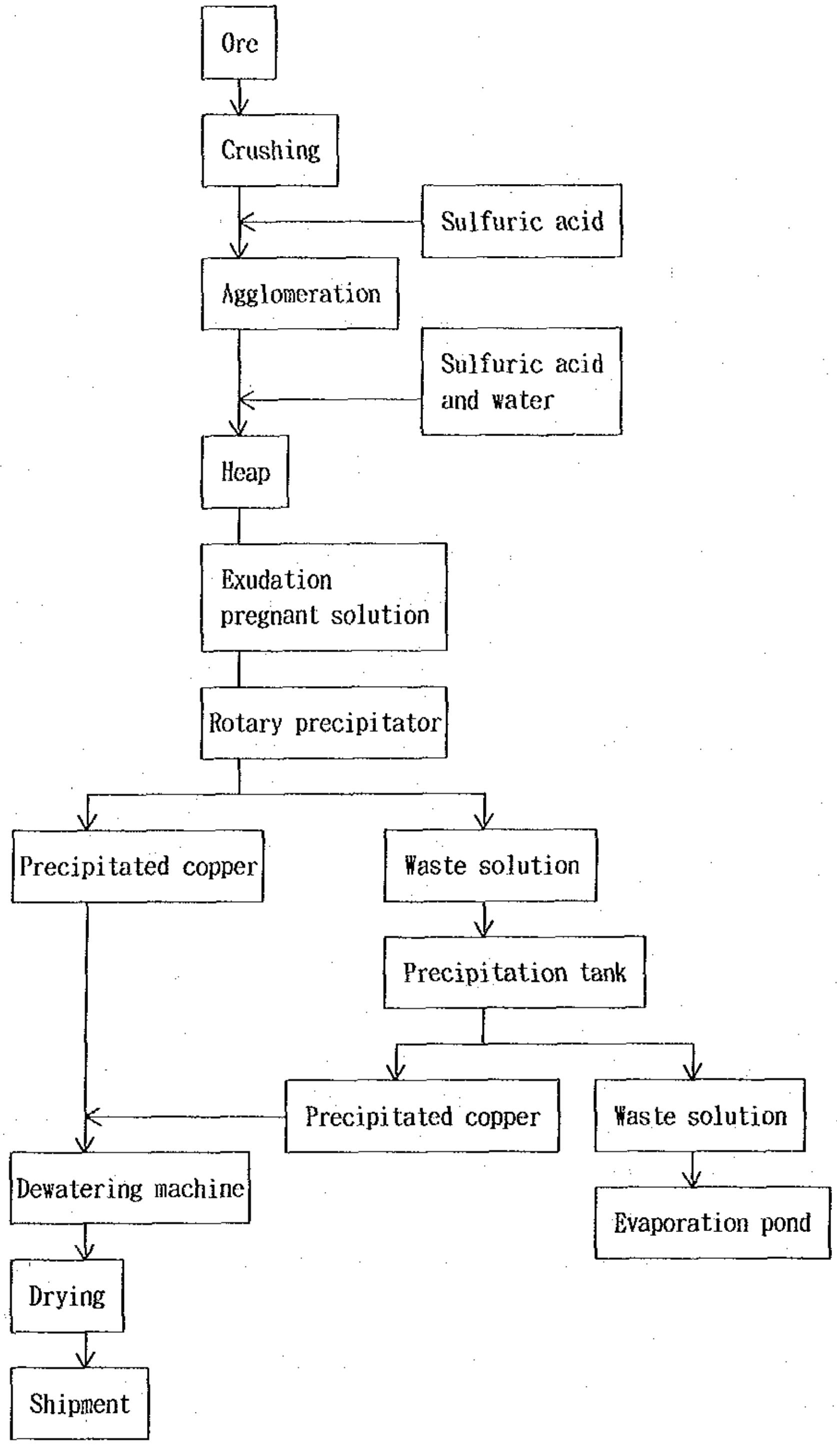

Fig. II-3-10 Flowsheet of Oxide Ore Processing in MANUEL ANTONIO MATTA Mill

2) Flowsheet of the plant

Fig.II-3-11 shows the flowsheet of the major parts of the refinery.

If the El Teniente process under construction and the extension of the sulfuric acid workshop are completed, the refining amount will increase from 200,000 tons/year to 300,000 tons/year, the production of the anode will increase from 66,000 tons/year to 90,000 tons/year and then the production of sulfuric acid will increase from 45,000 tons/year to 100,000 tons/year.

The stock yard has 12 chambers of 2,500 tons each. The reverberating furnace is 8 x 32m x 4mH large, charged once every 2.5 hours and has the capacity of 600t/d. The temperature of slag is 1,200 °C. The ball mill for pulverized coal, made of CLAUDIUS PETERS (Germany), has the capacity of 8 tons/hour. The El Teniente furnace is of revolution type, 4m in dia x 15m and one of the converter is made by PS while another is made by CHK HOBOKEN, and the refining furnace is made by PEIRSE SMITH. The venturi scrubber for dust collection, made in LURGI (Germany) is under construction and will have the efficiency of 95%. The power plant generating 2,500 kW from steam is equipped with a diesel generator for an emergency. The sulfuric acid plant consisting of a drying tank, heat exchanger, catalyst converter and absorption tank is shut down and scheduled until February.

The 16 mold and 40t/h mold casters cast changing the size for CHUQUICAMATA (375kg) and LAS VENTANAS (275kg).

3) Impression and comment

* In construction of El Teniente furnace and sulfuric acid plant, a large number of subcontractors were working actively.

* Although the working environment was not clean, the environment as a refinery was satisfactory.

* They said that they didn't receive any order for analysis from outside.

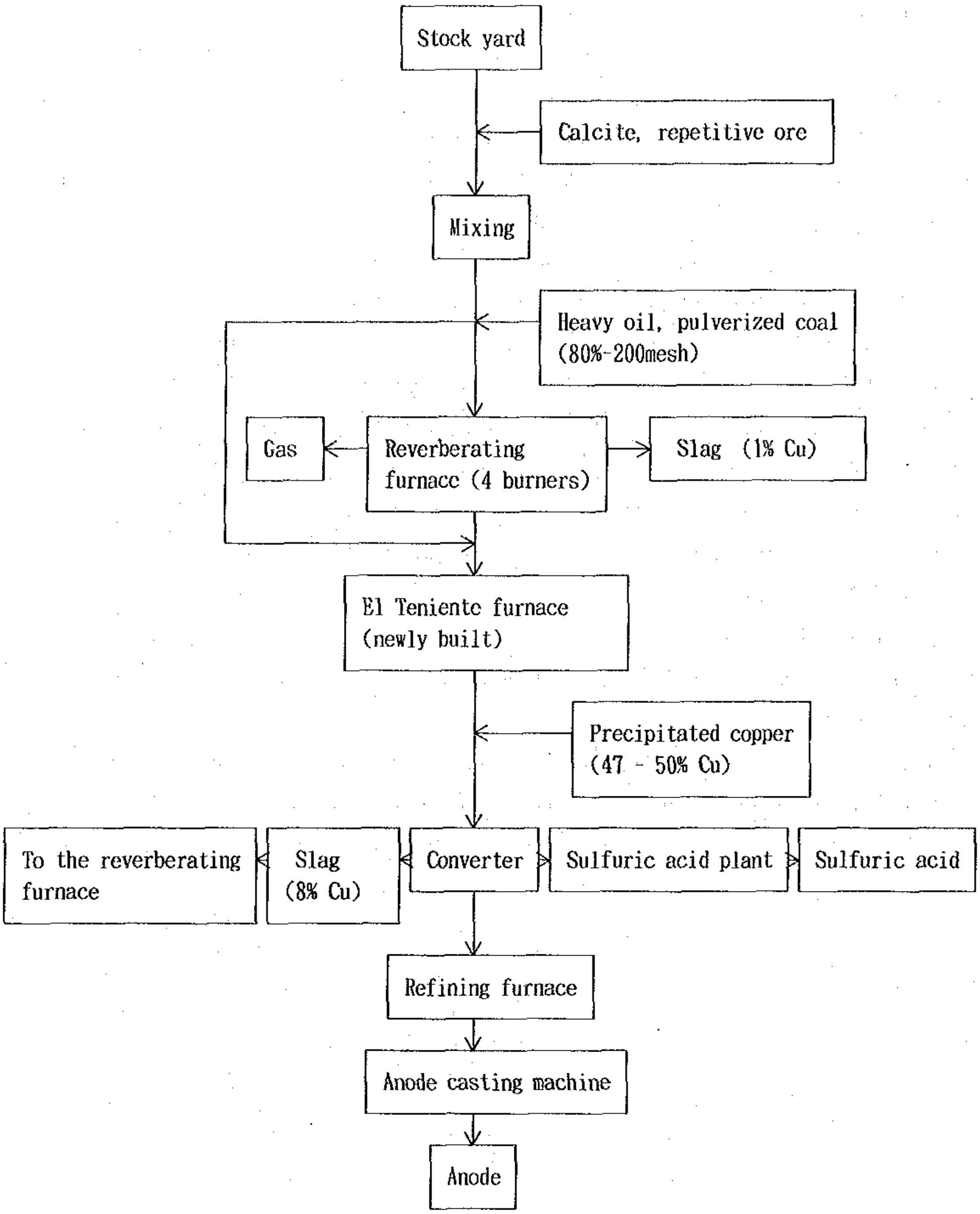

Fig. II-3-11 Flowsheet of HERNAN VIDELA LIRA FUNDACION

3-4-11 PLANTA DE MINERA VALLENAR (ENAMI) (Enami, Vallenar mill)

Destination for visit: PLANT DE MINERA VALLENAR (Vallenar mill)

Five minutes from Vallenar city by car

Date: 10:00 – 13:00, January 15, 1993

Interviewees:

Hugo BALOCCHI VELASTIN	**Administrador**
Luis Bogdanic	**Jefe de Produccion**

Content:

1) Outline of the plant

This plant purchases five types of ores, high quality ore (12%Cu, 40g-Au/t, 4kg-Ag/t), sulfide copper ore (2.0% Cu), gold ore (6g-Au/t), mixed ore (3.25%Cu Sol, 1.1-1.2%Cu Insol,. 1.0-1.5g-Au/t) and processes other ores than high quality ore. Sulfide ore (14,000t/month) and gold ore (6,000t/month) are processed by flotation to ensure the copper collection rate of 90% and gold collection rate of 65 to 75%, so that refined copper of 24 to 25% Cu is produced. The particle section of mixed ore (6,000t/month) and oxide ore is processed by flotation first (actual collection rate: 40 – 45%) and then the tailing is processed by agitation leaching to ensure the total copper collection rate of 85 to 86%.

The coarse grain of oxide ore is made to lump and then precipitated copper is collected by heap leaching.

Although this plant possesses SX/EW pilot plant (250 kg-Cu/d), it canceled the test three years before. The major reason for canceling the test said to be that the operation cost for producing 99.88%Cu copper cathodes was as high as 108 to 118U$/t-Cu. At the operating time, four operators were employed and the estimated reason may be high electricity cost.

In this plant, a crushing workshop containing Chile type mill is rented for a small sized miner at the fee of 1g-Au/t. The sampling chamber contains a pulverizer, vibration mill and other equipment and five workers work under working shift. Additionally, a leaching column, flotation test machine, test mill and filter are equipped to present the system making possible a flotation test.

2) Flowsheet of the flotation workshop for processing sulfide ore and mixed ore

Fig.II-3-12 shows the flowsheet of the flotation workshop. Oxide ore is weighed by a common truck scale, sampled for reference analysis and then loaded in the yard. The ore is supplied to the hopper (4x4x2mHx 10 chambers) through a grizzly (12 inch opening) by means of a loader and 8-inch ore is crushed to 1/4 inch by 85-90% through the primary (JAW), secondary (5FT STD SYMON CONE) and third (5FT SHD SYMON CONE) crushers. This crushing circuit has the capacity of about 120t/h. After crushing, 1,000g is sampled for each lot (12 to 100 tons) and undergoes chemical analysis to determine the purchase price. The grinding and flotation circuits are divided to two types for sulfide ore and mixed ore. Grinding for sulfide ore is carried by 2-stage ball mill

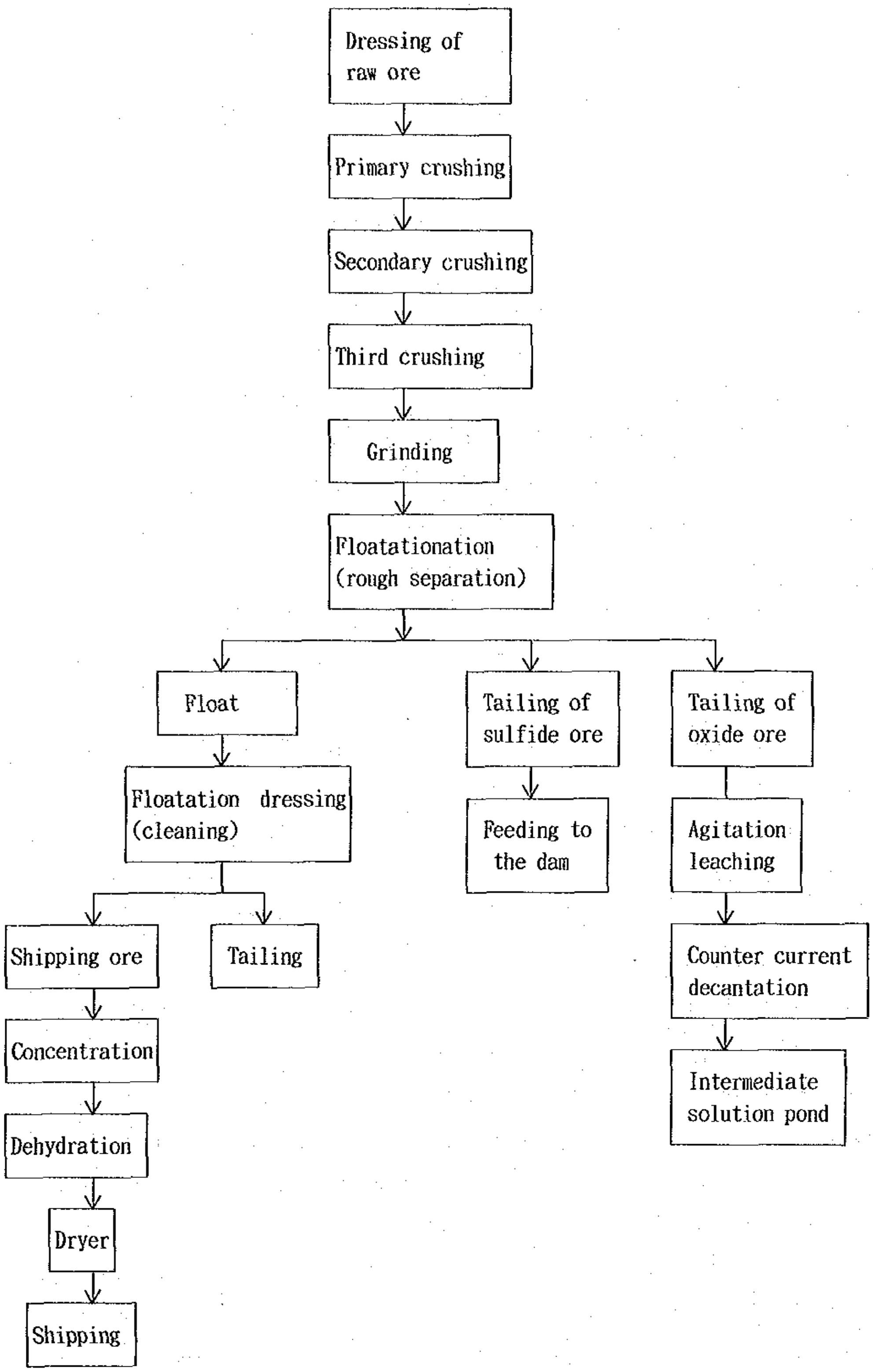

Fig. II-3-12 Flowsheet of the Floatationation Workshop in MINERA VALLENAR Mill

(7x9FT) and cyclone to crush copper ore and gold ore to 65%-200 mesh and 75%-200 mesh respectively. The capacity of grinding is 360 to 400 t/d. Grinding of oxide ore is carried out by 2-stage ball mill (4x5FT) and cyclone to crush ore to 60%- 200 mesh. The capacity of grinding is 460 to 500 t/d.

Flotation of sulfide ore is performed by rough separation (18 cell x NEDAG 1.5m3) and three-stage fine separation to produce 24-25% Cu copper refined ore while the copper collection rate is 90% and gold collection rate is 65 to 75%. Flotation of mixed ore is performed by rough separation (10 cellx DENVER #21) and 2-stage fine separation (DENVER#18) to produce 19% Cu copper refined ore while the copper collection rate is 40 to 45%. For sulfide ore, the major reagents are collector AF-323 45 to 60g/t, foaming agent MIBC of 20 to 30g/t, slaked lime 3.5 to 4kg/t (pH10.5) (natural Ph for gold flotation), and for mixed ore, mixture of collector F-114, AF-208 and AF323 by equal amount 45 to 60 g/t.

Through the dewatering/drying process, the water content of copper refined ore becomes 10% and that of gold refined ore becomes 25%. Fr flotation tailing of mixed ore, after concentration with a thickener, 4.5kg/kg-Cu sulfuric acid is added and agitation leaching is performed with three tanks for two hours. Eluted copper (8-10g-Cu/l) is separated from the solid by counter current decantation and sent to the intermediate solution pond in the oxide ore leaching process.

3) Flowsheet of oxide ore processing

Fig.II-3-13 shows the flowsheet of oxide ore processing. Ores are crushed while particles are removed with a screen, sulfuric acid (equivalent 125%LAB amount) and water (80 to 90l/t) are added to produce a lump. The lump is loaded on a heap (18 x 30 x 2mH), sprayed with water 18-20l/m2 for 16 to 19 days so as to make about 75% copper exude.

From exudation pregnant solution (15-20g-Cu/l), precipitated copper is collected using scrap iron (55 Peso/kg) of 1.2kg/kg-Cu by means of five units of precipitators on two stages and six precipitation tanks (6x6m) and the final product with 82-83%Cu and water content of 10-11% is produced by a vacuum dewatering machine and daylight drying.

4) Impression and comment

* Although this mill was best equipped in the Enami's mills which we visited this time, this looked to have no capacity enough to receive a request for test from outside.

* The process combining flotation of mixed ore and agitation leaching is an excellent method, capable of collecting precious metal such as gold.

* Like MARTINEZ, this mill has not yet succeeded in making SX/EW as business although its pilot test was implemented. Although we could not consider enough in this survey for the reason of time, this reason should be considered further.

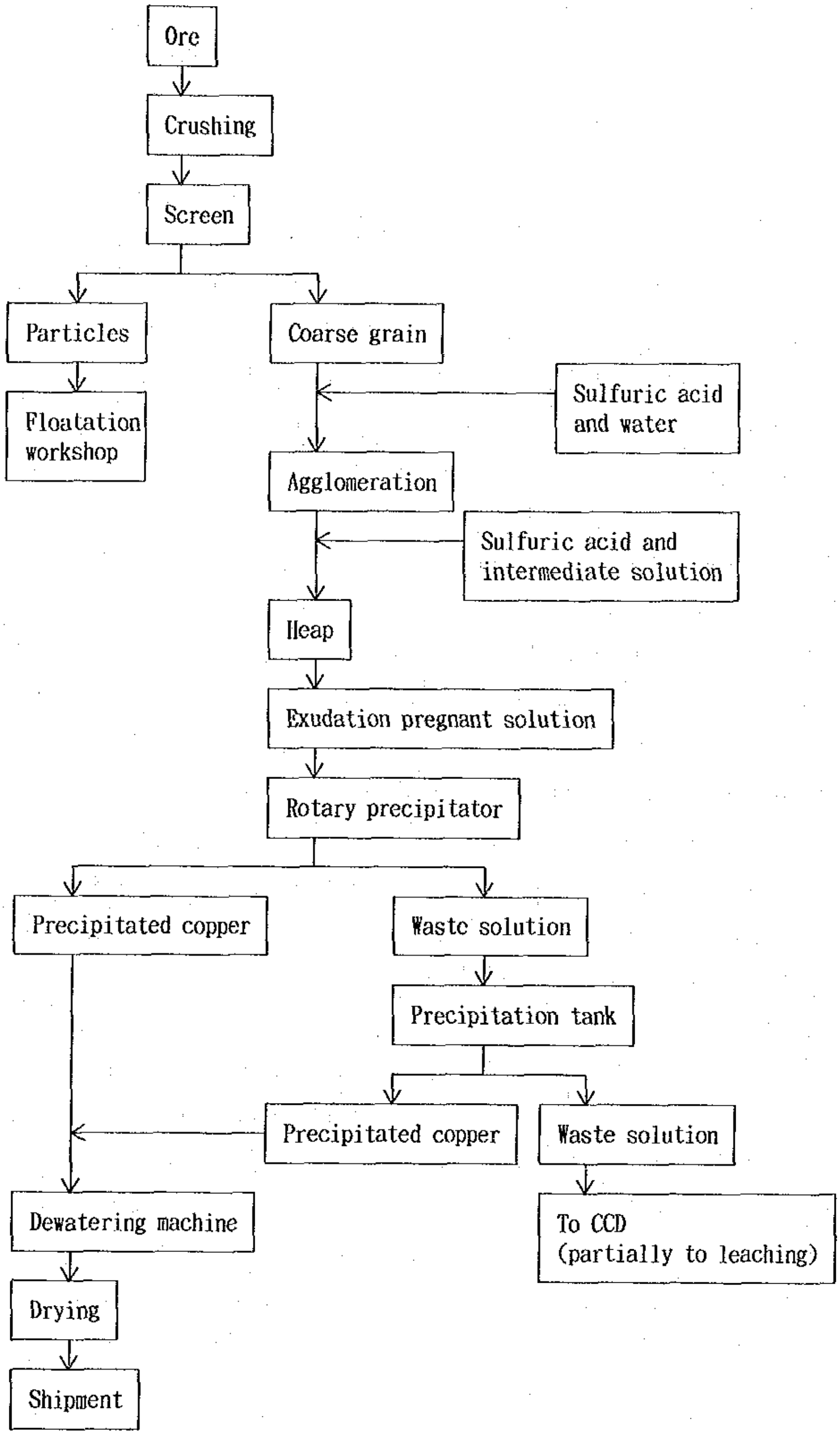

Fig. II-3-13 Flowsheet of Oxide Ore Processing in MINERA VALLENAR Mill

3-4-12 MINA DE LA CANDELARIA (MINERA CANCELARIA) (Mine of La Candelaria)

Destination for visit: MINA DE LA CANDELARIA (Mine of La Candelaria)

20 minutes from Copiapo city by car

Date: 9:00 - 11:00, January 16, 1993

Interviewees:

Robert I. PENNINGTON	**Concentrator Superintendent**
Robert E. PRESTIS	**Ingeniero Jefe de Planificacion mina**

Content

1) Progress of mining development

The receiving facility of electricity for construction power of 110kVA on mine site has been already completed, currently mining power 100P is under construction.

Working water is introduced through the pipe line placed from the water source of OJOS DEL SALADO and stored in a newly built water tank. Day before our visit (January 15), the preparation for mining started. As soon as electricity supply is prepared, stripping will start from February. The stripped soil of 2.5 million tons will be used to fill the foundation of the conveyer from the primary crusher.

For road operation, bulldozers, graders and cranes are operating and the loaders, boring drills and large sized trucks (dresser Komatsu: 4) are under assembly. Two trucks are scheduled to be completed in this week and the truck vessel, which was unloaded on Antofagasta with halves and welded together, is under transportation.

Currently, 800 to 900 workers work in 48 hours every week and two groups work on pipe line separately. After Christmas, US staff arrived successively and now 12 US persons work there.

The major equipments completed or under construction are: powder magazine house (completed),gas station foundation), loader (under assembly), drill (under assembly), truck (under assembly), warehouse (partially completed), staff office (electrical equipment not completed), heavy machine repair section (GILDEMEISTER, P&H OTERO, DICSA, foundation), mining power loop (part such as a transformer completed), temporary water tank (completed), batcher plant (completed), primary crusher (foundation), intermediate stock pile (foundation), employee dining room (under construction), mill (foundation), tailing thickener (foundation), and main transformer (foundation).

3-4-13 PLANTA DE PUDAHUEL (SOCIEDAD MINERA PUDAHUEL)(Plant of Pudahuel)

Destination for visit: PLANTA DE PUDAFUEL (Plant of Pudahuel)

30 minutes from Santiago city by car

Date: 16:00 - 17:30, January 19, 1993

Interviewees:

Carlos LASSERRE DORLHIAC	**Gerente general**
Herrando ALCAYAGA	**Jefe de Operaciones**

Co-visitors:

Julio CHAZARRO ORTIZ

Content:

1) Outline of the plant

This plant is a (oxide) copper ore processing plant based on leaching, SX/EW method with the capacity of 1 million tons/year, established in 1980. Although it started with the processing of only oxide ore (2.2%Cu) first, the mixture of sulfide ore increased gradually, so that this plant is currently processing sulfide ore (chalcocite, Chalcopyrite, Pyrite, bornite, Covellin, etc.,). The current quality level of raw ore is 1.25 to 1.3%Cu. This plant has remaining amount of ore for three years and ensures the synthetic collection rate of 80% (The exudation rate of Chalcopyrite is less than 20%). First, this plant used the patent of HOMELS&NURVER, however it invented the method capable of processing sulfide ore (including bacteria leaching) and sold the technology to other companies (QUEBRADA BLANCA, CERRO COLORADO). Agglomeration is important to improve the penetration of solution, thereby preventing channeling and shortage of oxygen. The cost is as low as 50-55CENT/1bCu and the products are exported to Europe, Japan and US. The mining department is operated with two shifts a day and the processing department is operated with three shifts throughout 365 days. The total number of the workers working in all the mines is 350 to 400. Leaching for six months (20 days for oxide ore) is carried out for a heap 4 - 6m high. After exudation finishes, the heap is not moved and a new heap is loaded thereon (currently, the third stage is being loaded). Sulfuric acid required is purchased from Chailes and electricity is purchased from CHILECTRA.

2) Flowsheet

Fig.II-3-14 shows the flowsheet of the plant. The ores carried from mines are crushed to 1/4 inches through the four stages of crushing process (JAW & CONE CRUSHERS). With sulfuric acid (15-30 Kg/t ore, 100-120kg water/t ore) added, agglomeration is carried out and a pile (400,000 m2) 4 to 6m high is loaded on the plastic lining equipped with drain pipes by means of a truck (20-25t), loader and stacker (by four workers). Ores are divided and processed according to a surveyed collection rate and acid consumption amount. Exudation solution (1.5-2g-Cu/l) is collected in a groove and after particles are removed in a precipitation pond, copper is concentrated (50g-Cu/l) using

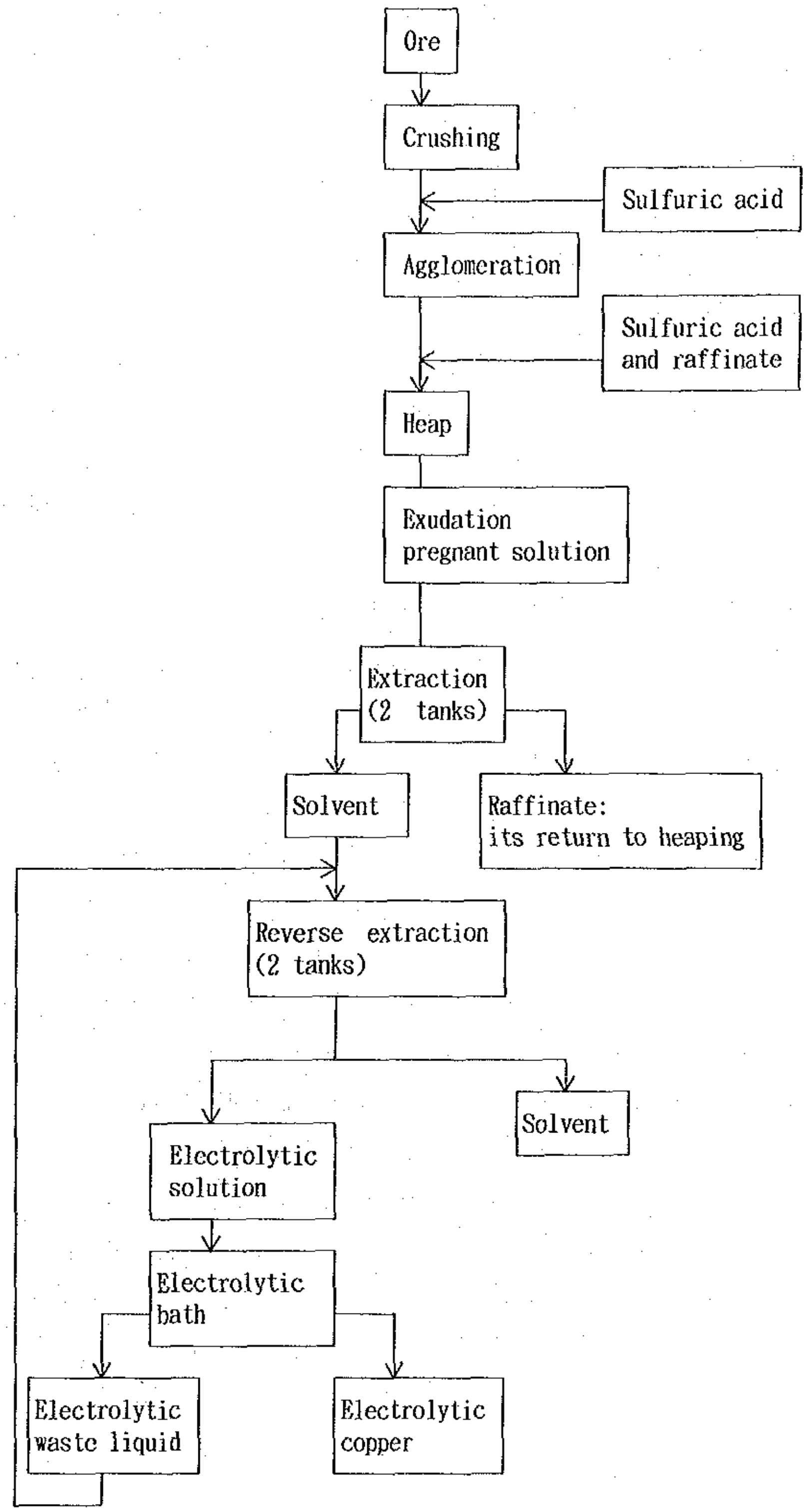

Fig. II-3-14 Flowsheet of Ore Processing in PLANTA DE PUDAHUEL

LIX984(860+84) in the SX process (7000l/min x 2 lines). After solution is removed completely with a post settler, cathode coppers of 99.98–99.99%Cu (Pb, Fe and S are impurities) are produced by electrolytic collection (EW) method. The tank house is 72 cells (8 of them are for starting sheet) x 60 pairs large and the lead anode uses ROYSTON&RSR. The cathode area is 1m2, the interval is 10 cm, the voltage is 1.9–2.1V/cell, the current in winter season is 180A, the current in summer season is 220A and the electric power consumption rate is 0.84kWH/1bCu.

3) Impression and comment

* This is the largest leaching equipment that we surveyed time and the technology level is high.

* The major copper ore of the object is chalcocite, which enables bacteria leaching and keeps a long leaching cycle.

* This company has an engineering department, which has an experience in engagement in mine development.

3–4–14 Summary of Survey Result (research section)

Table II–3–7 summarizes the result of our survey this time. CIMM is more excellent than any other companies except the problem that it does not possess SX/EW equipment internally and has the world–wide top level facility and technology, therefore we think that this is the first candidate when we request for dressing test related to Cerro Negro in future. Whichever research institute we ask to make test, it is important and natural to test the important parts to check the result in Japan.

In consultation with Enami's counterpart held in January 21, we were requested to make the detail of a dressing test schedule for phase 2, have it approved by Metal Mining Agency of Japan and submit that schedule to Enami. Enami intends to receive a proposal and estimate based on that schedule from several research institutes. At that meeting, Enami's counterpart proposed about the flowsheet for agitation leaching after flotation. We think that the detail of the flowsheet should be considered synthetically according to the basic test.

Table II–3–8 outlines the mills which we surveyed this time. If oxide ore, mixed ore and sulfide ore coexist like Cerro Negro as seen in this survey, several combinations of processing methods can be considered, therefore it is desirable to make sufficient dressing test.

Table II-3-7 Research Facilities (Summary)

Name	Bench scale		Pilot plant		Engineering staff		Equipment		Actual result		Others		Synthetic order
	FL	LIX	FL	LIX	FL	LIX	FL	LIX	FL	LIX	CH	MIN	
CIMM	○	○	○	△	○	○	○	△	◎	◎	○	○	1
UDATAC	○	○	○	△	○	○	△	△	○	○	△	△	2
INTEC	○	○	○	×	○	△	○	×	○	○	○	○	3
UDCHILE	○	×	△	×	○	△	○	×	○	×	△	○	4

Note: CIMM: INTEC:
UDATAC: Atacama University, UDCHILE: Chile University, FL: Floatationation, LIX: leaching,
◎ excellent, ○ good △ normal × bad

Table II-3-8 Survey Results of the Mineral Processing Plants (summary)

Mill	Applied technology				Ore processing capacity	
	Floatation	LCH/SX/EW	LCH/PREC	FLOAT/AGIT	FLOATATION	LEACHING
MANTO VERDE	absent	present	absent	absent		10t/d
EL SALVADOR	present	absent	absent	absent	33,000t/d	
MARTINEZ	present	absent	present	absent	400t/d	600t/d
FLORIDA	absent	present	absent	absent		200t/d
MATTA	present	absent	present	absent	2,500t/d	200t/d
VALLENAR	present	absent	present	present	670t/d	600t/d
PUDAHUEL	absent	present	absent	absent		2,740t/d