No. 31

REPORT ON INTEGRAL UTILIZATION OF PYRITES PROJECT IN THE STATE OF GUERRERO, UNITED MEXICAN STATES

OCTOBER 1981

JAPAN INTERNATIONAL COOPERATION AGENCY

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REPORT ON INTEGRAL UTILIZATION OF PYRITES PROJECT

IN

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PREFACE

In response to the request of the Government of United Mexican States, the Japanese Government decided to conduct a survey on Integral Utilization of Pyrites Project in the State of Guerrero of United Mexican States and entrusted the survey to the Japan International Cooperation Agency. The J.I.C.A. sent to United Mexican States a survey team headed by Mr. Tatsuo Konada from Oct. 10 to Nov. 14, 1980.

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

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

I wish to express my deep appreciation to the officials concerned of the Government of United Mexican States for their close cooperation extended to the team.

October, 1981

Keisuke Arita

Keisuke Arita
President
Japan International Cooperation Agency

MEMBERS OF THE FEASIBILITY STUDY TEAM

Metallurgist (Leader)	:	Tatsuo Konada	*
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Mining engineer	:	Mizushiro Inoue	*
Mining engineer	:	Shigeaki Sudo	
Geologist	:	Hisashi Kamono	*
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Mechanical engineer	:	Yoshihiro Kudo	
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Coordinator (JICA)	:	Hisamitsu Moriwaki	*

Note:

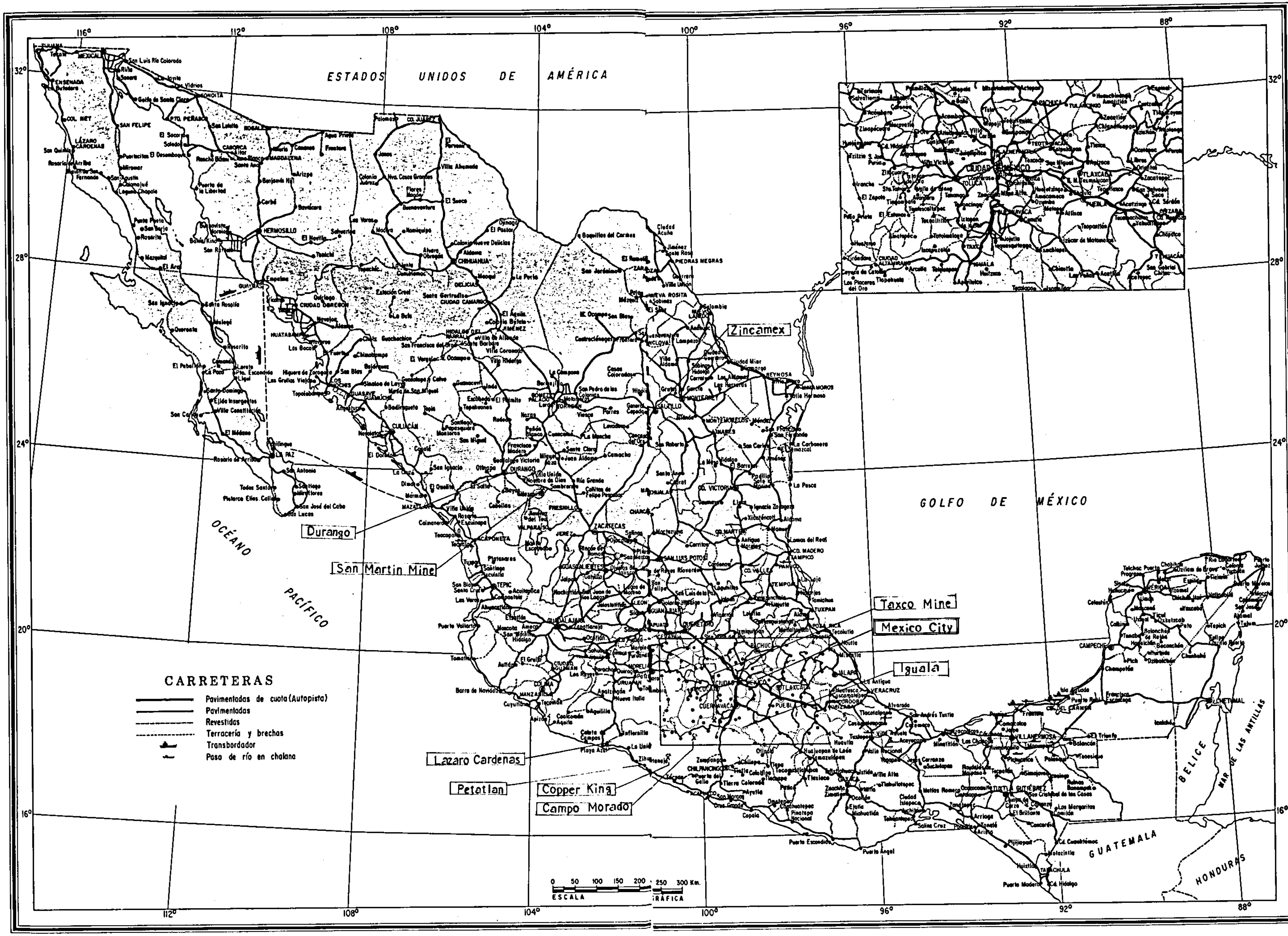
JICA	:	Japan International Cooperation Agency
* mark	:	Member of Site Survey

MEMBERS OF THE MEXICAN PARTNER

General director of CRM	:	Ing. Guillero P. Salas
Economic consultant of EC	:	Lic. Gustavo Martinez Cabanas
Director of DM	:	Ing. Luis Reyes Rodriguez
Geologist of DM	:	Ing. Betanzos

Note:

CRM	:	Consejo de Recursos Minerales
DM	:	Direccion de Mineria del Estado de Guerrero



ESTADOS UNIDOS DE AMÉRICA
GOLFO DE MÉXICO
OCÉANO PACÍFICO
GUATEMALA
BELICE
HONDURAS
MAR DE LAS ANTILLAS
Zincamex
Durango
San Martin Mine
Taxco Mine
Mexico City
Iguala
Lazaro Cardenas
Petatlan
Copper King
Campo Morado
CARRETERAS
Pavimentadas de cuota (Autopista)
Pavimentadas
Revestidas
Terracería y brechas
Transbordador
Paso de río en chalana
0 50 100 150 200 250 300 Km.
ESCALA GRÁFICA
116° 112° 108° 104° 100° 96° 92° 88°
32° 28° 24° 20° 16°

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1 INTRODUCTION

1. INTRODUCTION

Basically an agricultural country, Mexico is also a leading mineral producing nation in Latin America along with Chile and Peru. The minerals produced in this country are one of the major products for export and play an important role in the economic advancement of Mexico.

The economic advancement in recent years has been remarkable due particularly to the rapid industrial growth. Around 1973 the amount of oil reserve confirmed increased drastically.

In addition to the promotion of oil related industries Mexico is launching various programs to modernize and expand ironworks and fertilizer plants.

In an effort to close the regional gap between the highly industrialized regions on the Atlantic coast and the developing regions on the Pacific coast, the federal government is undertaking a large-scale project to expand the ironworks and construct a fertilizer complex in Lazaro Cardenas district.

In the field of mining, to increase employment and reserve of foreign currency, Mexican government is stepping up its effort to promote exploitation of the mineral resources.

Differing from nonferrous sulfide minerals, pyrites have not been utilized to date as raw materials for industries in United Mexican States, though the state of Guerrero and some other states have a large amount of undeveloped pyrite ore deposits. One of the main reasons why pyrites have not come into production is that the contents of pyrites have not fully been utilized since only the sulfur, 50% of the contents, is used for the production of sulfuric acid, discarding other minerals as waste, with conventional technology.

However, the chloridizing volatilization process developed in Japan has made it possible to extract not only iron oxide but also valuable nonferrous metals from the pyrite cinder which has so far been discarded as waste. The burnt pellet (iron oxide) produced in this process can be used as the raw material for steel making and the nonferrous metals may be sent to nonferrous metal refineries.

Consequently, a project to exploit the pyrite ore deposits in the state of Guerrero by introducing the chloridizing volatilization process mentioned above will contribute to meeting the domestic demand for iron ore as well as to the development of this state.

This study was entrusted to the Japan International Cooperation Agency (JICA) by the government of Japan, at the request of the government of United Mexican States, as one of the technical cooperation from Japan.

Based on "the Scope of Work for the Feasibility Study of the Project for Integral Utilization of Pyrites in the State of Guerrero, United Mexican State" agreed among Consejo de Recursos Minerales, el Gobierno del Estado de Guerrero, and the Japan International Cooperation Agency on January 30, 1980, Campo Morado deposit and Copper King deposit were selected by the primary study team as the deposits to be surveyed for the study.

Following to the primary study, the secondary study team carried out the field survey on the selected two pyrite deposits in October, 1980 as specified in the Scope of Work signed. And this report, the Metallurgical and Preliminary Economic Feasibility Report, was made basing on the informations collected by the secondary study team as well as the successive works in Japan.

2 CONCLUSION

2. CONCLUSION

Geological, mining and infrastructural surveies on the selected undeveloped pyrite deposits and metallurgical and infrastructural surveys in Lazaro Cardenas district were carried out by the secondary study team for 35 days from October 10 to November 14, 1980 after the rainy season was over. From the informations collected by the secondary study team and successive flotation, roasting and chloridizing volatilization test results on the sample ores, it was confirmed that the application of the latest technology for integral utilization of pyrites on the pyrites of the said two deposits could be feasible. Furthermore, the preliminary economic feasibility of the project was studied in the case that the said latest technology was applied on the pyrites of the said two deposits. The outline of the project is as follows.

i) It was said that the Campo Morado deposit had not been developed because the ore structure was too fine to be separated by flotation, though it contained considerable amounts of such valuable metals as silver, copper, lead and zinc. Adopting the latest flotation technology for complex sulfide ores, however, the Campo Morado ore could be separated into each concentrate, judging from the flotation test results. Consequently, surplus revenue will be expected from the sale of the recovered concentrates in case of Campo Morado, while no concentrate will be produced from the Copper King ore since it contains little amount of nonferrous metals. This is the reason why the Campo Morado ore became the core of this project.

Mining is to be operated at the rate of 420,000 tons per year which corresponds to the allowable maximum mining rate of this deposit. Copper, silver-lead, and zinc concentrates are separated respectively from the mined ore at the flotator to be located at the mine site and sold to nonferrous refineries. On the other hand, most of valuable metals left in the tailing are recovered together with the pyrite concentrate which is otherwise discarded to a dam. The pyrite concentrate containing valuable metals constitutes the main raw material for the metallurgical plant of this project. Mine life is expected to be about 20 years, because there is a possibility to consider the expansion of the ore reserve to lower portion under the level 6. 375 employees excluding sub-contractors are estimated.

ii) The amount of the pyrite concentrate from Campo Morado is 58% of the total supply to the metallurgical plant of which capacity is planned to be one line of the largest chloridizing volatilization kiln (approx. 350,000 tpy) with a view to enjoying scale merit. To make up the balance, Copper King pyrite is planned to be mined because of low transportation cost besides low mining cost, though it contains little amount of valuable nonferrous metals. Of course, no flotation is used and mine life is assumed to be 45 years. More than 200 emploees are expected in operation not including sub-contract workers.

iii) It is considered to be most economic to install the metallurgical plant adjacent to the Las Truchas ironworks of SIDERMEX in Lazaro Cardenas district, Michoacan, judging from the transportation costs for pyrites and products as well as supplies of utilities.

At first, about 480,000 tons per year of pyrites received are converted into concentrated sulfuric acid of approx. 700,000 tons per year which is though to be used as a raw material for fertilizer producing in the adjacent fertilizer complex of FERTIMEX and other uses. However, contamination of the sulfuric acid with heavy metals should be examined further. From pyrite cinder, on the other hand, about 340,000 tons per year of domestic pellets with high quality for steel making are produced and may also be consumed in the ironworks.

Therefore, the study was elaborated on the assumption that the sulfuric acid and pellets produced could be sold to the fertilizer complex in Lazaro Cardenas district and other plants, and the ironworks in the Lazaro Cardenas district respectively. Nonferrous metals recovered by the chloridizing volatilization are able to be sold to nonferrous refineries near-by. (As regards the outline of this project, please refer Fig. 2.1)

Result of the preliminary economic feasibility of the project is shown below. (Please refer table 2.1 and 2.2 and as for detail please open Chapter 11.)

Original invetment cost (base; January, 1981) 5.5 billion Peso

ROI (Return On Invest) rate * 17.9%

assumption; i) Funds; Bank loan with interest of 8% a year
ii) Escalation; Not considered
iii) Taxes and duties; Not counted
iv) Replacement; 5 years for mining facilities
10 years for other facilities

BASIC PLAN OF INTEGRAL UTILIZATION OF PYRITE IN GUERRERO

※ unit : g/t

CAMPO MORADO

Mine development

Mining method	Upper hand room and piller with filling
Transportation	Truckless

Ore reserve	8,300,000 T						
Average grade %	Au	Ag	Cu	Pb	Zn	Fe	S
	1.20 ※	112.00 ※	0.68	1.07	3.12	40.98	40.00

Access road construction	13.1 km + (Existing road improvement 33.0 km)
Residence (A, B, C, D - Class)	321
Dormitory (C, D - Class)	70
Club house	1
Guest house	1
Clinic	1

Monthly production rate 35,000 T/M

↓

Concentrator

Py. ave. grade %	Au	Ag	Cu	Pb	Zn	Fe	S
	0.92 ※	86.00 ※	0.35	0.44	0.80	45.43	44.25

Tailings	Cu conc.	Zn conc.	Ag-Pb conc.	Py conc.
8,820 T	455 T	1,470 T	770 T	23,485 T
	Cu 24 %	Zn 54 %	Pb 27 %	

Tailings disposal

Rockfill dom, height 60m

Pond cap. 2,400,000 m^3

Py conc.: 350 km Truck transportation → LAZARO CARDENAS

Cu, Zn, Ag-Pb conc. → Non ferrous metal refinery

COPPER KING

Mine development

Mining method	Sub level stoping
Transportation	Truckless

Ore reserve	12,000,000 T						
Average grade %	Au	Ag	Cu	Pb	Zn	Fe	S
	0.18 ※	7.50 ※	0.40	0.01	0.54	42.85	51.35

Access road construction	2.0 km + (Existing road improvement 24.0 km)
Mine water settling pond	height 5 m, cap. 200,000 m^3
Residence (A, B, C - Class)	25
Dormitory (C-Class)	5
Club house	1
Guest house	1

Monthly production rate 16,700 T/M

↓

Primary crushing

→ 180 km Truck transportation → LAZARO CARDENAS

LAZARO CARDENAS

Metallurgical plant

PbS	Zn(OH)2	PbSO4	Cement Cu	Gypsum	H2SO4	Pellet
65 T	401 T	130 T	155 T	1,501 T	57,100 T	28,200 T
Pb 30 %	Zn 60 %	Pb 55 %	Cu 80 %	SO3 43 %	98 %	

PbS, Zn(OH)2, PbSO4, Cement Cu → Non ferrous metal refinery

H2SO4 → FERTIMEX

Pellet → SICARTSA

Raw material of metallurgical plant							
Ore \ %	Au	Ag	Cu	Pb	Zn	Fe	S
FeS_2 conc. (40,175 T)	0.61	53.40	0.37	0.26	0.69	44.36	47.21
Cinder (28,500 T)	0.85	74.46	0.52	0.37	0.97	61.88	0.61

Pellet average grade %	Au	Ag	Cu	Pb	Zn	Fe	S
	0.02 ※	5.00 ※	0.04	0.02	0.05	62.06	0.04

Residence (extra A, A, B - Class)	32
Dormitory (B - Class)	8
Guest house	1

Fig. 2.1

20 years for buildings

Note ; *

$$\sum_{i}^{n} \frac{Ii}{(1+r)^i} = \sum_{i}^{n} \frac{Ci}{(1+r)^i}$$

where Ii : required fund of i-th year

Ci : cash flow (profit + depreciation) of i-th business year

r : ROI rate

i : i-th year

n : 20 years

ROI Income Statement/Cash flow

Table 2.1

(Unit: 1,000 pesos)

Year elapsed	(1) Gross income on sales	(2) Manufacturing expense	(3) Depreciation expense	(4) Profit	(A) Cash in flow (3) + (4)	(B) Cash out flow Invested capital	Cash flow (A) – (B)
–2						204,810	
–1						2,468,696	
0						2,165,614	
1	955,942	561,473	476,527	–82,058	394,469	138,660	255,809
2	1,911,884	720,812	"	714,545	1,191,072	0	1,191,072
3	"	"	"	"	"	0	"
4	"	"	"	"	"	0	"
5	"	"	"	"	"	188,671	1,002,401
6	"	"	481,744	709,328	1,191,072	0	1,191,072
7	"	"	"	"	"	0	"
8	"	"	"	"	"	0	"
9	"	"	"	"	"	0	"
10	"	"	"	"	"	3,129,525	–1,938,453
11	"	"	386,471	804,601	"	0	1,191,072
12	"	"	"	"	"	0	"
13	"	"	"	"	"	0	"
14	"	"	"	"	"	0	"
15	"	"	"	"	"	84,333	1,106,739
16	"	"	"	"	"	0	1,191,072
17	"	"	"	"	"	0	"
18	"	"	"	"	"	0	"
19	"	"	"	"	"	0	"
20	1,911,884	720,812	386,471	804,601	1,191,072	0	1,191,072

ROI rate: 17.9%

Remarks (1) Original investment : 4,977,780,000 pesos

(2) Reinvestment
- Mining equipment : 84,333,000 pesos/every 5 years
- Construction cost of tailings disposal : After 5 years from start up
- Other equipment : After 10 years from start up

Income Statement/Cash flow

Table 2.2

(Unit : 1,000 pesos)

Year elapsed	(1) Gross income on sales	(2) Manufacturing expense	(3) Interest cost	(4) Depreciation expense	(5) Profit (1)–(2+3+4)	(A) Cash in flow (4)+(5)	(B) Cash out flow		(A)–(B) Cash flow
							Repayment	Invested capital	
–2								204,810	
–1								2,468,696	
0								2,165,614	
1	955,942	561,473	430,544	476,527	–512,602	–36,075	551,980	138,660	–726,715
2	1,911,884	720,812	386,386	"	328,159	804,686	"	0	252,706
3	"	"	342,228	"	372,317	848,844	"	0	296,864
4	"	"	298,069	"	416,476	893,003	"	0	341,023
5	"	"	268,627	"	445,918	922,445	"	188,671	181,794
6	"	"	222,959	481,744	486,369	968,113	570,847	0	397,266
7	"	"	177,292	"	532,036	1,013,780	"	0	442,933
8	"	"	131,624	"	577,704	1,059,448	"	0	488,601
9	"	"	85,956	"	623,372	1,105,116	"	0	534,269
10	"	"	284,391	"	424,937	906,681	"	3,129,525	–2,793,691
11	"	"	224,727	386,471	579,874	966,345	331,820	0	634,525
12	"	"	198,181	"	606,420	992,891	"	0	661,071
13	"	"	171,636	"	632,965	1,019,436	"	0	687,616
14	"	"	145,090	"	659,511	1,045,982	"	0	714,162
15	"	"	125,500	"	679,101	1,065,572	"	84,333	649,419
16	"	"	99,789	"	704,812	1,091,283	321,386	0	769,897
17	"	"	74,078	"	730,523	1,116,994	"	0	795,608
18	"	"	48,367	"	756,234	1,142,705	"	0	821,319
19	"	"	22,656	"	781,945	1,168,416	"	0	847,030
20	1,911,884	720,812	3,205	386,471	801,396	1,187,867	321,386	0	866,481

Remarks (1) Original investment: 4,977,780,000 pesos

(2) Reinvestment
- Mining equipment : 84,333,000 pesos/every 5 years
- Construction cost of tailings disposal: After 5 years from start up
- Other equipment : After 10 years from start up

As defined in the Scope of Work signed on January 30, 1980, the objectives of this study are to conduct the metallurgical feasibility of pyrite utilization and preliminary economic feasibility study.

Consequently, the study results shall lead further detailed studies required prior to application for the development in industrial scale, since this study was mainly based on the ore reserves and grades of the surveyed ore deposits which were estimated from the limited available informations and samples collected during the site surveys for the short period of about one month. Therefore, a comprehensive feasibility study including detailed exploration of the ore deposits with drilling and tunnel prospecting, metallurgical test of pilot scale and infrastructural detailed survey is imperative to proceed this project further, as shown Fig. 3 on page A–10 of the Scope of Work signed.

An alternative plan to operate Campo Morado mine only is thought to be less feasible than this project because of small scale of a metallurgical plant.

Another plan to process the Copper King pyrite only with the maximum capacity of one line of the metallurgical plant is estimated also as less feasible since the Copper King pyrite has little revenue brought by valuable nonferrous metals. (please refer Table 2–3)

Owing to the flotation test result that the latest flotation technology for complex sulfide ores could separate the Campo Morado complex ore into each concentrate, expectant revenue from Campo Morado ore will be increased remarkably. This flotation technology will be applicable also to some of the other Campo Morado type of complex multi-metal sulfide ores in United Mexican States.

This plan vs alternatives

Table 2–3

(1) Mining rate and product

	This plan C.M.*	M.P.* C.K.*	C.M. only	C.K. only
Mining (t/y)				
· Mining rate	420,000	200,400	420,000	512,900
· Pyrite	281,820	200,400	281,820	512,900
· Concentrate for sale				
Cu-concentrate	5,460	–	5,460	–
Ag-Pb "	9,240	–	9,240	–
Zn "	17,640	–	17,640	–
M.P. (t/y)				
· Pyrite fed	482,220		281,820	512,900
· Product for sale				
Pellet	338,400		206,400	338,400
Sulfuric acid	685,200		375,600	793,440
Cement copper	1,860		1,008	2,235
Lead sulfide	780		480	–
Lead sulfate	1,560		1,740	–
Zinc hydroxide	4,812		3,288	3,960
Gypsum	18,012		12,099	20,052
Employee				
Mine	375	203	375	303
M.P.	380		350	380
Total	958		725	683

Note*; C.M.; Campo Morado
C.K.; Copper King
M.P.; Metallurgical plant

(2) Original investment cost

(x10³ Pesos)		This plan C.M. M.P C.K.		C.M. only	C.K. only
Mine					
Mine development	(20y)*	38,394	36,432	38,394	70,314
Earth work & access road	(–)	146,477	38,936	146,477	75,146
Mining equipment	(5y)	111,780	74,520	111,780	190,697
Other equipment	(10y)	599,807	30,064	599,807	76,934
Building	(20y)	611,056	53,130	611,056	147,963
Sub-total		1,507,514	233,082	1,507,514	561,054
		1,740,596			
M.P.					
Equipment	(10y)	2,313,354		1,521,294	2,625,130
Building	(20y)	458,354		316,620	515,342
Sub-total		2,771,708		1,837,914	3,140,472
Others					
Reserve	(10y)	197,143		146,195	161,757
Initial expense	(10y)	213,571		158,239	175,082
Operation fund	(–)	54,762		40,480	44,788
Interest during construction	(10y)	542,017		401,786	444,553
Sub-total		1,007,493		746,700	826,180
Total		5,519,797		4,092,128	4,527,706

Note * ; years for depreciation

(3) Estimated rate of return

(x10³Pesos/y)	This plan	C.M. only	C.K. only
Revenue for sale			
· Concentrate	(329,035)	(329,035)	
Cu-concentrate	87,603	87,603	–
Ag-Pb "	132,942	132,942	–
Zn "	108,490	108,490	–
· Pellet	406,080	247,680	406,080
· Sulfuric acid	787,980	431,940	912,456
· By-product	(388,789)	(328,787)	(80,611)
Cement copper	147,320	82,756	60,428
Lead sulfide	5,506	3,388	–
Lead sulfate	212,828	226,880	–
Zinc hydroxide	19,190	13,113	15,792
Gypsum	3,945	2,650	4,391
Total (A)	1,911,884	1,337,442	1,399,147
Operating cost (B)	720,811	529,388	475,671
Depreciation (C)	486,724	353,392	423,166
Interest (8%) (D)	220,792	163,685	181,108
Profit (A)–(B)–(C)–(D)	483,557	290,977	319,202
Estimated rate of return			
· before cost of interest*	12.76%	11.11%	11.05%
· before cost of interest** and depreciation	21.58%	19.75%	20.40%

Note; *) {(A)–(B)–(C)} x100/original investment cost

**) {(A)–(B)} x100/original investment cost

As pyrite concentrates with much valuable nonferrous metals may be recovered by flotation of tailings of existing mines, the technology for integral utilization of pyrites will be applied to the said pyrite concentrates.

Differing from the Campo Morado type of ores consisting of complex multi-metal sulfide minerals, the Copper King type of ores will bring little revenue from valuable nonferrous metals through the chloridizing volatilization process. On the contrary, however, the iron in the Copper King type of ores is thought to be a subject of the further study as raw materials for iron powder and ferrite magnets.

The installation of the metallurgical plant in this project not only promote employment in Lazaro Cardenas district, but also it can process flue dusts, mill-scales, acid washing residues etc. discharged from the Las Truchas ironworks.

3 SUMMARY

3. SUMMARY

3–1 BACK GROUND OF THIS PROJECT

The government of Mixico is now undertaking various development programs including port and heavy industry development, particularly at thinly populated regions across the country. This is intended to disperse the population, which might otherwise concentrate in large cities, so as to achieve balanced modernization and provide increased employment.

In the field of mining, one of the mainstays of Mexican industry, the government has shown positive attitude toward the exploitation of ore reserves, adopting the policy of promoting the mining industry.

While oil related industries prosper along the coast of the Atlantic, the development of heavy industry on the Pacific is remarkable, with the Las Truchas ironworks operating in Michoacan near the border with Guerrero. The expansion program made up of four stages of expansion works is now under progress to make the Las Truchas ironworks one of the largest steel complex in Mexico.

Adjacent to this steel complex, a fertilizer complex is under construction, which will use as raw material the rock phosphate and the natural sulfur. In this area a large industrial park is being constructed as part of the Balsas River basin development program and various kinds of enterprises are starting their business here.

On the other hand, in the State of Guerrero, no exploitation is being made of the large sulfide deposits except the Taxco mine. This state's income mainly comes from agriculture, stock farming and tourism.

The pyrites has been used for the production of sulfuric acid which constitutes the main raw material for fertilizer and other chemical industries. However, the value of the pyrites was not particularly high since only the sulfur component (about 50%) was utilized as the material for the sulfuric acid production.

As the chloridizing volatilization process was developed and put into service in Japan, the situation has changed and the pyrites have gained particular importance. In addition to sulfur, iron can be used as good raw material for ironworks by eliminating nonferrous metals and the nonferrous metals eliminated are recovered for use in the nonferrous refineries.

It is thus considered highly feasible to exploit the pyrite deposits in Guerrero and produce sulfuric acid for fertilizer, pellets for ironworks and nonferrous metals including gold, silver, copper, lead and zinc by chloridiging volatilization. This will also contribute to the development and economic advancement of Guerrero.

This project is very important since the exploitation of the pyrite deposits will ensure stable supply of domestic raw material for the ever expanding steelmaking industry.

This study has been conducted to help determine the metallurgical and economic feasibility of the project; in which two of the many pyrite deposits in Guerrero will be mined and concentrated at the site, and transported to the Lazaro Cardenas industrial complex for metallurgical treatment, after which the treated products will be supplied to ironworks, fertilizer plants and others.

3–2 BASIC PLAN OF THIS PROJECT

Pyrite ores have been used only as the raw material for sulfuric acid. To fully utilize the pyrites to be mined in this project from the state of Guerrero, a chloridizing volatilization process will be employed.

The process, however, has a limit on its application. That is, there is a limit on the overall content of nonferrous metals to be eliminated and the gangue content in the pyrite cinder that can be used in the process. Excess amount of nonferrous metals results in reduced efficiency of volatilization in the process and the resulting burnt pellets cannot meet the requirement as the raw material to be processed in the blast furnace. In addition, excess amount of gangue such as SiO_2 and Al_2O_3 will not only reduce the iron content of the burnt pellets but also lower the melting point in the blast furnace. This will deteriorate the physical property of the burnt pellets as the raw material to be fed to the said furnace.

Thus, where the contents of the nonferrous metals and gangue in the pyrite ore exceed the allowable limits, it is necessary to reduce the content of these materials either by metallurgical means or by dressing.

The most practical means is a dressing and whether the cost of dressing can be born by the income from sale of nonferrous metal concentrates depends on the content of these metals in the ore. If the nonferrous metal income to be brought by the concentrates is small, the dressing cost must be met by the pyrite concentrate. The content and recovery rate of valuable nonferrous metals are therefore important factors in determining whether the project is commercially viable.

In this basic plan, the Campo Morado ore deposit will be mined to maximum capacity, in consideration of the profitability of this project because of the relatively large amounts of valuable nonferrous metals contained in the ore.

On the other hand, the maximum capacity per unit of the chloridizing volatilization process is approx. 350,000 tons per year which, however, depends mainly on the nonferrous metal content of the pyrites fed to the process. Since the stated capacity of the plant exceeds the maximum production rate of the Campo Morado mine, the ore shortage will be met with ore from the Copper King deposit, the output of which although not the most economical for this mine, will be the most economical for this project as a whole, all things being considered.

As an alternative, the metallurgical plant may be supplied with raw material only from the Campo Morado deposit. But this was not taken up seriously because the maximum amount of ore that could be mined from the deposit is limited as 420,000 t/y, resulting little scale of a metallurgical plant. Another plan to operate a largest metallurgical plant with Copper King ore only was thought to be less feasible than this project, as little revenue from recovered nonferrous metal was expected. A rough comparison shown in Table 2–3.

The Copper King ore has small proportion of nonferrous metal content and gangue, so that no dressing will be performed at the mining site and the raw pyrite ore will be used in the metallurgical plant.

The pyrites from Campo Morado and Copper King are processed in the metallurgical plant to produce the sulfuric acid and burnt pellets as main products as well as nonferrous metal cakes as by-products. The basic plan of this project is summarized in Fig. 2–1.

3–3 PRECONDITION FOR THIS STUDY

This study has been done based on the preconditions as described below.

a) Object of this study

This study is to asses the metallurgical feasibility of the pyrite utilization and economical feasibility of the project. But this is not final, and before making a final decision a comprehensive feasibility study will be needed, which will involve test drilling, pilot plant test and accurate survey on related facilities, as shown in Fig.–3 on page A–10 of the Scope of Work signed.

b) Estimation of ore reserve and ore grade

The amount of ore reserve and the ore grade have been estimated using the ore samples taken from the mine site and geological data obtained during the secondary study.

c) Mineral processing and metallurgical tests

The ore samples collected by the secondary study team have been bench-tested to determine the adaptability of each process.

d) Market survey for major products

The major products and by-products will be marketed in Mexico.

- Burnt pellet will be sold 100% to the ironworks in Lazaro Cardenas district.
- Sulfuric acid will be sold to the fertilizer plant in Lazaro Cardenas distric and other plants.
- Products from concentration (copper, zinc, and silver-lead concentrates) will be sold 100% to nonferrous metal refinery.
- By-products from the chloridizing volatilization process (zinc hydroxide, lead sulfate, and copper precipitates) will be sold 100% to the nonferrous metal refinery.
- Gypsum from the metallurgical plant will be sold to cement manufacturer and others.

e) Concession

In evaluating this project, royalties and other restictions arising from the mining law are not considered.

f) Procurement of site

Various expenses arising from the procurement of site for the installation of processing facilities and welfare facilities in the Copper King and Campo Morado mines as well as from the procurement of site for the metallurgical plant and related facilities were excluded from our evaluation.

g) Taxes

Various taxes (corporate income tax, mineral production tax, import duties and trade tax) were not taken into account on the assumption that special tax exemption measures will be applied.

h) Utility

- Electric power

  The mines and concentrator are located at a remote place and thus will be equipped with generating facilities. The metallurgical plant will be supplied electric power (230 kV, 60 Hz) from Mexico Power Co. through overhead cables.

- Water supply

The water to be used in the metallurgical plant will be supplied from the main pipe of the industrial park.

· Fuel

The metallurgical plant will use heavy oil or gas. The fuel gas will be supplied from the natural gas main pipe in the industrial park or the coke gas will be supplied from the ironworks.

i) Preferential measures for cheap energy

It is assumed that the preferential measures for cheap energy (discounted by 30%) will be applied to this project.

j) International cooperation

In executing this project, it is assumed that procurement and transportation of the construction materials and equipment will be carried out smoothly.

k) Basic data for calculating feasibility

· General condition

Exchange rate : 210 yen/USdollar, 23 peso/USdollar
yen/peso 0.1095

· Depreciation

Residual price : 0

Life of facility : building	20 years, 5%/year
Equipment and electric facilities	10 years, 10%/year
Facilities for mining	5 years, 20% /year

· Finance

- Bank loan : 100%
- Interest : 8%/year
- Term of repayment : 10 years after start-up

· Selling price of major product and investment cost

- Price of main products : Pellet 1200 peso/T
  Sulfuric acid 1150 peso/T
- Price of nonferrous metals : according to international market price as of February 1981.
- Investment cost : based on the data obtained in the field survey of October to November, 1980 with no inflationary escalation considered.

3–4 OUTLINE OF THIS PROJECT

3–4–1 CAMPO MORADO DEPOSIT

1) Geology

The Campo Morado is located in the northern part of Guerrero state, at Campo Morado village about 70 km southwest of Iguala city. It is situated in moutenous terrain 35 km from Villa de Ayala, which is near the national highway linking Iguala city and Altamirano city. It is also 710 km distant from Lazaro Cardenas city via Acapulco. A road connecting Cindad Altamirano and Zihuatanejo is under construction and, when completed, will shorten the distance between the Campo Morado ore deposit and Lazaro Cardenas city to about 350 km.

As to the Campo Morado, Geocon, a subsidiary of Union Oil, carried out a large-scale exploration to determine the amount of reserve of existing deposits and to locate new deposits. The results of this exploration have been published that the estimated ore reserve are 9,500,000 tons, and average metal contents are Au–1.2 g/t, Ag–111.8 g/t, Cu–0.68%, Pb–1.07% and Zn–3.12%.

The secondary study team surveyed mainly the Reforma deposit. Unfortunately, it has been found that most of the levels in the deposit except for 5th and 6th levels were broken down or filled with underground water. Even in the 5th and 6th levels, sufficient amount of samples could not been collected because bad ventilation, lack of oxygen and high temperature prevented the team from staying and searching there for sufficiently long period of time.

Based on the result of analysis of limited samples and the geological data collected, the amount of ore reserve was estimated as about 8,300,000 tons and the metal contents are; Au–0.84 g/t, Ag–95.4 g/t, Cu–0.83%, Pb–0.6%, Zn–1.36%. However, the area covered by our short-period survey was very limited due to the bad condition of the mine and the samples collected are not sufficient to infer the nature of the entire deposit. To do so accurately, much more extensive research will be required.

Considering the history and background of the deposit, it have been decided to use the average value of metal contents provided by Geocon's survey as the basis for this preliminary economic feasibility study. The data from the Geocon's survey is regarded relatively reliable among those available ones at present.

2) Development of Campo Morado deposit

Basic assumption of the planning is that the ore reserve is 8,300,000 tons, the amount of ore that can be mined is 6,300,000 tons (76%) and the monthly crude ore production is set at 35,000 tons. The deposit is formed of soft shale and breccia, so that an overhand room and pillar with filling is employed as the mining method. The tailings after dressing operation will be too fine to be used as the filling material, so it has been dicided to introduce waste excavated from other places outside the mine as the filling material.

The stoke is mined overhand and the ore is carried by LHD of 2 cubic yard to the central ore bin. As the means of transporting ore out of mine, a trackless mining system is used, in which 9-ton trucks transport ore from the haulage level to the primary crushing machine outside the mine.

In the mountainous road from Villa de Ayala along National Highway No. 51 to the mine, the portions with any radius of curvature or grade inconvenient for the travel of 10-ton concentrate trucks will be improved by the state or federal government, and the road shifting in the sharp grade portion near the mine and the road construction in the mine site will be made under this project.

Gravel roads of 6 m wide 5.4 km section and 3 m wide 7.7 km section are to be newly constructed, and 48 km section is to be maintained.

In lxcatepec about 12 km apart from the mine, concrete block buildings will be constructed. Company dwelling houses, a dormitory, a club house, a guest house and a clinic as welfare facilities for all the 375 employees are planned to be proveided.

3) Concentration

A new flotation process developed for complex sulfide ores was applied to the sample ores. Since this flotation process takes advantage of the interfacial chemical properties, the surface oxidation of ore with the lapse of time greatly affects the degree of concentration.

In the viewpoint of oxidation, the sample ores would have been oxidized by contacting with air for a long period since they were collected mainly from the surface of adits, differing from fresh ores to be mined. Therefore, metal contents and distributions are estimated from the test results, microscopic ore observations and past experiences for separating complex sulfide ores, assuming that the ore with the average metal contents presented by Geocon is processed.

The estimated result shows that the ore will be concentrated into 1.3% copper concentrate, 2.2% silver-lead concentrate, 4.2% zinc concentrate and 67% pyrite concentrate, and the metal content of pyrite concentrate will be Ag–86 g/t, Au–0.92 g/t, Cu–0.35%, Pb–0.44%, Zn–0.8% and Fe–45.43%. Siderite, iron carbonate, was found in iron and this is the cause for low recovery of the pyrite concentrate.

The concentrator is planned at the site 3.6 km from the mine and at the level of 1,380 m from sea. Tailings will be transported by gravity flow through steel pipeline to the dam, which will be constructed downstream. As for the dressing process, the latest flotation process suitable for complex ores will be used for efficient recovery.

The concentrator will process 1,400 tons of crude ore daily (80% of the ore is about minus 100 mm in size), which will be ground in two steps into fine particles of minus 400 mesh. Magnetic separation and regrinding are employed to improve the concentration efficiency. The concentrates will be dewatered until the water content is reduced to 13%, and then shipped.

The dam to be built about 1 km downstream of the dressing site will have the capacity of 2 million m^3 for receiving tailings.

The total manpower of workers required for mining, concentrator and supervision will be 375.

3–4–2 COPPER KING DEPOSIT

1) Geology

The Copper King ore deposit is located in the western part of the state of Guerrero, at Camalotito village about 25 km north of Petatlan city. It is situated 25 km from the national highway on the Pacific coast, 0.7 km from the village, and 180 km from Lazaro Cardenas city where the metallurgical plant is planned to be built.

Discovered in 1905–1906, the Copper King deposit is made up of two ore deposits, Rio Tinto and El Cinco, with the area of mining property of about 207 hectares. It has been surveyed by several companies by means of crosscuts and Cia Minera del Rio Murga has the right to mine the Copper King deposit. The shares of this company are owned 51% by the Mexicans and 49% by Texasgulf Inc.

In 1972 Cia Minera del Rio Murga and Mr. Spring conducted extensive survey to determine the amount and grade of reserves. The survey included sampling in all drifts, surface geological survey, geochemical survey, I.P. survey and surface drilling.

The secondary study team surveyed the No. 2 mine of Rio Tinto, conducting an underground sampling in crosscuts and drifts. According to its overall analysis, this deposit is massive in shape and contains typical low grade cupriferrous sulfide ores and the ore reserve is estimated at 12 million tons. The average value of metal content is Cu–0.4%, Pb–0.01%, Zn–0.54%, Au–0.18 g/t and Ag–7.5 g/t, basing on the samples taken from the drift. And the said ore reserve and metal content are used in this study.

In Japan there is a trend that chloridizing volatilization process might be payable when pyrites contain considerable amount of valuable metals because of high energy cost. But in Mexico, considering the cheap energy and other factors, it is expected that the Rio Tinto pyrite containing little valuable nonferrous metals can be exploited on the commercial basis

2) Development of Copper King deposit

The development plan is made based on the estimation that the amount of ore reserve is 12 million tons, the amount of ore that can be mined is 8,040,000 tons (67%) and that the monthly production of crude ore is about 17,000 tons.

This deposit is formed of firm green schist and is massive and large in all three dimensions. Therefore a sublevel stoping is to be adopted as the mining method, in which sublevels are driven at the interval of 20 m with the stope width of 20 m and the pillar width of 10 m.

Broken ore that has fallen to the bottom of the stope is carried by LHD of 5 cubic yard to the collector bin. At the lowest haulage level 12-ton trucks are used to transport ore to the primary crushing machine located outside. That is, a trackless mining system is used. The total manpower of the mine shall be 203 and the size of ore after the primary crushing operation shall be minus 100 mm.

The road from Petatlan to the mine is relatively good for 30-ton concentrate trucks. The 2 km section on the mine side will be newly constructed or improved under this project, and the remaining 23 km section will be improved, where required, by the state or federal government.

As the buildings, in addition to company dwelling houses and a dormitory to be used by 30 employees, out of 203 employees, excluding those estimated to commute from their own houses, a club house and a guest house will be constructed.

3–4–3 METALLURGICAL PLANT

1) Site for metallurgical plant

At Lazaro Cardenas district on the Pacific, a candidate site for the metallurgical plant of this project, the Las Truchas ironworks of Sidermex is already operating and the work to increase its production capacity is now under way. Also under construction in this district is a fertilizer complex of Fertimex. The Lazaro Cardenas district is situated in Michoacan state at the mouth of Balsas River near the border with Guerrero. In this district a large scale industrial park is being constructed as part of the Balsas River basin development program. This district is blessed with abundant energy and water resources, is equipped with good transportation systems, and has a large number of labor population in Lazaro Cardenas city which is rapidly expanding in recent years. The main products of this project, such as sulfuric acid and raw material for steel making, were assumed to be consumed by the industrial complexes here. Considering the various factors mentioned above, Lazaro Cardenas district can be said to be a suitable site for the metallurgical plant.

2) Basic plan

The area near the ironworks in Lazaro Cardenas district has been selected as the site for the metallurgical plant. The plant consists of a stock yard, a roasting plant, a sulfuric acid plant, a pelletizing plant, and a metal recovery plant. The stock yard is capable of storing ore in the amount equal to one-month consumption. The grinding facility planned in the stock yard will grind the ore about minus 100 mm in size brought in from the Copper King Mine by trucks, into 80% of minus 200 mesh.

Roasting method is of fluidizing roasting and a double contact method is used in the production of sulfuric acid.

The pyrite concentrate from the Campo Morado Mine and the ground pyrite ore from the Copper King Mine are mixed in repulper tanks and fed to the roaster.

An in-plant power generating facility, which converts the heat of gas in the roasting plant into electric power, is also planned.

The pyrite cinder is added with chloridizing agent, moistened and mixed properly in the blending system, and then formed into green pellets and dried. The dried pellets are then burnt in the chloridizing volatilization furnace or rotary kiln for further process in the blast furnace. In the chloridizing volatilization process developed in Japan, nonferrous metals volatilize and the volatilized metals are absorbed into the solution that will be processed to recover valuable nonferrous metals.

The burnt pellet production is planned at 340,000 tons per year by one line of kiln. The burnt pellet product will be transported to the ironworks by railroad; the sulfuric acid

LOCATION OF METALLURGICAL PLANT

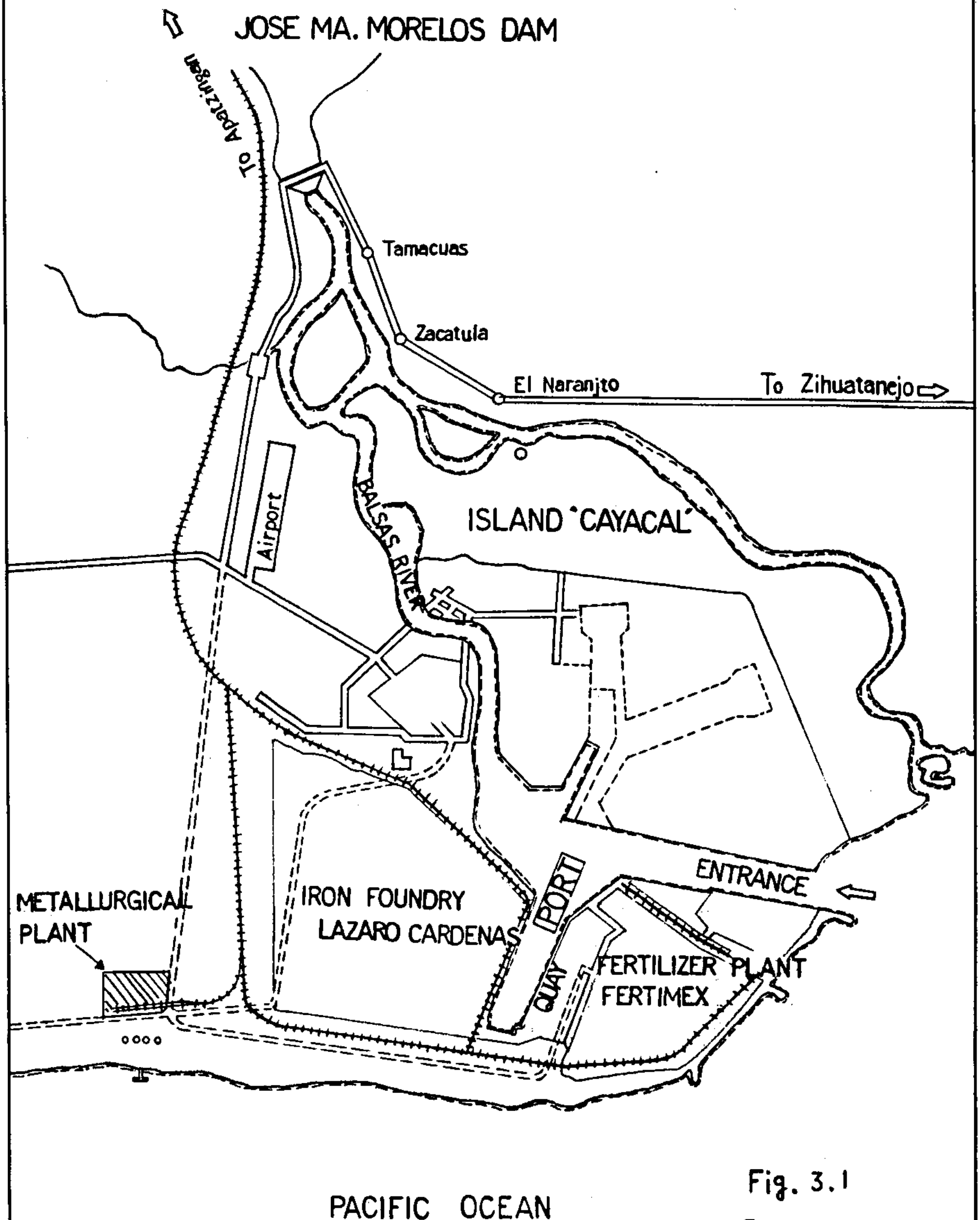


Fig. 3.1

SCALE 1 : 40000

will be transported by tank cars and tank ships; and the recovered nonferrous metals will be railroaded.

The area of plant site is about 130,000 m^2. The plant will take various measures against environmental pollution conforming to regulations of this country that apply to newly built factories.

This area where the metallurgical plant is scheduled to be constructed has sufficient urban functions. Therefore, only houses for technicians recruited from remote places and a guest house will be constructed.

3–5 EMPLOYEES OF THE PROJECT

Employees for operating the mines, concentrator and metallurgical plant will be as follows :

	Copper King Mine	Campo Morado Mine	Metallurgical Plant
General Manager	1	1	1
Exploration	12	15	0
Mining	52	151	0
Mineral Processing	0	40	0
Metallurgy	0	0	194
Analysis	5	11	36
Maintenance	*55	*62	101
Administration	78	95	48
Total	203	375	380

Note: * including the power station.

3–6 ECONOMIC FEASIBILITY OF THE PROJECT

Based on the basic conception consisting of mine developments and a metallurigical plant, the development plan was worked out, and the preliminary economic feasibility was examined.

1) Total Amount of Investment

a.	Earth work and access roads	185,413 (10^3 pesos)
b.	Mine development	74,826
c.	Civil and buildings	1,122,540
d.	Equipment, machinery and apparatus	3,129,525
e.	Contingencies	197,143
f.	Initial expenses (expenses required before operation)	213,571
g.	Operating funds	54,762
h.	Interest during construction	542,017
	Total	5,519,797

2) Funds raising and development schedule

The development funds of this project were trially calculated based on a bank loan with interest of 8% with 10 years as the period of repayment after start-up. It was assumed that the test operation would be started 30 months after the commencement of the project, and that the production would be 50% in the initial business year of operation and 100% from the second business year.

3) Economic feasibility

As an index of economic feasibility, the IRR (Internal Rate of Return) was calculated for an operation period of 20 years.

ROI (Return On Investment) 17.9%

Discussion : In light of ROI, the rate is 17.9%, and the project cannot be said to be so high in the rate, in view of general commercialism, but, if the funds with low interest is available, it shows a favorable value. As for the cash flow of ROE basing on the interest of 8% a year, the accumulated cash flow in the previous year of equipment replacement at the 10th year will be 2,208,741 (10^3 pesos). Though there is a margin in view of fund position during the operation period in case of annual interest of 8%, the constitution of the project can be made stronger, needless to say if lower interest funds can be raised by using advantageous funds in Mexico. Please refer Table 2.1

(reproduction of Table 11.7) and Table 2.2 (reproduction of Table 11.8).

If the investment cost be escalated by 20% and 30%, the ROI rates will be 14% and 12.5% respectively, for reference.

The calculation was carried out on an assumption that all equipment and machineries except for mining are replaced at the 10th year from the start up. But, taking into consideration that many equipment and machineries could be used more than 10 years without replacement, the rate will be improved to a certain extent.

Evaluation : The evaluation of this project in view of feasibility is as mentioned above. However, since the development aims at the utilization of unused domestic resources and local development, evaluation should be made also in view of national economy and local community. That is, the follwoing matters should be considered.

- Promotion of local development (influence on communities and related industries)
- Promotion of employment (stabilization of living of employees and families)
- Effective utilization of unused resources (production of sulfuric acid for fertilizer, production of raw material for ironworks)
- Influence on international payments (meeting the demand for iron ores)

3–7 STUDY RESULT

Considering the above generally, the "Integral Utilization of Pyrites in the State of Guerrero, United Mexican States" covered by this study is technically feasible and preliminary said to be a economically feasible project. It can be said also that this project will be highly evaluated in effect since it will favorably affect national development and contribute to the promotion of local development.

3–8 PROBLEMS AND PROPOSALS IN PROMOTING THE PROJECT

- The modern industrialization of the United Mexican States is remarkable, and recent projects tend to be realized as large scale industrial complexes for petrochemistry, iron manufacture, fertilizer, etc. This project covers Campo Morado Mine and Copper King Mine in the state of Guerrero and Lazaro Cardenas distruct of the state of Michoacan, and what form should be adopted in realizing this project is a large problem. Various products are involved, including nonferrous metals concentrates, sulfuric acid as a raw material for fertilizer, and pellets as a raw material for ironworks, etc. Public corporations, governmentally financed companies and private companies of the United Mexican States are surmised to be large consumers, and there are many related quarters. Smooth promotion of this project must be intended.

- As a result of mineral processing and chloridizing volatilization tests, it was confirmed that the chloridizing volatilization process of Japan is metallurgically feasible for the pyrite ores of the mines surveyed. Meanwhile, the confirmation of the reserves and grades of ores is of course decisive to the success of this project. The secondary study team presumed and tentatively concluded the reserves and grades based on the data and samples obtained during the period of the study, but they must be confirmed sufficiently by detailed exploration viz. boring and drifting.

- Contamination with heavy metals of sulfuric acid to be produced in this project may affect the quality of fertilizer. Therefore, further study about the contamination will be required in the next stage of study.

- In the next stage of study, large quantities of samples of the deposits in question must be used to conduct tests by pilot plants of mineral processing and metallurgy, confirming the quality and obtaining basic data for plant design. And markets for sulfuric acid and gypsum to be produced in this project must be studied including sale of SO_2 gas generated to the adjacent fertilizer complex of FERTIMEX.
  Furthermore, local detailed investigation concerned with infrastructure must be made, to make a comprehensive feasibility study further improved in accuracy.

- With regard to welfare facilities, the levels and scales must be examined, in relation with local development.

- In this project, all iron in the pyrites was planned to be converted into pellets. However, a part of iron in the Copper King type of pyrites has been used as raw materials for iron powder and ferrite magnets in Japan utilizing a characteristic of little impurities in the pyrites. So further examination for other feasible uses of iron in pyrites than pellets is considered to be preferable to develop utilization of pyrites.

4 ESTIMATION OF ORE RESERVES AND GRADE

4. ESTIMATION OF ORE RESERVES AND GRADE

4–1. COPPER KING DEPOSITS

4–1–1. LOCATION AND ACCESS

The Copper King deposits are situated near the village of Camalotito of Petatlân municipalty about 25 Kilometers north of Petatlân city in the western part of the State of Guerrero (Fig. 4.1, Fig. 4.2). The property is at Latitude 17° 40′ N and Longitude 101° 17′ W. Access and required time by jeep from Mexico are as follows.

Mexico —highway 410 Km / 6 hours→ Acapulco —highway 205 Km / 3 hours→

Petatlân —dirty road 25 Km / 1 hour 20 minutes→ Camalotito —on foot / 20 minutes→

Rio Tinto Adit

It takes about 3 hours and a half to get Lâzaro Cârdenas city from Camalotito by jeep 180 Kilometers through Petatlân and Zihuatanejo-Ixtapa, a famous resort area. Regularly scheduled jet services from Mexico to Zihuatanejo-Ixtapa are available daily.

4–1–2. PHYSIOGRAPHY

The Copper King deposits are on the southern slope of Sierra Madre del Sur mountain range. The property covers mountanous terrene of 200 meters to 800 meters above the sea level. The relative altitude is 150 meters.

Murga river, which is about 600 meters north of Rio Tinto Adit, flows to southwest carring abundant water throughout the year. The flow was about 900 m^3/min late in October. The area is covered by dense tropical vegetation and the main species are as follows.

High tree	:	pine, oak, mangrove,etc.
Low tree	:	banana, ornage, lemon,etc.
Farm produce	:	corn, chile, onion, rice, tomato,etc.

According to the map of climate, dry and rainy seasons are November to May and June to October respectively which are clearly separated. Almost of an annual precipitation of 1,200 mm to 1,500 mm concentrates into the rainy season. Annual temperature fluctuates between 22 degrees and 35 degrees, and 24 degrees is estimated as an annual average temperature.

4–1–3. PROPERTY

The claim configuration around the Copper King deposits is shown in Fig. 4.3. The property consists of 10 titled concessions covering 207 hectares.

There are documents in the Dirección de Mina which verify legal justice over the claims. Owner of the claim is Compania Minera del Rio Murga which is a Mexican subsidiary of Texasgulf Incorporation. Its shareholders are Texasgulf Inc. (49%) and Mexicans (51%).

4–1–4. HISTORY

The historical records of the exploration and development on the Copper King deposits are summarized as follows (Velasquez Spring 1972).

1905–1906 : The property was discovered as a massive pyrite prospect.

1906–1914 : The initial examination, including the development of underground workings, was made by the Pacific Copper Company. After the examination, the company concluded that the mining area had the following reserves.

Deposit	Reserves tons	Cu %	Fe %	S %
Rio Tinto	2,585,000	0.3	41.9	47.8
El Cinco	8,000	1.22	36.4	39.4

(The Copper King deposits consist of Rio Tinto and El Cinco deposits. Their geological relation is shown in Fig. 4.4.)

1952 : The property was acquired by Texasgulf Inc.

1952–1954 : An extensive examination of the property consisting of geological mapping, geochemical soil sampling and diamond drillings was conducted by Cia. Minera del Rio Murga, which is a subsidiary of Texasgulf Inc.. Nineteen holes were drilled on the Rio Tinto mineralized zone and four on the El Cino zone.

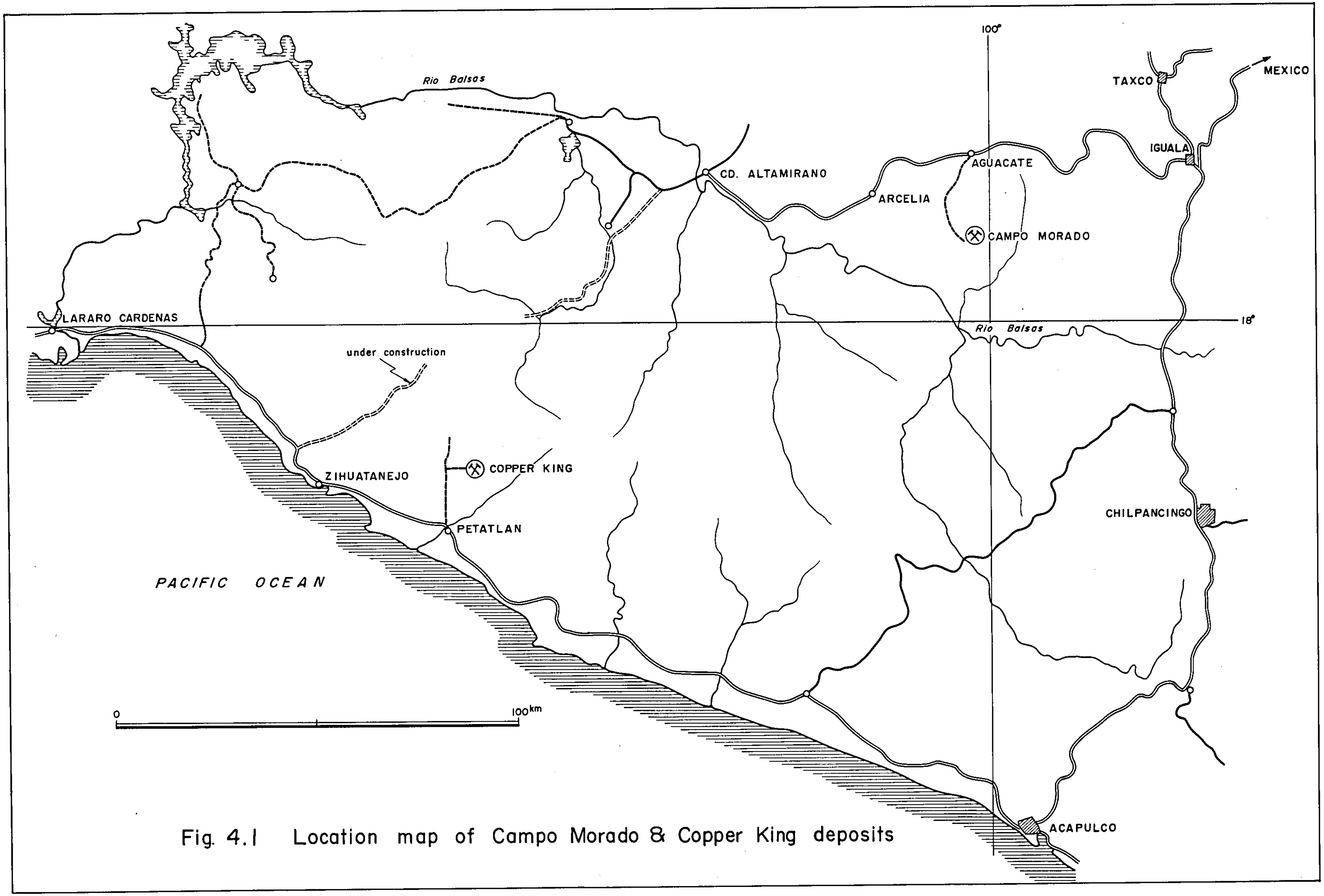


Fig. 4.1 Location map of Campo Morado & Copper King deposits

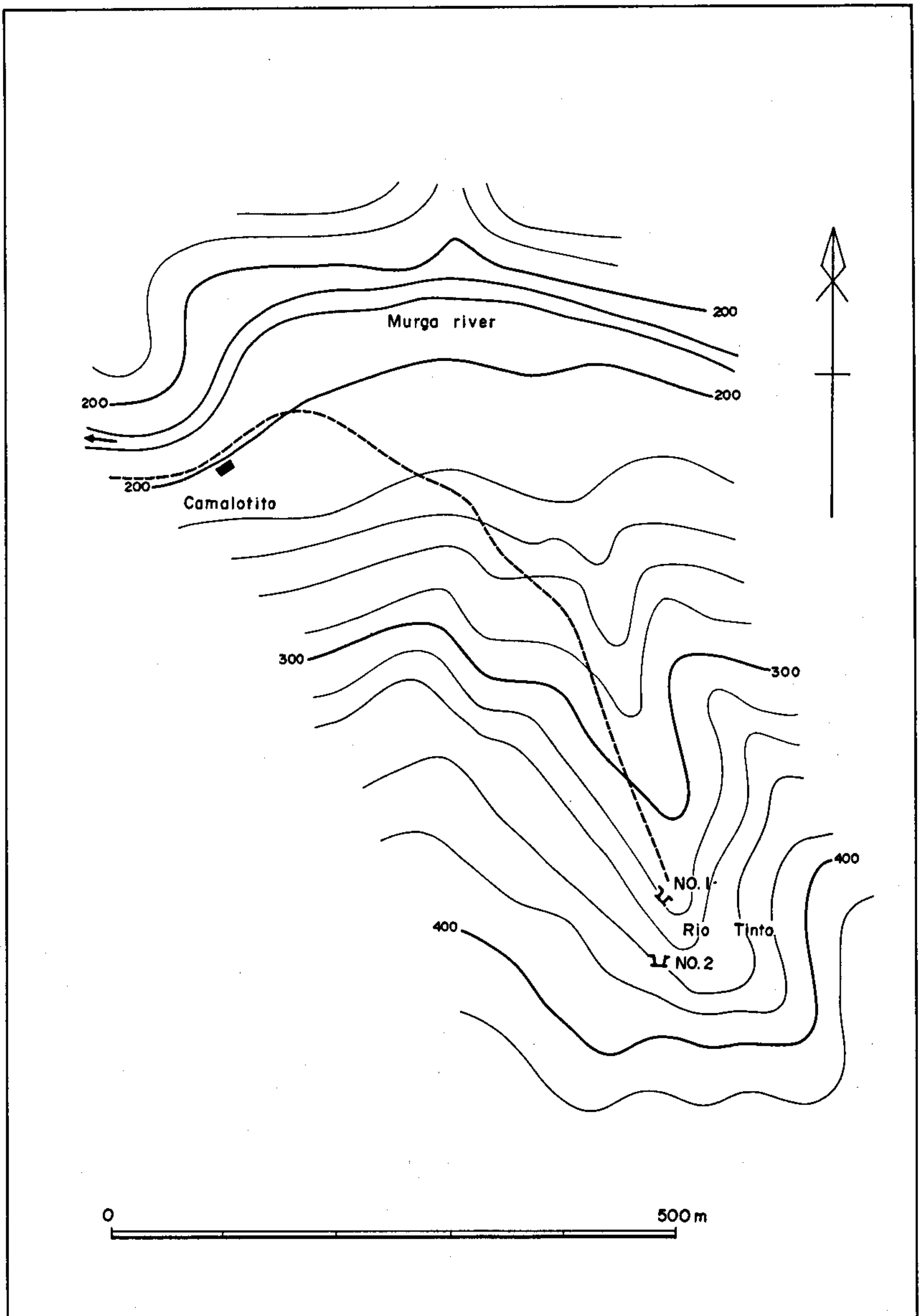
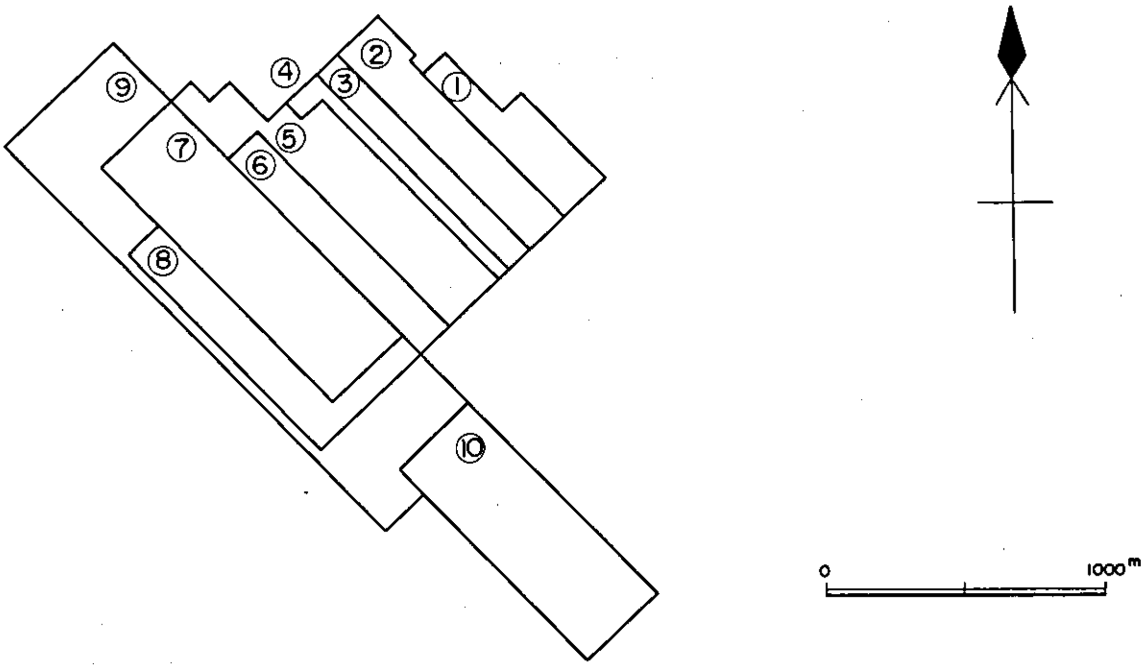


Fig. 4.2 Location map of Adit Rio Tinto, Copper King



NAME OF CLAIM		NO. OF TITLE	SURFACE
①	La Vainlla	- T 139027	- 9 Has
②	Don Pepe	- T 138134	- 26.1450
③	Lloron	- T 132145	- 9
④	Suriano	- T 141308	- 5.80
⑤	Rio Murga	- T 133111	- 26.50
⑥	Rey del Cobre	- T 115930	- 15
⑦	Rio Tinto	- T 102298	- 36
⑧	2a Amp. Rio Tinto	- T 110178	- 18
⑨	Amp. Rio Tinto	- T 110019	- 42
⑩	La Trinided	- T 107790	- 30
			207.1450 Has

Fig. 4.3 Configuration of Copper King mining claims

This study concluded that only the Rio Tinto mineralized zone contained a possible ore body. An evaluation of the zone indicated following reserves.

Deposit	Reserves tons	Au g/t	Ag g/t	Cu %	Fe %	S %
Rio Tinto	4,586,000	Tr.	8	0.86	41.2	45.3

At that time, the deposit was considered to be a massive cupriferous iron sulphide body and if mined, sulphur would be the main product with copper and precious metals as by-products. It was concluded that it was not feasible to bring the ore body into production at that time.

1968 : Three diamond drill holes were drilled on the Rio Tinto zone on the basis of detailed geological mapping together with magnetometric and electromagnetic surveys.

1968–1972 : Detailed geological mapping and geochemical soil sampling and I.P. survey were carried out. A detailed mapping and channel sampling program of the underground workings in the Rio Tinto Adit were also conducted to correlate grade values from the diamond drill core.

1973–1975 : The extensive exploration works, including 17 diamond drill holes of about 2,400 meters of total length, were conducted by Cia. Minera del Rio Murga on the Rio Tinto and El Cinco mineralized zones.

According to the documents made by Dirección de Mina, the total expenditure of the exploration works for three years is approximately 2,040,000 pesos (163,000 USD).

4–1–5. GEOLOGICAL INVESTIGATION

Rio Tinto and El Cinco deposits are known to exist in Copper King area. The former is larger and more extensively explored than the later which is not accessible physically.

Consequently the mission has carried out the geological investigation in Rio Tinto deposit. There are two adits, Rio Tinto No.1 and No.2. Rio Tinto No.1 exists about 40 m below No.2. Rio Tinto No.1 was not accessible and about a half of No.2 has been accessible because of insufficient natural ventilation and collapse in spite of preceeding reopening of these adits.

Geological mapping and 2 meters channel sampling with 5 meters and 10 meters spacing along accessible crosscut and drift respectively have been performed by the mission.

Twenty four ore samples which amount to 100 kilograms and 5 rock samples were collected.

After coming back to Japan, these ore samples were analized chemically, of which 10 samples were also examined under microscope together with 5 rock samples.

4–1–6. GEOLOGY

According to Yanez (1977), the geology of the area of the Copper King deposits is characterized by volcano-sedimentary sequence of Upper Triassic to Lower Jurassic age. Andesitic to dacitic pyroclastics, shale and sandstone have suffered low grade metamorphism to green schist and phyllite, etc. (Fig. 4.4.). Detailed description of the sequence, Soyamichil formation, is shown in Table 4.1.

It was confirmed by the mission that the rocks around the Adit Rio Tinto were composed of andesitic to dacitic pyroclastics being suffered weakly metamorphism to green schist and the Rio Tinto deposit, a massive sulphide deposit, was associated with the green schist sequence. The sequence strikes northwest and dips southwest or notheast steeply but locally 20 degrees to 30 degrees, and suffers silicification strongly near the deposit (Fig. 4.5).

According to Velasquez Spring (1972), the geological structure at the Rio Tinto zone was thought to be a non-plunging syncline striking N50°W that was overturned to the southwest, and the sulphides were concentrated in the trough of the fold and pinched out upwards along the wings of the fold.

Also El Cinco zone was thought to be similar in structure with the sulphides related to a syncline, the fold axis of which strikes northwest. It was emphasized that the sulphides in the wings of the structure, particularly the southern wing, may not come to surface and could be present at depth, since the synclinal axis appears to plunge to the southeast. However, the mission could not confirm these mentioned above because an access to the all adits was restricted and no information of the drillings was available.

The result of microscopical observation of 5 rock samples taken by the mission in Rio Tinto Adit No.2 is as follows (microphotographs are appended).

KR–1 : Silicified dacitic andestite

The specimen has aphanitic texture with feldspar lath of 0.2–0.4 mm in size. No phenocrysts are observed. A lot of quartz veinlet of 0.3–0.5 mm in width is abundant with pyrite dissemination. A small amount of pyrite crystals of less than 1 mm in diameter scatters in the specimen.

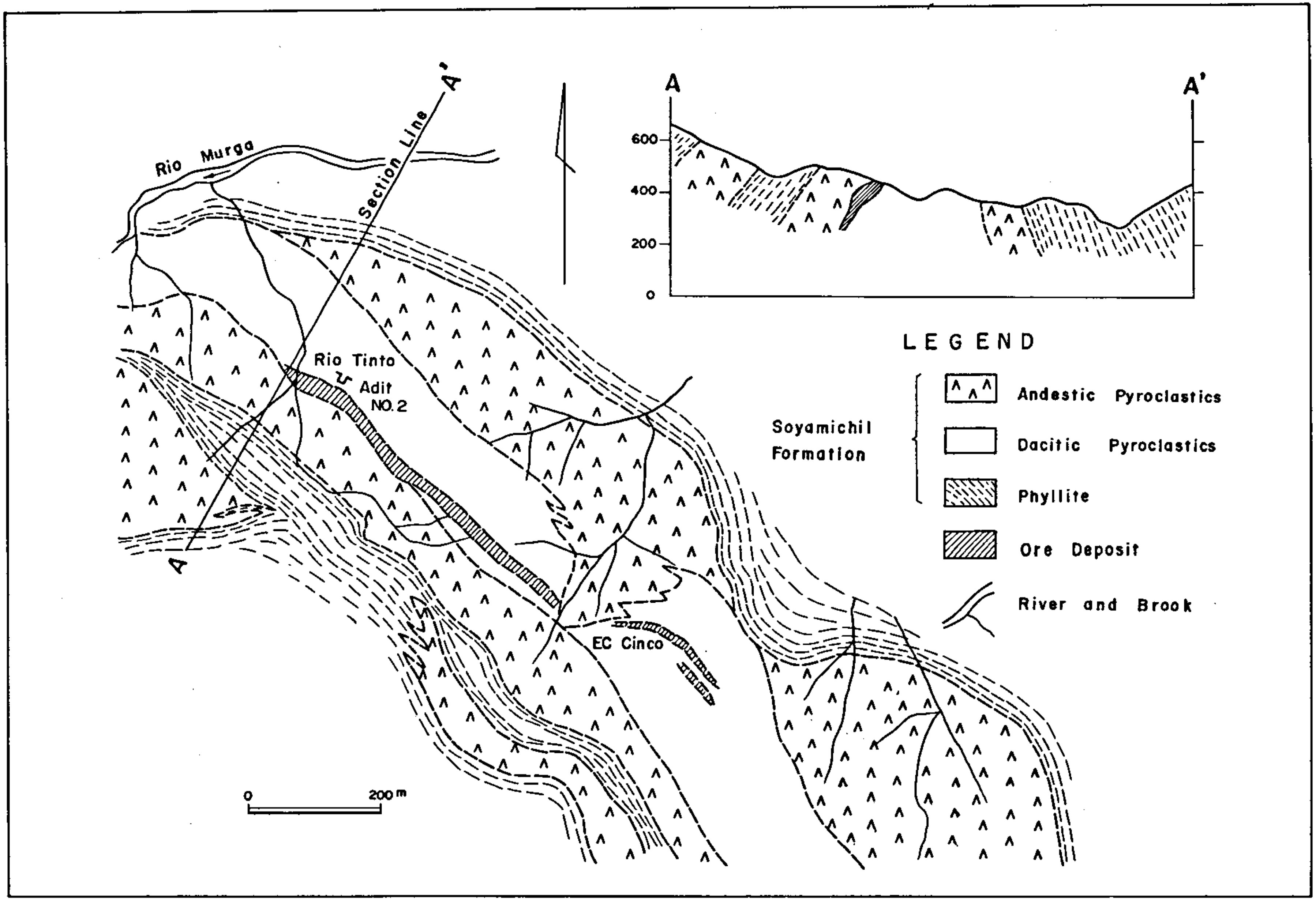


Fig.4.4 Geological map of Copper King mining area : modified after Yanes (1977)

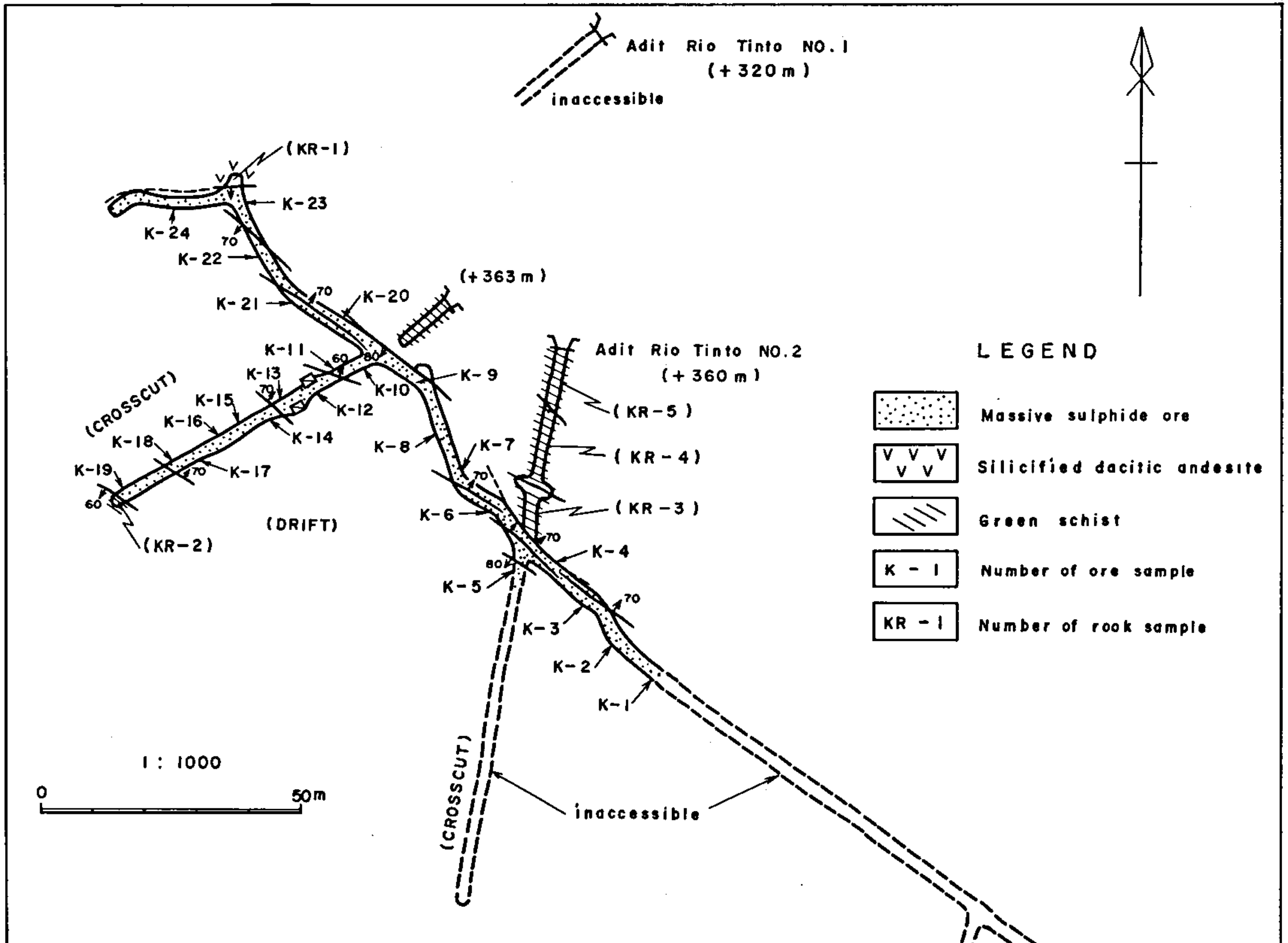


Fig. 4.5 Geological map of Adit Rio Tinto, Copper King

Table 4.1 Geological sequence of Soyamichil Formation

Rocks	Thickness	Remarks
Marble and Phyllite with intercalation of Metasandstone.	370 M	
Andestic Metapyro-clastics.	200 M	
Dacitic Metapyro-clastics.	270 M	Massive sulphide deposits are encoutered in this subformation.
Metadiorite.	140 M	
Phyllite.	110 M	
Andestic Metapyro-clastics.	170 M	
Phyllite.	130 M	

KR–2 : Green schist (Actinolite-quartz schist)

Phenocrysts of 0.5–1 mm in size as a consituent of pyroclastics are observed. Actinolite needle crystals of 0.1–0.2 mm long are arranged along the foliation. Very small crystals up to 0.01 mm of rutile scatters within the flow of actinolite needles.

KR–3 : Green schist (Actinolite-quartz schist)

The specimen has nearly the same characteristics as of KR–2.

KR–4 : Green schist (Actinolite-quartz schist)

Plagioclase phenocrysts of up to 1 mm in diameter are abundant in the fine grained groundmass with dominated foliation. Actinolite needle crystals of up to 0.05 mm in length are dominant in the groundmass along the foliation with small amount of rutile crystals. Pyrite and pyrrhotite replace a part of phenocrysts with actinolite crystals being grown up to 0.5 mm in length.

KR–5 : Green schist (Zoicite-actinolite-quartz schist)

Feldspar crystals of up to 2 mm are occasionaly seen along the foliation of actinolite needle arrangements. Zoicite grains of up to 0.2 mm are also seen with catacrastic quartz grains which are the main constituents of the specimen. Pyrite crystals are occasionally found in the actinolite rich parts. Very small crystals of rutile are predominant also in actionolite rich parts.

4–1–7. ORE DEPOSITS

Rio Tinto deposit, the largest at Copper King, is of a typical massive sulphide which appears to be concordant with the schistosity of the green schist sequence.

According to Velasquez Spring (1972), the sulphides at the Rio Tinto zone occur over a strike distance of nearly 400 m and attain a thickness of approximately 70 m. Also the structure was thought to be a non-plunging syncline striking N 50° W that is overturned to the southwest, and the sulphides are concentrated in the trough of the fold and pinch out upwards along the wings of the fold.

It is said that pyrite is the predominant sulphide mineral comprising about 75% of the total volume and occurring as a fine-grained, extremely dense mass. Also chalcopyrite with a coarse crystalline texture is associated with pyrrhotite-rich bands which are common near the outer edge of the fold.

The mission could not understand sufficiently the mode of occurrence of the deposit because of restricting an access to the deposit and no available information of the drillings.

However, it was confirmed that the Rio Tinto deposit was extending over 140 m in length and 60 m in thickness along the drift and crosscut respectively in the accessible Adit Rio Tinto No. 2 (Fig. 4.5.). No compositional ore texture within the deposit was generally observed, though where oxidized and etched along tunnel walls a delicate lamination, which mainly due to variations within pyrite grain size, was apparent.

Megascopically no copper sulphide minerals are seen, but a small amount of chalcanthite is partly recognized in the ore.

It is observed under microscope that the ore is principally composed of mozai aggregate of pyrite crystals of 0.2–1.5 mm in diameter whose matrix is filled partly by quartz and sericite though is remaining empty in major parts. Chalcopyrite and sphalerite are found in pyrite crystals as inclusion, though as interstitial partly. A part of sphalerite has been replaced by covelline as a product of supergene activity. Slightly banded texture, caused by a variation within pyrite grain size, is partly observed. Chalcopyrite tends to concentrate on the marginal parts of the ore body.

The result of microscopical observation of the representative ore is as follows (microphotographs are appended).

K–1 : Pyrite ore

Mozaic aggregate of pyrite crystals of 0.1–0.5 mm in diameter is main constituents of the specimen. Matrix of pyrite mozaics is filled partly by quartz and sericite. Chalcopyrite and sphalerite occur in pyrite crystals as a small inclusions of less than 0.05 mm in diameter.

K–5 : Pyrite ore

Very similar feature to K–1 is observed for this specimen.
A part of the matrix of mozaic pyrite crystals of 0.2–0.6 mm in diameter is filled by mainly quartz in part and other part is remaining empty. Chalcopyrite and sphalerite inclusions in pyrite crystals have a size of less than 0.05 mm.

K–9 : Pyrite ore

The specimen has nearly the same features as K–1 and K–5 except to have slightly banded texture owing to a variation within pyrite grain size. The amount of chalcopyrite or sphalerite is very small and the size is less than 0.05 mm.

K–10 : Cu bearing pyrite ore

Mozaic aggregates of pyrite crystals of 0.2–1.5 mm in diameter contain interstitial chalcopyrite and sphalerite of 0.1–0.5 mm in diameter. A part of sphalerite has been replaced by covelline as a product of supergene activity.

K–12 : Pyrite ore

Euhedral cubic crystals of pyrite of 0.2–1.5 mm in diameter form a mozaic aggregates with interstitial quartz and sericite. Chalcopyrite, sphalerite and pyrrhotite are found in pyrite crystals as inclusion of less than 0.02 mm in diameter.

K–14 : Pyrite ore

The specimen has nearly the same features as K–12. The amount of interstitial quartz and sericite is less than those of K–12.

K–16 : Pyrite ore

The specimen has nearly the same features as K–12 and K–14. The amount of chalcopyrite and sphalerite inclusions is very little for this specimen.

K–18 : Pyrite ore

Mozaic aggregate of pyrite crystals of 0.2–1.5 mm in size contains small amount of interstitial quartz and occasional sericite. Very small amount of chalcopyrite and sphalerite inclusions of up to 0.01 mm in size are seen in pyrite crystals.

K–20 : Pyrite ore

Mozaic aggregate of pyrite crystals of 0.2–1.0 mm in size has interstitial quartz and sericite as matrix. Very small amount of small rutile crystals are occasionally seen at the boundary between quartz and pyrite.

K–24 : Pyrite ore

The specimen has slightly banded texture caused by a variation of the grain size and concentration of pyrite crystals. A little amount of chalcopyrite and sphalerite is seen in matrix of pyrite grains with nearly the same amount of quartz.

4–1–8. ORE RESERVES AND GRADE

The following reserves and grade of Copper King deposits had been estimated by Spring and Cia. Minera del Rio Murga on the basis of the result of sampling along all adits of Rio Tinto and El Cinco, geological, geochemical and geophysical (I.P.) surveys and drillings.

Table 4.2 Ore reserves of Copper King deposits (Spring et. al)

	Deposit	Reserves tons	Grade
Spring (1972)	Rio Tinto	4,753,000	Cu < 1%
	El Cinco	2,300,000	Cu 1%
	Total	7,053,000	
Cia. Rio Murga	Rio Tinto El Cinco	21,500,000	

Also the following average grades are availbale (Spring 1972). The first two are of 2 meters channel samples taken by Cia. Minera del Rio Murga with 4 meters spacing along all crosscuts and drifts in Rio Tinto Adit No. 1 and No. 2.

Table 4.3 Average grades of Rio Tinto deposit (Spring 1972)

Location	Au g/t	Ag g/t	Cu %
Rio Tinto Adit No. 1	0.26	8.15	0.68
No. 2	0.28	6.85	0.52
Total	0.27	7.31	0.62
Diamong drilling	Tr.	8.00	0.86

The mission has confirmed a dimension of 140 meters in length and 60 meters in thickness collecting samples along crosscut and drift as mentioned before, however it has seemed that the deposit would continue farther strikwise (Fig. 4.4, Fig. 4.5).

The following reserves of Rio Tinto deposit (Table 4.4) are expected by the mission presuming a dimension of 400 meters in length, 60 meters in thickness and 120 meters in width based on the report of Spring (1972) and preceeding geologica; reconnaissance (1979).

Table 4.4 Ore reserves of Rio Tinto deposit (Mission 1981)

Possible reserves	Au g/t	Au g/t	Cu %	Pb %	Zn %	Fe %	S %
12,000 000 tons	0.18	7.50	0.40	0.01	0.54	42.85	51.35

The average grades of ore samples taken by the mission along the drift (Table 4.5 drift average) were applied to those of the deposit Fig. 4.4, Fig. 4.5).

It was thought that the average grades of the crosscut samples (Au 0.1 g/t, Ag 2.40 g/t, Cu 0.04 %) were representative of the accessible partial deposit, taking account of a tendency that the assay values of the ore samples, specially of copper and zinc, were relatively poor in the inner parts, though rich in the drift along the marginal zone of the deposit whose thickness appears to be several meters.

However, it seems problematic to look on the representative grade of the accessible partial deposit as that of the whole deposit, taking into consideration that an access to the all adits has been physically restricted and it has been said that an average copper grade of the deposit is more or less than 1% on the basis of the result of the drillings in 1973–1975.

The average grade of the ore samples taken by the mission along the drift (Table 4.5 drift average) is resemble to that of ore samples taken by Cia. Minera del Rio Murga along the all crosscuts and drifts in Rio Tinto adit No.1 and No.2 (Table 4.3, Au 0.27 g/t, Ag 7.31 g/t, Cu 0.62 %).

Consequently, the mission looked on the drift average grade as a representative one of the Rio Tinto deposit, though the followings are necessary to estimate more detailed ore reserves and grade.

Table 4.5 Assays of ore samples (Rio Tinto)

Sample No.	Location	Au g/t	Ag g/t	Cu %	Pb %	Zn %	Fe %	S %
K – 1	Drift	0.2	9	0.13	0.02	0.09	42.22	52.10
2	"	0.1	11	0.97	0.01	0.79	43.43	50.47
3	"	0.1	6	0.06	0.01	0.07	43.94	53.71
4	"	0.1	9	0.18	0.01	0.19	44.54	52.31
5	"	0.1	3	0.05	0.01	0.05	43.03	50.97
6	"	0.1	5	0.15	0.01	0.09	44.14	53.88
7	"	0.1	4	0.08	0.01	0.09	43.83	52.33
8	"	0.1	3	0.08	0.01	0.14	43.43	52.03
9	"	0.1	13	0.09	0.01	0.11	42.62	52.12
20	"	0.1	8	0.27	0.02	0.82	42.94	51.24
21	"	0.1	2	0.30	0.01	0.58	42.64	50.46
22	"	0.1	6	0.77	0.02	1.31	39.73	47.25
23	"	0.2	17	1.77	0.01	0.79	41.23	48.45
24	"	1.1	9	0.69	0.03	2.40	42.14	51.56
Drift average		0.18	7.50	0.40	0.01	0.54	42.85	51.35
10	Crosscut	0.1	4	0.24	0.01	0.05	42.02	49.58
11	"	0.1	4	0.03	0.01	0.04	44.24	51.64
12	"	0.1	2	0.02	0.01	0.05	43.53	50.93
13	"	0.1	2	0.01	0.01	0.04	44.03	52.33
14	"	0.1	2	0.01	0.01	0.04	44.44	52.22
15	"	0.1	2	0.02	0.01	0.03	44.24	52.56
16	"	0.1	2	0.06	0.01	0.07	45.65	52.93
17	"	0.1	2	0.02	0.01	0.07	43.74	49.92
18	"	0.1	2	0.01	0.01	0.05	39.83	46.42
19	"	0.1	2	0.01	0.01	0.04	41.34	48.34
Crosscut average		0.10	2.40	0.04	0.01	0.05	43.31	50.69

1) Collection and examination of assay maps made by Cia.
   Minera del Rio Murga using assay values of adit samples and diamond drill core.
2) Geological survey and sampling after additional reopening of the adits which have not been accessible.
3) Confirmation of location and cores of the diamond drillings.
4) Additional diamond drillings based on the above examination to confirm downward continuity and grades of the deposit.

4–2. CAMPO MORADO DEPOSITS

4–2–1. LOCATION AND ACCESS

The Campo Morado deposits are situated near the settlement of Campo Morado about 70 kilometers west-southwest of Iguala city in the northern part of the State of Guerrero (Fig. 4.1, Fig. 4.8). From the village of Villa de Ayala, which is along the iguala-Arcelia-Ciudad Atlamirano highway, an unpaved road leads to Campo Morado.

The main ore deposit, Reforma, is at Latitude 18° 10′ 30″ N and Longitude 100° 07′ 40″ W. Access and required time by jeep from Mexico city are as follows.

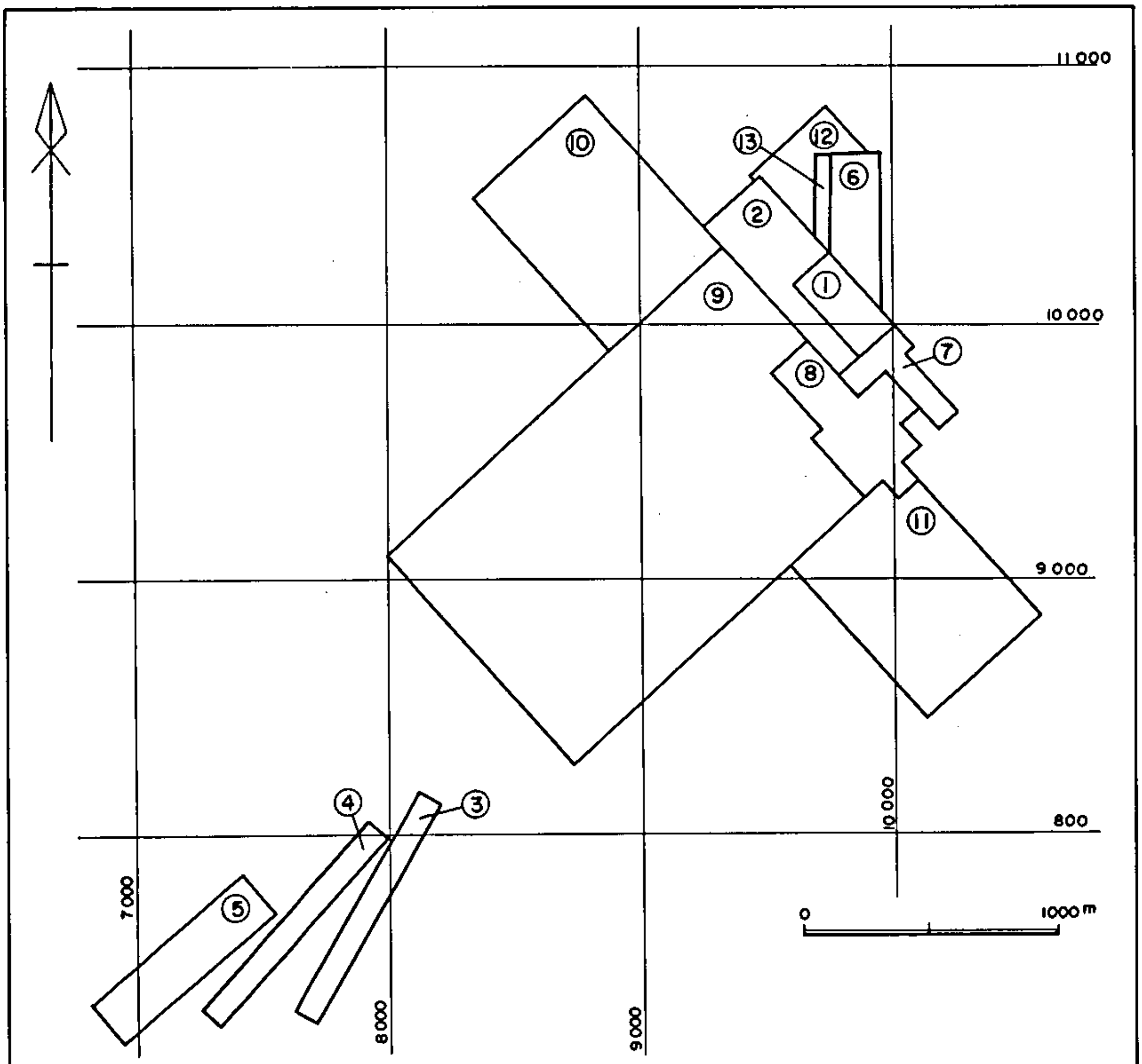
Mexico —(highway 180 Km / 2 hours)— Iguala —(highway 90 Km / 1 hour 30 minutes)— Villa de Ayala

—(dirty road 35 Km / 2 hours)— Campo Morado

It takes now more than 12 hours to get Lázaro Cárdenas city by jeep 710 kilometers from Campo Morado through Acapulco, though it is expected that the distance must be shorten to about a half when a construction of the Ciudad Altamirano - Zihuatanejo highway, which has been under construction, is completed.

4–2–2. PHYSIOGRAPHY

The Campo Morado property is on the northern slope of Sierra Madre del Sur mountain range and covers mountanous terrene of 1000 to 1500 meters above the sea level. The terrene is rugged and deeply dissected showing relative altitude of approximately 500 meters. Small blanch streams trending east-west flow into La Canita river, which is a



NAME OF CLAIM	NO. OF TITLE	SURFACE
① La Reforma	– T-10619	– 10.00 Has
② Amp. de La Reforma	– T 10620	– 14.00
③ La Purisima	– T 10621	– 10.00
④ El Porvenir	– T 10622	– 10.00
⑤ La Independenia	– T 10623	– 16.00
⑥ La Sonorense	– T 19821	– 10.15
⑦ Amp. de La Retorma	– T 19993	– 6.00
⑧ Otilia	– T 24133	– 18.00
⑨ El Naranjo	– T 24134	–184.00
⑩ Reforma Norte	– T 32306	– 48.00
⑪ Reforma Sur	– T 34648	– 47.00
⑫ Demasias de La Sonorense	– T 52190	– 9.50
⑬ Amp. de La Sonorense	– T 52545	– 1.50
		384.65 Has

Fig.4.6 Configuration of Campo Morado Mining claims

tributary of well known Balsas river situated at 15 kilometers south of Campo Morado. The Canita river has a current only in the rainy season.

Rainy and dry seasons are June to Octover and November to May respectively. Annual average temperature is 24 degrees to 26 degrees and precipitation is 1200 mm. Vegetation is scarce. Tall trees are roughly limited near the communities and along the tribulary. Pine, oak and mango are main trees.

4–2–3. PROPERTY

The claim configuration around the Campo Morado deposits is shown in Fig. 4.6. The property consists of 13 claims, which are titled and grouped in the sense of the Mexican mining law, covering 384.7 hectares. The owner, Cia. El Fenix de Campo Morado, can invest effectively on this property under favor of the grouped claims.

Its shareholders are Canute Corporation (62%) and Mexicans (38%). The former is a subsidiary of Chaise Manhattan Bank. The latter is composed of Family of Ortiz Mena.

According to the documents made by the Direccion de Mina, legally obligated exploration works have been carried out through Cia. Minera Rio Morado on contract basis with the owner.

4–2–4. HISTORY

The history of the Campo Morado mine is summed up as follows.

1890 : Discovery of massive sulphide ore deposit.

1903–1910 : Oxide zones of the Campo Morado deposits were extracted principally for gold and silver. Reforma ore deposit, the largest known occurrence for which a smelter was constructed in 1903, was extensively explored and exploited at Campo Morado. It is said that more than three thousands miners were working there.

1920–1927 : High grade pyrite and other high grade oxide ore were mined.

1937–1939 : Mine operation on a small scale were performed to maintain the concessions. Since then ,the mine was abandoned till 1971 because mainly of unfavorable results of flotation for the ore.

1971 : Chaise Manhattan Bank asked Mineral Industries Engineers Inc. to plan exploration works of 500,000 pesos which were equivalent to about 40,000 USD. Mineral Industries Engineers Inc. contracted with McPher Geophysics of Toronto, Canada which conducted I.P. method and resistivity method on the property.

1973 : Union Oil Co. of Los Angeles, U.S.A., which was interested in this project, looked for Mexican investors through its subsidiary Mineral Exploration Co. Ingenieros Civiles Asociados S.A. (ICA), which was one of the largest civil engineering campanies in Mexico, accepted to become associated Mexican partner of this exploration project.

1974–1976 : Cia. Minera Rio Morado S.A. (51% ICA, 49% Mineral Exploration Co.) was founded at minimum fixed capital of 500,000 pesos. Simultaneously with the constitution of the company a contract was signed between the company and El Fenix del Campo Morado for exploration with an option to purchase.

Also a contract was signed between the company and GEOCON, a subsidiary of Union Oil Co., covering a undertaking of studies and field works for verification of ore reserves, localization of new ore deposits and metallurgical studies to establish a smelting process.

The field program of the exploration works carried out by GEOCON was as follows.

1) Surface geological mapping
2) Reopening and advancing of 3,700 meters of shaft drifts and crosscuts and routine mine sampling in Level 5 and Level 6 of Reforma Adit.
3) Underground diamond drillings of 20 holes, which amount to 840 meters, in Level 6.
4) Bulk sampling for dressing test.

The investment for the exploration works and dressing studies amounts to 1,250,000 USD.

1980 : Cia. Minera Rio Morado S.A. canceled the contract. It seems that the cancellation is owing to mainly unfavorable result of the dressing studies.

4–2–5. GEOLOGICAL INVESTIGATION

Within an area of 30 square kilometers around Campo Morado, four medium-sized deposits (Reforma, Naranjo, La Lucha and Suriana) and several small deposits are known to exist. Among them Reforma is the largest, most extensively explored and exploited at Campo Morado and the others are not accessible physically (Fig. 4.7).

Consequently the mission gave priority to the Reforma deposit over the others on a target of the geological investigation. Six adits of Adit Level 1 to Level 6 in descending order were encountered there, though none of them was accessible except for Level 5 and Level 6 (Fig. 4.8, Fig. 4.9).

In these two adits, however, an acess to all the crosscuts and drifts has been restricted

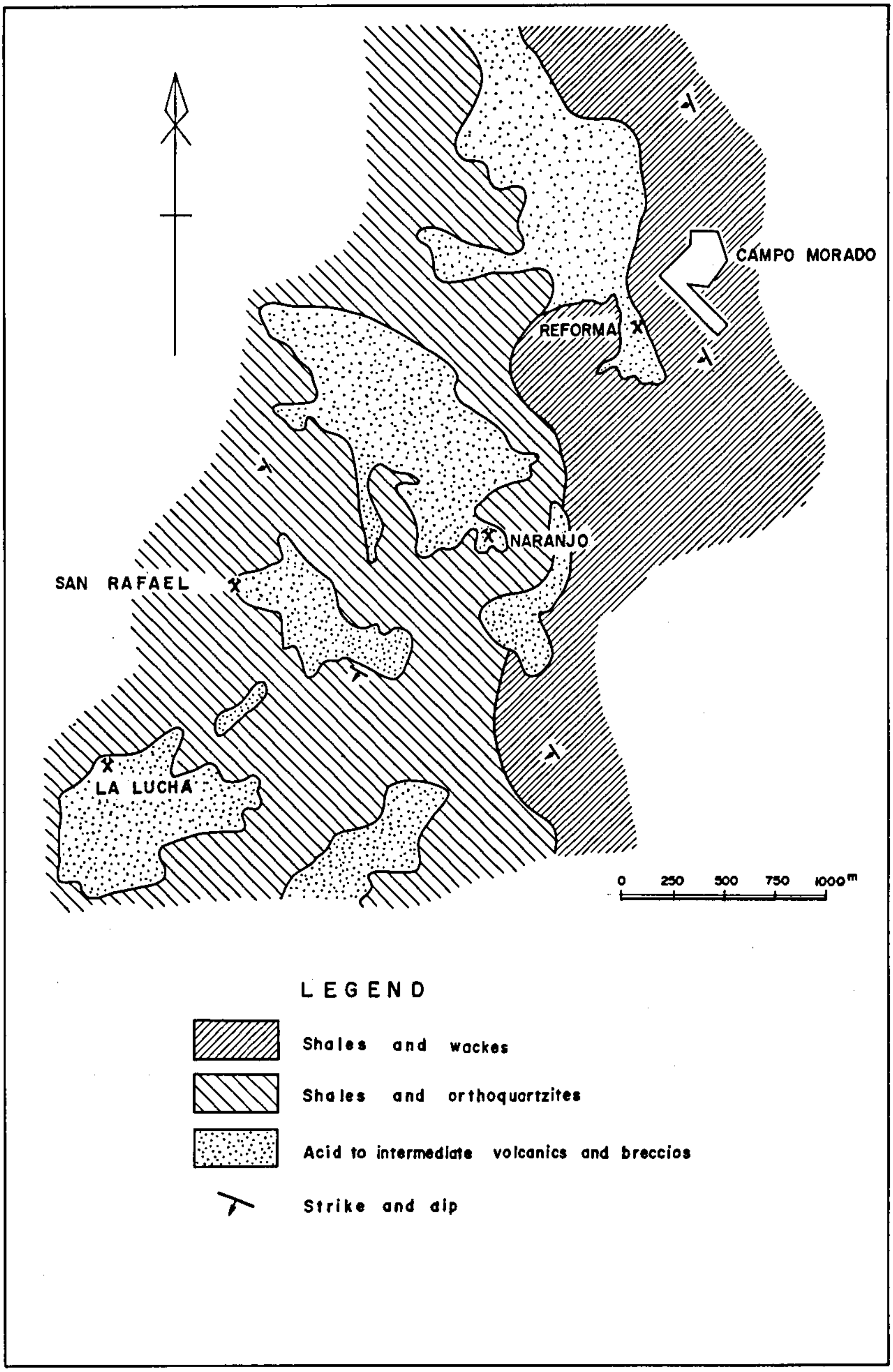


Fig.4.7 Simplified geology of the Campo Morado area (Lorinczi 1978)

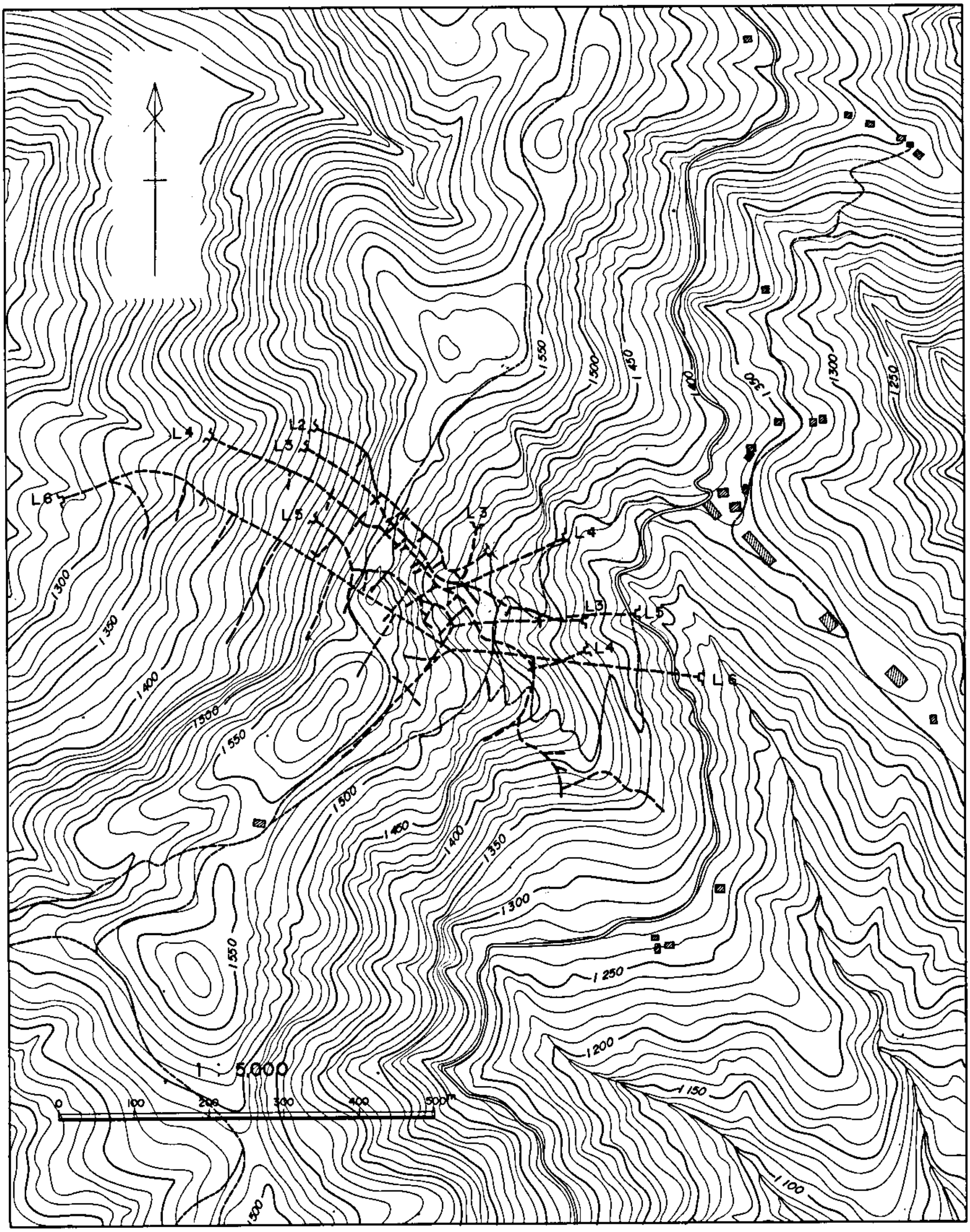


Fig.4.8 Topographic map of Campo Morado (Reforma)

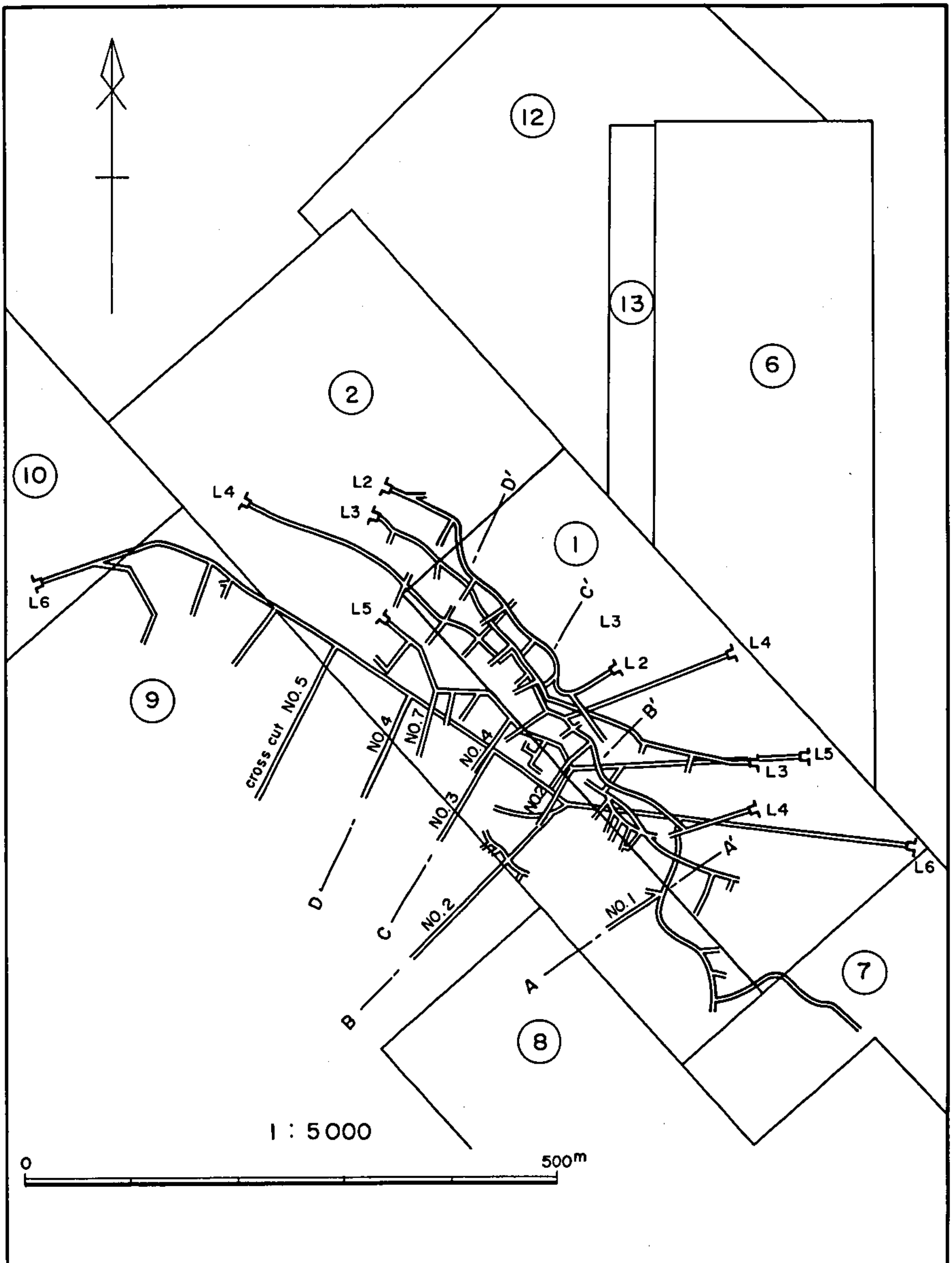


Fig.4.9 Underground Map of Campo Morado (Reforma)

owing to collapse and abnormally high temperature caused by oxidation of ore and insufficient natural ventilation, in spite of reopening works which had been performed prior to the investigation.

Consequently geological mapping and 2 meters channel sampling with 10 meters spacing along the accessible crosscuts and drifts have been performed by the mission. Also the mission has attained the following information regarding the Reforma deposit, which was useful for the geological investigation.

1)	Topographic map	1/5000
2)	Underground map of Adit Level 2 to Level 6	"
3)	Geological map of Adit Level 6	1/200
4)	Geological profiles betwen Level 5 and Level 6	"
5)	Assay of underground diamond drill core	

Eighteen ore samples which amount to 50 kilograms and 7 rock samples were collected. Further 20 samples which amount to 70 kilograms were gathered as a reference specimen at a stockpile near the entrance of Adit Level 6.

After coming back to Japan, these ore samples were analized chemically, of which 10 samples were also examined under microscope together with the rock samples (Fig. 4.10 – Fig. 4.12)

4–2–6. GEOLOGY

The Campo Morado (Reforma) deposit occurs in the volcano-sedimentary sequence of Lower Cretaceous age. The dating of the sequence is based on fossil identification evidence (G.I. Lorinczi and J.C. Miranda, 1978).

The rocks in this area are shale, wacke, sandstone, breccias, acidic lava and andesite. The sedimentary sequence has several fine pyroclastics and intraformational folding and slumping are occasionally encountered. Two types of wacke are common in the area : graywacke and tuffwacke. The former generally has lithic fragments as well as fragments of feldspar and quartz and the later has tuff and other fine pyroclastics in the matrix of clay minerals, chlorite and quartz. The volcanics are predominantly acidic with the most common being acidic pyroclastics and these are also conformable with the sediments. Several types of breccia have been identified in the area ; laharic breccia, lithic-quartz breccia, lithic breccia, etc. (Fig. 4.7, Fig. 4.13, Fig. 4.14).

The Campo Morado area has been undergone serious deformation resulting in some folds, though the sequence strikes generally north-westnorth and dips south-westsouth 10° – 75°. The sequence in the area have been suffered from low grade regional burial metamorphism.

The deposit, typical massive sulphide deposit, occurs in the volcano-sedimentary sequence and are peneconcordant with the country rocks. It is thought that the deposit do not keep the primary sequence but may be overturned (G.I. Lorinczi et. al. 1978). The evidence for overturning is as follows.

1) Pattern of drag folding in shale.
2) Reversed graded bedding.
3) Reversed compositional zoning within the massive sulphide.
4) Stratigraphical position of alteration zone.

The rock sequence, which was confirmed by the mission from northeast to southwest (from foot wall to hanging wall with reference to physical position) along No.2 crosscut in Reforma Adit L6, is as follows (Fig. 4.11).

1) Intercalated Shale and wacke.
2) Lithic breccia and lithic quartz breccia.
3) Massive pyrite.
4) Laharic breccia and lithic quartz breccia.
5) Quartz-Sericite-rock.
6) Intercalated shale and wacke.
7) Sericite-calcite-quartz-rock.
8) Altered rhyolite.

The result of microscopical observation of 5 rock samples taken by the mission along the crosscut No.2 is as follows (microphotographs are appended).

MR–2 : Lithic breccia

Blocks of the breccia consist mainly of shale and sandstone. The size of breccia varies from centimeters to several decimeters. The shape of the blocks ranges subangular to round type. Sericite veinlets make a network texture around quartz grains of sandstone. Pyrite and pyrrhotite dissemination is occasionally found with limonite bearing fissure around them.

MR–4 : Quartz-sericite rock

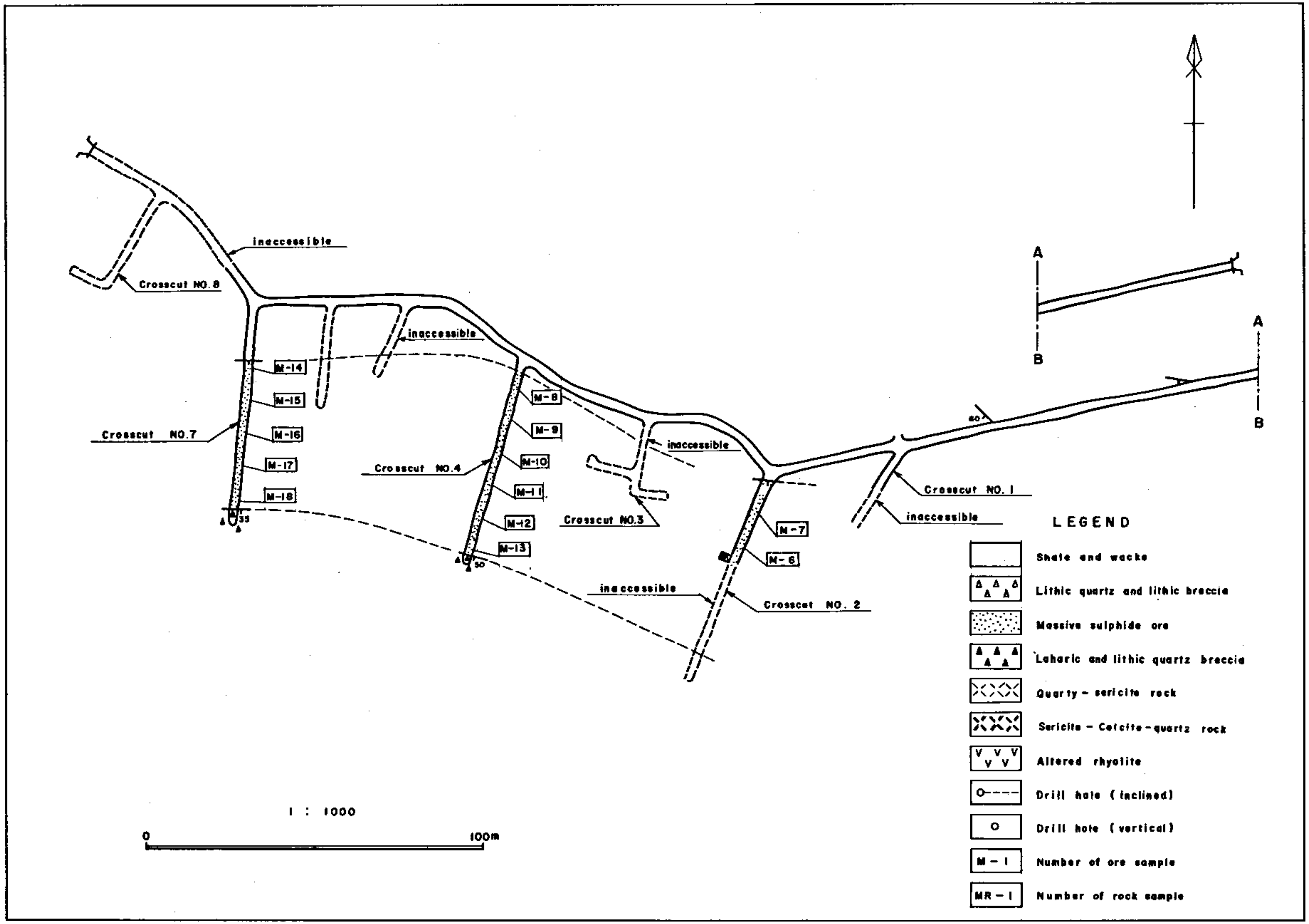


Fig.4.10 Geological map of Adit Level 5 (Campo Morado, Reforma)

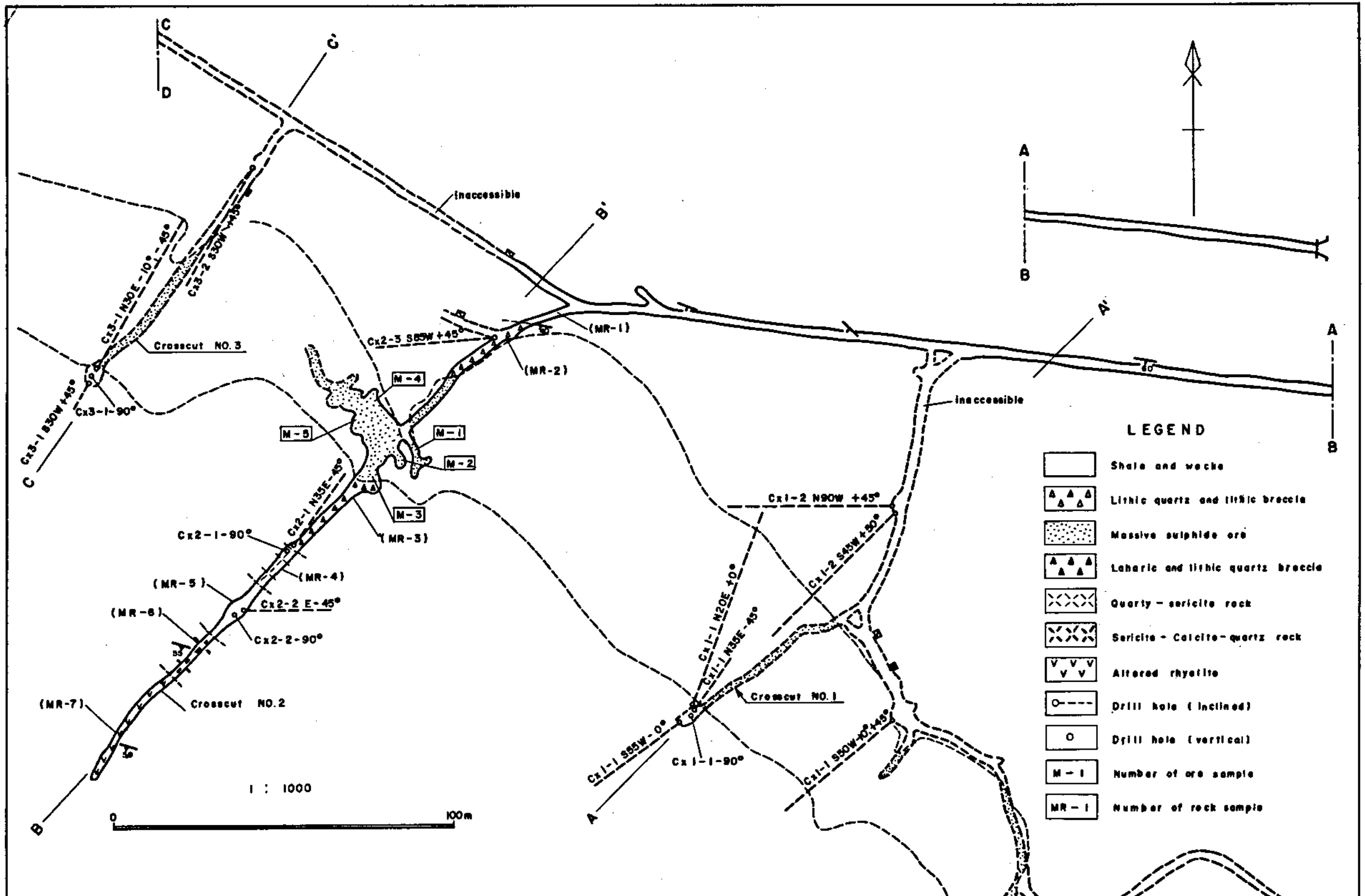


Fig. 4.11 Geological map of Adit Level 6 (Campo Morado, Reforma) I

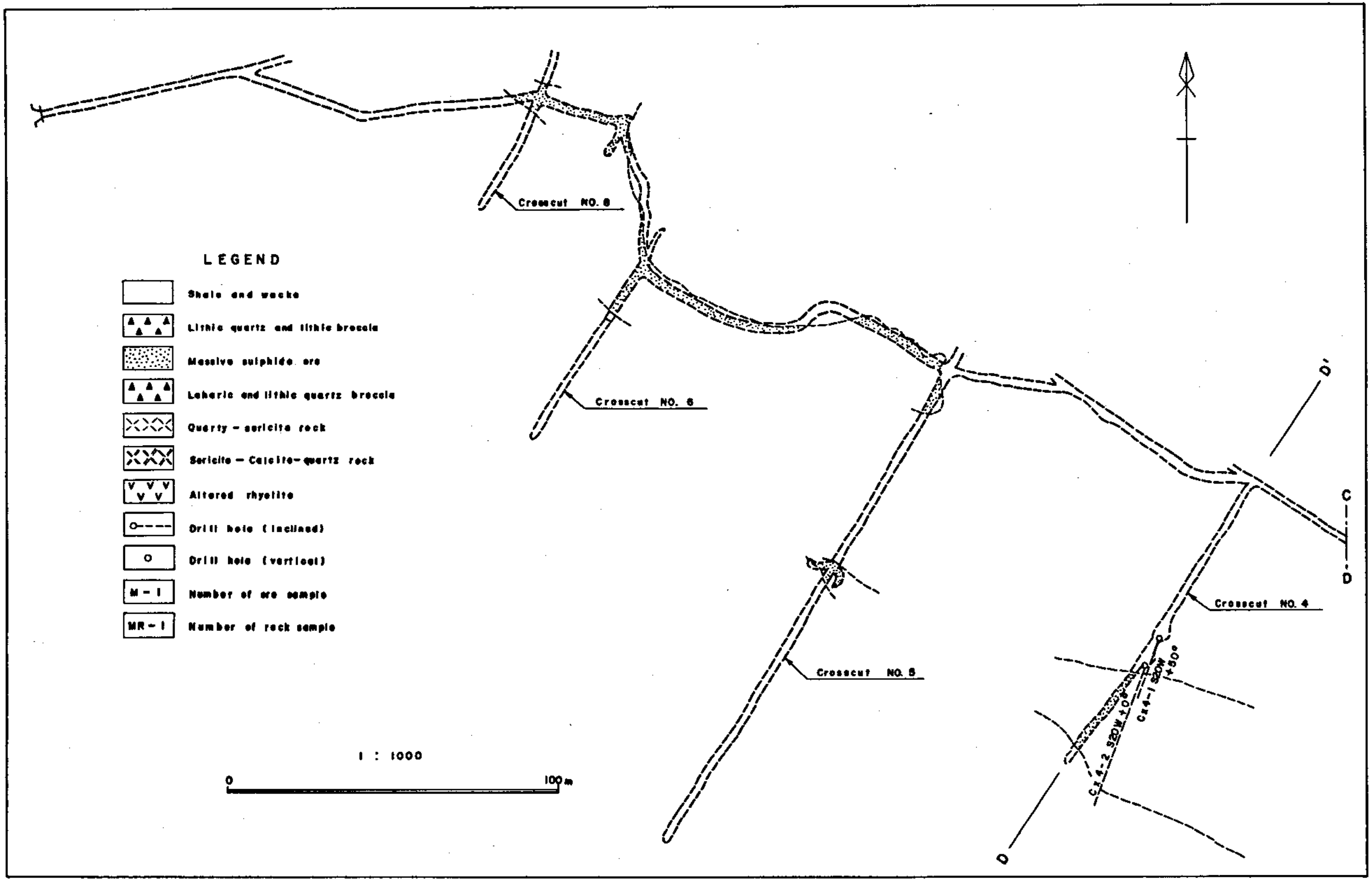


Fig. 4.12 Geological map at Adit Level 6 (Campo Morado, Reforma) II.

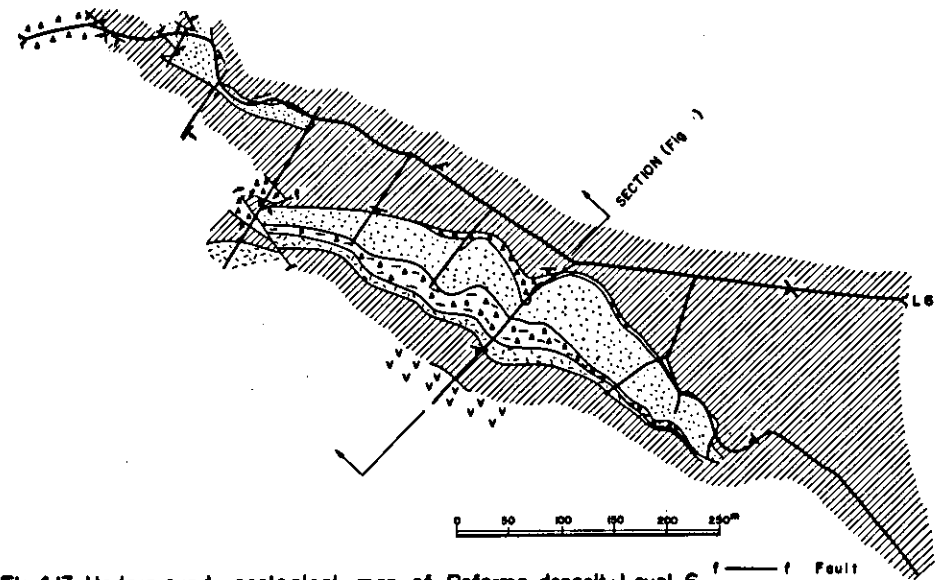


Fig.4.13 Underground geological map of Reforma deposit: Level 6
(Lorinczi 1978)

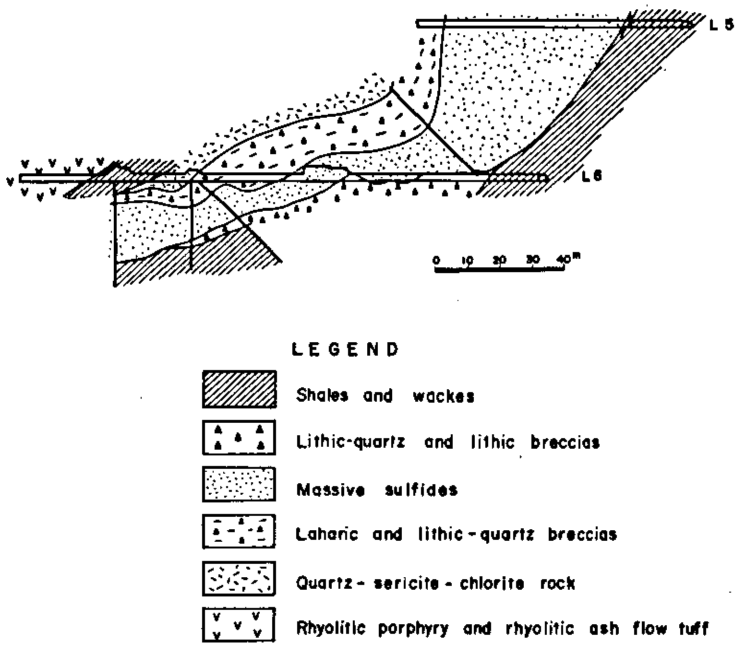


Fig.4.14 Cross section through Reforma deposit, looking northwest
(Lorinczi 1978)

It seems that the original rock is greywacke. Sericite flakes arrange along the foliation which is nearly parallel to the bedding plane of the original rock. Pyrite crystals of 0.05–0.1 mm in size are disseminated also along the foliation.

MR–5 : Shale (Black shale)

Very small flakes of illite and amorphous clay minerals are filling the matrix. Quartz grains of less than 0.05 mm are dominated in aggregate of carbonaceous materials and calcareous minerals.

MR–6 : Sericite-calcite-quartz rock

Fine grained quartz aggregate with textures of shale, sandstone or breccia is main body of the rock. Abundant small crystals of calcite and sericite occur along the foliation of the rock. Pyrite crystals of less than 0.05 mm occasionally occur together with calcite or sericite.

MR–7 : Altered rhyolite

Phenocrysts of euhedral high quartz of more than 1 mm are observed in the fine grained and carbonatized matrix. Abundant calcite and moderate amount of sericite are replacing groundmass along the foliation. A small amount of leucoxene is found in the matrix.

4–2–7. ORE DEPOSITS

Reforma deposit, the largest at Campo Morado, is of a typical massive sulphide peneconcordant with the volcano-sedimentary sequence. According to G.I. Lorinczi et. al, Economic Geology Vol. 73, 1978, a dimension of the deposit in Adit Level 6 is approximately 500 meters in strike length and 20 meters to 50 meters in thickness. The continuation of the ore body had been confirmed by underground drillings and crosscutting in the portion between 1,260 meters and 1,330 meters above the sea level. Also it is said that the ore body continues to the lower and upper parts of these levels (Fig. 4.13, Fig. 4.14).

The mission confirmed a dimension of 150 meters in length and 45 meters – 55 meters in thickness between accessible crosscut No.2 and crosscut No.7 in Adit L5, though only a thickness of 60 meters was recognized along accessible crosscut No.2 of Adit L6, because of restricting an aceess (Fig. 4.10 – Fig. 4.12).

The ore is composed by mainly pyrite which is finer than that of Copper King deposit. Physically lower parts of the ore body are rich in sphalerite and galena, also both assay values of ore samples taken by the mission and the underground drill core indicate that zinc, lead, gold and silver are concentrated in the parts.

It is said that a banded structure concordant with the boundary between the ore body and wall rocks is seen in the ore. Though the structure is recognized in only fresh core of underground diamond drill. Also the apparent structure, caused by a variation within pyrite grain size and compositional zoning, is observed in the ore of stockpile, though it is said that the ore was derived from crosscut No.3 in adit L6.

It is observed microscopically that the ore is mainly composed of mozaic aggregate of pyrite crystals of 0.01 – 0.2 mm in diameter, which are finer than those of Copper King deposit, with small cavities in various size. Most of the cavities are empty, though some of them are filled by quartz, chalcopyrite, sphalerite and galena. Pyrite crystals tend to be larger at the wall of the small cavities and the aggregate of pyrite crystals has zonal texture. Also a banded texture, caused by a variation of size and content of pyrite grains, is observed and chalcopyrite and sphalerite partly tend to concentrate in specific layer.

Chalcopyrite, sphalerite, galena and pyrrhotite fill the pores in pyrite aggregate or compose the matrix of the aggregate in addition to be contained in pyrite crystals as inclusions of less than 0.02 mm in diameter. Argentite is observed as a silver mineral.

The result of microscopical observation of the representative ore is as follows (microphotographs are appended).

M–1 : Pyrite ore.

The specimen is an aggregate of very fine grained pyrite crystals of 0.01 – 0.05 mm in diameter which has zonal texture and cubic euhedral form against small cavities in the aggregates. The size of pyrite crystals tends to be larger at the wall of the small cavity. Most of the cavities are empty but some of them are filled by quartz and occasionally chalcopyrite. Galena and sphalerite are rarely found in the same mode of occurrence as that of chalcopyrite.

M–3 : Pyrite ore.

The specimen is an aggregate of pyrite crystals of around 0.05 mm with many various size of cavities. Pyrite crystal has euhedral form against to the cavity. Chalcopyrite occurs in pyrite crystals as inclusions of less than 0.02 mm in diameter. Sphalerite occurs in the nearly same as the mode of occurrence of chalcopyrite, but the amount is less than the latter.

M–6 : Pyrite disseminated ore.

Pyrite grains of 0.05 mm – 0.2 mm in diameter are disseminated in the porous quartz aggregates. Chalcopyrite, sphalerite and pyrrhotite grains of less than 0.02 mm occur as inclusions in the pyrite crystals.

M–8 : Pyrite ore.

Sphalerite fills the pores in pyrite aggregates mainly along the fissure. Chalcopyrite, which is less in amount than sphalerite, occurs in the same as the mode of occurrence of sphalerite. Very few amount of galena is seen together with sphalerite or chalcopyrite. Main materials are pyrite grains of 0.01 – 0.1 mm in diameter with zonal texture and mozaic texture.

M–10 : Pyrite ore.

Matrix or pyrite mozaic aggregates is mostly filled by quartz and a little amount of siderite. Sphalerite, chalcopyrite and galena are seen with siderite and quartz. The size of pyrite crystals varies from 0.01 mm to 0.5 mm.

M–12 : Pyrite ore.

Coarse grained euhedral crystals of pyrite of 0.05 mm – 0.2 mm in diameter form a mozaic aggregate with interstitial quartz and siderite. Very fine grained crystals of pyrite of less than 0.01 mm arrange along the flowage in the specimen. Chalcopyrite and sphalerite are seen mostly in quartz and siderite rich part.

M–14 : Pyrite ore.

Networks of siderite veinlet with quartz fill the matrix of brecciated mozaic aggregate of pyrite crystals. The size of pyrite breccia varies from 1.0 mm to less than 0.001 mm. Very small amount of chalcopyrite, sphalerite and galena are occasionally found in the pyrite grains as inclusions of less than 0.01 mm in diameter.

M–16 : Pyrite ore.

Breccia of mozaic pyrite aggregate of several mm to less than 0.05 mm in diameter has matrix of mainly limonite which may be considered to be weathering product from siderite. Sphalerite and chalcopyrite mainly occur in the matrix of mozaic pyrite which has average grain size of 0.05 mm in diameter.

M–18 : Pyrite ore.

The specimen has banded texture caused by a variation of pyrite grain size and its content. Pyrite grains are fragments of mozaic aggregate of pyrite crystals of 0.05 mm – 0.2 mm in diameter. Matrix of pyrite aggregate fragments is filled mostly by quartz and partly siderite. Chalcopyrite and sphalerite tend to concentrate in specific layer.

M–19 : Pyrite disseminated ore.

The specimen was collected at stockpile near the entrance of adit Level 6. Distinct banded texture is dominated. The structure is caused by a variation of the content and size of pyrite grains in the matrix of quartz and siderite. Accicular aggregate of arsenopyrite crystals of 0.01 mm in average diameter surrounds the pyrite grains along the flowage texture parallel to that of sulfide minerals. Chalcopyrite, spahlerite and occasional galena are found mostly in siderite rich part.

4–2–8. ORE RESERVES AND GRADE

The mission has estimated the following ore reserves and grade of Reforma deposit using four geological profiles which include drill holes and crosscuts in main levels (Table 4.6).

Table 4.6 Ore reserves of Reforma deposit (1981)

Block	Reserves – tons		Au g/t	Ag g/t	Cu %	Pb %	Zn %
Drilling area	Provable	2,085,000	1.08	123.9	0.83	0.44	1.42
L6 ~ L5	"	1,977,000	0.89	70.6	0.89	0.71	1.65
Sub total		4,062,000	0.99	98.0	0.86	0.57	1.53
L5 ~ L3	Possible	4,282,000	0.70	92.9	0.80	0.63	1.19
Total		8,344,000	0.84	95.4	0.83	0.60	1.36

This basis used for the ore reserves calculation is shown in Fig. 4.15 – Fig. 4.18 and Table 4.7 – Table 4.13.

On a course of the calculation, the ore body was divided into three blocks of drilling area, L6–L5 and L5–L3 according to a quality of the geological information. On the drilling area, it was able to use the assay value made by GEOCON using drill cores splited at an interval of 1–2 meters. On the L6–L5 adjacent to the drilling area, the average grade was estimated on the basis of the assay values of the ore samples collected by the mission at an interval of 10 meters along the accessible crosscuts in Level 5 in addition to those of drill cores near the crosscuts. However, as no information of the grade and dimention of the ore body above Level 5 was available, the grade was valuated as much as the average grade of the crosscut samples taken in Level 5 and drill cores near Level 5 where was no crosscut. The dimention was presumed using underground maps of Level 4 and Level 3 (Fig. 4.9).

Table 4.7 Assays of Crosscut Ore Samples (Reforma)

Sample No.	Level	Au g/t	Ag g/t	Cu %	Pb %	Zn %	Fe %	S %
M– 1	Level 6	0.6	61	0.11	0.20	0.13	43.94	50.99
2	"	0.8	86	0.28	0.37	1.12	41.34	47.33
3	"	1.1	65	0.16	0.41	0.55	40.13	48.16
4	"	0.6	61	0.09	0.31	0.07	41.03	49.06
5	"	0.5	55	0.08	0.59	0.07	38.43	44.62
6	Level 5	0.1	36	0.28	0.91	1.36	24.48	28.59
7	"	0.8	59	0.26	2.88	3.26	37.42	43.33
8	"	2.4	117	0.33	0.48	1.98	42.54	51.37
9	"	2.0	85	0.57	1.05	2.31	43.14	46.70
10	"	0.3	11	0.46	0.05	0.24	36.92	41.29
11	"	0.1	15	0.57	0.21	1.66	34.51	29.98
12	"	0.1	18	0.60	0.02	0.45	27.69	22.76
13	"	0.9	117	4.88	0.02	0.21	36.92	42.73
14	"	2.8	173	0.11	0.34	0.08	38.12	40.95
15	"	2.3	129	0.14	2.52	0.91	42.54	51.56
16	"	0.1	44	0.31	0.16	1.28	42.94	47.74
17	"	0.1	40	0.31	0.26	0.98	42.34	44.94
18	"	0.1	18	0.69	0.03	0.22	38.22	35.09
Average grade		0.87	66.1	0.57	0.60	0.94	38.48	42.62

Table 4.8 Assays of Underground Drilling (Reforma)

Drill No.	Grade	Drill run (m)		Interval (m)	Au g/t	Ag g/t	Cu %	Pb %	Zn %
		From	To						
L6 CX1–2 S45W +50°	High	25.8	33.8	8.00	0.61	86.5	6.96	1.53	2.58
	Low	33.8	77.3	43.50	0.28	225.1	0.35	0.10	0.23
L6 CX1–1 N35E - 45°	Low	1.65	5.5	3.85	Tr.	Tr.	0.62	0.03	0.62
	High	5.5	15.95	10.45	1.07	58.2	0.53	0.24	1.42
L6 CX1–1 - 90°	High	9.9	18.0	8.10	5.62	177.6	0.64	0.23	2.12
L6 CX2–3 S85W +45°	Low	0	20.0	20.00	0.62	36.7	0.48	0.49	1.77
L6 CX2–1 N35E - 45°	Low	5.65	11.0	5.35	Tr.	8.0	0.32	0.30	1.61
	High	11.0	17.0	6.00	15.28	436.7	1.26	2.49	6.23
L6 CX2–1 - 90°	High	7.4	18.85	11.45	2.34	175.7	0.45	2.59	4.62
L6 CX2–2 - 90°	High	22.25	26.2	3.95	3.03	223.8	0.35	1.64	3.56
L6 CX3–3 S85W +45°	High	3.8	12.0	8.20	3.13	110.4	0.60	0.84	3.82
	Low	12.0	35.9	23.90	0.40	33.2	0.84	0.10	0.86
L6 CX3–1 N30E - 10°	Low	0	11.55	11.55	0.35	32.2	1.04	0.09	0.58
L6 CX3–1 N30E - 10°	High	11.55	36.05	24.50	2.65	75.8	0.31	0.75	3.57
L6 CX3–1 N30E - 45°	Low	5.15	11.25	6.10	0.05	43.0	1.25	0.11	0.70
L6 CX3–1 - 90°	High	7.9	14.9	7.00	6.15	100.9	0.45	0.91	8.17
L6 CX4–1 S20W +50°	High	11.5	20.2	8.70	1.76	62.0	0.53	0.83	2.70
	Low	20.2	26.95	6.75	1.27	31.3	0.67	0.03	0.57
L6 CX4–2 S20W + 0°	High	2.95	30.15	27.20	1.60	59.6	0.51	0.47	2.48
	Low	30.15	43.0	12.85	0.37	40.8	0.46	0.18	0.93

Table 4.9. **Basis of Ore Reserves Calculation (Profile A – A′)**

Block		Area m^2	Au g/t	Ag g/t	Cu %	Pb %	Zn %
Drilling area	1	607	1.14	75.4	2.98	0.73	1.90
	2	1,774	0.26	208.0	0.37	0.09	0.26
		2,381	0.48	174.2	1.04	0.25	0.68
L6 – L5	3	340	0.28	225.1	0.35	0.10	0.23
	4	200	0.61	86.5	6.96	1.53	2.58
		540	0.40	173.8	2.80	0.63	1.85
Sub-total		2,921	0.47	174.1	1.36	0.32	0.76
L5 – L3	5	2,329	0.33	203.6	1.38	0.32	0.60
Total		5,250	0.41	187.2	1.37	0.32	0.69

Table 4.10. **Basis of Ore Reserves Calculation (Profile B – B′)**

Block		Area m^2	Au g/t	Ag g/t	Cu %	Pb %	Zn %
Drilling area	1	368	6.41	262.2	0.68	2.44	4.98
	2	720	0.49	30.7	0.45	0.45	1.74
		1,088	2.49	109.0	0.53	1.12	2.83
L6 – L5	3	1,050	0.62	36.7	0.48	0.49	1.77
	4	740	0.45	47.5	0.27	1.90	2.31
		1,790	0.55	41.2	0.39	1.07	1.99
Sub-total		2,878	1.28	66.8	0.44	1.09	2.31
L5 – L3	5	3,463	0.55	41.1	0.40	1.06	1.99
Total		6,341	0.88	52.8	0.42	1.07	2.14

Table 4.11. **Basis of Ore Reserves Calculation (Profile C – C′)**

Block		Area m^2	Au g/t	Ag g/t	Cu %	Pb %	Zn %
Drilling area	1	318	3.22	86.7	0.39	0.79	4.23
	2	972	0.40	33.2	0.84	0.10	0.86
		1,290	1.09	46.4	0.73	0.27	1.69
L6 – L5	3	1,193	0.37	37.5	1.31	0.09	0.73
	4	864	2.46	103.6	0.49	0.79	2.62
		2,057	1.25	65.3	0.97	0.38	1.52
Sub-total		3,347	1.19	58.0	0.87	0.34	1.59
L5 – L3	5	2,763	0.97	60.5	1.24	0.31	1.14
Total		6,110	1.09	59.1	1.04	0.33	1.39

Table 4.12. **Basis of Ore Reserves Calculation (Profile D – D')**

Block		Area m^2	Au g/t	Ag g/t	Cu %	Pb %	Zn %
Drilling area	1	240	1.64	60.2	0.51	0.56	2.52
	2	240	0.68	37.5	0.53	0.13	0.81
		480	1.16	48.9	0.52	0.35	1.67
L6 – L5	3	355	0.45	29.7	0.55	0.11	0.59
	4	489	1.38	78.5	0.33	1.17	1.62
	5	110	2.80	173.0	0.11	0.34	0.08
		954	1.20	71.2	0.39	0.68	1.06
Sub-total		1,434	1.19	63.7	0.43	0.57	1.26
L5 – L3	6	2,743	1.08	80.8	0.31	0.66	0.70
Total		4,177	1.12	74.9	0.35	0.63	0.89

Table 4.13. **Basis of Ore Reserves Calculation of Reforma Deposit**

Block	Profile No.	Area m^2	Length m	S.G.	Reserves	Au g/t	Ag g/t	Cu %	Pb %	Zn %
Drilling area	A – A'	2,381	110	4	1,047,640	0.48	174.2	1.04	0.25	0.68
	B – B'	1,088	100	4	435,200	2.49	109.0	0.53	1.12	2.83
	C – C'	1,290	85	4	438,600	1.09	46.4	0.73	0.27	1.69
	D – D'	480	85	4	163,200	1.16	48.9	0.52	0.35	1.67
					2,084,640	1.08	123.9	0.83	0.44	1.42
L6 – L5	A – A'	540	110	4	237,600	0.40	173.8	2.80	0.63	1.85
	B – B'	1,790	100	4	716,000	0.55	41.2	0.39	1.07	1.99
	C – C'	2,057	85	4	699,380	1.25	65.3	0.97	0.38	1.52
	D – D'	954	85	4	324,360	1.20	71.2	0.39	0.68	1.06
					1,977,340	0.89	70.6	0.89	0.71	1.65
Sub-total					4,061,980	0.99	98.0	0.86	0.57	1.53
L5 – L3	A – A'	2,329	110	4	1,024,760	0.33	203.6	1.38	0.32	0.60
	B – B'	3,463	100	4	1,385,200	0.55	41.1	0.40	1.06	1.99
	C – C'	2,763	85	4	939,420	0.97	60.5	1.24	0.31	1.14
	D – D'	2,743	85	4	932,620	1.08	80.8	0.31	0.66	0.70
					4,282,000	0.70	92.9	0.80	0.63	1.19
Total					8,343,980	0.84	95.4	0.83	0.60	1.36

	Area m²	Au g/t	Ag g/t	Cu %	Pb %	Zn %	Basis of the mean
①	532	0.87	70.5	3.32	0.80	1.92	Cx1-2 S45W +50° & Cx1-1 N35E -45°
	75	3.06	110.4	0.58	0.24	1.73	Cx1-1 N35E -45° & Cx1-1 -90°
Sub-total	607	1.14	75.4	2.98	0.73	1.90	
②	1,774	0.26	208.0	0.37	0.09	0.26	Cx1-2 S45W +50° & Cx1-1 N35E -45°
③	340	0.28	225.1	0.35	0.10	0.23	Cx1-2 S45W +50° 43.5 m
④	200	0.61	86.5	6.96	1.53	2.58	Cx1-2 S45W +50° 8.0 m
⑤	2,329	0.33	203.6	1.38	0.32	0.60	Cx1-2 S45W +50° 51.5 m

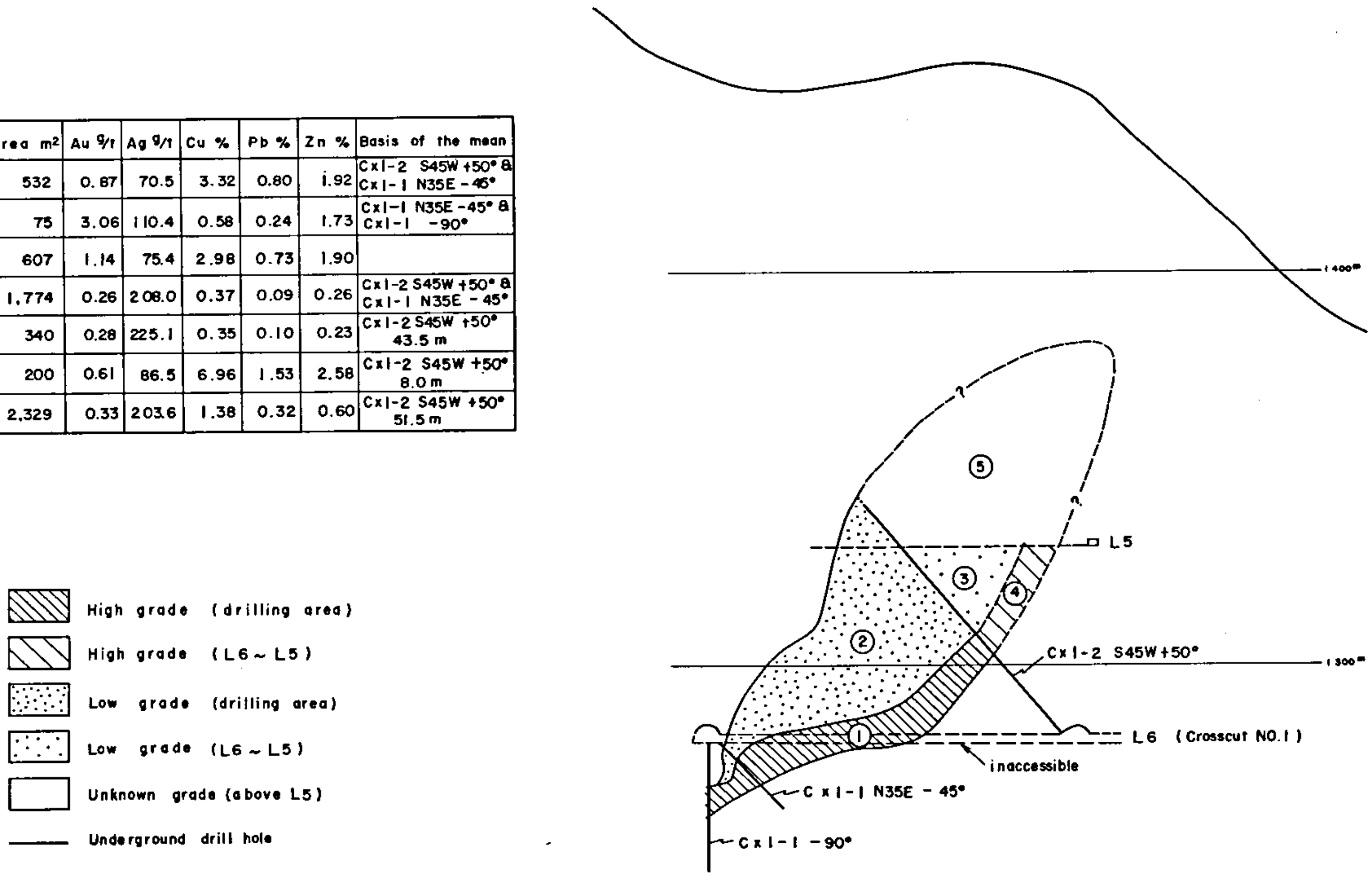


Fig.4.15 Profile of Reforma deposit A - A'

See: Fig. 4.11

	Area m²	Au g/t	Ag g/t	Cu %	Pb %	Zn %	Basis of the mean
①	78	15.28	436.7	1.26	2.49	6.23	Cx 2-1 N35E -45°
	102	6.79	265.4	0.73	2.56	5.17	Cx 2-1 N35E-45° & Cx 2-1 -90°
	188	2.52	188.1	0.42	2.35	4.35	Cx 2-1 -90° & Cx 2-2 -90°
Sub-total	368	6.41	262.2	0.68	2.44	4.98	
②	720	0.49	30.7	0.45	0.45	1.74	Cx 2-3 S85W+45° & Cx 2-1 N35E -45°
③	1,050	0.62	36.7	0.48	0.49	1.77	Cx 2-3 S85W +45°
④	740	0.45	47.5	0.27	1.90	2.31	L5 M-6, M-7
⑤	3,463	0.55	41.1	0.40	1.06	1.99	L5 M-6, M-7 & Cx2-3 S85W + 45°

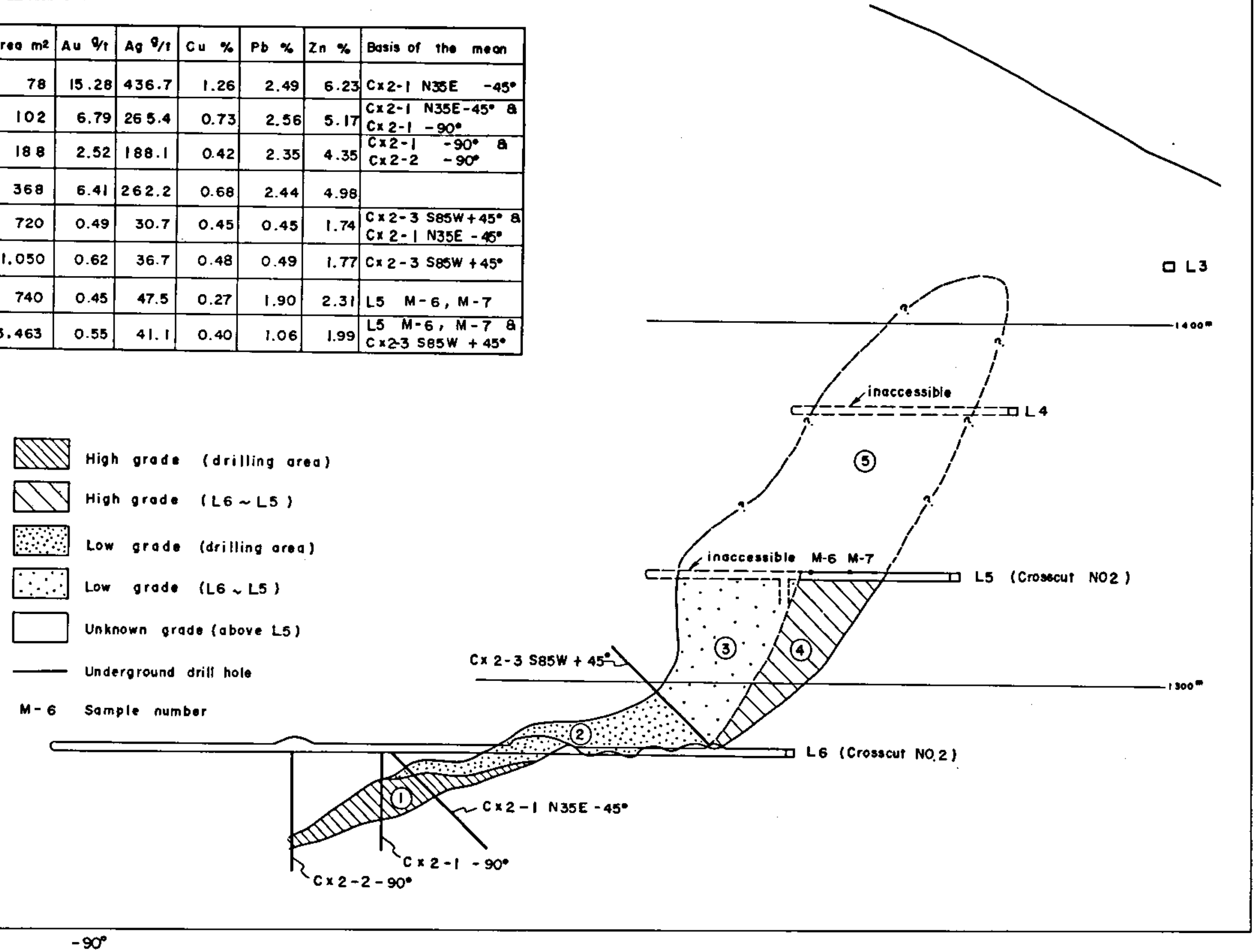


Fig. 4.16 Profile of Reforma deposit B - B'

See : Fig. 4.11

	Area m²	Au g/t	Ag g/t	Cu %	Pb %	Zu %	Basis of the mean
①	276	2.77	84.5	0.38	0.77	3.63	Cx3-3 S85W+45° & Cx3-1 N30E-10°
	42	6.15	100.9	0.45	0.91	8.17	Cx3-1 -90°
Sub-total	318	3.22	86.7	0.39	0.79	4.23	
②	917	0.41	32.9	0.82	0.10	0.87	Cx3-3 S85W+45° & Cx3-1 N30E -10°
	25	0.24	35.9	1.11	0.10	0.62	Cx3-1 N30E-10° & Cx3-1 N30E -45°
	30	0.05	43.0	1.25	0.11	0.70	Cx3-1 -90°
Sub-total	972	0.40	33.2	0.84	0.10	0.86	
③	1,193	0.37	37.5	1.31	0.09	0.73	Cx3-3 S85W+45° & L5 M-10 ~ M-13
④	864	2.46	103.6	0.49	0.79	2.62	Cx3-3 S85W+45° & L5 M-8, M-9
⑤	2,763	0.97	60.5	1.24	0.31	1.14	L5 M-8 ~ M-13

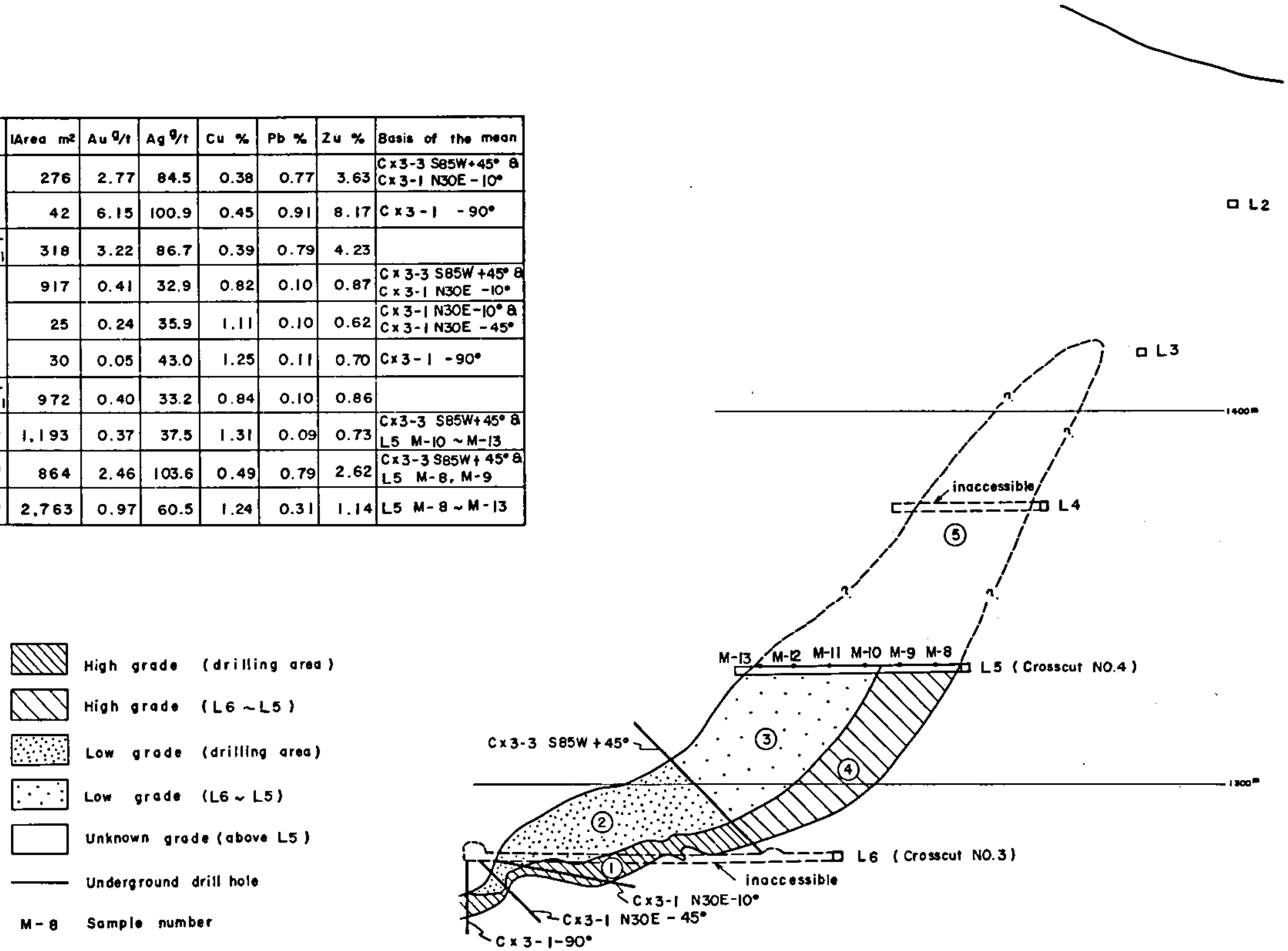
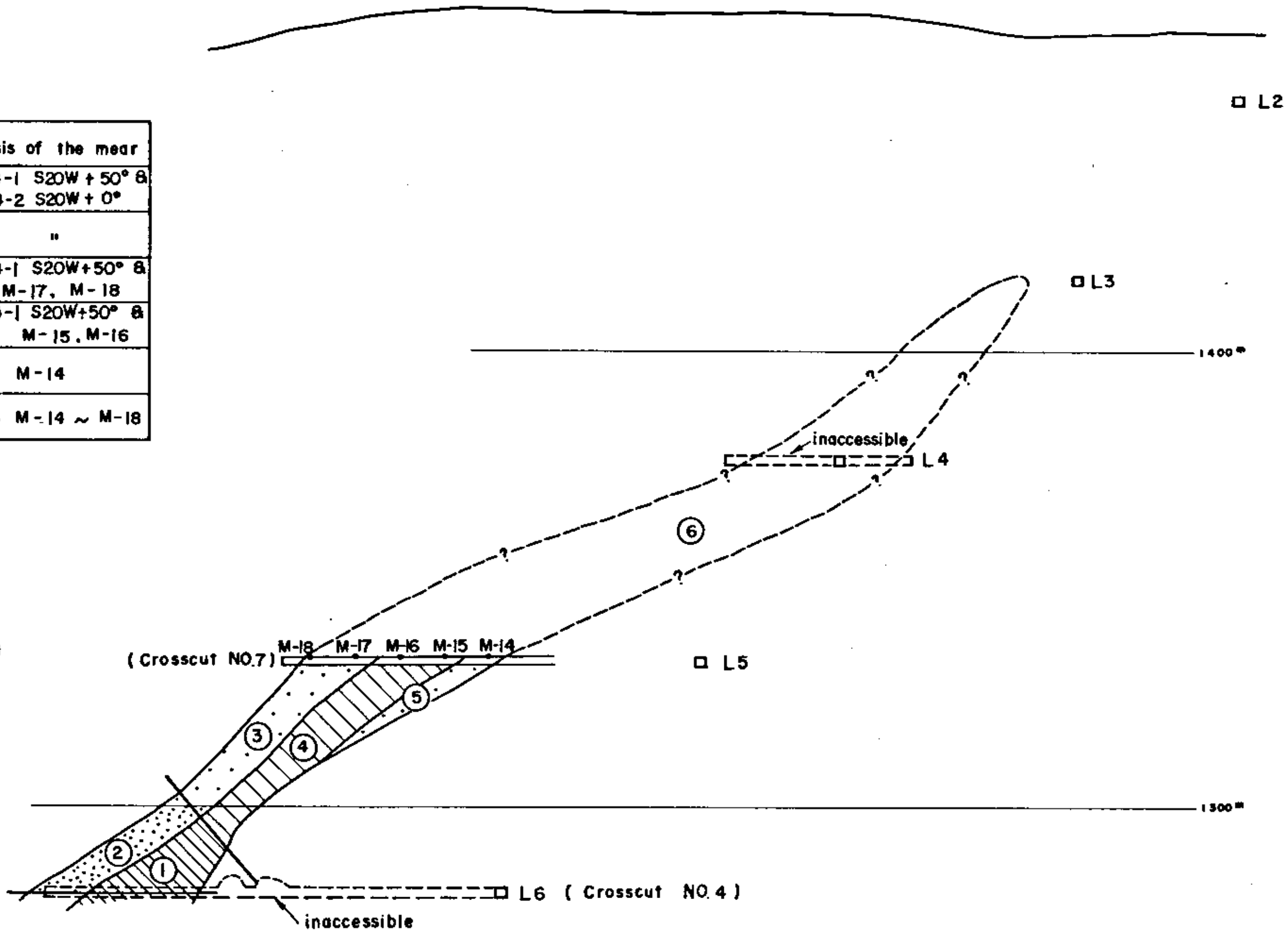


Fig. 4.17 Profile of Reforma deposit C - C'

See: Fig. 4.11

	Area m²	Au g/t	Ag g/t	Cu %	Pb %	Zn %	Basis of the mear
①	240	1.64	60.2	0.51	0.56	2.52	Cx4-1 S20W + 50° & Cx4-2 S20W + 0°
②	240	0.68	37.5	0.53	0.13	0.81	"
③	355	0.45	29.7	0.55	0.11	0.59	Cx4-1 S20W+50° & L5 M-17, M-18
④	489	1.38	78.5	0.33	1.17	1.62	Cx4-1 S20W+50° & L5 M-15, M-16
⑤	110	2.80	173.0	0.11	0.34	0.08	L5 M-14
⑥	2,743	1.08	80.8	0.31	0.66	0.70	L5 M-14 ~ M-18



- High grade (drilling area)
- High grade (L6 ~ L5)
- Low grade (drilling area)
- Low grade (L6 ~ L5)
- Unknown grade (above L5)
- Underground drill hole
- M-14 Sample number

Fig.4.18 Profile of Reforma deposit D - D' See : Fig. 4.12

The ore body below Level 5 was subdivided into high and low grade lead-zinc parts, as the assay values of the drill core and crosscut camples suggested a general tendency that comparatively high grade lead-zinc ores were concentrated to the lower part of the ore body with reference to physical position.

On the other hand, GEOCON had delineated the following ore reserves after the realization of 20 diamond drillings in Adit Level 6 and crosscut explorations in Level 6 and Level 5 (Table 4.14).

Table 4.14 Ore reserves of Reforma deposit (GEOCON)

Block	Reserves	tons	Au g/t	Ag g/t	Cu %	Pb %	Zn %
Drilling area	Proved	2,248,000	1.2	111.8	0.68	1.07	3.12
L6 ~ L4	Provable	7,200,000					
Total		9,448,000	(1.2)	(111.8)	(0.68)	(1.07)	(3.12)

It seems that the proved reserves are correspond to reserves of drilling area, and the grades are based on the assay of the drill cores splited at an interval of 1 to 2 meters in addition to ore samples taken by GEOCON along the main crosscuts. It is said that the grades of the provable reserves are nearly same to those of the proved reserves.

There is a difference between both average grades of lead and zinc estimated by the mission and GEOCON. The difference seems to be caused by that an access to the main crosscuts, where ore sampling had been done by GEOCON, have been physically restricted as mentioned before and/or other matters.

Therefore, the followings are necessary to extimate more detaited ore reserves and grade clearing up the question.

1) Collection and examination of assay maps made by GEOCON and anterior mine owners which have not been available.
2) Geological survey and sampling after additional reopening of the main crosscuts in Level 6, Level 5 and specially Level 4 on which no geological information has

been available.

3) Diamond drillings based on the result of the geological survey to confirm both downward and upward continuity of the Reforma deposit.

It seems that the provable reserves and ore grades below L5, estimated by the mission, will not be exchanged remarkably, because the main crosscuts in Adit L5 were accessible except for a part, in addition to be able to use the assay values of underground drill core. Additional ore reserves are expected after drillings, as a farther downward continuity of the ore body has not been confirmed.

However, it is necessary to revaluate the possible reserves and ore grade above L5, which were not based on any reliable information as mentioned before, through geological survey and sampling after reopening of main crosscuts, specially in Adit L4.

On the basis of the geological investigation and information obtained this time, the mission has adopted the average grade of Reforma deposit estimated by GEOCON as a representative grade of the deposit. The average grade had been published through Economic Geology (1978) by Mrs. Lorinczi and Miranda who have been engaged in the prospecting works as geologists of GEOCON.

A reason of the adoption is as follows.

1) GEOCON had estimated the average grade of drilling area on the basis of assay values of drill core and ore sample taken along the all main crosscuts in L6. On the other hand, the access to the all main crosscuts has been physically restricted, though the information of the drillings has been available for the mission.

2) It is said that the grade of L6–L4 is similar to that of drilling area. It seems that the estimation of the grade is based on assay maps of adit L4 in addition to those of L6 and L5 which have not been available for the mission, though the method of the estimation is not clear. In regard to the ore body above L5, the grade was evaluated by the mission as much as the average grade of crosscut samples taken in L5 or that of drill core near L5 where was no crosscut, as no information of the grade was available. The dimension was presumed using underground maps of L4 and L3 (Fig. 4.9).

3) On the basis of the above results, it was considered that the average grade

estimated by GEOCON was more suitable, though it is necessary to reconfirm the ore reserves and grade.

4–3 ESTIMATION OF ORE RESERVES AND GRADE

4–3–1 COPPER KING DEPOSITS

The mission has estimated the following ore reserves and grade of Rio Tinto deposit on the basis of the result of geological investigation of accessible crosscut and drift in Rio Tinto adit No.2 and information obtained this time (Table 4.4).

Table 4.4 Ore reserves of Rio Tinto deposit (Mission 1981)

Possible reserves	Au g/t	Ag g/t	Cu %	Pb %	Zn %	Fe %	S %
12,000,000 tons	0.18	7.50	0.40	0.01	0.54	42.85	51.35

The ore reserves were estimated presuming a dimension of 400 meters in length, 60 meters in thickness and 120 meters in width and specific gravity 4.0 (Fig. 4.4, Fig. 4.5). It is necessary to carry out geological survey after reopening of adits, which has not been accessible, and confirm data of the drillings to estimate detailed ore reserves. Also, additional drillings based on the examination are necessary to confirm downward continuity of the deposit.

The average grades of the ore samples taken by the mission along the drift were applied to those of the deposit (Table 4.5 drift average, Fig. 4.4, Fig. 4.5). The reason is as follows.

1) It was thought that the average grades of the crosscut samples (Table 4.5 crosscut average, Au 0.1 g/t, Ag 2.40 g/t, Cu 0.04 %) were representative of the accessible partial deposit, taking account of a tendency that the assay values of the ore samples, specially of copper and zinc, were relatively poor in the inner parts, though rich in the drift along the marginal zone of the deposit whose thickness appears to be several meters.
2) However, it seems problematic to look on the representative grade of the accessible partial deposit as that of the whole deposit, taking into consideration

that an access to the all adits has been physically restricted and it has been said that an average copper grade of the deposit is more or less than 1% on the basis of the result of the drillings in 1973–1975.

3) The average grade of the ore samples taken by the mission along the drift (Table 4.5 drift average) is resemble to that of ore samples taken by Cia. Minera del Rio Murga along the all crosscuts and drifts in Rio Tinto adit No.1 and No.2 (Spring 1972, Table 4.3, Au 0.27 g/t, Ag 7.31 g/t, Cu 0.62 %).

4) Consequently, the mission looked on the drift average grade as a representative one of the Rio Tinto deposit, though the followings are necessary to estimate more detailed grade.

a. Geological survey and ore sampling after reopening of the crosscuts and drifts which have not been accessible.

b. Collection and examination of assay map made by Cia. Minera del Rio Murga using assay values of adit samples and diamond drill core.

4–3–2 CAMPO MORADO DEPOSITS

The mission has estimated the following ore reserves and grade of Reforma deposit on the basis of the geological investigation of the accessible crosscuts in adit L6 and L5 and the information obtained this time (Table 4.14).

Table 4.15 Ore reserves of Reforma deposit (Mission 1981)

Ore reserves	Au g/t	Ag g/t	Cu %	Pb %	Zn %	Fe %	S %
8,344,000 tons	1.2	111.8	0.68	1.07	3.12	40.98	40.00

The ore reserves were estimated each one of the three blooks (drilling area, L6–L5 and L5–L3) divided according to a quality of the information of the deposit (Fig. 4.9 – Fig. 4.12, Fig. 4.15 – Fig. 4.18, Table 4.6 – Table 4.13).

Concerning the former two of the three blooks, an assay of the underground diamond drill core and geological map of L6 were available, in addition to the geological information taken by the mission in the accessible crosscuts in L6 and L5. However, a dimension of the deposit in L5–L3 was presumed using underground map of L4 and L3, because no information was available (Fig. 4.9).

Consequently, it is necessary to confirm the possible ore reserves of L5–L3 on the basis of the result of geological survey, specially of main crosscuts of L4, after reopening them in addition to collection and examination of ore distribution maps.

Additional ore reserves are expected underneath the ore deposit by drilling, because a downward continuity of the deposit has scarcely been confirmed. Also, the ore reserves will be increased by additional exploration, as several zones of similar mineralization have been known around there.

The mission has adopted the average grade of Reforma deposit estimated by GEOCON (Table 4.13) as a representative grade of the deposit. The average grade had been published through Economic Geology (Vol. 73, 1978). A reason of the adoption is as follows.

1) GEOCON had estimated the average grade of drilling area on the basis of assay values of drill core and ore samples taken along the all main crosscuts in L6. On the other hand, an access to the all main crosscuts has been physically restricted, though the information of the drillings has been available for the mission.
2) It is said that the grade of L6–L4 is similar to that of the drilling area. It seems that the estimation of the grade is based on assay maps of adit L4 in addition to those of L6 and L5 which have not been available for the mission, though the method of estimation is not clear. The mission could estimate the grade of L6–L5 using the assay of drill core and ore samples taken by him along the accessible crosscuts in L5, though the grade of L5–L3 was evaluated by him as much as the average grade of crosscut samples taken in L5 or that of drill core near L5 where was no crosscut, as no information of the grade was available.
3) Consequently, it was considered that the average grade estimated by GEOCON is more suitable, though the followings are necessary to estimate more detailed grade.
   a. Collection and examination of assay map made by GEOCON.
   b. Geological survey and ore sampling after reopening of L6, L5 and specially L4 on which no information has been available.

As no information of grades of iron and sulphur made by GEOCON was available, the grades were evaluated by the mission as much as those of the sample prepared by him for the dressing test. The sample was prepared by means of mixing of ore samples, taken along the crosscuts in L6 and L5, taking into consideration to bring the grades of gold, silver, copper, lead and zinc close to those estimated by GEOCON.

5 MINERAL PROCESSING TEST

5. MINERAL PROCESSING TEST

5–1 TEST RESULT

5–1–1 MINERALOGICAL STUDIES

Campo Morado "A" (sample No.1–18), Campo Morado "B" (sample No.19.6–19.20), Campo Morado "H" (sampled by a member of the first mission), and Copper King (sample No.1–25) were prepared for flotation tests. Mineralogical studies were carried out on these samples from the viewpoint of mineral processing. The results of complete chemical analysis are shown in Table 5–1.

1) Campo Morado ore

The elements of Fe, Zn, Cu, Pb, As, Sb, S, Ag, Cd are detected by X-ray fluoresence analysis and the minerals of pyrite, sphalerite, chalcopyrite, siderite and quartz are identified by X-ray diffraction analysis.

Optical microscopic observation revealed that Campo Morado ore consists of pyrite, as a predominant mineral, pyrrhotite, sphalerite, chalcopyrite, galena, tetrahedrite, arsenopyrite, and a minor amount of anglesite and electrum mostly in the form of small sizes, and that these sulfide minerals were intimately intergrown with each other. It is also suggested that liberation between sulfide minerals is relatively difficult though the ore is finely ground. Investigation by EPMA revealed that silver is held in tetrahedrite, argentite and electrum.

2) Copper King ore

The elements such as Fe, Zn, Cu, S, Ca, K, Ti are detected by X-ray fluoresence analysis and the minerals of pyrite and quartz are identified by X-ray diffraction analysis.

Pyrite is observed under microscope such that the grain is significantly large without other sulfide minerals, but that some carries a small amount of chalcopyrite, sphalerite and covellite in small sizes as inclusions. The ore is relatively coarse-grained as mentioned above and the liberation between pyrite and gangue minerals can be satisfactorily obtained at a coarse grind.

5–1–2 GRINDABILITY TEST

Work indexes (Wi) were obtained by standard procedure. Wi of Campo Morado "A", Campo Morado "B" and Copper King are 13.4, 15.6 and 8.5, respectively. It is considered that Campo Morado ore is relatively hard from Wi data, but that Copper King ore is much harder to grind to smaller sizes such as minus 400 mesh from another grinding test as shown in Table 5–3.

5–1–3 FLOTATION TEST ON CAMPO MORADO ORE

The results of the mineralogical studies indicated that fine grinding was required for flotation. From this reason, samples at a grind of 97% minus 400 mesh were prepared.

Many kinds of flotation tests were carried out and it was found that good results could not be obtained by usual flotation methods because of too much pyrite. Then, new flotation processes, developed for complex sulfide ores in Japan (pattent pending), were tried to apply to Campo Morado ore. The processes newly developed are effective to obtain good results in comparison with conventional methods.

Locked cycle flotation tests using new processes were carried out on the sample Campo Morado "M" assaying 0.5% Pb, which was made by blending the samples Campo Morado "B" and "H" in order to investigate the flotation behavior of lead minerals (Campo Morado "H" which contains significant amounts of Ag, Pb and Zn was sampled by a member of the first mission).

The processes consist of 1) copper-lead flotation conditioned with sulfur dioxide succeeding to aeration, and adding thiourea and zinc sulfate, 2) zinc flotation conditioned with lime, sulfur dioxide accompanied with aeration and 3) iron sulfide flotation at a pH of 4 regulated with sulfuric acid. The rougher concentrates from copper-lead flotation and zinc flotation were cleaned three times, and the rougher concentrate from iron sulfide flotation twice. Each cleaner tailing was returned to each next cycle flotation circuit as shown in Fig. 5.1. The results obtained are shown in Table 5–4. Average metallurgical result of second and third cycles is presented in Table 5–5.

The fact that the recycled ore was still increasing at third stage showed that these locked cycle tests were not stable yet. Therefore, the total amounts of all products in each cycle did not reach to 100%. It is expected that the recoveries of metals in the actual plant are somewhat greater than the one obtained in Table 5–5.

The final copper-lead concentrate from third cycle was separated using sulfur dioxide, activated charcoal and KL 310, and copper concentrate assaying 30.80% Cu with 51.8% recovery was produced.

5–1–4 FLOTATION TEST ON COPPER KING ORE

In this project the ore of Copper King mine is planned to be fed to the roasting plant of Metallurgical plant without dressing.

However the flotation test was carried out because the ore concentrated has the room of further utilization as the material of powder metallurgy and ferrite.

The ore was ground to 52% minus 400 mesh for iron sulfide flotation. Rougher flotation was carried out at a pH of 4 with sulfuric acid and pottasium amyl xanthate and three cleaners at pH 3. The good result was obtained as shown in Table 5–6.

5–1–5 MINERALOGICAL STUDIES ON FLOTATION PRODUCTS

1) Copper concentrate

Optical microscopic observation revealed that most of the particles in copper concentrate were chalcopyrite, besides a small amount of tetrahedrite and a minor amount of covellite. Pyrite, sphalerite and galena were also observed as locked particles with copper minerals. EPMA investigation revealed that tetrahedrite and argentite carried silver.

2) Zinc concentrate

Sphalerite with some amounts of pyrite, chalcopyrite, tetrahedrite and galena as locked particles were observed under microscope.

EPMA examination revealed also that sphalerite crystals occluded 6.38% Fe in average.

3) Iron sulfide concentrate

It is apparent from the microscopic observation that most of chalcopyrite and sphalerite are contained in the pyrite particles and is concluded that better results cannot be obtained unless these locked particles should be liberated. EPMA analysis revealed that tetrahedrite and argentite, as small size inclusions, carried silver in the concentrate.

4) Tailings

Most of the particles are siderite and quartz.

5) The flotation products of Copper King ore

Pyrite is identified in iron sulfide concentrate and quartz in tailings.

Table 5–1　Chemical composition of Campo Morado ore and Copper King ore

Ore	Assay (%)																			
	Au g/t	Ag g/t	Cu	Pb	Zn	Fe	S	SiO_2	CaO	Al_2O_3	MgO	$BaSO_4$	As	Cd	Co	Ni	Bi	Sb	Na_2O	Hg ppm
Campo Morado A	1.0	70	0.62	0.30	0.53	38.89	43.74	8.60	0.049	0.040	0.060	Tr	0.253	0.008	0.011	0.004	0.047	0.047	0.035	18.5
Campo Morado B	0.2	42	1.31	Tr	0.53	40.34	31.34	7.90	0.034	0.040	1.934	Tr	0.010	0.004	0.036	0.003	0.028	0.028	0.451	3.8
Campo Morado H	3.2	681	0.45	3.03	3.81	39.49	45.47	4.08	0.029	0.080	0.039	Tr	0.460	0.015	0.0003	0.005	0.008	0.019	0.148	64.0
Copper King	0.1	5	0.39	Tr	0.26	43.83	50.80	3.06	0.040	0.040	0.019	Tr	0.008	0.002	0.062	0.012	0.013	0.023	0.026	1.7

Table 5–2 Work index

	Campo Morado A	Campo Morado B	Copper King
Wi	13.4	15.6	8.5

Table 5–3 Grindability test

	Campo Morado A	Campo Morado B	Copper King
Grinding time to produce 80% – 400 mesh by test batch mill (min.)	15	18	37

Table 5–4 (1) The result of locked cycle flotation test on Campo Morado ore

Product	W %	Assay %					Distribution %				
		Ag g/t	Cu	Pb	Zn	Fe	Ag	Cu	Pb	Zn	Fe
Feed	100.0	354	1.05	0.50	1.14	40.98	100.0	100.0	100.0	100.0	100.0
Cycle 1											
CuPbRo.Conc.Mag Conc.	2.1	281	1.21	0.40	0.53	51.77	1.7	2.4	1.6	1.0	2.7
CuPb3.Clr Conc.	2.5	2676	21.46	6.06	2.36	30.60	18.9	51.3	30.7	5.2	1.9
ZnRo.Conc.Mag Conc.	0.7	228	0.88	0.10	2.36	53.78	0.5	0.6	0.2	1.5	0.9
Zn3.Clr Conc.	0.7	254	0.65	0.40	54.91	8.83	0.5	0.5	0.6	33.7	0.1
Fe Ro.Tail	16.6	75	0.12	0.10	0.13	32.61	3.5	1.9	3.4	1.9	13.2
Fe2.Clr Conc.	54.9	195	0.30	Tr	0.26	45.95	30.2	15.8	0	12.6	61.6
Fe Conc.Total	57.7	199	0.34	0.02	0.30	46.27	32.4	18.8	1.8	15.1	65.2
Cycle 2											
CuPbRo.Conc.Mag Conc.	2.8	377	1.62	0.61	0.66	50.17	3.0	4.3	3.4	1.6	3.4
CuPb3.Clr Conc.	2.8	2825	21.56	6.47	2.50	29.10	22.3	57.8	36.6	6.2	2.0
ZnRo.Conc.Mag Conc.	0.2	228	0.88	0.10	2.36	53.78	0.1	0.2	0.2	0.4	0.2
Zn3.Clr Conc.	1.4	717	1.65	0.40	53.57	8.83	2.2	1.7	0.8	51.8	0.2
Fe Ro.Tail	24.9	140	0.31	0.40	0.08	34.42	9.8	7.4	20.2	1.8	20.9
Fe2.Clr Conc.	61.2	231	0.44	0.05	0.37	44.13	40.1	25.8	5.7	20.0	66.2
Fe Conc.Total	64.2	235	0.48	0.07	0.14	44.60	42.6	29.8	8.8	7.9	69.8
Cycle 3											
CuPbRo.Conc.	27.9	1123	3.29	1.94	1.80	39.86	88.4	87.7	109.5	44.2	27.2
CuPbRo.Conc.Mag Conc.	3.4	456	1.70	0.81	0.80	47.76	4.4	5.5	5.7	2.4	4.0
CuPbRo.Conc.Mag Tail	24.5	1216	3.51	2.10	1.94	38.78	84.0	82.2	103.8	41.8	23.2
CuPbRo.Conc.Mag Tail	24.5	1216	3.51	2.10	1.94	38.78	84.0	82.2	103.8	41.8	23.2
CuPb1.Clr Conc.	10.0	2224	7.54	4.26	3.16	36.10	62.8	72.1	86.0	27.8	8.8
CuPb1.Clr Tail	14.5	520	0.73	0.61	1.10	40.64	21.2	10.1	17.8	14.0	14.4

Table 5–4 (2)

Product	W %	Assay %					Distribution %				
		Ag g/t	Cu	Pb	Zn	Fe	Ag	Cu	Pb	Zn	Fe
CuPb1.Clr Conc.	10.0	2224	7.54	4.26	3.16	36.10	62.8	72.1	86.0	27.8	8.8
CuPo2.Clr Conc.	5.2	2997	13.02	6.33	3.35	32.88	44.0	64.7	66.4	15.3	4.2
CuPo2.Clr Tail	4.8	1387	1.61	2.02	2.96	39.63	18.8	7.4	19.6	12.5	4.6
CuPo2.Clr Conc.	5.2	2997	13.02	6.33	3.35	32.88	44.0	64.7	66.4	15.3	4.2
CuPb3.Clr Conc.	3.3	3222	18.77	7.17	3.15	30.50	30.0	59.2	47.8	9.1	2.5
CuPb3.Clr Tail	1.9	2607	3.07	4.85	3.68	36.72	14.0	5.5	18.6	6.2	1.7
CuPbRo.Tail	101.3	275	0.44	0.43	1.04	40.23	78.8	42.6	87.2	118.1	99.4
ZnRo.Conc.	5.9	1135	2.76	2.39	14.07	28.64	19.0	15.5	28.5	73.0	4.1
ZnRo.Tail	95.4	222	0.30	0.31	0.54	40.94	59.8	27.1	58.7	45.1	95.3
ZnRo.Conc.	5.9	1135	2.76	2.39	14.07	28.64	19.0	15.5	28.5	73.0	4.1
ZnRo.Conc.Mag Conc.	0.2	140	1.50	0.50	3.50	50.02	0.1	0.3	0.2	0.6	0.2
ZnRo.Conc.Mag Tail	5.7	1170	2.80	2.46	14.44	27.89	18.9	15.2	28.3	72.4	3.9
ZnRo.Conc.Mag Tail	5.7	1170	2.80	2.46	14.44	27.89	18.9	16.2	28.3	72.4	3.9
Zn1.Clr Conc.	2.4	1140	3.21	2.71	29.67	17.08	7.8	7.4	13.1	62.6	1.0
Zn1.Clr Tail	3.3	1192	2.52	2.27	2.09	35.82	11.1	7.8	15.2	9.8	2.9
Zn1.Clr Conc.	2.4	1140	3.21	2.71	29.67	17.08	7.8	7.4	13.1	62.6	1.0
Zn2.Clr Conc.	1.4	698	2.07	1.57	43.29	12.14	2.8	2.8	4.4	53.3	0.4
Zn2.Clr Tail	1.0	1758	4.80	4.30	10.60	24.50	5.0	4.6	8.7	9.3	0.6
Zn2.Clr Conc.	1.4	698	2.07	1.57	43.29	12.14	2.8	2.8	4.4	53.3	0.4
Zn3.Clr Conc.	1.0	391	1.22	0.84	52.02	9.31	1.1	1.2	1.6	45.7	0.2
Zn3.Clr Tail	0.4	1465	4.25	3.50	16.75	20.50	1.7	1.6	2.8	7.6	0.2

Table 5–4 (3)

Product	W %	Assay %					Distribution %				
		Ag g/t	Cu	Pb	Zn	Fe	Ag	Cu	Pb	Zn	Fe
ZnRo.Tail	95.4	222	0.30	0.31	0.54	40.94	59.8	27.1	58.7	45.1	95.3
FeRo.Conc.	59.1	290	0.38	0.31	0.60	42.20	48.3	21.6	36.9	31.0	60.9
FeRo.Tail	36.3	112	0.16	0.30	0.44	38.90	11.5	5.5	21.8	14.1	34.4
FeRo.Tail	36.3	112	0.16	0.30	0.44	38.90	11.5	5.5	21.8	14.1	34.4
Mag Conc.	10.8	146	0.22	0.06	0.65	50.37	4.3	2.2	1.2	6.2	13.3
Mag Tail	25.5	100	0.14	0.40	0.27	34.04	7.2	3.4	20.6	7.9	21.1
FeRo.Conc.	59.1	290	0.38	0.31	0.60	42.20	48.3	21.6	36.9	31.0	60.9
Fel.Clr Conc.	54.0	308	0.40	0.28	0.63	43.02	46.9	20.7	30.8	29.4	56.7
Fel.Clr Tail	5.1	98	0.16	0.61	0.35	33.57	1.4	0.9	6.1	1.6	4.2
Fel.Clr Conc.	54.0	308	0.40	0.28	0.63	43.02	46.9	20.7	30.8	29.4	56.7
Fe2.Clr Conc.	51.2	311	0.41	0.25	0.66	43.44	45.3	20.0	25.7	29.0	54.2
Fe2.Clr Tail	2.8	199	0.25	0.89	0.14	36.39	1.6	0.7	5.1	0.4	2.5
Fe Conc.Total	62.2	283	0.38	0.22	0.66	44.61	49.7	22.5	27.1	35.8	67.7
CuPb3.Clr.Conc.	3.30	3222	18.77	7.17	3.15	30.50	30.0	59.2	47.9	9.1	2.5
CuRo.Conc.	1.92	2398	28.85	2.76	2.97	28.65	13.0	52.8	10.7	5.0	1.4
CuRo.Tail 1	1.38	4369	4.71	13.33	3.41	33.33	17.0	6.4	37.2	4.1	1.1
CuRo.Conc.	1.92	2398	28.85	2.76	2.97	28.65	13.0	52.8	10.7	5.0	1.4
Cu Clr Conc.	1.76	1728	30.80	1.76	2.22	28.98	8.6	51.8	6.3	3.4	1.3
Cu Clr Tail 2	0.16	9769	7.50	13.75	11.25	25.00	4.4	1.0	4.4	1.6	0.1
1 + 2	1.54	4930	5.00	13.38	4.22	32.47	21.4	7.4	41.6	5.7	1.2

Table 5–5 Flotation result of Campo Morado ore

Product	W %	Assay %					Distribution %				
		Ag g/t	Cu	Pb	Zn	Fe	Ag	Cu	Pb	Zn	Fe
Cu-Pb Conc.	3.1	3040	20.05	6.85	2.85	29.84	26.2	58.5	42.2	7.6	2.2
Zn. Conc.	1.2	581	1.46	0.58	52.92	9.04	1.7	1.5	1.2	51.0	0.2
Fe. Conc.	63.2	259	0.43	0.14	0.40	44.60	46.5	26.4	18.2	28.9	68.8
Tail	25.2	120	0.23	0.40	0.22	34.25	8.5	5.4	20.4	4.9	21.0
Total	92.7						82.9	91.8	82.0	92.4	92.2

Table 5–6 Flotation result of Copper King ore

Product	W %	Assay (%)									Distribution (%)								
		Au g/t	Ag g/t	Cu	Pb	Zn	Fe	S	SiO_2	MgO	Au	Ag	Cu	Pb	Zn	Fe	S	SiO_2	MgO
Feed	100.0	0.09	7	0.23	0.008	0.20	44.16	50.67	2.89	0.022	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Fe Conc	94.9	0.10	7	0.24	0.005	0.21	45.95	53.11	0.10	0.004	100.0	93.5	97.9	61.2	98.0	98.8	99.5	3.3	17.0
Tail	5.1	Tr	9	0.09	0.059	0.07	10.83	5.24	54.78	0.362	0	6.5	2.1	38.8	2.0	1.2	0.5	96.7	83.0

Table 5–7 Chemical composition of sphalerite from Campo Morado mine

	Zn	Fe	S	Total
Position 1	61.55	5.75	32.83	100.13
2	62.64	6.73	29.82	99.19
3	60.32	6.66	32.82	99.80
Average	61.50	6.38	31.82	99.64

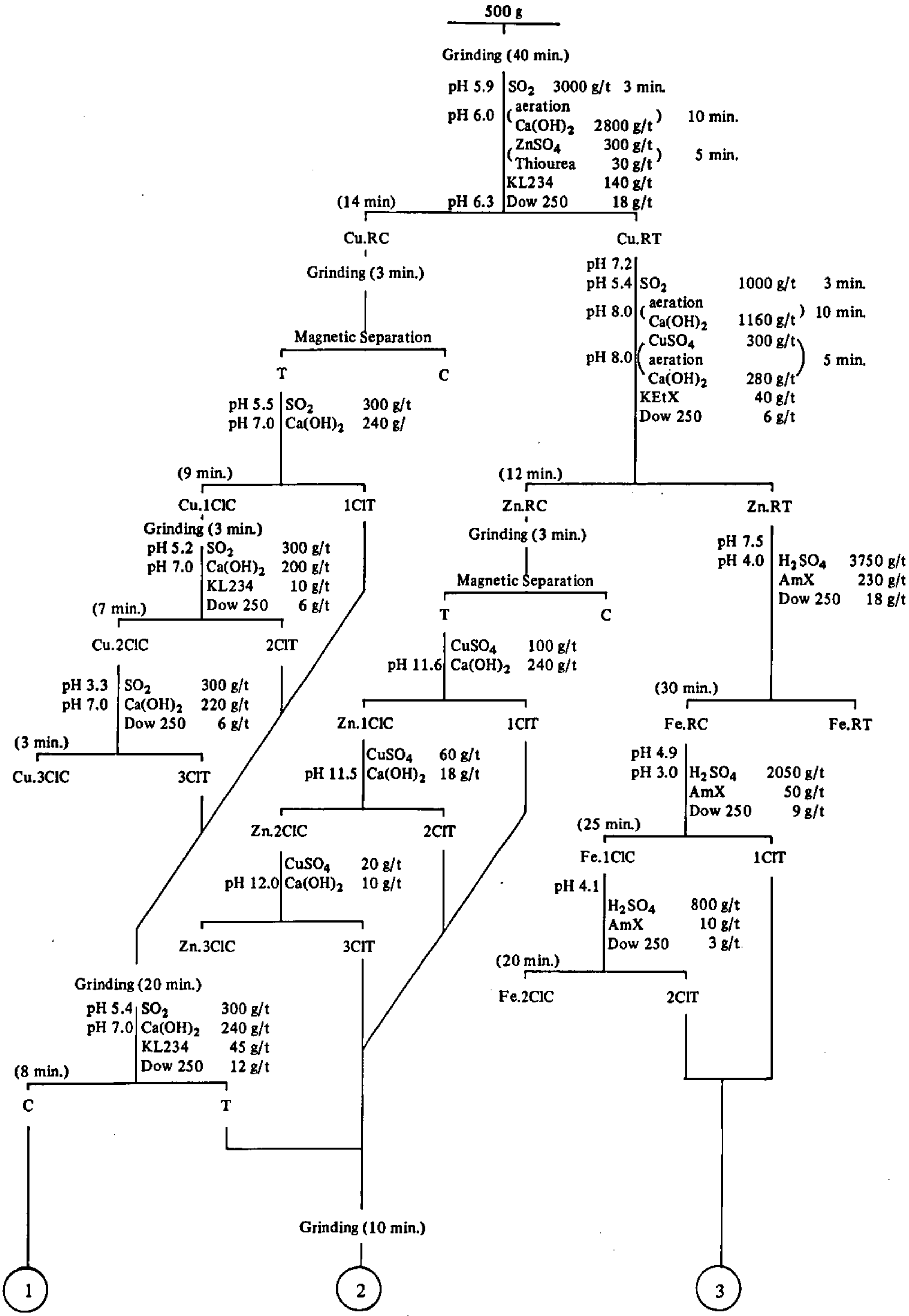


Fig. 5–1 (1) Flowsheet of locked cycle flotation test on Campo Morado ore.

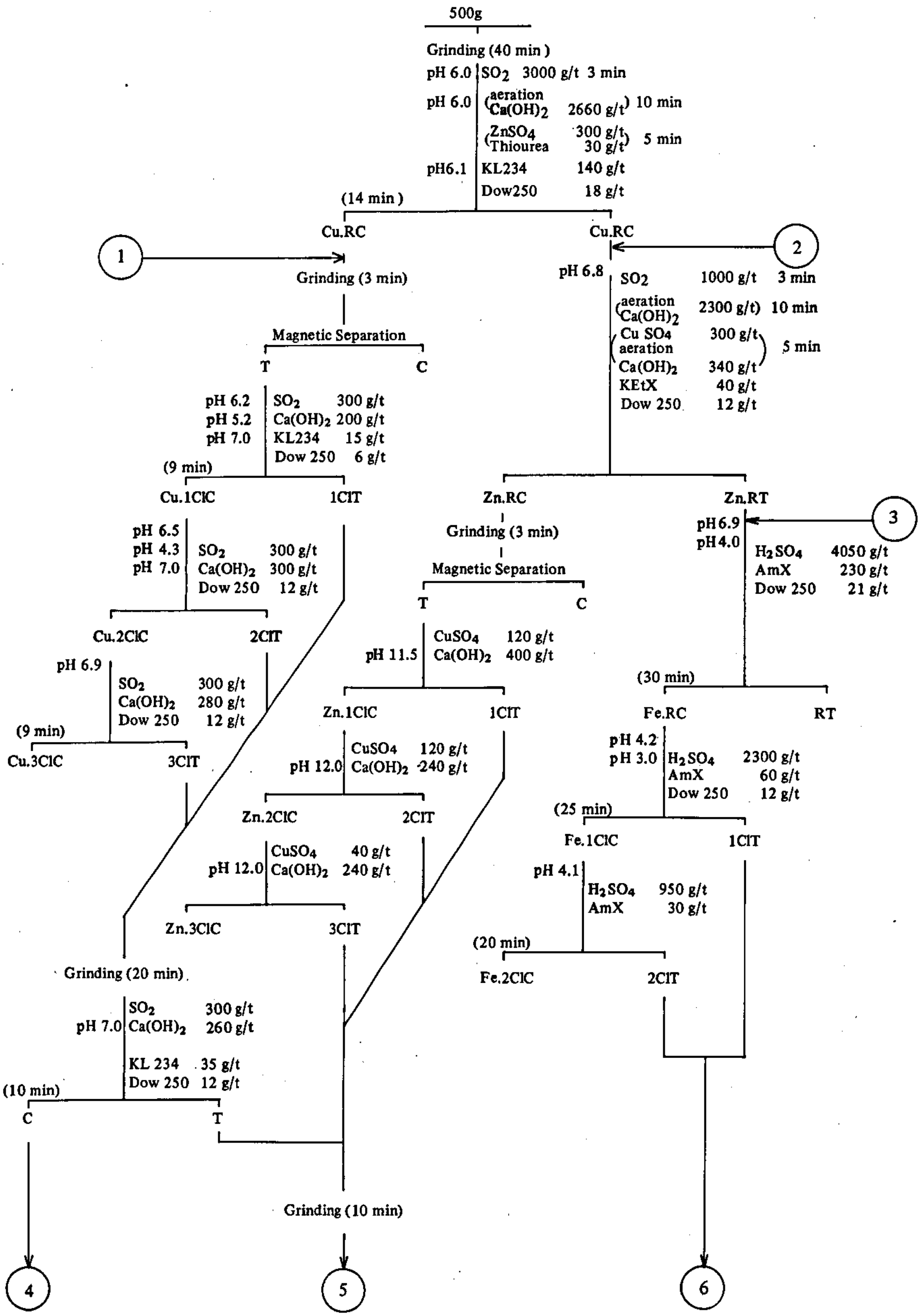

500g
Grinding (40 min)
pH 6.0 SO2 3000 g/t 3 min
pH 6.0 (aeration Ca(OH)2 2660 g/t) 10 min
(ZnSO4 300 g/t Thiourea 30 g/t) 5 min
pH6.1 KL234 140 g/t
Dow250 18 g/t
(14 min)
Cu.RC
Cu.RC
1
2
Grinding (3 min)
Magnetic Separation
T
C
pH 6.8
SO2 1000 g/t 3 min
(aeration Ca(OH)2 2300 g/t) 10 min
(Cu SO4 300 g/t aeration Ca(OH)2 340 g/t) 5 min
KEtX 40 g/t
Dow 250 12 g/t
pH 6.2 SO2 300 g/t
pH 5.2 Ca(OH)2 200 g/t
pH 7.0 KL234 15 g/t
Dow 250 6 g/t
(9 min)
Cu.1ClC
1ClT
Zn.RC
Zn.RT
3
Grinding (3 min)
Magnetic Separation
T
C
pH6.9
pH4.0
H2SO4 4050 g/t
AmX 230 g/t
Dow 250 21 g/t
pH 6.5
pH 4.3 SO2 300 g/t
pH 7.0 Ca(OH)2 300 g/t
Dow 250 12 g/t
Cu.2ClC
2ClT
CuSO4 120 g/t
pH 11.5 Ca(OH)2 400 g/t
(30 min)
Fe.RC
RT
pH 6.9
SO2 300 g/t
Ca(OH)2 280 g/t
Dow 250 12 g/t
(9 min)
Cu.3ClC
3ClT
Zn.1ClC
1ClT
CuSO4 120 g/t
pH 12.0 Ca(OH)2 240 g/t
pH 4.2
pH 3.0 H2SO4 2300 g/t
AmX 60 g/t
Dow 250 12 g/t
(25 min)
Fe.1ClC
1ClT
Zn.2ClC
2ClT
CuSO4 40 g/t
pH 12.0 Ca(OH)2 240 g/t
pH 4.1
H2SO4 950 g/t
AmX 30 g/t
(20 min)
Fe.2ClC
2ClT
Zn.3ClC
3ClT
Grinding (20 min)
SO2 300 g/t
pH 7.0 Ca(OH)2 260 g/t
KL 234 35 g/t
Dow 250 12 g/t
(10 min)
C
T
Grinding (10 min)
4
5
6

Fig. 5–1 (2)

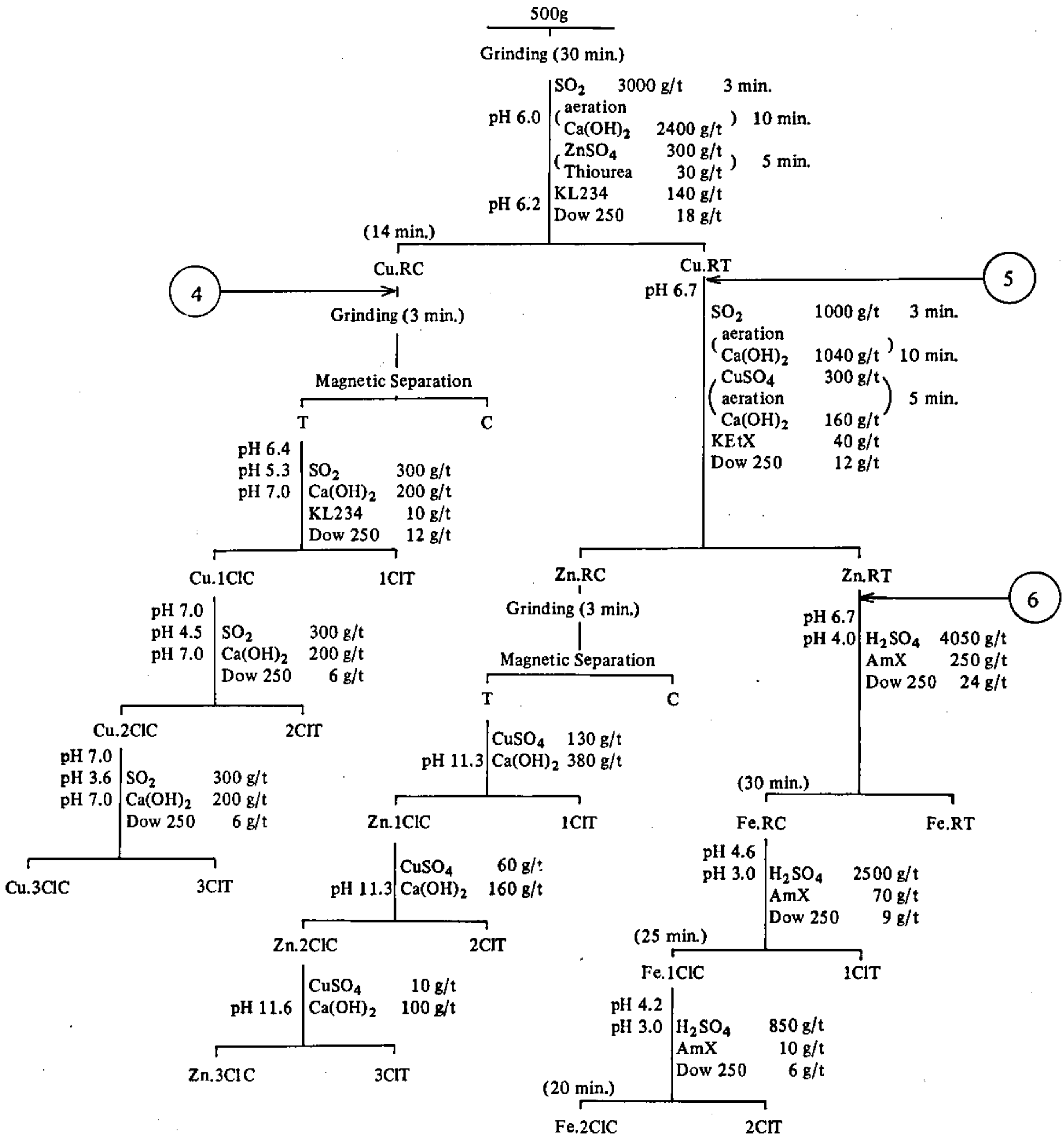

500g
Grinding (30 min.)
SO2 3000 g/t 3 min.
pH 6.0 (aeration Ca(OH)2 2400 g/t) 10 min.
(ZnSO4 300 g/t Thiourea 30 g/t) 5 min.
pH 6.2 KL234 140 g/t
Dow 250 18 g/t
(14 min.)
Cu.RC
Cu.RT
4
5
pH 6.7
Grinding (3 min.)
SO2 1000 g/t 3 min.
(aeration Ca(OH)2 1040 g/t) 10 min.
(CuSO4 300 g/t aeration Ca(OH)2 160 g/t) 5 min.
KEtX 40 g/t
Dow 250 12 g/t
Magnetic Separation
T
C
pH 6.4
pH 5.3
pH 7.0
SO2 300 g/t
Ca(OH)2 200 g/t
KL234 10 g/t
Dow 250 12 g/t
Cu.1ClC
1ClT
Zn.RC
Zn.RT
6
Grinding (3 min.)
pH 7.0
pH 4.5
pH 7.0
SO2 300 g/t
Ca(OH)2 200 g/t
Dow 250 6 g/t
Magnetic Separation
T
C
pH 6.7
pH 4.0
H2SO4 4050 g/t
AmX 250 g/t
Dow 250 24 g/t
Cu.2ClC
2ClT
CuSO4 130 g/t
pH 11.3 Ca(OH)2 380 g/t
pH 7.0
pH 3.6
pH 7.0
SO2 300 g/t
Ca(OH)2 200 g/t
Dow 250 6 g/t
(30 min.)
Zn.1ClC
1ClT
Fe.RC
Fe.RT
Cu.3ClC
3ClT
CuSO4 60 g/t
pH 11.3 Ca(OH)2 160 g/t
pH 4.6
pH 3.0
H2SO4 2500 g/t
AmX 70 g/t
Dow 250 9 g/t
Zn.2ClC
2ClT
(25 min.)
Fe.1ClC
1ClT
CuSO4 10 g/t
pH 11.6 Ca(OH)2 100 g/t
pH 4.2
pH 3.0
H2SO4 850 g/t
AmX 10 g/t
Dow 250 6 g/t
Zn.3ClC
3ClT
(20 min.)
Fe.2ClC
2ClT

Fig. 5–1 (3)

5–2 CONCLUSION OF TEST RESULT

1) According to fluorescent X-ray analysis, X-ray diffraction, microscopic test, EPMA, etc., the Campo Morado ores comprise pyrite, chalcopyrite, zincblende, galena, arsenopyrite, pyrrhotite, tetrahedrite, azurite, argentitie, lead sulfate, electrum, siderite, silica, etc., including various minerals, and in addition, liberation is difficult. Therefore, the ores are relatively difficult to isolate by flotation.

2) For executing the mineral processing test, the flotation technique developed for treating complex sulfide ores was thoroughly used, since the conventional flotation process could not raise the respective grades of concentrates for the reason mentioned above, and the results as described in the ore mineral processing test report could be obtained. Since the samples had been oxidized, with no fresh samples obtained, the results cannot be said perfect enough. With fresh samples, better results are surmised to be obtained.

3) The mineral processing results based on the grades obtained by the investigation of Geocon as the basis of this project were calculated based on the results obtained by cycle tests in reference to actual complex sulfide ores. However, the approximate rate of the ores difficult to liberate cannot be obtained from test samples. In the next stage of study, the ore dressing test must be made on large quantities of fresh samples regarded to be typical.

6 METALLURGICAL TEST

6. METALLURGICAL TEST

6–1 INTRODUCTION

Metallurgical test was classified into roasting test and chloridizing volatilization test.

The roasting test was carried out to confirm the properties of the pyrite for roasting as well as to make samples for the successive chloridizing volatilization test.

The chloridizing votatilization test was achieved to confirm whether such burnt pellet as can be fed to ironworks were produced or not, depending on the properties of calcine cinders.

These tests were performed for the following ores and calcine cinders.

Roasting test

1) Campo Morado ore sampled from the pit
2) Campo Morado ore artifically mixed, based on the Geocon grade
3) Copper King ore

Chloridizing volatilization test

1) Calcine cinders produced from the ores specified in the above items of 1) – 3)
2) Mixed calcine cinder at the following ratio

Campo Morado ore (Geocon base)	: 35
Copper King ore	: 15

6–2 SUMMARY OF TEST RESULT

6–2–1 ROASTING TEST

1) According to the result of the test, there is no factor giving any special problem for desulfurization, and the residual sulfur will be reduced to 0.5 or 0.6% at a roasting temperature of 900°C in actual furnace.

2) For the process design, it has been decided to make conceptional design based on a roasting temperature of 900°C and an air ratio of 1.1.

6–2–2 CHLORIDIZING VOLATILIZATION TEST

6–2–2–1 CAMPO MORADO (GEOCON)

1) 8% or more addition of calcium chloride to the cinder (8% addition of calcium chloride is upper limit for commercial plant operation.) was necessary because of the high

contents of copper and zinc in the raw cinder (Cu = 1.00%, Zn = 0.94%).
In this case, the residual copper and zinc contents in the burnt pellet were 0.041% and 0.025% respectively.

2) As for the removal of lead and sulfur, there was no problem due to the low contents of them in the raw cinder. (Pb = less than 0.01%, S = less than 0.02% in the burnt pellet).

3) Chloridizing volatilization of gold and silver showed satisfactory results, though considerable amount of gold and silver were contained in the cinder.

	raw cinder	burnt pellet
Au	1.67 g/t	0.02 g/t
Ag	66.58 g/t	3.34 g/t

4) The crushing strength of the burnt pellet was more than 250 kg in case of the burning temperature of 1,250°C

5) The iron content in the burnt pellet was about 61.5%.

6–2–2–2 COPPER KING

1) The adequate additional amount of calcium chloride was 4% due to the low contents of copper and zinc in the raw cinder (Cu = 0.42%, Zn = 0.35%).
The residual copper and zinc contents in the burnt pellet were 0.041% and 0.026% respectively, and chloridizing volatilization of copper was unsatisfactory in spite of the low contents of them in the raw cinder.
It is considered that the above-mentioned results were caused by high pellet basicity (CaO/SiO_2 = 5.1), because the cinder of the pyrite concentrate was used for the test. In the project, however, the pellet basicity will be improved by using the pyrite ore instead of the pyrite concentrate.

2) Concerning the removal of lead and sulfur, there was no problem because of the low contents of them in the raw cinder. (Pb = less than 0.01%, S = less than 0.02% in the burnt pellet)
However, removal rate of sulfur was low due to the high pellet basicity. Therefore, in case of high sulfur content in the raw cinder, there is a suspicion that the residual

sulfur content in the burnt pellet becomes high, if the countermeasures of pellet basicity control, etc. are not taken.

3) The crushing strength of the burnt pellet was about 250 kg at the burning temperature of 1,250°C.

4) The iron content in the burnt pellet was about 68%.

6–2–2–3 MIXED CINDER (C.M (GEOCON) 35 + C.K. 15)

1) 6–7% addition of $CaCl_2$ was necessary because of the high contents of copper and zinc in the raw cinder (Cu = 0.83%, Zn = 0.76%).
   In this case, the residual copper and zinc contents in the burnt pellet were 0.047–0.051% and 0.037–0.027% respectively, and it is not considered that the satisfactory result was obtained in chloridizing volatilization of copper.

2) As for the removal of lead and sulfur, there was no problem due to the low contents of them in the raw cinder. (Pb = less than 0.01%, S = less than 0.01% in the burnt pellet)

3) Chloridizing volatilization of gold and silver was satisfactory.

	raw cinder	burnt pellet
Au	1.27 g/t	0.01 g/t
Ag	49.63 g/t	1.75 g/t

6–2–2–4 CAMPO MORADO (PIT)

1) Copper and zinc contents in the raw cinder were 0.65% and 0.36% respectively, and 4% addition of $CaCl_2$ to the raw cinder was necessary. The residual copper and zinc content in the burnt pellet were 0.022% and 0.016% respectively, and the said results were deemed satisfactory.

2) The residual lead and sulfur contents in the burnt pellet were less than 0.01% and less than 0.02% respectively.

3) Chloridizing volatilization of gold and silver was sulficient.

	raw cinder	burnt pellet
Au	1.50 g/t	0.01 g/t
Ag	97.25 g/t	1.06 g/t

4) The crushing strength of the burnt pellet was about 250 kg at the burning temperature of 1,250°C.

5) The iron content of the burnt pellet was about 67%.

6–3 ROASTING TEST

Each sample was roasted in a rotary type muffle furnace of which specification is as follows ;

Inside diameter of silica tube	80 mm
Heating zone	600 mm
Inclination	2 degrees
Rotation	1.2 rpm

And the test same as the above mentioned tests was carried out for the pyrite ore of which properties were well known.

The roasting result of each sample in the actual roaster was estimated from the sulfur contents in the calcine cinders produced in the test furnace. Thus, sulfur content in the colcine cinder is assumed as 0.6% in this project.

6–3–1 TEST RESULT

Table 6.1

Sample	Roasting Temp. (°C)	Chemical composition (%)				Remarks
		Pyrite		Cinder		
		Fe	S	Fe	S	
Campo Morado (Geocon)	900	43.95	39.81	61.56	0.16	Muffle furnace
Copper King	900	45.79	53.31	68.68	0.04	do.
Compo Morado (Pit)	900	45.23	50.83	66.83	0.39	do.
Pyrite conc.	900	44.18	47.15	62.18	0.42	do.
(in Japan)	900	44.18	47.15	62.10	0.51	Fludized roaster (Air ratio: 1.1)

6–4 CHLORIDIZING VOLATILIZATION TEST

6–4–1 CHEMICAL COMPOSITION OF SAMPLE CINDER

Table 6.2

		Used sample			Mixed cinder
		Campo Morado (Geocon)	Copper King (Conc.)	Campo Morado (Pit)	*1
T.Fe	%	61.56	68.68	66.83	63.70
FeO	%	0.29	0.14	2.37	0.25
Cu	%	1.00	0.42	0.64	0.83
Zn	%	0.94	0.35	0.36	0.76
Pb	%	0.057	0.015	0.12	0.044
T.S	%	0.14	0.029	0.39	0.11
W.S.S. *2	%	–	–	0.16	–
SiO_2	%	7.34	0.40	1.54	5.26
CaO	%	0.22	0.039	0.12	0.17
MgO	%	1.28	0.021	0.042	0.90
Al_2O_3	%	0.010	0.11	0.00	0.04
As	%	0.011	0.010	0.016	0.011
F	%	0.010	0.011	0.011	0.010
Na_2O	%	0.017	0.025	0.006	0.019
K_2O	%	0.007	0.019	0.003	0.011
Bi	%	0.003	0.003	0.002	0.003
Mn	%	0.031	0.003	0.012	0.023
Co	%	0.076	0.099	0.015	0.083
Cd	%	0.006	0.011	0.002	0.005
Au	g/T	1.67	0.33	1.50	1.27
Ag	g/T	66.58	10.09	97.25	49.63
H_2O	*3	0.2	0.0	0.1	–

Remark ; *1 : Campo Morado (Geocon) and Copper King in the ratio of 35:15
*2 : W.S.S. : Water Soluble Sulfur
*3 : Unit : wt% Wet Base

6–4–2 PARTICLE SIZE DISTRIBUTION

Table 6.3

mesh	micron	Campo Morado (Geocon)	Copper King (Conc.)	Campo Morado (Pit)
+ 60	+ 250	0.0 %	0.0 %	0.0 %
+ 100	+ 149	0.0	1.6	0.8
+ 150	+ 105	3.2	11.1	4.3
+ 200	+ 74	6.3	16.5	4.0
+ 250	+ 62	5.8	11.0	4.8
+ 325	+ 44	8.1	13.9	8.2
- 325	- 44	76.6	45.9	77.9
	+ 30	14.8	12.8	9.2
	+ 20	7.9	10.3	24.8
	+ 10	47.1	17.9	31.4
	- 10	6.8	4.9	12.5

\+ 44 micron : JIS Standard Sieve

\- 44 micron : Sedimentation Balance

6–4–3 BULK DENSITY

	Bulk Density
Campo Morado (Geocon)	1.48 (H_2O = 0.2%)
Copper King	1.37 (0.0)
Campo Morado (Pit)	1.04 (0.1)

6–4–4 TEST PROCEDURE

Each sample was ground to about 85% of -44 micron due to rather coarse materials as it is.

Table 6.4 Sise distribution of test sample after grinding

mesh	+ 60	+100	+150	+200	+250	+325	+325	Sedimentation Balance			
micron	+250	+149	+105	+ 74	+ 62	+ 44	- 44	+30	+20	+10	-10
C.M. (Geocon)	0.0 %	0.0	0.4	3.1	4.5	8.1	83.9	23.8	7.7	43.4	9.0
C.K. (Conc.)	" %	"	0.3	2.8	4.2	8.0	84.7	22.8	11.0	38.6	12.3
Mixed cinder	" %	"	0.2	2.3	4.1	8.5	84.9	19.1	11.9	47.4	6.5
C.M. (Pit)	" %	0.1	1.3	1.3	4.4	5.3	87.6	15.6	16.2	32.8	23.0

After a certain amount of $CaCl_2$ and $Ca(OH)_2$ ($Ca(OH)_2$ was mixed with Campo Morad Morado (Pit) only.) were mixed with the each ground sample, the green pellet was made by hands. The green pellet was dried in a thermostatic dryer and it was fired with an electric furnace.

Test conditions are as follows :

1) $CaCl_2$ addition : C.M. (Geocon) –– 7.8% (to the cinder)
   : C.K. (Conc.) –– 3, 4, 5, 6% (")
   : Mixed cinder –– 5, 6, 7, 8% (")
   : C.M. (Pit) –– 3, 4, 5, 6% (")

2) $Ca(OH)_2$ addition : C.M. (Geocon) –– 0%
   : C.K. (Conc.) –– 0%
   : Mixed cinder –– 0%
   : C.M. (Pit) –– 0.37% * (to the cinder)

   * : Calcium chloride reacts with W.S.S. in the raw cinder and decomposes uneffectively at low temperature. Therefore, calcium hydroxide was added in order to restrain the said unfavorable reaction.

3) Burning Temperature : 1250°C (max.)

6–4–5 TEST RESULT (SUMMERY)

Table 6.5

Sample	Test Condition		Burnt Pellet								
	$CaCl_2$ %	$Ca(OH)_2$ %	Cu %	Zn %	Pb %	S %	Cl %	T.Fe %	CaO/SiO_2	C.St. kg	Au / Ag g/t
Campo Morado (Geocon)	(Raw Cinder)		(1.00)	(0.94)	(0.057)	(0.14)	–	(61.56)	–	–	(1.67) / (66.58)
	7	0	0.057	0.051	0.008	0.009	0.00	61.80	0.51	295	} 0.02 / 3.34
	8	"	0.041	0.025	0.007	0.011	"	61.45	0.58	278	
Copper King (Conc.)	(Raw Cinder)		(0.42)	(0.35)	(0.015)	(0.029)	–	(68.68)	–	–	(0.33) / (10.09)
	3	0	0.066	0.079	0.006	0.013	0.01	68.91	3.9	186	
	4	"	0.041	0.026	0.005	0.018	0.00	68.36	5.1	302	
	5	"	0.055	0.020	"	0.015	0.09	67.69	6.4	257	
	6	"	0.077	0.017	"	0.014	0.31	66.60	7.7	249	
Mixed cinder *1	(Raw Cinder)		(0.83)	(0.76)	(0.044)	(0.11)	–	(63.70)	–	–	(1.27) / (49.63)
	5	0	0.063	0.069	0.007	0.006	0.00	64.39	0.51	355	} 0.01 / 1.75
	6	"	0.047	0.037	0.005	0.008	"	64.12	0.61	341	
	7	"	0.051	0.027	"	0.006	"	63.81	0.70	272	
	8	"	0.060	0.022	0.005	"	"	63.14	0.80	456	
Campo Morado (Pit)	(Raw Cinder)		(0.64)	(0.36)	(0.12)	(0.39)	–	(66.83)	–	–	(1.50) / (97.25)
	3	0.37	0.031	0.046	0.007	0.019	0.00	68.11	1.2	290	} 0.01 / 1.06
	4	"	0.022	0.016	0.004	0.010	0.02	67.26	1.6	283	
	5	"	0.024	0.016	0.005	0.013	0.02	66.74	1.9	256	
	6	"	0.028	0.014	0.003	0.017	0.03	66.21	2.2	267	

Note : *1 Campo Morado (Geocon) and Copper King in the ratio of 35 : 15

Above figure is the averaged one of the obtained data from 4 tests. Each data obtained from the tests is shown in the Table 6.6. Analysis of residual Au and Ag in pellet was done with composite sample of two $CaCl_2$ level.

6–4–6 CONCLUSION OF TEST RESULT

From the results of this bench scale tests on the pyrite cinder sample, the followings are confirmed.

1) As for the raw cinder such as Copper King (Conc.) with very low content of silica, good results was not obtained in chloridizing volatilization even if the metal (Cu, Zn) contents were comparatively low. However, the suitable silica content is expected in the actual operation since the pyrite ore is to be used as a raw material.
2) Fluorine content in the samples was a little high. (Campo Morado (Geocon) : 0.010%, Copper King : 0.011%, Campo Morado (Pit) : 0.011%)
   From experiences through chloridizing volatilization process, it can be said that some amount of fluorine has an inclination to volatilize in firing of pellet and fluorine causes the corrosion trouble to each equipment in the gas treatment section. Accordingly, it is desirable that fluorine content is as low as possible.

However, it is considered that the proper countermeasures for the above-mentioned questions could be taken. Therefore, it is judged that satisfactory results could be obtained in chloridizing volatilization process.

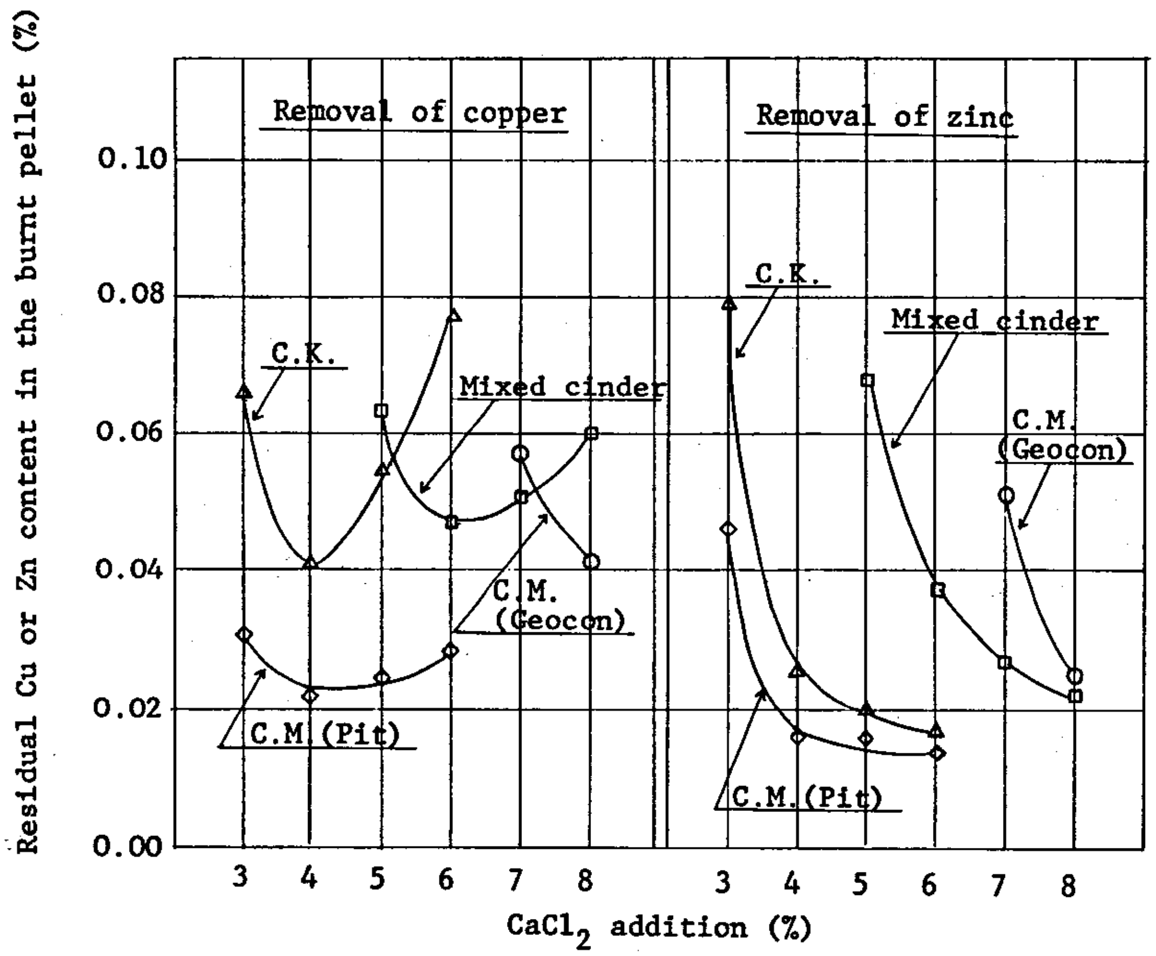
This bench scale test is preliminary one in order to examine the applicability of chloridizing volatilization process to the sample.

Accordingly, in case that this process is applied to the project, the pilot plant test will be required for the purpose of confirming the results of the chloridizing volatilization of specified cinder and obtaining the available data for the design of commercial plant.

Moreover, concerning the sample for pilot plant test, it is advisable to pay attention to the said (1), (2), and the followings.

> "Judging from experiences, the raw cinder specification to apply chloridizing volatilization process has a temporary standard as follows :

Fig. 6.1 Results of chloridizinc volatilization on each sample



Sulfide S	:	max	0.4 %
Sulfate S	:	"	0.4 %
FeO	:	"	5 %
CaO	:	"	1 %
MgO	:	"	1 %
SiO_2	:	"	8 %
$Na_2O + K_2$	:	"	0.15 %
F	:	"	0.01 %
(pellet-CaO / SiO_2)	:	"	1

Raw cinder specification for this study of the project is now decided as follows :

1) Project plan

Campo Morado (Geocon) + Copper King

Treatment (Capacity : 17,410 + 11,090 T/M)

Cu = 0.517%	Zn = 0.965%	Pb = 0.365%	S = 0.60%
SiO_2 = 4.52%	CaO = 0.15%	Au = 0.85 g/t	Ag = 74.46 g/t
T.Fe = 61.88%			

2) Alternative

Campo Morado (Geocon) Treatment (Capacity : 17,410 T/M)

Cu = 0.467%	Zn = 1.068%	Pb = 0.587%	S = 0.60%
SiO_2 = 4.74%	CaO = 0.22%	Au = 1.22 g/t	Ag = 114.68 g/t
T.Fe = 60.65%			

Above-mentioned specification is different from the sample for bench scale tests, however, it is judged that it is possible to apply the said specified cinder to chloridizing volatilization because copper content is not high and silica content is not low. Moreover, as for fluorine content in it, it is necessary to confirm the flourine content in the specified cinder by investigation, and even if the flourine content may be comparatively high, it is possible to take countermeasures for it.

Based on the said specification of cinder, estimated quality of product pellet is as follows :

1) Project plan

Campo Morado (Geocon) + Copper King

Cu = 0.04%	Zn = 0.05%	Pb = 0.02%	S = 0.04%
Au = 0.02 g/t	Ag = 5.0 g/t	(CaO/SiO_2 = 0.95)	

2) Alternative

Campo Morado (Geocon)

Cu = 0.04%	Zn = 0.05%	Pb = 0.03%	S = 0.04%
Au = 0.03 g/t	Ag = 8.0 g/t	(CaO/SiO_2 = 0.92)	

$CaCl_2$ addition is 7% to each specified cinder, and in this case, pellet basicity (CaO/SiO_2) is 0.92, 0.95. From experiences concerning pellet basicity, it is advisable to lower basicity to about 0.6.

The said matters and quality of product pellet have to be confirmed by carrying out the pilot plant test.

Fig. 6.2 Bench Scale Test Apparatus

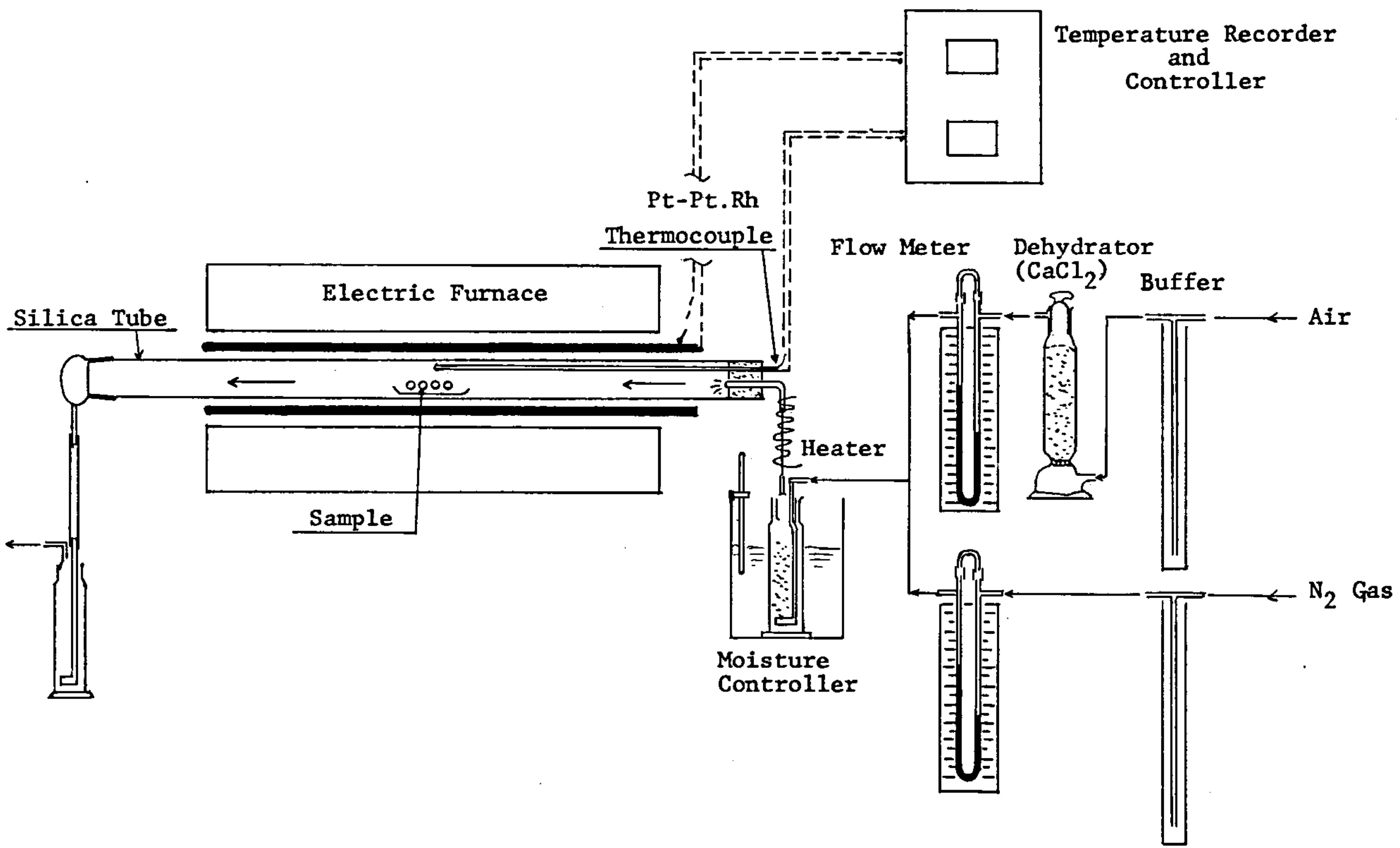


Table 6.6 Result of Chloridizing Volatilization Test

Raw Cinder	Cu	Zn	Pb	S	T.Fe
Campo Morado (Geocon)	(1.00)	(0.94)	(0.057)	(0.14)	(61.56)

Sample	Test Condition			Burnt Pellet							
	$CaCl_2$ %	$Ca(OH)_2$ %	Carrier GAS condition *1	Cu %	Zn %	Pb %	S %	Cl %	T.Fe %	CaO/SiO_2	C.St. *2 kg
Campo Morado (Geocon)	7	0	30	0.045	0.039	0.006	0.014	0.00	61.74	0.51	357
	"	"	"	0.037	0.031	"	0.008	"	61.93	"	271
	"	"	60	0.083	0.076	0.013	"	"	61.72	"	334
	"	"	"	0.063	0.059	0.008	0.006	"	61.80	"	218
	8	0	30	0.031	0.025	0.007	0.012	0.00	61.76	0.58	305
	"	"	"	0.035	0.023	"	"	"	61.34	"	257
	"	"	60	0.052	0.031	0.006	0.014	"	61.35	"	267
	"	"	"	0.046	0.021	"	0.007	"	61.34	"	281

Note : *1 Unit : gH_2O/dry gas kg
*2 C.St. : Crushing Strength

Raw Cinder	Cu	Zn	Pb	S	T.Fe
Copper King	(0.42)	(0.35)	(0.015)	(0.029)	(68.68)

Sample	Test Condition			Burnt Pellet							
	$CaCl_2$ %	$Ca(OH)_2$ %	Carrier GAS Condition	Cu %	Zn %	Pb %	S %	Cl %	T.Fe %	CaO/SiO_2	C.St, kg
Copper King (Conc.)	3	0	30	0.062	0.072	0.008	0.014	0.00	68.66	3.9	175
	〃	〃	〃	0.059	0.062	0.005	0.010	〃	69.32	〃	161
	〃	〃	60	0.072	0.084	〃	0.013	〃	68.63	〃	192
	〃	〃	〃	0.069	0.098	0.006	0.014	0.03	69.01	〃	214
	4	0	30	0.039	0.030	0.005	0.016	0.00	68.58	5.1	370
	〃	〃	〃	0.037	0.028	〃	0.017	〃	68.13	〃	274
	〃	〃	60	0.042	0.025	〃	0.019	0.01	68.70	〃	290
	〃	〃	〃	0.044	0.022	0.006	0.020	0.00	68.03	〃	272
	5	0	30	0.052	0.020	0.005	0.016	0.12	67.80	6.4	254
	〃	〃	〃	0.050	0.019	〃	0.014	0.11	67.55	〃	268
	〃	〃	60	0.062	0.021	〃	〃	0.07	67.36	〃	273
	〃	〃	〃	0.054	0.020	〃	0.015	0.05	68.03	〃	234
	6	0	30	0.070	0.018	0.006	0.013	0.26	67.02	7.7	268
	〃	〃	〃	0.076	0.017	0.005	0.017	0.39	66.46	〃	210
	〃	〃	60	0.080	0.016	〃	0.014	0.28	66.35	〃	253
	〃	〃	〃	〃	〃	〃	0.013	0.29	66.57	〃	266

Raw Cinder	Cu	Zn	Pb	S	T.Fe
Mixed cinder	(0.83)	(0.76)	(0.044)	(0.11)	(63.70)

Sample	Test Condition			Burnt Pellet							
	$CaCl_2$ %	$Ca(OH)_2$ %	Carrier GAS Condition	Cu %	Zn %	Pb %	S %	Cl %	T.Fe %	$\frac{CaO}{SiO_2}$	C.St. kg
Mixed cinder *1	5	0	30	0.041	0.042	0.008	0.006	0.00	64.72	0.51	332
	〃	〃	〃	0.050	0.051	0.005	0.004	〃	63.96	〃	339
	〃	〃	60	0.085	0.100	0.008	0.005	〃	64.07	〃	440
	〃	〃	〃	0.076	0.083	0.006	0.009	〃	64.82	〃	309
	6	0	30	0.033	0.026	0.004	0.006	0.00	64.43	0.61	368
	〃	〃	〃	0.040	0.031	0.005	0.007	〃	64.02	〃	322
	〃	〃	60	0.056	0.047	0.006	0.010	〃	64.23	〃	350
	〃	〃	〃	0.057	0.042	0.005	0.008	〃	63.81	〃	324
	7	0	30	0.038	0.022	0.006	0.007	0.00	64.02	0.70	314
	〃	〃	〃	0.044	〃	0.005	0.002	〃	63.81	〃	247
	〃	〃	60	0.065	0.033	〃	0.006	〃	63.61	〃	307
	〃	〃	〃	0.057	0.032	〃	0.010	〃	63.81	〃	223
	8	0	30	0.049	0.018	0.005	0.005	0.00	63.50	0.80	440
	〃	〃	〃	0.044	0.017	0.004	〃	〃	63.40	〃	384
	〃	〃	60	0.078	0.027	0.002	0.006	〃	62.78	〃	431
	〃	〃	〃	0.070	〃	0.007	0.007	〃	62.89	〃	567

Note : *1 Campo Morado (Geocon) and Copper King (Conc.) in the ratio of 35 : 15

Raw Cinder	Cu	Zn	Pb	S	T.Fe
Campo Morado (Pit)	(0.64)	(0.36)	(0.12)	(0.39)	(66.83)

Sample	Test Condition			Burnt Pellet							
	$CaCl_2$ %	$Ca(OH)_2$ %	Carrier GAS Condition	Cu %	Zn %	Pb %	S %	Cl %	T.Fe %	CaO/SiO_2	C.St. kg
Campo Morado (Pit)	3	0.37	30	0.023	0.029	0.004	0.019	0.00	68.25	1.2	322
	〃	〃	〃	0.028	0.030	0.007	〃	〃	68.14	〃	226
	〃	〃	60	0.038	0.067	0.009	〃	〃	68.19	〃	285
	〃	〃	〃	0.033	0.059	〃	〃	〃	67.85	〃	327
	4	0.37	30	0.021	0.015	0.003	0.010	0.02	67.12	1.6	218
	〃	〃	〃	0.020	〃	0.005	〃	〃	67.23	〃	217
	〃	〃	60	0.023	0.017	0.004	〃	〃	67.56	〃	358
	〃	〃	〃	〃	0.018	〃	〃	0.03	67.13	〃	340
	5	0.37	30	0.024	0.015	0.006	0.010	0.00	67.02	1.9	215
	〃	〃	〃	〃	〃	0.005	0.022	0.02	66.54	〃	217
	〃	〃	60	〃	〃	〃	0.010	0.03	66.69	〃	330
	〃	〃	〃	0.025	0.017	0.004	0.011	0.02	〃	〃	260
	6	0.37	30	0.026	0.014	0.003	0.016	0.03	66.01	2.2	228
	〃	〃	〃	〃	0.013	0.004	〃	〃	66.36	〃	211
	〃	〃	60	0.030	0.016	0.003	0.018	〃	66.01	〃	259
	〃	〃	〃	0.028	0.014	〃	0.019	〃	66.46	〃	368

7 DEVELOPMENT PLAN OF MINES

7. DEVELOPMENT PLAN OF MINES

7–1. COPPER KING DEPOSIT

7–1–1. MINING PLAN

7–1–1–1. BASIC DEVELOPMENT PLAN AND PRODUCTION RATE

The copper king deposit is massive cupriferrous iron sulphide deposit which is cylindrical in shape 50–60 m in diameter and surrounded by the host rock of firm green schist. The cylindrical deposit is inclined about 15° downward toward southeast and is estimated to stretch 350 m. It has a potential of extending further downward.

The topography of the mine site is steep and the deposit lies on the side of the mountain, so that the lowest adit can be used for ore transportation and drainage, making it unnecessary to provide a shaft winch and drainage pumps.

Sublevel stoping is adopted as the mining method since the rock strength is high and the deposit is large and massive. For the loading and underground transportation of ore, a trackless system is employed using LHD and trucks. Pillars 10 m thick will be left between stopes of 20 m width and this will make the mining recovery 67%. Hence,

The amount of minable ore = ore reserve x 0.67
= 12 million tons x 0.67
= 9,120,000 tons

The production rate is set at 17,000 tons per month, which is the balance of the metallurgical plant capacity and the amount of iron concentrate supplied from the Campo Morado mine.

A two-shift system will be employed in the mining operation and the annual operation day is estimated to be 300 days. Then the daily production is 680 tons and the life of mine will be more than 45 years.

The content of nonferrous metals such as Cu, Pb and Zn in the ore is small, so that the pyrite can be used directly in the metallurgical plant without further dressing. This makes it unnecessary to provide a concentrator.

In addition, since the ore deposit is large and massive, dilution during the mining operation can be minimized. To make the dilution as small as possible, a process of hand-picking for removing waste rocks is added after the primary crushing process. The metal contents of the ore mined are adopted as those of ore reserve.

Production Rate	Cu	Pb	Zn	Fe	S
17,000 T/M	0.40%	0.01%	0.54%	42.85%	51.35%

Auxiliary facilities required for mining are installed on the flat surface near the mouth of the adit. The arrangement of the surface facilities such as the mine office, compressor room, repair shop, warehouse, primary crusher, ore bin and generator are shown in Figs. 7–2. and 7–7.

The character of mine drainage water is expected to be strong acid. To neutralize the acid water a neutralization facility is provided, by which the mine water is neutralized before being discharged into a storage dam from which only clean water is released to the river.

As the serveice water to be used in the mine, the water in the Rio Murga river flowing beside the mine site is pumped up to the surface facility and to the underground.

The ore that was crushed by the primary crusher to the size of - 100 mm is removed of waste rocks by hand-picking and stored in the ore bin, from which it will be transported by 30-ton trucks to the metallurgical plant.

The mine workers living in Petatlan, a city located beside the national highway and about 28 km apart from the mine site, will come to work by bus. Company houses for engineers and staffs will be built in Petatlan.

7–1–1–2 MINING METHOD

1) Development

Because the deposit lies under the side of mountain, surface facilities will be installed at the flat surface adjacent to Rio Murga river. Main haulage level is driven at 230 m above sea level into the lower part of the deposit. From this level, ramps (10°) are driven upward and then upper drawpoint levels and sublevels are driven from these ramps at required positions. (See Figs. 7–2. and 7–3.)

Between the main haulage level and the uppermost drawpoint level, about 100 m apart from each other, two bins –– one for ore and the other for waste –– will be driven. The capacity of the ore bin is maximum 1,400 tons and the waste bin 1,000 tons.

In the main haulage level the ore is loaded into a 15-ton truck for transport to the primary crusher 800 m distant. One truck will be used for each of the two shifts.

17,000 T/M ÷ 25 D/M = 680 T/D

680 T/D ÷ 405 T/truck = 1.68 trucks/D (1 truck x 2 shifts/D)

The waste stored in the waste bin is transported out of the mine by a ore transport. Since the development of drift will be only 42 m/month, so one truck is enough. The waste will be crushed for use of road gravel.

2) Mining

Sublevel stoping without filling is adopted as the mining method because the deposit is massive and the rock and the ore body are firm. The width of stope is 20 m and between these stopes ore pillar 10 m in width will be left (See Fig. 7–3, and 7–4.)

The ore body extends east and west and therefore the stopes 20 m wide and the pillars 10 m wide are set alternately in the north and south direction. At the lowest part of each stope draw cones are driven; transportation drifts are driven under the center of each pillar; from this level crosscuts are driven to the draw points on either side of the pillar. In this way a pair of stopes are mined at the same time. Draw points are provided at 14 m intervals and crosscuts are like rib as shown in Fig. 7–4.

Sublevels are driven above the draw cones at 20 m intervals. From the sublevels, fan drillings are performed. One long-hole fan-drilling jumbo in one shift work per day is sufficient to excavate 680 T/D.

At the draw point a 5yd^3-LHD is used to carry blasted ore to the central ore bin through the levels and ramps. The 5yd^3-LHD has the loading capacity of 410 tons per shift and therefore one LHD will be used in each shift (See Figs. 7–5, and 7–6).

680 T/D ÷ 410 T/LHD = 1.65 LHDs/D (I LHD x 1.7 shifts)

Ventilation level is driven in the upper portion of the ore body to the surface so that the exhaust gas from LHD and trucks can be discharged by the main fan and fresh air will be introduced from the main haulage level. Local fans and mine tubes may be used, if required, in the stope to assure enough ventilation.

7–1–1–3. MINING EQUIPMENT

Three main underground equipments used for drilling, loading and transporting will be described in the following.

1) Drilling machine

a) 1 2-boom jumbo for development (spare 1)

b) 2 fandrills for sublevels (spare 0)

One 2-boom jumbo is enough for monthly development of 42 m. While a required amount of work can be done by one fandrill, two fandrills will be used, one for drilling at the sublevel and one for drilling from draw cone, to save the time for moving the fandrill between the sublevel and the draw cone.

<u>Calculation of drilling efficiency</u>

Drilling efficiency in the draw cone is as follows

(Fig. 7–5.)

Tonnage per silice (1.5m thick)

$(20m + 4m) \frac{1}{2} \times 14m \times 1.5m \times 4\ T/m^3 = 1{,}008$ tons

Total hole length ($\ell_1 + \ell_2 + \ldots + \ell_7$) = 103.4m

Average drilling speed (bit dia. 75mm) = 20 cm/min = 12 m/H

Hole length by one drill per shift

6.5 H/shift x 50/60 x 12 m/H = 65 m/shift

Tonnage per meter of bore hole 1,008 ÷ 103.4

= 9.7 T/m

Drilling efficiency in sublevel is as follows.

Tonnage per slice

$20m \times 20m \times 1.5m \times 4\ T/m^3$ = 2,400 tons

Total hole length

($\ell_1 + \ell_2 + \ldots + \ell_{17}$) = 219.5m

Tonnage per meter of bore hole

2,400T ÷ 219.5 = 10.9 T/m

Amount of ore ratio

3 x sublevel: draw cone = 7:1

Average tonnage per meter of bore hole

$(7 \times 10.9\ T/m + 9.7\ T/m) \frac{1}{8}$ = 10.6 T/m

Required hole length per day

680 T/D ÷ 10.6 T/m = 64m

Number of required drills

64 m/D ÷ 65 M/drill = 0.98 ≒ 1.0 drill/day

2) Loader

a)	$5yd^3$-LHD for development	1
b)	$5yd^3$-LHD for draw point	1
c)	$5yd^3$-LHD for spare	1
	Total	3 LHDs

One loader is provided separately at the development face since it is remote from the draw point. Ore is loaded and transported by LHD from the draw point to the central ore bin. Here two LHDs are required in one day, so one each will be used in 1st and 2nd shift.

Loading efficiency

Traveling speed (average)		8 km/H = 133 m/min
Average transport distance (one way)		215m
Time of one cycle	Load and dump	1.4 min
	Haul (8 km/H)	1.6
	Empty (8 km/H)	1.6
		4.6 min
	Allowance (20%)	0.9
	Total	5.5 min

Apparent specific gravity of ore

$4.0 T/m^3 \div 1.6 = 2.5 T/m^3$

Amount of ore per one cycle of LHD

$2.5 T/m^3 \times 3.4m^3 \times 0.8 = 6.8$ T/cycle

Number of cycles in one shift

6.5 H/shift $\times 50/60 \div 5.5$ min/cycle $= 59$ cycles/shift

Tonnage loaded by one LHD in one shift

59 cycles/shift x 6.8 T/cycle = 401 T/shift

$\fallingdotseq$ 400 T/shift·LHD

Number of required LHDs in one day

680 T/D ÷ 400 T/LHD = 1.7 LHDs/D

3) Transport truck

a)	for transport of waste	1
b)	for transport of ore in main haulage level	
c)	Spare	1
	Total	2

A 15-ton truck is used for the transportation of ore and waste over the distance of 800m from the central ore bin to the primary crusher. The use of two trucks·shift a day will be sufficient. One truck will be provided for 1st and 2nd shift.

Transport efficiency

Travel speed: { load 12 km/H = 200 m/min
empty 15 km/H = 250 m/min

One cycle time (travel distance 800m)

Fixed time	Load	1.5 min
	Park	0.6
	Dump	1.0
	Total	3.1 min.
Variable time	Transport (load)	4.0 min
	Transport (empty)	3.2
	Allowance	0.7
	Total	8.9 min
	Grand total	12.0 min

Number of cycle per shift

6.5H x 50/60 ÷ 12.0 min = 27 cycles/shift

Truck capacity per one shift

27 cycles/shift x 15 ton = 405 T/shift·truck

Number of required trucks per day

680 T/D ÷ 405 = 1.68 trucks/D ÷ 1 truck x 2 shifts/D (including waste)

7–1–1–4 SURFACE FACILITIES

A concentrator is not required in the Copper King mine. This make it possible to build all the facilities, except for company house, on the flat plate near the mouth of Adit (See Fig. 7–7.)

1) Facilities for crushing, storing and loading

Taking advantage of the inclination (1/10) of the mine site surface, the primary crusher will be set higher than the ore bin. The crushed ore will be discharged from the chute at the bottom of the ore bin and loaded directly onto the truck. The conveyor carrying the ore from the crusher to the ore bin will pass through a waste hand-picking process.

Main equipment	a)	50-ton surge hopper, grizzly and grizzly feeder	1 each
	b)	(20"x34") brake crusher 55 kW	1
	c)	Ore bin 300 tons	1

2) Repair shop

Since there are no maintenance service companies around here, this repair shop is planned to be equipped with such tools as will enable somewhat difficult repair. The equipments to be repaired in this shop include underground heavy machines, generator and other large machines. The shop building is 288 m^2 (12m x 24m).

Main equipments
a) 2.5 ton ceiling travel crane, 2-ton chain blocks
b) Welding machine, cutting machine, pit for repairing vehicles, etc.

3) Compressor station

The air compressor capacity may be small because the air machine used underground is only the drilling machine. The compressor station is accommodated in the same building in which the generator is installed.

Air consumption

a)	2-boom jumbo, 4 m^3/min x 2 drills		= 8 m^3/min
b)	Fandrill for sublevel,	1 drill	= 6.3 m^3/min
		Total	= 14.3 m^3/min

Depending on the combination of works the air consumption may reach the maximum of 14.3 m^3/min. Normally one fandrill is operated at all times. The compressor will be designed so that the maximum air consumption can be covered. If the drilling work for development and sublevel is divided in two shifts, the air supply of 8.0 m^3/min will be sufficient for each shift. Thus, two compressors, each having capacity of 11 m^3/min, will be provided.

Main equipments
a) 2 compressors: 11 m^3/min x 55 kW x 2
b) 2 air receivers: 2 m^3 each

4) Power station

As there are no large-capacity electric power lines nearby, it is planned to install a diesel generator for electric power to be used in the mine.

Required electric power

a)	Air compressor	55 kW x 2 =	110 kW
b)	Main fan	55 x 1 =	55
c)	Underground power (local fans, etc.)		100
d)	Underground lighting		50
e)	Primary crusher		55
f)	Neutralization plant		55
g)	Repair shop and service water pump		110
h)	Office and laboratory		10
			545 kW

Generator capacity: 600 kW x 1 generator (with 1 standby)

The generator room including a distributor room is 750 m^2 (15m x 50m).

5) Warehouse

The warehouse building is 288 m^2 (12m x 24m) and stores machine parts and electric equipment parts, safety materials and tools. Also installed in the warehouse are underground cap lamps and charger as well as a clothes-changing room and a dining hall of workers.

6) Neutralization plant

In the Copper King mine having pyrite ore, the underground water is expected to be strong acid. To neutralize the acid water, a neutralization facility will be provided. The composition of underground water is assumed as shown below. The water will be oxidized by bacteria and then neutralized by calcium carbonate.

Amount of underground water	PH	Fe^{++}	Fe^{+++}	Cu
0.5 m^3/min	2.0	2.8 g/ℓ	0.4 g/ℓ	0.01 g/ℓ

The neutralized sludge will be discharged into the pond which will be dug in a flat place near the mine.

7) Service water facility

From the Rio Murga river flowing by the mine site, the water is pumped up to the mine for use with the underground drilling machines and for cooling the air compressors and diesel generators in the surface facility. The water to be used underground will be pumped 300m up to the mountain-top tank by a high-pressure small-capacity turbine pump.

Service water facility

a) Underground: 0.5 m^3/min x 300m x 37kW
Mountain top tank 10 m3

b) Surface facility: 0.5 m^3/min x 20m x 3.7kW
Tank 10 m^3

8) Powder magazine

Five tons of explosives will be used in a month in the mining (300 g/T x 17,000 T). A powder magazine will be built in the mountain side 100m apart from the minemouth to store 5 tons of dynamite and detonators and blasting fuses.

9) Main fan for ventilation

To extract the exhaust gases from LHDs and trucks and supply fresh air, an incline will be driven from the upper level to the surface and a main fan will be installed on the surface at the outlet of the incline. Supply of air at the rate of 3 m^3/min is sufficient for each kW of working engine.

Horse power of working engines

LHD	180 HP x 2 = 360 HP
Truck	135 HP x 2 = 270 HP
Jeep	100 HP x 1 = 100 HP
Powder vehicle	100 HP x 1 = 100 HP
Repair vehicle	100 HP x 1 = 100 HP
	Total 930 HP

kW of working engines: 930 HP x 0.75 kW/HP x 0.7 = 488 kW

Required air: 488 kW x 3 m^3/min = 1,464 ÷ 1,500 m^3/min

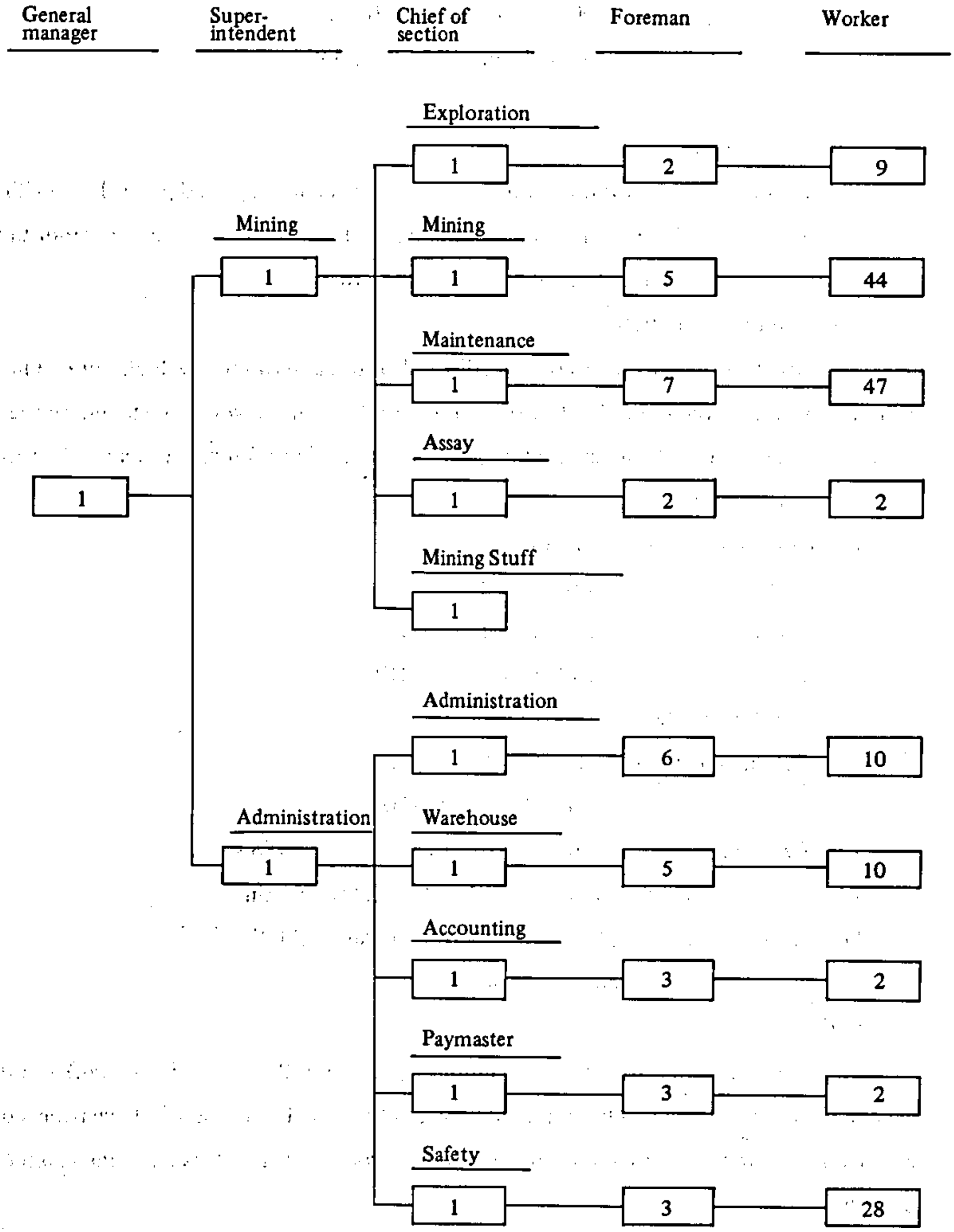
Specification of fan: 1,500 m^3/min x 100 mmAq x 55 kW

Number of fan = 1

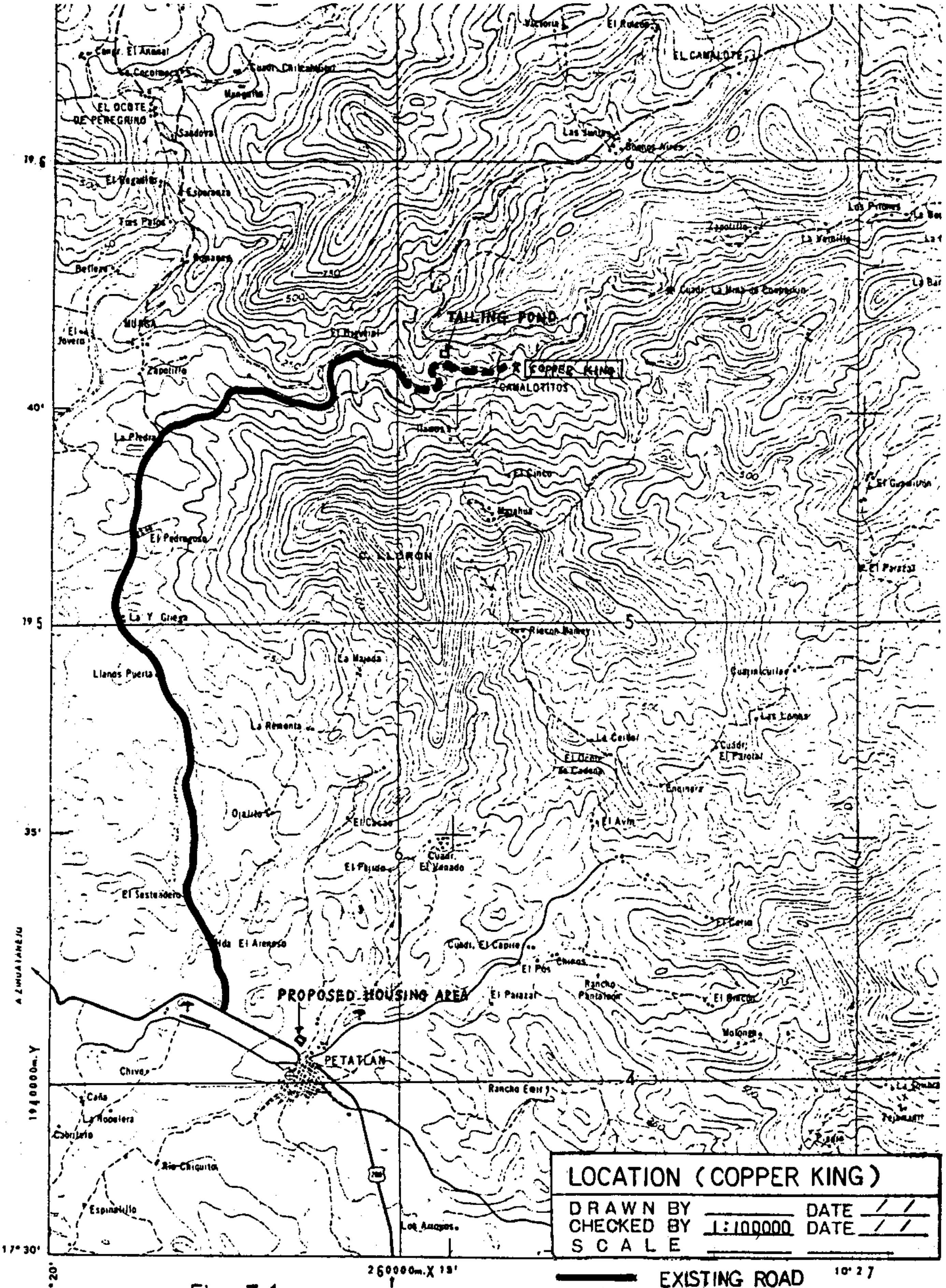
10) Office

The mine office that supervises the mining operation is 240 m^2 (12m x 20m) and the general manager of mine will be stationed here at all times. The office will have rooms of administration and mining sections, miner's waiting room and a clothes-changing room of officers.

7–1–1–5 ORGANIZATION FOR OPERATING COPPER KING MINE



Total	1	2	10	36	154	203



LOCATION (COPPER KING)

DRAWN BY ________ DATE / /

CHECKED BY 1:100000 DATE / /

SCALE ________ ________

EXISTING ROAD

PROPOSED ROAD

Fig. 7.1

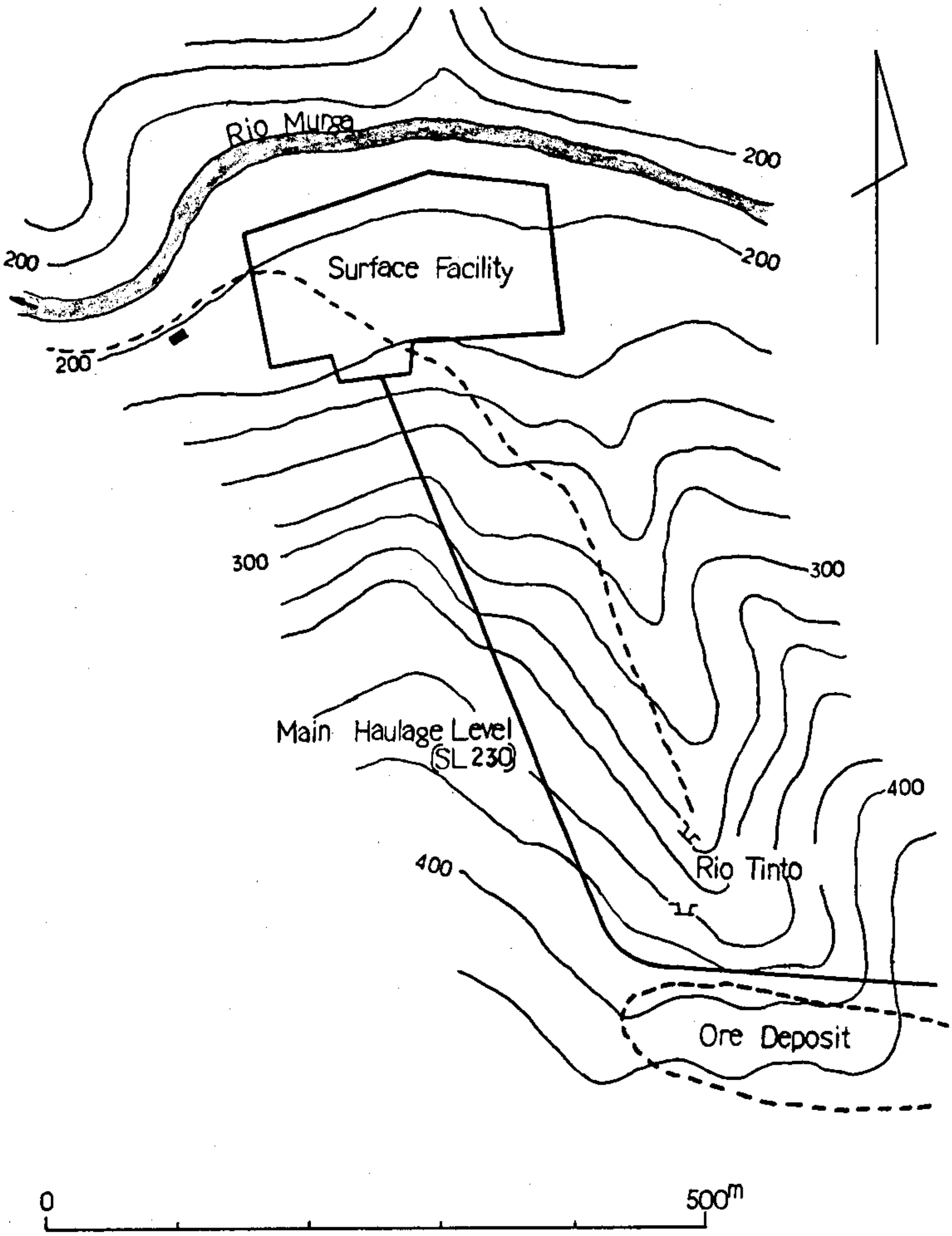


Fig.7.2 Location map of Copper King Project

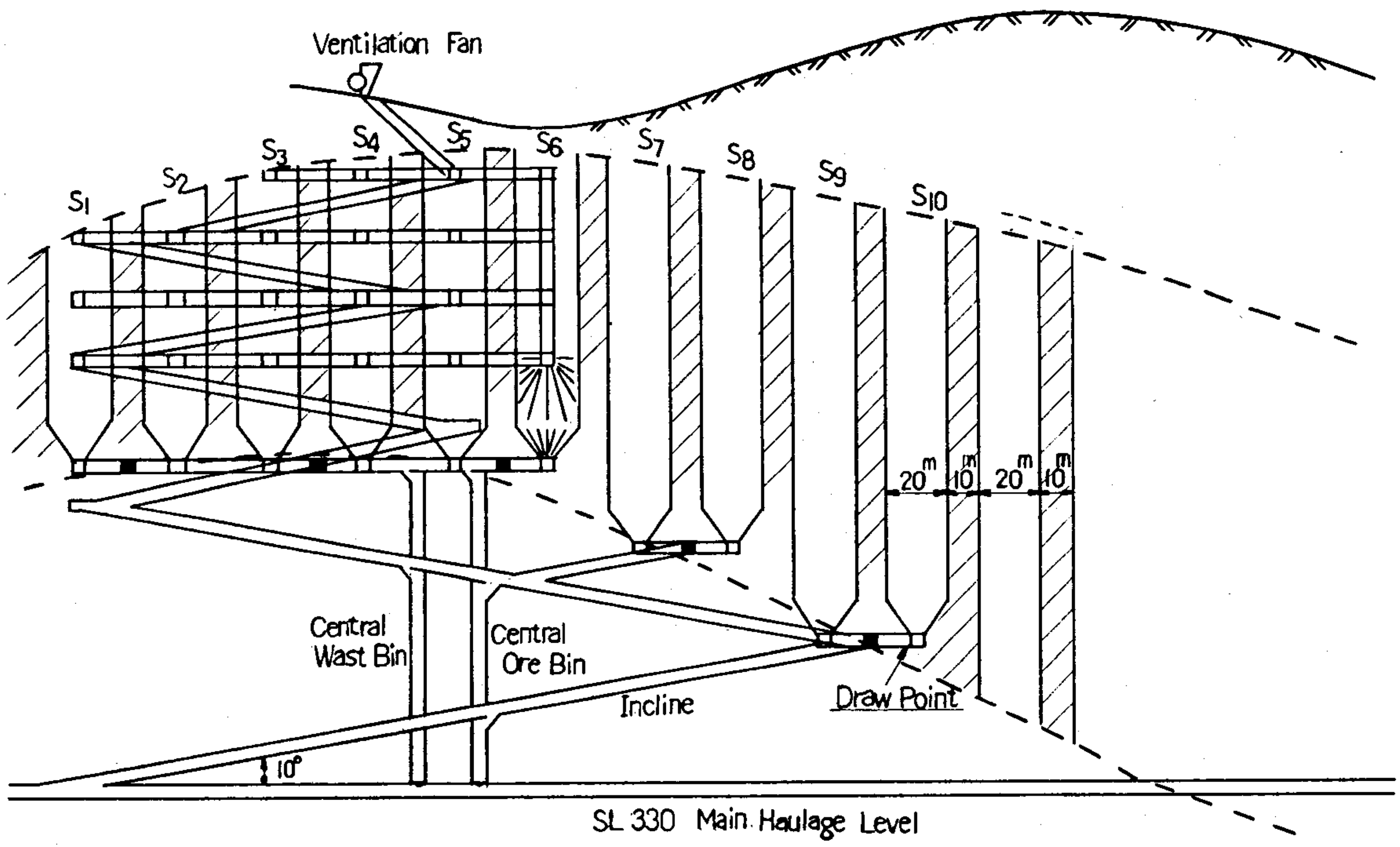


Fig. 7.3 Section of Underaround Development

Copper King Mine

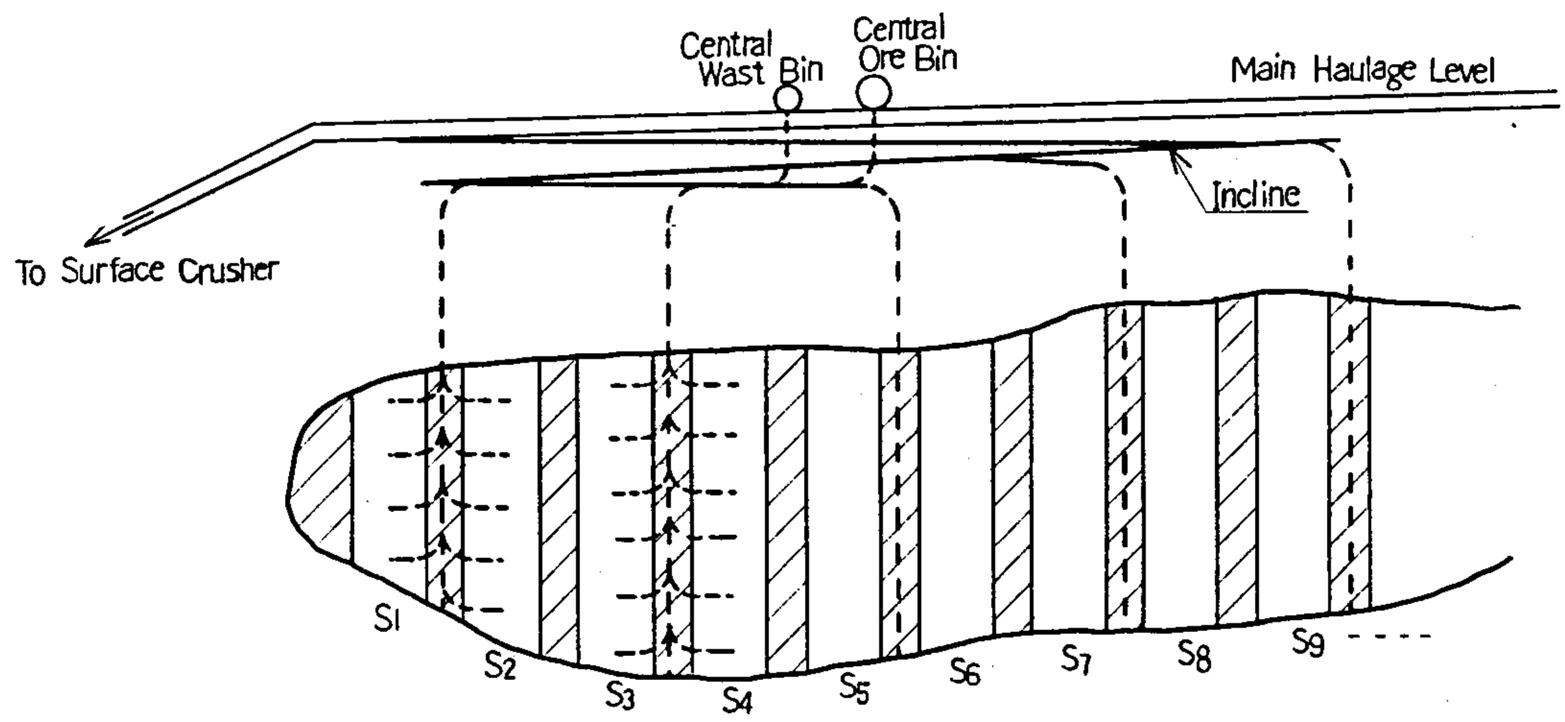
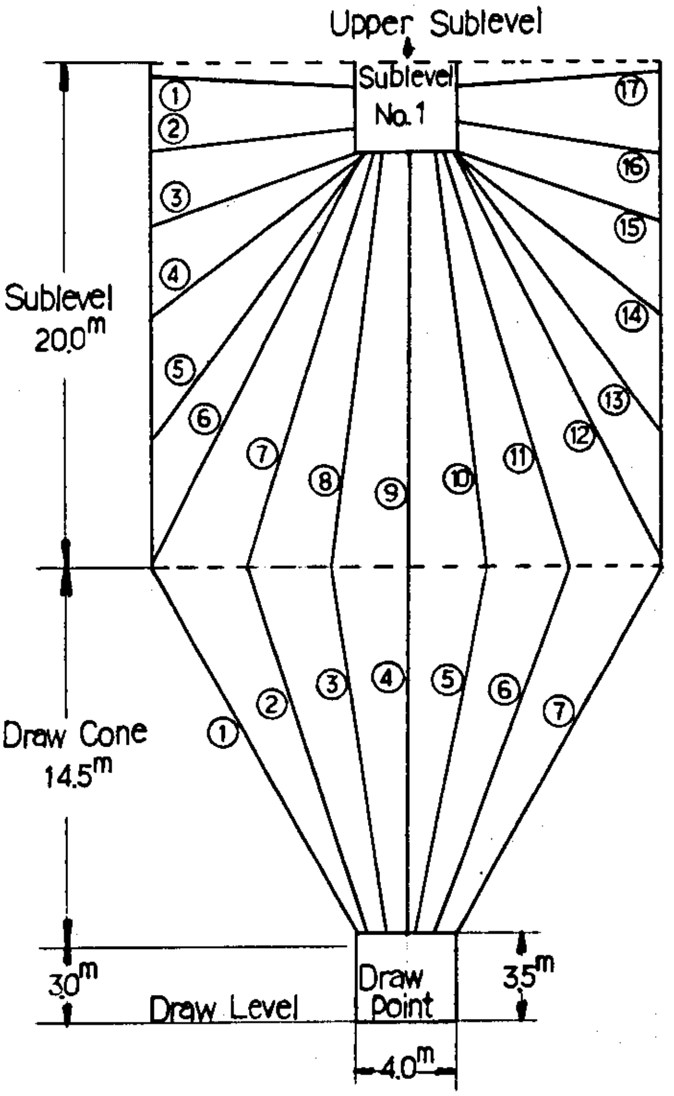


Fig. 7.4 Plan of Draw Point Level



Powder factor 300 g/t

Hole No.	Numb.	Hole Leng.	
① ⑰	2	8.2 m	1.5
② ⑯	2	8.3	·
③ ⑮	2	8.8	·
④ ⑭	2	10.5	·
⑤ ⑬	2	13.8	·
⑥ ⑫	2	18.4	·
⑦ ⑪	2	17.0	·
⑧ ⑩	2	16.5	·
⑨	1	16.5	·
Total	17	Total 219.5	

Powder factor 350 g/t

Hole No	Numb	Hole Leng.	
① ⑤	2	15.2 m	
② ⑥	2	15.0	1.5
③ ⑦	2	14.4	
④	1	14.2	
Total	7	103.4	

Fig. 7.5 Drilling Pattern of Sublevel Stoping (Section N-S)

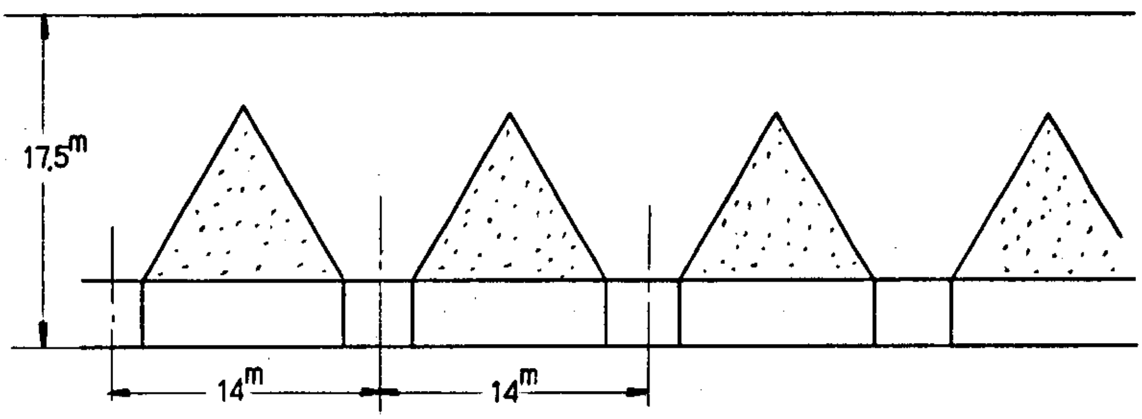


Fig. 7.6 Space of Draw Point (Section W-E)

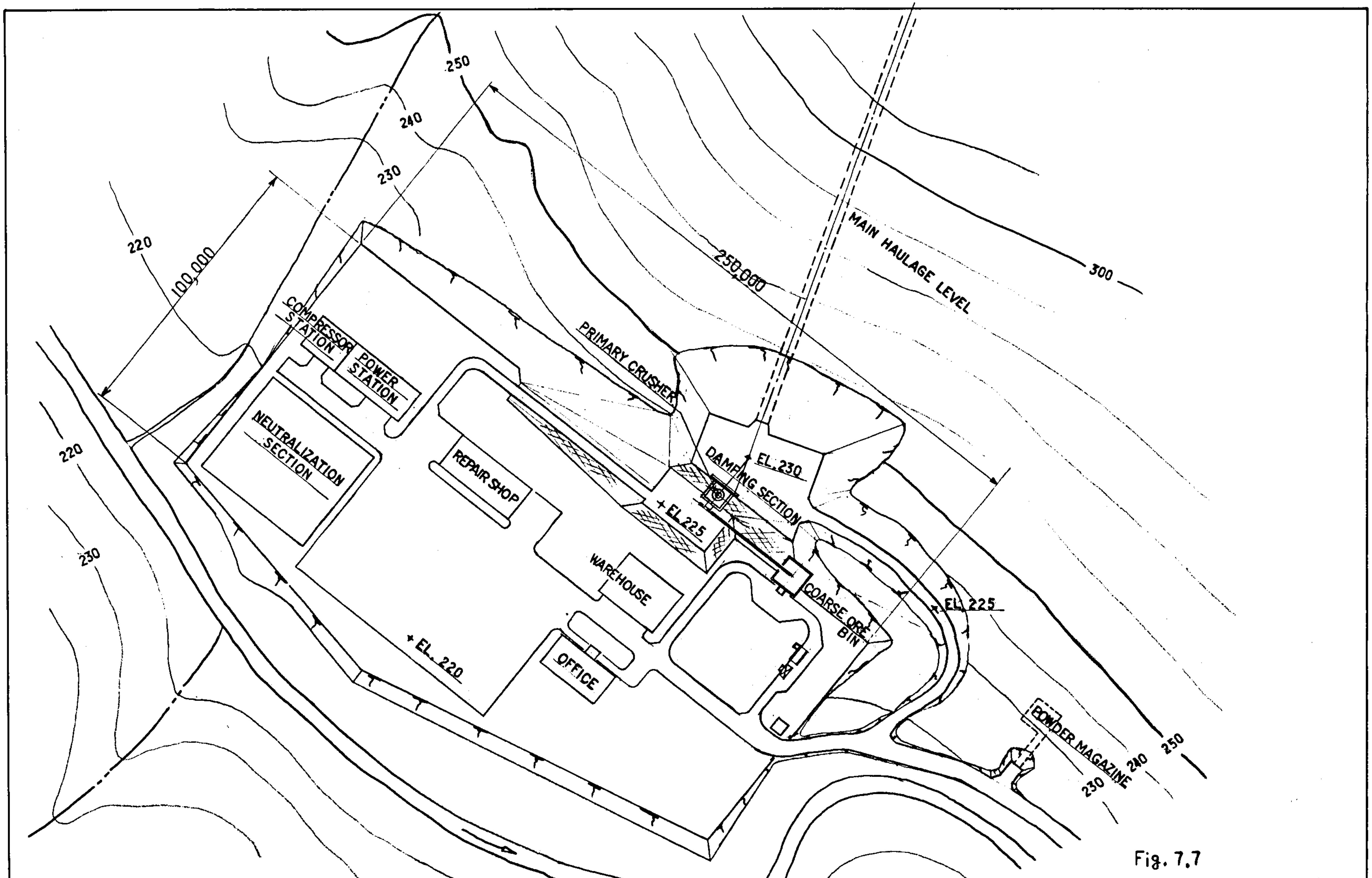


Fig. 7.7

MINE SITE PLAN (COPPER KING)	
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7–2 CAMPO MORADO DEPOSIT

7–2–1. MINING PLAN

7–2–1–1. BASIC DEVELOPMENT PLAN AND PRODUCTION RATE

The Campo Morado deposit is a firm pyrite ore deposit containing copper, lead and zinc, which is surrounded by soft shale and breccia consisting of horizontal layers. It is a medium scale massive deposit lying under the mountain ridge which extends north and south. The deposit is about 350m long and 60m wide and dips about 40° toward south. The height of the ore body is estimated at more than 100m.

Although it is possible to mine below the currently lowest level (L-6; 1,280 m above sea level), it is planned to mine the ore above L-6 level this time. Thus, since the lowest L-6 adits (to be newly advanced) will be used for ore transportation and drainage, the shaft winch and drainage pump are not required.

As the host rock is soft, room-and-pillar mining method with waste fill is used, in which the ore is mined from the bottom toward the upper portion of the ore body. The mining equipments includes LHD and other heavy machines and a trackless system is used as ore transportation system.

Considering the size of the ore deposit, the production rate at 35,000 T/M at maximum is set. The mining recovery is estimated at 76%. With the ore reserve estimated at 8,340,000 tons the amount of minable ore will be 6,340,000 tons and the mine life is expected to be about 20 years, because there is a possibility to consider the expansion of the ore reserve to lower portion under the level 6.

Mining operation will be performed in three shifts and 300 days per year.

The ore contains valuable metals such as copper, lead, zinc and silver, and thus a flotation process is required to separate these metals. The values of mineral contents published by GEOCON is applied to the ore to be mined from this deposit.

Production rate	Ag	Cu	Pb	Zn	Fe	S
35,000 T/M	112 g/t	0.68%	1.07%	3.12%	40.98%	40.0%

As the topography around the mining site is steep, the valley near the adit will be reclaimed to provide the site for the surface facilities required for mining operation. The facilities to be built near the adit includes the mine office, compressor station, primary crusher, werehouse, repair shop and powder magazine. There is no suitable site for concentrator, thus it will be built at a site 3.5 km from the mine, where the central office and generator will be built. The power will then be sent to the mine by power lines.

The ore broken by the primary crusher to the size of -100mm will be transported by 10-ton trucks to the concentrator. It is expected that the underground water is strongly acidic, so that a neutralization plant will be built near the adit. The sludge produced in the neutralization process is discharged into the tailings dam. The underground water is estimated at 0.5 m^3/min.

The room-and-pillar mining with filling requires filling material but the tailings cannot be used the filling material, since they are very fine (-400 mesh) and results in poor dewatering. Hence, waste is excavated in the small open pit on top of the mountain. The waste is thrown into the underground through the waste pass (see Fig. 7–9).

7–2–1–2. MINING METHOD

1) Development

The deposit lies under the side of the mountain as in the case of Copper King mine, so the development are driven in almost the same manner. That is, at the lowest level L-6, the main haulage level is driven into the western part of the ore body where the rock is somewhat hard. From the main haulage level, ramps (10°) are driven for access to the upper portion of the deposit and for ventilating the underground. Levels are driven at 25m intervals and extended, one for each two levels, to the surface to assure ventilation.

The transportation system of waste as filling material comprises a waste bin driven from outside, horizontal waste transport levels, and waste chute to the stopes. The waste produced from underground development is directly filled in the stopes or thrown into the waste chutes.

The ore transport system consists of two central ore bins driven upward to the height of 100m from the haulage level L-6. Each bin has the capacity of 1,400 tons at maximum. The underground structure is schematically shown in Fig. 7–10.

These development will be advanced 75m per month, including ramps and levels. As the supporting materials of these drifts, roof bolts and shotcrete will be used.

2) Mining

The shape of ore deposit is about 40–50m wide and 350m long though constructed at the center by plan. The deposit is divided into a number of stopes at a right angle to the strike direction.

Each stope has the width of 32.5m with band pillars (5m in thickness) left between the stopes so that they can be mined out independently. Each stope will have two rows of square pillars (5m x 5m) (see Fig. 7–11.). As a access ramp to the stopes, branch ramps will be driven from the main ramps with an inclination of 10°. Assuming the each slice of mining is 2.5m high, the branch ramp will be required for every 3 slices.

With the deposit stretching about 350m, it is possible to divide it into 9 blocks of stope (32.5m in width). Assuming that the daily production is 1,400 tons and if 3 stopes are driven at all times, then 467 tons of ore must be mined from each stope. The effective stope width is 32.5m x 0.76 = 24.7m. Thus the amount of ore excavated for 1m advancement is 24.7m x 2.5m x 1m x 4 T/m^3 = 247 tons. This means the stoping speed is about 2 m/day, so if the width of deposit (= length of stope) is 50m, one slice will be excavated in 25 days.

The ore is drilled by the overhand drill jumbo with double booms standing on the waste fill. The blasted ore is mucked and carried by LHD of 2 yd^3 to the ore bin. In the main haulage level a 9-ton truck transports the ore stored in the central ore bin to the primary crusher which is about 600m distant and located surface of the mine.

The waste rock thrown into the waste bin is carried by 2 yd^3-LHD for discharge into the waste pass extending down into the top of each stope. The waste rock thus supplied into the stope is then uniformly distributed by a small bulldozer. In addition to three ore production stopes one waste rock filling stope is prepared, and these four stopes are mined and filled alternately.

7–2–1–3. MINING EQUIPMENT

1) Rock Drill . . . Pattern of Bore Holes

- o Burden x space = 0.7m x 0.8m
- o Depth of bore hole = 2.8m
- o Blasted ore per bore hole

  = 0.7m x 0.8m x 2.5m x 4.0 t/m^3

  = 5.6 tons
- o Bore hole length per ton

  = 2.8m ÷ 5.6T = 0.5 m/T
- o Required bore hole length per day

  = 1,400 T/D x 0.5 m/T = 700 m/D

o Total bore hole length per drill

= 60 m/drill

o Required number of drills per day

= 700 m ÷ 60 m/drill = 11.7 drills

o Required number of drills per shift

= 11.7 drills/D ÷ 3 shifts/D = 3.8 drills/shift

Thus, three overhand drill jumbo with two booms will be used, one for each stope.

2) Loader (2yd^3-LHD)

o Average transport distance (one way) = 200m

o Travel speed = 4 km/H = 67 m/min

o One cycle trip time:

	Loading	0.41 min
	Travel (loaded)	2.99
	Unloading	0.25
	Travel (empty)	2.99
	Accelerate and decelerate	0.07
		6.71 min

o Amount of ore for each loading

= 1.4 m^3 x 0.8 x 2.4 = 2.7 tons

o Number of loading operations per one shift

= 6.5 H/shift x 50 min/H ÷ 6.71 min = 48 times/shift

o Amount of ore transported by one LHD per one shift

= 2.7 ton x 48 times/shift = 130 ton/shift/LHD

o Number of LHDs required for one day

= 1,400 T/D ÷ 130 T/LHD = 10.76 = 11 LHDs/D

o Number of LHDs required per one shift

= 11 LHDs/D ÷ 3 shifts/D = 3.7 LHDs/shift

= 4 LHDs/shift

Thus, operation of four LHDs in three shifts is sufficient to produce daily 1,400 tons of ore.

3) Haulage Truck (9-Ton Truck in Main Haulage Level)

o Average transport distance = 600m

o Travel speed = 10 km/H = 167 m/min

o One cycle trip time:

	Loading	3.0 min
	Travel (loaded)	3.6
	Dumping	1.0
	Travel (empty)	3.6
	Parking	0.6
	Allowance	0.7
		12.5 min

o Number of transport operation per one shift

= 6.5 H/shift x 50 min/H ÷ 12.5 min/cycle

= 26 times/shift

o Amount of ore transported by one truck in one shift

= 9 tons x 26 times/shift = 234 tons/truck

o Number of trucks required in one day

= 1,400 T/D ÷ 234 T/truck ≒ 5.98   6 trucks/day

From the above calculation, it is evident that 1,400 tons of ore can be transported if three trucks are operated in two shifts.

4) Equipments for Waste Filling

Waste is excavated and transported at the small open pit on top of the mountain, using 20-ton dump cars, shovel bulldozers, crawler drills. The rock of the mountain is soft shale, so that the waste will be fractured when thrown into the waste pass. This eliminates the installation of a crusher. The waste production is scheduled only one shift per day.

Amount of waste required in one day

$1{,}400\ T/D \div 4\ T/m^3 = 350\ m^3$ (broken)

$350\ m^3 \div 1.5 = 233\ m^3$ (solid)

$233\ m^3 \times 2.4 = 560$ tons

a) Equipments for open pit

Number of 20-ton dump cars

3 times/H x 6.5 H/shift x 50/60 = 16 times/shift

560 T/D ÷ 20 T/truck = 28 trucks/D

28 trucks/D ÷ 16 times/shift = 1.75 ≒ 2 trucks/D

Dozer shovel (17-ton with 1.8 m^3 bucket): 1

Drawler drill: 1

b) Equipment for underground

Waste carrying $2yd^3$-LHD

Efficiency = $1.4\ m^3$ x 50 times/loader

= $70\ m^3$/loader

Number of required loaders

= $350\ m^3/D \div 70\ m^3$/loader = 5.0 loaders/D

Waste distributing bulldozer (12-ton) in stope

Travel distance = Max. 30m

Amount of distributing work = $65\ m^3/H$

Time spend = $350\ m^3 \div 65$ = 5 hours

In the underground the required amount of waste can be carried from the waste bin to the pass immediately above the stope by using two LHD in 2.5 shifts. In the stope one small bulldozer in one shift will be enough to distribute and level the waste fill piled beneath the pass.

7–2–1–4. SURFACE FACILITIES

The surface around the Campo Morado deposit is steep and houses of nearby villages are built on narrow flat places on the ridges of mountains. Since there is no flat places around here available for building the surface facilities, the valley will be reclaimed in step-like configuration (Fig. 7–13).

1) Facilities for crushing, storage and loading

A primary crusher will be installed near the adit to crush ore to the size of -100 mm, which will then be transported to the concentrator by 10-ton trucks. Since the surface elevation is slow, a stockpile system will be employed instead of a coarse ore bin. The piled ore will be loaded onto the truck by the loader. The stockpile has the capacity of 2,000 tons.

Main equipments:

a)	50-ton surge hopper, grizzly and grizzly feeder	1 each
b)	Primary crusher, 75 kW brake type	1
c)	Stockpile	1
d)	Wheel loader with $3\ m^3$ bucker	1

The ore transportation will be assigned to a subcontractor (as in the case with concentrates) who will operate 3 or 4 ten-ton trucks in three shifts per day.

2) Repair shop

With this repair shop it is possible to perform daily check and maintenance of the heavy machines, but those repair requiring sophisticated equipment shall be done in another repair shop built at the concentrator site.

Main equipments:

a) 2.5-ton manual crane and other loading equipment

b) Welding machine and pit for repairing vehicles

3) Compressor station

As the loading machines are equipped with engines, no large compressor facility is required. The compressor station will be installed at the same level (1,270m) of the adit. The size of the building is 216 m^2 (12m x 18m).

Main equipments:

a)	16 m^3/min x 7.5 kg/cm^2 x 75 kw	3 (2+1 spare)
b)	Air receiver, capacity 2 m^3	2

4) Electric Distribution Room

Electric power generated by the generator installed at the concentrator site 2.5 km from the mine site will be sent to the electric distribution room by the power lines. The building of the electric room is 40 m^2 (5m x 8m) and contains transformers, panel boards and other equipment.

Required power

a)	Air compressor	75 kW x 2	= 150 kW
b)	Fan	90 kW x 1	= 90
c)	Underground power		100
d)	Underground lighting		50
e)	Primary crusher		75
f)	Neutralization plant		55
g)	Repair shop and service water facility		110
h)	Office and laboratory		10
			640 kW

Capacity of electric room: 750 kW, 6000V, 60 Hz

5) Warehouse

The warehouse building is 288 m^2 (12m x 24m) and stores machine parts, electric parts, tools and safety materials. Check will be made everyday on the inlet materials and delivery is made from the stock of these parts and equipment. Installed in the warehouse are cap lamps, charger and a clothes-changing room of workers.

6) Neutralization plant

Since it is expected that the underground water is strong acid (pH of current underground water is 2.0), the Campo Morado mine will also be equipped with the neutralization plant using calcium carbonate, as in the case with the Copper King mine. This neutralization plant will be operated continuously in all three shifts. The processed muddy water will be discharged into the tailings dam by taking advantage of natural head.

7) Service water facility for mining operation

There is a pond for the concentrating operation which is 800m above sea level. Because of the big difference 500m in height between the pond and the mine site, the use of the water in this pond will require a large pumping system incurring additional cost. Thus it has been decided to use spring water in the mountain.

The amount of spring water may be small, estimated at 10 liters/minute; therefore a cooling tank will be installed to recycle cooling water for air compressor. As the water is used for the drilling, a tank 15 m^3 will be installed at the top of the mountain to deliver pressurized water to the underground as well as to the office on the surface.

8) Powder magazine

About 13 tons of explosives will be used monthly in the mining and in the excavating waste from the open pit. The powder magazine for storing dynamites, detonators and fuses will be built into the side of the mountain at the end of the neutralization plant site, as shown in Fig. 7–13.

9) Main fan for ventilation

A main fan will be installed in the level at 1,400m above the sea level, to exhaust underground gas emitted from the engines of the heavy machines. The amount of fresh air required to dilute exhaust gas of engines is calculated as shown below.

Total horsepower of working engines

6 LHDs	100 HP x 6	= 600 HP
39-ton trucks	120 HP x 3	= 360 HP
1 jeep	100 HP x 1	= 100 HP
2 powder vehicles	100 HP x 2	= 200 HP
2 repair vehicles	100 HP x 2	= 200 HP
Total		1,360 HP

Effective kW: 1,360 HP x 0.75 kW/HP x 0.7 = 714 kW

Required amount of fresh air: 714 kW x 3 m^3/min

= 2,142 m^3/min

Fan specification: 2,200 m^3 x 100 mm x 90 kW; 1 fan

Although there will be no problem in the ventilation of the block of stope because each block has a pass through which the waste is thrown into the stope, a local fan and mine tube may be installed, if necessary, to send fresh air.

10) Office

The office building, which supervises the mining section, is 240 m^2 (12m x 20m). This office accommodates a room of mining section, a miner's waiting room, and a clothes-changing room for officers.

7–2–2. SCHEME OF CONCENTRATOR

7–2–2–1. BASES TO DESIGN CAMPO MORADO CONCENTRATOR

The test results showed that Campo Morado ore had the remarkable features of high pyritic multi metal sulfide ore at the viewpoint of the mineral processing. Designing of the concentrator was done in consideration of the ore characters as follows.

1) Oxidation at the mineral surface easily occurs and influences the flotation separation, for the large amount of pyrite (FeS_2) and pyrrhotite (FeS) as component minerals are contained. Preventing the excessive ore oxidation, the concentrator was decided to be located close to the mine where cooler climate expected by high altitude may prevent further oxidation of ore.

2) It is very difficult to isolate mutually the sulfide minerals amont the ore. Herein lies the reason why the particle size at the flotation circuits should be reduced to all-minus 400 mesh.

3) Providing for the dry season, the recycled water should be utilized in milling practice

as much as possible instead of the fresh water.

4) Diesel power generation should be installed to supply regularly the stable electric power at the mine-site.

5) There are mines suspended and mineral veins cropped out around Campo Morado, and discovering new mines is expected. Hence concentrator planned has to have extra space for the future expansion.

6) To keep the grades of milling feed at a certain range is indispensable to gain stable metallurgical results in polymetalic sulfide ore flotation. Bin blending system will be adapted to the above purpose.

7) The concentrator will have the control systems which are equipped with sophisticated instruments. In order to utilize effectively the instruments, the special training course is prepared for the engineers in charge of the operation.

8) In the Campo Morado concentrator, the process adapted in the concentrator of black ore will be applied. However the further works to search better process are needed for the confirmation of the flowsheet after obtaining representative and enough samples for the tests.

7–2–2–2. PRESUMPTION OF MINERAL PROCESSING RESULT

Full and detail samplings were not done yet, so that the grade of ore published officially by GEOCON was used as the grade of ore in this feasibility study work.

The expective mineral processing result shown in table 7–1 was performed by deducing the test results to the GEOCON GRADE.

Copper and zinc will be produced as salable concentrates. Lead will be recovered as silver-bearing low grade lead concentrate, but up-grading of lead concentrate should be studied at the next stage of study.

Silver, copper, lead and zinc contained in iron sulfide concentrate will be regained with the chloridizing volatilization process at higher recovery.

7–2–2–3. TENTATIVE FLOWSHEET AND SPECIFICATIONS OF CONCENTRATOR

The tentative flowsheet was drafted in drawing No. MP–1000. Campo Morado ore contains much utilizable minerals to recover and various sulfide minerals. The particle size at the flotation is to be finely reduced to make each minerals free. Consequently, the power installed at the crushing and grinding circuits should have been right for the size reduction to be large.

The primary crushing plant will be laid down near the mining main level. The crushed ore will be transferred with dump truck to the secondary crushing plant located close to the concentrator. The grinding circuit is distinguished by introducing a compartment ball mill for the purpose of improvement the grinding effectivity.

The flotation circuits were decided on the bases of the test results and the experiences through black ore processing.

7–2–2–4. INSTRUMENTS

The process instruments will be complete with on-stream-X-ray analyzers, titraters to measure remained collectors in pulp, density meters, continual particle analizer, etc., for the stable operation controls.

7–2–2–5. LOCATION OF CONCENTRATOR

The location of the concentrator is illustrated in Fig. 7–12. The location satisfies the requirements of the relevant engineering matters, which are of the mining place, the water supplying, tailing dam, etc.

Table 7–1 Expective Metallurgical Result Based on GEOCON GRADE

Product	Weight T/M	W %	Assay g/t %							Kg, T/M					Distribution %				
			Ag g/t	Cu %	Pb %	Zn %	Fe %	S %	SiO_2%	Ag Kg	Cu t	Pb t	Zn t	Fe t	Ag	Cu	Pb	Zn	Fe
Feed	35,000	100.0	112	0.68	1.07	3.12	40.98			3920.0	238.0	374.5	1092.0	14,343	100.0	100.0	100.0	100.0	100.0
Cu Pb Conc.	1,225	3.5	1012	10.37	18.40	7.49	23.11			1238.6	127.1	225.4	91.7	283	31.6	53.3	60.2	8.4	2.0
Zn Conc.	1,470	4.2	181	1.00	1.19	53.95	8.28			266.0	14.7	17.5	793.0	122	6.8	6.2	4.7	72.6	0.8
Fe Conc.	23,485	67.1	86	0.35	0.44	0.80	45.43	44.25	3.55	2011.5	82.2	105.0	188.0	10,668	51.3	34.6	28.0	17.2	74.4
Tail	8,820	25.2	46	0.16	0.30	0.22	37.08			403.9	14.0	26.6	19.3	3,270	10.3	5.9	7.1	1.8	22.8
Cu-Pb Separation																			
Cu Conc.	455	1.3	782	24.46	3.23	3.23	25.00			356.0	111.3	14.7	14.7	114	9.1	46.7	3.7	1.3	0.8
Ag-Pb Conc.	770	2.2	1147	2.05	27.36	10.00	22.00			882.6	15.8	210.7	77.0	169	22.5	6.6	56.3	7.1	1.2

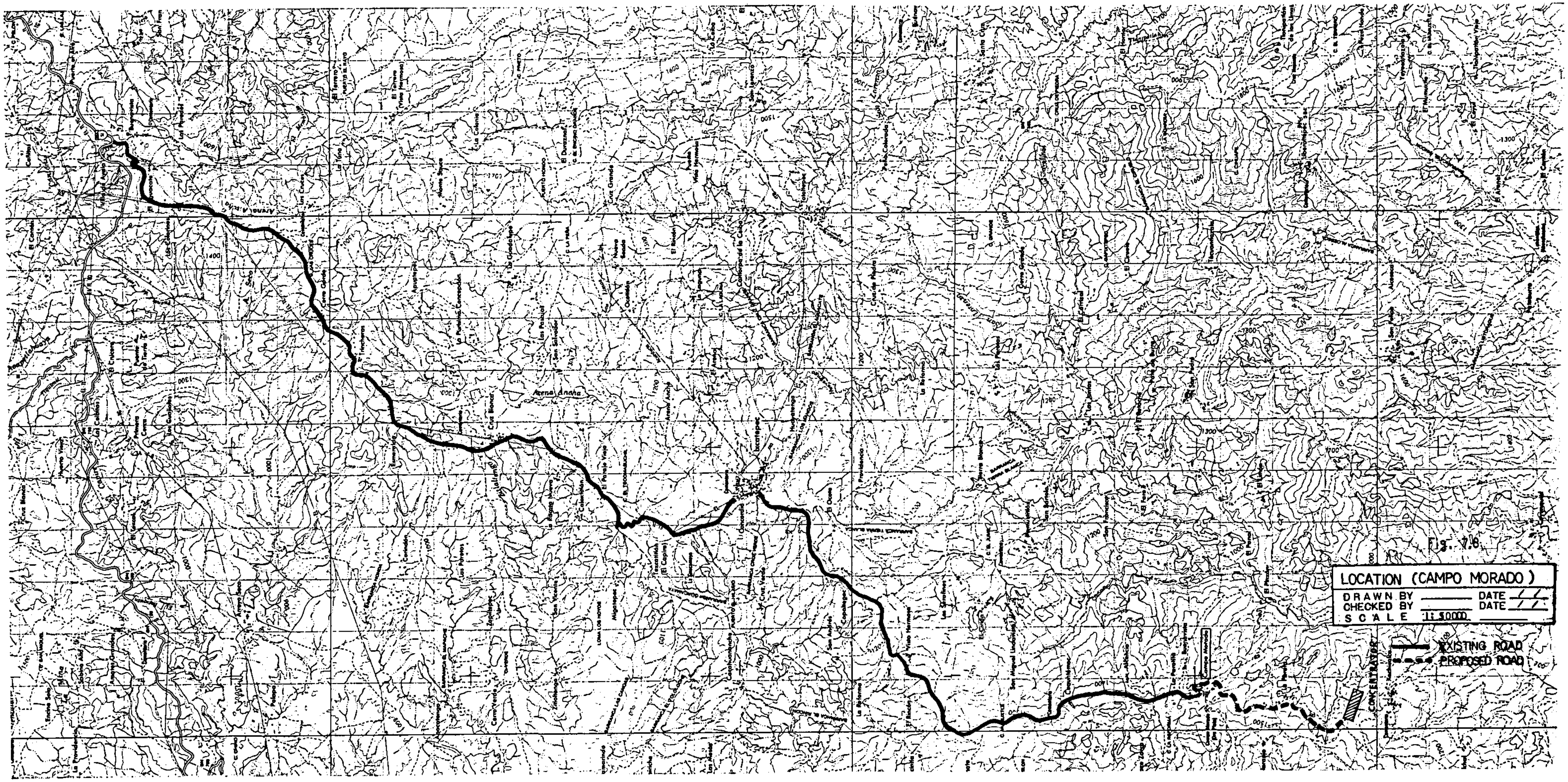
Fig. 7.6
LOCATION (CAMPO MORADO)
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EXISTING ROAD
PROPOSED ROAD
CONCENTRATOR

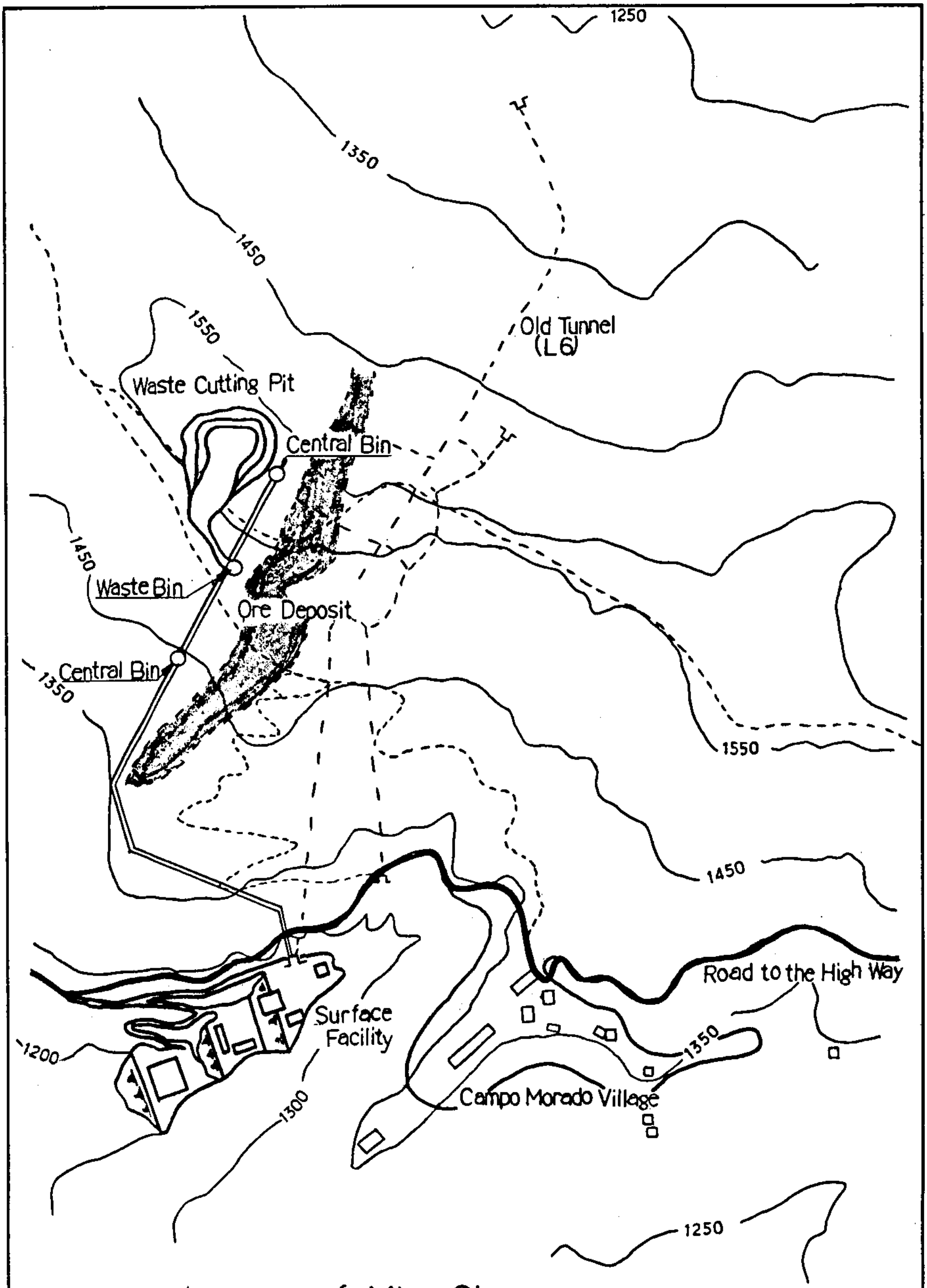
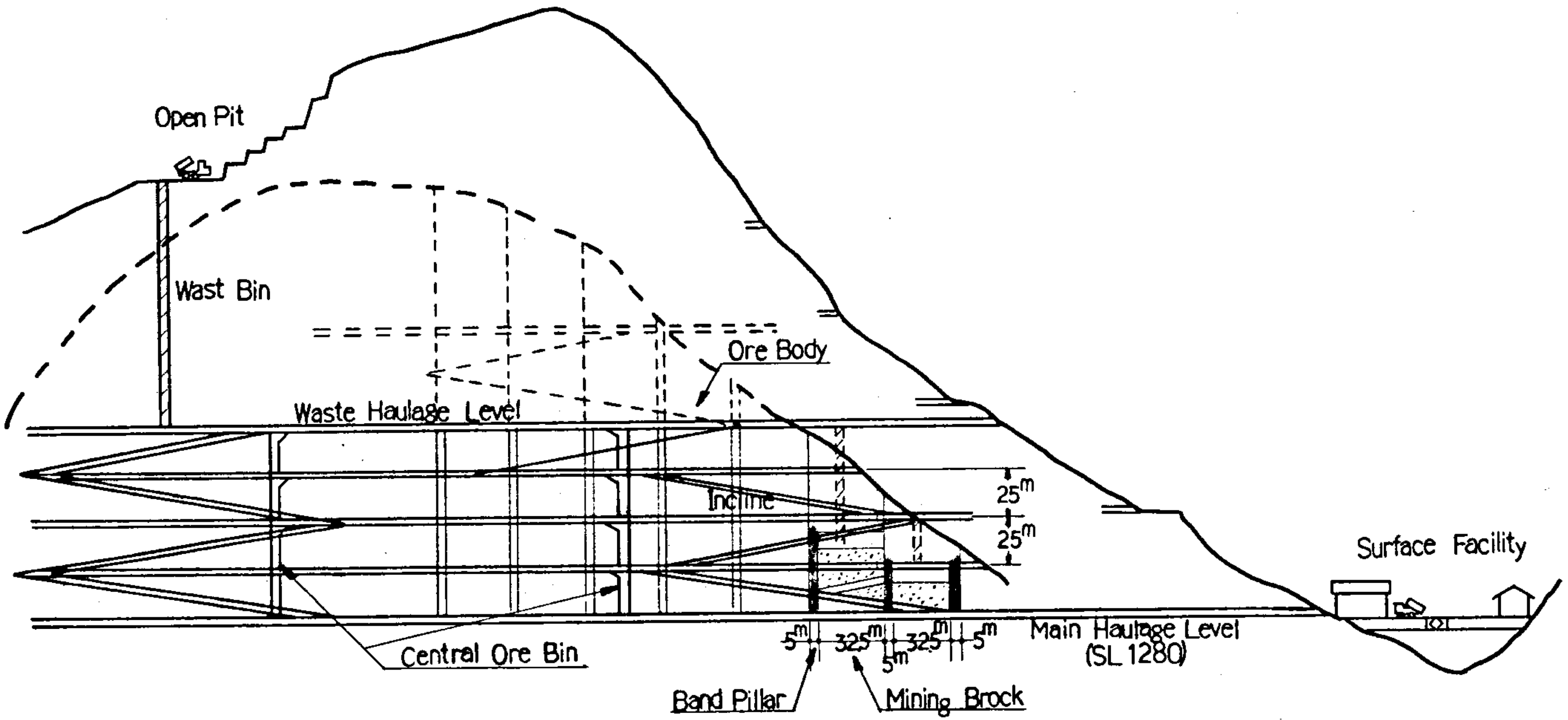
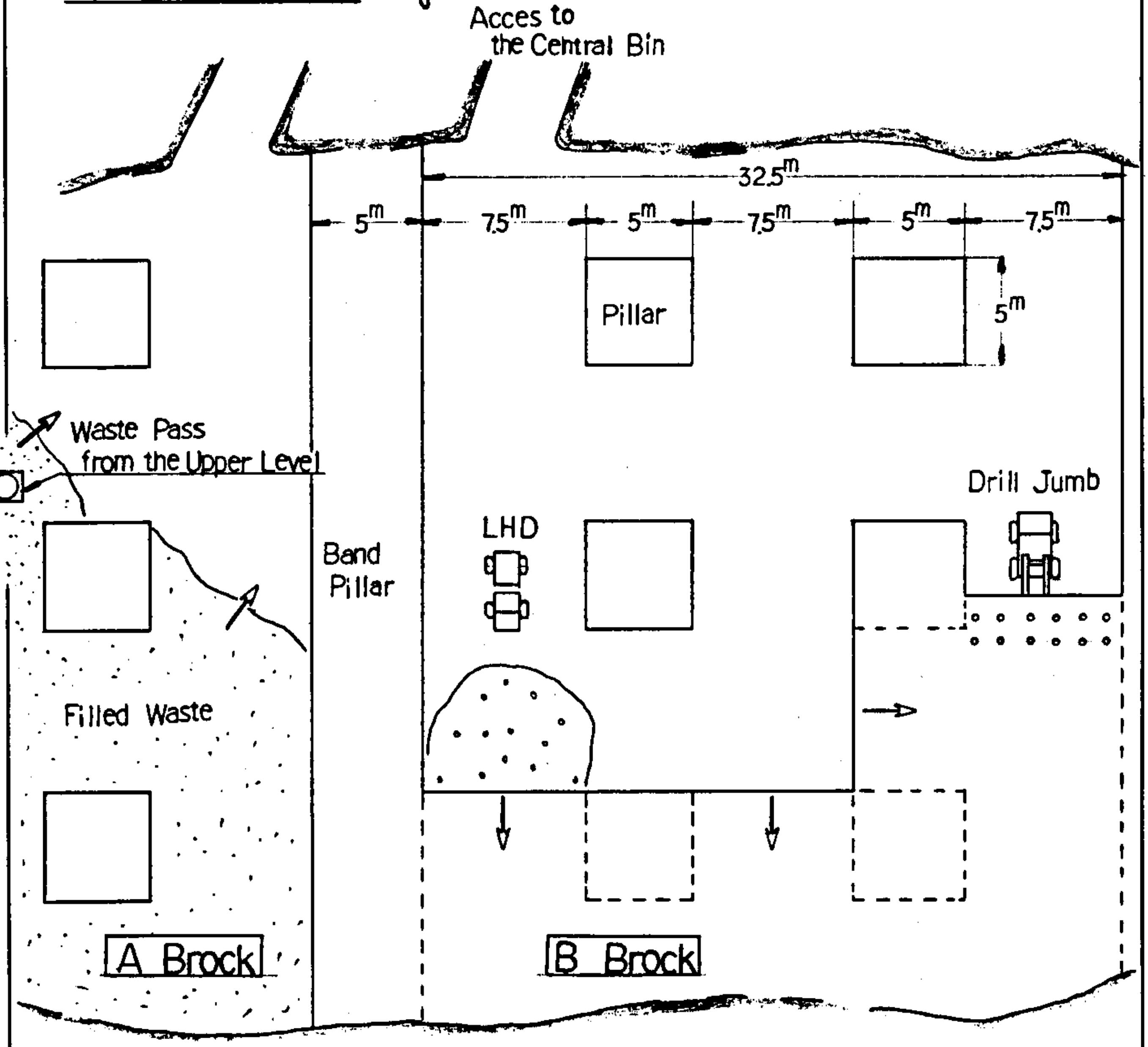


Fig. 7.9 Lay out of Mine Site

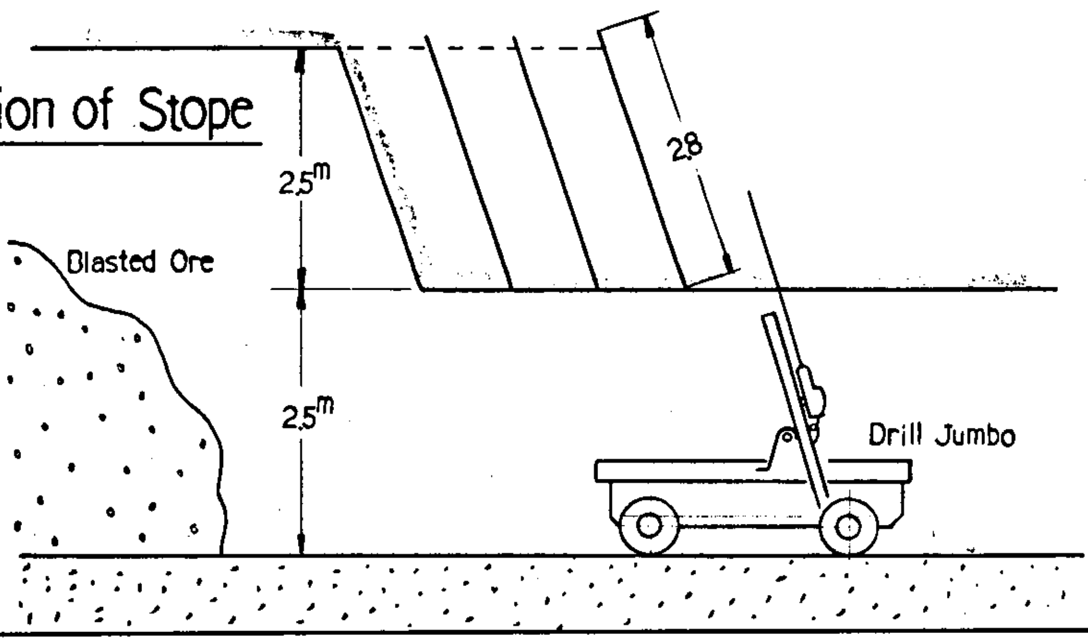
Fig. 7.10 Schematic Diagram of Underground Campo Morad



Plan of Stopes Fig. 7.11



Section of Stope



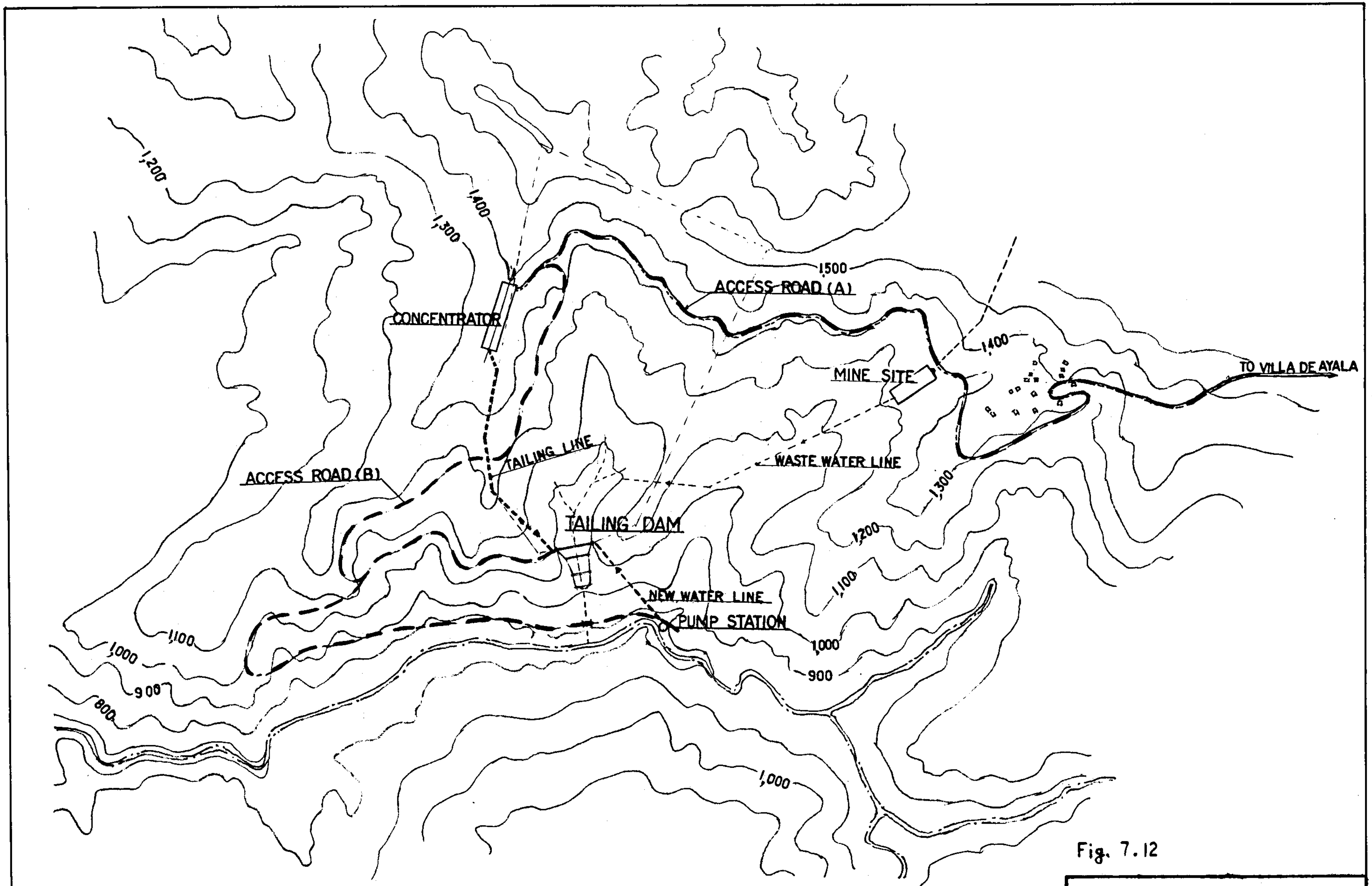


Fig. 7.12

GENERAL PLAN (CAMPO MORADO)

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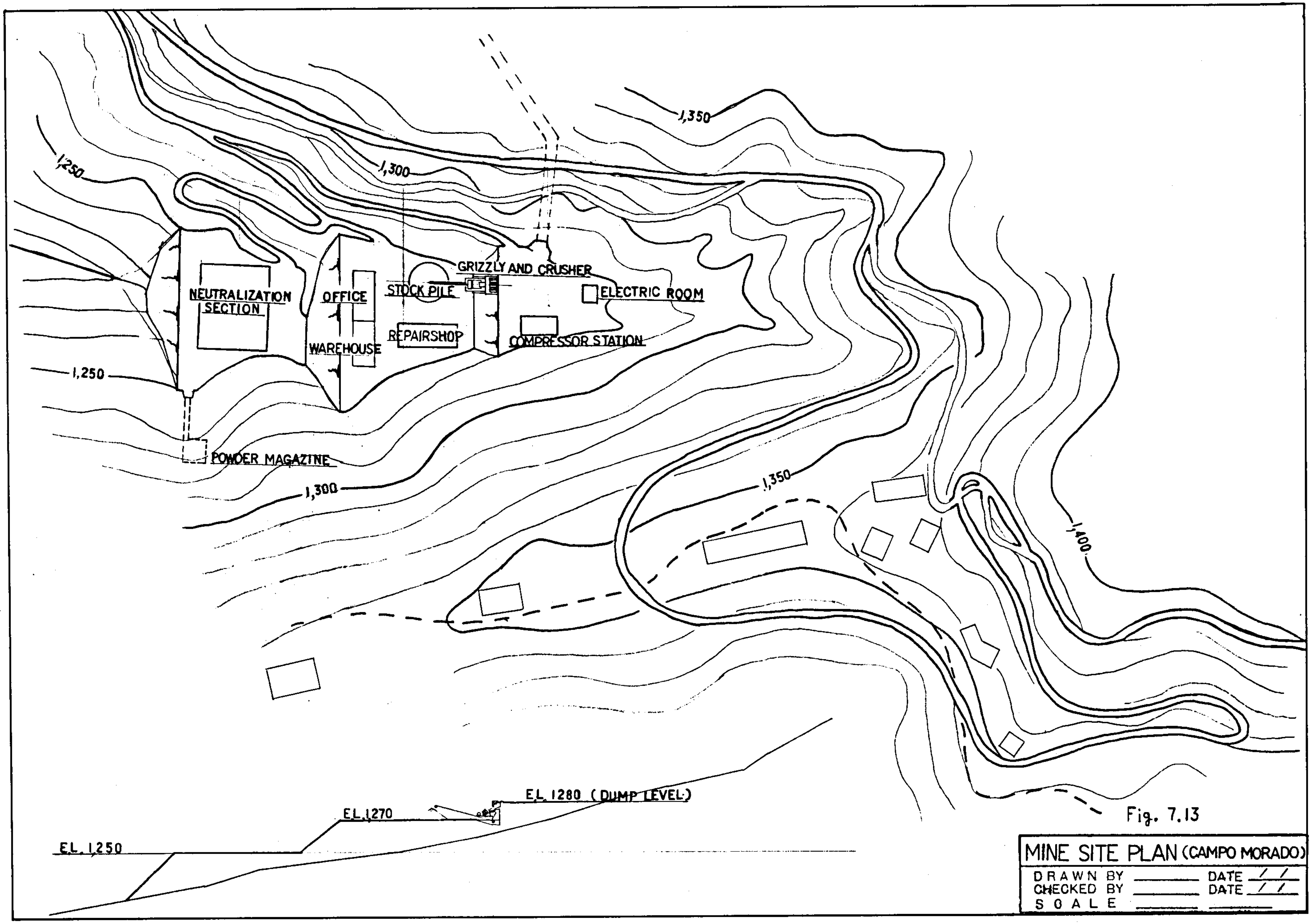

Fig. 7.13

MINE SITE PLAN (CAMPO MORADO)			
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7–2–2–6. EQUIPMENT SPECIFICATION

1) Crushing section

a) Receiving hopper

Quantity	: 1 unit
Capacity	: $12m^3$
Material	: Reinforced Concrete
Accessories	: Apron feeder 1 set
	Belt conveyer 1 set

b) Rippleflow screen

Quantity	: 1 set
Size	: 1,800W x 4,200L
Screen area	: $7.5m^2$ (22m/m)
Material	: Carbon steel
Motor power	: 15KW

c) Primary crusher

Quantity	: 1 set
Type	: Coarse cone crusher
Size	: 12" x 60"
Material	: Carbon steel + Alloy liner
Motor power	: 130KW
Accessories	: Belt conveyer 3 sets

d) Rippleflow screen

Quantity	: 1 set
Size	: 2,100W x 6,000L
Screen area	: $12.6m^2$ (12m/m)
Material	: Carbon steel
Motor power	: 22KW

e) Secondary crusher

Quantity	: 1 set
Type	: Short head type
Size	: 3" x 51"
Material	: Carbon steel + Alloy liner
Motor Power	: 150KW
Accessories	: Belt Conveyor 2 sets

2) Grinding section

a) Mill bin

Quantity	: 8 unit		
Capacity	: 500T x 8 = 4,000T		
Size	: 6,500I.D x 9,000H		
Material	: Reinforced concrete		
Accessories	: Shuttle conveyor	1 set	
	Belt feeder	32 sets	
	Constant feed weight	1 set	

b) Compartment mill

Quantity	: 1 unit	
Type	: Wet type closed circuit	
Size	: 2,700I.D x 8,550L	
Material	: Carbon steel + Alloy liner	
Motor power	: 850KW	
Accessories	: Akims classifier	1 set

c) Ball mill

Quantity	: 1 unit	
Type	: Wet type closed circuit	
Size	: 3,000I.D x 4,350L	
Material	: Carbon steel + Alloy liner	
Motor	: 520KW	
Accessories	: Akims classifier	1 set
	Slurry pump	2 sets
	Cyclone	2 sets

d) Regrinding mill

Quantity	: 2 units	
Type	: Wet type closed circuit	
Size	: 2,100I.D x 2,550L	
Material	: Carbon steel + Alloy liner	
Motor power	: 140KW	
Accessories	: Slurry pump & cyclone	2 units

3) Flotation section

a) Conditioner

Quantity : 12 sets

Capacity : $5m^3$

Material : Carbon steel + Rubber lining

Accessories : Agitator 15KW x 12 sets

b) Flotation machine

Quantity : 232 cells

Type : Agitator

Size : No. 60

Material : Carbon steel + Rubber lining

Motor power : 15KW x 116 sets

Accessories : Air blower $500m^3$/min. x 1,200H x 3 sets
Slurry pumps & Tanks

c) Flotation machine

Quantity : 62 cells

Type : Agitator

Size : No. 48

Material : Carbon steel + Rubber lining

Motor power : 11KW x 31 sets

Accessories : Slurry pumps & Tanks

d) Flotation machine

Quantity : 14 cells

Type : F.W type

Size : No. 24

Material : Carbon steel + Rubber lining

Motor power : 7.5KW x 7 sets

Accessories : Slurry pumps & Tanks

4) Concentration and water supply section

a) Thickener

Quantity	: 2 units
Size	: 30,000I.D x 4,500H
Material	: Carbon steel
Motor power	: 3.7KW
Accessories	: Slurry pump 2 sets

b) Thickener

Quantity	: 2 units
Size	: 20,000I.D x 4,500H
Material	: Carbon steel
Motor power	: 2.2KW
Accessories	: Slurry pump 2 sets

c) Py. concentrate filter

Quantity	: 1 unit	
Type	: Vacuum filter (Belt type)	
Capacity	: Filtration area 47m^2	
Material	: Carbon steel	
Accessories	: Vacuum unit	1 unit
	Belt conveyer	1 set

d) Zn concentrate and Pb concentrate filter

Quantity	: 2 units	
Type	: Vacuum filter (Drum type)	
Capacity	: Filtration area	13.5m^2
Material	: Carbon steel	
Accessories	: Vacuum unit	1 unit
	Belt conveyer	2 sets

e) Cu concentrate filter

Quantity	: 1 unit	
Type	: Vacuum filter (Drum type)	
Capacity	: Filtration area	6.7m^2
Material	: Carbon steel	
Accessories	: Belt conveyer	1 set

f) Concentrate yard

Quantity	:	1 unit
Size	:	55,000W x 15,000L
Material	:	Reinforced concrete
Accessories	:	Building

g) Water tank

Quantity	:	2 sets
Capacity	:	1,000m^3
Size	:	20,000I.D x 3,800H
Material	:	Reinforced concrete

7–2–2–7. TAILINGS DISPOSAL

To dispose of tailings of 8,820 T/M resulting from the ore of 35,000 T/M mined from the Campo Morado deposit, a valley near the concentrator will be dammed up by a rock fill type retaining dam. The decant water in the pond will be flowed downstream through a decant tower and a underdrainage conduit.

The site for the tailings disposal including the retaining dam is estimated to have the top soil about 1 m deep and a relatively firm sedimentary rock underneath. Proposed borrow pit near the dam site are expected to have the same geological structure. For this kind of geological structure a rock fill type retaining dam is most suitable with its upstream face formed of gravel clay.

The tailings dam will have the catchment area of about 2.2 km^2, and an open channel will be provided surrounding the final tailings pond surface to trap rainwater flowing down from the surrounding slopes and to prevent it from flowing into the pond. The retaining dam will be built to the height of 30 m at first stage. Five years after the mining operation starts, the dam will be enhanced by 30 m, making it 60 m high.

The major specifications of the tailings disposal is as follows.

a) Retaining dam

Type : rock fill dam (with gravel-clay zone)

Dam height : 60 m

Embankment volume: 1,208,000 m^3

Pond capacity : 2,400,000 m^3

b) Underdrainage conduit

Structure : reinforced concrete

Dimension : 1.5 m (width) x 1.5 m (height)

Length : 1,400 m

c) Open channel

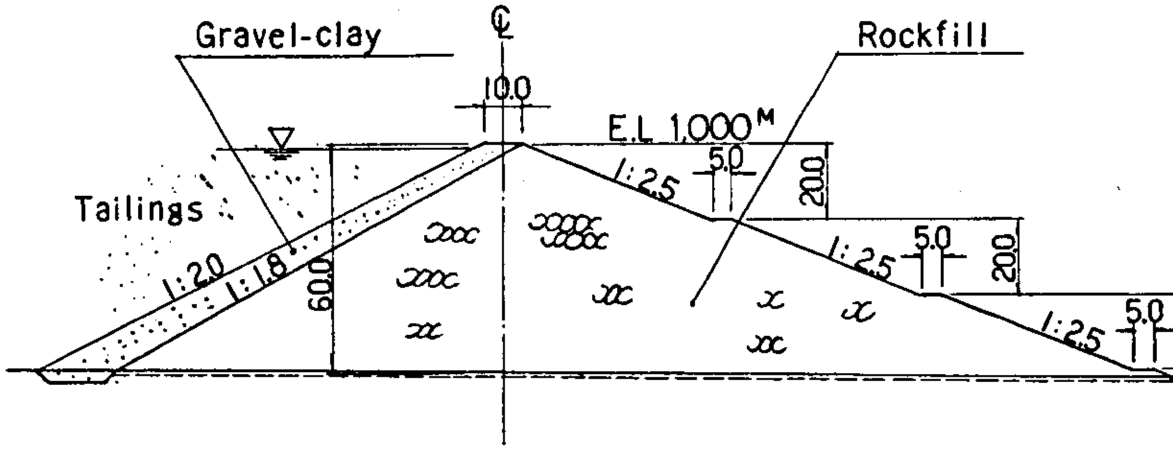
Structure : reinforced concrete

Dimension : 1.4 m (upper width), 1.0 m (lower width) x 0.9 m (depth)

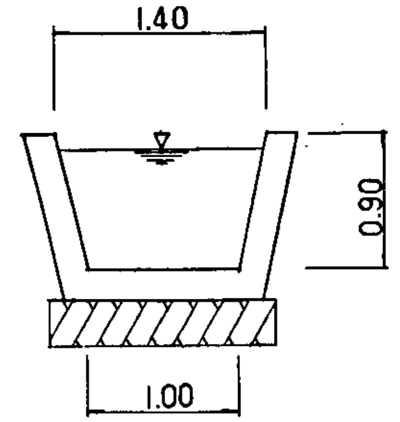
Length : 1,400 m

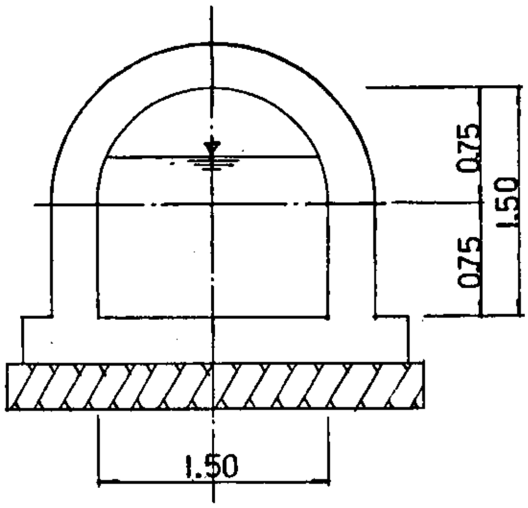
d) Designed max. discharge capacity

20 mm/hour, 12.4 m^3/sec.



Retaining Dam S : 1/2,000





Open Channel S : 1/50 Drainage Tunnel S : 1/50

Unit : m

Fig. 7・14

Tailing Dam (Campo Morado)			
DRAWN BY	K. Sakaino	DATE	9 Mar/'81
CHECKED BY		DATE	/ /
SCALE			

7–2–3. ANCILLARY SERVICES

7–2–3–1. COPPER KING MINE

1) Generator

   Described in section 7–1–1–4, 4)

2) Water supply system

   Described in section 7–1–1–4, 7)

3) Neutralization plant

   Described in section 7–1–1–4, 6)

4) Settling pond

   Capacity : 200,000 m^3

   Area : 40,000 m^2

   Depth : 5 m

5) Repair shop

   Described in section 7–1–1–4, 2)

6) Office building

   Described in section 7-1–1–4, 10)

7) Warehouse

   Described in section 7–1–1–4, 5)

7–2–3–2. CAMPO MORADO MINE

1) Ancillary equipment for mine

   a) Water supply system

      Described in section 7–2–1–4, 7)

   b) Neutralization plant

      Described in section 7–2–1–4, 6)

   c) Repair shop

      Described in section 7–2–1–4, 2)

   d) Office building

      Described in section 7–2–1–4, 10)

   e) Warehouse

      Described in section 7–2–1–4, 5)

2) Ancillary equipment for concentrator

a) Water supply system

Pump	: 2.5 m^3/min x 750 mH
Quantity	: 3 sets (including one spare unit)
Piping	: 150 I.D. x 2,800 m
Other	: Water intake facility
	(1,500 I.D. well, 600 I.D. lateral intake pipe)

b) Pipe line for tailings

Size	: 150 I.D.
Length	: 2,000m x 2 sets

3) Common facility

a) Generator

Type	: Diesel generator
Output	: 3,500 KW
Voltage	: 6 KV, 60 Hz
Revolution	: 450 rpm
Quantity	: 3 sets (including one spare unit)
Others	: Cooling tower, oil tank etc. 1 set

b) Repair shop for machinery

Structure	: Steel structure
Area	: 12 m x 32 m = 384 m^2
Equipment	: Equipment for repair, manual crane 1 set

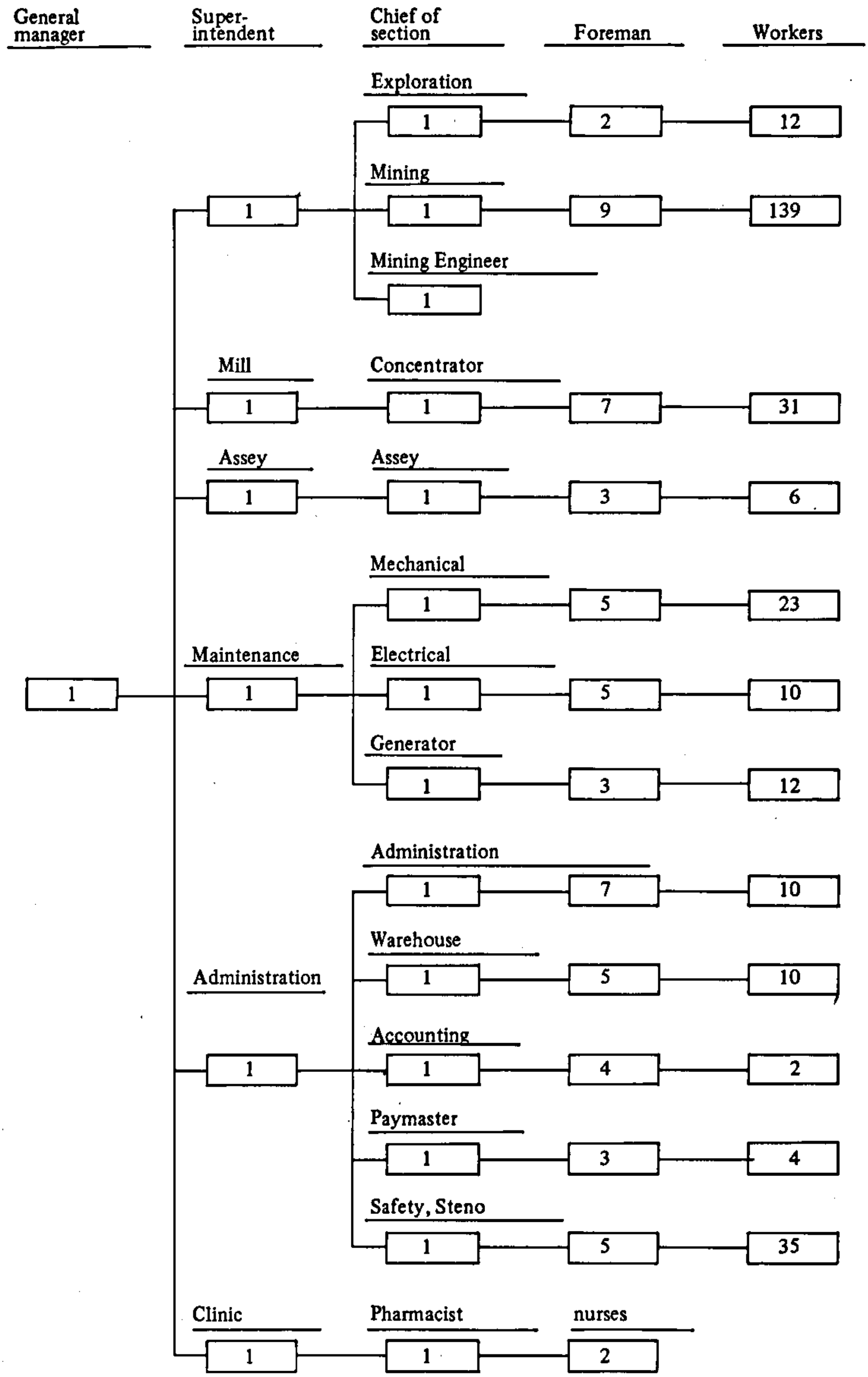
c) Repair shop for car

Structure	: Steel structure
	High 5.5 m
Area	: 15 m x 32 m = 480 m^2
Equipment	: Equipment for repair, manual crane 1 set

d) Office building

Structure	: Steel structure
	Hight 4.5 m
Area	: 17 m x 32 m = 544 m^2

7–2–4 ORGANIZATION FOR OPERATING CAMPO MORADO MINE



Total	1	6	14	60	294	375

8 PLANNING OF THE METALLURGICAL PLANT

8. PLANNING OF THE METALLURGICAL PLANT

8–1 INTRODUCTION

Lazaro Cardenas city of Michoacan state, situated on the Pacific coast at the mouth of Balsas River flowing along the border between Michoacan and Guerrero states, has a registered population of 230,000; but it virtually has an estimated population of 650,000 to 750,000. In 1963 a "Comission del Rio Balsas" was established to promote the overall development of the region on the basin of River Balsas in an effort to eliminate regional gap between the developing region on the Pacific coast and the industrialized region along the coast of Mexico Bay. This comprehensive development program includes the production of steels and chemicals, the exploitation of natural resources, and the construction of roads, railways and ports.

In 1972, an integrated iron and steel works and started construction ahead of other projects of the program and the first phase of construction was completed in 1976. This steel complex– Sidrurgica Lazaro Cardenas Las Truchas S.A. and a direct affiliate of the steel making public corporation Sidermex– is producing 1 million tons of crude steel annually.

Adjacent to this steel complex, a large-scale fertilizer plant of the fertilizer public corporation Fertimex is under construction for the completion in 1982.

A vast delta of Balsas River divided by canals is being prepared as the site for the coastal industrial zone which is now being reclaimed and expanded. The canal is 14 m deep and 300–600 m wide. The land reclamation will be carried out in three phases.

The first phase of work will be completed in 1982 reclaiming 1,200 ha, the second phase in 1985 reclaiming 1,000 ha and the third phase in 1990 reclaiming 800 ha. Planned to be built on the reclaimed land are the petrochemical complex of Pemex, shipbuilding plant, steel complex (Japanese enterprises will also participate), marine product processing plant, food processing plant, commercial center, and shipping company.

A comprehensive development program currently undertaken along the River Balsas includes a water supply system for industrial use, power plants (power output of existing power plants is about 1 million kw), railways and roads. This district is also designated as the coastal industrial zone and entitled to a benefit of being supplied with industrial energy at 30% discounted rate.

Piping for natural gas and liquefied gas base are also being planned. Considering these, this site can be said a desirable one for building plants.

In its area of 160 ha, the ironworks is operating its blast furnace (1,750 m^3). The ore are supplied from the Fertipec mine, 27 km distant, which is said to have an ore reserve of about

100 million tons. The ore is mined from the open pit and, after being dressed and concentrated by magnetic separation, is transported by slurry transportation system to the ironworks (Marcona slurry system). The ironworks employs a Lurgi process in pelletizing the transferred ore.

This ironworks is now being expanded as a national project to increase its annual crude steel production capacity to 3,650,000 tons by 1982, 6,500,000 tons by 1988 and 10,000,000 tons by 1994, eventually making it the largest iron and steel works in Mexico. To meet the expanding demand for iron ores, it is planned to import the material from Australia. According to one official in the ironworks, the pellets produced by the Japanese chloridizing volatilization process have good chemical and physical properties as compared with the pellets formed by existing Lurgi process of this ironworks. He also said that the pelletizing plant project would contribute to exploitation of natural resources in Mexico and therefore would be welcomed.

The fertilizer plant being constructed at the site of 120 ha adjacent to the ironworks will complete its second phase of construction work by 1982 – 1983.

At the same time Fertimex is also constructing a sulfuric acid plant with a capacity of 660,000 t/y at Queretaro and another of 198,000 t/y at Guauajuato.

Furthermore, Fertimex plans to build two fertilizer complexes about the same scale of the Lazaro Cardenas plant and it is said the locations of these plants will soon be determined.

Despite these stepped up efforts to increase sulfuric acid production, it cannot catch up with the demand and the import from the U.S. of sulfuric acid should be continued. Thus the prospect of marketing in this country the sulfuric acid produced in this project is bright.

8–2 PRODUCTION CAPACITY AND QUALITY OF PRODUCT

According to the plans of mine development and mineral processing, the production of pyrite concentrate from the Campo Morado mine will be 23,500 tons/month.

The burnt pellet production was planned at 340,000 tons per year, because, from the result of metallurgical tests, the maximum capacity of a single rotary kiln for the chloridizing volatilization process was estimated at 340,000 tons per year, which is expected to make the metallurgical plant the most economical. Considering the annual utilization of rotary kiln, this is equivalent to the monthly average production of 28,200 tons of pellet and will require 28,500 tons of cinder per month, which is the material for pellets. To produce this amount of cinder, 40,200 T/M of pyrite concentrates will be required. Since this cannot be covered only by the Campo Morado mine, the Copper King deposit will have to be minded to make up for the balance. 16,700 tons of pyrite ore will be mined from the Copper King deposit. The quality of the pellet will comply with the quality standard of one of the largest steel making companies in Japan. With these conditions set, the sulfuric acid plant will produce 57,100 T/M of sulfuric acid.

Quality of main products

a) Sulfuric acid: 98% H_2SO_4

b) Pellet

Chemical composition:	Cu<0.04%, Zn<0.05%, Pb<0.02%, S<0.04% and Fe > 61.5%.
Physical property:	Crushing strength > 250 kg/pellet, Tumbler strength = +5 mm 98%. Pellet size = 11 ∿ 13 mmϕ.
Reducing property:	Reduction ratio > 50%, Crushing strength after reduction = 20 ∿ 50 kg/pellet.

8–3 PRODUCTION PROCESS

The metallurgical plant consists of a roasting process, a sulfuric acid process and a chloridizing volatilization process and is designed to fully utilize the pyrite ore. Each process has the latest technology and facilities to ensure efficient processing.

8–3–1. ROASTING PROCESS

While the material from the Campo Morado is pyrite concentrate (-400 mesh, 100%), the Copper King mine will supply pyrite ore (-100 mm). Therefore a crushing and wet grinding process will be provided in the plant to grind the pyrite ore from the Copper King deposit into fine particles (-200 mesh, 80%), which will be blended in pulp condition with the Campo Morado pyrite concentrate.

The roasting process employs the fluidized bed roasting system, and the method of ore feeding is a wet type. In this process, the feed ore in the pulp condition with 75% solid is charged uniformly from the distributor into the top of the roasters where it is roasted at 900°C with the space velocity of 40–50 cm/sec.

The gas from the roasters is cooled in the waste heat boilers down to 350°C and sent to cyclones and Peabody scrubbers where it is scrubbed and cooled further down to 40°C. At this stage the SO_2 content in the gas will be about 13%. This gas is then transferred to the sulfuric acid plant.

The waste heat boilers produce steam (32 kg/cm^2) at the rate of 50 tons/hour, which is used partly for miscellaneous purposes and for generator to supply 10,000 kw of electric power.

The calcine cinder recovered from the roasting process is cooled by adding calcium chloride solution and will be used as the material for the chloridizing volatilization process. The planned recovery rate of sulfur in the roasting process is 97.5%.

8–3–2. SULFURIC ACID PLANT

The gas, which was recovered from the roasters and then scrubbed and cooled, is now sent through the mist precipitators to the drying towers. In the drying towers, flue gas is dried by the circulating sulfuric acid and then sent under pressure by the blowers through the heat exchangers to the converters where SO_2 gas is converted into SO_3 with the use of catalyst.

SO_3 gas is then led to the absorbing tower where it is absorbed by the circulating acid. In this plant, conversion from SO_2 gas into SO_3 gas and absorption of SO_3 gas are carried out two times to prevent environmental pollution by SO_2. The SO_2 content in the final exhaust gas will be about 300 ppm. The total recovery rate of sulfur will be 96.8%.

8–3–3. PELLETIZING PLANT

Conventionally, pyrite ores have not been fully utilized since only sulfur is extracted from the ores as the raw material for sulfuric acid and other minerals contained such as iron and nonferrous metals are not extracted.

In Japan with scarce iron resources, these pyrite ores began to be used as the material for steel making since around 1950. The use of pyrite ores for steel making posed various problems, such as reduced efficiency of sintering process caused by increased proportion of pyrite cinder and air pollution by residual sulfur.

In this situation, steel makers were calling for the material of better quality and began importing a large amount of rich and cheap iron ore, further reducing the value of the pyrite ores as the material for steel making.

In order to efficiently utilize the pyrite ores, a chloridizing volatilization process was invented in Japan. In this process, the pyrite cinder is added with chloridizing agent (calcium chloride), pelletized and heated to bring about chloridizing action for volatilizing nonferrous metals. The volatilized metals are recovered from the flue gas for further treatment by nonferrous metal refineries. At the same time green pellets are sintered to produce burnt pellets of good quality.

In Japan the whole pyrite cinders are being processed at Tomakomai, Amagasaki, and Tobata works by using this chloridizing volatilization process.

The primary objective of this project is to develop the pyrite deposits in Guerrero and integrately utilize the pyrite ore by employing this process in processing the cinder.

The outline of this process is described in the following.

Cinder produced in the roasting plant is cooled and mixed with 40% calcium chloride solution in a rotary mixer and uniformly blended in a blending system. As a preliminary treatment for pelletizing process, the blended cinder is thoroughly kneaded by a semi-dry type ball mill. Then it is pelletized by a pan type pelletizer into green pellets with the crushing strength of 6–8 kg/pellet and the moisture content of 12–13%. The green pellets are then dried to the water content of 0.3% and sent into a rotary kiln or a chloridizing volatilization furnace.

The chloridizing volatilization reaction is greatly affected by the rotating movement of the kiln, the burning condition of fuel, the characteristic of raw cinder, and the retention time. The heat pattern of the kiln will be selected so as to give the pellets satisfactory chemical composition and physical property. The burnt pellets are cooled before being shipped.

The flue gas from the kiln is extracted at the temperature of about 700°C and cooled by a wet type gas cooler where the valuable nonferrous metals are collected in the circulating solution. The waste gas is then passed through a scrubber and mist precipitator and out into the open air.

The valuable metals arrested in the solution are recovered in a recovery plant by neutralization, cementation or oxidation. Tailing solution is concentrated to the calcium chloride content of 40% and returned to the rotary mixer. Precipitates containing valuable metals are filtered and the filtered cakes are then supplied to nonferrous metal refineries.

In the process of treating the solution, gypsum is produced as by-product.

8–4 BASIC CALCULATION OF THE PLANT CAPACITY

1) Basic Conditions

In planning this project the latest technology will be used as far as possible and the following conditions are used.

o Campo Morado pyrite concentrate (dry):	23,485 T/M
	(281,820 T/Y)
o Copper King pyrite ore (dry):	16,700 T/M
	(200,400 T/Y)
Total	40,185 T/M)
	(482,220 T/Y)

2) Basic Calculation

a) Stock yard for raw materials

Storing capacity

Campo Morado pyrite concentrate (dry):	23,485 T/M
(wet):	26,994 T/M
(water content):	13%

This stock yard is capable of storing the raw material in the amount equal to about one month consumption in this plant. That is, if we let the bulk density be 2.0, the volume will be

$(26{,}994) \div (2.0) = 13{,}497\ m^3/\text{month}$

The height of the pile of material is set at 5 m. The stock yard will be equipped with an unloader facility and a feed hopper. The rainfall during the rainy season will also be considered in the designing.

o Copper King pyrite ore (dry):	16,700 T/M
(wet):	17,041 T/M
Water content :	2.0%

This stock yard has the capacity of storing the pyrite ore from Copper King in the amount equal to about one month of consumption in this plant. Performing the same calculation as with Campo Morado case, the material volume will be 8,521 m^3/M. Since this ore will be subjected to the wet grinding process, measures for protecting the ore from rainfall will not be taken.

b) Crushing and grinding process for Copper King pyrite ore

o Crushing

A cone crusher will be used for this process.

Calculation on the amount of crushed ore

Amount of ore crushed per year: 200,400 T/Y

If the yearly operating days are set at 339.5 days/year the same as the roasting plant, the amount of ore crushed daily will be

$$200,400 \text{ T} \div 339.5 = 590.3 \text{ tons/day}$$

Daily operating time (day work) is assumed to be 6 hours; then the cone crusher must process

$$590.3 \text{ T/D} \div 6 = 98.4 \text{ T/H}$$

Thus the capacity of the crushing facility will be designed for 100 T/H.

o Grinding

In order to reduce the facility cost, this facility will be operated 24 hours a day. Thus the capacity will be

$$(590.3 \text{ T/D}) \div 24 = 24.6 \text{ T/H} \fallingdotseq 30 \text{ T/H}$$

c) Repulping of pyrite ores

Amount of ores to be processed yearly: 482,220 T/Y

The same yearly operating days as the roasting plant is used. The amount of ore that must be processed daily will be

$$(482,220 \text{ T/Y} - \overset{*}{120} \text{ T/Y}) \div 339.5 \text{ D/Y} = 1,420 \text{ T/D}$$

(* Note: Losses of Copper King ore: 120 T/Y)

Assuming the daily operating hours (day work) to be 6 hours, this facility must process

$$(1,420 \text{ T/D}) \div 6 = 236.7 \text{ T/H}$$

Considering the low efficiency of operation during the rainy season, the facility will be designed for the capacity of 250 T/H.

d) Roasting plant

o Utilization: Overall utilization during normal operation 93%

Annual operating days

$$(365) \times (0.93) = 339.5 \text{ D/Y}$$

Annual maintenance days

$$(365) \times (1 - 0.93) = 25.5 \text{ D/Y}$$

(* Periodical maintenance day: 18 D/Y)

o Capacity: Amount of ore to be roasted

yearly 482,100 T/Y

Amount of ore to be roasted daily

(482,100) ÷ (339.5) = 1,420 T/D

Thus, the hourly roasting capacity is set at 59.2 T/H. The number of roasters will be 2.

e) Sulfuric acid plant

Utilization: Same as the roasting plant

Capacity: Amount of ore roasted daily 1,420 T/D

The content of sulfur in the mixed pyrite ore is 47.21% as shown in the material balance. The following losses are assumed in roasting and sulfuric acid plant.

o	Residual sulfur loss in cinder (sulfur content 0.6%)	0.9%
o	SO_3 loss (waste acid)	1.2%
o	SO_2 loss of gas purification	0.2%
o	Handling loss of roasting and sulfuric acid plant	0.4%
o	Converting loss	0.3%
o	Absorbing loss	0.2%
o	Measuring loss of sulfuric acid (Density of product acid 98.4%)	(0.4%)
	Total loss of sulfur	3.2%

Thus the daily acid production will be

(1,420) x (0.4721) x (1–0.032) x (98/32) x (1/0.98) = 2,028 T/D

The capacity of this plant is set at 2,040 T/D.

f) Pellet plant

o Utilization: Overall utilization during normal operation 87%

Annual operating day

(365) x (0.87) = 317.6 D/Y

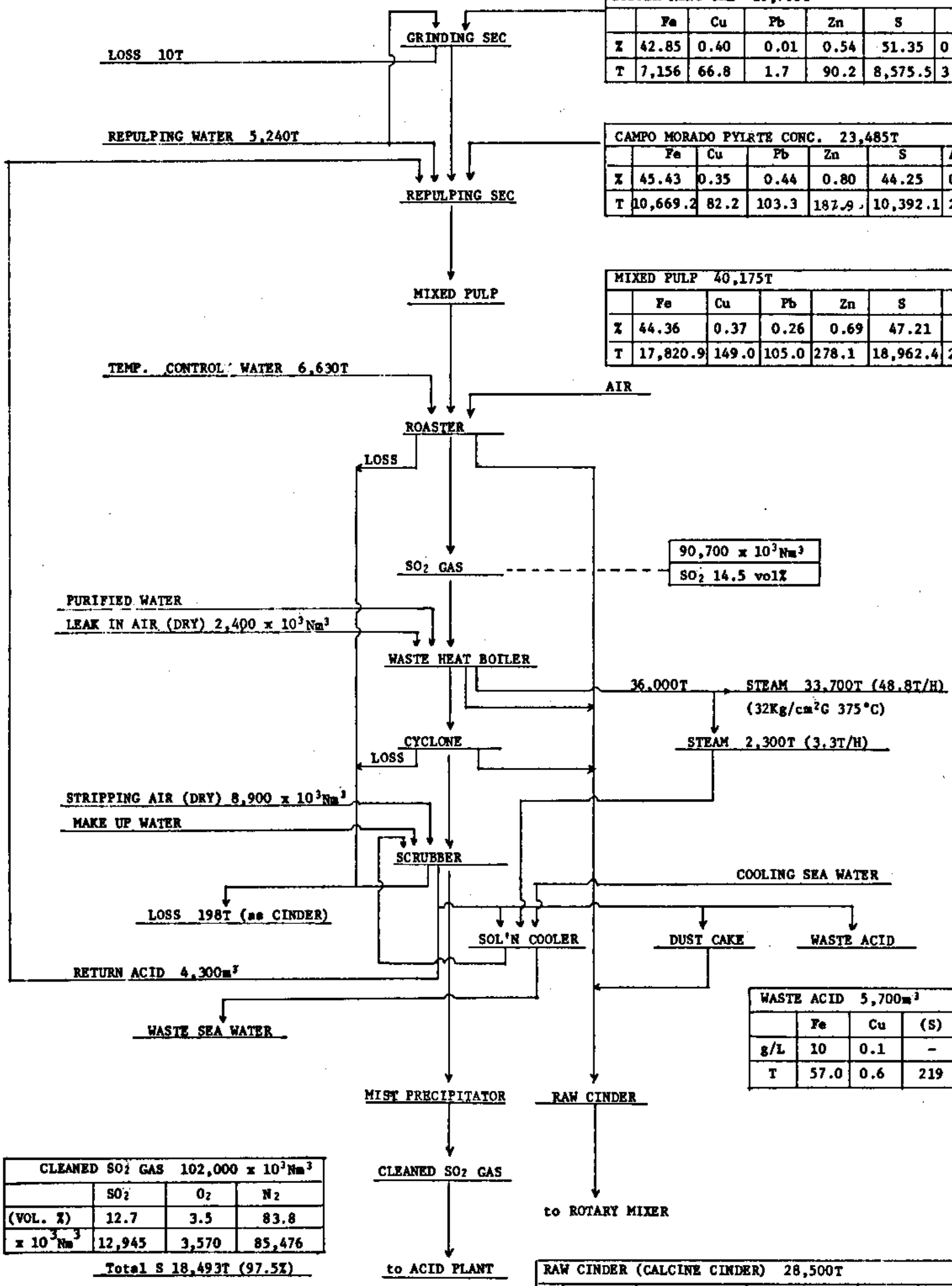
Annual maintenance days

(365) x (1 – 0.87) = 47.4 D/Y

In principle, this plant will be placed out of operation at the same time that the sulfuric acid plant is stopped for periodical maintenance. It will also be removed from operation for about 10 days every 3 months for maintenance to ensure good operating condition and long life.

(I) MATERIAL BALANCE SHEET OF THE ROASTING PLANT

(CAMPO MORADO 35,000T/M + COPPER KING 16,700T/M)



COPPER KING ORE 16,700T								
	Fe	Cu	Pb	Zn	S	Au	Ag	H_2O
%	42.85	0.40	0.01	0.54	51.35	0.18	7.5	2.0
T	7,156	66.8	1.7	90.2	8,575.5	3.01	125.3	340.8

CAMPO MORADO PYLRTE CONC. 23,485T								
	Fe	Cu	Pb	Zn	S	Au	Ag	H_2O
%	45.43	0.35	0.44	0.80	44.25	0.92	86	13.0
T	10,669.2	82.2	103.3	187.9	10,392.1	21.60	2,019.7	3,509.3

MIXED PULP 40,175T								
	Fe	Cu	Pb	Zn	S	Au	Ag	H_2O
%	44.36	0.37	0.26	0.69	47.21	0.61	53.39	25
T	17,820.9	149.0	105.0	278.1	18,962.4	24.61	2,145.0	13,392

90,700 x $10^3 Nm^3$
SO_2 14.5 vol%

WASTE ACID 5,700m^3					
	Fe	Cu	(S)	H_2SO_4	$CaSO_4$
g/L	10	0.1	-	100	2.0
T	57.0	0.6	219	570	-

CLEANED SO_2 GAS 102,000 x $10^3 Nm^3$			
	SO_2	O_2	N_2
(VOL. %)	12.7	3.5	83.8
x $10^3 Nm^3$	12,945	3,570	85,476

Total S 18,493T (97.5%)

RAW CINDER (CALCINE CINDER) 28,500T									
	Fe	Cu	Pb	Zn	S	Au	Ag	(CL)	H_2O
%	61.88	0.517	0.365	0.965	0.60	0.85	74.46	-	0
T	17,634.6	147.4	103.9	275.1	171.0	24.12	2,122.2	-	-

(II) MATERIAL BALANCE SHEET OF THE ACID PLANT

CLEANED SO_2 GAS

CLEANED SO_2 GAS 102,000 x 10^3Nm^3			
	SO_2	O_2	N_2
(VOL %)	12.7	3.5	83.8
x 10^3Nm^3	12,945	3,570	85,476

Total S 18,493T (97.5%)

DILUTION AIR (DRY) 41,700 x 10^3Nm^3

DRYING TOWER

LOSS 16T (as SULFUR)

DRIED SO_2 GAS

DRIED SO_2 GAS 143,700 x 10^3Nm^3			
	SO_2	O_2	N_2
(VOL %)	9.0	8.6	82.4
x 10^3Nm^3	12,934	12,331	118,435

(Total S 18,477T)

CONVERTER

LOSS 16T (as SULFUR)

SO_3 GAS

SO_3 GAS 137,250 x 10^3Nm^3				
	SO_2	SO_3	O_2	N_2
(VOL %)	0.03	9.4	4.3	86.3
x 10^3Nm^3	39	12,884	5,890	118,435

(Total S 18,461T)

DILUTION WATER

ABSORBING TOWER

LOSS 16T (as SULFUR)

PRODUCT SULFURIC ACID

WASTE GAS

WASTE GAS 124,400 x 10^3Nm^3				
	SO_2	SO_3	O_2	N_2
(VOL %)	0.03	0.02	4.7	95.2
x 10^3Nm^3	39	25	5,890	118,435

180,000Nm^3/H

PRODUCT SULFURIC ACID 57,100T		
	H_2SO_4	H_2O
%	98.4	1.6
T	56,206	-

(Total S 18,353T)

* TOTAL S RECOVERY 96.8%

(III) MATERIAL BALANCE SHEET OF THE WASTE ACID TREATMENT

WASTE ACID 5,700m^3					
	Fe	Cu	(T-S)	H_2SO_4	$CaSO_4$
g/L	10	0.1	-	100	2.0
T	57.0	0.6	219	570	-

CHALK POWDER 600T ($CaCO_3$ 95%)

WASHING WATER 660T

NEUTRALIZING

RECOVERED GYPSUM

(6,170m^3)

RECOVERED GYPSUM 1,090T			
-	SO_3	Fe	H_2O
%	42	1	15
T	458	10.9	192

SLAKED LIME 95T ($Ca(OH)_2$ 90%)

OXIDIZING AIR

DE-Fe REACTOR

WASTE CAKE

H_2SO_4 (as 98%)

WASTE CAKE 460T				
	Fe	SO_3	(S)	H_2O
%	10.0	19.5	-	70
T	46.1	90	(37)	1,073

PH CONTROL TANK

WASTE SOL'N

WASTE SOL'N 5,100m^3					
	Fe	Cu	Pb	Zn	PH
ppm	5.0	1.0	1.0	5.0	7
Kg	—	—	—	—	

(IV) MATERIAL BALANCE SHEET OF THE PELLET PLANT

RAW CINDER

RAW CINDER 28,500T											
	Fe	Cu	Zn	Pb	S	Cl	CaO	SiO_2	Au*	Ag*	H_2O
g	61.88	0.517	0.965	0.365	0.60	-	0.15	4.52	0.85	74.46	0
T	17634.6	147.4	275.1	103.9	171.0		42.7	1287.7	24.12	2,122.[illegible]	-

* g/t, Kg

SLAKED LIME 208T $Ca(OH)_2$ 95%

$CaCl_2$ 4,988T (40% SOL'N)

ROTARY MIXER

FERRIC CAKE 460T											
	Fe	Cu	Zn	Pb	S	Cl	CaO	-	-	-	H_2O
g	34.67	–	5.0	0.3	–	8.3	6.5				55
T	159.5	–	23.0	1.3	-	38.2	30.1				562

BLENDING

MIXED CINDER

MIXED CINDER 31,163T											
	Fe	Cu	Zn	Pb	S	CL	CaO	SiO_2	Au*	Ag*	H_2O
g	57.10	0.473	0.957	0.338	0.549	4.22	3.94	4.13	0.77	68.1	10.2
T	17794.1	147.4	298.1	105.2	171.0	1314.3	1288.8	1287.7	24.12	2122.2	3555

BALL MILL

PELLETIZER

GREEN PELLET

FUEL GAS 587,500Nm³ (HL 9,600Kcal/Nm³)

DRYER

DRIED PELLET

DRIED BALL 30,696T											
	Fe	Cu	Zn	Pb	S	Cl	CaO	SiO_2	Au*	Ag*	H_2O
g	57.10	0.473	0.957	0.338	0.549	4.22	3.94	4.13	0.77	68.1	-
T	17527.2	145.2	293.6	103.6	168.4	1294.6	1210.4	1268.4	23.76	2090.4	-

FUEL GAS 1,410,000Nm³ (HL 9,600Kcal/Nm³)

ROTARY KILN

KILN OFF GAS → to GAS TREATMENT

VOLATILE MATTER 1,963T											
	Fe	Cu	Zn	Pb	S	Cl	CaO	SiO_2	Au*	Ag*	Dust
T	(26.2)	133.9	279.5	98.0	157.1	1266.4	-	-	23.20	1949.4	-

IGNITION LOSS 533T

LOSS 467T

COOLING AIR

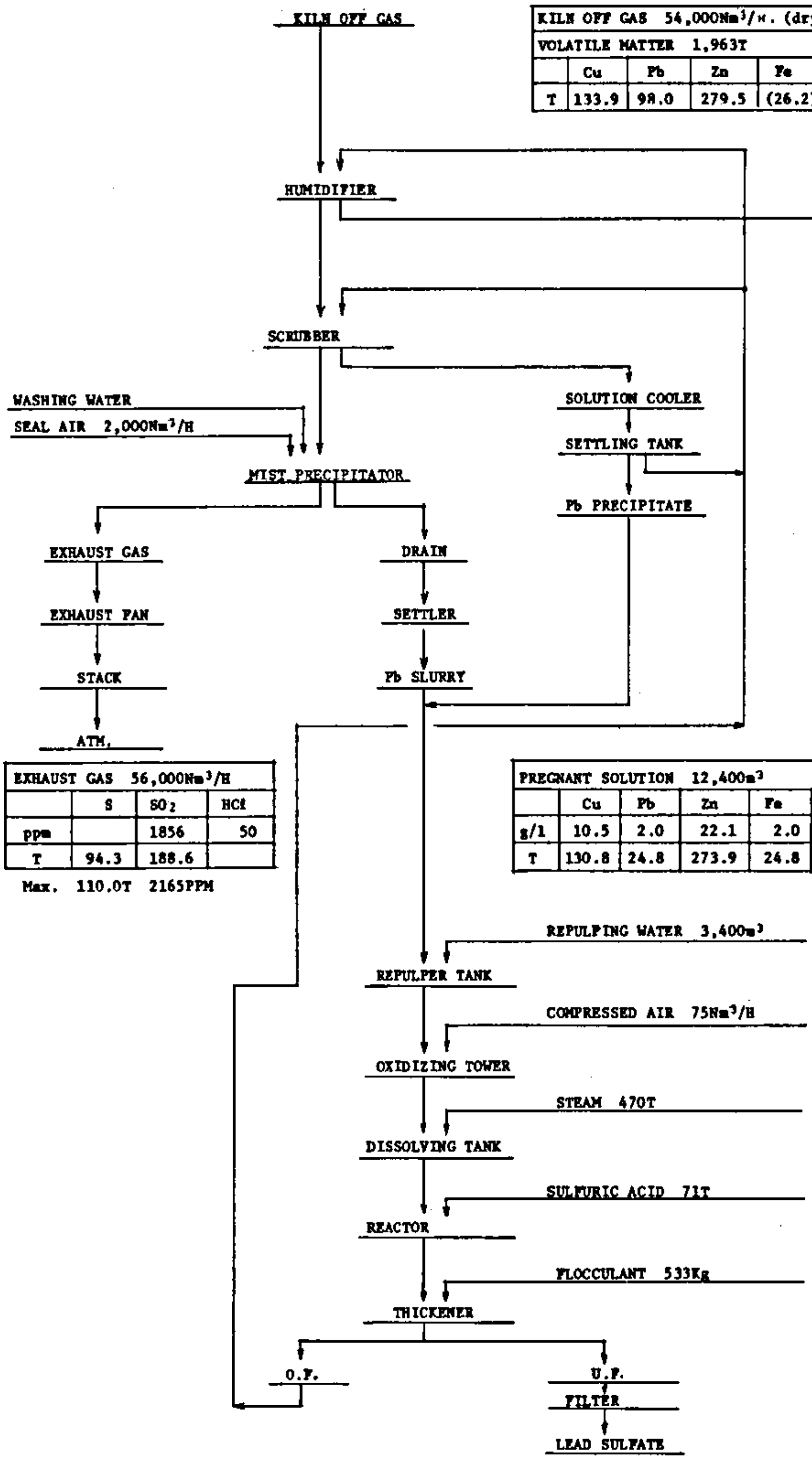
PELLET COOLER

HOT AIR 29,000Nm³/H (to $CaCl_2$ CONCENTRATOR)

BURNT PELLET

BURNT PELLET 28,200T										
	Fe	Cu	Zn	Pb	S	Cl	CaO	SiO_2	Au*	Ag*
g	62.06	0.04	0.05	0.02	0.04	0.1	4.29	4.50	0.02	5.0
T	17501	11.3	14.1	5.6	11.3	28.2	1210.4	1268.4	0.56	141.0

(V) MATERIAL BALANCE SHEET OF THE GAS TREATMENT



KILN OFF GAS 54,000Nm³/ʜ. (dry)									
VOLATILE MATTER 1,963T									
	Cu	Pb	Zn	Fe	S	Cl	Au*	Ag*	Dust
T	133.9	98.0	279.5	(26.2)	157.1	1266.4	23.20	1949.4	

EXHAUST GAS 56,000Nm³/H			
	S	SO_2	HCℓ
ppm		1856	50
T	94.3	188.6	

Max. 110.0T 2165PPM

PREGNANT SOLUTION 12,400m³									
	Cu	Pb	Zn	Fe	SO_4	Cl	Au**	Ag**	F.Acid
g/l	10.5	2.0	22.1	2.0	14.9	100	0.5	50	76.5
T	130.8	24.8	273.9	24.8	185.0	1239.8	6.20	620	948.2

** mg/L (as HCL)

LEAD SULFATE 130T									
	Pb	Cu	Zn	Fe	SO_3	Cl	Au*	Ag*	H_2O
g	55	0.3	-	0.4	22.2	1.0	127	9926	30
T	71.3	0.4		0.5	28.8	1.3	16.54	1290.4	56

(VI) MATERIAL BALANCE SHEET OF THE METAL (RECOVERY)

PREGNANT SOLUTION

PREGNANT SOLUTION 12,400m³									
	Cu	Pb	Zn	Fe	SO_4	Cl	Au**	Ag**	F.Acid
g/l	10.5	2.0	22.1	2.0	14.9	100	0.50	50	76.5
T	130.8	24.8	273.9	24.8	185.0	1239.8	6.20	620	948.2

** mg/L

↓ ← LIMESTONE 1,302T ($CaCO_3$ 95%)

NEUTRALIZER

↓

THICKENER

↓ O.F. → (to DE SO3 SOLUTION)

↓ U.F.

↓ ← WASHING WATER 620m³

CENTRIFUGE

↓

GYPSUM CAKE

GYPSUM CAKE 411T									
	SO3	Cu	Pb	Zn	Fe	Cl	Au*	Ag*	H_2O
%	45	—	0.2	—	0.2	1.0	2.0	4.0	12
T	185.0		0.8		0.8	4.2	0.83	1.7	57

DE SO_3 SOLUTION

DE-SO3 SOLUTION 12,970m³						
	Cu	Pb	Zn	Fe	Cl	SO_4
g/l	10.1	1.9	21.1	1.9	95.3	(1.0)
T	130.8	24.0	273.9	24.0	1235.6	-

↓ ← IRON SCRAP 144T (Fe 98%)

TUMBLER

↓

SETTLER

↓ O.F. → (to DE-Cu SOLUTION)

↓ U.F.

↓ ← WASHING WATER 330m³

FILTER

↓

CEMENT COPPER

CEMENT COPPER 155T								
	Cu	Pb	Zn	Fe	Cl	Au*	Ag*	H_2O
%	80	2.0	0.2	2.0	1.0	34.2	3947	20
T	124.2	3.1	0.3	3.1	1.6	5.30	6118	39

DE-Cu SOLUTION

DE-Cu SOLUTION 13,260m³					
	Cu	Pb	Zn	Fe	Cl
g/l	0.5	1.6	20.6	12.2	93.1
T	6.6	20.9	273.6	162.2	1234.0

(VII) MATERIAL BALANCE SHEET OF THE METAL RECOVERY (2)

DE-Cu SOLUTION

DE-Cu SOLUTION 13,260m³					
	Cu	Pb	Zn	Fe	Cl
g/l	0.5	1.6	20.6	12.2	93.1
T	6.6	20.9	273.6	162.2	1234.0

NaSH SOL'N 57m³ (NaSH 25%)

REACTOR

FLOCCULANT 27m³ (1g/L) (268Kg)

THICKENER

O.F. → DE-Pb SOLUTION

U.F. → FILTER (WASHING WATER 630m³)

FILTER → LEAD SULFIDE

FILTER → RECYCLE WATER → to GAS TREATMENT

DE-Pb SOLUTION 13,430m³					
	Cu	Pb	Zn	Fe	Cl
g/l	-	0.1	19.6	12.0	91.8
T	-	1.3	263.8	160.9	1233.3

LEAD SULFIDE 65T								
	Pb	Cu	Zn	Fe	Cl	Au*	Ag*	H_2O
%	30	10.1	15.0	2.0	1.0	1.0	100	40
T	19.6	6.6	9.8	1.3	0.7	0.07	6.5	43

OXIGEN GAS 20,000Nm³

EXHAUST GAS (to GAS T.M.T SEC)

$NaNO_2$ SOL'N 32T ($NaNO_2$ 25%)

IRON OXIDIZER

LIMESTONE 322T ($CaCO_3$ 95%)

REACTOR

FLOCCULANT 57m³ (1g/L) (566Kg)

THICKENER

O.F. → DE-Fe SOLUTION

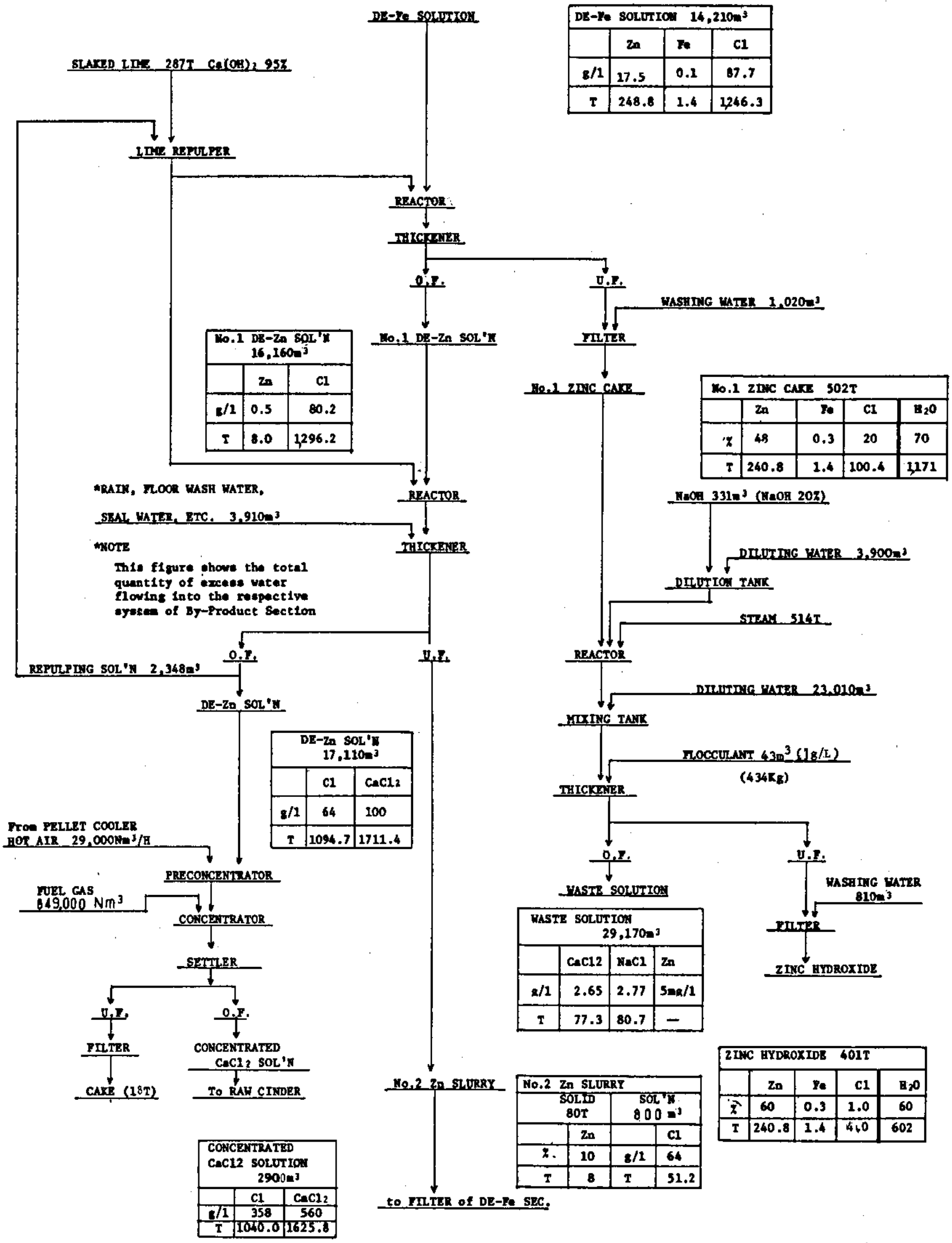
U.F. → FILTER (No2. Zn SLURRY 800m³; WASHING WATER 460m³)

FILTER → FERRIC CAKE

DE-Fe SOLUTION 14,210m³			
	Zn	Fe	Cl
g/l	17.5	0.1	87.7
T	248.8	1.4	1246.3

FERRIC CAKE 460T						
	Fe	Cu	Pb	Zn	Cl	H_2O
%	34.7	-	0.3	5.0	8.3	55
T	159.5	-	1.3	23.0	38.2	562

(VIII) MATERIAL BALANCE SHEET OF THE METAL RECOVERY (3)



DE-Fe SOLUTION 14,210m³

	Zn	Fe	Cl
g/l	17.5	0.1	87.7
T	248.8	1.4	1246.3

No.1 DE-Zn SOL'N 16,160m³

	Zn	Cl
g/l	0.5	80.2
T	8.0	1296.2

No.1 ZINC CAKE 502T

	Zn	Fe	Cl	H_2O
%	48	0.3	20	70
T	240.8	1.4	100.4	1171

DE-Zn SOL'N 17,110m³

	Cl	$CaCl_2$
g/l	64	100
T	1094.7	1711.4

WASTE SOLUTION 29,170m³

	$CaCl_2$	NaCl	Zn
g/l	2.65	2.77	5mg/l
T	77.3	80.7	—

ZINC HYDROXIDE 401T

	Zn	Fe	Cl	H_2O
%	60	0.3	1.0	60
T	240.8	1.4	4.0	602

No.2 Zn SLURRY

SOLID 80T		SOL'N 800 m³	
	Zn		Cl
%	10	g/l	64
T	8	T	51.2

CONCENTRATED $CaCl_2$ SOLUTION 2900m³

	Cl	$CaCl_2$
g/l	358	560
T	1040.0	1625.8

(IX) MATERIAL BALANCE SHEET FOR MEXICO PROJECT

(CAMPO MORADO 35,000T/M)

PYRITES CONC. 23,485T (C.M)

	Fe	S	Cu	Zn	Pb	Au *	Ag*
%	45.43	44.25	0.35	0.80	0.44	0.92	86
T	10,669.2	10,392.1	82.2	187.9	103.3	21.6	2,019.7

* g/t, Kg

ROASTING PLANT → SULFUR LOSS 335T

SULFURIC ACID (98.4%) 31,300T

CALCINE CINDER 17,410T

	Fe	S	Cu	Zn	Pb	Au *	Ag*
%	60.65	0.6	0.47	1.07	0.59	1.22	114.78
T	10,559.2	104.5	81.3	185.9	102.2	21.24	1,998.3
						(g/t)	(g/t)

Fe-PPT 253T (from SOL'N TREATMENT SEC)

$CaCl_2$ SOL'N 3,048T (1,219T as DRY)

SLAKED LIME 127T

MIXING, KNEADING

HANDLING LOSS 285T

FUEL GAS 358,300Nm^3 (9,600Kcal/Nm^3)

PELLETIZING,DRYING

DRIED PELLET 18,724T

	Fe	S	Cu	Zn	Pb	Au*	Ag*	Cl	H2O (W.B)
%	56.01	0.55	0.43	1.04	0.54	1.12	105.12	4.21	0.3
T	10,487.0	102.9	80.1	195.5	101.5	20.9	1,968.3	788.6	—

FUEL GAS 860,000Nm^3 (9,600Kcal/Nm^3)

FIRING

IGNITION LOSS 283T

BURNT PELLET 17,200T

	Fe	S	Cu	Zn	Pb	Au*	Ag*	Cl
%	60.88	0.04	0.04	0.05	0.03	0.03	8.0	0.1
T	10,471.3	6.9	6.9	8.6	5.2	0.52	137.6	17.2
						(g/t)	(g/t)	

GAS TREATMENT

PREGNANT SOL'N 7,550m^3 (To SOLUTION TREATMENT SEC)

	Cu	Zn	Pb	Fe	Cl	S	(SO3)	Au	Ag
g/l	9.4	24.3	2.0	2.0	100	—	17.2	0.5	50
T	71.3	183.2	15.1	15.1	754.5	—	129.8	3.78 Kg	377.5 Kg
								(mg/L)	(mg/L)

STEAM 522T

WATER 3,800m^3

SULFURIC ACID (98%) 80T

FLOCCULANT 595Kg

COMPRESSED AIR 81Nm^3/H

LEAD RECOVERY

LEAD SULFATE 145T

	Pb	Au*	Ag*	SO3
%	55	111.8	9,770	20.9
T	79.7	16.21	1,416.6	30.3
		(g/t)	(kg)	

(X) PREGNANT SOLUTION 7,550 m^3 (From GAS TREATMENT)

CHALK POWDER 840T

WASHING WATER 432 m^3

NEUTRALIZING

GYPSUM CAKE 288T

	S	(SO3)	H2O (W.B)
%	18	(45)	12
T	—	(129.8)	39

NEUTRALIZED SOL'N 7,940 m^3

SCRAP IRON 78T

WASHING WATER 168 m^3

Cu RECOVERY

FLOCCULANT 164Kg

NaSH SOL'N 35 m^3 (NaSH 25%)

WASHING WATER 250 m^3

Pb RECOVERY

CEMENT COPPER 84T

	Cu	Au*	Ag*	Zn	Pb	Fe	H2O (W.B)
%	80	37.6	4,432	0.2	2.0	2.0	20
T	67.3	3.16	372.3	0.2	1.7	1.7	21

OXYGEN 11,000 Nm^3

NaNO2 SOL'N 18T (NaNO2 25%)

WASHING WATER 250 m^3

CHALK POWDER 177T

FLOCCULANT 345Kg

PbS CAKE 40T

	Pb	Cu	Zn	Cl	Au*	Ag*	H2O 9W.B)
%	30.0	10.0	15.0	1.0	1.0	100	40
T	12.0	4.0	6.0	0.4	0.04	4.0	27

Fe SEPARATION

Fe P.P.T 253T (To MIXING SEC)

	Fe	Zn	Pb	Cu	Cl	H2O (W.B)
%	34.6	5.0	0.3	—	8.3	55
T.	87.5	12.6	0.8	—	20.9	45

SLAKED LIME 196T

CAUSTIC SODA 227 m^3 (NaOH 20%)

WASHING WATER 19,760 m^3

STEAM 351T

Zn RECOVERY

WASTE SOL'N 20,060 m^3

REFINED ZINC CAKE 274T

	Zn	Pb	Cl	H2O (W.B)
%	60	—	1.0	60
T	164.4	—	—	411

CaCl2 SOL'N 10,330 m^3 (CaCl2 1,033T as DRY)

HOT AIR (From FIRING SEC)

PRECONCENTRATOR

FUEL GAS 512,000 Nm^3

CaCl2 CONCENTRATOR

RECOVERED CaCl2 SOL'N 1,750 m^3

	CaCl2
g/l	560
T	982

MAKE-UP CaCl2 237T (as DRY)

To MIXING SEC.. CaCl2 SOL'N 1,219T (as DRY) o Calculation of kiln capacity

The production rates of cinders from the Campo Morado pyrite concentrate and the Copper King pyrite ore are 74.90% and 67.15% respectively.

Thus, the annual cinder production will be

(for Campo Morado) 281,820 x 0.7490 = 211,038 T/Y

(for Copper King) (200,400–120*) x 0.6715 = 134,488 T/Y

(Note*: Losses (10 T/M x 12 M/Y = 120 T/Y) are considered in the crushing and grinding processes.)

Annual cinder production:

211,083 T/Y + 134,488 T/Y = 345,571 T/Y

Assuming the handling loss of cinder in the roasting plant to be 1.05%, the actual production of cinder will be

345,571 x (1–0.0105) = 341,943 T/Y

÷ 342,000 T/Y

Thus, the monthly average production will be

342,000 ÷ 12 = 28,500 T/M

Since the production rate of pellet is 1/1.01 for this ore, the actual pellet production will be

28,500 T x 1/1.01 = 28,200 T/M (44.4 T/H)

The actual pellet production will be 338,400 T/Y

g) Nonferrous metal recovery plant

o Utilization: same as the pellet plant

o Capacity: The solution pregnant with nonferrous metals that is supplied to this plant will have the chlorine ion concentration of 100 g/l.

* Material balance of the metallurgical plant calculated according to the basic conditions and the basic calculation is shown in material balance sheet (I)-(VIII). And also material balance in case of developing only Campo Morado mine as an alternative is shown in page (IX) - (X).

8–5. EQUIPMENT SPECIFICATION

8–5–1. MECHANICAL EQUIPMENT

8–5–1–1. STOCK AND FEEDING PLANT

Copper King

1) Receiving hopper with belt feeder

a) Hopper

Quantity	:	1 unit
Capacity	:	15 m^3
Material	:	Carbon steel

b) Belt feeder

Quantity	:	1 unit
Capacity	:	120 T/H
Size	:	1,000 W x 7,000 L
Motor power	:	7.5 KW

2) Stacker conveyor

Quantity	:	1 unit
Capacity	:	120 T/H
Size	:	600 W x 95,000 L
Motor power	:	7.5 KW
Accessories	:	Tripper
		Shuttle conveyor

3) Stock yard

Quantity	:	1 unit
Capacity	:	16,700 Ton
Dimension	:	40,000 W x 80,000 L
Material	:	Reinforced concrete

4) Hopper with belt feeder

a) Hopper

Quantity	:	4 units
Capacity	:	6 m^3
Material	:	Carbon steel

b) Belt feeder

Quantity	:	4 units
Capacity	:	72 T/H
Size	:	1,000 W x 5,000 L
Motor power	:	5.5 KW

5) Belt conveyor

600 W x 20,000 L x 3.7 KW	1 set
600 W x 40,000 L x 5.5 KW	2 sets
600 W x 20,000 L x 3.7 KW	2 sets
600 W x 50,000 L x 5.5 KW	1 set
600 W x 75,000 L x 7.5 KW	1 set
600 W x 20,000 L x 3.7 KW	1 set

6) Primary crusher

Quantity	:	1 unit
Type	:	Coarse cone crusher
Capacity	:	100 T/H
Size	:	45 inch
Motor power	:	110 KW

7) Secondary crusher

Quantity	:	1 unit
Type	:	Fine cone crusher
Capacity	:	100 T/H
Size	:	36 inch

8) Mill bin and belt feeder

a) Mill bin

Quantity	:	1 unit
Type	:	Vertical
Capacity	:	500 Ton
Material	:	Carbon steel

b) Belt feeder

Quantity	:	1 unit
Capacity	:	75 T/H
Size	:	1,000 W x 5,000 L
Motor power	:	5.5 KW

9) Wet grinding mill

Quantity	:	1 unit
Type	:	Wet ball mill
Capacity	:	30 T/H
Size	:	2,130 W x 6,750 L
Motor power	:	350 KW

10) Classifier

Quantity	:	1 unit
Type	:	Akins classifier
Capacity	:	43 T/H
Size	:	1,070 W x 6,600 L
Motor power	:	3.7 KW

11) Slurry pump

Quantity	:	2 sets
Type	:	Centrifugal
Capacity	:	0.6 m^3/min x 20 mH
Material	:	Grey iron casting + Rubber lining
Motor power	:	5.5 KW

12) Cyclone

Quantity	:	2 units
Type	:	Wet cyclone
Size	:	9 inch
Material	:	Carbon steel + Rubber lining

13) Thickener

Quantity	:	1 unit
Size	:	24,000 I.D. x 4,500 H
Material	:	Carbon steel
Motor power	:	2.2 KW
Accessories	:	Pump 0.4 m^3/ min x 15 mH x 3.7 KW 2 sets

14) Storage tank

Quantity	:	2 units
Type	:	Vertical cylindrical
Capacity	:	200 m^3
Size	:	7,000 I.D. x 6,000 H
Material	:	Carbon steel
Accessory	:	Agitator 7.5 KW

15) Slurry pump

Quantity	:	2 sets
Type	:	Centrifugal
Capacity	:	0.6 m^3/min x 20 mH
Material	:	Grey iron casting + Rubber lining
Motor power	:	5.5 KW

16) Belt conveyor

600 W x 15,000 L x 3.7 KW	3 sets
600 W x 20,000 L x 3.7 KW	1 set

17) Conveyor scale

Quantity	:	1 set
Type	:	Merrick type
Capacity	:	20 T/H - 50 T/H

Campo Morado

1) Receiving hopper with belt feeder

a) Hopper

Quantity	:	1 unit
Capacity	:	15 m^3
Material	:	Carbon steel

b) Belt feeder

Quantity	:	1 unit
Capacity	:	120 T/H
Size	:	1,000 W x 7,000 L
Motor power	:	7.5 KW

2) Stacker conveyor

Quantity	:	1 unit
Capacity	:	120 T/H
Size	:	600 W x 110,000 L
Motor power	:	11 KW
Accessories	:	Tripper
		Shuttle conveyor

3) Stock yard (with building)

Quantity	:	1 unit
Capacity	:	23,485 Ton
Dimension	:	40,000 W x 95,000 L
Material	:	Reinforced concrete

4) Hopper with belt feeder

a) Hopper

Quantity	:	4 units
Capacity	:	6 m^3
Material	:	Carbon steel

b) Belt feeder

Quantity	:	4 units
Capacity	:	120 T/H
Size	:	1,000 W x 5,000 L
Motor power	:	5.5 KW

5) Belt conveyor

600 W x 40,000 L x 5.5 KW	2 sets
600 W x 25,000 L x 3.7 KW	2 sets
600 W x 55,000 L x 5.5 KW	1 set
600 W x 95,000 L x 7.5 KW	1 set
600 W x 25,000 L x 3.7 KW	1 set

8–5–1–2. ROASTING PLANT

1) Repulper

a) Primary repulper

Quantity	:	1 unit
Type	:	Vertical cylindrical
Capacity	:	26 m^3
Size	:	3,300 I.D. x 4,500 H
Material	:	Carbon steel + Rubber lining
Accessories	:	Agitator 95 KW
		Feed pump
		1.4 m^3/min x 25 mH x 37 KW 2 sets

b) Secondary repulper

Quantity	:	2 units
Type	:	Vertical cylindrical
Capacity	:	26 m^3
Size	:	3,300 I.D. x 4,500 H
Material	:	Carbon steel + Rubber lining
Accessory	:	Agitator 75 KW

2) Screen

Quantity	:	1 unit
Type	:	Single stage
Size	:	1,500 W x 3,600 L
Screen area	:	5 m^2
Material	:	SUS* (Stainless steel)
Motor power	:	1.5 KW x 2 sets
Accessories	:	Sump tank 7 m^3
		Feed pump
		1.6 m^3/min x 21 mH x 37 KW 4 sets

3) Storage tank

Quantity	:	4 units
Type	:	Vertical cylindrical
Capacity	:	210 m^3
Size	:	6,500 I.D. x 8,000 H
Material	:	Carbon steel + Rubber lining
Accessories	:	Agitator 5.5 KW
		Feed pump
		1.6 m^3/min x 21 mH x 37 KW 4 sets

4) Service tank

Quantity	:	4 units
Type	:	Vertical cylindrical
Capacity	:	70 m^3
Size	:	4,700 I.D. x 5,000 H
Accessories	:	Agitator 2.2 KW
		1st. Feed pump
		0.6 m^3/min x 17 mH x 22 KW 4 sets
		2nd. Feed pump
		0.5 m^3/min x 11 mH x 15 KW 4 sets

5) Roaster (refer to Fig. 8.1)

Quantity	:	4 units
Type	:	Fluidizing type
Size	:	12,800 I.D. (free board brick inner dia.)
		12,570 I.D. (bed brick inner dia.)
		Shell height 8,000
Material	:	Carbon steel + insulation brick + fire brick
Accessories	:	Feed guns
		Oil burners

6) Air blower

Quantity	:	4 sets
Type	:	Turbo blower
Capacity	:	870 Nm^3/min
Pressure	:	3,000 mm Aq

Material	:	Casing	Carbon steel
		Impeller	Ni-Cr steel
Motor power	:	700 KW	

7) Waste heat boiler

Quantity	:	4 units
Type	:	Forced circulation type
Pressure	:	32 kg/cm^2 (normal)
Capacity	:	13 T/H/1 unit
Steam temperature	:	375°C (Superheater outlet)
Accessories	:	Screw conveyor 3.7 KW x 4 sets
		Hammering device
		Deaerator
		Water circulation pump
		220 T/H x 46 kg/cm^2 x 75 KW 8 sets
		Deaerator feed pump
		52 T/H x 4 kg/cm^2 x 15 KW 4 sets
		Boiler feed pump
		32 m^3/H x 49.5 kg/cm^2 x 95 KW 6 sets

8) Demineralization equipment

Quantity	:	1 unit	
Type	:	Three bed four tower type	
Capacity	:	13 m^3/H	
Size	:	Cation exchanger	760 I.D. x 2,400 H
		Degasifier	578 I.D. x 2,700 H
		Anion exchanger	760 I.D. x 2,400 H
		Polisher	664 I.D. x 2,400 H
Material	:	Carbon steel	
Accessories	:	Filter	
		Filtrate tank 15 m^3	
		Filtrate pump	
		0.25 m^3/min x 22 mH x 2.2 KW 2 sets	
		Degasified water pump	
		0.25 m^3/min x 40 mH x 11 KW 2 sets	

Demineralized water tank

150 m^3 x 2 sets

Demineralized water pump

0.25 m^3/min x 20 mH x 2.2 KW   2 sets

9) Turbine generator

a) Turbine

Quantity	:	1 unit	
Type	:	Single flow impulse direct coupling, condensing turbine	
Rated output	:	11,000 KW	
Steam pressure	:	30 kg/cm^2	
Steam temperature	:	345°C	
Material	:	High pressure part	Mo steel
		Low pressure part	Grey iron castings
		Impeller	Ni-Mo steel
Accessories	:	Condenser	1 set
		Condensing pump	2 sets
		Cooling pump	2 sets
		Air ejector	1 set
		Gland steam condenser	

b) Generator

Quantity	:	1 unit
Type	:	Horizontal cylinder type A.C rotating exciter
Capacity	:	13,000 KVA power factor 85%

10) Cyclone

Quantity	:	4 units (four sets/ 1 unit)	
Type	:	Parallel cyclone (four sets)	
Size	:	Cone part	
		Upper part	1,600 I.D. x 1,000 I.D. x 2,300 H
		Lower part	1,000 I.D. x 500 I.D. x 1,800 H
		Chamber	1,600 I.D. x 3,000 H x 850 I.D.
Material	:	Cone part	Carbon steel
		Chamber	SUS*

11) Rotary mixer

Quantity	:	2 units
Type	:	Horizontal rotary type
Size	:	2,600 I.D. x 8,500 L
Material	:	Carbon steel + Castable
Motor power	:	45 KW
Accessories	:	Screw conveyor 2 sets
		Belt feeder
		1,000 W x 6,600 L 2 sets

12) Peabody scrubber

Quantity	:	4 units
Size	:	Scrubbing section 3,420 I.D. x 4,800 H
		Humidifing section 3,550 I.D. x 5,300 H
		Stripping section 1,150□
Material	:	Scrubbing section
		Carbon steel + Pb homogen
		Humidifing section
		Carbon steel + Pb homogen
		+ Acid proof brick
		Stripping section
		Carbon steel + Pb homogen
Accessories	:	Circulation pump
		3 m^3/min x 10 mH x 22 KW 8 sets
		Middle tank 14 m^3 x 4 sets
		Seal tank 1.6 m^3 x 4 sets

13) Thickener

Quantity	:	2 units
Size	:	20,000 I.D. x 4,500 H
Material	:	Carbon steel + Pb homogen
		+ Acid proof brick

Accessories	:	Mechanism	2 sets
		Over flow tank	2 sets
		Over flow pump	
		6 m^3/min x 25 mH x 60 KW	4 sets
		Under flow pump	
		0.2 m^3/min x 20 mH x 7.5 KW	4 sets

14) Cooling equipment

Quantity	:	2 units	
Type	:	Vacuum cooler	
Capacity	:	20 x 10^6 Kcal/H	
Material	:	Carbon steel + Rubber lining	
Accessories	:	Feeder unit of sea water 2 sets	
		Cooling pump	
		6.7 m^3/min x 30 mH x 75 KW	6 sets

15) Filter

Quantity	:	2 units	
Type	:	Rotary vacuum filter	
Capacity	:	Filtration area 50 m^2	
Material	:	Carbon steel + Rubber lining	
Accessories	:	Filtrate tank	
		Cascade condenser	
		Vacuum pump	
		40 m^3/min x -500 mmHg x 150 KW	2 sets

16) Chain conveyor

Usage	Q'ty	Cap.	Size	Motor power
Boiler chain conveyor	4	4 T/H	15,000 L	2.2 KW x 4 sets
Cyclone chain conveyor	4	10 T/H	15,000 L	2.2 KW x 4 sets
No. 1 Chain conveyor	2	30 T/H	25,000 L	11 KW x 2 sets
No. 2 Chain conveyor	2	30 T/H	30,000 L	11 KW x 2 sets
No. 3 Chain conveyor	2	30 T/H	50,000 L	15 KW x 2 sets
No. 4 Chain conveyor	1	30 T/H	60,000 L	15 KW x 2 sets
No. 5 Chain conveyor	1	60 T/H	120,000 L	36 KW x 1 set
No. 6 Chain conveyor	1	60 T/H	20,000 L	15 KW x 1 set

17) Compressor (for acid plant)

Quantity	:	3 units
Type	:	Vertical, reciprocating compressor
Capacity	:	35 Nm^3/min
Pressure	:	5 kg/cm^2G
Motor power	:	190 KW
Accessories	:	After cooler
		Receiver tank

18) Compressor (for instrumentation)

Quantity	:	3 sets
Type	:	Vertical, reciprocating compressor
Capacity	:	15 Nm^3/min
Pressure	:	7 kg/cm^2G
Motor power	:	75 KW
Accessories	:	Dehumidifier
		After cooler
		Receiver tank

19) Waste acid treatment plant

a) Storage tank

Quantity	:	1 unit
Type	:	Vertical cylindrical
Size	:	4,600 I.D. x 5,000 H
Material	:	Carbon steel + Rubber lining

b) Neutralizer

Quantity	:	2 units
Type	:	Vertical cylindrical
Size	:	2,200 I.D. x 5,000 H
Material	:	Carbon steel + Rubber lining
Accessory	:	Agitator 11 KW

c) Thickener

Quantity	:	1 unit
Size	:	10,000 I.D. x 3,000 H
Material	:	Carbon steel + Rubber lining
Accessory	:	Mechanism 1.5 KW

d) De - Fe reactor

Quantity	:	2 units
Type	:	Vertical cylindrical
Size	:	2,200 I.D. x 3,000 H
Material	:	Carbon steel + Rubber lining
Accessory	:	Agitator 11 KW

e) Thickener

Quantity	:	1 unit
Size	:	10,000 I.D. x 3,000 H
Material	:	Carbon steel
Accessory	:	Mechanism 1.5 KW

f) Gypsum filter

Quantity	:	3 units
Type	:	Automatic vertical basket type
Capacity	:	0.43 m^3 (1,400 I.D. x 550 H)
Material	:	Carbon steel + Rubber lining
Motor power	:	30 KW, 15 KW

g) Filter press

Quantity	:	2 units
Type	:	Manual type
Size	:	1,300 □
Number of plate	:	60
Area of Filtration	:	160 m^2
Material	:	Grey iron castings

h) Storage bin for slaked lime

Quantity	:	1 unit	
Type	:	Vertical cylindrical	
Capacity	:	80 m^3	
Material	:	Carbon steel	
Accessory	:	Screw conveyor	2.2 KW

i) Storage bin for chalk powder

Quantity	:	1 unit	
Type	:	Vertical cylindrical	
Capacity	:	50 m^3	
Material	:	Carbon steel	
Accessory	:	Screw conveyor	2.2 KW

8–5–1–3. SULRUFIC ACID PLANT

1) Mist precipitator

Quantity	:	8 units	
Type	:	Tube type	
Size	:	5,300W x 5,300L x 9,300H	
Material	:	Casing	Carbon steel + Pb homogen + Acid proof brick (bottom)
		Collecting tube	Pb
		Discharge electrode	Pb
Accessories	:	Rectifier (Silicon type)	
		Hot air equipment	

2) Drying tower

Quantity	:	2 units
Type	:	Packed tower
Size	:	7,600 I.D. x 12,500 H
Material	:	Carbon steel + Asbestos + Acid proof brick
Packing	:	Cross ring Paul ring Raschig ring

3) Gas blower

Quantity	:	4 sets	
Type	:	Turbo blower	
Capacity	:	1,050 Nm^3/min	
Pressure	:	Suction	− 1,200 mmAq
		Delivery	+ 3,400 mmAq
Material	:	Casing	Grey iron castings
		Impeller	Ni-Cr-Mo steel
Packing	:	Cross ring Paul ring Raschig ring	

4) No. 1 Absorbing tower

Quantity	:	2 units
Type	:	Packed tower
Size	:	7,600 I.D. x 12,500 H
Material	:	Carbon steel + Asbestos + Acid proof brick
Packing	:	Cross ring Paul ring Raschig ring

5) No. 2 Absorbing tower

Quantity	:	2 units
Type	:	Packed tower
Size	:	7,600 I.D. x 12,500 H
Material	:	Carbon steel + Asbestos
		+ Acid proof brick
Packing	:	Cross ring
		Paul ring
		Raschig ring

6) Heat exchanger

Quantity	:	12 units	
Type	:	Vertical, shell and tube	
Size	:	4,300 I.D. x 12,760 H	
Material	:	Shell	Carbon steel
		Tube	Carbon steel boiler and heat exchanger tube

7) Converter

Quantity	:	2 units	
Type	:	Multi-V_2O_5 catalyst-layer	
Size	:	10,740 I.D. x 14,926 H	
Material	:	1st. stage	
		Shell	Carbon steel + SUS clad
		Grate	Heat resisting steel
		2nd, 3rd, 4th stage	
		Shell	Carbon steel + Al metallikon
		Grate	Heat resisting steel

8) Starter

Quantity	:	2 units
Type	:	Horizontal
Size	:	2,300 I.D. x 4,580 L
Material	:	Carbon steel + Fire brick
		+ Insulating brick
Accessory	:	Oil burner

9) Preheater

Quantity	:	2 units	
Type	:	Vertical shell and tube	
Size	:	3,000 I.D. x 11,120 H	
		+ Stack 930 I.D. x 4,500 H	
Material	:	Shell	Carbon steel
		Tube	Carbon steel boiler and heat exchanger tube
		Lower gas room	
			Insulating brick + Fire brick

10) Acid circulation tank

Quantity	:	6 units	
Type	:	Vertical cylindrical closed type	
Size	:	8,080 I.D. x 2,400 H	
Material	:	Carbon steel + Acid proof brick	

11) Acid circulation pump

Quantity	:	6 sets	
Type	:	Vertical centrifugal type	
Capacity	:	12.3 m^3/min x 21 mH	
Material	:	Casing	Acid proof cast iron
		Impeller	Illium G
		Shaft	SUS*
Motor power	:	130 KW	

12) SO_2 stripping tower

Quantity	:	2 units
Type	:	Cylindrical, packed type
Size	:	1,900 I.D. x 7,700 H
Material	:	Carbon steel + Acid proof brick
Packing	:	Paul ring

13) Acid cooler

Quantity	:	2 units	
Type	:	Irrigation tube type	
Cooling	:	Drying tower	1,800 m^2 x 2 sets
		No. 1 Absorbing tower	1,400 m^2 x 2 sets
		No. 2 Absorbing tower	590 m^2 x 2 sets
		Product	70 m^2 x 2 sets
Material	:	Tube	Acid proof cast iron
			Pb-cemented on exterior

14) Product acid pump tank

Quantity	:	2 units
Type	:	Vertical cylindrical closed type
Size	:	6,500 I.D. x 2,600 H
Material	:	Carbon steel + Acid proof brick

15) Product acid pump

Quantity	:	4 sets	
Type	:	Vertical centrifugal type	
Capacity	:	0.55 m^3/min x 20 mH	
Material	:	Casing	Acid proof cast iron
		Impeller	Stainless steel casting
		Shaft	SUS*
Motor power	:	15 KW	

16) Acid storage tank

Quantity	:	7 units	
Type	:	Vertical cylindrical closed type	
Size	:	24,700 I.D. x 12,700 H	6 sets
		15,000 I.D. x 10,500 H	1 set
Material	:	Carbon steel	

17) Stack

Quantity	:	1 set
Type	:	Supported by steel structure
Size	:	2,260 I.D. 55,000 H
Material	:	Carbon steel + Acid proof brick

18) Acid loading facilities

a) Pump tank

Quantity	:	4 sets	
Type	:	Vertical cylindrical closed type	
Size	:	6,900 I.D. x 2,000 H	
Material	:	Carbon steel + Acid proof brick	

b) Acid pump

Quantity	:	4 sets	
Type	:	Vertical centrifugal type	
Capacity	:	1.8 m^3/min x 19 mH	
Material	:	Casing	Stainless steel casting
		Impeller	Stainless steel casting
		Shaft	SUS*
Motor power	:	30 KW	

c) Loading arm

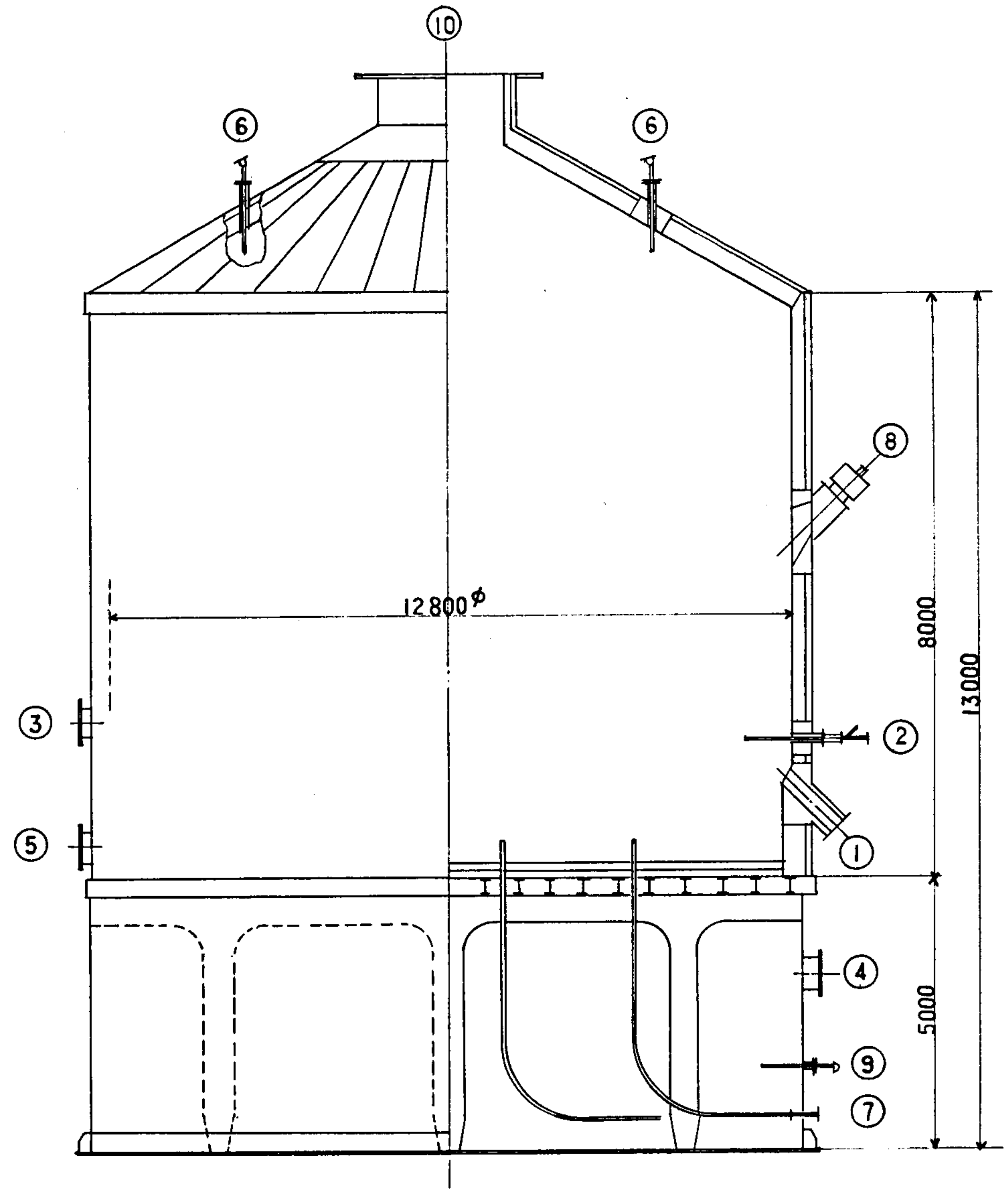
Quantity	:	3 units
Type	:	Swing
Capacity	:	200 T/H
Size	:	200 I.D.
Material	:	Carbon steel pipes for high pressure service

d) Measuring tank

Quantity	:	4 units
Capacity	:	22 m^3
Material	:	Carbon steel

19) Sea water pump

Quantity	:	3 sets	
Type	:	Centrifugal	
Capacity	:	110 m^3/min x 35 mH	
Material	:	Casing	2%Ni cast iron
		Impeller	Stainless steel casting
Motor power	:	900 KW	



1 Over Flow Nozzle
2 Feed Gun Nozzle
3 Free Board Manhole
4 Wind Box Manhole
5 Bed Manhole
6 Thermocouple Nozzle at Free Board
7 Thermocouple Nozzle at Bed
8 Oil Burner
9 Pressure Gauge Nozzle
10 Gas Exhaust Nozzle

Fig. 8.1

ROASTER	
DRAWN BY K.S	DATE 20/Fev/'81
CHECKED BY	DATE / /
SCALE	

8–5–1–4. PELLETIZING PLANT

1) Cinder yard

Quantity	:	1 unit	
Capacity	:	12,500 Ton	
Size	:	25,000 W x 55,000 L	
Material	:	Reinforced concrete	
Accessories	:	Stacker conveyor	1 unit

2) Blending bin

Quantity	:	4 units	
Type	:	Vertical cylindrical cone-bottom closed type	
Size	:	5,600 I.D. x (5,400 + 5,400) H	
Material	:	Carbon steel + Wood lining	
Accessories	:	Tripper conveyor	900 W x 87,000 L x 30 KW x 1 set
		Belt feeder	900 W x 4,000 L x 5.5 KW x 4 sets

3) Discharge bin

Quantity	:	1 unit	
Type	:	Vertical rectangular wedge-bottom closed type	
Size	:	2,000 W x 3,000 L x (1,900 + 2,600) H	
Material	:	Carbon steel	
Accessories	:	Constant-feed weigher	900W x 7,000 L x 3.7 KW x 1 set
		Belt feeder	900 W x 4,000 L x 3.7 KW x 1 set

4) Kneading mill unit

Quantity	:	2 units	
Type	:	End peripheral discharge type ball mill	
Size	:	3,100 I.D. x 4,700 L	
Material	:	Body	Carbon steel + Alloy steel
		Ball	Chilled ball
Motor power	:	550 KW	
Accessories	:	Screw feeder	

5) Pelletizer unit

Quantity	:	2 units
Type	:	Pan type pelletizer
Size	:	5,500 I.D. x 850 H
Material	:	Carbon steel + Rubber lining (inside)
Motor power	:	90 KW
Accessories	:	Magnetic separator
		Bottom rake and side scraper
		Water spray unit

6) Green pellet dryer unit

Quantity	:	1 unit	
Type	:	Conveyor dryer	
Size	:	5,000 W x 57,500 L	
Material	:	Carbon steel	
Motor power	:	15 KW	
Accessories	:	Swing conveyor	1 set
		Furnace	8 sets
		Circulating fan	24 sets
		Vent fan	2 sets
		Cyclone	1 set
		Stack	1 set

7) Dried pellet conveyor

Quantity	:	1 unit
Type	:	Apron conveyor closed type
Size	:	700 W x 64,000 L
Material	:	Carbon steel
Motor power	:	37 KW

8) Chloridizing kiln unit (refer to Fig. 8.2)

Quantity	:	1 unit
Type	:	Rotary kiln
Size	:	(5,200 I.D. x 22,000 L) + (4,300 I.D. x 30,000 L)
Material	:	Carbon steel + Refractory brick
Motor power	:	350 KW

Accessories	:	Emergency motor
		Seal fan
		Cooling fan
		Vibrating feeder

9) Burner unit

Quantity	:	1 unit
Type	:	Gas burner
Heat duty	:	21–22 x 10^6 Kcal/H

10) Pellet cooler unit

Quantity	:	1 unit
Type	:	Special air contact vertical type
Size	:	4,500 I.D. x 7,600 H
Material	:	Carbon steel and SUS* + Alloy steel + Refractory brick
Accessories	:	Table type discharger
		Cooling fan
		Dust chamber

11) Burnt pellet conveyor

Quantity	:	1 unit
Type	:	Apron conveyor
Size	:	600 W x 25,000 L
Material	:	Carbon steel
Motor power	:	15 KW

12) Pellet cooler fan

Quantity	:	1 set
Type	:	Centrifugal
Capacity	:	1,500 Nm^3/min. x 1,300 mmAq. x 640 KW
Material	:	Carbon steel

13) Hot fan

Quantity	:	1 set	
Type	:	Centrifugal	
Capacity	:	650 Nm^3/min. x 450 mmAq. x 300 KW	
Material	:	Casing	High tension steel
		Impeller	Shaft sleeve SUS*

14) Return dust charge hopper

Quantity	:	1 unit
Type	:	Vertical rectangular cone-bottom
Size	:	1,200 W x 2,500 L x (400 + 1,000) H
Material	:	Carbon steel
Accessories	:	Belt feeder 600 W x 5,000 L x 2.2 KW

15) Belt conveyor list

(Closed type)

900 W x 71,000 L x 15 KW x 1 set

750 W x 25,000 L x 7.5 KW x 1 set

600 W x 43,000 L x 7.5 KW x 1 set

500 W x 56,000 L x 5.5 KW x 1 set

400 W x 58,000 L x 1.5 KW x 1 set

(Open type)

600 W x 40,000 L x 5.5 KW x 2 sets

600 W x 23,000 L x 2.2 KW x 1 set

500 W x 19,000 L x 1.5 KW x 1 set

500 W x 8,000 L x 1.5 KW x 4 sets

400 W x 48,000 L x 2.2 KW x 1 set

16) Pellet yard

Quantity	:	1 unit
Capacity	:	7,000 Ton
Dimension	:	30,000 W x 55,000 L
Material	:	Reinforced concrete
Accessories	:	Stacker conveyor
		Hopper with feeder

8–5–1–5. GAS TREATMENT PLANT

1) Humidifer unit

Quantity	:	1 unit	
Type	:	U-type spray tower	
Size	:	1st Stage	2,200 I.D. x 6,200 H
		2nd Stage	4,700 I.D. x 9,900 H
Material	:	1st Stage	Carbon steel + (Ti-Pd) Alloy
			+ Heat-resisting and acid proof brick
			+ Carborundum
		2nd Stage	Carbon steel + Rubber lining
			+ Acid proof brick

2) Dust slurry thickener

Quantity	:	1 unit	
Size	:	8,000 I.D. x 3,000 H	
Material	:	Reinforced concrete + Acid proof lining	
		+ Acid proof brick	
Motor power	:	1.5 KW	
Accessories	:	Slurry pump	6 m^3/H x 35 mH x 7.5 KW x 2 sets
			30 m^3/H x 20 mH x 5.5 KW x 2 sets

3) Humidifier reflux pump

Quantity	:	2 sets
Type	:	Centrifugal slurry pump
Capacity	:	450 m^3/H x 32 mH x 75 KW
Material	:	Casing, Impeller, Cast iron + Rubber lining shaft sleeve Shaft sleeve
	:	Shaft sleeve Ti

4) Dust slurry filter

Quantity	:	1 set
Type	:	Semi-automatic filter press
Capacity	:	Filtration area 20 m^2
Material	:	Cast iron + Rubber lining

5) No. 1 Scrubber unit

Quantity	:	1 unit
Type	:	Special packed tower
Size	:	2,900 I.D. x 9,700 H
Material	:	Carbon steel + Rubber lining + Acid proof brick (Lower part only)

6) No. 2 Scrubber unit

Quantity	:	1 unit	
Type	:	Special packed tower	
Size	:	2,800 I.D. x (3,800 + 1,700) H	
Material	:	Carbon steel + Rubber lining + Acid proof brick (Bottom only)	

7) Mist precipitator unit

Quantity	:	1 unit	
Type	:	Vertical gas flow plate type	
Size	:	7,200 W x 2,600 L x 12,300 H x (4 + 1) Rooms	
Material	:	Casing	FRP
		Collector electrode	FRP
		Discharge electrode	Ti
Accessories	:	Rectifier	5 sets
		Air fan	5 sets
		Air heater	5 sets
		Control panel	1 unit

8) Exhaust fan

Quantity	:	2 sets	
Type	:	Centrifugal	
Capacity	:	1,200 Nm^3/min. x 800 mmAq. x 380 KW	
Material	:	Casing	Carbon steel + Rubber lining
		Impeller, Shaft sleeve	Ti
Accessories	:	Emergency induced fan	
		120 Nm^3/min. x 400 mmAq. x 30 KW	
		Stack	

9) Solution cooler unit

Quantity	:	1 unit
Type	:	Vacuum cooler
Capacity	:	15 x 10^6 Kcal/H
Material	:	Carbon steel + Rubber lining
Accessories	:	Solution feed slurry pump
		380 m^3/H x 35 mH x 95 KW x 3 sets
		Feeder unit of sea water

10) Scrubber solution thickener

Quantity	:	1 unit
Size	:	12,000 I.D. + 3,500 H
Material	:	Reinforced concrete + Acid proof lining + Acid proof brick
Motor power	:	1.5 KW
Accessories	:	Slurry pump 6 m^3/H x 20 mH x 3.7 KW x 2 sets

11) Scrubber reflux pump

Quantity	:	2 sets
Type	:	Centrifugal slurry pump
Capacity	:	750 m^3/H x 25 mH x 100 KW
Material	:	Casing, Impeller Cast iron + Rubber lining
		Shaft sleeve Ti

12) Lead slurry settler

Quantity	:	1 unit
Type	:	Cone tank
Size	:	5,000 I.D. x (1,300 + 3,000) H
Material	:	Carbon steel + Rubber lining

13) Lead slurry repulper

Quantity	:	2 units
Type	:	Vertical cylindrical
Capacity	:	10 m^3
Material	:	Carbon steel + Rubber lining
		+ Acid proof brick (Bottom only)
Accessories	:	Slurry pump 6 m^3/H x 15 mH x 3.7 KW x 2 sets

14) Oxidizing tower

Quantity	:	1 unit
Type	:	Vertical cylindrical closed type
Size	:	2,000 I.D. x 7,000 H
Material	:	Carbon steel + Rubber lining
		+ Acid proof brick (Bottom only)

15) Disolving tank

Quantity	:	2 units
Type	:	Vertical cylindrical cone bottom closed type
Capacity	:	15 m^3
Material	:	Carbon steel + Rubber lining
Accessories	:	Steam heater

16) Lead reactor

Quantity	:	1 unit
Type	:	Vertical cylindrical cone-bottom closed type
Capacity	:	30 m^3
Material	:	FRP

17) Lead slurry thickener

Quantity	:	1 unit
Size	:	7,000 I.D. x 2,500 H
Material	:	Reinforced concrete + Acid proof lining + Acid proof brick
Motor power	:	1.5 KW
Accessories	:	Slurry pump 36 m^3/H x 15 mH x 5.5 KW x 2 sets

18) Lead slurry filter unit

Quantity	:	1 unit
Type	:	Rotary vacuum filter
Capacity	:	Filtration area 5 m^2
Material	:	Carbon steel + Rubber lining
Accessories	:	Slurry pump 6 m^3/H x 15 mH x 3.7 KW x 2 sets Vacuum unit

8–5–1–6. METAL RECOVERY PLANT

1) Neutralizer

Quantity	:	2 units
Type	:	Vertical cylindrical cone-bottom closed type
Capacity	:	30 m^3
Material	:	Carbon steel + Rubber lining + Acid proof brick (Bottom only)
Accessories	:	Feeder unit of chalk powder

2) Gypsum thickener

Quantity	:	1 unit
Size	:	10,000 I.D. x 2,500 H
Material	:	Reinforced concrete + Acid proof lining + Acid proof brick (Bottom only)
Motor power	:	1.5 KW
Accessories	:	Slurry pump 36 m^3/H x 15 mH x 7.5 KW x 2 sets

3) Gypsum filter

Quantity	:	3 sets
Type	:	Automatic vertical basket type centrifuge
Capacity	:	0.43 m^3 (1,400 I.D. x 550 H)
Material	:	Casing Carbon steel + Rubber lining Basket Ti
Motor power	:	30 KW, 15 KW

4) Tumbler unit

Quantity	:	2 units
Type	:	Rotary type
Capacity	:	18 m^3
Material	:	Carbon steel + Rubber lining + Acid proof brick
Accessories	:	Magnetic hoist

5) Tumbler feed pump

Quantity	:	2 sets
Type	:	Centrifugal slurry pump
Capacity	:	200 m^3/H x 15 mH x 30 KW
Material	:	Casing and impeller Cast iron + Rubber lining Shaft sleeve Ti

6) Copper slurry pump

Quantity	:	2 sets
Type	:	Centrifugal slurry pump
Capacity	:	30 m^3/H x 15 mH x 5.5 KW
Material	:	Casing and impeller Cast iron + Rubber lining Shaft sleeve Ti.

7) Copper slurry settler

Quantity	:	1 unit
Type	:	Cone tank
Size	:	6,000 I.D. x (1,000 + 3,000) H
Material	:	Carbon steel + Rubber lining
Accessories	:	Slurry pump 30 m^3/H x 15 mH x 5.5 KW x 2 sets

8) Copper filter

Quantity	:	2 sets
Type	:	Automatic vertical basket type centrifuge
Capacity	:	0.16 m^3 (1,100 I.D. x 450 H)
Material	:	Casing Carbon steel + Rubber lining
		Basket Ti.
Motor power	:	15 KW

9) Lead sulfide reactor

Quantity	:	1 unit
Type	:	Vertical cylindrical closed type
Size	:	2,600 I.D. x (3,300 + 300) H
Material	:	Carbon steel + Rubber lining
		+ Acid proof brick (Bottom only)
Accessories	:	Feeder unit of NaSH

10) Lead sulfide thickener

Quantity	:	1 unit
Size	:	10,000 I.D. x 3,000 H
Material	:	Reinforced concrete + Acid proof lining
		+ Acid proof brick (Bottom only)
Accessories	:	Slurry pump 36 m^3/H x 25 mH x 7.5 KW x 2 sets
		Feeder unit of flocculant

11) Lead sulfide filter

Quantity	:	2 units
Type	:	Semi-automatic filter press
Capacity	:	Filtration area 40 m^2
Material	:	Cast iron + Rubber lining
Accessories	:	Slurry pump 15 m^3/H x 35 mH x 7.5 KW x 2 sets

12) Iron oxidizer unit

Quantity	:	1 unit
Type	:	Vertical cylindrical closed type spray tower
Size	:	(2,300 I.D. x 8,500 H) + (1,800 I.D. x 8,000 H)
Material	:	Carbon steel + Rubber lining
		+ Acid proof brick (Bottom only)
Accessories	:	Feeder unit of $NaNO_2$ solution
		Feeder unit of O_2 gas

13) Iorn precipitaror

Quantity	:	2 units
Type	:	Vertical cylindrical closed tank
Capacity	:	30 m^3
Material	:	Carbon steel + Rubber lining
		+ Acid proof brick (Bottom only)
Accessories	:	Feeder unit of chalk powder

14) Ferric slurry thickener

Quantity	:	1 unit
Size	:	12,000 I.D. x 4,000 H
Material	:	Reinforced concrete + Acid proof lining
		+ Acid proof brick (Bottom only)
Accessories	:	Feeder unit of flocculant

15) Ferric slurry filter

Quantity	:	1 unit
Type	:	Rotary vacuum filter
Capacity	:	Filtration area 18 m^2
Material	:	Carbon steel + Rubber lining
Accessories	:	Slurry pump 9 m^3/H x 15 mH x 5.5 KW x 2 sets
		Vacuum unit

16) Zinc precipitaror

Quantity	:	3 units (No. 1 2 units, No. 2 1 unit)
Type	:	Vertical cylindrical
Capacity	:	30 m^3
Material	:	Carbon steel + Rubber lining
		+ Acid proof brick (Bottom only)

Accessories : Feeder unit of slaked lime milk

17) No. 1 Zinc slurry thickener

Quantity : 1 unit

Size : 14,000 I.D. x 4,000 H

Material : Reinforced concrete + Acid proof lining
+ Acid proof brick (Bottom only)

Accessories : Slurry pump 42 m^3/H x 15 KW x 7.5 KW x 2 sets

18) No. 2 Zinc slurry thickener

Quantity : 1 unit

Size : 9,000 I.D. x 3,500 H

Material : Reinforced concrete + Acid proof lining

Accessories : Slurry pump 6 m^3/H x 15 mH x 3.7 KW x 2 sets
12 m^3/H x 15 mH x 5.5 KW x 2 sets

19) No. 1 Zinc slurry filter

Quantity : 1 unit

Type : Rotary vacuum filter

Capacity : Filtration area 16 m^2

Material : Carbon steel + Rubber lining

Accessories : Vacuum unit
Feed pump 9 m^3/H x 15 mH x 3.7 KW x 2 sets

20) Zinc cake repulper

Quantity : 2 units

Type : Vertical cylindrical closed tank

Capacity : 12 m^3

Material : Carbon steel

Accessories : Slurry pump 15 m^3/H x 15 mH x 5.5 KW x 2 sets
Feeder unit of NaOH

21) $Zn(OH)_2$ slurry thickener

Quantity : 1 unit

Size : 14,000 I.D. x 4,000 H

Material : Carbon steel

22) $Zn(OH)_2$ slurry filter

Quantity	:	1 unit
Type	:	Rotary vacuum filter
Capacity	:	Filtration area 24 m^2
Material	:	Carbon steel
Accessories	:	Vacuum unit
		Feed pump 12 m^3/H x 15 mH x 5.5 KW x 2 sets

23) Preconcentrator unit

Quantity	:	1 unit
Type	:	Spary tower
Size	:	3,000 I.D. x 20,000 H
Material	:	Carbon steel

24) $CaCl_2$ concentrator unit

Quantity	:	2 units
Type	:	Submerged combustion type
Capacity	:	27.7 m^3/H
Material	:	Carbon steel + Rubber lining
		Acid proof brick (Bottom and weir)

8–5–2. ELECTRICAL APPARATUS

1) Substation

a) Receiving

230KV, 60HZ, 3 phase 3 wire system

b) Extra-high tension switchgear

Quantity	:	1 set	
Type	:	Indoor	
Main apparatus	:	Disconnecting switch	3 sets
		Circuit breaker	1 set
		Instrument transformer	3 sets
		Potential-current transformer	1 set
		Arrester	3 sets

c) Extra-high tension transformer

Quantity	:	1 set	
Type	:	Outdoor, oil cooled	
Main specification	:	Primary voltage	230KV
		Secondary voltage	6KV
		Capacity	25,000KVA

d) High tension distribution board

Quantity	:	1 set	
Type	:	Indoor enclosed	
Main usage	:	Feeder	8 units
		Station service	1 unit
		Static condenser	2 units

e) Supervisory control panel

Quantity	:	1 set
Type	:	Indoor bench board
Accessories	:	Relay board

f) Station service

Quantity	:	1 set	
Main specification	:	DC power supply	1 set
		AC power board	1 set

2) Transformer & distribution panel (Installed at each electric room)

Quantity & main apparatus:

High tension switchgear board	1 set
Transformer for motors 3 phase, 6KV/440V	1 set
Transformer for illumination Single phase, 6KV/220V	1 set
Low tension load center	1 set
Low tension motor control center	1 set

Main electric room:

For stock yard

For roasting plant

For pelletizing plant

For metal recovery plant

3) Electric motor

Quantity	:	1 set
Main specification	:	
Protection system	:	Totally-enclosed-fan-cooled
Voltage	:	6KV for over 150 KW
		440V for less than 150 KW
		220V for control motor & small single phase motor
Insulation class	:	Class "B" for high tension motor
		Class "E" for low tension motor
Temperature rise	:	Design ambient temperature is less than 40°C.
Size, Noise, etc.	:	IEC standard

4) Process control

a) Supervisory control panel

Quantity	:	5 sets
Type	:	Indoor, dust-proof bench board (including self-standing instrument panel and auxiliary relay board)

b) Local operation board

Quantity	:	1 set
Type	:	Outdoor, dust-proof self-standing
Accessories	:	Control switch, ammeter

c) Instrumentation

Quantity	:	1 set	
Type	:	Indoor and/or outdoor, dust-proof	
Common specification	:	Supply power	DC 24V
		Signal	DC 4 – 20 mA

5) Illumination

Quantity & main specification :

Distribution board for illumination	1 set
Mercury-arc lamp for exterior lighting & interior high ceiling general lighting	1 set
Fluorescent lamp for interior general lighting & emergency illumination	1 set
Incandesent lamp for local lighting	1 set
Switch board for welder	1 set

Note : Illumination standard

Interior

Control room	250 – 500 lx
Plant	More than 100 lx

Exterior

Plant	More than 50 lx
Road	More than 10 lx

6) Communication system

Quantity : 1 set

Type : Automatic telephone exchange

Main specification :

Capacity : Office telephone 3

Private 50

Mounting 30

Power source : Battery

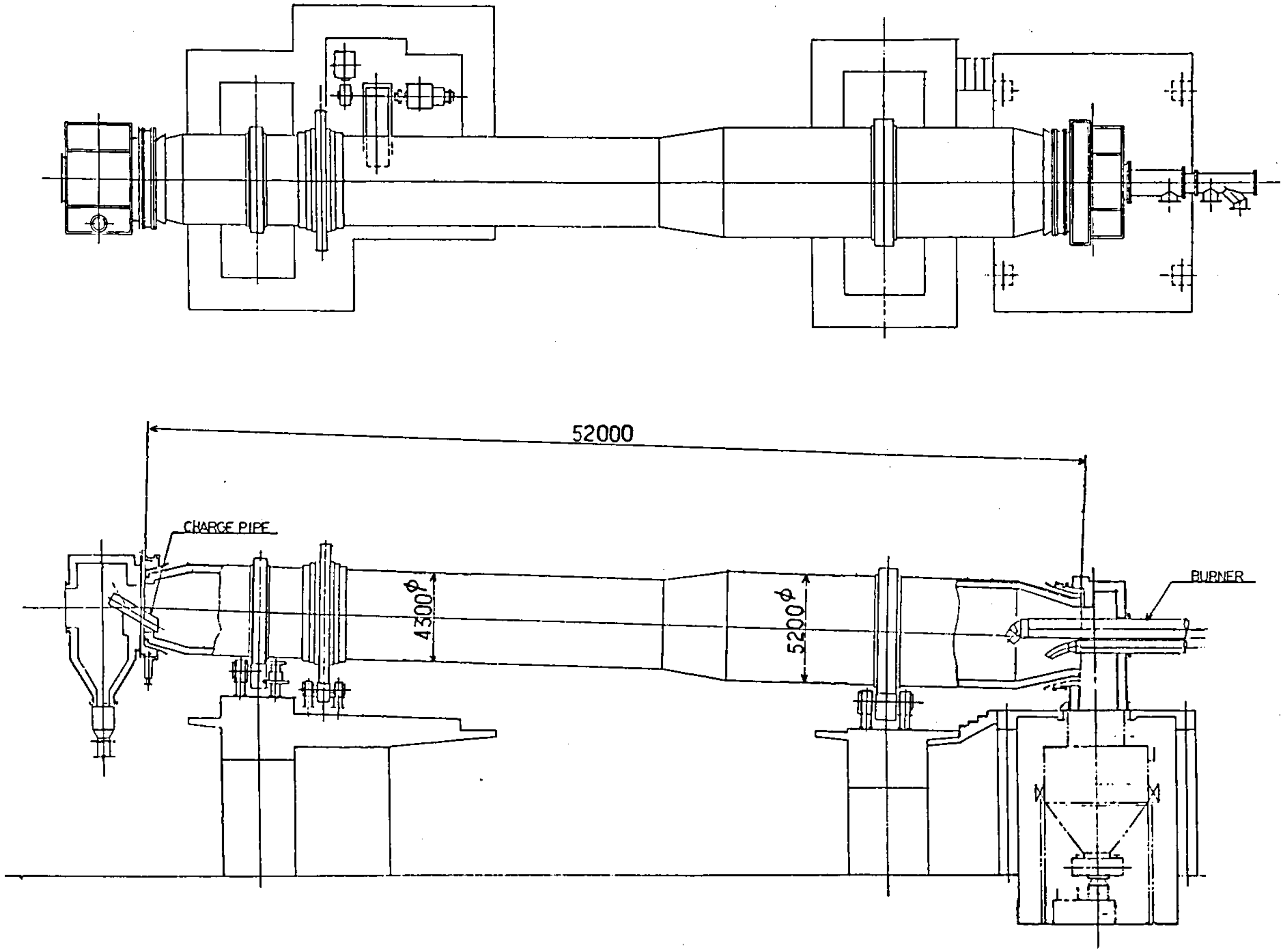


Fig. 8.2

ROTARY KILN

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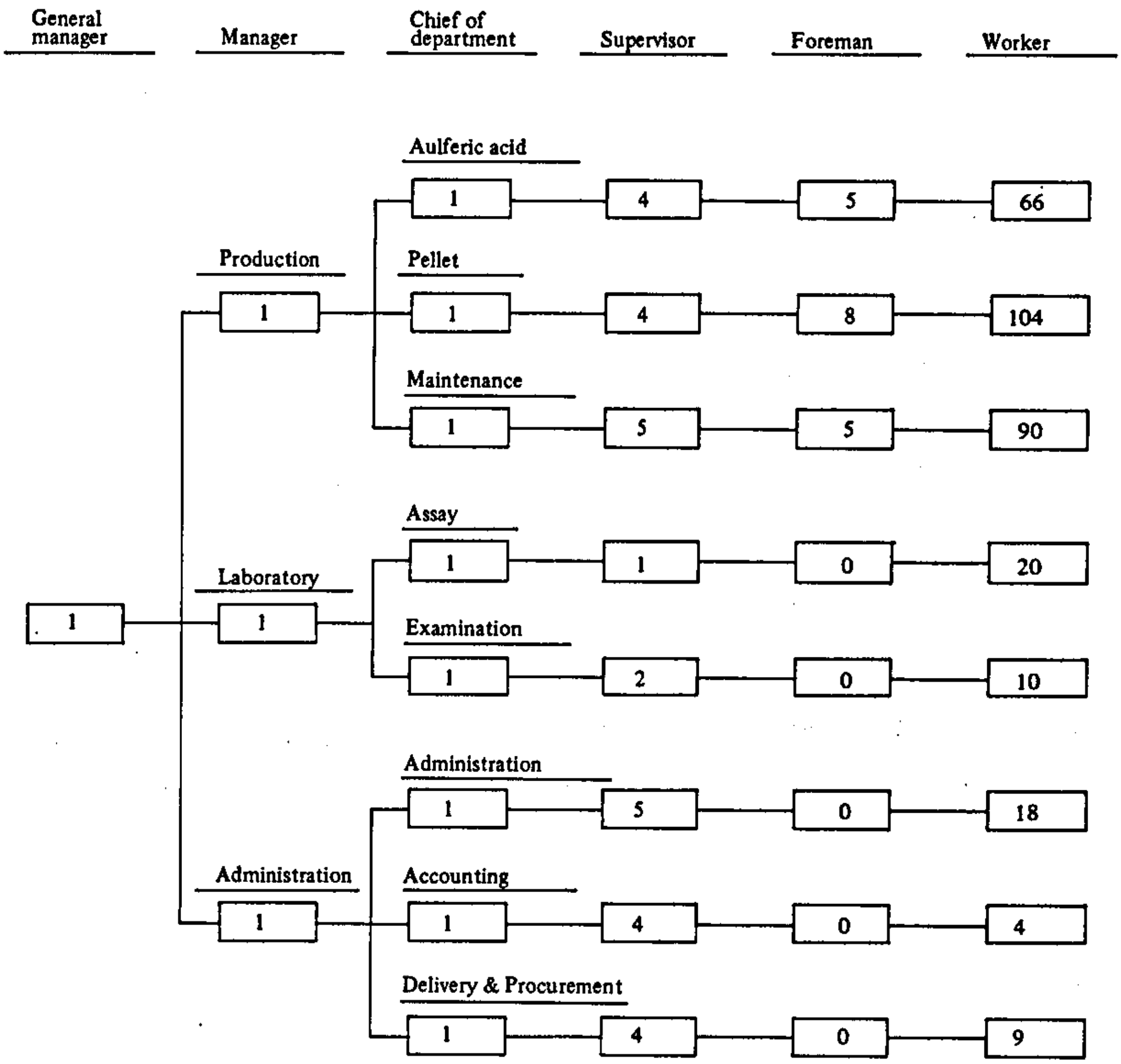
SCALE ________

8–6. ORGANIZATION FOR OPERATING THE METALLURGICAL PLANT

The organization for operating the metallurgical plant will be shown as follows.



Total	1	3	8	29	18	321	380

8–7. OTHER DATA

8–7–1. CLIMATE

1) Location

Latitude	:	17°55′ to 17°53′
Longitude	:	102°12′ to 102°15′
Altitude	:	1.5m to 2.5m above the sea

2) Temperature

Maximum	:	39.0°C
Minimum	:	11.5°C
Mean	:	26.2°C

3) Humidity

Maximum	:	91.7%
Minimum	:	49.1%

4) Rainfall amount

10-minute maximum	:	32.00mm
Hourly maximum	:	100.00mm
Yearly mean	:	1,320.47mm

8–7–2. VIBRATION AND GROUND

1) Vibration

o	Seismic coefficient	:	0.2
o	Machine vibration	:	Must be determined, considering the vibration conditions of the respective machines.

2) Ground

Since the plant is located in reclaimed land, the ground is surmised to have little bearing capacity. According to information obtained in a near-by plant, there is data that the bearing layer was reached by 12 to 14 m piles, and calculation will be made in reference to this data. However, in actual construction, subsurface exploration must be made for major structures, to determine allowable bearing capacity of the ground.

9 BASIC PLAN OF INFRASTRUCTURE

9. BASIC PLAN OF INFRASTRUCTURE

9–1 INTRODUCTION

This project consists of the development of the Copper King and the Campo Morado mines and the construction of metallurgical plant in Lazaro Cardenas.

For the project to be run smoothly, it is a prerequisite to ensure transportation and provide the workers, particularly at the mine site, with welfare facilities for ensuring stable labor force and reproduction.

Infrastructure accompanying the exploitation of the mines will contribute to the development of regional society. Thus it should not be viewed from the stand point of payability of the project alone but it should also be studied as part of the nationwide public development program. The roads leading to the mines will be used by people in the region for various purposes other than for the construction work and mining operation. Therefore, they should not be viewed as the investment on this project alone.

Assuming that the main roads will be constructed by the state or federal government, we have planned access roads connecting the mine site and the associated facilities. The infrastructure plan based on the above concept is described in the following.

9–2 COPPER KING MINE

The mine is located about 28 km from the center of Petatlan city and is about 26 km distant from the branch point of the national highway No. 200. Along the road small villages are sparsely scattered but there is nothing in this area that may be used as welfare facilities for mine workers.

Petatlan city has a substantial population, hospitals and schools and the existing public facilities can be used as welfare facilities for the workers of this project. Thus, houses for workers, a club house and a guest house will be built in the suburb of the city.

The road leading to the mine is relatively wide gravel road except for a 2 km section near the mine. The existing road can be used as a construction, commutation and transportation (30-ton truck carrying concentrate) road if slight improvements and construction of submerged bridge for small rivers are done.

In this project, the 2 km section of the road nearest the mine site will be newly constructed (partly improved) and the improvement of other section will be done by the state or federal government. The maintenance of the 26 km road will be financed by the income of the mine.

1) Houses and dormitory

Of the 203 employees, a part of section chiefs and foremen and the all workers will be employed from the people of this district. They are supposed to come to work from their own homes. We plan to build 4 A-class houses for 4 managers and superintendent, 5 B-class houses for 9 section chiefs, 16 C-class houses for 36 foremen and 5 rooms of dormitory for unmarried persons.

4 A-class houses : made of concrete blocks, 128 m^2 each, (total floor area 512 m^2)

5 B-class houses : made of concrete blocks, 117 m^2 each, (total floor area 585 m^2)

16 C-class apartments : made of concrete blocks; a pair of apartments make up a single houses; 100 m^2 for each apartment; 8 houses; (total floor area 1600 m^2)

1 C-class dormitory for unmarried persons: 5 rooms; 20 m^2 for each room; a dining hall and playing hall; (total floor area 333 m^2)

2) Club house

As a place for communication among workers, a club house will be built, in which a rest room, a library, a play room and a bar are accommodated. The hall will be made of concrete blocks and its area is 512 m^2.

3) Guest house

To accommodate guests, a concrete block guest house (571 m^2) equipped with a bar, a dining hall and 5 sleeping rooms will be built.

4) Road

A road about 26 km long running from the national highway No. 200 to the mine site will be improved with some portion newly constructed so that the gravel road is 6 m wide. A 24 km section of this road on the side of national highway will be broadened, repaired and bridged by the state or federal government. The remaining 2 km section on the side of the mine will be newly constructed and repaired by this project. The maintenance of the 26 km road from the national highway to the mine site will be financed by the mining operation.

9–3 CAMPO MORADO MINE

The mine is located about 35 km from Villa de Ayala, which is situated beside the national highway No. 51. From Villa de Ayala, it will take a jeep about 2 hours to drive a 35 km mountenous road to the mine. Near the mine there are some villages each made up of 200 or less inhabitants. In Ixcatepec about 12 km before the mine with a population of 3,000, there are no welfare facilities that may be used for the mine workers.

The topography around the mine site is steep and mountenous and there is no suitable site for the construction of welfare facilities. So it is planned to build houses, dormitory for unmarried persons, club house, guest house, clinic, and play ground near Ixcatepec; it is also planned to dig a well for underground water. The electricity for these facilities will be supplied from 6.6 kV distribution lines branching from the 44 kV trunk line.

The 35 km road leading to the mine is steep and narrow and will require substantial repair and improvement. But to minimize the initial investment, it is planned to transport the concentrates by 10-ton trucks. The road will eventually be broaden to a width of 6 m.

About 32 km section of the existing 35 km road will be repaired and improved as a public investment by the state or federal government.

The steep section of the road near the mine will be replaced by a newly constructed road of 2.2 km. The construction of the new road will be financed by this project. A road connecting the minehead and the dressing and concentrating plant as well as the service road to the tailings dam and water intake point, all amounting to 10.9 km, will also be constructed in this project.

1) Houses and dormitory

Housing facilities will be built to accommodate 375 employees. It is planned to build 8 A-class houses for 8 managers, superintendents, doctors and pharmacists; 13 B-class houses for 13 section chiefs; 40 C-class apartment houses for 60 foremen; a C-class dormitory with 20 rooms for unmarried persons; 260 D-class house for 294 workers; and a D-class dormitory with 50 rooms for unmarried persons.

8 A-class houses: made of concrete blocks; 128 m^2 each (total floor area 1,024 m^2)

13 B-class houses: made of concrete blocks; 117 m^2 each (total floor area 1,521 m^2)

40 C-class apartments: made of concrete blocks; a pair of apartments make up a single house; 100 m^2 for each apartment; 20 houses; (total floor area 4,000 m^2)

1 C-class dormitory for unmarried person: made of concrete blocks; 20 rooms; 20 m^2 for each room; dining hall and playing hall; (total floor area 832 m^2)

260 D-class apartments: made of concrete blocks; 13 2-storied apartment houses will be built, each containing 20 apartments; 85 m^2 for each apartment; (total floor area 24,232 m^2)

1 D-class dormitory for unmarried persons: made of concrete blocks; 50 rooms 12 m^2 for each room; a dining hall and a playing hall; (total floor area 1,267 m^2)

2) Club house

As a place for communication among workers, club house will be built, in which a rest room, a library, a play room and a bar are accommodated. The hall will be made of concrete blocks and its area is 512 m^2.

3) Guest house

To accommodate guests, a concrete block guest house (571 m^2) equipped with a bar, a dining hall and 10 sleeping rooms will be built.

4) Clinic

A clinic made of concrete blocks (240 m^2) with a waiting room, a consultation room, an operation room, a resting room, maternity room, a pharmacist room and a medical treatment room will be built.

5) Playground

A playground will be constructed for soccer game or any other outdoor sports and recreation.

6) Road

The road about 32 km in length from Vill de Ayala beside the national highway No. 51 to the foot of the mountain will be reparired and improved by the state or federal government. This project covers the following road constructions.

Replacement road near mine site: 2.2 km gravel road 6 m wide

Minehead - concentrator:	3.2 km gravel road 6 m wide
Concentrator - tailings dam site:	4.2 km gravel road 3 m wide
Concentrator - water intake tank:	3.5 km gravel road 3 m wide

Maintenance of the road from the national highway No. 51 to the mine site will be financed by the operating income.

9–4 METALLURGICAL PLANT

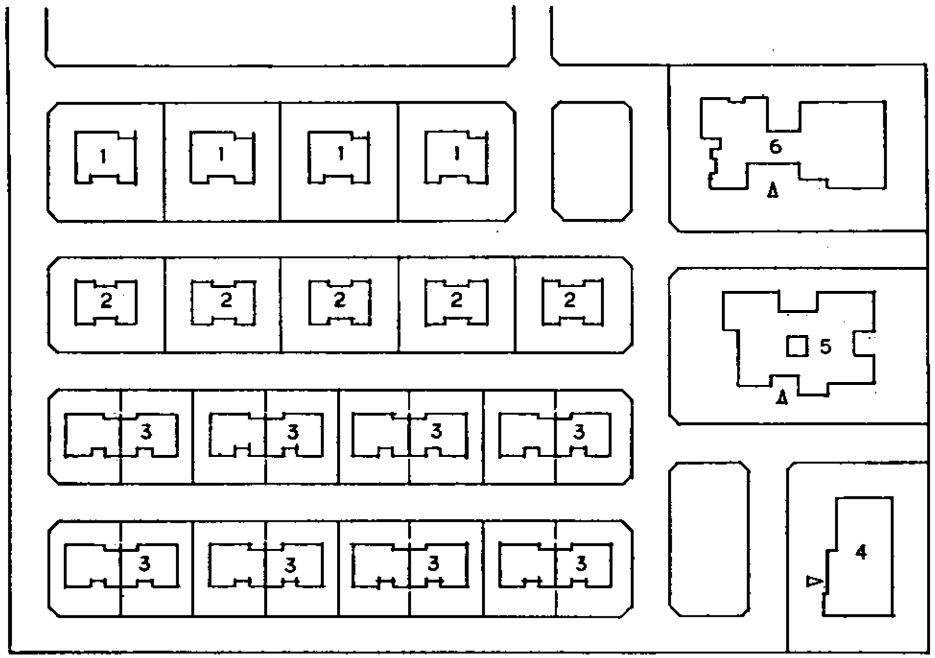
The Lazaro Cardenas district, a site for the metallurgical plant, has the population of about 700,000 and various welfare facilities. It is planned to build here houses for employees who come to work from remote places. The housing facilities are: 4 extra A-class houses for the head of the factory and managers, 8 A-class houses for 8 superintendents, 20 B-class houses for 28 section chiefs, and a dormitory with 8 rooms for unmarried persons.

Foremen and workers will be employed from residents in the city who can commute from their own homes. It is also planned to build a guest house equipped with a bar, a dining hall and 8 sleeping rooms.

1) Houses and dormitory

4 extra A-class houses:	made of concrete blocks; 135 m^2 each (total floor area 540 m^2)
9 A-class houses:	made of concrete blocks; 128 m^2 each (total floor area 1,024 m^2)
20 B-class houses:	made of concrete blocks; 117 m^2 each (total floor area 2,340 m^2)
B-class dormitory for unmarried persons:	made of concrete blocks; a dining hall and a play room; 8 rooms; 37.5 m^2 for each room; (total floor area 566 m^2)

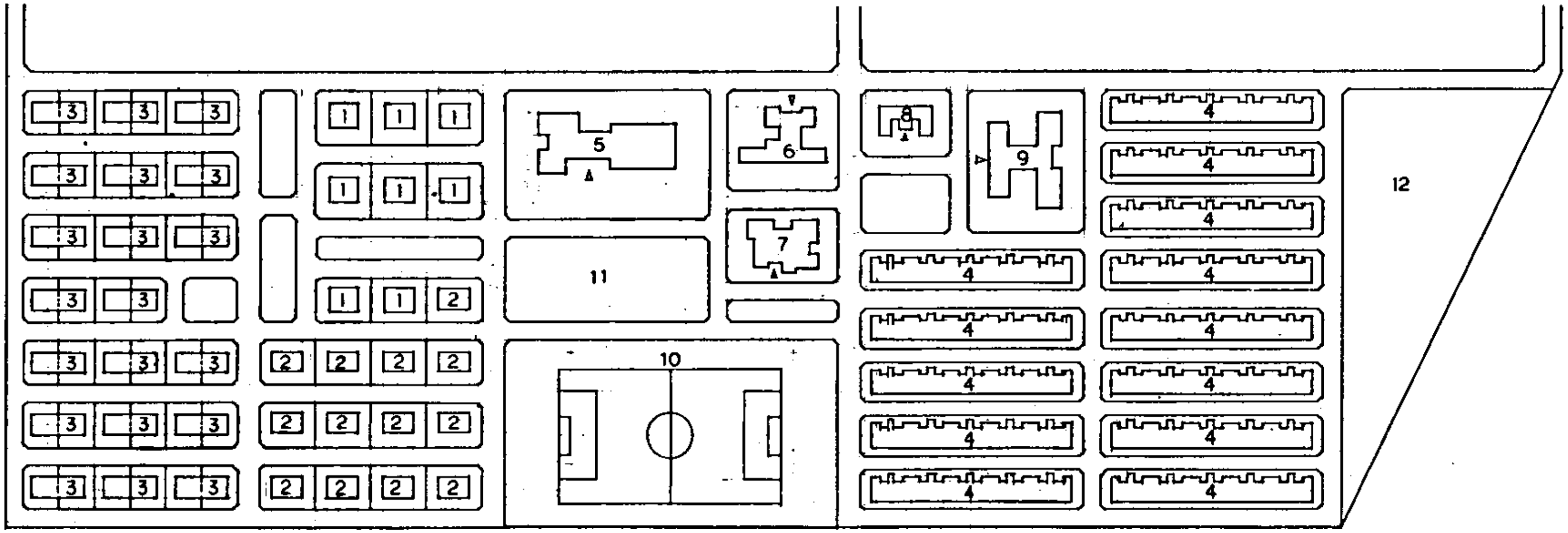
2) Guest house: made of concrete block; 1,356 m^2



1 Residence A
2 〃 B
3 〃 C
4 Dormitory C
5 Clubhouse
6 Guest house

Fig. 9·1

Site Plan (Copper King)			
DRAWN BY	K. Sakai	DATE	8/Mar/'93
CHECKED BY		DATE	/ /
SCALE	1/1,000		



1 Residence A
2 〃 B
3 〃 C
4 〃 D
5 Guest house
6 Dormitory C
7 Clubhouse
8 Clinic
9 Dormitory D
10 Soccer
11 Shopping area
12 Park

Fig. 9-2

Site Plan (Campo Morado)

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SCALE	1/2,000		

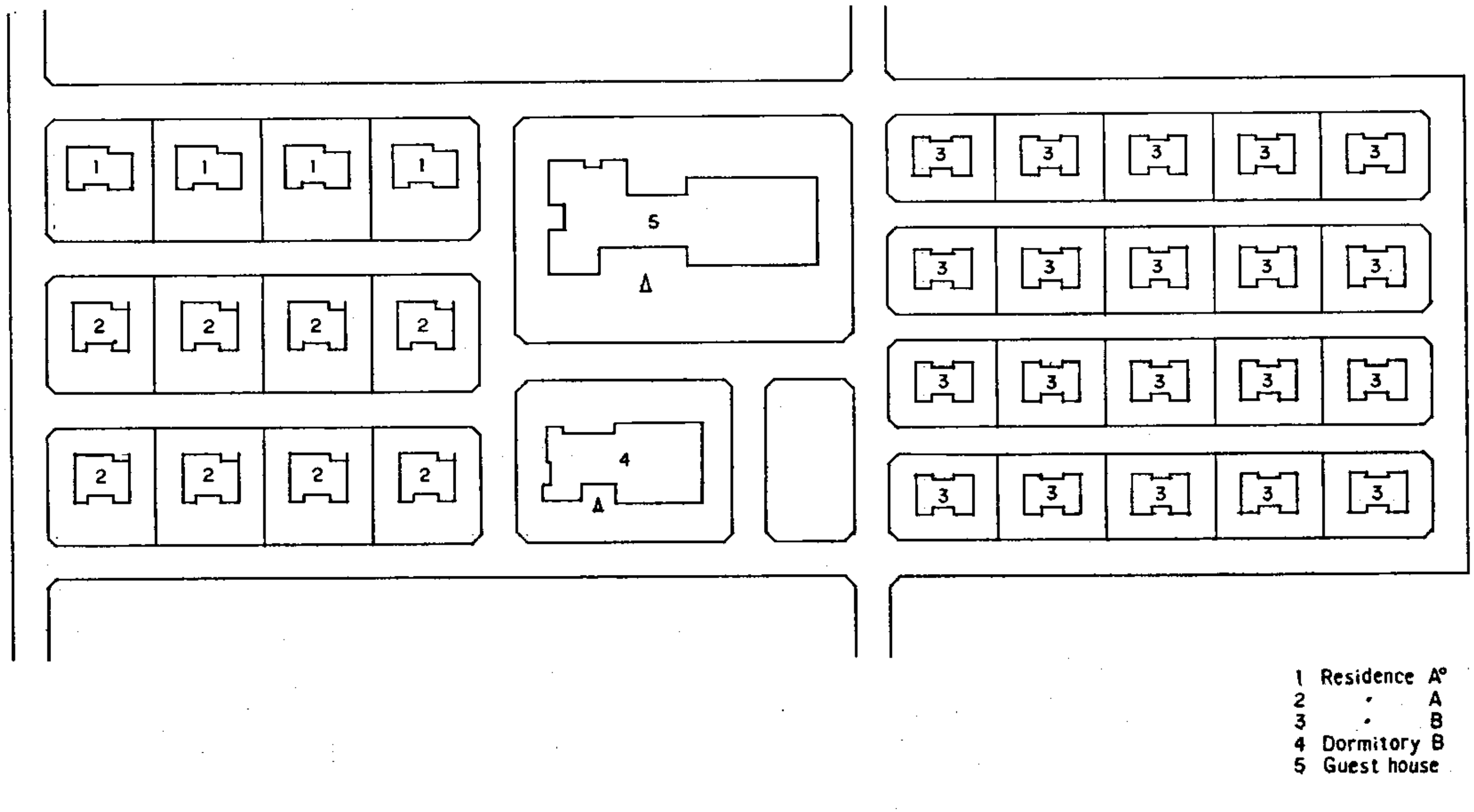

Fig.9.3

Site Plan (Metallurgical Plant)

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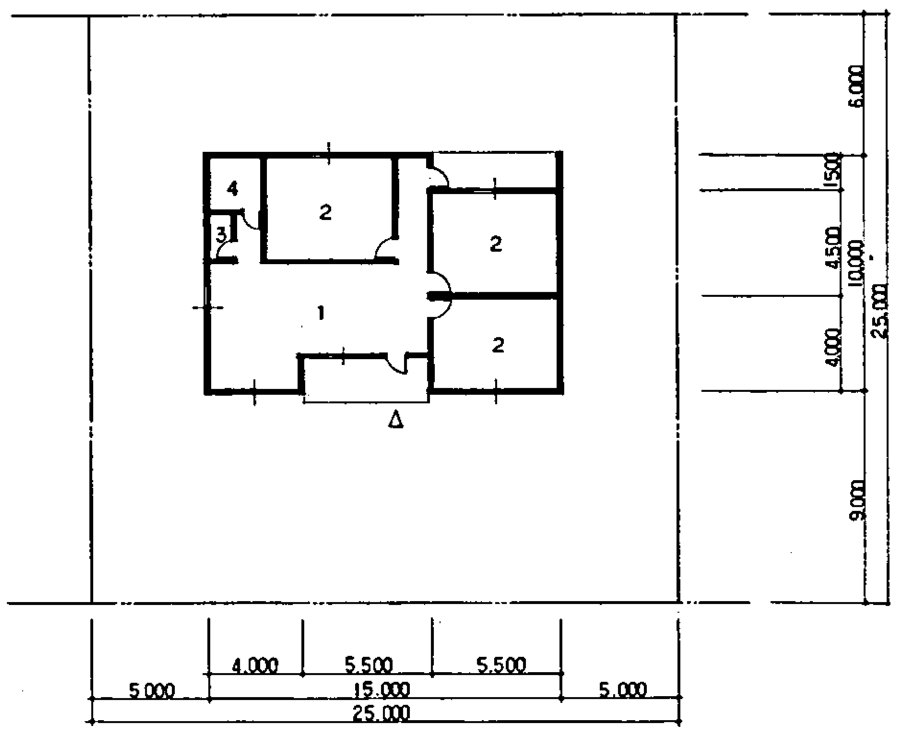
SCALE	1/1,000		



1 L.D.K.
2 Bed room
3 W.C
4 Bath room

Fig. 9-4

135 m²

Residence A° (M.P)			
DRAWN BY	K. Sakaino	DATE	5/Nov/81
CHECKED BY		DATE	/ /
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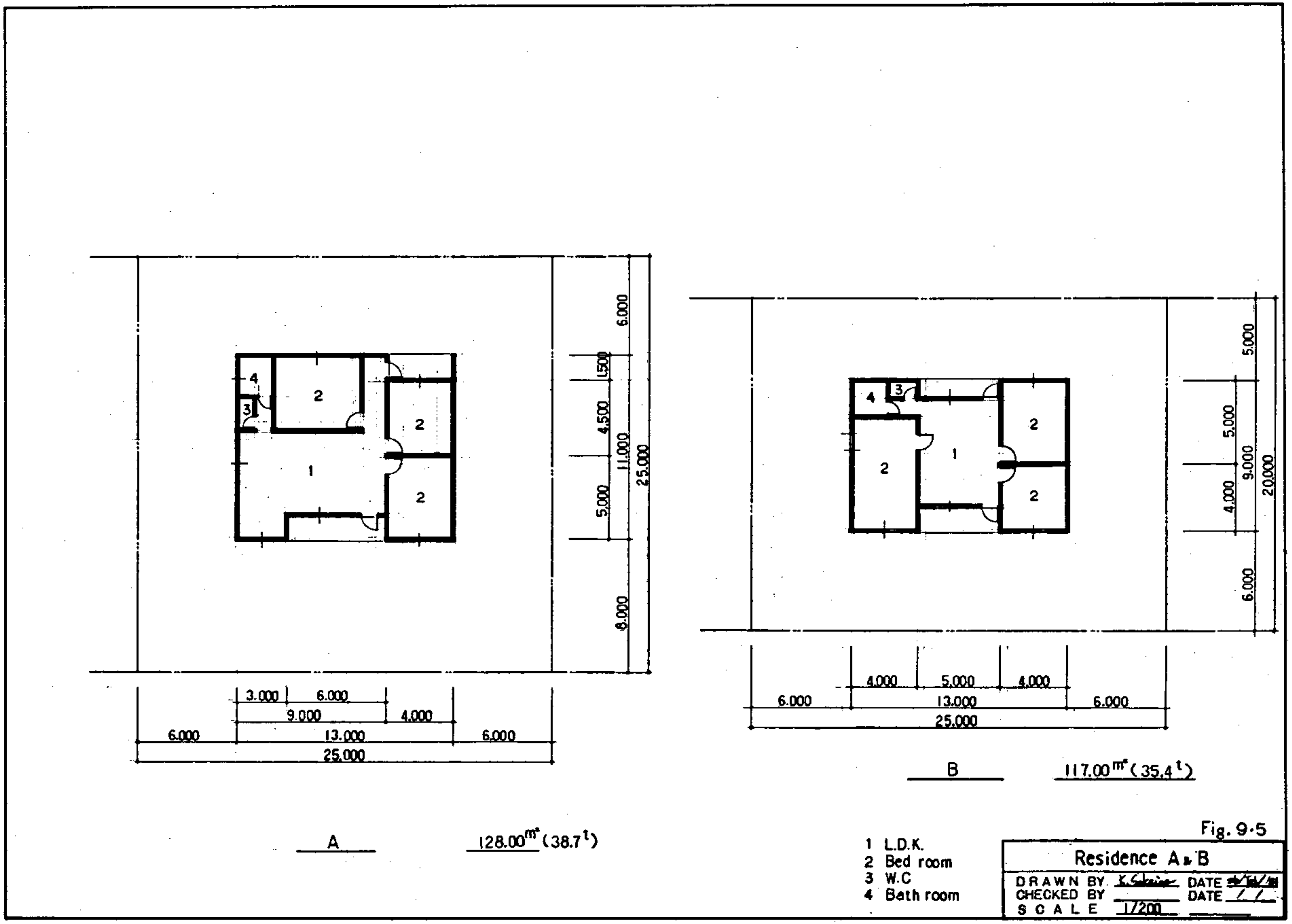
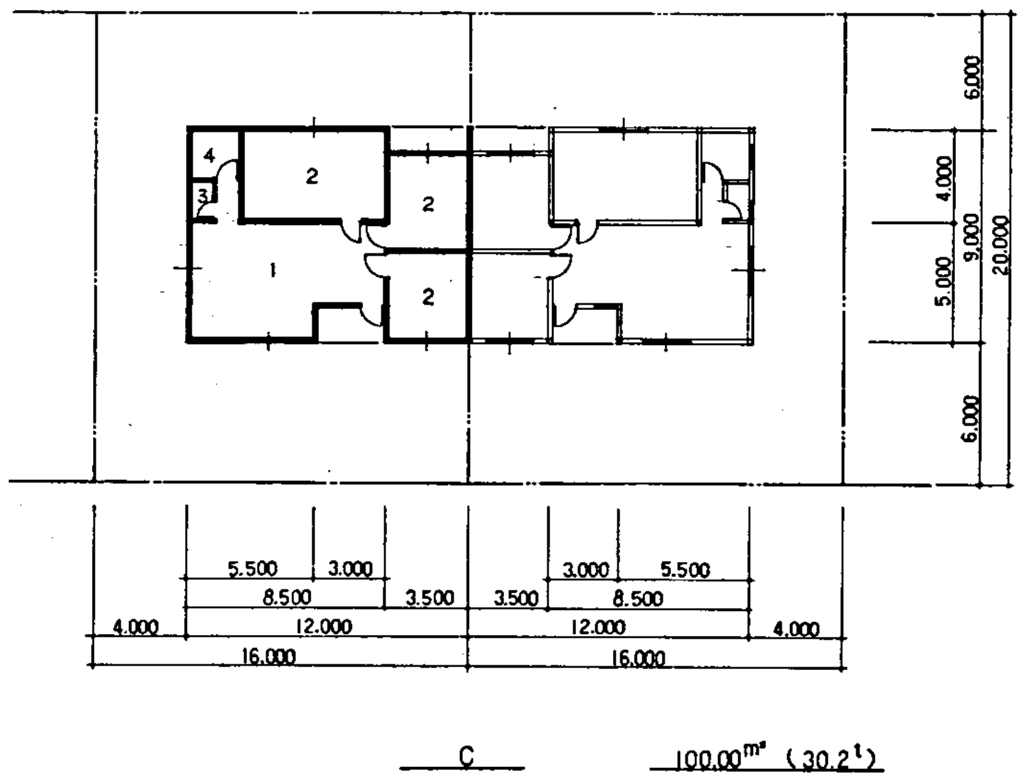

A
128.00m² (38.7t)
B
117.00m² (35.4t)
1 L.D.K.
2 Bed room
3 W.C
4 Bath room
Residence A & B
DRAWN BY
CHECKED BY
SCALE 1/200
DATE
DATE

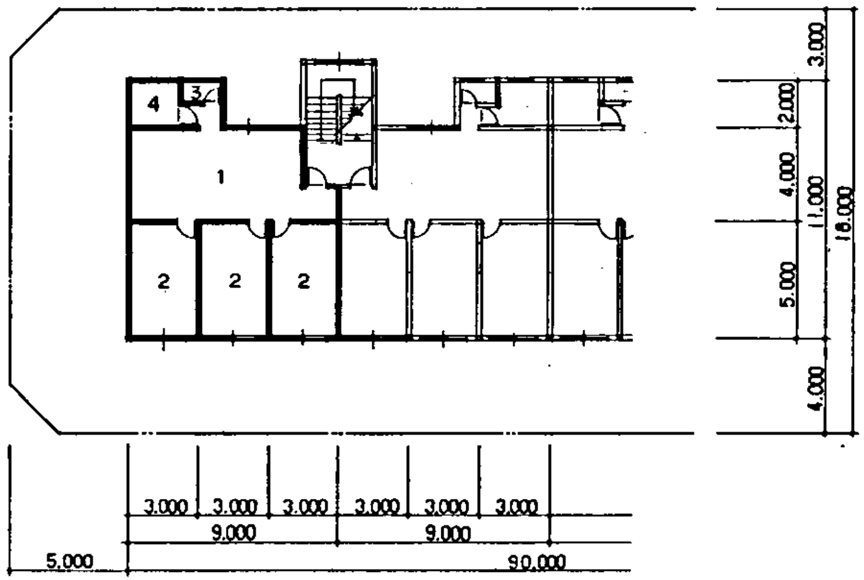
Fig. 9·5



1 L.D.K.
2 Bed room
3 WC
4 Bath room

Fig. 9·6

Residence C (C.K & C.M)			
DRAWN BY	K. Cabrine	DATE	/ /
CHECKED BY		DATE	/ /
SCALE	1/200		



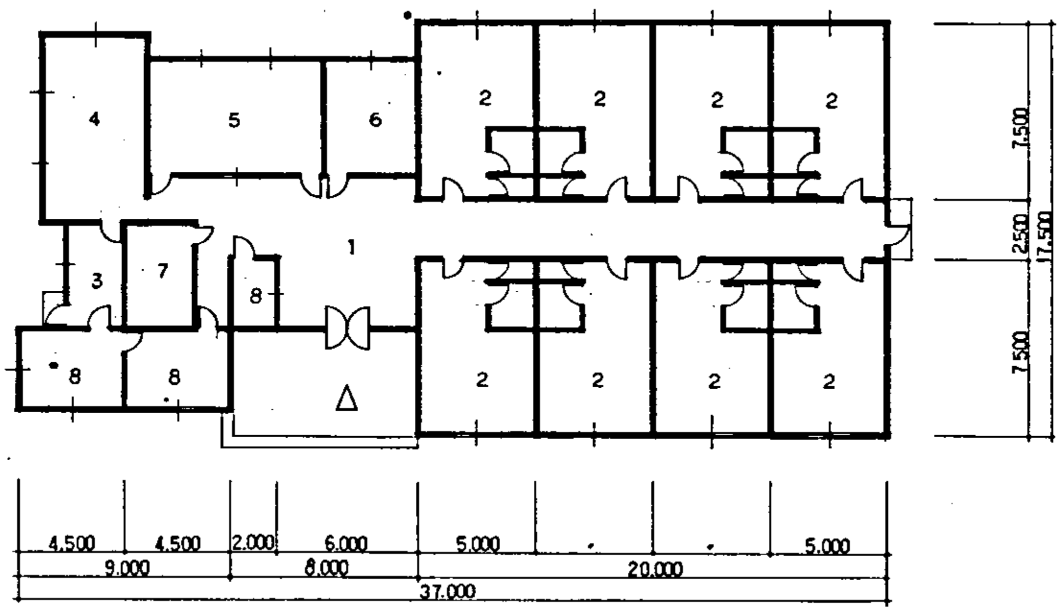
D

85.3 m² (25.8 t)

1 LDK
2 Bed room
3 WC
4 Bath room

Fig. 9-7

Residence D (C.M)			
DRAWN BY		DATE	
CHECKED BY		DATE	
SCALE	1/200		

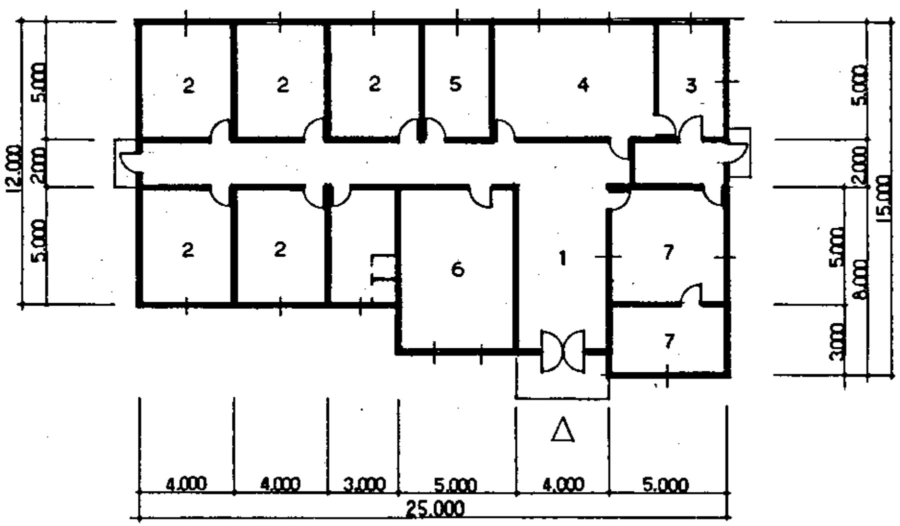


1 Entrance hall
2 Bed room (8 rooms)
3 Cuisine
4 Dining room
5 Recreation room
6 Bar room
7 Storeroom
8 Janitor room

Fig.9-8

566 m²

Dormitory (B) (M.P)	
DRAWN BY K. Sakaino	DATE 4/Mar/91
CHECKED BY	DATE / /
SCALE 1/200	

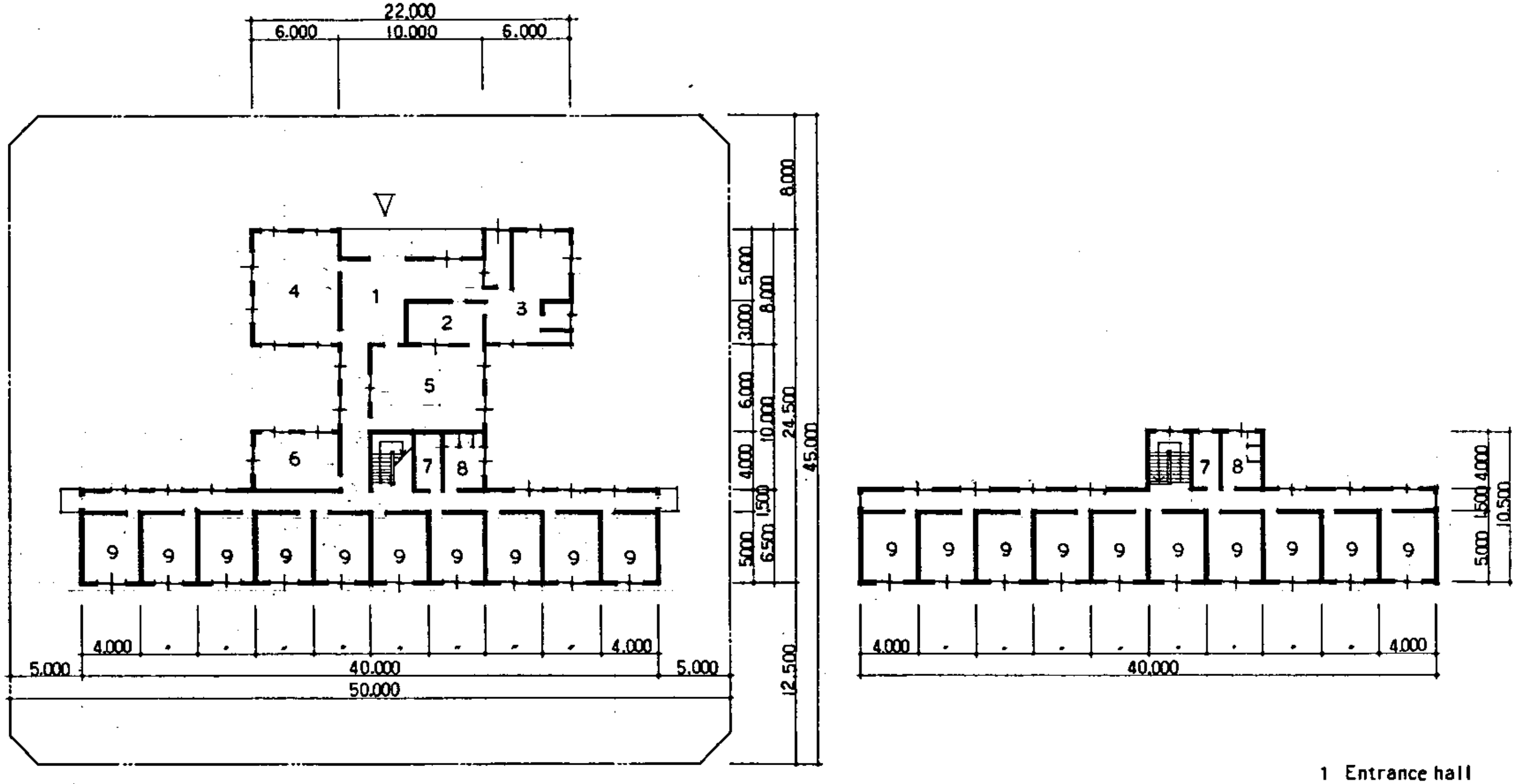


1 Entrance hall
2 Bed room
3 Cuisine
4 Dinining room
5 Shower room
6 Recreation room
7 Janitor room

Fig. 9-9

333 m²

Dormitory (C) (C.K)	
DRAWN BY K. Sakuine	DATE 5/Mar/81
CHECKED BY	DATE / /
SCALE 1/200	



1st Floor Plan

2nd Floor Plan

1 Entrance hall
2 Cuisine
3 Janitor room
4 Recreation room
5 Dining room
6 Shower room
7 Storeroom
8 W.C
9 Bed room

Fig.9-10

832 m²

Dormitory (C) (C.M)			
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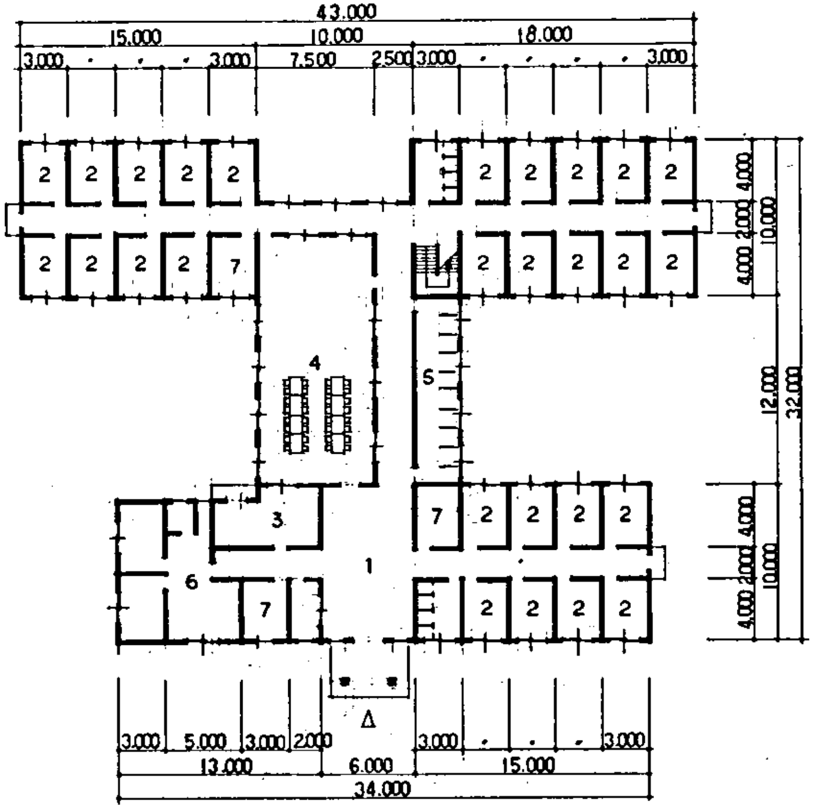
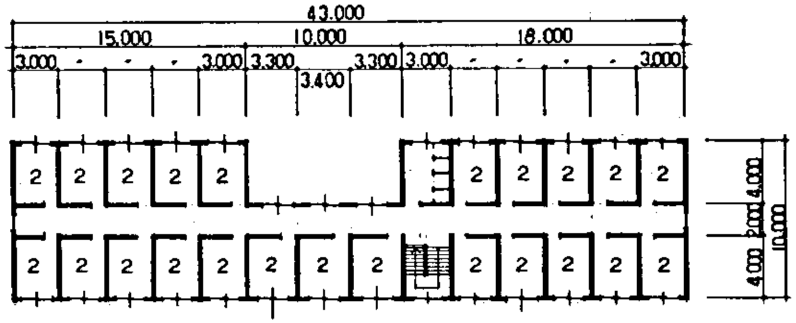
CHECKED BY		DATE	/ /
SCALE	1/300		



1st Floor Plan



2nd Floor Plan

1 Entrance hall
2 Bed room (50 rooms)
3 Cuisine
4 Dining room & rereation room
5 Shower room
6 Janitor room
7 Storeroom

Fig. 9-11

1267 m²

Dormitory (D) (C.M)	
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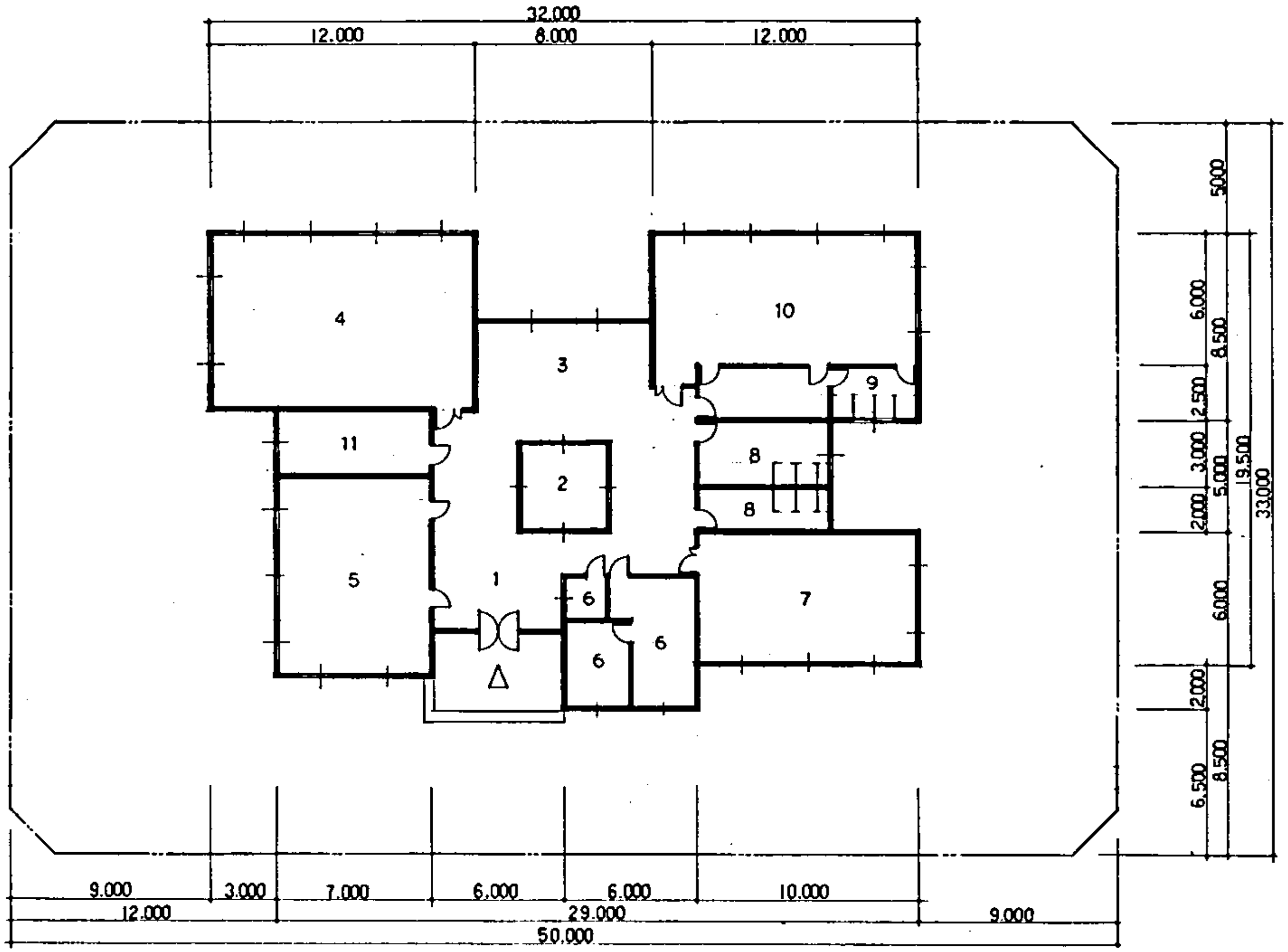
CHECKED BY	DATE / /
SOALE 1/300	



1 Entrance hall
2 Court
3 Lobby
4 Meeting room
5 Bar room
6 Janitor room
7 Library
8 W.C
9 Shower room
10 Recreation room
11 Storeroom

532 m²

Fig. 9·12

Clubhouse (C.K & C.M)			
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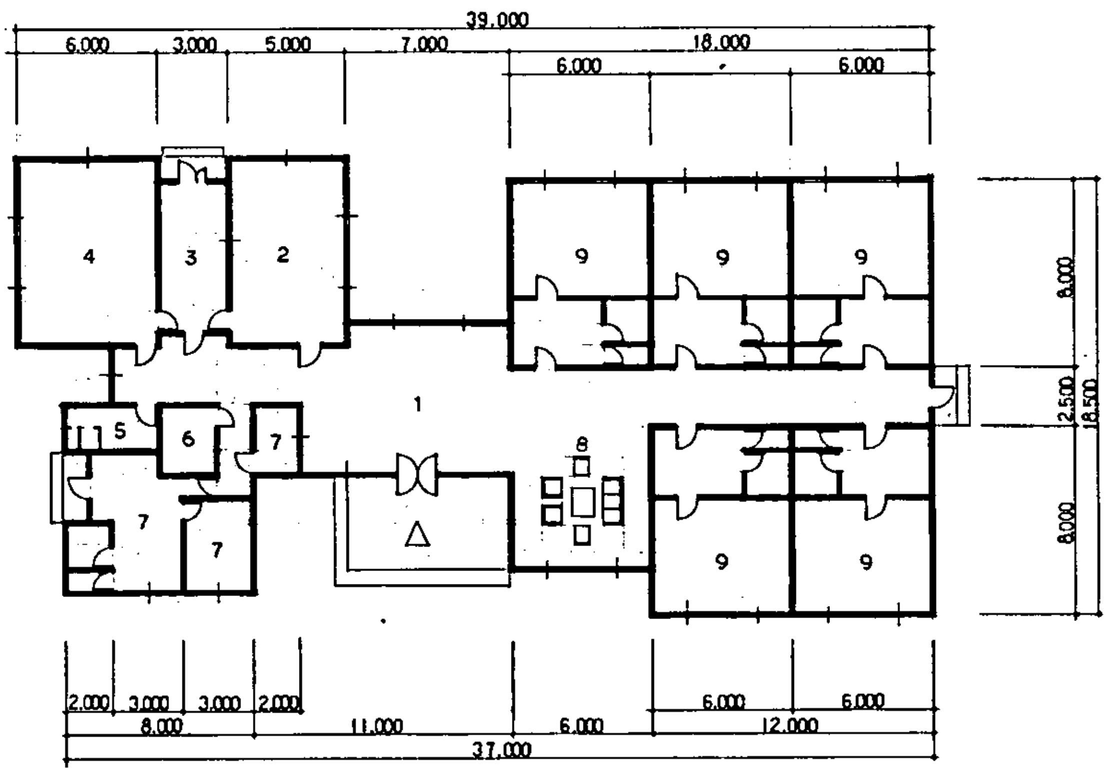
CHECKED BY		DATE	/ /
SCALE	1/200		

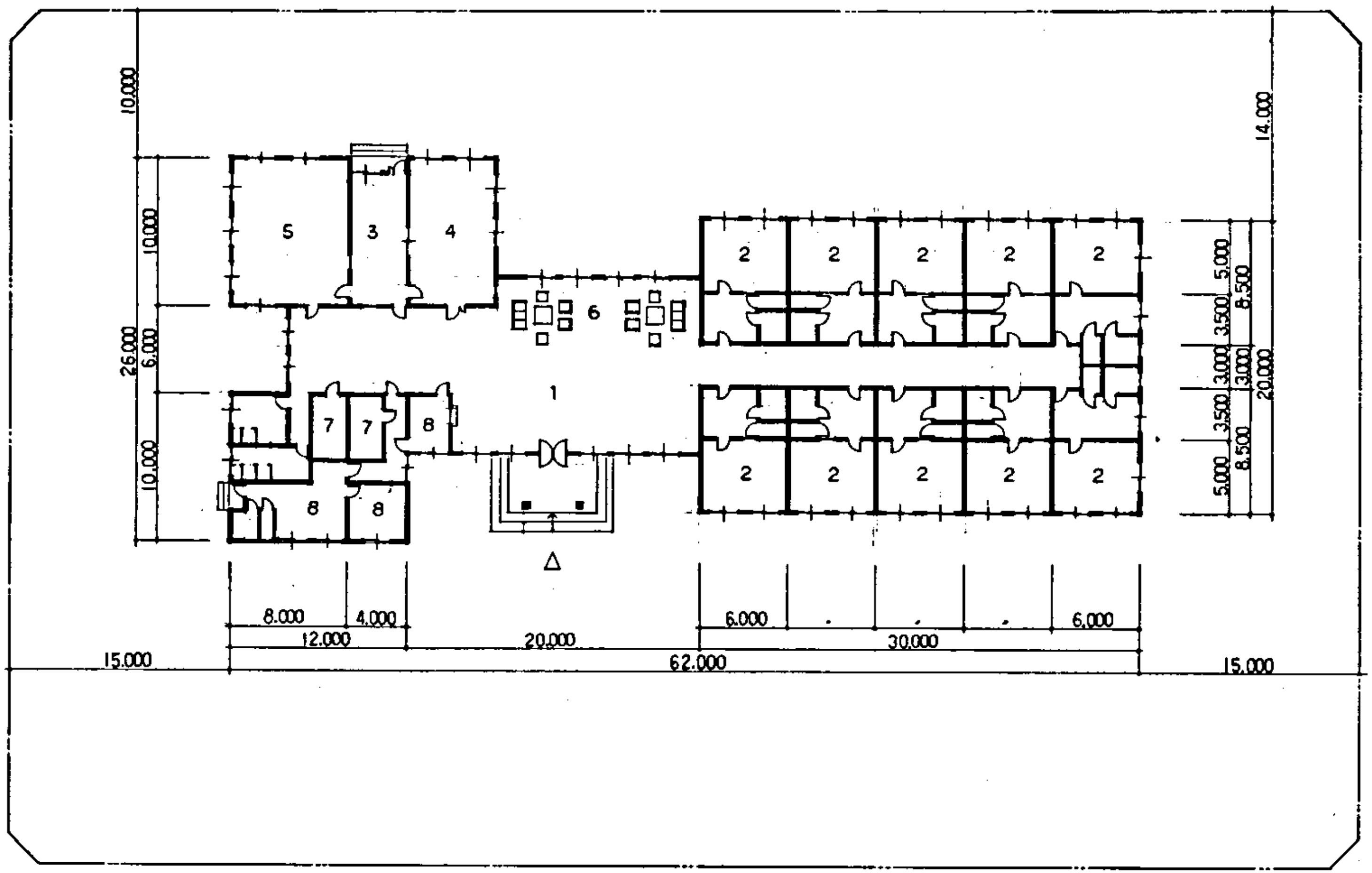


1 Entrance hall
2 Dining room
3 Cuisine
4 Recreation room
5 W.C
6 Storeroom
7 Janitor room
8 Lobby
9 Bed room

Fig. 9·13

571 m²

Guest house (C.K)	
DRAWN BY K. Sekine	DATE 5/Mar/91
CHECKED BY	DATE / /
SCALE 1/200	

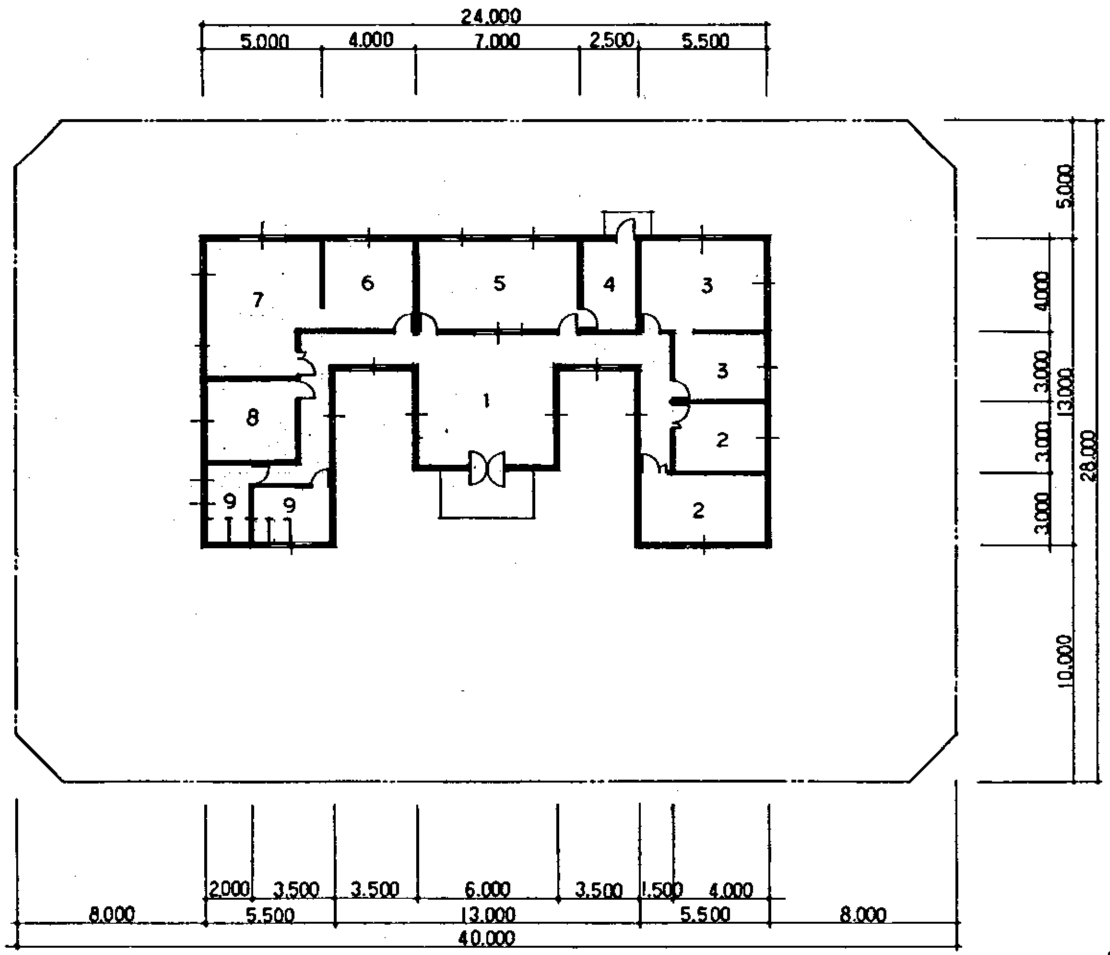


1 Entrance hall
2 Bed room
3 Cuisine
4 Dining room
5 Recreation room
6 Lobby
7 Storeroom
8 Janitor room

Fig. 9-14

1,356 m²

Guest house (C.M.&M.P)	
DRAWN BY K. Sakaine	DATE 3/Aug '91
CHECKED BY	DATE / /
SCALE 1/300	



1 Waiting room
2 Sick room
3 Maternity room
4 Storeroom
5 Office & Medicine
6 Consulting room
7 Treatment room
8 Doctor room
9 W.C.

Fig.9-15

Clinic (C.M)	
DRAWN BY K. Sekine	DATE 4/Mar/'81
CHECKED BY	DATE / /
SCALE 1/200	

10 COMPREHENSIVE DEVELOPMENT AND CONSTRUCTION PLAN

10. COMPREHENSIVE DEVELOPMENT AND CONSTRUCTION PLAN

10–1. HOW TO BASICALLY FORWARD THE PROJECT

This plan has been comprehensively formed based on the respective plans of mine development, concentrator, metallurgical plant and infrastructure respectively disigned conceptually based on the basic conception of the project. Unlike general construction, the mine development covers two areas, and furthermore the metallurgical plant is to be established in another state. The type of management for promoting this project, fund raising method, operation, etc. are complicated problems to be considered, but for evaluation in this study, unified comprehensive operation was assumed. How to proceed with the construction should be determined, needless to say, considering various conditions such as the characteristics of this project, situations in the United Mexican States, actual industrial might, and national policies toward import. However, the form in this study was considered as full-turn key-contract, to guarantee the business of the plant excluding the mine development and to clarify the responsibility.

10–2. EXECUTION SCHEDULE OF THE PROJECT

The approximate execution schedule of the comprehensive development and construction works is shown in Fig. 10–1. The one year after commencing this project is taken as the period for preparation and design, and two years are taken as the period of construction. For the initial working year after ore production, 50 % production is estimated, including test run and test operation, and from the 2nd year, 100 % production is planned. This schedule is made on the assumption that the project will be executed smoothly. The tailing disposal is planned to be constructed in two terms (the 2nd term starts 5 years after the commencement of operation).

10–3. COMPREHENSIVE DEVELOPMENT AND CONSTRUCTION COST

The comprehensive development and construction cost is broken down in Table 10–1, and the total cost is 4,961,642,000 pesos. The total amount of funds required including the initial expenses, operating funds and the interest during construction is 5,519,797,000 pesos. The 2nd term construction cost of the tailing disposal is excluded from the funds.

Table 10.1 Total construction cost

1) Copper King mine

(unit : x 10^3 pesos)

Item	Specification	Construction cost		Total
		Mechanical & Electric	Civil & Building	
Underground development		1,656	34,776	36,432
Mining equipment	leg drill, Jumbo 12 ton Truck, etc.	74,520		74,520
Surface facilities		6,013	887	6,900
• Primary crushing	Brake crusher	(3,253)	(394)	(3,647)
• Compressor, Ventilation	55 KW 3 7.5 KW 4	(2,760)	(493)	(3,253)
Ancillary services		24,051	15,114	39,165
• Power Station	600 KW	(15,279)	(690)	(15,969)
• Powder magazine		(49)	(246)	(295)
• Neutralization plant	30 m^3/H	(3,301)	(838)	(4,139)
• Settling pond	200,000 m^3		(7,776)	(7,776)
• Maintenance shop	288 m^2	(2,957)	(1,971)	(4,928)
• Office building	240 m^2	(986)	(2,169)	(3,155)
• Warehouse, Water supply, etc.		(1,479)	(1,424)	(2,903)
Infrastructure			37,129	37,129
• Company house	Residence:25 Dormitory:1		(37,129)	(37,129)
Preparation			38,936	38,936
• Access road	about 2 Km		(19,517)	(19,517)
• Earth work	64,600 m^3		(19,419)	(19,419)
Total		106,240	126,842	233,082

2) Campo Morado mine

(unit : x10^3 pesos)

Item	Specification	Construction cost		Total
		Mechanical & Electric	Civil & Building	
Underground development		1,035	37,359	38,394
Mining equipment	Jumbo, Shovel car, 20 ton Truck etc.	111,780		111,780
Surface facilities		12,026	2,070	14,096
• Primary crushing	Brake crusher	(4,140)	(493)	(4,633)
• Compressor, Ventilation	75 KW 3 7.5 KW 8	(3,943)	(1,380)	(5,323)
• Substation, etc.	750 KVA, 3.6 Km	(3,943)	(197)	(4,140)
Concentrator		474,030	184,230	658,260
• Grinding	Crusher, Mill	(113,850)		
• Flotation	Agitator #60, #48	(107,640)		
• Thickening Filtration	Thickener, Filter	(31,050)		
• Reagent supply system	Dissolver, Pump	(22,956)		
• Instrumentation	RH Recorder	(20,700)		
• Power supply system	5,100 KW	(73,304)		
• Analysis	Analysis room	(104,530)		
Tailing disposal	2,400,000 m^3		208,676	208,676
Ancillary services (Mining plant)		113,751	38,285	152,036
• Powder magazine		(49)	(246)	(295)
• Neutralization plant	30 m^3/H	(3,302)	(838)	(4,140)

(unti : 10^3 pesos)

• Office building	240 m^2	(493)	(3,253)	(3,746)
• Maintenance room		(2,957)	(4,436)	(7,393)
(Concentrator)				
• Water supply system	Pump, Piping	(11,828)	(986)	(12,814)
• Accessory	Piping	(7,886)	(1,971)	(9,857)
(Common facility)				
• Generator	3,500 KW	(78,857)	(8,379)	(87,236)
• Maintenance shop	included car repair	(4,929)	(6,949)	(11,878)
• Office building, Warehouse	544 m^2	(1,971)	(10,734)	(12,705)
• Accessory	Truck scale	(1,479)	(493)	(1,972)
Infrastructure				
Company house	Residence 301 Dormitory 2		282,133	282,133
Preparation			146,477	146,477
• Access road	about 13 Km		(96,699)	(96,699)
• Earth work			(49,778)	(49,778)
Total		712,622	899,230	1,611,852

3) Metallurgical plant

(unit : x 10^3 pesos)

Item	Specification	Construction cost		Total
		Mechanical & Electric	Civil & Building	
Roasting and acid plant		1,479,735	222,966	1,702,701
• Ore stock, Feeding	Stock yard 52,000T Crushing, Repulper	(79,054)	(53,721)	(132,775)
• Roasting	12.8 mϕ x 4 units	(603,177)	(43,671)	(646,848)
• Acid plant	1,000 T/D 2 trains	(533,431)	(48,688)	(582,119)
• Generator	11,000 KW	(69,788)	(11,040)	(80,828)
• Acid tank, etc.	10,000 T x 6	(62,889)	(35,683)	(98,572)
• Auxilliary		(131,396)	(30,163)	(161,559)
Pelletizing and metal recovery		825,240	165,797	991,037
• Blending, Kneading	45 T/H	(113,554)	(15,081)	(128,635)
• Balling, Drying	45 T/H	((89,799)	(18,926)	(108,725)
• Chloridizing volatilization	Rotary kiln 1 unit	(136,127)	(23,164)	(159,291)
• Gas treatment	54,000 Nm^3/H	(167,670)	(27,896)	(195,566)
• Metal recovery	20 m^3/H	(174,767)	(58,749)	(233,516)
• $CaCl_2$ concentrator	Submearged type	(99,064)	(13,504)	(112,568)
• Auxilliary		(44,259)	(8,477)	(52,736)
Ancillary services		8,379	17,250	25,629
• Analysis room	300 m^2	(4,929)	(2,070)	(6,999)
• Office building	900 m^2, 300 m^2	(1,971)	(10,449)	(12,420)
• Maintenance shop	400 m^2	(1,479)	(2,760)	(4,239)
• Warehouse	400 m^2		(1,971)	(1,971)
Infrastructure			52,341	52,341
• Company house	Residence 42 Dormitory 1 Guest house 1		(52,341)	(52,341)
Total		2,313,354	458,354	2,771,708

4) Engineering fee

(unit : x 10^3 pesos)

Item	Specification	Cost
Engineering fee	included License fee Know-how fee	147,857

5) Contingencies

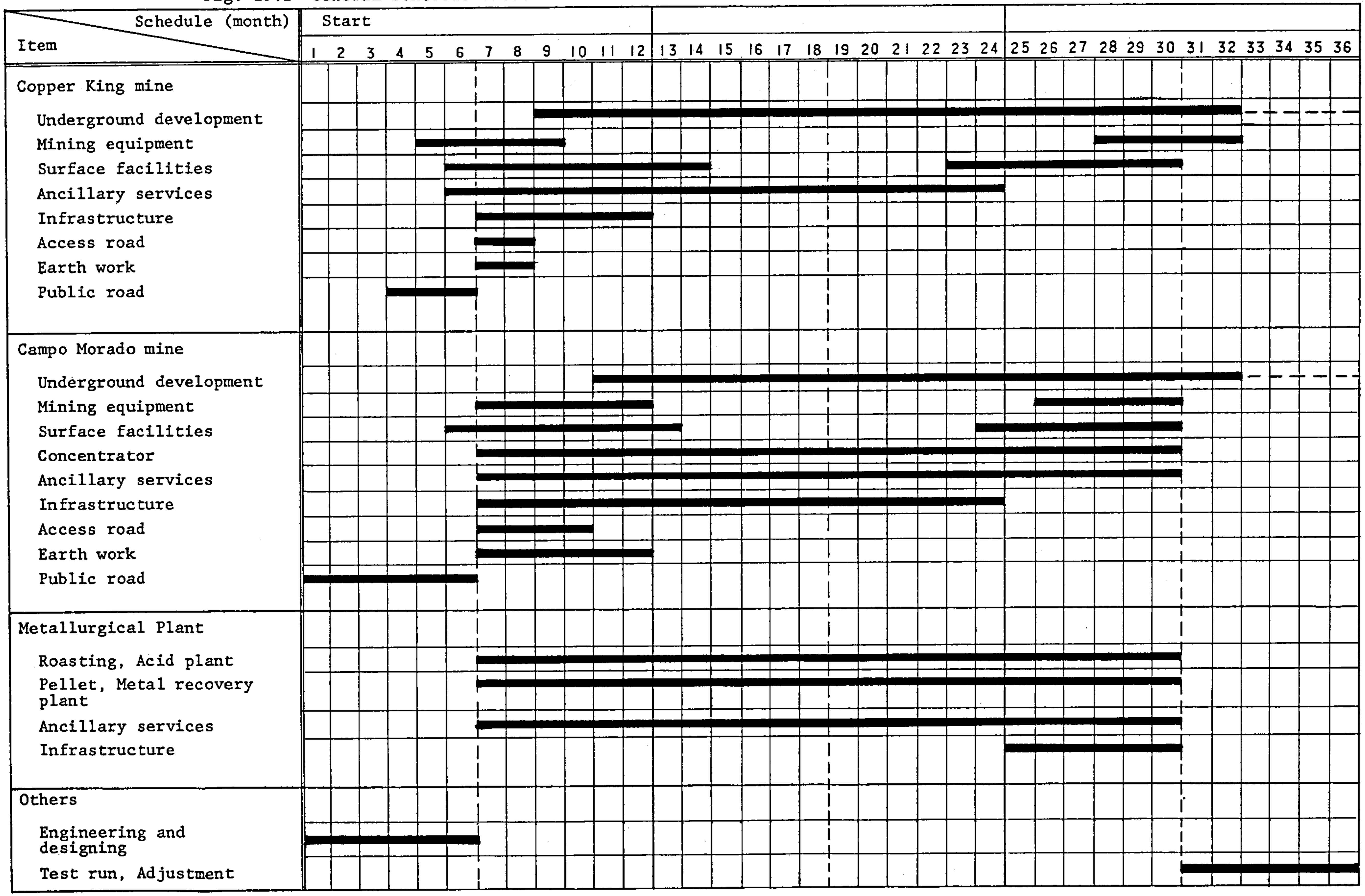
(unit : x 10^3 pesos)

Item	Specification	Cost
Contingencies		197,143

6) Total sum

1)	Copper King mine	233,082,000 pesos
2)	Campo Morado mine	1,611,852,000 pesos
3)	Metallugical plant	2,771,708,000 pesos
4)	Engineering fee	147,857,000 pesos
5)	Contingencies	197,143,000 pesos
	Total sum	4,961,642,000 pesos

Fig. 10.1 General schedule sheet of construction



11. PRELIMINARY ECONOMIC FEASIBILITY OF THE PROJECT

11. PRELIMINARY ECONOMIC FEASIBILITY OF THE PROJECT

11–1. EVALUATION OF ECONOMIC EFFICIENCY

This project consists of the respective basic plans of mine development, concentrator, and metallurgical plant construction based on the basic conception, but it has been decided to comprehensively analyze and consider the evaluation of economic efficiency. This project aims at the utilization of unused domestic resources and local development. Therefore, the effect of investment only should not be pursued, and it must be looked at also in light of national policies.

11–1–1. PRECONDITIONS FOR THE STUDY

1) Scope of the study
   - Development of Campo Morado Mine, construction of concentrator, and their operation
   - Development and operation of Copper King Mine
   - Construction and operation of a metallurgical plant in Lazaro Cardenas
   - Welfare facilities and incidental facilities required in the respective areas
   - The following were excluded
     - Public roads and railways required to be newly constructed
     - Social facilities such as schools and churches
     - Quay facilities
2) Schedule and calculation basis
   - Schedule : Operation to be started 36 months after the start of the project.
   - Production operation : In the initial year, 50% production including test operation, and from the 2nd year, 100% production.
   - Calculation basis of invested amount, etc. : Based on the data obtained in the field study of October to November, 1980.
   - Evaluation of intermediate products of nonferrous metals : According to calculation method, in reference to the international market prices in February 1981.

3) Funds

- The total funds required for development are assumed to be raised by usual commercial loans. The financial conditions are as follows:

  Interest : 8 p.a.

  Period : 10 years (after start up)

  Method of repayment : Half-year installments, fixed amount repayment.

11–1–2. AMOUNT OF INVESTMENT

1) Total required funds

• Earth work and access roads (not to be considered for repayment)	185,413 (10^3 pesos)
• Mine development	74,826
• Civil and building (Tailing disposal for 1st term construction only. For 2nd term construction, additional investment to be made 5 years later.)	1,122,540
• Equipment, machinery and apparatus	3,129,525
• Contingencies	197,143
• Initial expenses (expenses required before operation such as personnel expenses, consultant expenses, etc.)	213,571
• Operating fund (not to be considered for repayment)	54,762
• Interest during construction (Interest for the funds required in the period of construction)	542,017
• Total	5,519,797

1) Interest during construction

Table 11.1 (Unit : 1,000 pesos)

LOAN	Amount (Year elapsed)	1	2	3	Operation	Total sum of Interest during construction
		Loan (1) 5%	(2) 24% (3) 22%	(4) 28% (5) 18%	(6) 3%	
LOAN (1)	204,810	8,192	17,040	17,748	[Loan(6) 138,660]	42,980
LOAN (2)	1,337,186		106,975	115,533		222,508
LOAN (3)	1,131,510		45,260	94,142		139,402
LOAN (4)	1,262,566			101,005		101,005
LOAN (5)	903,048			36,122		36,122
(LOAN Total)	(4,839,120)					
Interest cost total		8,192	169,275	364,550		542,017

2) Investment amount and Funds supply program

Table 11.2 (Unit : 1,000 pesos)

Item	Invested cost	Funds supply program (Year elapsed)				Remark
		1	2	3	Operation	
(1) Earch work Access road	185,413	185,413				
(2) Underground development	74,826	4,347	25,254	31,443	13,781	
(3) Divil & Building	1,122,540	566,079	504,120	52,341	0	
(4) Mechanical & Electric equip.	3,129,525	581,232	1,752,091	769,895	26,308	
(5) Contingencies	197,143	32,857	65,714	65,714	32,857	
(6) Initial expenses	213,571	158,810	21,905	21,905	10,952	
(7) Operation fund	54,762	0	0	0	54,762	
(8) Interest during construction	542,017	8,192	169,275	364,550	0	
Total sum	5,519,797	1,536,930	2,538,359	1,305,848	138,660	

11–1–3. MANUFACTURING EXPENSE AND REVENUES

1) Investment amount and Depreciation

Table 11.3 (unit : 1,000 pesos)

Item	Amount	Annual depreciation			
		(1)	(2)	(3)	(4)
(1) Earth work Access road	185,413				
(2) Underground development	74,826	3,741			
(3) Civil & Building	1,122,540	56,127			
(4) Mechanical & Electric Equip.	3,129,525		304,519		16,867
(5) Contingen-cies	197,143		19,714		
(6) Initial expenses	213,571			21,357	
(7) Operating fund	54,762				
(8) Interest during construction	542,017			54,202	
Total sum	5,519,797	59,868	324,233	75,559	16,867

o Depreciation method

Item	Life (year)	Rate *
1) Building. Structure	20	5%
2) Mechanical & Electric equip.	10	10%
3) Initial expenses & Interest during construction	10	10%
4) Mining equipment	5	20%
5) Earth work & Access road, Operating fund	–	–

* Depreciation rate %/Year

o Tailing disposal : Original investment 50%
Additional investment 50% after 5 years from startup

2) Restitution of borrowed money and interest cost

Table 11.4 (unit : 1,000 pesos)

Year elapsed	Amount of restitution	Interest cost	Remarks
1	275,990 x 2	430,544	
2	"	386,386	
3	"	342,228	
4	"	298,069	
5	"	253,911	
6	"	209,752	
7	"	165,594	
8	"	121,436	
9	"	77,277	
10	275,990 x 2	33,119	
Ave.		231.832	

3) Summary of Manufacturing expense (Table 11.5)

Item	Manufacturing expense (x 10^3 pesos/year)	Basic cost (pesos/T-crude ore)
Variable expenses		
(1)[1] Article cost		
Mining	64,388	103.79
Concentrator	53,859	86.81 (128.23) *
Metallurgical plant	113,574	183.07
Total	231,821	373.67
(2) Cost of Electric power		
Mining	2,017	3.25
Concentrator	7,728	12.45 (18.40) *
Metallurgical plant	35,668	57.49
Total	45,413	73.20
(3) Freight Outward	153,660	247.68
Total (1 + 2 + 3)	430,894	694.55
Fixed expenses		
(4) Maintenance cost		
Mining	18,518	29.85
Concentrator	33,613	54.18 (80.03) *
Metallurgical plant	80,812	130.26
Total	132,943	214.29
(5) Cost of labours		
Mining	20,916	33.71
Concentrator	9,390	15.14 (22.36) *
Metallurgical plant	27,641	44.55
Total	57,947	93.40
(6) Management expenses		
Mining	36,423	58.71
Concentrator	16,779	27.05 (39.95) *
Metallurgical plant	25,351	40.86
Total	78,553	126.62
(7) Sundry articles cost		
Mining	8,601	13.86
Concentrator	3,925	6.33 (9.35) *
Metallurgical plant	7,949	12.81
Total	20,475	33.00
(8) Depreciation & Interest expenses	708,359	1,141.77
Total (4 + 5 + 6 + 7 + 8)	998,277	1,609.08
Manufacturing expenses Total	1,429,171	2,303.63

Reference

1. Production capacity of crude ore
   - Copper King mine 200,400 T/Y
   - Compo Morado mine 420,000 T/Y
   - Total 620,400 T/Y
2. Plant capacity of concentrator
   - Crude ore 420,000 T/Y
   - Pyrite conc. 281,820 T/Y
3. Production capacity of acid
   - Sulfuric acid (98%) 685,200 T/Y
4. Production capacity of pellet
   - Burnt pellet 338,400 T/Y
5. By-product
   - (1) Cu conc. 5,460 T/Y
   - (2) Zn conc. 17,640 "
   - (3) Ag-Pb conc. 9,240 "
   - (4) Cement Cu 1,860 "
   - (5) Zinc hydroxide 4,812 "
   - (6) Pb cake 2,340 "
   - (7) Gypsum 18,012 "
6. Basic cost
   - Sulfuric acid 124.18 pesos/T-acid
   - Burnt pellet 475.81
7. Depreciation expenses
   - Total 476,527,000 pesos/Year
8. Annual interest *
   - Total 231,832,000 pesos/Year
   - * 8%, average annual
9. Net manufacturing expenses
   - (1 + 2 - + 7) 720,812,000 pesos/Year
   - * peso/T – Campo Morado ore

4) Revenues

Calculation base : Campo Morado ore 35,000 T/M
Copper King ore 16,700 T/M
Table 11.6

Product	Quantity (T/Y)	Quality Cu (%)	Pb (%)	Zn (%)	Au (g/t)	Ag (g/t)	Unit price (pesos/T)	Amount ($x10^3$ pesos/Y)	Remark
1. Concentrator									Calculation base of unit price (1) H_2SO_4, Burnt pellet Conc. : On rail base Others: C.I.F. base (2) International market price of metal : July, 1981
Cu conc.	5,460	24.46	–	–	7.43	782	16,044.50	87,603	
Zn conc.	17,640	–	–	53.95	–	181	6,150.22	108,490	
Ag-Pb conc.	9,240	2.05	27.36	10.00	12.27	1,147	14,387.70	132,942	
Total								329,035	
2. Acid plant									
H_2SO_4 (98%)	685,200	–	–	–	–	–	1,150	787,980	
Gypsum (SO_3 : 42%)	13,080			–	–	–	219	2,865	
Total								790,845	
3. Pellet plant									
Burnt pellet	338,400	–	–	–	–	–	1,200	406,080	
4. Metal recovery plant									
Gypsum (SO_3 : 45%)	4,932			–	–	–	219	1,080	
Lead sulfate	1,560	–	55.00	–	127.0	9,926	136,428	212,828	
Cement Cu	1,860	80	–	–	34.2	3,947	79,204	147,320	
Lead sulfide	780	10.1	30.0	–	1.0	100	7,059	5,506	
Zinc cake	4,812	–	–	60	–	–	3,988	19,190	
Total								385,924	
Total sum								1,911,884	

11–1–4. TRIAL CALCULATION OF ECONOMIC EFFICIENCY

As an index of profitability, the IRR (Internal Rate of Return) was calculated for an operation period of 20 years.

1) ROI (Return on Investment)

This is to know the profitability of a project, and does not reflect loan conditions. Therefore, all the required funds are assumed to be on hand.

$$\Sigma_i^n \frac{Ii}{(1+r)^i} = \Sigma_i^n \frac{Ci}{(1+r)^i}$$

where Ii : Required funds

Ci : Cash flow (profit + depreciation) . . of each business year

r : ROI rate (DCF rate)

i : i-th year

n : 20 years

The ROI rate obtained from above is r = 17.9%

2) ROE (Return on Equity)

This reflects loan conditions and is obtained to know actual fund position. However, since all the amount is assumed to be covered by borrowing in this project, the rate is not sought. It has been decided to see the flow of funds by cash flow (see Tables 11.7 and 11.8).

ROI Income Statement/Cash flow

Table 11.7 (Unit : 1,000 pesos)

Year elapsed	(1) Gross income on sales	(2) Manufacturing expense	(3) Depreciation expense	(4) Profit	(A) Cash in flow (3) + (4)	(B) Cash out flow Invested capital	Cash flow (A) – (B)
-2						204,810	
-1						2,468,696	
0						2,165,614	
1	955,942	561,473	476,527	-82,058	394,469	138,660	255,809
2	1,911,884	720,812	"	714,545	1,191,072	0	1,191,072
3	"	"	"	"	"	0	"
4	"	"	"	"	"	0	"
5	"	"	"	"	"	188,671	1,002,401
6	"	"	481,744	709,328	1,191,072	0	1,191,072
7	"	"	"	"	"	0	"
8	"	"	"	"	"	0	"
9	"	"	"	"	"	0	"
10	"	"	"	"	"	3,129,525	-1,938,453
11	"	"	386,471	804,601	"	0	1,191,072
12	"	"	"	"	"	0	"
13	"	"	"	"	"	0	"
14	"	"	"	"	"	0	"
15	"	"	"	"	"	84,333	1,106,739
16	"	"	"	"	"	0	1,191,072
17	"	"	"	"	"	0	"
18	"	"	"	"	"	0	"
19	"	"	"	"	"	0	"
20	1,911,884	720,812	386,471	804,601	1,191,072	0	1,191,072

ROI rate: 17.9%

Remarks : (1) Original investment : 4,977,780,000 pesos

(2) Reinvestment
- Mining equipment : 84,333,000 pesos/every 5 years
- Construction cost of tailings disposal : After 5 years from start up
- Other equipment : After 10 years from start up

Income Statement / Cash flow

Table 11.8 (Unit : 1,000 pesos)

Year elapsed	(1) Gross income on sales	(2) Manufacturing expense	(3) Interest cost	(4) Depreciation expense	(5) Profit (1)-(2+3+4)	(A) Cash in flow (4) + (5)	(B) Cash out flow		(A) - (B) Cash flow
							Repayment	Invested capital	
-2								204,810	
-1								2,468,696	
0								2,165,614	
1	955,942	561,473	430,544	476,527	–512,602	–36,075	551,980	138,660	–726,715
2	1,911,884	720,812	386,386	"	328,159	804,686	"	0	252,706
3	"	"	342,228	"	372,317	848,844	"	0	296,864
4	"	"	298,069	"	416,476	893,003	"	0	341,023
5	"	"	268,627	"	445,918	922,445	"	188,671	181,794
6	"	"	222,959	481,744	486,369	968,113	570,847	0	397,266
7	"	"	177,292	"	532,036	1,013,780	"	0	442,933
8	"	"	131,624	"	577,704	1,059,448	"	0	488,601
9	"	"	85,956	"	623,372	1,105,116	"	0	534,269
10	"	"	284,391	"	424,937	906,681	"	3,129,525	–2,793,691
11	"	"	224,727	386,471	579,874	966,345	331,820	0	634,525
12	"	"	198,181	"	606,420	992,891	"	0	661,071
13	"	"	171,636	"	632,965	1,019,436	"	0	687,616
14	"	"	145,090	"	659,511	1,045,982	"	0	714,162
15	"	"	125,500	"	679,101	1,065,572	"	84,333	649,419
16	"	"	99,789	"	704,812	1,091,283	321,386	0	769,897
17	"	"	74,078	"	730,523	1,116,994	"	0	795,608
18	"	"	48,367	"	756,234	1,142,705	"	0	821,319
19	"	"	22,656	"	781,945	1,168,416	"	0	847,030
20	1,911,884	720,812	3,205	386,471	801,396	1,187,867	321,386	0	866,481

Remarks : (1) Original investment : 4,977,780,000 pesos

(2) Reinvestment
- Mining equipment : 84,333,000 pesos/every 5 years
- Construction cost of tailings disposal : After 5 years from start up
- Other equipment : After 10 years from start up

11–2. DISCUSSION

The ROI rate of this project is 17.9%, and the invested amount will be paid out in about 5 years. In view of general commercial application of funds, the index of the project cannot be said high, but sufficiently exceeds the interest of bank loan. According to the cash flow of ROE, the accumulated cash flow in the previous year of equipment renewal at the 10th year will be 2,208,746 (10^3 pesos), and most of the equipment renewal will be able to be covered by the funds on hand. If a low interest is applied favorably in raising the funds for this development project, from a comprehensive viewpoint, the constitution of the project will be intensified further needless to say. In case of developing only Campo Morado Mine considered as an alternative proposal, the return on investment will be smaller, showing there is an influence of scale merit. The difference due to scale merit is caused by the metallurgical plant. Considering the time when this project is started, if the escalations of construction cost only are 20% and 30%, the ROI rates are 14% and 12.5%, respectively. While the profitability of this project was discussed as above, evaluation should be made also in light of national economy and local economy since the project aims at the development and utilization of unused resources and local development. This is described below, and this project is surmised significant for the United Mexican States.

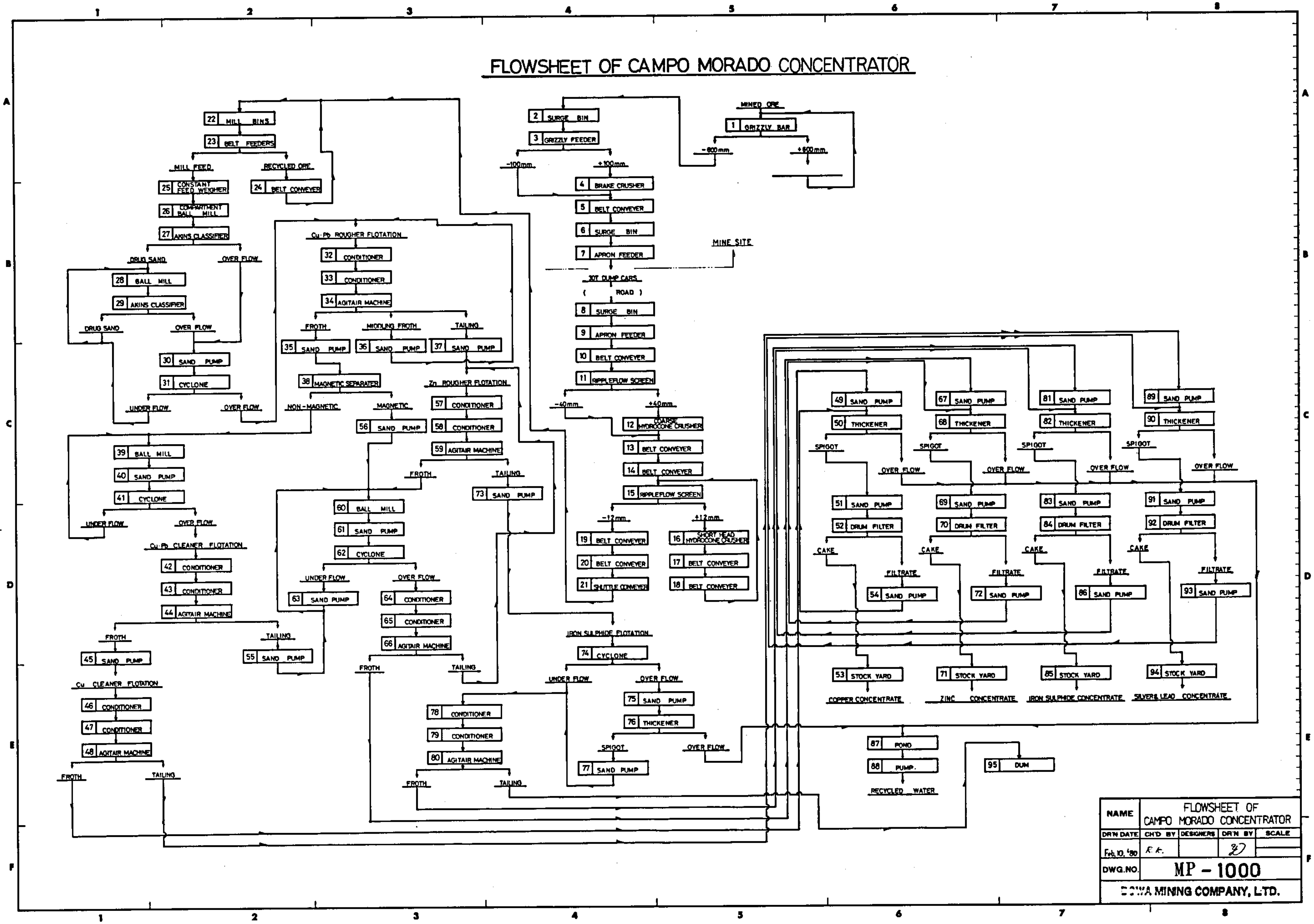
Local development and promotion of employment

The modernization by the development of 2 mines and the construction of a concentrator in the state of Guerrero will further promote local development, and the stable employment of total 582 persons in both the mines is assured. Including family members, a mine society of about 3,500 persons will be established. It will give a large and favorable influence directly and indirectly to the communities and related industries. Furthermore, the metallurgical plant to be constructed in Lazaro Cardenas of Michoacan State will provide employment for 380 persons, and stability of living including family members, which will greatly contribute to modernization as will be observed in the mines.

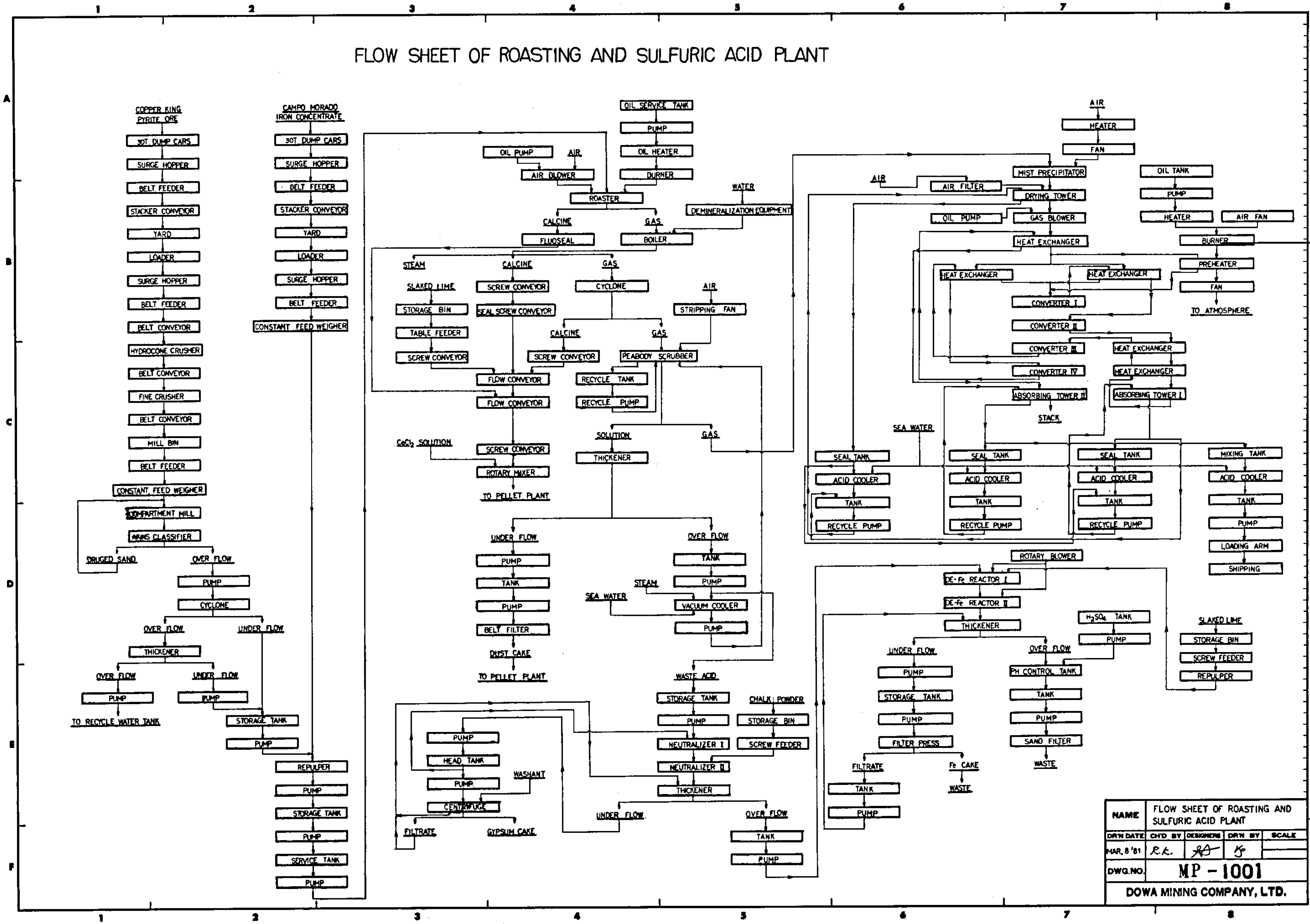
Utilization of unused domestic resources and influence on international payments

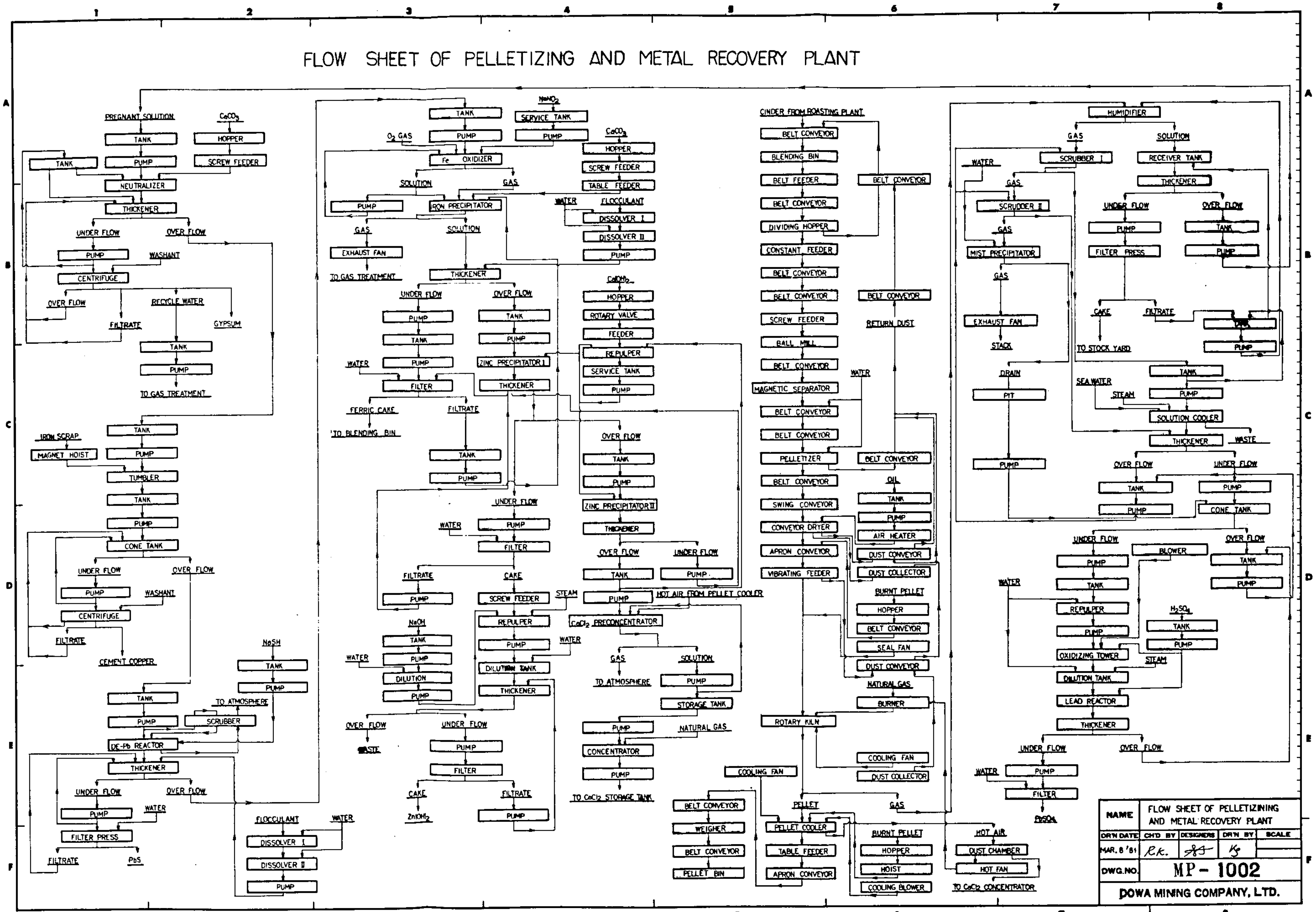
If the integral utilization of pyrite ores abundantly reserved in the state of Guerrero is realized by this project, 685,200 tons of sulfuric acid and 338,400 tons of pellets as a raw material for iron manufacture (iron content 62%) will be produced annually from pyrite concentrate as mineral processing product and from crude pyrite ore, and in addition, intermediate products of nonferrous metals will be produced as by-products (1,460 tons of copper, 1,060 tons of lead 2,583 tons of zinc, 240 kg of gold and 21 tons of silver recovered). The increase of demand for iron ores and fertilizer in the United Mexican States where modernization progresses fast will be partially covered by the utilization of unused domestic resources, and the significance is large. It also contributes to the improvement of international payments. The effects will be highly evaluated.

ATTACHED DRAWING

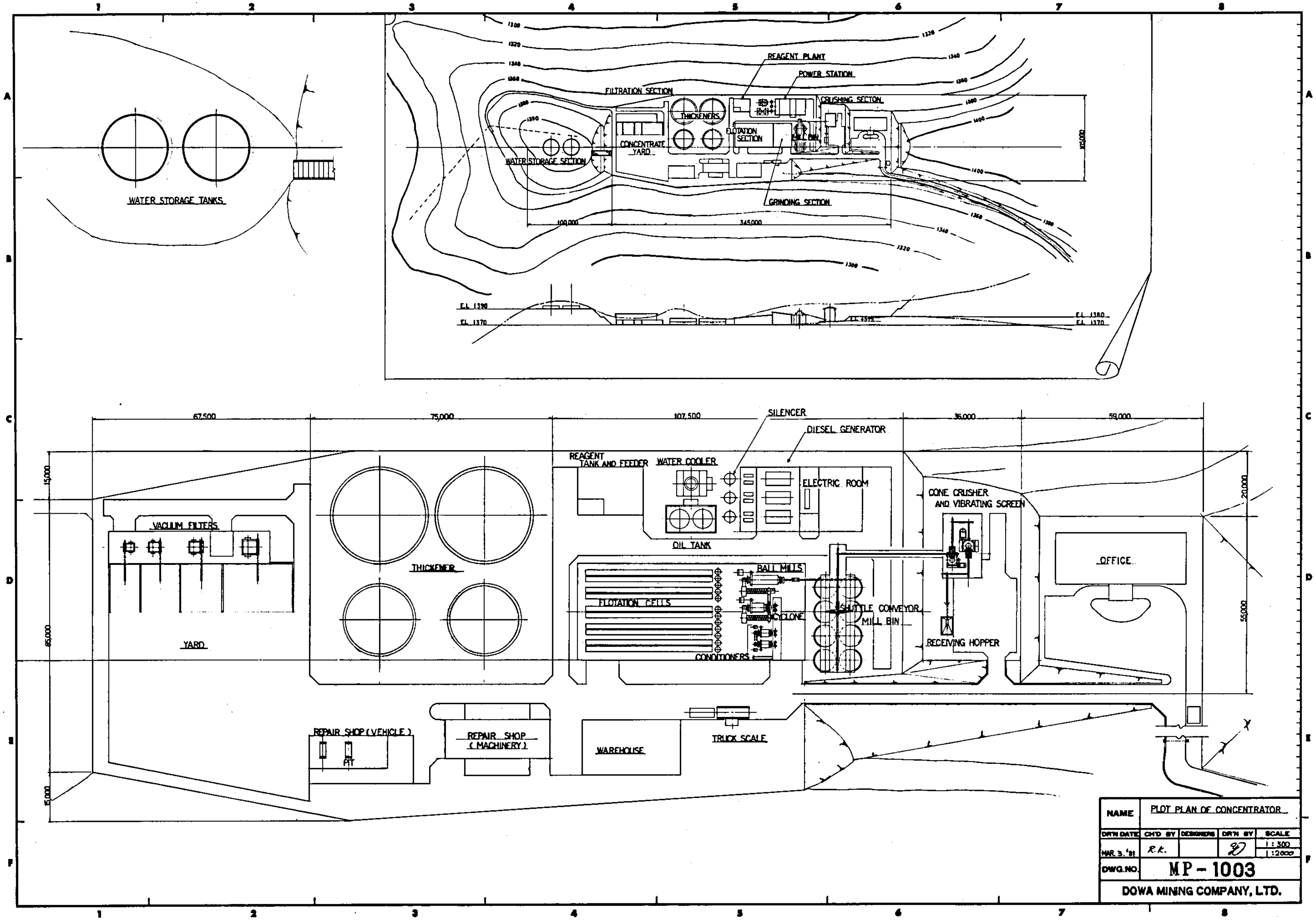

FLOWSHEET OF CAMPO MORADO CONCENTRATOR
MINED ORE
1 GRIZZLY BAR
-600mm
+600mm
2 SURGE BIN
3 GRIZZLY FEEDER
-100mm
+100mm
4 BRAKE CRUSHER
5 BELT CONVEYER
6 SURGE BIN
7 APRON FEEDER
MINE SITE
30T DUMP CARS
(ROAD)
8 SURGE BIN
9 APRON FEEDER
10 BELT CONVEYER
11 RIPPLEFLOW SCREEN
-40mm
+40mm
12 COARSE HYDROCONE CRUSHER
13 BELT CONVEYER
14 BELT CONVEYER
15 RIPPLEFLOW SCREEN
-12mm
+12mm
16 SHORT HEAD HYDROCONE CRUSHER
17 BELT CONVEYER
18 BELT CONVEYER
19 BELT CONVEYER
20 BELT CONVEYER
21 SHUTTLE CONVEYER
22 MILL BINS
23 BELT FEEDERS
MILL FEED
RECYCLED ORE
24 BELT CONVEYER
25 CONSTANT FEED WEIGHER
26 COMPARTMENT BALL MILL
27 AKINS CLASSIFIER
DRUG SAND
OVER FLOW
28 BALL MILL
29 AKINS CLASSIFIER
DRUG SAND
OVER FLOW
30 SAND PUMP
31 CYCLONE
UNDER FLOW
OVER FLOW
Cu-Pb ROUGHER FLOTATION
32 CONDITIONER
33 CONDITIONER
34 AGITAIR MACHINE
FROTH
MIDDLING FROTH
TAILING
35 SAND PUMP
36 SAND PUMP
37 SAND PUMP
38 MAGNETIC SEPARATER
NON-MAGNETIC
MAGNETIC
56 SAND PUMP
Zn ROUGHER FLOTATION
57 CONDITIONER
58 CONDITIONER
59 AGITAIR MACHINE
FROTH
TAILING
73 SAND PUMP
39 BALL MILL
40 SAND PUMP
41 CYCLONE
UNDER FLOW
OVER FLOW
Cu-Pb CLEANER FLOTATION
42 CONDITIONER
43 CONDITIONER
44 AGITAIR MACHINE
FROTH
TAILING
45 SAND PUMP
55 SAND PUMP
Cu CLEANER FLOTATION
46 CONDITIONER
47 CONDITIONER
48 AGITAIR MACHINE
FROTH
TAILING
60 BALL MILL
61 SAND PUMP
62 CYCLONE
UNDER FLOW
OVER FLOW
63 SAND PUMP
64 CONDITIONER
65 CONDITIONER
66 AGITAIR MACHINE
FROTH
TAILING
78 CONDITIONER
79 CONDITIONER
80 AGITAIR MACHINE
FROTH
TAILING
IRON SULPHIDE FLOTATION
74 CYCLONE
UNDER FLOW
OVER FLOW
75 SAND PUMP
76 THICKENER
SPIGOT
OVER FLOW
77 SAND PUMP
49 SAND PUMP
50 THICKENER
SPIGOT
OVER FLOW
51 SAND PUMP
52 DRUM FILTER
CAKE
FILTRATE
54 SAND PUMP
53 STOCK YARD
COPPER CONCENTRATE
67 SAND PUMP
68 THICKENER
SPIGOT
OVER FLOW
69 SAND PUMP
70 DRUM FILTER
CAKE
FILTRATE
72 SAND PUMP
71 STOCK YARD
ZINC CONCENTRATE
81 SAND PUMP
82 THICKENER
SPIGOT
OVER FLOW
83 SAND PUMP
84 DRUM FILTER
CAKE
FILTRATE
86 SAND PUMP
85 STOCK YARD
IRON SULPHIDE CONCENTRATE
89 SAND PUMP
90 THICKENER
SPIGOT
OVER FLOW
91 SAND PUMP
92 DRUM FILTER
CAKE
FILTRATE
93 SAND PUMP
94 STOCK YARD
SILVER & LEAD CONCENTRATE
87 POND
88 PUMP
RECYCLED WATER
95 DUM
NAME
FLOWSHEET OF CAMPO MORADO CONCENTRATOR
DR'N DATE
CH'D BY
DESIGNERS
DR'N BY
SCALE
Feb. 10, '80
DWG. NO.
MP - 1000
DOWA MINING COMPANY, LTD.

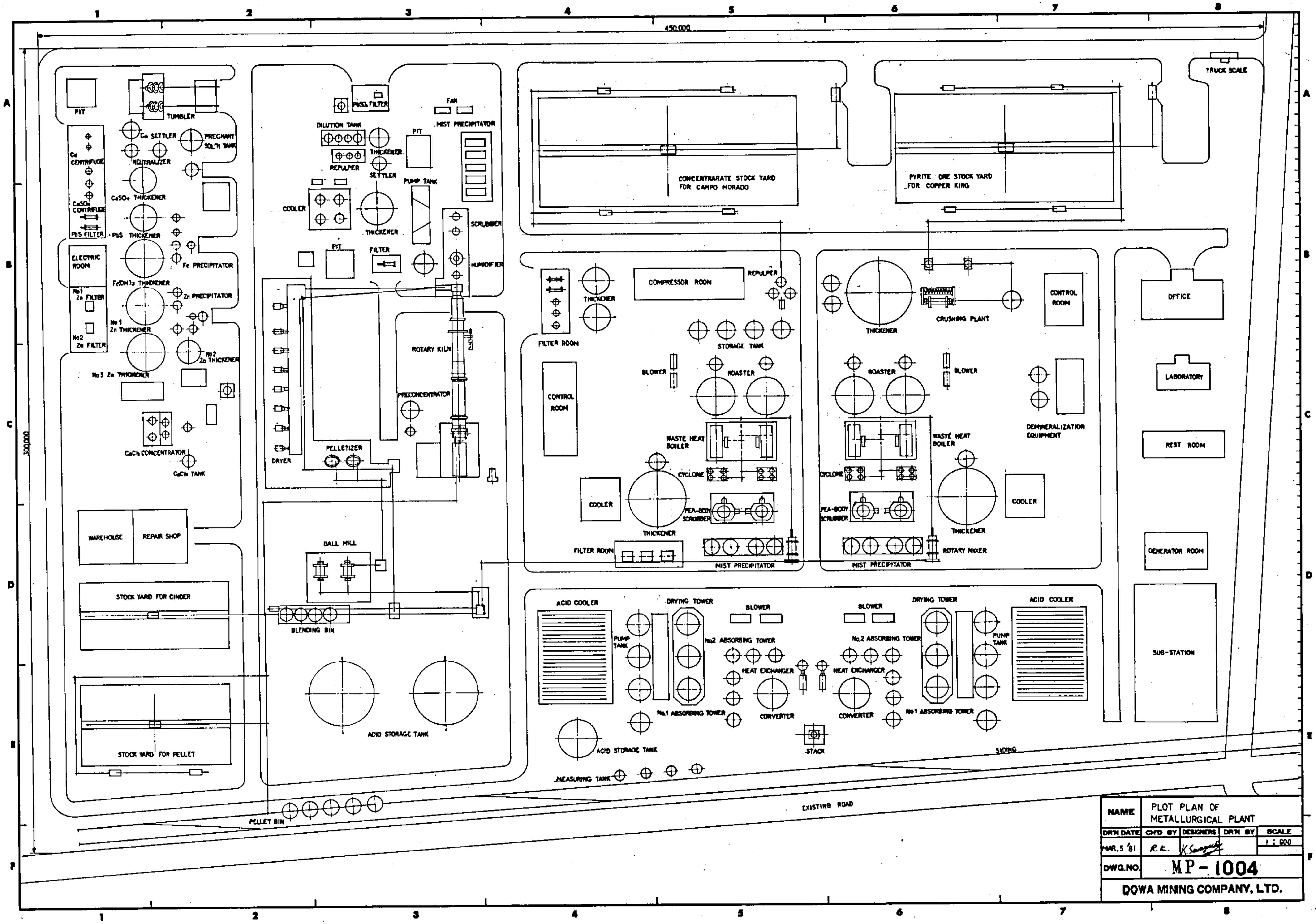
FLOW SHEET OF ROASTING AND SULFURIC ACID PLANT





FLOW SHEET OF PELLETIZING AND METAL RECOVERY PLANT
PREGNANT SOLUTION
$CaCO_3$
TANK
HOPPER
PUMP
SCREW FEEDER
NEUTRALIZER
THICKENER
UNDER FLOW
OVER FLOW
WASHANT
CENTRIFUGE
RECYCLE WATER
FILTRATE
GYPSUM
TO GAS TREATMENT
IRON SCRAP
MAGNET HOIST
TUMBLER
CONE TANK
CEMENT COPPER
NaSH
TO ATMOSPHERE
SCRUBBER
DE-Pb REACTOR
WATER
FILTER PRESS
PbS
FLOCCULANT
DISSOLVER I
DISSOLVER II
$NaNO_2$
SERVICE TANK
O_2 GAS
Fe OXIDIZER
SOLUTION
GAS
IRON PRECIPITATOR
TABLE FEEDER
EXHAUST FAN
TO GAS TREATMENT
$Ca(OH)_2$
ROTARY VALVE
FEEDER
REPULPER
FERRIC CAKE
TO BLENDING BIN
ZINC PRECIPITATOR I
ZINC PRECIPITATOR II
FILTER
CAKE
STEAM
HOT AIR FROM PELLET COOLER
$CaCl_2$ PRECONCENTRATOR
NaOH
DILUTION
DILUTION TANK
WASTE
$Zn(OH)_2$
STORAGE TANK
NATURAL GAS
CONCENTRATOR
TO $CaCl_2$ STORAGE TANK
CINDER FROM ROASTING PLANT
BELT CONVEYOR
BLENDING BIN
BELT FEEDER
DIVIDING HOPPER
CONSTANT FEEDER
BALL MILL
RETURN DUST
MAGNETIC SEPARATOR
PELLETIZER
OIL
SWING CONVEYOR
AIR HEATER
CONVEYOR DRYER
DUST CONVEYOR
APRON CONVEYOR
DUST COLLECTOR
VIBRATING FEEDER
BURNT PELLET
SEAL FAN
BURNER
ROTARY KILN
COOLING FAN
WEIGHER
PELLET
PELLET COOLER
PELLET BIN
HOIST
COOLING BLOWER
HOT AIR
DUST CHAMBER
HOT FAN
TO $CaCl_2$ CONCENTRATOR
HUMIDIFIER
SCRUBBER I
RECEIVER TANK
SCRUBBER II
MIST PRECIPITATOR
STACK
DRAIN
PIT
TO STOCK YARD
SEA WATER
SOLUTION COOLER
BLOWER
H_2SO_4
OXIDIZING TOWER
LEAD REACTOR
$PbSO_4$
NAME
FLOW SHEET OF PELLETIZING AND METAL RECOVERY PLANT
DR'N DATE
CH'D BY
DESIGNERS
DR'N BY
SCALE
MAR. 8 '81
DWG. NO.
MP-1002
DOWA MINING COMPANY, LTD.


WATER STORAGE TANKS
REAGENT PLANT
POWER STATION
FILTRATION SECTION
CRUSHING SECTION
THICKENERS
FLOTATION SECTION
CONCENTRATE YARD
WATER STORAGE SECTION
GRINDING SECTION
100,000
345,000
105,000
E.L. 1390
E.L. 1370
E.L. 1380
E.L. 1370
67,500
75,000
107,500
36,000
59,000
SILENCER
DIESEL GENERATOR
REAGENT TANK AND FEEDER
WATER COOLER
ELECTRIC ROOM
OIL TANK
CONE CRUSHER AND VIBRATING SCREEN
VACUUM FILTERS
THICKENER
BALL MILLS
FLOTATION CELLS
CYCLONE
CONDITIONERS
SHUTTLE CONVEYOR
MILL BIN
RECEIVING HOPPER
OFFICE
YARD
15,000
85,000
20,000
55,000
REPAIR SHOP (VEHICLE)
PIT
REPAIR SHOP (MACHINERY)
WAREHOUSE
TRUCK SCALE
NAME
PLOT PLAN OF CONCENTRATOR
DRN DATE
CHD BY
DESIGNERS
DRN BY
SCALE
MAR. 3. '81
R.K.
1 : 500
1 : 2000
DWG.NO.
MP-1003
DOWA MINING COMPANY, LTD.


450.000
300.000
TRUCK SCALE
PIT
TUMBLER
Cu SETTLER
PREGNANT SOL'N TANK
Cu CENTRIFUGE
NEUTRALIZER
CaSO4 THICKENER
CaSO4 CENTRIFUGE
PbS FILTER
PbS THICKENER
Fe PRECIPITATOR
ELECTRIC ROOM
No1 Zn FILTER
No2 Zn FILTER
Fe(OH)3 THICKENER
Zn PRECIPITATOR
No1 Zn THICKENER
No2 Zn THICKENER
No3 Zn THICKENER
CaCl2 CONCENTRATOR
CaCl2 TANK
WAREHOUSE
REPAIR SHOP
STOCK YARD FOR CINDER
STOCK YARD FOR PELLET
PELLET BIN
PbSO4 FILTER
DILUTION TANK
REPULPER
THICKENER
SETTLER
PIT
PUMP TANK
FAN
MIST PRECIPITATOR
COOLER
THICKENER
FILTER
SCRUBBER
HUMIDIFIER
ROTARY KILN
PRECONCENTRATOR
DRYER
PELLETIZER
BALL MILL
BLENDING BIN
ACID STORAGE TANK
CONCENTRARATE STOCK YARD FOR CAMPO MORADO
PYRITE ORE STOCK YARD FOR COPPER KING
FILTER ROOM
THICKENER
COMPRESSOR ROOM
REPULPER
STORAGE TANK
BLOWER
ROASTER
CONTROL ROOM
WASTE HEAT BOILER
CYCLONE
COOLER
PEA-BODY SCRUBBER
THICKENER
FILTER ROOM
MIST PRECIPITATOR
THICKENER
CRUSHING PLANT
CONTROL ROOM
ROASTER
BLOWER
DEMINERALIZATION EQUIPMENT
WASTE HEAT BOILER
CYCLONE
PEA-BODY SCRUBBER
THICKENER
COOLER
ROTARY MIXER
MIST PRECIPITATOR
OFFICE
LABORATORY
REST ROOM
GENERATOR ROOM
SUB-STATION
ACID COOLER
PUMP TANK
DRYING TOWER
BLOWER
No2 ABSORBING TOWER
HEAT EXCHANGER
No1 ABSORBING TOWER
CONVERTER
STACK
ACID STORAGE TANK
MEASURING TANK
SIDING
EXISTING ROAD
NAME
PLOT PLAN OF METALLURGICAL PLANT
DR'N DATE
CH'D BY
DESIGNERS
DR'N BY
SCALE
MAR. 5 '81
R.K.
K. Sawaguchi
1 : 600
DWG. NO.
MP-1004
DOWA MINING COMPANY, LTD.

APPENDIX

APPENDIX

1. SURVEY OF TWO MINES IN CURRENT OPERATION

The mission have surveyed the Taxco mine and the San-Martie mine both in operation and collected various data (such as mining capacity, the method of mining, equipment used, working system, wage system, material prices, infrastructure, etc.) which are instrumental in mapping out the development plan for the Copper King and Campo Morado mines.

1–1. OUTLINE OF TAXCO MINE

The Taxco mine is situated at the center of Taxo city, a city in the northern part of the Guerrero state and 160 km southwest of Mexico city. It is managed by Industrial Minera Mexico S.A. (IMSA).

This mine is one of the oldest mines in Mexico and was started in 1523 as the silver mine. The Mexican revolution caused it to be closed but it reopened afterward. In 1920 the mine introduced the flotation method. A large-scale exploration was performed in 1942 when Asarco obtained the concession. The management of the mine was transferred to Industrial Minera Mexico with its capital shared 34% by Asarco and 66% by the Mexican. The current mining operation and various facilities may be summarized as follows.

1) The major vein currently mined is the Veta Cobre (stretching 200 m with average width of 10 m). The daily production rate is 2,600 T/D (this is planned to be increased to 3,300 T/D after 1981) and the metal content in the crude ore is Ag 150 – 200 g/t, Pb 1.5 – 2.8% and Zn 2.5 – 3.9%. The maximum content of Ag is 250 g/t.

2) The mining method employed is a room-and-pillar stoping with filing. 6′ x 6′ pillars are left in 10 m x 10 m grid pattern. Broken ore at the stope is mucked and transported by LHD to the central combined shaft, (cage and skips) 583 m deep, from which it is taken out by the modern winch and the skips (6 m/sec). The winch and skip are of ASEA make. The shaft and the concentrator were built in 1973. This mine uses the latest technologies in slurry explosives, rock bolts and shotcrete as well as in concentrating. The technical level of engineers is high. This modernization capital costed Industrial Minera Mexico 200 million peso.

3) The number of employees is 1,200, of which 200 are staffs and 1,000 workers (500 inside and 500 outside the mine). Thus the productivity is 2,600 tons/500 workers ÷ 5.2 tons/ worker·day. This productivity can be increased to 3,300 tons/500 workers ÷ 6.6

tons/worker-day. A 3-shift system is employed (7:30–3:30; 3:00–10:30, 10:30–5:30). Staffs are provided with company houses and other workers are commuting from towns surrounding the mine and given governmental subsidies for their housing. Since this mine is located at the center of Taxco, it has an advantage of being easily accessible and sufficient labor force.

4) The product of the concentrator is 2,000 – 3,000 T/M (Ag 3,500 g/t, Pb 44%, Zn 6%) of lead concentrate and 3,000 –4,000 T/M (Ag 160 g/t, Zn 55%, Pb 0.5%) of zinc concentrate. The zinc concentrate is sent to Vuevo Rosita and Met Mex Penoles refineries of this company (Industrial Minera Mexico); the lead concentrate is sent to Chihvahua and Chontacuat refineries of this company; and the tailings are sent to Colasa and Presadejales. Truck and railroad are used for transportation. Zinc concentrate is also exported.

5) The secondary crusher of the concentration consists of a 5.5'ϕ cone crusher and a short head type cone crusher and the crushing process is closed-circuited by the use of 6'–14' Ty-Rod screen. The ore is crushed in two stages, first to 3/4" and then to 1/2". Grinding is performed by two tube ball mills 10 1/2' ϕ x14' with another one line of ball mill under construction. Two flotation circuits are provided, one for zinc concentrate and one for lead concentrate.

Three 8'ϕ drum filters are used to dewater the zinc concentrate (-200 mesh, 85%) to the water content of 9.5% and the lead concentrate (-200 mesh, 99%) to 12% water content. The crushing and concentrating machines are all of American make but most of the parts of these machines can be obtained in Mexico. The number of workers in this concentrator is 130 men/shift.

6) Although accurate data on the cost is not available, the water costs 6.5 pesos/m^3 and is used 17ℓ/sec. The demand is 6,000 kw.

7) This mine is located at convenient place which is also near Mexico City so that the equipment and material are easily obtained and there are many construction work companies in Taxco city.

1–2. OUTLINE OF SAN MARTIN MINE

The property is near the boundary between States of Zacatecas and Durango. It takes 1 hour and 20 minutes to get there from Durango city which is capital of the State of Durango, and about 7 hours from Mexico city which is about 620 km southeast of the mine.

San Martin mine was discovered by Spanish in 1548 and then 250,000 tons of oxidized

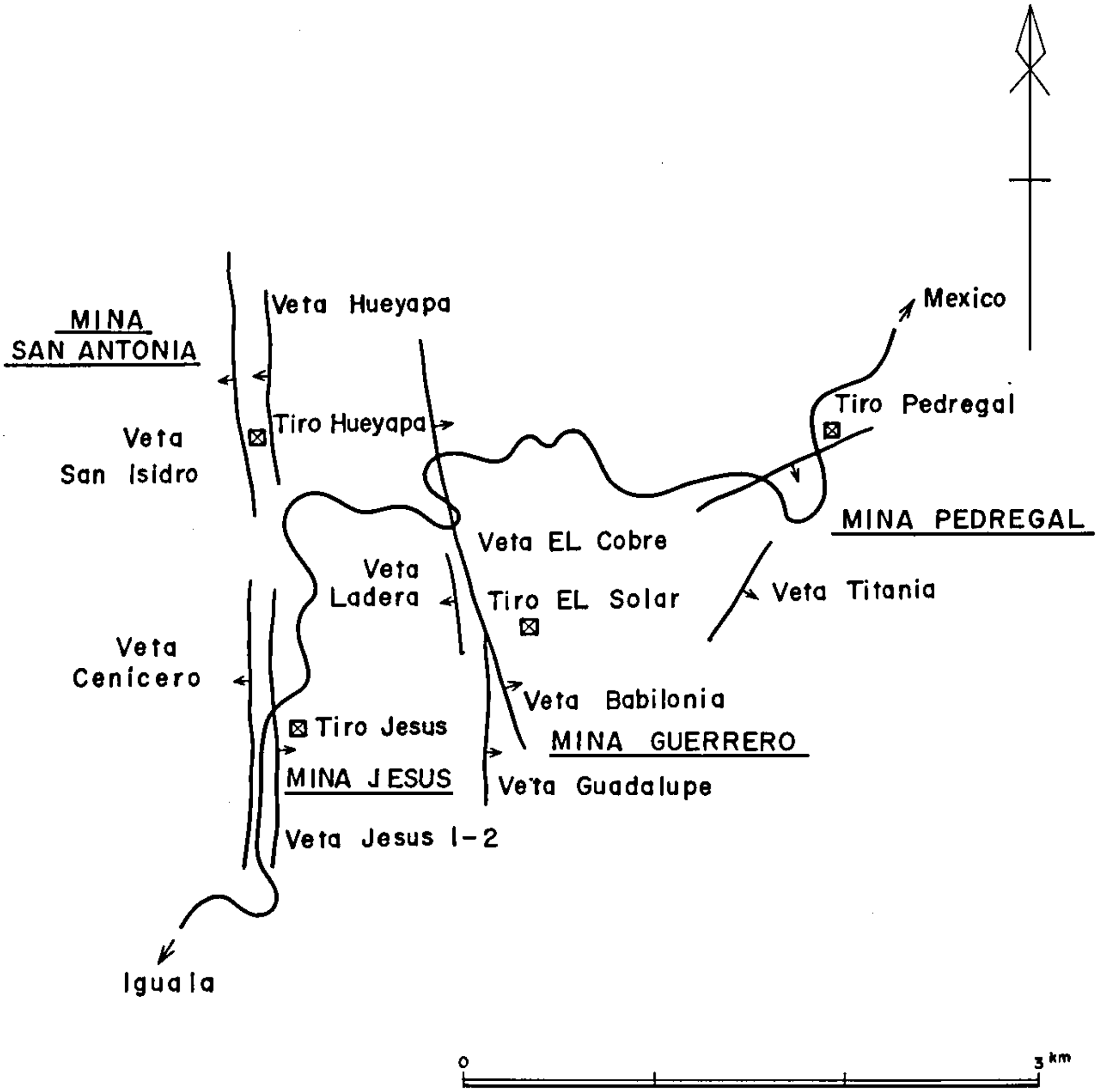


Fig A-I-I Map of ore deposits of Taxco mine silver ore (Ag 450 g/t) were mined till 1821. Since 1938, primary sulphide ore composed of sphalerite, chalcopyrite, covelline, galena,etc. has been mined.

The main ore deposits are of vein, manto and impregnation near the contact between limestone of Cretaceous age and granodiorite which intruded into limestone.

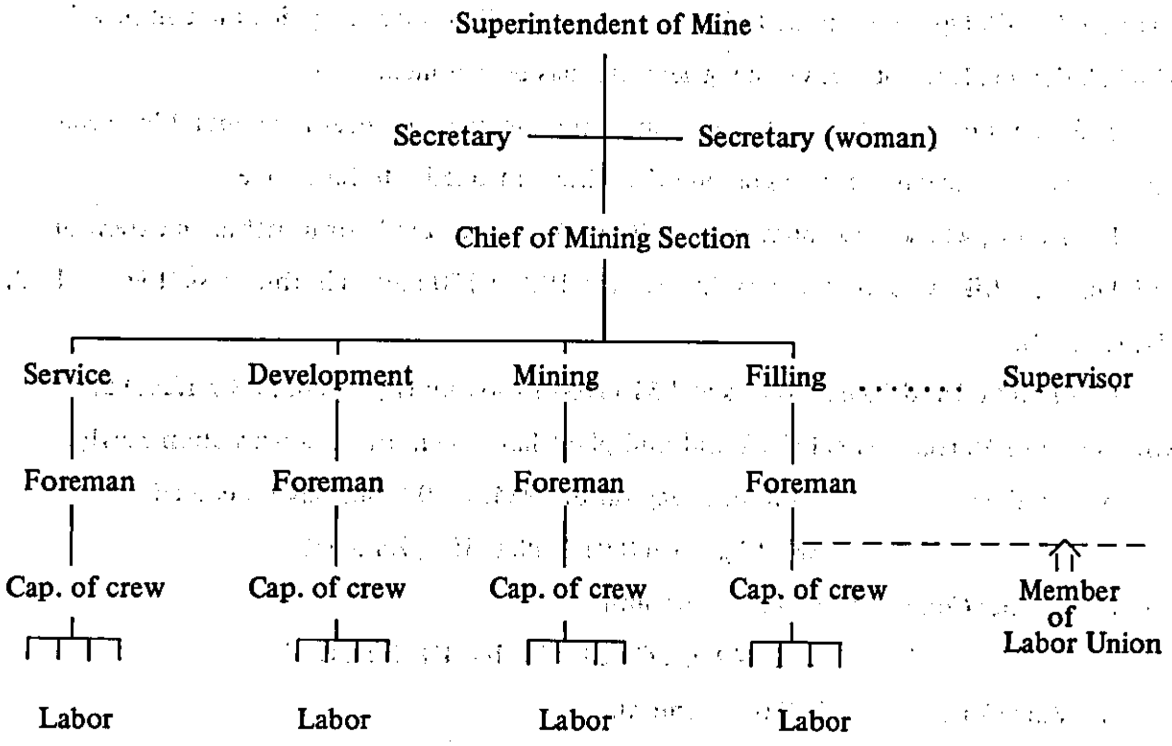
Four veins, whose maximum width is 30 to 40 meters, are known within an extent of 1,000 meters strikewise, 600 meters dipwise and 100 to 150 meters in thickness (Fig. A–1–2, Fig. A–1–3).

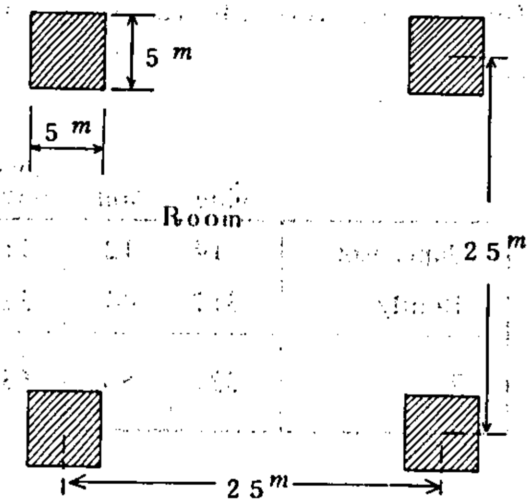
One hundred and 10 employees and 515 labors (307 underground, 208 surface) are working. San Martin vertical shaft and mill plant have been under construction newly.

- o Crude ore : 1,300 tons/day (after 1984, 6,800 tons/day scheduled)
  Ag 117 g/t, Cu 0.91%, Pb 0.35%, Zn 5.41%
- o Copper Conc. : 1,240 tons/month
  Ag 2,844 g/t, Cu 23.0%, Pb 8.1%, Zn 11.9%
- o Zinc Conc. : 2,950 tons/month
  Ag 113 g/t, Cu 1.1%, Pb 0.24%, Zn 55.5%

The number of workers for each section and the organization of the mining section are as follows:

	Mine	Mill	plant service	Admi. (geology, engineering, measuring)	Vigilance	Total
Supervisor	14	12	11	61	2	110
Hourly	317	44	52	65	47	515
Total	331	56	63	126	49	625





The mining method is a room-and pillar with filling, and as the filling material tailings outside the mine are transported into the stope by hydraulic system. Relatively slender square pillars (5 m x 5 m) are left in grid pattern of the square measuring 25 m. Therefore, the recovery rate is as high as 96%. This may be attributable to the fact that both the ore and rock are hard.

The drilling in the stopes, which is a horizontal drilling using leg drill, is performed on the previously blasted ore as the foothold. The length of bore hole is 3 m.

The blasted ore is mucked by the ST-5 scooptram of Wagner and loaded onto the 20-ton capa. underground truck, which transports it to the ore bin. The ore is then crushed by the primary crusher installed beneath the bin at the level L–8. The crushed ore is moved up the shaft by a 4.5-ton skip and then transported by the side dump mine cars hauled by the diesel engine locomotive to the concentrator.

The mining equipments used are as follows.

1) Shaft winding machine: 765 HP, 550V, 4.5-ton skip (blind shaft)
2) 20 scooptrams of Wagner : 5 yd^3
3) 12 20-ton underground trucks of Wagner
4) 60 leg drill : Ly 34
5) 4 stopers
6) 1 Robins raise boreer : type SL-71 (up to 7 feet in diameter can be bored)
7) Compressor and others

Electric power is supplied from Commission Fedelal de Electricidad (CFE). The total power consumption is 1,672,000 kW (51 kWH per ton of crude ore) and the power unit price is 0.9 – 0.95 pesos/kWH.

The mining operation is performed in three shifts a day, six days a week, and the working time is 7.5 hours per shift on average.

1st shift	2nd shift	3rd shift
7:00 – 15:00	15:30 – 23:00	23:00 – 6:00
(8 hours)	(7.5 hours)	(7 hours)

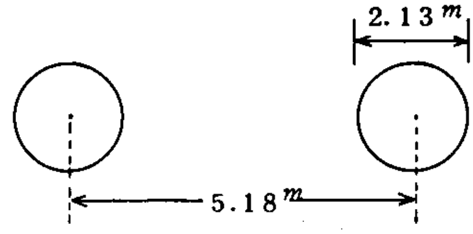
As can be seen in the organization diagram, a captain of crews (CAVO) is responsible for the work done in his stope and the foreman gives him daily direction.

The San Martin mine is a modern mine employing latest mining technologies such as a hydraulic filling and a trackless mining method using underground heavy equipments with diesel engine. This mine has become the first in the world to introduce a newly developed shaft sinking method.

The conventional shafts have a large circular (4–6 m in diameter) or rectangular (3 m x 9 m) cross section and are equipped with guide rails for skip and cage. Its interior is divided by bantons.

In the San Martin mine, taking advantage of the hard rock, two raises 2.13 m in diameter, arranged side by side, are being bored by the Robins raise borer. The guide rails are installed directly to the wall of the boreholes (shafts) for the travel of the skip through the holes.

This shaft sinking is being done to increase the production rate from the current 1,300 tons/day to 4,400 tons/day. The concentrator is also under construction.



Workers are reciprocated between nearby Sombrrerete city and the mine by the company bus for all three shifts. Absentee rate is high with the rate reaching as high as 10 days a month. To cope with this situation the company seeks to introduce modern machines and equipment as far as possible to reduce dependence on manpower.

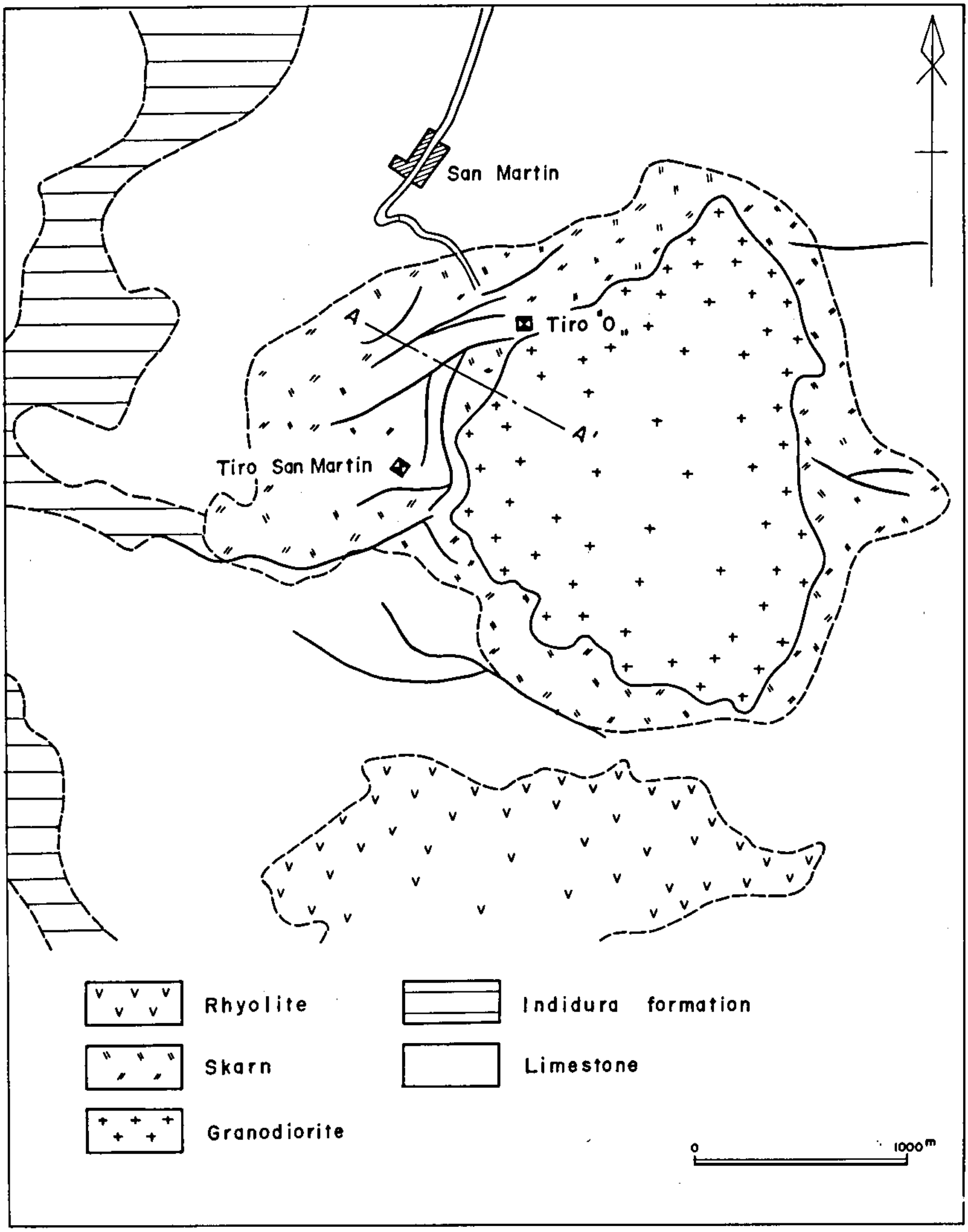


Fig A-1-2 Geological map of San Martin mine

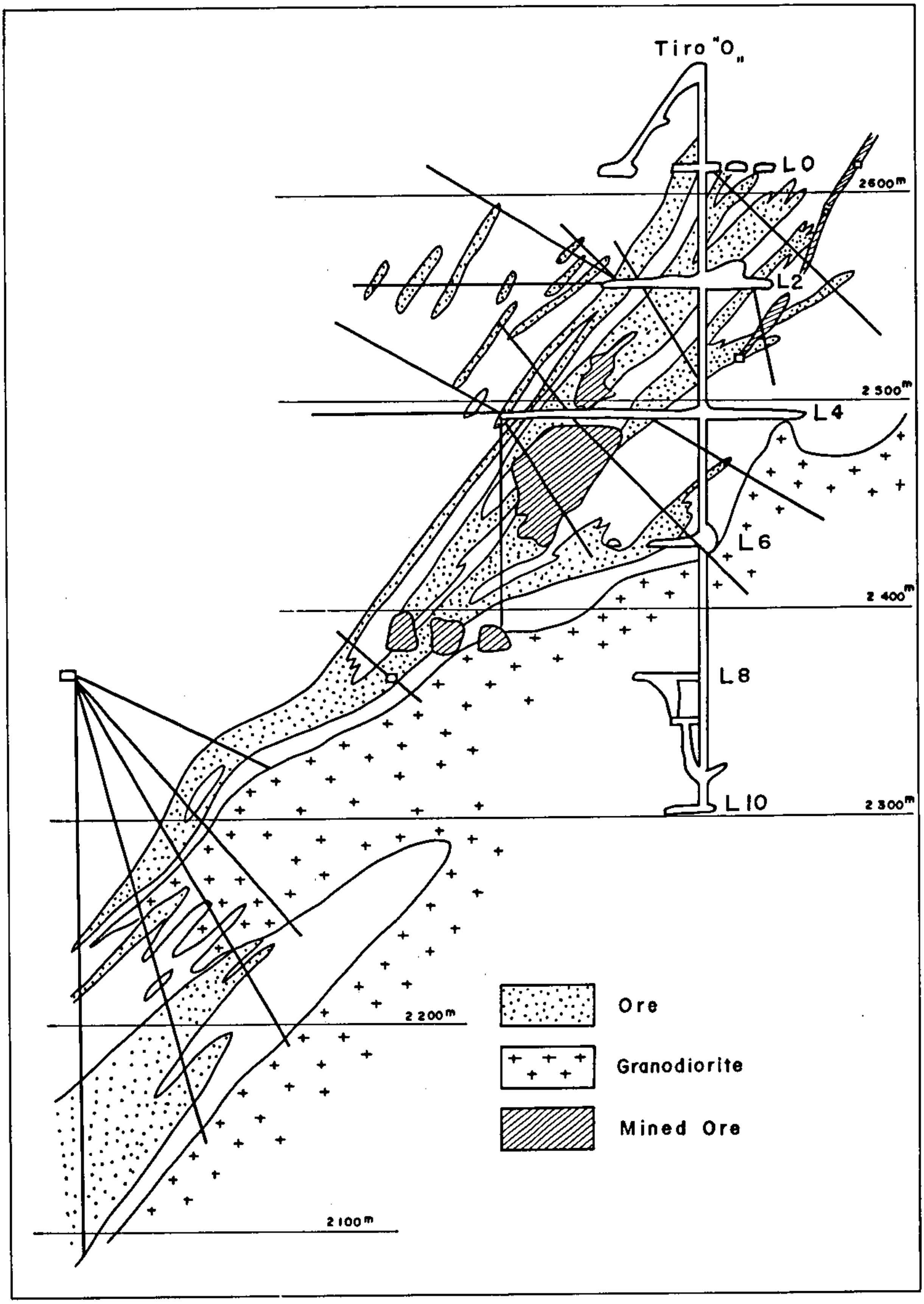


Fig A-1-3 Geological profile of San Martin deposits (A - A)

2. SURVEY OF THREE PLANTS IN CURRENT OPERATION

2–1. OUTLINE OF LAS TRUCHAS IRON AND STEEL WORKS

1) Company Name : SIDERURGICA LAZARO CARDENAS-LAS TRUCHAS S.A.

2) Founded on July 1, 1969

3) Starting Capital and its Breakdown :

50 million pesos (US$ 4 million)

Federal government	51 %
State owned industrial bank (NFFINSA)	25 %
Others	24 %

(Note) Current capital : 2 billion pesos

4) Background

In 1963, under the order of then President Lopes Mantos, a "Commission del Rio Balsas" (commission for promoting the overall development of regions along the River Balsas) was set up to map out the comprehensive development program for the regions along the River Balsas, flowing through Michoacan State on the Pacific coast, with the program to include the production of iron and steel, development of natural resources, and the construction of roads, railways and port facilities.

This comprehensive program was intended to minimize the regional differences in the standard of living between the industrialized region along the Gulf of Mexico and the region on the Pacific.

The commission assigned a West German company, Krupp, to the feasibility study for the construction of an integrated iron and steelworks, and the company produced a study favoring the construction. Various other preliminary studies were conducted before the commission finally decided to give the go-ahead on the project to construct the coastal integrated ironworks at the mouth of the River Balsas. In order to start the ironworks project separately from other projects of the overall development program, a new company, SIDERURGICA LAZARO CARDENAS-LAS TRUCHAS S.A., was established. As the first phase of the project, the construction of ironworks started in 1972 and was completed in 1976. This ironworks is capable of producing 1 million tons of crude steel annually.

5) Present status of steel making

The iron ore, a main raw material for steel making, is supplied to the ironworks from the Fertipec mine, about 27 km from the ironworks. The Ferrotepec and El mango y Volcan mines has been operating the open pit since 1977, and is said to have an estimated ore reserve of 104 million tons. At the mine site there is an ore dressing plant where the pulverized ore undergoes a magnetic separation process to be concentrated into 50% and 68% concentrates. These concentrates are mixed with liquid, by the Marona process, into 40% solid slurry which is then transported through the pipeline to the ironworks at the rate of 400 to 500 tons per hour. At the ironworks, the pelletizing plant using the Lurgi method sinters the solid slurry carried from the mining site to form pellets for further processing by the blast furnace.

With the operation continuing, a second phase of work is now under way to expand the ironworks. The annual production capacity is planned to be increased to 3,650,000 tons by 1982. Constituting the core of the national project to increase the iron and steel production, this ironworks will continue to be expanded in the future. According to the plan, the production will be increased to 6,500,000 tons per year by 1988 and 10 million tons per year by 1994. Although there are problems reported concerning the bursting of pellets as well as other troubles, the average yearly production of 700,000 to 800,000 tons is maintained.

a) Main facilities

Blast furnace	1,750 m^3	(IMPIANTI)
Converter	110 T x 2	(VOEST)
Coke-oven	60 sets	(Nihon Kokan)
Continuous casting equipments	6 ST x 3 sets	(SCHLOEMANN-CONCAST)
Slabbing and blooming mill	500,000 ton/year	(SCHLOEMANN)
Rod mill	500,000 ton/year	(DAVY-LOEWY)
Pelletizing plant		(LURGI)

b) Main products

Pig iron, billet, wire rod, reinforced bar, steel bar, square steel, flat bar, shaped steel (angle, tee, channel)

Kinds of steel :	Low carbon steel	25 %
:	Medium carbon steel	70 %
:	High carbon steel	5 %

c) Main facilities to be constructed in the 2nd phase of work

- o Pretreatment plant for iron ore
- o Lime stone calcination plant;

  Rotary kiln type, 350 tons/day
- o Pelletizing plant;

  2,500,000 tons/year
- o Pellet reducing plant;

  1,850,000 tons/year
- o Electric furnace;

  200 T x 4 (100 MVA)

  2 million T/Y (scrap 20 %, DR 80 %)
- o Continuous casting equipment for slabs;

  2 ST x 3

  (Slab size : 200 – 300 mm thick, 800 – 1600 mm wide)
- o Plate mill;

  1,500,000 T/Y (slab size 6 – 75 mm thick)
- o Preheating furnace;

  180 T/HR x 2
- o Roughing roll;

  4,500 kw x 2
- o Finishing roll;

  6,000 kw x 2
- o Boiler and power plant

6) Others

a) As for the port facility, the quay is 600 m in length with a water depth of 16 m and is accessible by ships up to 70,000 tons. It is equipped with 1 crane having a lifting capacity of 40 tons with a balance weight of 30 tons, and with another crane for loading coal and coke.

b) The plant area is about 16 km^2 and there are green tracts of land sparsely scattered around the area. No regulatory measures have been imposed by Government on this iron-works for the control of air, water or other environmental pollutants.

c) The population of Lazaro Cardenas city is estimated at 650,000 to 750,000, although it is officially said to be 230,000. The number of employees in the iron and steelworks is 7,200, of which the mining division has 600, the ore dressing division 20, and the iron and steel making division 6,580. The mining and ore dressing divisions employ a 2-shift operation system and the steelworks a four crew, three shift operation. (Working time is 10 hours, including two hours break.) The average salary of this company is higher than that in the Mexico City, and the lowest salary is 230 pesos. As for housing systems, the company provides apartment houses of 3 LDK (on the average) to the staff members and 2 DK to the site workers. They pay 18 % of their income as rent.

7) Summary of discussions, with the staff of Las Truchas Iron & Steel Work, on the pyrite ore treatment plant project in Guerrero.

a) If the pellets conform to the pellet quality standards of Nippon Steel Corporation, which is the user of the current Japanese pellets, they can be used in this iron and steel company.

b) The cost of processing pellets at this steel works is 100 pesos/t-steel. The pellet price is estimated at about 1200 pesos/ton in Mexico.

c) Currently, the coke-oven gas is not used, but it will be possbile to supply coke-oven gas after completion of the 2nd phase of the work. The supply of natural gas is now under study. There will be no fluctuation in the caloric content of gases.

d) Steam generated from the other plant is not required for the ironworks.

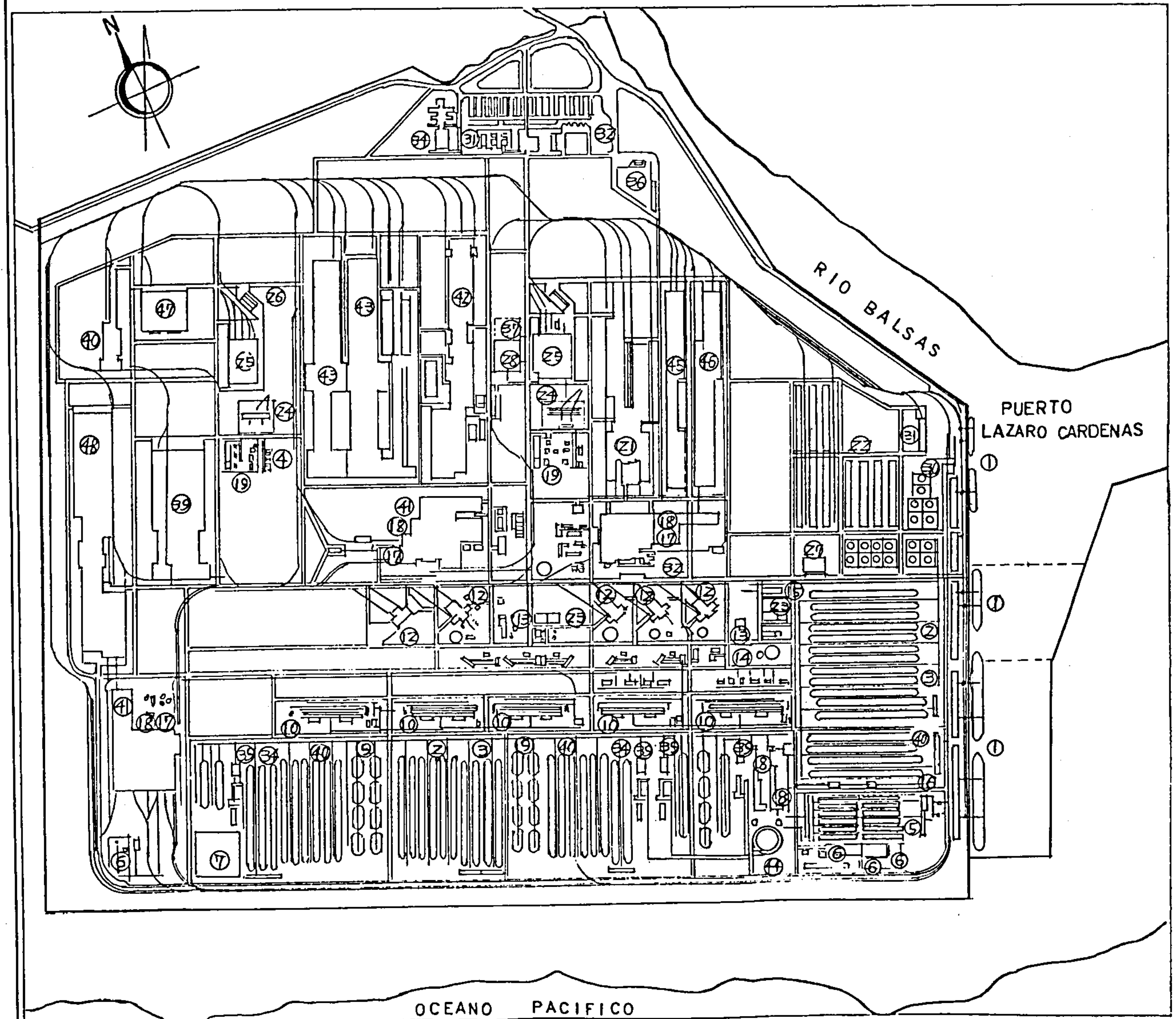
e) Since the iron resources in Mexico are scarce, the pellet production in Guerrero state will be welcomed. The decision whether to buy the pellets is on the hand of SIDERMEX.

f) The pellet size of this plant is 15 – 20 mm in diameter. The sulfur content in the sintered pellets is 0.025 % as compared with 0.25 % in the raw material.

The chemical composition of the pellets currently under production is as shown below.

o Chemical composition

		(as example in Japan)
Fe	63.38 %	(63.5)
Cu	Tr	(0.035)
Zn	0.04	(0.045)
Pb	Tr	(0.012)
Al_2O_3	0.47	
CaO	2.50	
MgO	0.80	
S	0.021	



DISPOSICION GENERAL DE LA PLANTA

1 MUELLE "SICARTSA"
2 ALMACEN DE CARBON
3 HOMOGENEIZACION DE CARBON
4 PLANTA DE AIRE COMPRIMIDO
5 ALMACEN Y HOMOGENEIZACION MATERIALES MISCELANEOS
6 PLANTA DE CAL
7 AREA PARA PLANTA DE TRATAMIENTO DE ESCORIA
8 PLANTA PELETIZADORA
9 ALMACENAMIENTO DE EMERGENCIA DE COQUE Y PELETS
10 PLANTA COQUIZADORA
11 PLANTA DE SUBPRODUCTOS
12 ALTO HORNO
13 PLANTA DE FUERZA
14 GASOMETROS
15 TALLER DE REPARACION CARROS TERMO
16 ALMACEN DE CALIZA
17 PLANTA DE ACERACION
18 PLANTA DE COLADA CONTINUA
19 PLANTA DE OXIGENO
20 PATIO DE CHATARRA
21 LAMINADORES DE ALAMBRON Y PERFILES LIGEROS
22 ALMACENAMIENTO DE PRODUCTOS TERMINADOS
23 PLANTA DE TRATAMIENTO DE AGUAS
24 SUBESTACION PRINCIPAL
25 TALLER GENERAL DE MANTENIMIENTO
26 TALLER DE REPARACION DE EQUIPO MOVIL
27 ALMACEN DE REFRACTARIOS
28 ALMACEN GENERAL
29 ALMACEN DE COMBUSTIBLE
30 ALMACEN DE TRANSITO
31 OFICINAS GENERALES
32 BASCULAS
33 HOMOGENEIZACION DE MINERAL
34 CENTRO DE CAPACITACION
35 ALMACEN DE LUBRICANTES
36 GASOLINERIA Y TRAFICO
37 PLANTA SINTETIZADORA
38 ALMACEN DE MINERAL
39 TREFILACION Y LAMINACION EN FRIO DE TUBOS
40 LAMINACION DE TUBOS
41 ACONDICIONAMIENTO DE PLANCHONES
42 LAMINACION EN CALIENTE DE ROLLOS
43 LAMINACION EN FRIO
44 DECAPADO
45 LAMINACION DE PERFILES MEDIANOS
46 LAMINACION DE BARRAS
47 TREFILACION EN FRIO DE ALAMBRE
48 LAMINACION DE PERFILES PESADOS

Fig. A-2-1

o Physical property

Crushing strength : 418 kg/Pellet

2–2. OUTLINE OF THE LAZARO CARDENAS FERTILIZER WORKS

Following the ironworks, the Lazaro Cardenas fertilizer works, a direct affiliate of FERTIMEX, was the second in Rio Balsas to start construction. This fertilizer works, which began their first phase of construction work in 1978 on the site of 120 Ha adjacent to the ironworks, will be completed in October 1981.

Main products :

Granular ammonium nitrate	200,000	T/Y
Ammonium phosphate	275,000	T/Y
Complex-N-P-K	250,000	T/Y

Primary products :

Sulphuric acid	660,000	T/Y
Phosphoric acid	198,000	T/Y
Nitric acid	215,000	T/Y

The total construction costs are estimated at 5,843 million pesos. According to the original plan, the second phase of work was scheduled to be completed by Ocorber, 1982. However, since the first phase of work is behind schedule, the entire construction work will be completed around 1982 – 1983.

This large-scale plant uses as the main raw materials a large amount of rock phosphate mined at Baja, California and a natural sulphur produced at Jaltipan, on the Atlantic. The natural sulphur, as the raw material for sulfuric acid, is planned to be shipped by cargo ships of 60,000 tons from Veracruz, through the Panama Canal, to Lazaro Cardenas.

The sulfuric acid plant employs the Lurgi method and construction costs for the 2,000 T/D plant are estimated at 530 million pesos. With the second phase of work completed, the plant will be producing 1,320,000 tons of sulfuric acid annually.

In addition to this fertilizer plant, FERTIMEX is now constructing two sulfuric acid plants, one at Queretaro with a capacity of 660,000 tons/year, and one at Guanajuato with a capacity of 198,000 tons/year.

Furthermore, construction plans for two fertilizer works of the same scale as the Lazaro Cardenas fertilizer works are under study. The decision on locations and other particulars will reportedly be made soon. One official of FERTIMEX said that the current production of sulrufic acid is far from meeting the demand for fertilzer, and in this respect, the sulphuric acid project is welcomed as a good means to develop the natural resources in this country. Although an exact figure is not available, he added, sulfuric acid is also imported from the United States.

The ground conditions on which this fertilizer works is being built is similar to that of the industrial complex area along the River Balsas.

- o Rock bed : 25 m
- o Ground level : +3500 mm (from sea level)
- o Bearing capacity : 10 T/m^2

2–3. OUTLINE OF THE ZINCAMEX ZINC REFINERY

This zinc refinery is located in Saltillo city, 85 km northeast of Monterrey city. Monterrey city is in the middle of the industrialized central part of the Mexican United States. This refinery is a public enterprise with 95.62% capital participation from CFM, and has been operating since 1964.

1) Primary products and output

			Production capacity
o	Distillation zine	22,400 T/Y (98.5%)	30,000 T/Y
o	Rectification zinc	1,600 T/Y (99.996%)	
o	Lead	360 T/Y (99.8%)	300
o	Cadmium	144 T/Y (99.999%)	150
o	Sulfuric acid	50,000 T/Y (98%)	45,000

2) Present status of operation

The raw material used in this refinery is supplied 75% from eight mines around the country in the form of zinc concentrate and remaining 25% in the form of oxide. Two Waelz kilns are operating to provide pretreatment of miscellaneous raw materials. The concentrates are classified according to their quality and stored in the stock bins. After analysis is made of metal content, they are blended for further processing.

* Metal content of zinc concentrate :

Zn	50–55%
Fe	7–10%
S	23–30%
Pb	1– 2%

MACROLOCALIZACION DEL COMPLEJO INDUSTRIAL DE FERTILIZANTES

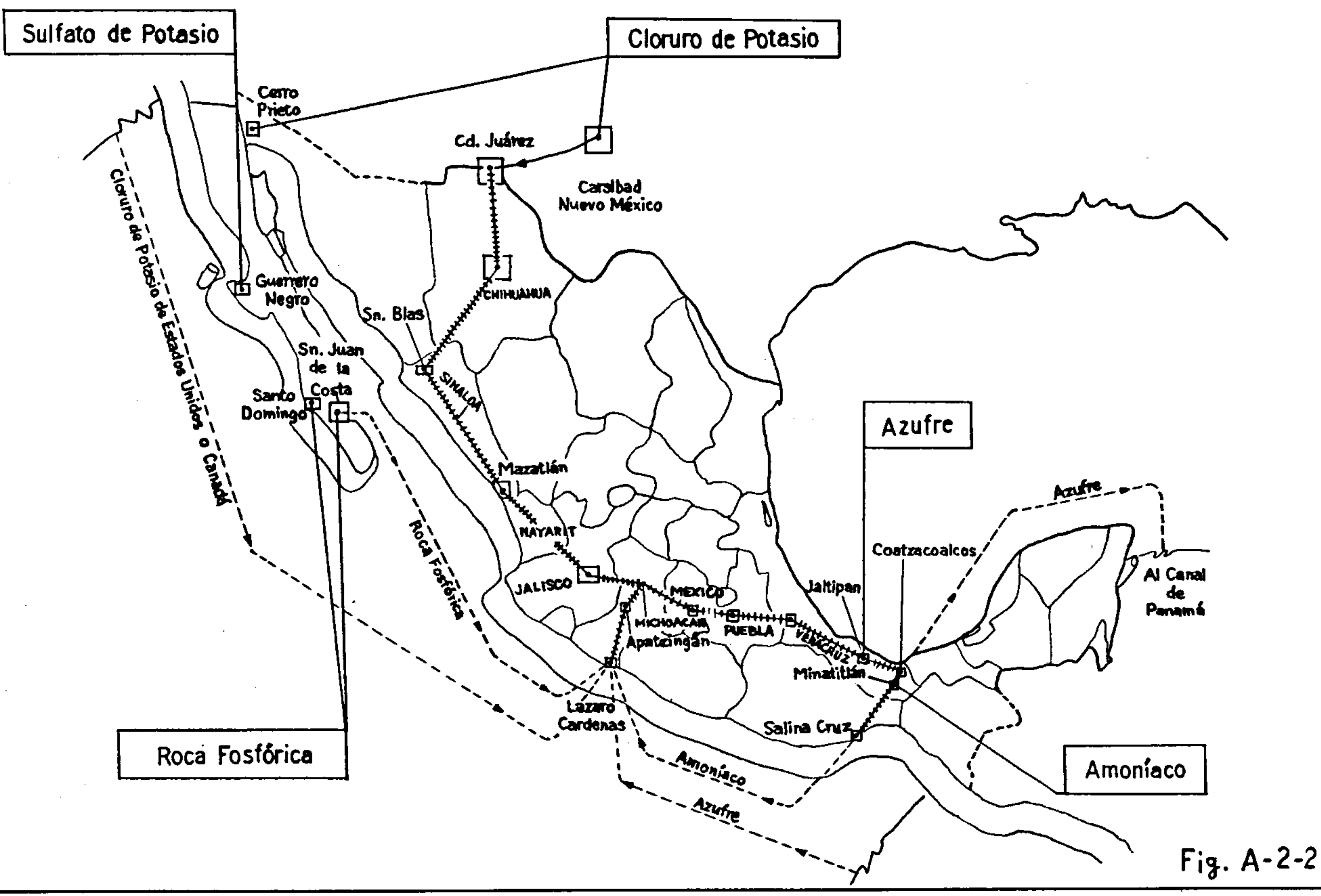


Fig. A-2-2

MICROLOCALIZACION DEL COMPLEJO INDUSTRIAL DE FERTILIZANTES

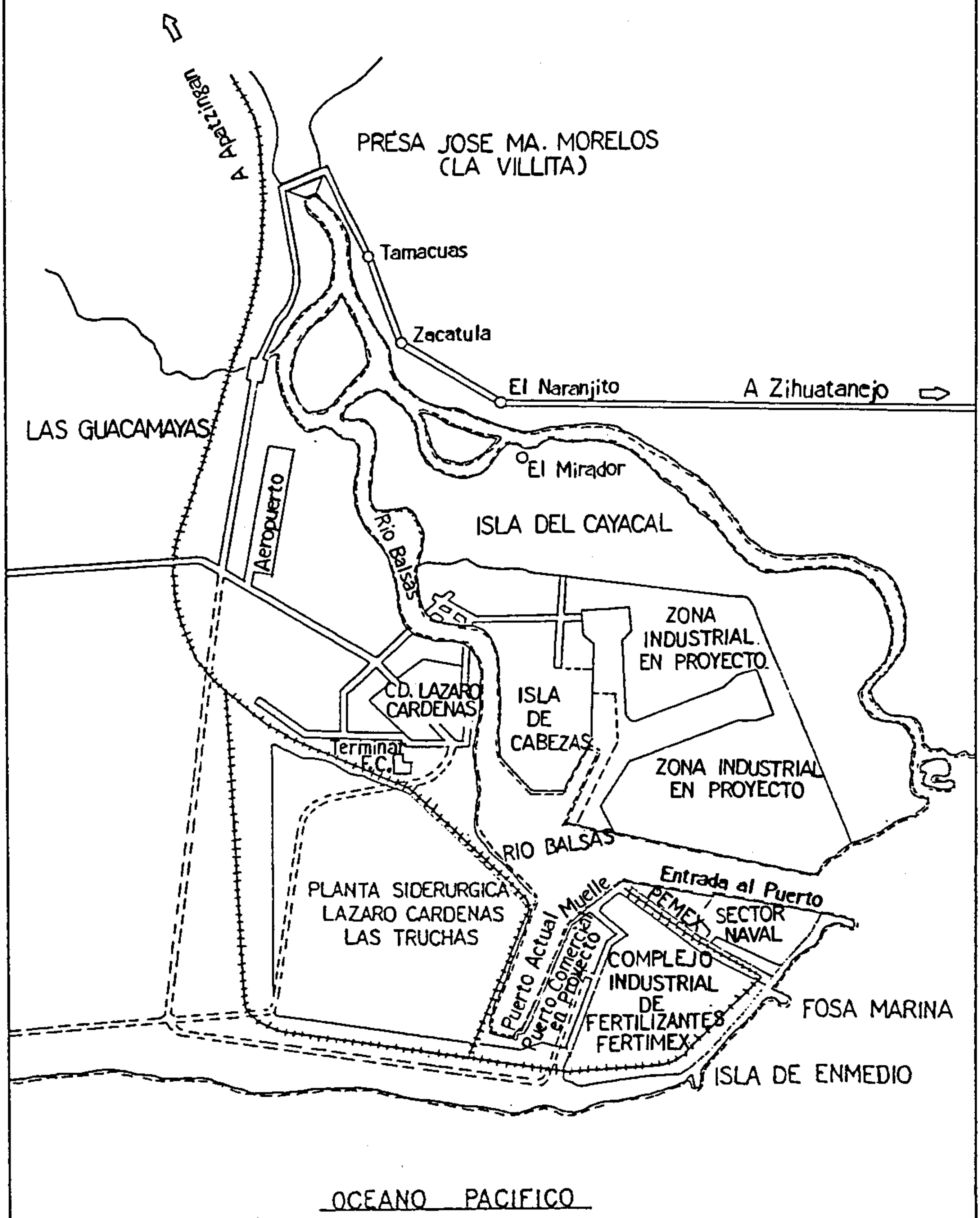


Fig. A-2-3

DISTRIBUCION DE AREAS DE PROCESO Y SERVICIOS AUXILIARES

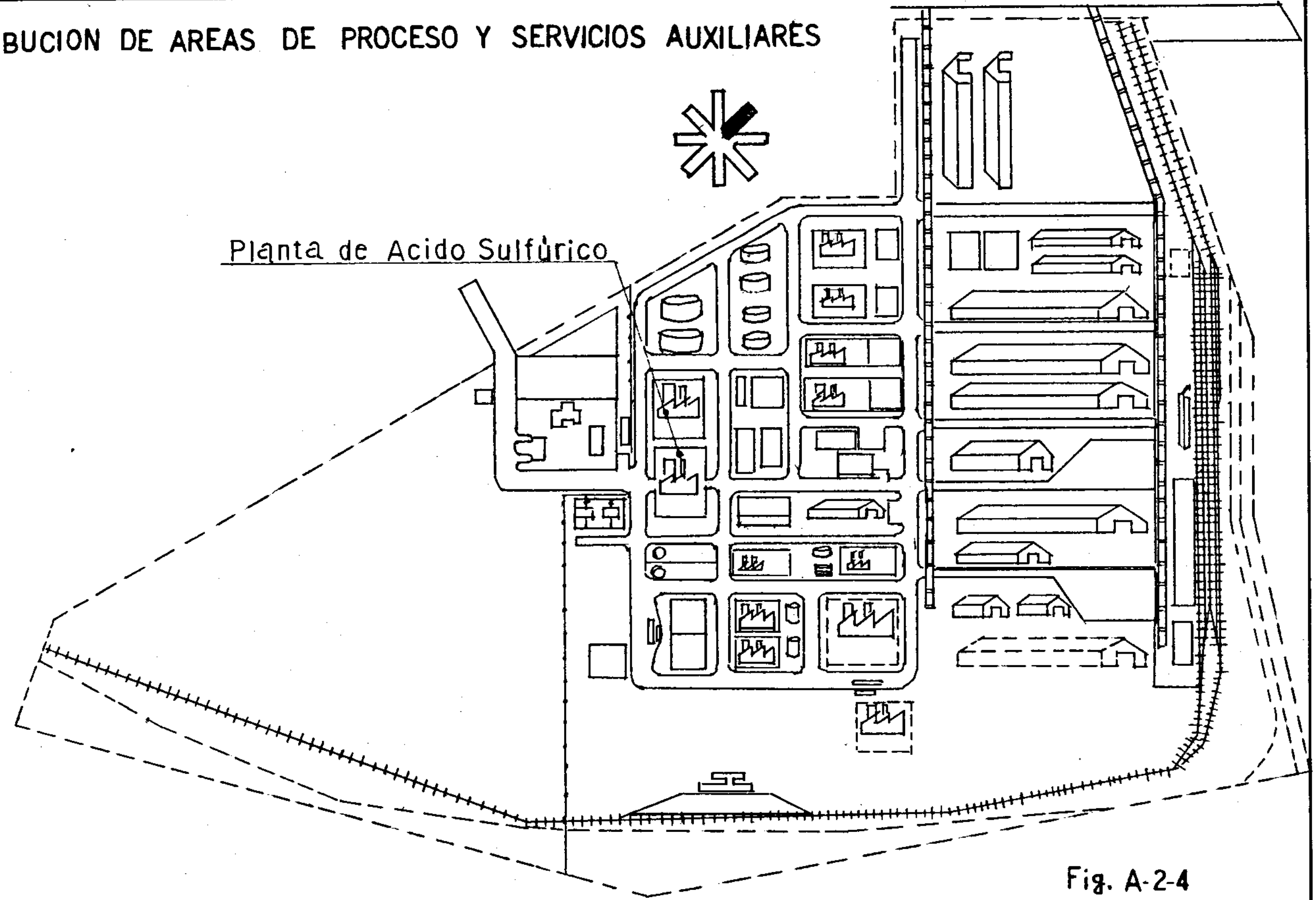
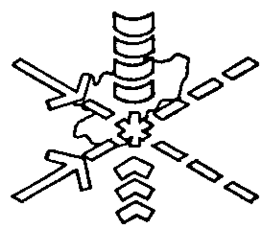


Fig. A-2-4

CARACTERISTICAS DEL LUGAR

LOCALIZACION



TEMPERATURA DE BULBO CECO (AMBIENT

MAXIMA
38.0°C

PROMEDIO ANUAL
26.2°C

MINIMA
11.5°C

HUMEDADES RELATIVAS PROMEDIO

MAXIMA
95.8

MINIMA
39.5

PROMEDIO ANUAL

MAXIMA	MINIMA
91.7	49.1

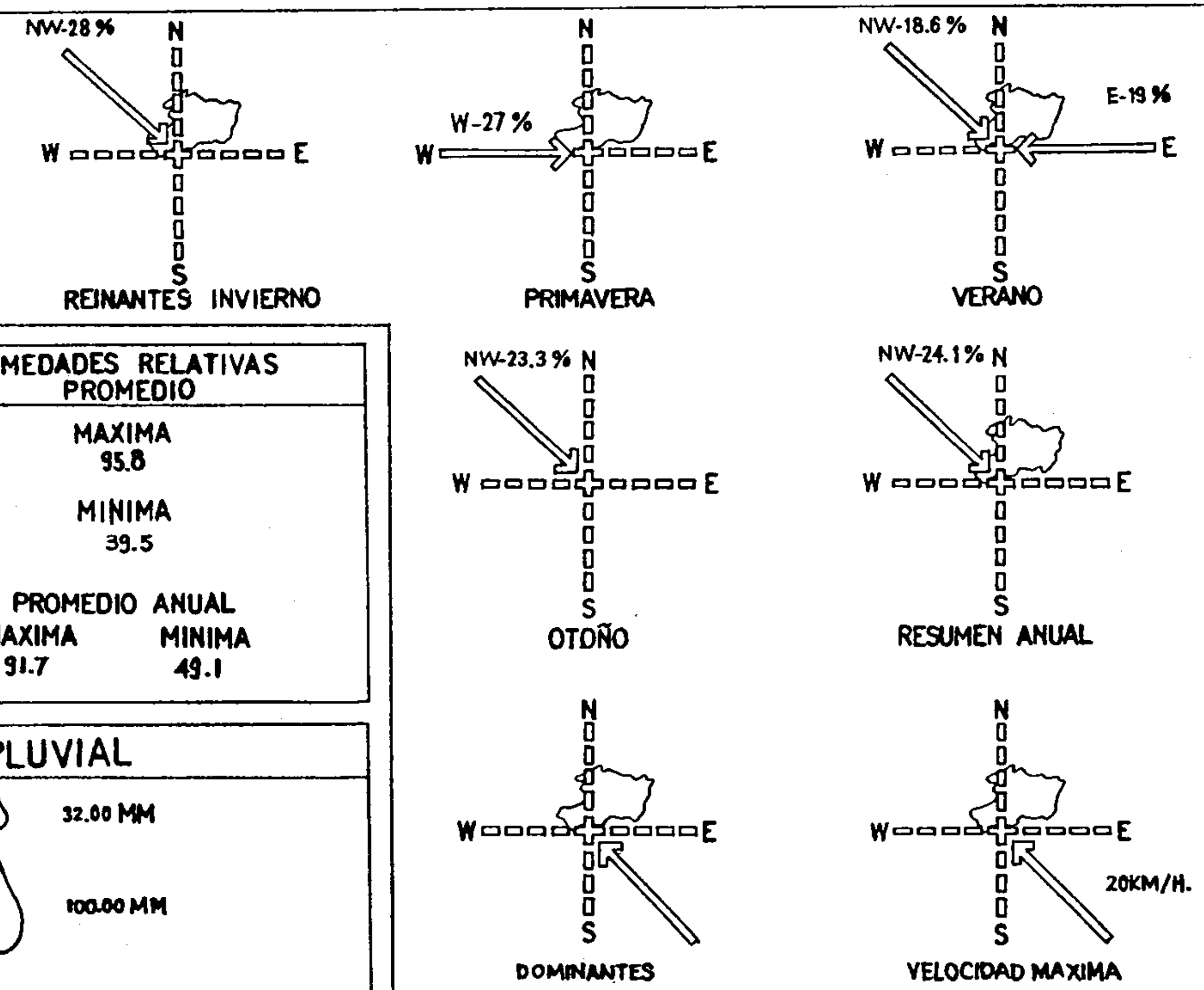
PRECIPITACION PLUVIAL

MAXIMA EN 10 MINUTOS 32.00 MM

MAXIMA EN UNA HORA 100.00 MM

PROMEDIO ANUAL DE PRECIPITACION PLUVIAL 1320.47 MM

VIENTOS:



SURESTE (SE) - CON INTENSIDAD MAXIMA EN VERANO

Fig. A-2-5

The concentrates fed from the bottom of the stock bin onto the continuous conveyor belt is carried into the rotary dryer, 2mϕ x 15mℓ, where they are dried and pelletized into small pellets about 4 mm in diameter.

The resulting pellets contain 23% sulfur and 1.0% moisture. The pellets are then carried by the bucket elevator and fed into the top of the square type fluo-solid roaster, where they are roasted at 950°C to 1050°C.

About 80% of calcine has the size of 1–2 mm in diameter and the remaining sulfer content is 0.8%. The flue gas is sent to the sulfuric acid plant that employs Monsant process. On the other hand, the zinc refining plant has six horizontal retort furnaces for distillation that are in 48-hour batch operation. Natural gas is used to heat the retort to max. 1350°C.

- o Charge:

Calcine	50–55%
Coke	25–30%
Flue dust and zinc oxide	25–30%

- o Example of crude zinc analysis :

Zn	97–98.5%
Cd	0.6–0.8%
Pb	2.0%
Cu	0.02%

The purification is carried out at 900°C to 1100°C in the vertical furnace which uses two special retorts made of silicon carbide. The crude zinc containing lead and cadmium is fed into the first retort to separate lead by vaporizing zinc and cadmium; in the second retort the cadmium is distilled and the rectified zinc (99.995%) is tapped from the bottom of the retort.

3) Summary of discussions on the pyrite ore treatment plant project in Guerrero

a) There is no problem as to the quality of zinc hydroxide, a byproduct of this project. This plant has a Waelz kiln for disposal of wastes such as slag, so there will be no problem except for moisture. The maximum allowable moisture content is 10%.

b) The price will be determined according to the international market price. The price of zinc concentrate (55% Zn, 10% water) is 2500 pesos/ton.

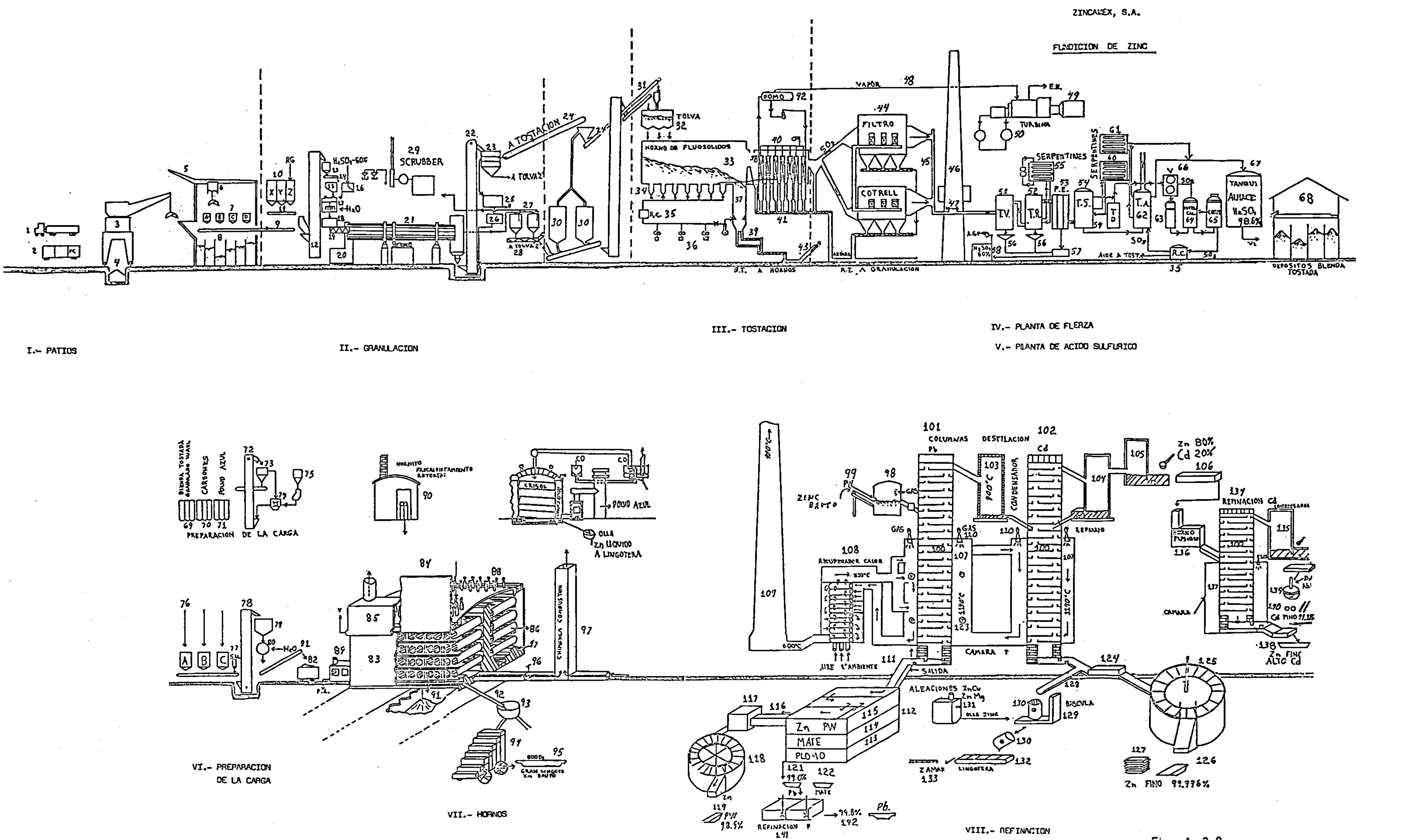


Fig. A-2-6

FLOW SHEET OF ZINCAMEX S.A.	
DRAWN BY ______	DATE / /
CHECKED BY ______	DATE / /
SCALE ______	