REPORT ON MINING DEVELOPMENT PLAN OF ISCAYCRUZ (OYON) AREA REPUBLIC OF PERU

MARCH 1986

JAPAN INTERNATIONAL COOPERATION AGENCY

METAL MINING AGENCY OF JAPAN

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PREFACE

The Government of Japan, in response to a request by the Government of the Republic of Peru, decided to conduct a preliminary study on the feasibility of the development of the Iscaycruz area located in the northeast part of Lima Department, and entrusted its execution to the Japan International Cooperation Agency (JICA). JICA consigned the project to the Metal Mining Agency of Japan (MMAJ), in that it belongs to a special field involved in mineral resources development.

The study was conducted from October, 1985 to February, 1986, and was completed as scheduled under close cooperation with the Government of the Republic of Peru and its various agencies, especially Instituto Geologico Minero y Metalurgico (INGEMMET), and Ministerio de Energia y Minas.

We wish to express our heartfelt gratitude to the Government of the Republic of Peru and the agencies and organizations concerned as well as the Ministry of Foreign Affairs, the Ministry of International Trade and Industry, the Embassy of Japan in Peru and the companies concerned for the cooperation and support extended to the Japanese survey team.

March, 1986

Keisuke Arita

President
Japan International Cooperation Agency

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President
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ACKNOWLEDGEMENTS

This report summarizes the results of the study carried out by the International Development Center of Japan, entrusted by the Metal Mining Agency of Japan.

The objective of the study was to formulate a plan to exploit copper, lead and zinc deposits existing in the Iscaycruz area located in the northeast part of Lima Department in the Republic of Peru, and to analyze its related economic effects.

It is my sincere wish that this study will contribute to the regional development in the area and further the economic development of the Republic of Peru, and that it will also help strengthen the friendly and cooperative relationship between Peru and Japan.

The members and schedule of the survey team are shown on the attached sheet. We would like to express our gratitude to the Government of Peru and its agencies concerned for their positive support and to the Embassy of Japan in Peru for its guidance during our team's stay in Peru. In particular, Instituto Geologico Minero y Metalurgico and Ministerio de Energia y Minas gave valuable advice and cooperation to the team.

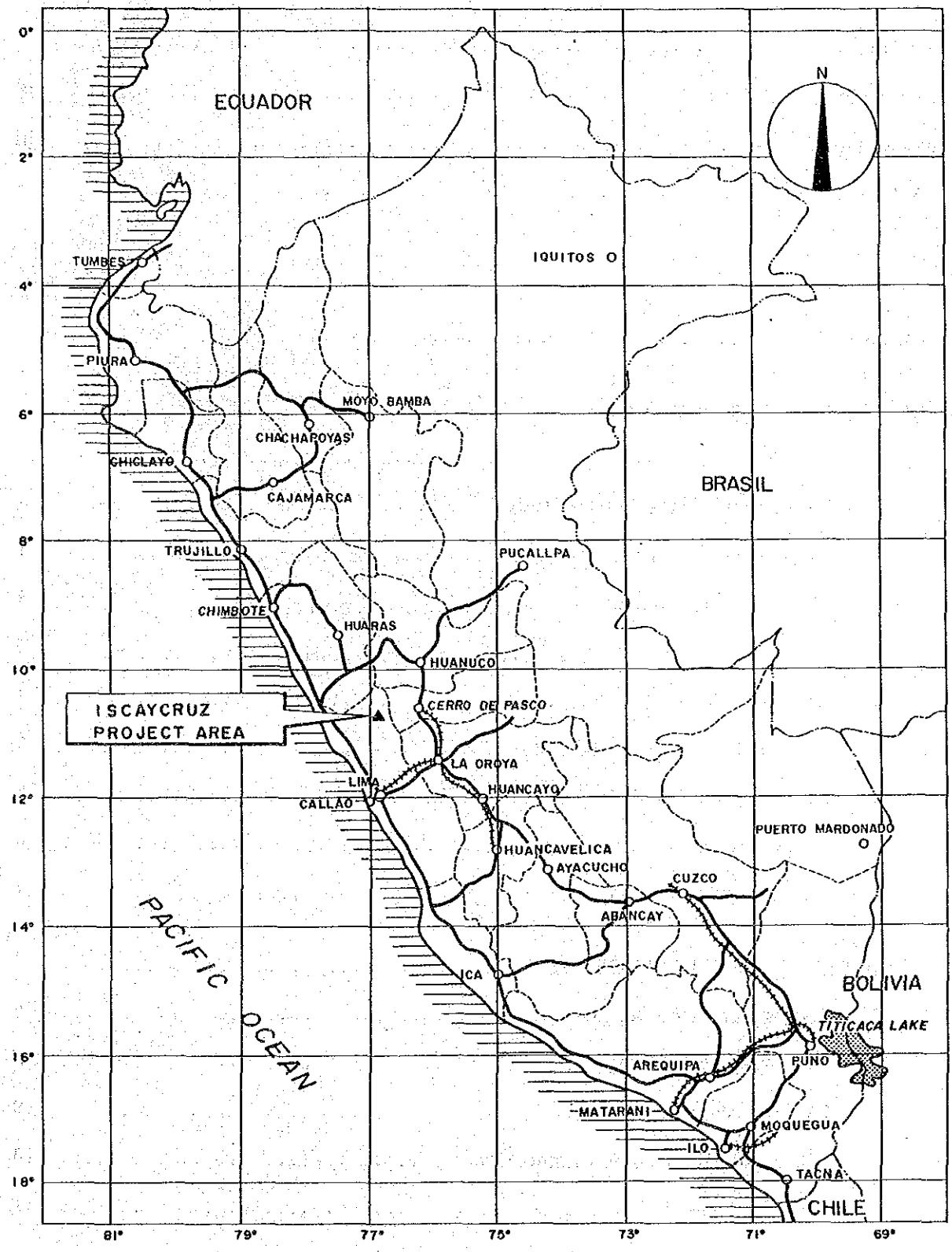
My deep appreciation is also extended to the Ministry of Foreign Affairs, the Ministry of International Trade and Industry, the Japan International Cooperation Agency, and the Metal Mining Agency of Japan for the guidance and support they gave us in performing the study.

March, 1986

Saburo Kawai

President
International Development Center of Japan

ISCAYCRUZ PROJECT INDEX MAP



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APPREVIATION USED

mm	:	Milimeter	...°...'	:	Degree, minute (Angle)
cm	:	Centimeter	ø	:	Diameter
m	:	Meter	ppm	:	Parts per million
km	:	Kilometer	HP	:	Horse power
ft,...'	:	Foot	A	:	Ampere
..."	:	Inch	V	:	Volt
m^2	:	Square meter	kV	:	Kilovolt
$,^3$	:	Cubic meter	W	:	Watt
ft^3	:	Cubic feet	kW	:	Kilowatt
yd^3	:	Cubic yard	MW	:	Megawatt
g	:	Gram	MWh	:	Megawatt hour
kg	:	kilogram	Hz	:	Hertz
t	:	Metric ton (dry)	MHz	:	Megahertz
wt	:	Metric ton (wet)	kVA	:	Kilovolt ampere
lb	:	Pound	S/.	:	Soles (Peruvian currency)
oz	:	Troy ounce	¥	:	Yen (Japanese currency)
g/t	:	Gram per metric ton	$	:	United States dollar
m^3/sec	:	Cubic meter per second	¢	:	United States cent
m^3/min	:	Cubic meter per minute			
m^3/day	:	Cubic meter per day			
t/hr	:	Metric ton per hour			
t/yr	:	Metric ton per year			
kg/cm^2	:	Kilogram per square centimeter			
°C	:	Degree Centigrade (Temperature)			

ABSTRACT

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Complying with the Peruvian Government request in 1985, preliminaly survey as well as the subject feasibility study, infrastructure to be related to develop the mine and economic intention for the district was conducted at the Iscaycruz district, which indicated high potentiality of occurrence of copper, lead and zinc deposits under the scheme of "Cooperative Mineral Exploration" since 1979.

The survey was carried out by the feasibility study team which comprised with six specialists from Japan International Cooperation Agency (JICA) and Metal Mining Agency of Japan (MMAJ) as a special participant together with the five Peruvian counter partners of Instituto Geologico Minero y Metalurgico (INGEMMET).

1. MINE DEVELOPMENT

Ore reserves: Iscaycruz mineralized zone exist in the area situated geologically in "Sub-Provincia Polimetalica del Altiplano" of "Provincia Metalogenica Andina Occidental". In the Iscaycruz mineralization, two types of deposits are distributed with the zonal arrangement; the massive sulphide deposit associated with copper, lead and zinc metals occurred by contact metasomatism to be characterized with the skarn rocks, and the hydrothermal alternation deposits disseminated of lead and zinc in the siderite layers. At the Limpe district of Iscaycruz zone where the survey was conducted closely by tunnelling and diamond drilling, ore reserves were calculated with applying the polygon method as follows;

Kind of ore	Ore reserves (1,000 t)	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)
Pb·Zn ore	3,257	48	0.13	1.95	18.99
Cu ore	102	32	2.84	0.03	0.39

Mining: While the operation by the open pit is difficult in order to this district locates in the deep valley where the high mountains of 5,000 m run to E-W, mechanized Cut & Fill mining method will be adopted on this mine operation. Mining will be conducted at four levels with the interval of 40 m (0 m; set at the elevation of present S-adit, +40 m, +80 m and +120 m; set present N-adit of 4,690 m above sea level), and main haulage level to deliver the ore to the concentrator will be established at 0 m level.

Ore mined out is correspondingly delivered to the four main ore passes which are connected to the 0 m haulage level through the trackless incline shafts from the stopes. Waste come from the tunnels and drifts is utilized for the filling materials, and the pebbles and gravels of the talus at the surface are used supplimentary. Two trackless inclines will be provided from the surface during the detail survey and development periods, and prior mining, these inclines will be connected to the main ore passes at each correspondent levels. All underground water are guided to the 0 m haulage level through the trackless inclines by the natural flow, and a fan is installed to boost the natural ventilation. Combination of Mobile jumbo mounted the middle size rock drill with 100 mm piston dia., 3.5 yd^3 LHD (Load & haul dump wheel loader) and 8 t trolley locomotive will be engaged on mining operation and tunnelling works. AN-FO explosives is used mainly for blasting.

85% of the extraction factor and 15% of the contamination to waste are expected on the operation.

Concentrator: Based on the test results of the composite samples taken from the adits N and S, streight differencial flotation method will be achieved to the good flotation performance, and following performance is expected on the actual operation.

	Grade	Recovery
Pb-concentrate	65% Pb	80% of Pb and 15% of Ag
Zn-concentrate	52% Zn	88% of Zn and 58% of Ag

The concentrator is in the capacity of max. 825 t/day, and composed of four plants of crushing, grinding, flotation and filtration. Two identical parallel circuits system will be adopted at the grinding and flotation plants. Main equipment used are: a 42" x 30" single toggle crusher, a 5' hydraulic cone crusher, two 9' x 12' ball mills, 16 units of 60 ft^3 flotation cells for Pb flotation, 36 units of 60 ft^3 flotation cells for Zn flotation and two pressed type filters.
The feed size to the flotation is in 74 micron of passing 80% to applied to the streight differential flotation. Both the concentrates of Pb and Zn are transported by the trucks to the port Callao.

Environmental facilities: Zn flotation tailing will be sent to the tailing pond by gravity through the pipe line, after it was thickened with a 18' callow cone and a 50'ϕ thickener. Sand and slime separate piling method is applied for making the dam, and the clear water separated from solids will be discharged into the Yarahuaino valley. Overflow of the thickener is re-used at the concentrator.
Underground water is guided to the tailing pond and delivered at the pH value of neutral into the Yarahuaino valley, after the slacked lime is added and mixed with clear water of the pond for neutralization.

Other plans: Annual power demand is expected in 15,600 MWh and maximum requirement of 2,500 kW for the mine operation. But, there are no power plants to be purchased in this area. Although some studies for prospectability in this area are progressively carring on by ELECTRO Peru, probably its completion will be in 15 years later at most earlier cases. So that, own mine diesel generators of 2,500 kW are installed to supply the power to the mine operation.
The lake Quellaycocha is used for the source of mine water as much of 1,920 m^3/day for both the industrial and domestic requirement. At the concentrator, 30% of total requirement is re-cycled in the plants.
11 km of access road to the mine site are constructed newly and some parts of the public road are necessary to make the detour and innovation although there exsist the road constructed tentatively for the survey but they are too rough and can not afford the mine activity.
For the welfare facilities, company's residential houses are not only provided but communication center, school and clinic, and canteen etc. are also provided for supplying the foods and daily necessary goods. The proposed population will reach to about 1,500 including their families.

Detailed surveys by drilling (4,365 m) and tunneling (1,763 m) are planned to confirm the horizontal and perpendicular shape, elongation and occurrence of ore

deposit, ore reserves and ore grades forcussing the target to the limits above S-adit level (4,570 m/above sea level) of Limpe ore deposit, and declined drillings at S-adit are also planned to grasp the ore potential of the limits below S-adit level.

Production plan: 750 t/day of crude ore will be mined and treated with 300 day-operation an annum having the mineable ore reserves of Pb-Zn existed in Limpe deposit (above the present S-adit). The production plan is as follows, and the mine life is 10 years.

Item	Tonnage (t)	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)
Mineable ore	2,050,000	35	0.10	1.61	15.92
Tonnages/annum	225,000	35	0.10	1.61	15.92
Pb-concentrate/ "	4,458	265	0.20	65.00	4.02
Zn-concentrate/ "	60,618	75	0.26	0.26	52.00

Manpower: All mine works are performed under the company's administration except the transportation of concentrates. Manpower requirement are 400 at the mine site and 14 in Lima head office, totalling 414. 260 day per man per annum is adopted to estimate the number of requirement.

Development schedule: Five years are scheduled to the completion of works as follows:

Two years : for detail surveying and feasibility study
One year : for detail design and financing
Two years : for construction and development

Investment: The initial investment are estimated as follows: (Based on as of Oct. 1985)

Item	Amount ($1,000)
Production, auxiliary and welfare facilities	25,211
Construction Management etc.	1,602
Inventory	200
Contingency	1,891
Detailed survey and feasibility study	3,095
Detailed design etc.	451
Interest during construction period	1,734
Working capital	2,195
Initial Investment Total	36,379

Additional investment and replacement cost: Totaling $2,877,000 of $475,000 for the additional and $2,402,000 for the replacement are estimated based on as of Oct. 1985.

Operation cost: Yearly operation cost is expected as follows: (Based on as of Oct. 1985)

Item	Amount ($1,000)	$/t ore
Production (mining & concentration)	4,090	18.18
Maintenance & administration	1,115	4.95
Subtotal	5,205	23.13
Concentrates hauling & ship loading	1,758	7.82
Tax and commission	353	1.57
Total	7,316	32.52

2. Infrastructure

Transportation: The route to the mine from Lima, the base for procuring and transporting materials and equipment during the mine development and operation, and from Callao, a shipping port used to export concentrates is Lima/Callao - Rio Seco (Pan American Highway) - Sayan - Churin - Oyon (National Road No. 16), totaling 270 km. The busy section from Lima/Callao to Sayan, most of which is asphalt-paved, has no problems. The section of National Road No. 16 from Sayan to Churin along the Huaura river, on the other hand, may be destroyed by floods and cut off traffic completely during the rainy season, especially from January to March. The annual average period of traffic cut-off is 15 - 20 days, with most of them usually occuring in March. The responsibility for the repair work is currently taken by the Ministry of Transportation and Communication and two mines (Raura and Uchuc Chacua) which use the road. When the Iscaycruz mine is developed, however, the mine probably needs to consider participating in the repair work or sharing in the cost.

Since the destruction of the road during the rainy season is quite predictable, it is more important to seek a permanent solution to the problem than to repeat temporary repairs and improvements. National Road No. 16 is one of the few Peruvian east-west arterial roads connecting Huacho on the Pacific coast to Pucallpa, a center of the forest region. The section between Churin and Oyon (30 km long) is as narrow as 3 - 4 m. The section between Oyon and Mishuya, which is a municipal road and in bad condition, will need partial repairs, improvement and reconstruction when developing Iscaycruz.

In this connection, trucks of 25 - 30t capacity can go through from the Pan American Highway to Oyon, and trucks of at least 20t capacity can go through to Mishuya. There is a temporary road used for the mine investigation from Mishuya to Iscaycruz (11 km long), which is passable only by trucks of 6t capacity or less. The mine development will require this road to be reconstructed if it is to serve the mine.

Electric Power: The electric power supply system is not well provided in the vicinity of Iscaycruz except in the Raura and Uchuc Chacua mines now in operation. Although there are small-scale public hydraulic or diesel electric power plants in Churin, Moroc and Oyon, they generate no more than 444 kW of electricity altogether, and the range of distribution is very limited. Raura and Uchuc Chacua mines have their own hydraulic and diesel power plants.

ELECTRO Peru is now conducting an extensive survey on the construction of hydro-electric power plants in the Huaura River basin; the plan is a large-scale one, including the construction of seven plants which generate 393.5 MW in total. In terms of feasibility, however, it is not certain whether any of them can be constructed by 1995. Therefore, these plants cannot be expected to be a source of electricity supply to the mine. It is also extremely difficult to purchase electricity from existing power plants, because the power-transmission line required is too long for a mining company to install and maintain. The mine will have to construct its own power plant.

Water Resources: The greatest use of water in the Huaura river basin is for irrigated agriculture, which has developed in topographically suitable areas in the middle and upper reaches of the Huaura river and along its tributaries. The Raura and Uchuc Chacua mines utilize lakes located in the mountain area in addition to rivers to store the necessary water and generate electric power.

From the hydrological and meteorological point of view, the lower reaches of the Huaura river are basically desert with very little rain, but precipitation increases gradually along the upper reaches, amounting to 1,700 mm annually in the northernmost upper reaches. According to the analysis of existing data, the annual precipitation in the Iscaycruz area is estimated at 1,100 mm, and the annual inflow into Lake Quellaycocha, located within the mining area, is estimated at about 1,000,000 m^3, the total of which exceeds the annual demand of about 690,000 m^3 by the mine. During the dry season, the lake, whose storage capacity is estimated at about 2.4 million m^3, can be utilized to cope with seasonal fluctuations. It is recommended that Lake Quellaycocha should be used as a natural reservoir to supply the water required for mining operation.

Communication: Whereas the Pacific coastal area and main cities are provided with cable telephone lines and microwave circuits, a large part of the mountain areas is not well provided with such services. Communication systems are also poor in the area concerned, where projects for system expansion and improvement have been suspended. Public facilities in the surrounding areas consist of a single cable telephone line connecting Sayan, Churin and Oyon to one another provided by ENTEL Peru, which could not meet the needs of the mine. The mine will need to establish its own system.

The Labor Force and Mine Camp: Data on the numbers of unemployed and underemployed workers in the area concerned is scant, but it is presumed that about 25% of the unskilled workers among the 400 total required personnel, can be locally supplied. There is also a high possibility of recruiting some laborers and employees experienced in mining, from coal and other mines existing in the area.

As candidates for the best site for the mine camp, the mining district itself and communities in nearby areas are possibilities. However, there seems to be no

other choice than set it up in the mine, if we consider the distance from existing communities, road conditions, the scale of the mine, and the examples of neighboring mines (Raura and Uchuc Chacua). The location of the mine camp should preferably be near Lake Quellaycocha, thus separating it from the production quarters to secure better living conditions. Attention should be paid to the layout of the mine camp; two residential areas, one for employees and workers and the other for the staff, should be separate as commonly observed in other Peruvian mines and share social service facilities within an equal distance from each.

3. The Overall Evaluation

Financial Evaluation: Expenditure and income were assessed on the assumption that a Special Mining Company would be established under the Peruvian General Mining Law and that all privileges provided by the current law system as of October, 1985 would be given to the company.

The assessment period is ten years, and factors for the assessment are based on prices as of October, 1985, except for quoted metal prices, without consideration of inflation during the mine development and operation period. All produced concentrates (Pb and Zn) are supposed to be exported. It is assumed that silver will be quoted at ¢700/oz, lead at ¢25/lb, and zinc at $900/t.

It is also assumed that about 25% of the investment in the development will be covered by owned capital paid in cash to the Special Mining Company, and the remainder will come from borrowed money at an interest rate of 9%, which is to be repaid in equal ten-year installments after the start of production with a two-year grace period during the development. All the costs of detailed survey, feasibility studies and detailed designs which will be incurred before the start of development works are assumed to be covered by the capital of the company. Accelerated depreciation of 20% per year was applied to the initial and additional investments and replacement costs.

The total profit/loss balance during ten years of operation are estimated as follows:

	($1,000)
Total revenue	128,819
Total cost	124,269
Profit before deduction	4,550
Deductions	599
Profit before tax	3,951
Income tax	825
Profit after tax	3,126
Financial internal rate of return (F.IRR)	
as against investment	7.68%
as against capital	3.56%

Economic Evaluation: The economic benefit of the Iscaycruz mine development from the national economic point of view is the acquisition of foreign currencies by exporting the concentrates produced, and this benefit (on an FOB and dollar basis) represents a direct financial benefit since the financial evaluation is based on prices in dollars. To convert financial costs into economic

costs which are needed to assess national economic benefits, several assumptions were made for taxes, labor costs and foreign exchange rates. On the basis of such assumptions, the costs of startup and operation, additional investments, replacement costs and residual value were converted from financial cost terms into economic cost terms.

The economic internal rate of return (E.IRR) was calculated at 24.99% from the annual series of economic benefit and cost obtained above.

Sensitivity Analysis: According to the financial and economic evaluation, the internal economic rate of return is as high as 29.36%, while the internal financial rate of return for entire investment is at 7.68%. Improvement in the internal financial rate of return would need either to increase income or to reduce expenditure. Although factors for such increase and decrease cannot be easily identified or clarified in terms of their nature and combinations in the present stage of the study, sensitivity analysis was made on the following assumptions.

	Assumed Cases	Internal Financial Rate of Return (%)
(1)	Use of the machinery and equipment of currently non-producing domestic mines	9.9
(2)	Increased grade of Zn at the expense of Zn concentrate recovery	8.7
(3)	Exemption from import tariffs on machinery and equipment	8.9

Effects on the Local Communities: Although various effects will conceivably be exerted on the neighboring communities by the Iscaycruz mine development, they may be classified into four categories: effects of newly generated income, effects of improvements in infrastructure, effects of an increase in population, and effects of productive activities on natural environment. Newly generated income, among other things, seems to be the most significant and was considered here. One of the improvements in infrastructure would be the participation in construction and improvement of roads near the mining district, and in the repairs of the flood-destroyed sections of National Road No. 16. In particular, the repairs of the national road is important to the area concerned. In this regard, however, a great contribution is not expected from the mine development because the Ministry of Transportation and Communication and the Raura and Uchuc Chacua mines have already largely undertaken repairs and maintenance.

Workers and their families who would migrate from outside the area concerned are estimated at over 1,000, even if a total of only 400 jobs are created by the mine development and part of the workers are locally recruited. Net increase in the total annual income is estimated at about one million dollars, and also capital income will increase. Against the background of these facts, most of the other economic effects on the local communities by the mine development will

come from the consumption of locally produced goods by consumers, such as the camp residents and the mining company. Various uncertain factors, however, make it difficult to quantify the consumption, and therefore, three alternative scenarios --optimistic, pessimistic, and neutral -- were chosen to estimate the amount of money (sales) that might be locally earned through consumption.

($1,000)

	Optimistic	Pessimistic	Neutral
Agricultural products	15.1	3.3	8.0
Livestock products	41.2	9.1	20.3
Other	298.4	59.7	118.3
Total	354.7	72.1	146.6

According to these estimates, the amount of money earned is at most $355,000 and at least $72,000 per year. As far as the six items of agricultural and livestock products are concerned, a maximum increase of 27% and a minimum increase of 6% from their respective current outputs is expected. Thus the economic impact through consumption may be large as compared with the current scale of the local economy, though the absolute value of the new gain will not be so large.

From a broad point of view, the mine's participation in the repairs and maintenance of National Road No. 16, as well as increases in employment and income, have major implications for regional and national planning.

4. Fact Findings and Recommendation

Fact Findings of the Overall Evaluation: The high internal economic rate of return indicates that investment in this project is feasible from the Peruvian national economic point of view. It is accordingly recommended that the Peruvian government take a positive attitude toward the project to promote the mine development, which also has a major economic effect on the local area.

Policy Recommendations: In consideration of the low internal financial rate of return (despite the high internal economic rate of return), it is recommended that the Peruvian government will adopt such measures as tax incentives, partial payment of infrastructure cost, and low-interest financing.

Technical Recommendations: If the conditions assumed in this report change and as a result the internal financial rate of return rises, it would be recommended that the company, as the executor of the project, carry out the following: precise prospecting; consideration of the possibility of using idle machinery and equipment; study and investigation of the characteristics and quality of Ag, and a method of improving the grade of Zn-concentrate.

Future Outlook: In addition to the Limpe deposits of Iscaycruz, the Limpe south deposits and Chupa deposits which have already been discovered are expected to be exploited (with the main focus on the Limpe deposits) for their favorable influence on the national economy contribution to the development of the local area.

CHAPTER 1 INTRODUCTION

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1. FORWARD

Complying with the request of the Peruvian Government, the Japanese Government commissioned the Japan International Cooperation Agency (JICA) and the Metal Mining Agency of Japan (MMAJ) to perform the survey, "Cooperative Mineral Exploration in the Oyon area" under the scheme of the bilateral technical cooperation, in close cooperation with Instituto Geologico Minero y Metalurgico (INGEMMET). This survey conducted from 1979 to 1981 indicated the Iscaycruz area, the object area of this project, as a potential area of an occurrence of the massive Cu-Pb-Zn deposit.

Subsequently in response to the request, JICA and MMAJ carried out the second survey, "Cooperative Mineral Exploration in the Iscaycruz (Oyon) area" from 1982 to 1984 and this survey confirmed the occurrence of the high-grade irregular massive Cu-Pb-Zn deposit.

The Iscaycruz mineralized zone containing the high-grade Cu-Pb-Zn deposit is situated about 7 km SSW to Oyon at the elevation of 4,700 m above sea level. The zone extends about 12 km in the limestone of Santa formation about 50-100 m thick in the Cretaceous age. The zone is mainly consisted of three kinds of deposit, the contact metasomatic deposit characterized by the Cu-Pb scarn deposit, the massive sulphide deposit containing Cu, Pb, Zn and the hydrothermal deposit characterized by disseminated Pb, Zn in the siderite bed.

At the first survey, "Cooperative Mineral Exploration in the Oyon area", geological survey, geochemical survey, geophysical survey and drilling survey were carried out. At the second survey, "Cooperative Mineral Exploration in the Iscaycruz (Oyon) area", drilling survey and tunnelling survey were carried out. The amount of work in each year is shown in Table 1.1. The outcome of these survey is as described in the following:

(1) The high-grade Cu-Pb-Zn deposit occurs in the Limpe zone, Iscaycruz area.

(2) The dimension of the ore body is supposed to be 300 m long, more than 150 m deep and 10-30 m thick.

(3) The ore reserve is calculated to be about 3,257 thousands tons graded about 20% (Pb, Zn total) by Polygon method

On the basis of these results, JICA and MMAJ concluded the Scope of Work on 28th June 1985 with INGEMMET on the collaborative preliminary investigation for the possible development plan of the mine in the Iscaycruz area including the infrastructure and the regional development.

This collaborative investigation was performed based on the Scope of Work.

Table 1.1 Cooperative Mineral Exploration

The first survey: Oyon area (1979-1981)

Item	1979	1980	1981	Total
Geological survey (km^2)	700 (Reconnaisance)	160 (Reconn.)	40 (Detail)	Total area 700
Geochemical survey (km^2)		40 (Detail)	2 (Detail)	
Geophysical survey				
IP method (km)		25.4 (8-line)	10.5 (7-line)	35.9 (15-line)
EM method (km)		3.0 (2-line)	10.0 (8-line)	13.0 (10-line)
Drilling survey (m)		564 (3-hole)	2,086 (9-hole)	2,650 (12-hole)
(Limpe area)		(157 1-hole)	(697 3-hole)	(854 4-hole)

The second survey: Iscaycruz (Oyon) area (1982-1984)

Item		1982	1983	1984	Total
Drilling survey (m)					
Limpe	Surface	1,300 (5-hole)	-	180 (1-hole)	1,480 (6-hole)
	N-adit	-	440 (2-hole)	680 (3-hole)	1,120 (5-hole)
	S-adit	-	470 (2-hole)	480 (3-hole)	950 (5-hole)
Limpe S	Surface		-	560 (3-hole)	560 (3-hole)
	Total	1,300 (5-hole)	910 (4-hole)	1,900 (10-hole)	4,110 (19-hole)
Tunnelling survey (m)					
N-adit	Approach	310	200	-	510
	Cross cut	-	#1 150	#2 175	325
S-adit	Approach	270	330	346	946
	Cross cut	-	-	#1 141 #2 86	227
	Total	580	680	748	2,008

2. PURPOSE AND SCOPE OF THE STUDY

2.1 PURPOSE OF THE STUDY

This study aimed to formulate the development plan of high-grade Cu-Pb-Zn deposit in the Iscaycruz area, Province of Oyon, Department of Lima under present optimum conditions and to propose the direction of the infrastructure in connection with the development plan. Furthermore, it was to be of use for the regional development by making rational development plan of this area based on the results of this survey.

The main theme is shown in the following three items:

(1) To investigate the possibility of development of high-grade Cu-Pb-Zn deposit in the Iscaycruz area and to evaluate the feasibility of investment by estimating the balance between incomings and outgoings and by planning optimum utilization on the national basis.

(2) To evaluate the investment effects on this whole area containing the Oyon area and the Churin area, which will be caused by the development of the Iscaycruz deposit.

(3) To propose the policy of development by investigating the influence of mine development on the development of the surrounding area and the local residents.

2.2 SCOPE OF THE SURVEY

2.2.1 Mine Development

To draw up the development plan by investigating the possibility of the development of the Iscaycruz deposit on the basis of the collected data on the geology and the ore reserve and on the basis of the metallurgical test report.

2.2.2 Infrastructure

Transportation (Roads): To work out a suitable improvement plan for the transportation of the materials and concentrates by investigating the transportation facilities, especially the present conditions of the roads. Not only the mine development but also the effects on the local residents are taken into account in the plan.

Electric power: To plan the source and the optimum method for supplying electric power required for the mine development by investigating the present situation of supply and demand for power in the Iscaycruz area and the supply plan of the Electro Peru S.A. To investigate the possibility of the hydroelectric power plant constructon.

Water supply: To work out the optimum supply plan for industrial and domestic water required for the mine operation by analyzing hydrogic and climatic characteristics and by investigating the present situation of the water source.

Communication: To draw up the optimum communication plan from the mine to other cities and on the mine site by investigating the communication facilities in the whole area containing the Sayan area and the communication methods adopted by the neighboring mines.

The labor force and mine camp: To work out the plan for securing manpower by investigating the working force in the surrounding area, the Oyon area and the Churin area. To select the optimum location for the mine camp construction by investigating the surrounding area and the present situation of the neighboring mines. To make the optimum plan for the allocation of the mine camp facilities by taking into account the intention of the Peruvian Government Agencies and by investigating the general customs of the mines in Peru.

2.2.3 The Overall Evaluation

The economic internal rate of return and the financial internal rate of return will be evaluated to determine the feasibility of the mine development on a national economy basis and on a private company basis, respectively. After such evaluation, the scale and timetable of the mine development will be considered to present a plan for the mine development. In addition, its effects on surrounding areas at large (especially in terms of agriculture) will be considered.

3. OUTLINE OF THE STUDY

3.1 STUDY AREA

Access and Transportation: The Iscaycruz area is situated about 150 km to the north of Lima, in Province of Oyon, Department of Lima. Province of Oyon is mainly composed of six areas, Pachangara, Oyon, Andajes, Caujul, Navan and Cochamarca.

The National Road No. 1 (Pan American Highway) runs from Lima to Rio Seco and runs the National Road No. 16 from Rio Seco to Oyon and the Iscaycruz area is connected with Oyon by the municipal road. From Lima to the Iscaycruz area it takes 7-8 hours by jeep drive over a distance of 270 km. The National Road No. 16 between Sayan and Churin is sometimes closed in wet season by flooding of the Huaura River.

Topography: The study area is situated in the western main range of the Andes, and located 11 km west of the watershed, where the Huaura River rises and flows out as one of the water systems of the Pacific coast. The altitude of the area surrounded by very steep mountains varies from 2,300 m (bottom of gorge) to 5,300 m (mountain tops) above sea level and the relative difference of altitude reaches 3,000 m. The area, from 4,200 m to 4,800 m above sea level in altitude, is comparatively flat plateau called Puna surface. The topographical feature between higher area and lower area from the plateau is much different. The higher area shows glaciated features and in the area higher than 4,800 m above sea level there are steep and rocky peaks. The area lower than the plateau is in the mature stage with deep V-shaped valleys.

The lowest altitude of the Iscaycruz area is 4,600 m above sea level, and in the eastern area, near the watershed, there are snowfalls during the whole year. The area higher than 4,800 m above sea level is covered with glacier.

Climate and Vegetation: The area belongs to the highland cold climate zone. The temperature in the daytime reaches 20°C while in the nighttime it falls below freezing point. It is the dry season from April to November and the wet season from December to March. Judging from the existing data, the annual precipitation in the Iscaycruz area is about 1,100 mm.

Because of highland cold climate, the vegetation is limited to specific herbs called pasto and its distribution is very bare.

Inhabitants: Only a few families settle in the area where the deposit exists. Inhabitants in the survey area, including Oyon area, are almost indios and settle in the basins along valleys and in the mild slopes of mountains. They are mainly engaged in farming and pasturage in primitive methods with small scale. The traffic is only by horses and on-foot connection.

Mines around the area: There are two mines in operation around the Iscaycroz area, Raura mine (Cu, Pb, Zn, operation rate: 1,800 t/day) and Huchuc Chacua mine (Ag, operation rate: 1,000 t/day). About 950 and 500 mine workers are living with their families in the respective mine. These mines, the largest industry in this area, greatly contribute to the social stability.
Some small scale coal mines are in production mainly in Mishuya and its vicinity.

3.2 OUTLINE OF STUDY METHOD

The study method and its progress until completion of this report are as follows:

(1) Advance investigation of existing data (in Tokyo)

(2) Dispatch of survey team, composed of 6 experts, to Peru. Consultation with Peruvian counterpart to confirm the principal plan and the allotment of work.

(3) Study in the area and collection of information by survey team and five members of counterpart. Cooperative study and drawing up of draft plan based on the survey results. Both parties confirmed that the final plan would be studied more in detail and drawn up by the survey team in Tokyo.

(4) Arrangement of data, detail calculation and drawing figures by every expert. Meetings were held four times. Investigation on the dressing test's report.

(5) Evaluation

- Financial evaluation for development of Iscaycruz deposit
- Economic evaluation after adjustment and rearrangement of basic figures and analysis of collected data.

Steps for evaluation:

- Drawing up the plan of production and manpower.
- Calculation of initial investment, additional investment and replacement cost.
- Calculation of operating cost.
- Calculation of sales income of concentrates.

(6) In order to analyze the possibility of private company investment, the DCF (Discounted Cash Flow) method was adopted for calculating discount rates or financial internal rates of return so as to offset the current value of expenditure and income during the mine operation. This is based on the assumptions that all preferential treatment would be given to the special mining company and that metal prices would remain at predicted levels. Exchange rates and input prices were based on figures and prices as of October, 1985, and no fluctuations during the mine development and operation were taken into consideration.

(7) In order to analyze the advisability of development from the national point of view, the DCF method was also used, and taxes, wages paid to unskilled workers, and exchange rates were adjusted, so that the discount rate or economic internal rate of return was calculated by means of conversion from financial cost to economic cost.

4. MEMBERS AND SCHEDULE

4.1 MEMBERS

4.1.1 Members Engaged in Negotation for Study Plan

Japanese Member		Peruvian Member	
Makoto Ishida	(MMAJ)	Francisco Sotillo P.	(INGEMMET)
Sumihiro Fure	(")	Juan Zegarra W.	(")
Takashi Kamiki	(")	Gregorio Flores N.	(")
		Erick Soriano B.	(")
		Carlos Guevara R.	(")
		Carlos Sotomayor G.	(")
		Yorry Elena C.	(")

4.1.2 Survey Team

Japanese Team;

Work responsibilities	Name	
Leader	Takeharu Yamaguchi	(IDCJ)
Mining	Kenji Tsurumi	(")
Concentration, Water supply	Hisamitsu Oki	(")
Power supply, Communication	Takashi Saito	(")
Welfare, Infrastructure	Masahiro Nakashima	(")
Evaluation	Yutaka Inoue	(")

Peruvian Counterparts;

Work responsibilities	Name	
Leader	Antonio Bararezo	(INGEMMET)
Mining	Alejandro Ladera	(")
Concentration	Aquiles Figueroa	(")
Welfare, Infrastructure	Eli Hernendez	(")
Evaluation	Alejandra Dias	(")

Notes; MMAJ: Metal Mining Agency of Japan
IDCJ: International Development Center of Japan
INGEMMET: Instituto Geologio Minero y Metalurgico

4.2 SCHEDULE OF SURVEY TEAM

Date	Journey , Visit	Object of Visit, Others
Oct. 7 Mon.	Lv. Norita	Overnight
8 Tue.	Ar. Lima	
9 wed.	Japanese Embassy JICA Lima Office, MMAJ Lima Office, INGEMMET	Courtesy Call
10 Thu.	Ministry of Energy and Mines	Courtesy Call to the Minister and the Director General of Mines
	INGEMMET	Consultation of the Principal Plan of Survey
11 Fri.		Openning of Survey Team Office
	INGEMMET	Consultation in general
12 Sat.		Prepartion for Survey
13 Sun.	Lima - Churin	All Members (including counterpart)
14 Mon.		Survey (in three groups)
15 Tue.		Survey (in three groups)
16 Wed.	Churin - Lima	
17 Thu.		Collection and Arrangement of Information
	Japanese Embassy, JICA Lima Office, MMAJ, Lima Office,	
18 Fri.	Mitsui Mining & Smelting Sucursal del Peru, Mitsui del Peru S.A.,	Ditto.
	Nippon Electric Co., Lima,	
19 Sat.	Ministry of Energy and Mines,	Ditto.
	Ministry of Transport and	
20 Sun.	Communication,	Ditto.
	Ministry of Labour and Social	
21 Mon.	Promotion	Ditto.
	SENAMHI,	

Date	Journey , Visit	Object of Visit, Others
Oct. 22 Tue.	Ministry of Agriculture, Electro Peru, Callao Custom House, Mining Society,	Collection and Arrangement of Information
23 Wed.	Cia. Minera Santa Luisa, Cia. Minera Buenaventura, Cia. Minera Raura, CENTROMIN,	Ditto.
24 Thu.	Huanzala Mine, Makers of Machinery and Electrical Machinery Appliances	Ditto.
25 Fri.		Plenary Meeting (Survey Team, Counterpart)
26 Sat.		Analysis of information and Data, Calculation and Drawing Figures, Collection of Information
27 Sun.		Ditto.
28 Mon.		Ditto.
29 Tue.		Ditto.
30 Wed.		Ditto.
31 Thu.		Ditto.
Nov. 1 Fri.		Making out Drafts of Development Plan by every expert in charge (Survey Team, Connecterpart)
2 Sat.		Ditto.
3 Sun.		Ditto.
4 Mon.		Ditto.
5 Tue.		Ditto.
6 Wed.		Ditto.
7 Thu.		Plenary Meeting (MMAJ, Survey Team, INGEMMET)
8 Fri.	Japanese Embassy, JICA	Greeting and Report
9 Sat.		Preparations for return home
10 Sun.	Lv. Lima	Overnight
11 Mon.	Ar. Narita	

CHAPTER 2 MINE DEVELOPMENT

CHAPTER 2 MINE DEVELOPMENT

1. GEOLOGY AND ORE DEPOSIT

1.1 GENERAL GEOLOGY

The Iscaycruz district belongs stratigraphically to the zone of Cretaceous Sedimentary basin, classified by Cobbing (1973), and thick Cretaceous sedimentary rocks are distributed widely. The clastic rocks are composed of siliceous sandstone and shale in the lower part, limestones with marl and shale in the upper part, and red formation in the uppermost. The lower part of clastic rocks are divided into Oyon, Chimu, Santa, Carhuaz and Farrat formations in ascending order, and the calcareous rocks consisting of the upper part are divided into Pariahuanca, Chulec, Pariatambo, Jumasha and Celendin formations in ascending order and the uppermost is Casapalca red formation.

The Cretaceous sedimentary rocks are uncomformably overlain by Tertiary CALIPUY volcanic rocks and intruded by tonalite, dacite, granite-porphyry and others. The cretaceous sedimentary rocks were subjected to intense structural movement by Andean Orogeny to form composite folded structure of fold axis trending NNW-SSE, and the overthrusts which are parralel to the axis are observed.

Santa formation which is composed well stratified dark gray limestone as thick as 50 m - 100 m exists between Chimu formation composed of quartzite and siliceous sandstone and Carhuaz formation which is alternating beds of shale and sandstone and distributed in elongate forming the country rock of the Iscaycruz mineralized zone.

Santa formation is situated on the wings of the folded structure and dips vertically owing to remarkable intrafolial fold. Overturned structures are observed in the Limpe district where located the central part of the project area and the Limpe South (Tinyag).

1.2 ORE DEPOSIT

Iscaycruz district is located geologically in "Sub-Provincia Polimetalica del Altiplano" belonging to "Provincia Metalogenica Andina Occidental" by Dr. Bellido et al. (1969) and the Iscaycruz mineralized zone and Chupa ore deposit were found in this district.

In the vicinity of this district, there are many middle scaled lead, zinc and silver mines on operation such as Raura (Pb. Zn), Uchuc Chacua (Ag), Atacocha (Pb. Zn & Ag), Cerro de Pasco (Pb. Zn & Ag) Huaron (Pb. Zn & Ag) and Santander (Cu & Zn). These deposits, distributed in the vecinity of Iscaycruz district, classified based on the kinds of ore, shape and genesis as follows;

- Copper-lead-zinc contact metasomatic ore deposits in Cretaceous limestones — Raura deposit, Chupa deposit and part of the Iscaycruz mineralized zone.
- Lead-zinc-pyrite massive hydrothermal metasomatic ore deposits in Cretaceous limestones, found in the Iscaycruz mineralized zone.
- Silver-lead-zinc fissure filling deposits in Cretaceous limestones — Uchuc Chacua deposit and part of Raura deposit.

- Silver-lead-zinc fissure filling deposits in Tertiary Volcanic rocks and intrusives — Chanca deposit and part of Raura deposit.

1.3 MINERALIZATION AND ALTERATION

1.3.1 Iscaycruz Mineralized Zone

Iscaycruz mineralized zone is formed in limestone of Santa formation, and is distributed inter-mittently in a distance of about 12 km from the northern part of Canaypata to the southern part of Antapampa. Dark colored gossan bearing Pb-Zn, massive pyrite ore bodies associated with galena and sphalerite, skarn massive ore with chalcopyrite and sphalerite, hematite masses with chalcopyrite and sphalerite, and siderite masses with galena and sphalerite are found as the mineralization.

The composite minerals on dark colored gossan which is exposed widely on the surface are mainly goethite, quartz and kaolinite associated with manganese oxides and siderite. Most of the minerals in the gossan are considered to be oxides such as franklinite and smithsonite. And dark colored gossan would be the oxidation products of manganiferous siderite. Massive pyrite deposit consist mainly of pyrite associated with pyrrhotite and marcasite, is occasionally enriched with galena, sphalerite and chalcopyrite. These occur a lot of druses in pyrite orebody and hematite in marginal zones. Dotted grains of chalcopyrite are commonly contained in sphalerite. The mineralized zone in the Iscaycruz district is characterized with the existence of both the contact metasomatizm at the later stage of magma and hydrothermal alteration at the hydrothermal stage and skarnization under the condition of the high temperature is influenced by retrogressive alteration.

Main skarn minerals are tremolite, garnet, epidote and quartz and ore minerals are mainly chalcopyrite, sphalerite and magnetite. Silicification, sericitization, argillization, sideritization, dolomitization and brecciation are observed remarkably in the host rocks of ore deposits. Igneous rocks related to mineralization are acidic intrusive rocks observed in Oyon and Chimu formations distributed near Cunsha Punta ridge.

Features of concentration of ore minerals in the Iscaycruz mineralized zone are variable and intermittent. Generally, skarn ore deposits containing copper and zinc are recognized in Limpe South district where is located nearest to the activity center of acidic intrusive rocks. Besides, massive sulphide ore deposits with lead and zinc are found in the Limpe district and Cumsha Punta district. And, in the mostouter zones of Iscaycruz ridge district and Antapampa district, dissemination type ore deposits of lead and zinc in the siderite layers including manganese are recognized. It is observed that these ore deposits of various type are distributed as a zonal arrengement centered in acidic igneous rocks, and they are considered to have been formed a series of mineralization as a whole.

1.3.2 Chupa Ore Deposit

Chupa deposit where exists in 600 m west of skarn outcrops in the Limpe South district is skarn type ore deposit replaced of a part of limestones belonging to Pariahuanca formation and contains zinc and copper minerals mainly. The ore deposit has been prospected in past by two adits and high grade ore was

encountered in both levels. Pariahuanca formation consisting of the host rocks of ore deposit is composed of massive limestones with about 100 m in thickness, and forms the reverse structure. Mineralization of this district is controlled by fault systems of ENE-WSW and E-W directions strongly.

Skarn minerals are mainly composed of tremolite, hedenbergite, quartz, siderite and small amount of chlorite, sericite, epidote and lievrite. Ore minerals are mainly sphalerite, pyrite and magnetite with minor amount of chalcopyrite, pyrrhotite and bismuthinite. The generation of ore deposit assumes due to the acidic igneous activity brought the same mineralization as Iscaycruz district, but igneous rocks are not appeared in this area.

1.4 ORE RESERVES

1.4.1 Calculation Method

Exploration in Limpe district has been done concentrically by drilling and tunnelling and the existence of the high grade copper, lead and zinc ores are confirmed (Limpe deposit).

Ore bodies occur as a irregular shaped massive ore deposits formed by the replacement of limestones, and it seems that the shapes of ore bodies vary widely and the ore grade might be distributed inhomogeneously althrough ores are found in both parts of the lower and upper of Santa formation in Limpe district and grade of the lower shows higher than upper. The informations are not enough to be lined the boundary of ore body even roughly and to be calculated ore reserves precisely, because only four cross cuts and diamond borings with the interval of 100 m have been conducted against the total length of 1,400 m along the strike direction of mineralization, although more than ten of high grade lodes have been confirmed.

However, it is assumed that they are related intimately to the pyritization and brecciation, and it is estimated that they have continuity to some extent being controlled by the structure of limestones. Therefore, tentative estimation of ore reserves estimation was conducted to know the rough assumption of ore reserves and ore grade. The polygon method was adopted for calculation of them, which is the most simple and objective method of ore reserves estimation.

1.4.2 Procedure and Basis of Calculation

(1) More than 2 m thick in actual thickness and having grade of more than 10% of Pb + Zn, but in case of copper ore, more than 2% of Cu. However, any indications which are composed of only one sample, even if satisfy the above conditions, have been excluded.

(2) The centeral point of ore encountered was projected on the profile section, which is established parallel to the extension of the mineralization zone (N 20°W - S 20°E).

(3) After real thickness of ore encountered was obtained according to the inclination angles of ore boundary, ore and structural plane of country rock for directions of drillings, then this length was converted to the horizontal length considering the inferred inclination of orebody and rocks.

(4) Area blocked out in both sides strike and vertical direction, which was taken within 5 times of the horizontal length from the center of ore encountered, but maximum 50 m.

(5) Ore existed within 30 m from surface was ommitted due to possibility as oxidized and leached zone.

(6) Polygon was established with centerring at the point of the indication and the boundary lines of polygon were positioned at the equal distance from each adjacent centers, when ore body was regarded to be on a single ore body such as i) the distance between any two center points of the indication was within 5 times of total horizontal length ii) continuity of mineralization was expected geologically.

(7) The polygon was established in the area where ore body was not found to eliminate the unmineralized zone, and tetragon was assigned for orebody which was captured in only one point.

(8) Ore reserves and their grade were summarized after calculation based on each by area and volume of polygon. The specific gravity is decided to 3.4, considering average value of 3.83 of 26 samples measured and the amount of 12% of porosity.

(9) A safety factor of 95% was adopted for ore grade calculation.

1.4.3 Results

Ore reserves were summarized for three ore bodies, such as Pb-Zn ore body existed in upper horizon of Santa formation (upper ore body), Pb-Zn ore body existed in lower (lower ore body) and Cu ore body. The results of each deposit by block and the location of ore blocks are shown in Fig. 2-1, Fig. 2-2 and Fig. 2-3.

Summarized ore reserves is as follows;

Kind of ore	Ore reserves (1,000 t)	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)
Pb · Zn Ore	3,257	48	0.13	1.95	18.99
Copper Ore	102	32	2.84	0.03	0.39

Table 2.1 Table for Ore Reserves Calculation

Zone	Body	Tonnage (t)	Grade				Metal content			
			Ag (g/t)	Cu (%)	Pb (%)	Zn (%)	Ag (kg)	Cu (t)	Pb (t)	Zn (t)
Pb·Zn Ore:										
Lower H.	D_1	66,300	15	0.32	0.02	21.59	994	212	13	14,314
	D_2	453,000	38	0.04	3.16	22.69	17,214	181	14,314	102,785
	D_{3-4}	509,300	20	0.11	2.01	15.36	10.186	560	10,236	78,228
	D_5	948,100	78	0.19	2.61	24.08	73,951	1,801	24,745	228,302
	D_{6-7}	250,500	172	0.15	3.36	28.62	43,086	375	8,416	71,693
	Subtotal	2,227,200	65	0.14	2.59	22.24	145,431	3,129	57,724	495,322
Upper H.	U_1	1,500	89	0.03	6.74	14.17	133	0	101	212
	U_2	161,500	13	0.07	0.04	14.49	2,099	113	64	23,401
	U_3	304,900	8	0.10	0.07	17.13	2,439	304	213	52,229
	U_4	156,400	25	0.06	4.53	9.39	3,910	93	7,084	14,685
	U_5	5,500	35	1,10	2.89	15.22	192	60	158	837
	U_6	36,700	26	0.08	2.63	11.75	954	29	965	4,312
	U_7	251,300	32	0.18	0.13	16.78	8,041	452	326	42,168
	U_8	111,900	22	0.18	0.20	16.04	2,461	201	223	17,948
	Subtotal	1,029,700	19	0.12	0.89	15.15	20,229	1,252	9,134	156,036
Total		3,256,900	51	0.13	2.05	19.99	165,660	4,381	66,858	651,114
Adjusted Total*)		3,256,900	48	0.13	1.95	18.99	157,377	4,161	63,515	618,558
Cu Ore:	C_1	41,600	23	2.48	0.02	0.46	956	1,031	8	191
	C_2	1,900	5	7.10	0.22	0.48	9	134	4	9
	C_3	47,700	46	3.43	0.03	0.43	2,194	1,636	14	205
	C_4	4,800	32	2.20	0.02	0.29	153	105	0	13
	C_5	5,900	23	2.43	0.11	0.11	135	143	6	6
Total		101,900	34	2.99	0.03	0.42	3,447	3,049	32	424
Adjusted Total*)		101,900	32	2.84	0.03	0.39	3,274	2,896	30	402

Note: *) Safety factor of ore grade is 0.95

Fig. 2.1 Perspective Section for Ore Reserve Calculation (Lower Horizon)

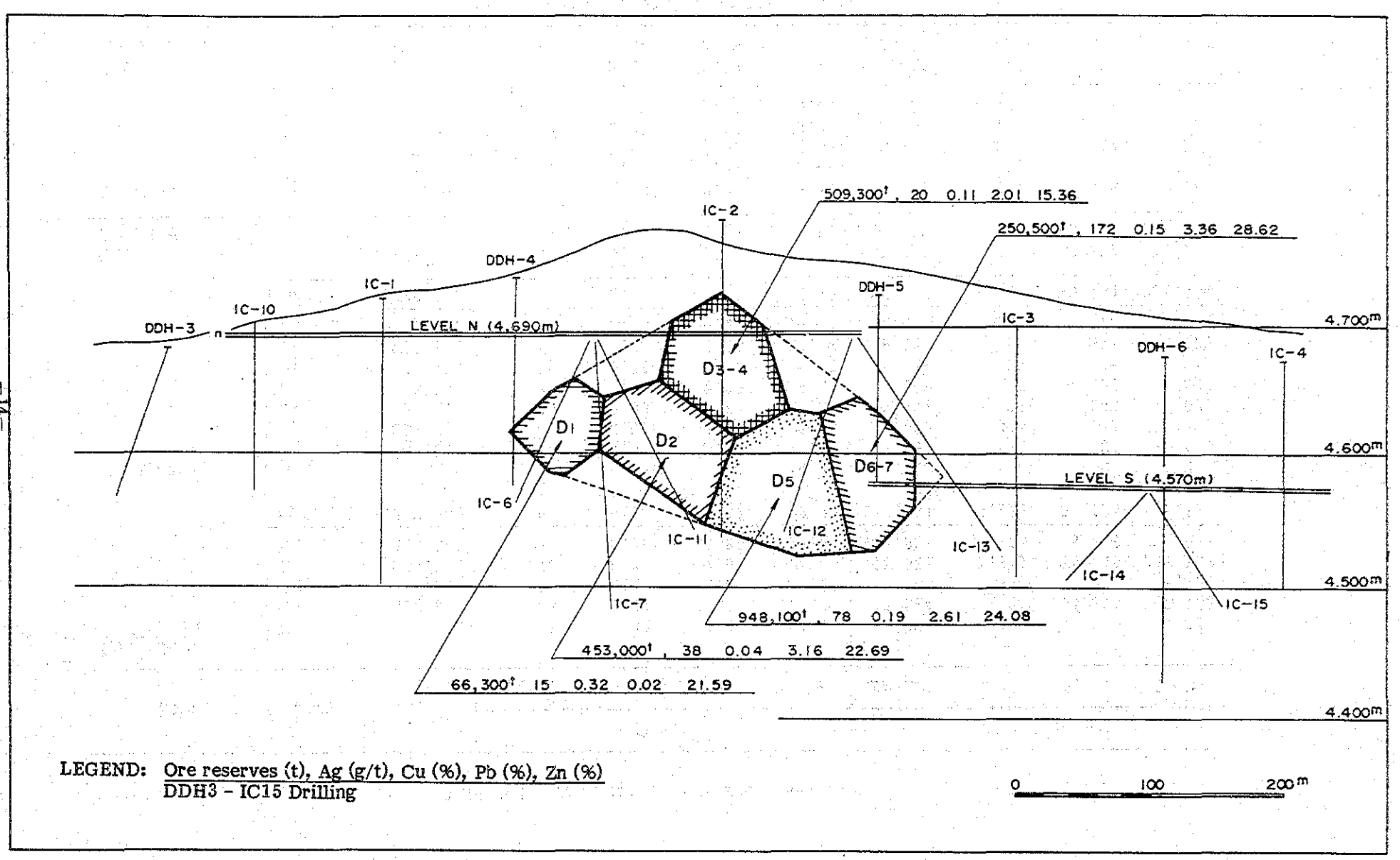
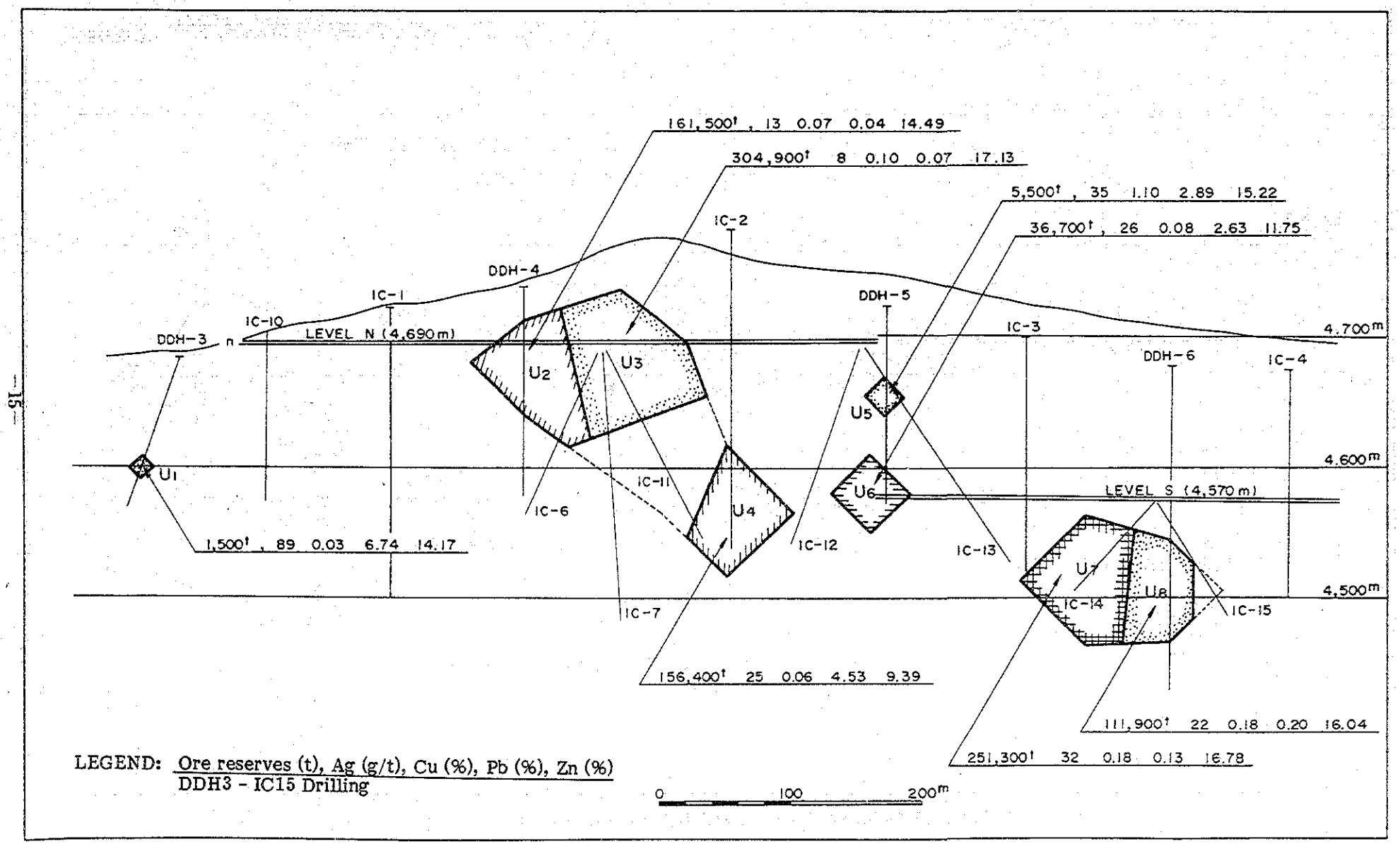
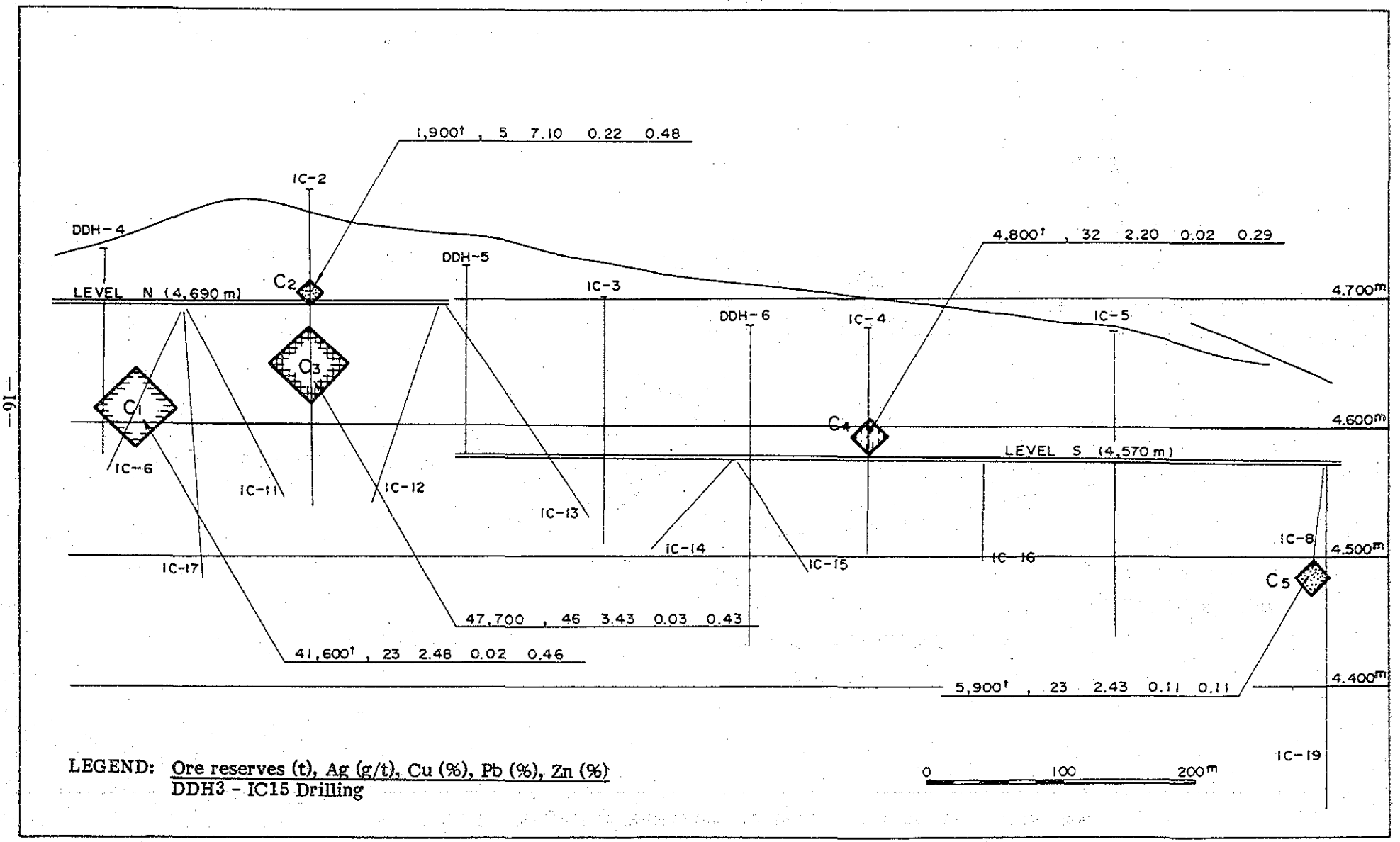


Fig. 2.2 Perspective Section for Ore Reserve Calculation (Upper Horizon)



LEGEND: Ore reserves (t), Ag (g/t), Cu (%), Pb (%), Zn (%)
DDH3 - IC15 Drilling

Fig. 2.3 Perspective Section for Ore Reserve Calculation (Cu Ore)



2. MINING

2.1 GENERAL

2.1.1 Selection of mining method

What mining methods are applied on this mine, surface or underground, have been studied under the consideration of the regional, topographic and economical conditions involved prior to make a decision of mining methods. Supposing open-pit is applied with the final pit slope of 60° as well, a stripping ratio goes up to more than 30, and the depth of pit reaches over more than 200 m, because of Iscayoruz district where ore body exists is located in the Alps mountains site and is formed the valley to be extended to the high mountains of 5,000 m so far. Therefore, surface mining is not easy to maintain satisfactory a economic and technical factor involved.

Mechanized Cut & Fill method was selected to meet on this mine the most favorable one for the following reasons:

(1) Development and preparation works to be performed before operation starts are relatively less compared to other mining method applied.

(2) It has so wide flexibility on operation that it can cope with less information on prospecting.

(3) High extraction factor and less contamination will be expected for this type ore body.

(4) It can be coped to expand and shrink of ore body existed.

(5) High efficiency on operation will be obtained together with the mechanization.

(6) Filling materials can afford easily from the talus of surface.

(7) This method has much of achievement in Peru.

2.1.2 Basic criteria of plan

The proposed mining area is above the present S-adit (4,570 m above sea level) and the basic criteria of plan is as follows:

Mineable ore reserves (t)	2,050,300
Extraction factor (%)	85
Contamination of waste (%)	15
Production, per annum (t)	225,000
Tonnage to be mined per day (t)	750
Operation days per annum (day)	300
Shifts employed per day	2
Working days per man per annum (day)	260

2.1.3 Skelton of underground (Refer to Drawing 004, 005 & 006)

Based on distribution of ore body existed, some surplus stopes will be necessary to maintain the daily production of 750 t, so that four levels of 0 m (present S-adit, 4,570 m above sea level), +40 m, +80 m and +120 m (present N-adit, 4,690 m above sea level) are opened with the interval of 40 m, and three to four access roads to stopes are driven with 100 m apart from each level.

The inclined trackless shaft which is connected correspondingly to the main level with main ore pass and waste chute will be developed into Santa formation. Also, waste chutes which are utilized for a part of ventilation system will be provided apart from ore body. A trackless incline to +120 m level will be developed during the detail surveying period and a trackless incline to +40 m will be provided during the development period from surface respectively. These inclines will be not only used for the purposes of service and ventilation but delivering ore and supplying waste when necessary.

2.2 DEVELOPMENT PLAN

2.2.1 Main level

Main levels will be set at 0 m, +40 m, +80 m and +120 m as mentioned above. 0 m main level will be utilized for the haulage level to deliver ore to the concentrator and for the inlet of fresh air and the outlet of underground water. Therefore, S-adit presented is improved in such as way the places where passed weak and narrow zone will be made a detour and extended during the development period. Finally, the main level will be innovated to the size of 3.0 m x 3.0 m with the drainage canal of 50 cm x 50 cm.

Development works will be performed with either using the rail-loader (2.6 m x 2.5 m in size) or LHD - Load & haul dump wheel loader (4.0 m x 2.8 m), depend upon the situation of ventilation and treatment of waste occurred. After drive, tunnel is enlarged up to standard size by the brest cut at the place where was advanced by the rail-loader.

2.2.2 Chutes

Main ore passes: Three ore passes (OR-1, 2 and 3) will be provided into Santa formation apart 30 m from ore body with the interval of about 100 m and these are served for mining of lower ore body (ore body existed in the foot wall). And for the same purpose, a ore pass (OR-4) will be also provided into Santa formation for upper ore body (ore body located in the roof-wall).

Three ore passes of OR-1, OR-2 and OR-3 which have 2.1 m in dia. and inclination of 80^{o} each will be developed by the raise-borer and depth of them assume as 120 m for OR-1 and OR-2 and 80 m for OR-3. OR-4 which has demension of 1.8 m x 1.5 m and 90 m in depth will be developed by the conventional method.

These four ore passes will be connected to the trackless incline and main level at each level correspondingly, and the ore bin with about 200 t capacity each on the main haulage level will be provided.

Waste chute and ventilation raise: Chutes will be developed in about 100 m interval near ore body and connected to the corresponding stopes to supply filling materials during the operation period. They will convert to the part of ventilation system after mined out.

Service raise: One service raise will be provided from +120 m level up to 0 m level for laying the pipes of compressed air and industrial water and the cable line for low voltage power. Waste chutes and service raise with 1.8 m x 1.5 m in dimension will be driven by the conventional method.

2.2.3 Trackless inclined shafts

Three trackless inclines, correspondence to OR-1, OR-2 and OR-3, will be developed for mining a lower ore body at the places where are between the main ore passes and footwall of ore bodies. A trackless incline which will be developed during the detail survey period may be utilized for mining the upper ore body, but additional trackless incline and ore passes might be required depend upon the results of the precise study. Standard dimension of the trackless incline will be 4.0 m wide x 2.8 m high, inclination of $9^{\circ}30'$ (about 1/6) and inner curvature of 10 m.

Only one trackless incline will be driven during the development period from 0 m level to +120 m level and others will be developed correspondingly to the progress of stopes with the twin shafts method during the operatoin period. Procedure of connection between trackless incline and stope are as follows:

(1) The access to the trackless incline is driven from the stope with inclination of +1/5.

(2) The roof of the access will be blasted slicely with relation of rising up of the stope to be maintained the connection to the trackless incline until the access reaches to inclination of -1/5.

(3) The access to the trackless incline will be driven and repeated procedure (1) before previous access reaches to inclination of -1/5.

2.2.4 Opening of stopes

The range to be mined will consider tentatively as follows;

For the lower ore body:	Above 0 m level 4 main levels of 0 m, +40 m, +80 m and 120 m will be provided.
For the upper ore body:	Above +80 m but it may have a enough size at even below +80 m level for mining. Tentatively, 2 main levels of +80 m and +120 m will be provided.

When operation starts, area where ore exists will be expanded and roof-blasted with 3 m a slice at each levels. However, the vertical pillar may established conventionally at the places of loosen and weaken ground or wider ore body.

2.3 OPERATION PLAN

2.3.1 Exploration and opening stopes

Continuously, prospecting tunnels and opening of stopes will be conducted following the plan and schedule. Length of prospecting tunnel to be conducted per annum is about 2,000 m (equiv. 9 m per 1,000 t mined out.).

2.3.2 Extraction of ore

Mechanized Cut & Fill method will be adopted for extraction ore using the same machines which were conducted during the development period. Combination of diesel drive mobile jumbo with 50 Hp class and 40 kg class leg-drill for drilling and LHD of 3.5 yd^3 capacity for transportation will be adopted.

Regarding to the process for ore extraction, area where ore exists will be expanded at the ground level and its roof will be blasted with 3 m a slice for opening the stope but 2 m a slice for mining and the open space where broken ore was extracted will be filled 2 m thick with filling materials such as waste occurred by tunnellings. A cycle of mining, so called, consists of a series of works of drilling toward to up, charging explosives into drilled holes, blasting, mucking and filling. When the ground conditions are unfavourable to be followed the standard procedure, method will be modified such as stope will be filled up till underneath of the roof to eliminate the exposed area of both roof and foot walls and drilled in horizontal direction and blasted and so on. Max. 3 m high will be regulated when adopted horizontal drilling although the height of open space to be exposed during ore extraction period reaches to 5 m. The ilastration of both methods shows on fig. 2·4.

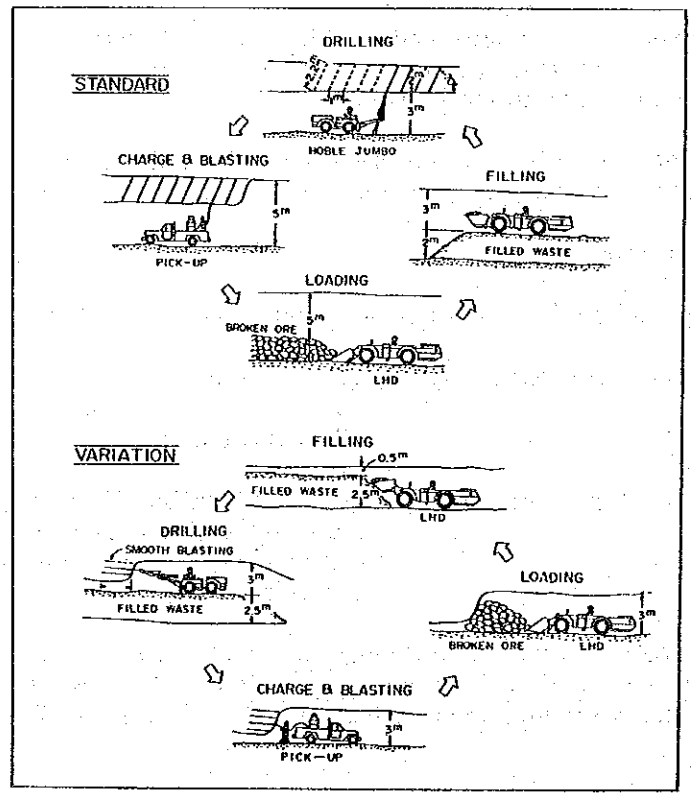


Fig. 2·4 Extraction Method

Extraction factor: About 5 m thick horizontal pillar will be remained between the upper stopes (equivalent to 10% of ore reserves) and some stopes will reach more than 30 m long, so that the vertical pillars may be necessary on a view of safety at stopes where are assigned in weaken and soft ground. 85% of extraction factor was used for the calculation purpose with consideration of losses occurred by the horizontal and vertical pillars and unmined by the contamination to wastes at stopes.

Contamination of waste: The most of contamination will come from waste of filling materials. Assuming that broken ore (having 1.6 of loosened specific gravity), which was blasted with a slice of 2.0 m, will be scooped into the bucket of LHD together with filling materials of 20 cm depth, contamination of waste will calculate as follows:

$$\frac{0.2\ \text{m} \times 1/1.6}{2.0\ \text{m} + (0.2\ \text{m} \times 1/1.6)} \times 100 = 5.9\%$$

It believes that the all over contamination factor reaches up to max. 15% while there will be expected on the actual operation due to the reasons such as contamination at mining boundary even if the pillar remains, overstoping and avoidable contamination mentioned above, and the record of other mines adopted trackless mining.

2.3.3 Drilling and blasting

Drilling: The diesel drive two booms mobile jumbo, mounted the pneumatic rock drills, will be engaged together with the leg-drills of 40 kg class supplimentally for both mining and tunnelling. Drilling pattern for mining is 1 m of both spacing and burden with 70° of up grade and 2.2 m deep. Smooth blasting with 50 cm of spacing will be adopted at tunnelling and horizontal drilling at stopes to prevent the growth of loosened rocks.

Blasting: The blasting crew will be taken care of all blasting works using the special truck (pick-up diesel) equipped AN-FO charger. AN-FO explosives mainly and No. 12 non-electric milli-second cap (no requied booster dynamite) with detonator will be used.

2.3.4 Transportation

3.5 yd^3 LHD which is commonly used in Peru will be signed for both ore and waste hauling at mining and tunnelling works. Ore, which is delivered to main ore passes (OR-1 ~ OR-4) through trackless incline from stope, will be drawn out through ore chutes and loaded on 5 t capacity gramby cars at 0 m main haulage level. A train composed of 10 gramby cars will be transported with a 8 t trolley electric-locomotive to the receiving ore bin of concentrator. In case of emergency, ore will be transported directly up to the portal of the trackless incline from stope by LHD and relayed to the dump truck to deliver it to the concentrator. A hydraulic breaker will be equipped on head of the receiving ore bin, and ore which is larger size than screen of 50 cm x 50 cm installed will be broken by it.

2.3.5 Filling and supporting

Waste come from prospecting tunnels and drifts in the operation period are used for filling materials, and when lacking, the broken freshed siliceous pebbles which yield at the talus on surface will be supplement. LHD will work for transportation from the waste chutes to stopes. Regarding the applisal of sand-slime filling, it seems it is not recommendable that the particle of tailing will be too fine to be dewatered. But it is still kept pending at a present stage. Further study will be necessary after operation starts.

Support: Smooth blasting will be adopted in principle at the loosen and weaken ground and roof-bolting will be added when necessary. Iron and wooden framing also are adopted at the breccia zone and fructured ground.

2.4 MINING EQUIPMENT AND INSTALLATION PLAN

2.4.1 Compressed air

The requirement of compressed air will be estimated to 109 m^3/min for boring machine, mobile jumbo, leg drill & stoper, rail loader, and certain amount of leackage and blow. Three units of the compressor with each 55 m^3/min capacity included the spare unit will be installed.

12" pipe will be lain in 400 m long from the compressor room up to the head of the service shaft at +120 m level through the trackless incline, and 8" pipe in the service shaft and 4" pipe at the main levels.

2.4.2 Ventilation system

Careful attention should be necessary on this mine not only for exhaust gas come from the diesel engine but for backgas and dust. Studied to the natural ventilation, a fan will be installed in the portal of the present N-adit at +120 m level for the reinforcement of the natural head obtained because only 120 m of the elevation difference will not give a enough head to be required as described belows: (5 mm H_2O column will be gained by 10°C of temperature difference between surface and underground). 0.117 Weisbach of the overall ventilation resistance has computed when assuming as the fresh air will enter from 0 m main haulage level and exhaust at +120 m present N-adit, and 2,200 m^3/min of fresh air will be required. And when 2,200 m^3/min of fresh air flows through the route mentioned above, its head loss becomes as follows:

$$h = RQ^2 = 0.117 \times \left(\frac{2,200}{60}\right)^2 = 157 \text{ mm column } H_2O$$

In this case, the high head fan will be necessary. If the trackless incline which goes down to +40 m level will be opened from the surface, overall ventilation resistance will sharply decrease to the value of 0.0426 Weisbach and required head becomes only 57 mm column H_2O.

Specification of the fan to be equipped on the portal of present +120 m level N-adit under the consideration of the reverse action of natural ventilation, additional and extension of the incline toward to below 0 m level and other head losses is decided as follows:

Capacity:	2,200 m^3/min
Head:	80 mm column H_2O
Motor:	75 kW

The local fan of 450 m^3/min, with 65 mm head and 11 kW class will be co-operated at the extrime places and branches.

The ventilation system to be adopted on operation shows on Fig. 2·5.

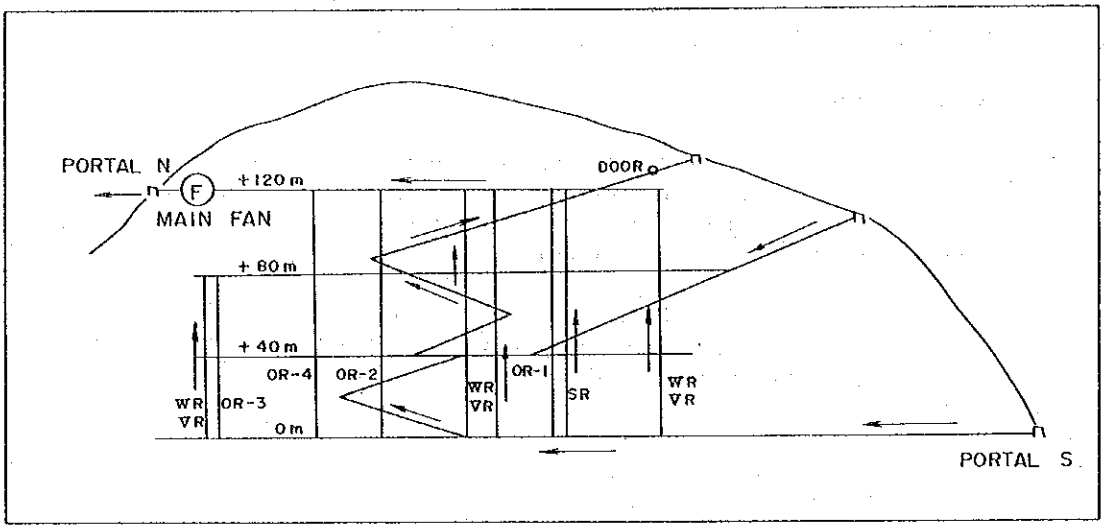


Fig. 2·5 Ventilation System

2.4.3 Water supply and drainage

Water used for the rock drills will be supplied from the water tank located in the concentator with 3" pipe up to the portal of the trackless incline going down to +120 m level, 2" pipe for the inside service shaft and 2" or 1" pipes at the main levels.

Underground water of each levels will be collected to the main haulage level through the trackless inclines by gravity and they flow naturally out through the canal, 50 cm x 50 cm, digged at the corner of the main haulage level.

2.4.4 Other facilities

A mine office, assign work office, warehouse, repair shop and compressor room will be built concentrately beside the portal of +120 m level trackless incline. The magazine will be provided in underground by adit. And repair house with pit for mine cars and locomotive will be built at the portal of 0 m main haulage level.

2.5 MAIN EQUIPMENT AND CONSUMPTION OF SUPPLY AND MATERIAL

2.5.1 Main equipment

Machine and equipment	Unit	Specification
Diesel drive mobile jumbo	6	Mounted 100 ϕmm class drills, 2 booms.
Load Haul and Dump	4	3.5 yd^3 class, 185 HP
Leg-rock drill	12	40 kg class
Stoper	6	40 kg class
Compressor	3	55 m^3/min capacity, 265 kW
Main fan	1	2,200 m^3/min capacity, 75 kW
Local fan	3	450 m^3/min capacity, 11 kW
Electric locomotive	2	Trolley, 8 t capacity
Mine car	15	Gramby type, 5 t capacity

2.5.2 Proposed consumption of supply and materials

Item	Unit	Consumption, annum	Consumption, t per mined
AN-FO	kg	46,700	0.208
Dynamite	kg	78,400	0.348
Cap	pc	82,700	0.37
Fuse	m	97,600	0.43
Diesel oil	ℓ	576,000	2.6

3. CONCENTRATION

3.1 METALLURGICAL TEST

3.1.1 Laboratory test were conducted for the ore samples, which was collected from the underground tunnel, from Oct. to Dec. 1985 to examine basic conditions for a concentrator design and to estimate the performance on operation.

3.1.2 Test samples

Composite of sample: Test samples were taken from the wall at each cross cuts of totaling 3 places as 2 places of S-adit and 1 place of N-adit. However, grade of these samples was so high compared to the proposed grade of the crude ore (Ag 35 g/t, Cu 0.1% Pb 1.61%, and Zn 15.92%), that it seems that these samples will not give a true picture. So that, low grade ore which existed near the boundary of ore body were mixed to make one composited test sample.

Grade: The results of complete analysis of the prepared sample are shown in Table 2.2.

Table 2.2 Complete assy results

Ag (g/t)	80.0	Hg (g/t)	< 0.5
Cu (%)	0.08	Ga (%)	0.004
Pb (")	1.3	Mn (")	0.12
Zn (")	20.5	T-S (")	30.8
Cd (")	0.03	SiO_2 (")	13.6
Sn (")	< 0.005	Al_2O_3 (")	2.0
Fe (")	20.2	CaO (")	4.2
Sb (")	< 0.001	MgO (")	2.1
As (")	0.04	LOI (")	5.8
Bi (")	< 0.001		

3.1.3 Characteristic of ore

Mineral composition: Summarized the results conducted by the observation under the Microscope, X-ray diffraction and EPMA as follows:

(1) Major zinc mineral are sphalerite and is in the coarse grain.

(2) Major lead mineral are galena. There were two types, one is the coarse grain, other includes with the veinlets form in part of pyrite.
Size of galena intrusive into pyrite is in order of 10 micron, and it seems probably concentrate will be yielded with the middling form because of their separation will be difficult.

(3) Chalcopyrite, bonite, covelline, enargite, stannite and others were observed for copper minerals but major ore is chalcopyrite which is disseminated in sphalerite with the size of fine grain and dotted forms. So that, copper will aggregate in the Zn-concentrate due to the difficult separation.

(4) Silver minerals are argentite and canfieldite. Canfieldite exists in sphalerite with the size of 2-10 micron and both canfieldite and argentite are in pyrite with the size of 2 - 20 micron. These silver minerals will move together with sphalerite and pyrite in flotation process while they are too fine and so difficult to separate. Silver will be recovered with two kinds of forms, one is occluded in galena, other is associated in sphalerite with the form of canfieldite.

(5) Iron minerals are pyrite mainly, arseno-pyrite, hamatite and pyrrhotite.

(6) Gangue rocks are mainly quartz, calcite and dolomite, and sericite, chlorite and talc for clay minerals.

Specific gravity and Work index (Wi): 3.8 of specific gravity was measured by the pycnometer for the composite sample and 11.0 kWh/t of Wi expects from the results measured by Hardgrove method.

3.1.4 Flotation test

Selection of flotation methods: Two flotation methods, bulk differential flotation and streight differential flotation, were conducted. Regarding the rougher concentrate, serious difference was not recognized on the recovery of Pb and Zn between both methods. But, recovery of Pb final in Pb-concentrate was very much low at bulk differential flotation compared to streight differential flotation because it will be thought that the flotability of galena is interfered extremely by slaked lime to be added to control pyrite into the cleaner at the bulk differential flotation method, although the recovery of Zn final in the Zn-concentrate shows almost the same value.

Based on the test results, the streight differential flotation method will be favourable for the apprisal on this ore treatment. It will be notice that 60% of silver were recovered together with Zn-concentrate, adopted whichever methods.

Comparison results between both methods are as follows:

	Bulk diff. f.	Streight diff. f.
Pb recovery in rougher (%)	94.0	90.8
Zn recovery in rougher (")	90.8	91.6
Pb recovery of Pb-concentrate (")	44.9	71.6
Zn recovery of Zn-concentrate (")	83.4	86.8
Pb grade in Pb-concentrate (")	59.9	63.0
Zn grade in Zn-concentrate (")	54.4	55.5

Flotation conditions: Based on the results conducted through a series of the test, the optimum streight differential flotation conditions are expected to be;

Grinding size - 200 mesh with 80% pass

	Pb flotation	Zn flotation
Roughing time (min.)	5	10
Stages of cleaning	5	3
Consumption of reagents (g/t):		
Slaked lime	250	1,400
Sodium cyanide	85	-
Copper sulphate	-	300
KAX	70	70
Frother	40	60
pH value in roughing	8.0 - 8.3	11.0 - 11.3

Operation performance: From the results of the batch test, the expected operational performance is as follows:

Concentrate	Grade	Recovery
Pb-concentrate (% Pb)	65	80
Zn-concentrate (% Zn)	52	88

The average recoveries of silver are 15% in Pb-concentrate and 58% in Zn-concentrate respectively.

Characteristic of the concentrate: The results of the complete analysis of Pb-concentrate, Zn-concentrate and tailings obtained from the composite sample is shown on Table 2.3, and assay of waste water delivered from the concentrator is shown on Table 2.4.

Table 2.3 Complete analysis of concentrate

	Pb-conc.	Zn-conc.	tail.		Pb-conc.	Zn-conc.	tail.
Ag (%)	770	150	17	Hg (ppm)	< 0.5	< 0.5	< 0.5
Cu (%)	0.15	0.22	0.02	Ga (%)	< 0.001	0.017	< 0.001
Pb (%)	70.8	0.16	0.10	T-S	17.6	33.1	33.0
Zn (%)	3.6	55.8	0.74	Mn (%)	0.02	0.05	0.13
Cd (%)	< 0.01	0.10	< 0.01	SiO_2 (%)	1.0	1.4	18.9
Sn (%)	0.06	< 0.005	< 0.005	Al_2O_3 (%)	0.30	0.11	2.5
Fe (%)	4.6	7.7	28.6	CaO (%)	0.58	0.04	5.6
Sb (%)	0.043	< 0.001	< 0.001	MgO (%)	0.25	0.03	2.5
As (%)	0.05	0.02	0.08	LOI (%)	-2.3	0.14	5.0
Bi (%)	0.005	< 0.001	< 0.001				

Table 2.4 Assay of waste water

pH	10.5	Zn (ppm)	0.02	As (ppm)	< 0.02
Fe (ppm)	< 0.05	Pb (")	< 0.02	CN (")	0.04
Cu (")	2.0	Cd (")	< 0.01	SO_4 (")	745

3.1.5 Findings

A series of laboratory test indicated that the good flotation performance will be achieved on Limpe's ore body without any complex treatment system or especially high technology although ore has characteristic to be produced with the middling forms in both lead and zinc. However, it is desirable to be conducted bach tests for different kinds of ore and continuous tests by a medium test facility in order to grade up the precision of the basic data, to design a full-scale concentrator, to select the optimum flotation conditions, and to estimate the operational performance because of the existence of characteristic of yielding the middlings might be influenced on the floatation performance, specially on Pb floatation.

3.2 CONCENTRATOR

3.2.1 Outline

Concentrator treats 225,000 t annum with 300 operation days an annum and produces Pb-concentrate and Zn-concentrate adopted with the streight differential flotation method. The daily average capacity of the plant is theoritically 750 t, but to compensate a fluctuation of the crude ore to be delivered from the mine and for the interruption by repairs, the treatment tonnages will be put on 825 t/day at the maximum capacity. The operation of ore receiving and crushing plant will be in two shifts per day to co-operate the mining and three shifts per day for the down-stream sections after crushing. The ore adjustment will be controlled by the fine ore bins.

The location of the concentrator will be about 800 m south away from the present S-adit portal considering the location of the portal, topography and foundation, and the tailing disposal. The concentrator will be divided to two, one is crushing plant and other is down stream's plant, with consideration of the relation between elevation of the main haulage level and the final elevation of tailing dam, and both plants are connected with the belt conveyor.

The construction of plants are the semi-buried horizontal type for the crushing plant and the inclined type for grinding, flotation and filtration plants agreed with the topography.

3.2.2 Design parameters

Basic conditions: Judging from the metallurgical test results, crude ore is considered to be easily concentrated without any special technique and treatment system, and the streight differential flotation is better than the bulk differential flotation. Basis designs of plant for reducing the initial investment and operation cost are as follows:

(1) Process should be standarlized and simplified as much as possible.

(2) Two rows of grinding and flotation will be adopted.

(3) No high instrumentation should be equipped and only a few members of major sections will be automatized.

(4) Washing facility is not provided since a little amount of clay are expected in the crude ore.

(5) The construction of the buildings will be simple and special attention of equipment's layout should be paid to obtain high efficiency and easy operation.

(6) Number of pumps will be eliminated to be adapted a incline plant.

(7) Recycled water should be used as much as possible to reduce the water cost.

Ore treated :	Average Grade (%)	Cu 0.10, Pb 1.16, Zn 15.92
	Average Grade (g/t)	Ag 35
	Specific gravity	3.8
	Average water content (%)	5.0
	Grinding work index (kWh/t)	11.0
Crushing :	Crushing process	Two stage closed circuit
	Max. feed size (mm)	500
	Receiving ore bin capacity (t)	200
	Max. hourly capacity (t)	90
	Final product 80% size (mm)	12
Grinding :	Grinding process	Ball mill - Classifier closed circuit.
	Fine ore bin capacity (t)	800
	Max. hourly capacity (t)	34.4
	Circulating load (%)	250
	Classifier o'flow density (%)	40
	Final product 80% size (micron)	74

Pb Flotation :		Density (%)	Time (min)
	Conditioning	40	2
	Roughing	40	10
	Cleaning	20	9
	Stage of cleaning	5	
	pH value in roughing	9	
	Grade of concentrate (% Pb)	65	
	Pb recovery (%)	80	

Zn Flotation :		Density (%)	Time (min)
	Conditioning	35	2
	Roughing	35	15
	Cleaning	25	7
	Stage of cleaning	3	
	pH value in roughing	11	
	Grade of concentrate (% Zn)	52	
	Zn recovery (%)	88	

Regrinding :	Feed	Zn cleaner tailing and scavenger froth
	Regrinding process	Ball mill - cyclone closed circuit.
	Feed size, 80% pass (micron)	147
	Product, 80% pass (micron)	74

Filtration :

	Pb-conc.	Zn-conc.
Thicknener spigot density (%)	45	45
Size of conc. (-200 mesh %)	90	85
Apparent specific gravity of conc.	3.1	2.0

Tailing thickening :

Method treated	Callow cone- thickener, 2 stages
Density of Zn-flotation tailing (%)	25
Density of thickener feed (%)	22
Density of callow cone spigot (%)	45
Density of thickener spigot (%)	40
Precipitation speed of tailing (mm/min)	9.8

3.2.3 Concentration process (Refer to Drawing 007, 008 & 009)

Receiving crude ore: Ore mined out is transported by a train composed to a 8 t trolley locomotive and ten 5 t gramby cars. A receiving ore bin, which is made of concrete with reinforced iron bar and 200 t capacity, is installed to adjust the operation hours and tonnages. A 50 cm x 50 cm screen on the top of the bin will be provided to control the oversize, and oversize is broken by a hydro-breaker installed beside the screen.

Crushing: Crushing plant consists of a series with two stages closed circuit and major equipment are a primary crusher, a secondary crusher and a vibrating screen copped a closed circuit with the secondary crusher. Ore stored in the receiving ore bin is drawn by a 40" apron feeder and fed to a 42" x 30" single toggle type crusher, and after crushed, fed to a 6' x 14' double deck vibrating screen (40 mm opening in upper screen, 15 mm opening in lower screen) and screened. Oversize are crushed by a 5' hydraulic cone crusher and fed again to the vibrating screen. Under of the vibrating screen are conveyed with a 24" belt conveyor to the fine ore bins

This storage bin consists of two 400 t capacity each made by the round shaped corrugate iron plates, and a 24" wide shuttle conveyor installed on the storage conveys ore to each ore bin.

Grinding: Grinding plant comparises two identical parallel circuits, each equipped with a 9' x 12' ball mill and a 72"ϕ spiral classifier co-operated with a closed circuit. Ore are drawn by a 20" belt feeder equipped the speed changeable motor.

Flotation: The flotation will be conducted in the streight differential flotation method, and the plant is divided to two of Pb flotation and Zn flotation sections. Two rows of 8 cells x 60 ft^3 for roughing and a row of 10 cells x 21 ft^3 for cleaning will be provided in the Pb flotation section. And Zn flotation section will be composed of two rows 18 cells x 60 ft^3 for roughing and two rows of 9 cells x 36 ft^3 for cleaning.

Cleaning of the rougher froth is done in 5 stages arrenged in 3-3-2-1-1 at Pb flotation section and in 3 stages of 4-3-2 at Zn flotation section. Pb cleaner tailing will be returned to the grinding circuit, because much amount of

middlings composed of galena and pyrite may be existed in tailing. While both cleaner tailing and scavenger froth at the Zn flotation section may be composed of the middlings which is matrixed finely with sphalerite and pyrite, and fine grained chacopyrite stopped into sphalerite, they will be reground.

Regrinding: The plant consists of a 6' x 6' ball mill and a 6"ϕ cyclone copped with the closed circuit, and grinds the cleaner tailing and the froth of scavenger. Overflow of cyclone is returned to the Zn rougher system.

Filtration: After the froth of final Pb cleaner is thickened with a 20'ϕ thickener, it is dewatered with a 17 ft^2 x 6 cambers pressed type filter. The filter cake is stored in a Pb-concentrate yard of 600 t capacity after weighed with the belt scale. The froth of Zn final cleaner is thickened with a 30'ϕ and dewatered by a 17 ft^2 x 14 chambers pressed type filter and stored in a Zn-concentrate yard at 5,000 t capacity after measured by the belt scale.

The thickener overflow is recycled and reused in the concentrator, and concentrates loaded on a truck with a shovel loader from the yard is shipped after weighed with a truck scale.

3.2.4 Auxiliary facilities

Reagents: All reagents to be used at both Pb and Zn flotation sections are transported to the each distribution rooms after dissolved and adjusted in a regent room located in beside fine ore bin. They will be supplied to each necessary places after adjusted by the cap feeder or the flowmeter at the distribution room. Slaked lime will be used for pH value control.

Instrumentation: Instrumentation in the plant is conducted at the necessary points for indicating and monitoring. The following are installed;
Weightometer will be at fine ore bin, feed conveyors to ball mills, and each Pb and Zn-concentrate conveyors. pH meter will be installed at the outlet of each Pb and Zn conditioners.

Samplers: Wet type samplers will be provided at feed of Pb flotation, each Pb and Zn flotation tailings, and a dry type sampler is on each conveyor of Pb and Zn-concentrate.

3.2.5. Principal unit consumption

Items		Consumption
Supply and material (g/t)		
Ball for ball mill		1,200
Slaked lime		4,000
Sodium cyanide		80
Potassium amyl xanthate		140
Copper sulphate		300
Frother		145
Frocculante reagent		5
Power (kWh/t)		37.3
Water (m^3/t)	Fresh	2.41
	Recycle	1.03
	Total	3.44

4. ENVIRONMENTAL FACILITIES

4.1 TAILING DISPOSAL

4.1.1 Outline

The tailing disposal facilities conform from the thickening equipment for Zn flotation tailing, a series of pipe line and a tailing pond. Overflow separated from solids at tailing thickener is reused in the concentrator. Tailing thickened is send to the tailing pond through pipe line, and overflow from the pond is discharged into Yarahuaino valley.

4.1.2 Thickening and transportation system

Tailing of Zn flotation having 25% solid of pulp density is thickened to 40% with two stages of 18'Φcallow-cone and 50'Φthickener. Thickener overflow separated from solids is pumped up to be used at Zn flotation section.

Both underflow come from the callow-cone and thickener are mixed and delivered to the reservior of 8 m^3 made of concrete. Then, from there it is fed to a 10"Φcyclones installed at the embankment creast. Natural flow by gravity will be adopted during seven years after operation starts, although the proposed tailing pond locates in 400 m apart from the concentrator and 25 m difference in elevation. But, operation by pump will be required after seven years due to rising of the embankment.

4.1.3 Piling

Slurry transported from the reservior is classified to two parts, sand and slime, with two 10"Φcyclones, and sand is used for banking materials and then slime is deposited separately behind sand. Proposed ratio between sand and slime will be 50% to 50%. Clear water separated from solids are collected at the upper stream of the pond and delivered to outside of the pond and discharged into Yarahuaino valley through the dicant towers and underlaing culvert.

4.1.4 Tailing pond

Selection of site: Two site, Pachangara valley and yarahuaino valley, were surveyed for comparision purpose. Consequently, the latter was selected for the following reasons:

(1) The area locates nearer to concentrator and it exists lower elevation than concentrator, so that transportation of slurry is easier.

(2) Area able to be seen a glance over from concentrator, as a result, good communication and closed attention on operation will be obtained.

(3) A spare area will be available to be expanded in the future.

(4) There is no big domestic residents in the down stream.

(5) Suitable construction materials can be obtained in the neighbourhood.

Topography: This area is surrounded by two hills, northern side (right bank) to the ridge of 5,000 m and southern side (left bank) to be extended to the ridge of 5,200 m. This valley is formed U-shape to the glacial movement bounded at 4,400 m and expanded widely to the upper stream. The back side is cliffed with wall running to N-S direction of 5,000 m high, and the lake Tinyag lies underneath of it.

At the down stream bounded 4,400 m, hard rocks are exposed in both banks and forms the sharp V-type nallow valley. In the left bank of the valley where is bounded to the U-shape valley, there are the large scale and many numbers of talus which starts from 4,800 m in elevation and ends at the valley bottom. Therefore, the pond will be constructed at elevation of 4,485 m to avoid the talus, while the end of down stream side should be above level of talus.

Type of tailing pond and its capacity: Sand and slime separate type dam will be adapted. Slurry is separated to sand and slime before piling, and slime (overflow of cyclone) is discharged toward to upper stream from the bank creast and clear water is delivered to the outside of the pond through the underlaing culvert. The pond capacity is in totalling 2,140,000 m^3 with about 878,000 m^3 of sand and 1,262,000 m^3 of slime, which is sufficient through the planned operation period.

Dam: A sand banking dam which is utilized only sand separated by the cyclones will be adopted. The dams constructed by stones will be built at both the upper site and lower site of proposed dam, and connected with under drain between both dams. The dam should be prevented from rising the water table of the embankment. Inside dam slope will be one to five during the construction period, but 5 meters wide of the step in every 10 m high will be maintained with the progress of the dam and a cut off will be done into the dam foundation to prevent the growth of water leakage for keeping the stability of the dam.

Drainage facilities: There are 7.4 km^2 of the catchment area but 2/3 of them are occupaied by the catchment of the lake Tinyag. As the catchment area is rather small and the surrounding hills are gently sloped with grass, no diversion channel is constructed. The rain-fall water in area will be discharged to the outside together with clear water of the pond through the drainage facilities. The demension of the culvert made by concrete is to 800 mmϕ and the decant tower will be provided every 1 2 m for removing clear water.

The design parameter for the drainage facilities are as follows:

Rainfall (mm/day)	48.2
Catchment area (km^2)	7.4
Run-off coefficiency	0.8
Clear water separated from slurry (m^3/sec)	0.020
Waste water (m^3/sec)	0.067
Rain-fall water (m^3/sec)	3.290
Maximum cuvert capacity (m^3/sec)	3.377

Construction schedule: The construction works which has enough capacity for six years operation will be carried out during the construction period and the remains will be again progressed at the time when five years operation passed.

4.2 TREATMENT FOR THE UNDERGROUND WATER

4.2.1 Nature of underground water

Water encountered at each levels flows through the canal on the trackless inclines by gravity and gathers at 0 m main haulage level, and delivers to surface through the canal of 50 cm x 50 cm by natural flows. Volume will vary by seasons, but the treatment should be conducted before discharge into the river due to pollution occurred by passing-through pyrite zone and stopes, such as low value of pH and contamination of slime and muds. Determination of water volumes and its nature is difficult due to lack of information, but based on the tunnel and boring carried out, volume will be suspected to 0.5 m^3/min in the dry season and 4.0 m^3/min in the wet season with average 1.5 - 2.0 m^3/min in annum, and pH value will be 2 - 3 through a year although varied slightly higher in the wet season.

4.2.2 Treatment

Underground water is guided up to the tailing pond by the canal constructed along the surface main haulage track. It treats to mixing together with the clear water of the pond having 11.0 of pH value as the same as value of Zn flotation tailing. Besides, slaked lime will be added to rise pH value at the canal on the way to go to tailing pond with the form of milk which is adjusted at the concentrator reagent room and delivered through pipe line. Proposed lime requirement for treatment expects to 1.5 t per day. Underground water adjusted on the normal value with mixing clear water and adding the lime will be discharged to the outside through the dicant tower and culvert. Also, suspension materials containing underground water are precipitated into the slime pond.

5. OTHER PLANS

5.1 POWER SUPPY

5.1.1 Mine power plant

Power supply for Iscaycruz mine can not espect to purchase from Electro Peru or other company because there is still on project finding or planning stages to be constructed the electric plants in this district. Own diesel generators of maximum output 2,500 kW will be provided to supply power on mine operation after consideration with comparison of three alternatives; construction of hydraulic plant, own diesel generator and purchase of power transmitted from far away.

5.1.2 Power requirement and voltage used

Power requirement: Maximum power requirement for the production and welfare facilities will be about 2,500 kW (average about 2,000 kW) and total annual requirement will be about 14,557 MWh which are distributed by department as follows:

Department	Max. power requirement (kW)	Average requirement (kW)	Power consumption annum (kWh)
Mining	620	414	2,981
Concentrator	1,460	1,167	8,402
Water supply	70	58	418
Auxiliary facilities	90	32	230
Welfare facilities	300	240	2,102
Subtotal	2,540	1,911	14,133
Max. resultant power	2,420		
Loss	70	57	424
Total	2,490	1,968	14,557

Voltage: Efficiency of the insulation will be deteriorated corresponding to rising of the elevation depend on the air insulation applied on the electrical apparatus and the same tendency will be on temperature limit. Therefore, rated voltage selected for each of these load facilities are listed below, while correlation factor of the insulation on the electrical apparatus is in about 53% for about 4,600 m elevation of mine site.

High voltage motor : Out put 110 kW or more, 3-phase, 2,200 V, 60 Hz
Low voltage motor : Out put 110 kW or less, 3-phase, 220 V, 60 Hz
Lighting/heating : Single phase, 220/110 V, 60 Hz

However, rated voltage for machinaries used is standardized as 600 V for low voltage, 7,200 V for high voltage.

5.1.3 Power plant (Refer to Drawing 011)

Diesel Generator: Correlation for output will be necessary since it will be installed in the elevation of 4,600 m. Based on British Standard of 649 "Output will be decreased of 2.5% for every 300 m high between from 150 m to 2,500 m in elevation when generator is installed in over 150 m in elevation.", 37.1% of correlation factor for the output will be calculated at 4,600 m elevation if applied proportionally over 2,500 m.

Therefore, capacity of the generator to be installed at mine site for matching the demand of mine operation is as follows:

$$2{,}500 \text{ kW} \div (1-0.371) \fallingdotseq 4{,}000 \text{ kW}$$

Five units of each average capacity 820 kW with the super charger and 1,200 rpm will be provided.

But, spare unit will not consider to eliminate the initial investment, and the lack of power occurred during overhaul of them and repair is adjusted by load factor. Generators of two 175 kW and a 75 kW used during the construction period are installed in the power house and utilized for the spare and emergency use.

Comparison among power supplying methods: Results studied among construction of hydraulic plant, diesel generator and purchase of power are as follows:

(1) Possible site to be constructed the hydraulic plant are chosen at two places: one is at Oyon, used the currents of Rio Paton and Rio Pachangara, other is at Viroc used the current of Rio Huaura.

These specification are as follows:

	Oyon	Viroc
Elevation of intake (m above sea level)	3,450	3,140
Elevation of plant (")	3,180	3,000
Length of canal (m)	4,200	1,300
Hight difference (m)	255	135
Min. water volume to be used (m^3/min)	2	3.2
Minimum out-put (kW)	4,000	3,400

(2) Comparison of present value between hydraulic plant and generator

Comparison of present value between hydraulic plant at Viroc and diesel generator at mine site are estimated as follows:

Assuming 10 years of mine life (n) and discount factor of 9% per annum (i),

$$\text{Present value} = \text{Initial investment} + \left(\text{Annual operation cost} \times \frac{(1+i)^n - 1}{i\,(1+i)^n}\right)$$

	Hydraulic	Diesel generator
Initial investment ($1,000)	10,145	3,769
Operation cost (")	88	1,450
Present value (")	10,710	13,075

Hydraulic plant seems available than diesel generator but, diesel generator method was decided on this report because of lower investment and shorter time compared to construction of hydraulic plant and the mine life is assumed on 10 years.

(3) Purchasing power

There are two sources to be transmitted power, one is from Hidro Andina S.A. and other is from CENTROMIN. The further will be favourable on the view of the commercial bases. In this case, the nearest hydraulic plant of Hidro Andina S.A. locates in Cahua, about 65 km far from the mine site in direct, but length of transmission line required will be over 100 km with voltage of 60 kV. However, the private mine company can not afford to construct the such long transmission line and to keep the good condition them always. Therefore, it is impossible to purchase power from the outsides.

5.1.4 Power distribution (Refer to Drawing 012)

Four substations will be provided and connection to the generator is performed at the main station. The stations and distribution line laying are as follows:

Main substation and concentrator substation: The combination substations of the main station and concentrator station will be built at the most upper level of concentator having the biggest demand. The main substation will consist of the receiving boards from the generator and transmitting boards with three lines to transmit to mining, water pump, auxiliary and welfare substations. At the concentrator substation, receiving panels, starter panels for high voltage motors, transformer of 2,200V/220V, distribution panels for low voltage motors to be connected to the each blocks (crushing, milling, flotation, filtration and others) and condesner for compensate the efficiency will be installed.

Mining substation: Substation will be provided near mine portal of 4,715 m elevation. Power will be supplied through 2,200 V transmission line from the main substation. Starter panels for compressor, transformer 2,200V/220V, and panels for low voltage motors will be installed. Also, substation which is branched from the line laying from the main substation to mining substation will be built near the portal of the main haulage track and transformer for low voltage power, panels for low voltage power and direct current panels for the locomotive are installed.

Water pumping substation: The substation will be provided near the pump station located in the south end of lake Quellaycocha and receives with 2,200 V from the main substation through the transmission line. The cubicle type station which consists of the transformer of 2,200V/220V, panels for low voltage and control panels for pumps is installed.

Auxiliary and welfare facilities station: These area will be also supplied with 2,200 V feeder line from the main substation. One transformer on platform will be provided auxiliary zone for supply low voltage power to the central office, warehouse, mess and others. The special attention of power shut-on-out will be provided to adjust the load requirement at the auxiliary and welfare facilities with off-on siwtches acted automatically when emergency happens. Other three platform will be provided to supply power with low voltage at the residential area.

Others: The transmission lines, except the line of the main substation to concentrator, pass through the western side of lake Tinyag and Quellaycocha and are supported together with the same supporters.

5.2 COMMUNICATION

5.2.1 Outline

The wire telephone system is sufficient at the districts along Pacific ocean coast but not enough at the mountain districts. Only one line was operated by ENTEL-Peru between Sayan - Churin - Oyon, so that it can not service for the mine needs. Therefore, to provide the own communication system will be necessary.

5.2.2 Radio communication system

The radio station that is the same system applied generally at the mines in Peru will be installed at the mine and Lima head office for inter communication. The opertion frequency will be 150 or 400 MHz band, and emergency power sources will be provided at the mine station.

5.2.3 Wire telephone system

Automatic crossbar 96-line switch board which will be able to connect to a public line in future at the Churin station, will be provided in the central office and the telephone sets will be positioned as listed below:

Item	Unit	Remarks
Mining	12	Surface facility and main levels at underground
Concentrator	5	Includes assay, labo, and tailing Pond.
Water pumping station	2	Includes purification plant.
Power plant	2	
Auxiliary facilities	14	Central office, repair shop and warehouse and others.
Welfare facilities	15	Camp houses, quarters, club and canteen
Total	50	

5.3 WATER SUPPLY FACILITIES

5.3.1 Requirement

Total water requirement will in amount of 909,000 m^3 an annum. However, used water will be re-cycled in concentrator as much as possible, so that freshed water requirement will be amount of 685,500 m^3 an annum.

Industrial water: About 96% of industrial water will be used in concentrator alone. In order to reduce the water cost, about 30% of total needs will be recycled. Detail are as follows:

(m^3/day)

	Fresh water	Recycled water	Total
Concentrator	1,800	780	2,580
Mining	100	-	100
Repair shop, others	20	-	20
Total	1,920	780	2,700

Domestic water: The required amount is 109,500m^3 (300m^3/day) will be consumed at the welfare facilities. The population of the residential area will be estiamted to reach 1,500 including the family, and maximum consumption for person per day will estimate to 200 liters.

5.3.2 Suppling method and facilities

Selection of water source: There are no river in mine area excluding some creeks which flow little in the wet season. Rio Pampahuay or its branch will be in source when water pumps up from the river. In this case, it is in distance of 8 km from the proposed point to mine site, and 700 - 800 m high ridge locates on the way. It seems it is not recommendable in economics to establish this system consisted of pumping equipments and apparatus, power line for them and pipe line and others, and it is too difficult to maintain the such system.

Therefore, the lake Quellaycocha, in 800 m long, 300 m wide and 10 m deep, located in 3.5 km north of the concentrator is selected as the source of industrial and domestic water. 1,080,000 m^3 of flow-in to the lake an annum will be expected and it enough meet to the mine requirement, based on the observation records such as the isohyet chart at Rio Huaura area and rain-fall in mines conducted by SENAMHI and the operated mines (Raura, Paton, and Uchuc Chacua).

Intake facilities and delivering system: Water of lake delivered from the pontoon, which is equipped a turbine pump and is copped with the water level varing in seasons, will be pumped up till the pump station situated in beside the lake. Each two turbine pumps, including the spare, of 1.5 m^3/min for industrial and 0.3 m^3/min for domestic will be provided in the station.

Industrial water is pumped up by 6"ϕ x 1,500 m pipe line to the reservoir tank (170 m^3) situated at near the ridge of 4,800 m high and delivered to concentrator, mining and repair shop and others by 6"ϕ and 3"ϕ pipe lines by gravity.

Domestic water will be pumped up to the filtration tank through 4"ϕ x 1,000 m pipe line, and after filtrated water is sterilized with sodium hypochlorite, treated water will be distributed to the each houses through pipe lines by gravity.

5.4 AUXILIARY FACILITIES

5.4.1 Outline

This works are composed of the construction of main access road to the mine, inside mine road, buildings such as central office, repair shop, warehouse and others, and purchase of the common vehicles used during the operation period.

It is an important factor for mine activity there is the road which is connected to the outside and maintained well. However, there is only a road which was constructed for the prospecting purpose on survey by Cooperative Mineral Exploration and probably it is available 6 t class truck will pass on it. So that new road construction will be necessary. In addition, improvement and construction of the detour on public roads between Oyon and Mishuya will be necessary.
Central office, warehouse, repair shop and others will be accommodated in the production zone to keep a good communication and administrative control.
Vehicles for the common use such as administratives, concentrates loading, road maintenance, supply material and so on and bus to be operated on schedule are purchased.

5.4.2 Road construction

Standard of road is : 4 m wide, max. inclination of 6%, single lain and sand and gravel pavement. The canal will be provided in mountain side but without special treatment, and some concrete culvert will be underlain to be drained into the valley accross the road. The sidetrack will be also provided when necessary. Fig. 2.6 shows the location to be improved and newly constructed.

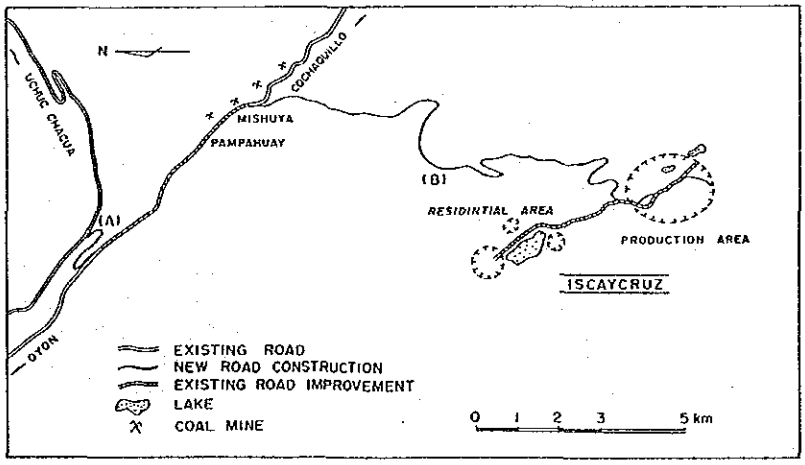


Fig. 2.6 Access Road Plan

Road construction (A): To avoid from passing the present route, new detour road of 1.5 km to be connected to Uchuc Chacua from the suburb of Oyon will be constructed because of the parts of road at the suburb of Oyon is stopped traffic by the soft ground and landslides occurred frequently during the wet season.

Improvement: Improvement works of 7 km long will be conducted to the road between the newly constructed detour road and Mishuya.

Road construction (B): 11.0 km of road between Mishuya to Iscaycruz will be constructed. The present road was tentatively constructed for the survey by Cooperative Mineral Exploration, so that it can not cope with the mining activities due to it has a many steep points of average 1/10, and its curvature was too small and besides, surface was not good.

Improvement of inside mine road: 4 km of improvement and new road of 4 km to be connected closely between the buildings will be provided at the production and residential areas.

5.4.3 Building and related construction

Central office: A one-story building made of concrete blocks, with a total floor area 150 m^2 will be constructed as the mine management center which will accommodate the mine manager, assistant mine manager and office staffs.

Repair shop: All mechanical and electrical machinaries and apparatus except them of mining department and common used vehicles will be repaired. It will be located in adjacent to the concentrator highly utilized, and equipped with lathe, drilling machine, shaper, grinders, welding machines and others.

Central warehouse: Divided into the mechanical-electrical parts storage and general storage. A one-story building with the steel frame; floor area of 600 m^2.

Mess: A one-story building made of concrete blocks with 150 m^2 in floor area will be built ajacent to the central office and serves foods during the working hours, and the seating capacity is 70 at a time.

Others: Parking for concentrates transportation trucks, weighing room with 30 t capacity of truck scale and guard houses and others will be provided.

5.4.4 Purchase of vehicles for common use

Item	Specification	Unit	Remarks
Pickup	400 kg	3	General use
Jeep (large type)		2	General and clinic
Bus	45 persons	1	General
Bulldozer	14.0 t class	1	Road maintenance
Shovel loader	1.2 m^3	1	Concentrate loading
Forklift	1.5 t	1	Repair shop and warehouse
Truck	8.0 t	1	General cargo

5.5 WELFARE FACILITIES

5.5.1 Residential population

Total of mine employees and workers including expatriates are 403. The pupulation that is the factor of the residential and various facility plan will be estimated as follows. The ratio of the single to the married will be go down following the progress of the operation although the single will be remarkably higher than the married in starting time of operation. Ratio of the single to the married is assumed to be 30% to 70% both the employees and workers and the number of a family of each married person will be assumed to be four in total, composed with wife and three children. All staffs are in married but out of 30% will be resident in mine site and 70% will be stay in mine site separated from the family, and all expatriates will be alone.

The detail of the population are as follows:

	Single	Married	Family	Total
Expatriate	3	-	-	3
Staff	21	9	36	66
Employee	20	46	184	250
Worker	91	213	852	1,156
Total	135	268	1,072	1,475

5.5.2 Location and layout of welfare facilities (Refer to Drawing 013)

The site is selected near the lake Quellaycocha apart completely from the production area. There will two residential site separate; one for staffs and other for employees and workers. Necessary services for their daily needs such as school, medical, recreation and shopping, and social service facilities will provided at the area between both the residential areas.

5.5.3 Residential houses and others

For employee and worker: 44 of three-stories building made of concrete blocks will be constructed for the married employees and workers. One story consists of two houses of 80 m^2 composed of a living and dining room, 3 bed rooms, bath-shower room, kitchen. A quarter made of concrete blocks with one-story with 20 rooms will be built for the bachelor employees, and each room of 15 m^2 is occupied by one parson. The bath and shower facilities will be provided one for every two rooms. Also, two quarters with 16 rooms of one-story will be built for the bachelor workers, and one room with 24 m^2 is occupied with three persons and a bath and shower facilities will be provided for every two rooms.

For staff: Five buildings of one-story made of concrete blocks will be constructed which consists of two houses of 90 m^2 with the same arrangement as the employee and worker house. For bachelor, two quarters having 12 rooms and 10 rooms, respectively, will be provided and one room with 20 m^2 is occupied by one person and prepared a bath and shower room for every two rooms. For

expatriate, they will accomodate in the club house, which is constructed at the staff residential area.

Other: Furniture will be completely prepared for the staff house but no furnished for employee and worker house except electrical heating facilities.

5.5.4 Social service facilities

School and kindergarten: A elementary school with the capacity of 540 children will be constructed as the two stories building made of concrete blocks with the floor area of 1,200 m^2, which will be divided into 20 rooms of 15 rooms for the class room, 3 rooms for the special room and 2 rooms for the teachers.

A kindergarten with the capacity of 100 children will be constructed as one story building made of concrete blocks with the floor area of 250 m^2.

Medical facilities: A one story clinic with 10 beds and consultation, dental, operation, X-ray, phermacy and waiting room will be built with the floor area of 720 m^2, and two doctors, one phermacist, one midwife and two nurses will be stationed fully.

Canteen: A one story canteen of 400 m^2 will be constructed for supplying the foods, clothes and daily goods and it will be divided to two of sales-corner and storage.

Club houses: A one story club house with the floor area of 420 m^2 will be built and it has 7 rooms for the welcome reception and overnight stay of visitors and expatriates at the staff residential area. And other a one story club house with 200 m^2 will be provided without any facility of overnight stay at the employee and worker residential area.

Recreation and others: One tennis court will be at staff residential area and one soccer court will be prepared at the employee and worker residential area. A guard house will be built at the entrance of each residential areas, and the security man will always be stationed. And, social service office will be associated to the clinic building.

5.5.5 Domestic water supply and sewage disposal

The domestic water is fed from a water tank, located in 4,720 m high between the staff and employee & worker residential areas, through the pipe lines to each houses and facilities by gravity.

The sewage from the houses will be collected through underground sewage pipes which are constructed at the staff and employee & worker residential areas, separately, and made harmless before discharge into the river.

The rubbish come from houses will be collected and burried in an favorable place of unused area.

5.6 Detailed Survey

5.6.1 General

The collaborative mineral explorations to be carried out up to the present in the Iscaycruz (Oyon) district are as follows:

1979-1981 (Phase I): Geological Survey, Geochemical Survey, Geophysical Survey, Drilling
1982-1984 (Phase II): Drilling, Tunneling

However, further advanced survey should be done to delineate the mine development concretely and precisely, because some subjects to be known more detailed still remain. Namely, by the survey results obtained till now, the mineral occurrences of ore deposits which is one of some important preconditions to design the development planning are grasped roughly, but the calculated results of ore reserves and ore grades are not so high in accuracy. Therefore, it is assumed that subsequently detailed survey should be carried out to clarify in detail for the above mentioned matter and to study characteristics of ore, lithologic character and flotability of mineral, and regular development planning must be designed and discussed based on data got additionally

5.6.2 Contents of Detailed Surveys

In the first place, detailed surveys by drilling and tunneling are planned to confirm the horizontal and perpendicular shape, elongation and occurrence of ore deposit, ore reserves and ore grades forcussing the target to the limits above S-adit level (4,570 m/above sea level) of Limpe ore deposit, and in addition, declined drillings at S-adit are also planned to grasp the ore potential of the limits below S-adit level. Contents of planning are shown in Table 2.5 and Table 2.6.

Table 2.5 Tunneling

	Level	Quantities (m)	
Tunnel	4,690 m (N-adit level)	320	drifting in upper ore body
	4,637 m	380	drifting in lower ore body
	4,570 m (S-adit level)	460	drifting in upper ore body
Trackless inclined shaft		383	surface ~ N-adit level, N-adit level ~ 4,637 m level
Raise etc.		220	4,637 m level ~ N-adit level, S-adit level ~ 4,637 m level
Total		1,763	

Note; be executed in (-5) (-4) years, a period is 18 months

Table 2.6 Drilling

Level	Numbers (holes)	Quantities (m)	Remarks
N-adit (4,960 m)	22	1,080	
4,637 m	27	1,280	
S-adit (4,570 m)	29	1,295	
"	7	710	for the limits below S-adit level
Total		4,365	

Note; be executed in (-5) (-4) years, a period is 24 months

6. SUMMARY

6.1 PRODUCTION PLAN

Mining will be started from the ore existed above the present S-adit surveyed closely. Parameters of the production plan are listed below:

6.1.1 Ore Reserves and Mineable Ore Reserves

Location	Kind of ore	Tonnage (1,000t)	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)
Ore reserves in full area						
Limpe	Pb·Zn	3,257	48	0.13	1.95	18.99
Limpe	Cu	102	32	2.84	0.03	0.39
Limpe-S*1)	-	1,461	10	1.85	0.01	19.59
Above present S-adit						
Ore reserves						
Limpe	Pb·Zn	2,050	42	0.11	1.89	18.72
Mineable ore*2)						
Limpe	Pb·Zn	2,050	35	0.10	1.61	15.92

Remarks: *1) Limpe south

*2) Assumes 85% of mining extraction factor
15% of contamination of waste

6.1.2 Production per Annum and Mine Life

Production per annum : 225,000 t (750 t x 300 days)

Period to be mined : 9.1 yrs (But, 10.0 yrs of mine life was made on the assumption since ore reserves will be increased due to the further prospecting.)

6.1.3 Production of Concentrates (Process of Concentrator)

	Tonnage (t)	Grade				Recovery (%)			
		Ag (g/t)	Cu (%)	Pb (%)	Zn (%)	Ag	Cu	Pb	Zn
Crude ore	225,000	35	0.10	1.61	15.92	100.0	100.0	100.0	100.0
Pb-concentrate	4,458	265	0.20	65.00	4.02	15.0	4.0	80.0	0.5
Zn-concentrate	60,618	75	0.26	0.26	52.00	58.0	70.5	4.3	88.0
Tailing	159,924	13	0.03	0.36	2.58	27.0	25.5	15.7	11.5

6.2 MANPOWER REQUIREMENT

The all production activities excluding concentrate transportation will be directly under the administration of the company management, and working days per man-year are 260 days. In the estimation of manpower requirement, this condition is considered to arrive at the total requirement. For work requiring 3-shift operation, a schedule of off- day will be formulated and implemented.

6.2.1 Organization Chart in the Mine

Department	S	E	W	Total	Department	S	E	W	Total
Mining:					Administration:				
Underground	6	8	120	134	Secretariate	2	1		3
Surface	2	2	44	48	Accounting	1	3		4
Safety	1	1	5	7	Purchasing	1	2	5	8
Total	9	11	169	189	Transportation		1	7	8
					Total	4	7	12	23
Geology:	3	4	20	27	Personnel & Welfare:				
Concentration:					Personnel	2	2		4
Concentrator	4	12	30	46	Social security	1	1		2
Assy & labo.	1	1	7	9	Canteen		1	5	6
Total	5	13	37	55	Mess, quarters		1	8	9
					Guard etc.		2	10	12
Power plant:	1	4	9	14	Total	3	7	23	33
Maintenance:					Others:				
Machine	1	2	15	18	Clinic	3	3	2	8
Electric		1	5	6	School etc.		12	2	14
Civil	1	2	10	13					
Total	2	5	30	37	Grand Total	30	66	304	400

6.2.2 Organization Chart in Lima Head Office

Department	S	E	W	Total
Board:	2			2
Administration:				
Legal, account.	1	2		3
Purchasing	1	2	2	5
Services		1	3	4
Total	4	5	5	14

Remarks:
S : Staff (Include boards, Mine manager and Asst. mine manager)
E : Employee
W : Worker

But included the following personnels, 3 expatriates in the mine site, and an expariate in Lima office. Also, one attorney and accountant will be in Lima at part timers basis.

6.2.3 Organization Chart