INFRASTRUCTURE DEVELOPMENT PLANNING
FOR
THE FAMATINA
THE REPUBLIC OF ARGENTINE

MARCH, 1981

Japan International Cooperation Agency
Metal Mining Agency of Japan
Government of Japan

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PREFACE

It is with great pleasure that we present this report entitled Infrastructure Development Planning for the Famatina mine in La Rioja province to the Government of the Republic of Argentine.

This report embodies the result of a regional development survey which was carried out from October 16 to November 14, 1980 by the Japanese survey team commissioned by the Japan International Cooperation Agency and the Metal Mining Agency of Japan following the request of the Government of the Republic of Argentine.

The survey team, headed by Mr. Masamitsu Toriyama, had a series of close discussions with the officials concerned of the Government of the Republic of Argentine and conducted a wide scope of field survey and data analyses.

I sincerely hope that this report will be useful as a basic reference for development of the region.

I am particularly pleased to express my appreciation to the officials concerned of the Government of the Republic of Argentine for their close cooperation extended to the Japanese team.

MARCH, 1980

Keisuke Arita
President
Japan International Cooperation Agency

Masayuki Nishiiye
President
Metal Mining Agency of Japan

ACKNOWLEDGEMENT

This report summarizes the result of the investigation carried out in fiscal year 1980 by the International Development Center of Japan, entrusted by the Ministry of International Trade and Industry through the Japan International Cooperation Agency and the Metal Mining Agency of Japan.

The objective of the investigation was to formulate a development plan for the Famatina mine, located in the Province of La Rioja, the north-western part of the Republic of Argentina, and a plan for improving and developing infrastructures related to the mine. It is my sincere wish that this investigation will contribute to the regional development around the mine and further to the economic development of the Republic of Argentina, and that it will also help strengthening the friendly and cooperative relationships between the Republic of Argentina and Japan.

A field investigation was conducted for a one-month period from October 16, 1980 by a mission, consisting of the following members:

Mission Leader	Masamitsu Toriyama International Development Center of Japan
Electric Power	Michio Takahashi Japan International Cooperation Agency
Mining	Akio Yokota Overseas Mineral Resources Development Co., Ltd.
Geology	Kaneo Kakegawa Nikko Exploration Development Company
Transportation, Mining Town	Masayuki Doi International Development Center of Japan
Water Resources	Tsuyoshi Hashimoto International Development Center of Japan
Advisor	Kazuhiko Uematsu Metal Mining Agency of Japan

Coordinator	Yoji Ono International Development Center of Japan

The detailed schedule of the field investigation is given in a separate table. I would like to express my gratitude to government organizations of Argentina for strong supports in all aspects, and also to the Japanese Embassy, trading companies and international organizations who cooperated the survey team in various ways. My deep appreciation is extended also to the Ministry of Foreign Affairs, the Ministry of International Trade and Industry, the Japan International Cooperation Agency, the Metal Mining Agency of Japan, the Argentina Embassy in Japan, Dirección General de Fabricaciones Militares, Secretaría de Estado de Mineria, Plan La Rioja and the Government of La Rioja Province.

This report was prepared by International Development Center of Japan, who takes the full responsibility of its contents.

March 1981

Saburo Kawai,
President
International Development Center
of Japan

TABLE OF CONTENTS

Page

Page

LIST OF TABLES

Page

Page

LIST OF FIGURES

Chapter 1.

SUMMARY AND CONCLUSIONS

CHAPTER 1. SUMMARY AND CONCLUSIONS

1. Basic Assumptions

1-1 Scope of Investigation

Objective of investigation: The objective of this investigation is to set forth propositions concerning the feasibility of and strategies for Famatina mine development by first establishing planning conditions that appear most likely at this stage and then carrying out comprehensive investigation and analysis of each sector of development under these conditions. To attain this objective, the following three specific tasks must be accomplished:

(1) To investigate the feasibility of Famatine mine development from the national viewpoint of most efficient resource utilization as well as from the viewpoint of a private enterprise undertaking seeking sufficient profit over cost to justify investment.

(2) To analyse the effects of development on the Province of La Rioja by establishing Famatina mine as a focal point for regional development.

(3) To propose policies and specific procedures for development through analysis of the mine and regional development.

Specific objectives of the investigation: All aspects of Famatina mine development are subjected to investigation, including the following:

(a) Mine development
(b) Development of transportation infrastructures
(c) Power development
(d) Water resources development
(e) Procurement of labor force and development of a mining town
(f) Overall project evaluation
(g) Recommendations for subsequent measures to be taken and efforts to be continued.

Method of planning: Development plans for the mine itself are formulated on the basis of analyses of existing data and previous works and also on investigation of the potential of the Famatina mineralized zone. Alternate development scales are established and the optimal scale is selected.

Water resources development includes not only water supply plans for the Famatina mine itself but also plans for securing water for development in the vecinity of the mine.

Power development planning examines the supply demand situation for power in the region of the mine to determine supply sources for the power required for mine development and to select the best supply scheme.

In planning transportation infrastructures, existing transportation facilities are first examined and transportation investment projects of the Argentine government are reviewed. Based on these analyses, the best alternate route is proposed, based on analysis of minimum costs and maximum benefits for transporting materials and equipment to the mine, concentrates from the mine and also mine workers to and from the mine, with all necessary arrangements included.

Wages and commodity prices prevailing in Argentina as well as other relevant data are used to determine the best method for securing the labor force necessary for mine development. The optimal scale of the mining town is also determined.

Organization of work: In analyzing each sector, various alternate plans are combined to determine the most appropriate development plan. Based on these sector analyses, comprehensive analysis involves examination of feasibility from the national viewpoint, including effects on regional development as well as examination of the profitability of the mine itself. Figure 1-1 illustrates the organization of the work. The project area is shown in Figure 2-1.

1-2. Procedures and Method of Analysis

Necessary steps in the analytic procedure are as follows:

(1) Establishment of the boundaries of the mining area and estimation of reserves, quality and other characteristics, based on the results of investigation over the past eleven years and analyses of such;

(2) Determination, based on (1) of crude ore quantity to be treated daily (an operating scale of 30,000 tons of crude ore per day was established for this study, with an alternative of 20,000 tons per day analyzed as an alternate scale);

(3) Drafting of plans for mining and dressing operations that best suit the development scale, and estimation of initial investment outlays and additional investments and operating costs for each subsequent year;

(4) Estimation for each development scale of requirements for water, power, transportation and facilities for mine workers;

Step (4) is broken down into the following:

(5) Selection of the best method for satisfying water requirements through analysis of surface water alternatives (with reservoirs) and ground water alternatives, and estimation of development costs;

(6) Comparison of alternate plans for procuring electricity, including independent power generation and purchase from the central system, and estimation of the costs

Fig. 1-1. Famatina Mine Development Flow Chart

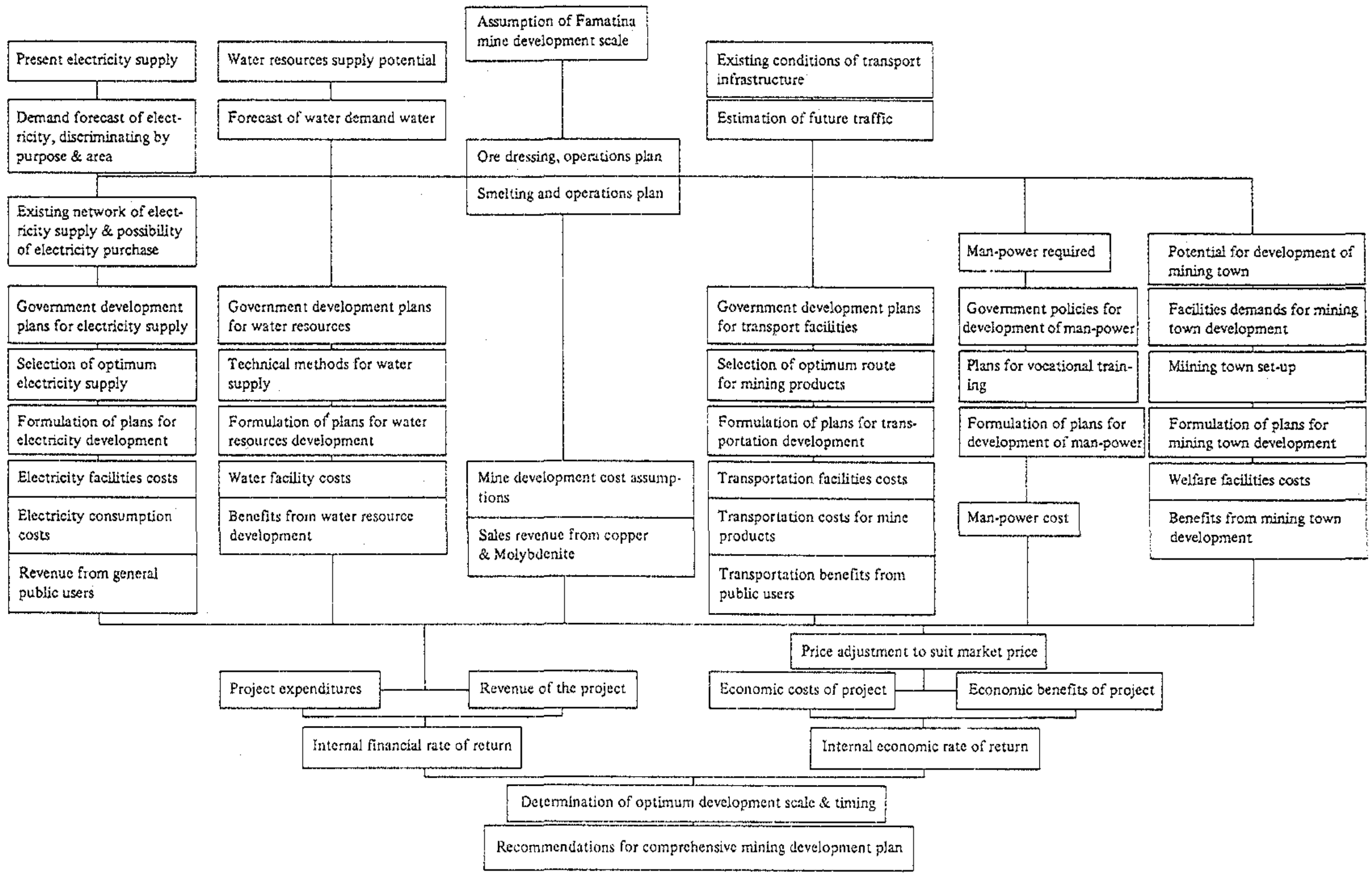
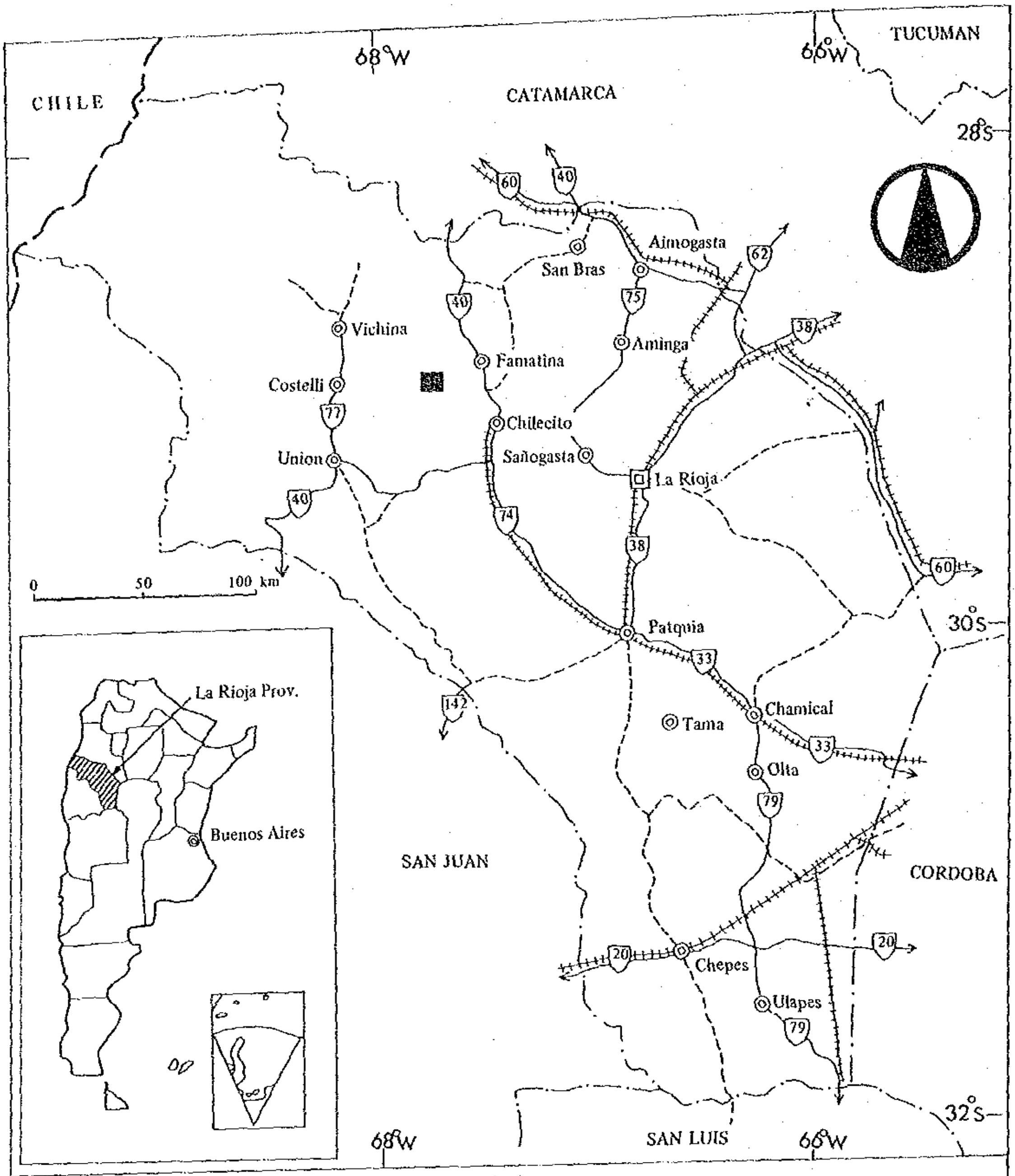


Fig. 2-1. Map of the Famatina Mineralized Zone



Legend:

National Boundary	National Route
Provincial Boundary	Main Provincial Road
Capital of Province	Railway
Capital of Department	Famatina Mineralized Zone

of the best alternative;

(7) Determination of the best route for transporting materials and equipment to and concentrates from the mine and estimation of costs for selecting the best-cost alternative for transportation;

(8) Drawing up of a labor supply plan that best suits demand, examination of housing, other facilities and the scale of the mining town, and estimation of costs.

The steps described above constitute the primary cost-side analysis. The benefit-side is analyzed in the following manner.

(9) Analysis of the supply-demand balance of copper and molybdenum, and establishment of future prices for these products;

(10) Calculation of revenues during the life of the mine based on future prices and annual production;

(11) Estimation of revenues from other sources, if any.

Using the basic data obtained in the preceding, the investment project is analyzed as described below as to adequacy from the national viewpoint.

(12) Use of the method of internal economic rate of return to judge the adequacy of the project from the viewpoint of the national economy;

(13) Estimation of real costs and real benefits for calculating the internal economic rate of return;

(14) Estimation of real costs and benefits by subtracting taxes, applying a shadow exchange rate, excluding salvage values or by any other methods deemed appropriate;

(15) Computation of a discount rate that makes the present value of real costs during the project life equal to the present value of benefits;

(16) Use of this particular discount rate value as an index for justifying development.

As the next steps, the adequacy of investment in mine development is analyzed as follows from the viewpoint of enterprise profitability.

(17) Adaption of the method of internal financial rate of return to judge from the viewpoint of an enterprise the profitability of investment;

(18) Calculation of the value of internal financial rate of return using actual prices (market prices) calculated in steps (1) through (11) and comparison of costs and revenues;

(19) Determination of a discount rate (internal financial rate of return) that makes the present value of costs over the project life equal to the present value of benefits.

Calculations described above are carried out based on the following premises:

(20) Use of price levels as of November, 1980, when field investigations were carried out.

(21) Exclusion of inflation and interest in comparing discounted current values.

(22) Inclusion in determining the internal economic rate of return of all cost and benefit elements associated with mine development and, in calculating the internal financial rate of return, enumeration of all costs to be borne by the mining company and all revenues accruing to the company.

Conclusions will be drawn as follows based on calculation results:

(23) Carrying out of sensitivity analyses to determine the effects of cost increases, benefit reductions and other changes;

(24) Giving priority to the internal economic rate of return (or economic analysis) over the internal financial rate of return (or financial analysis).

(25) Conclude the investment to be justified, if the internal economic rate of return exceeds the opportunity cost of capital, i.e., 10% unless the value of internal financial rate of return is extremely low.

(26) Establish reservations for conclusion of investment justification, which implies that further prospecting by boring and/or additional investment in analysis of ore quality, are justified and the project deserves an opportunity for international tender, since the analysis of costs and benefits reported herein is based on limited data.

1-3. Outline of Famatina Mineralized Zone

Past investigations: The Famatina mineralized zone is located in the north-western part of Argentina within the Famatina mountain range, centering around latitude 29°S and longitude 67°45'W. The altitude ranges from 4,000 to 4,500 m. Investigation and prospecting activities have been carried out since 1957 as a joint effort by the Provincial government of La Rioja, Secretaría de Estado de Minería (SM) and Dirección General de Fabricaciones Militares (FM). By 1980, the first phase was concluded with prospecting boring of 36 holes amounting to 10,677 m total depth. Specific activities involved are summarized in Table 2-1.

Mineral deposit model: As a result of exploration up to the present, it has been confirmed that the mineralized zone in the Rio Amerilla district contains disseminated type mineralization of copper and molybdenum. The principal zone of mineralization is horseshoe-shaped, over 4,000 m along a curved length and over 300 m in width (Refer to Figure 2-3). The depth reaches a maximum 600 m in some parts. Only the western section of the principle

Table 2-1. Volume of Main Explorative Works Implemented to Date

Type of Work	Volume of Work	Remarks
Topographical Survey (with Topographical Mapping)	1 : 10,000 90 km^2 1 : 5,000 3 km^2	Mapping by Aerial Photogrammetry Performed in Parallel and Based on Actual Field Survey
Geological Survey	25 km^2	
Geochemical Survey	940 Samples	Cu, Mo, Pb, Zn; Partly on Au, and Ag
Geophysical Investigation	43.5 km (26 Survey Lines)	I.P. Method
Drilling	10,677 m (36 Holes)	Deepest 639 m, Shallowest 98 m, 300 m on Average

mineralized zone is taken up for analysis at this time based on various considerations, and a mineral deposit model is established. The following estimates are made using this model: the area of the mine is 382,000 m², extractable reserves amount to 202 million tons and the average ore quality is, for Cu 0.17%, and for Mo 0.06%. Data for each section of the mining lot, as illustrated in Figure 2-4, are given in Table 2-4.

Table 2-4. Summary Tabulation of Calculated Ore Reserves (per Hypothetical Model of Ore Deposits)

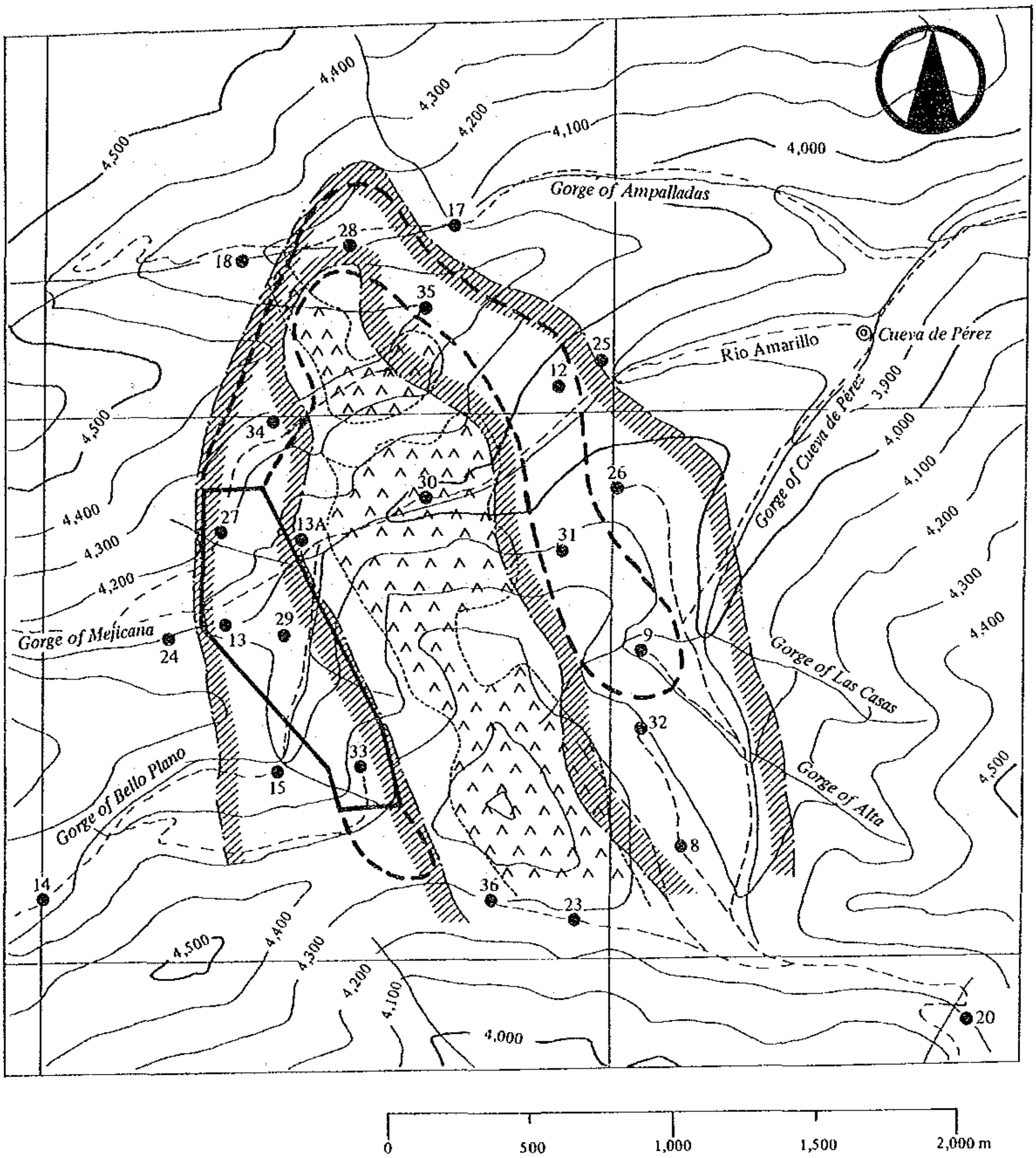
Ore Block No.	Area	Width	S.G.	Ore Reserves		Grade	
				Calculated	Exploitable	Cu	Mo
	1,000 m²	m		10,000 ton	1,000 ton	%	%
27	93	112	2.5	2,325	-	0.01	0.074
13	54	206	2.5	2,781	-	0.12	0.103
29	121	300	2.5	9,075	-	0.11	0.056
33	114	340	2.5	9,690	-	0.28	0.049
		(average)				0.17	0.060
Total	382	250	2.5	23,871	202,000	Cu equivalent 0.77	

Notes: 1) The product of existential security x mining yield is assumed as 85%.

2) The conversion ratio of Mo to Cu is assumed to be:
Cu : Mo = 1 : 10

Exploration costs required: During the period between 1973 and 1980, 1,950 million pesos were spent for exploration. As second phase exploration for the period 1981 through 1982, additional exploratory boring to a total depth of 19,600 m and analyses of core samples will be necessary. The cost of these activities is estimated to be 8,430 million pesos. A portion of the cost incurred in the past has to be included in the exploration costs for this project. Exploration costs between 1973 and 1980 totaled 1,950 million pesos. This is equivalent to 8,840 million pesos in 1981 prices if discounted at a 10% opportunity cost of capital rate. Of this, 60%, corresponding to 13,700 million pesos, is regarded as a part of project costs.

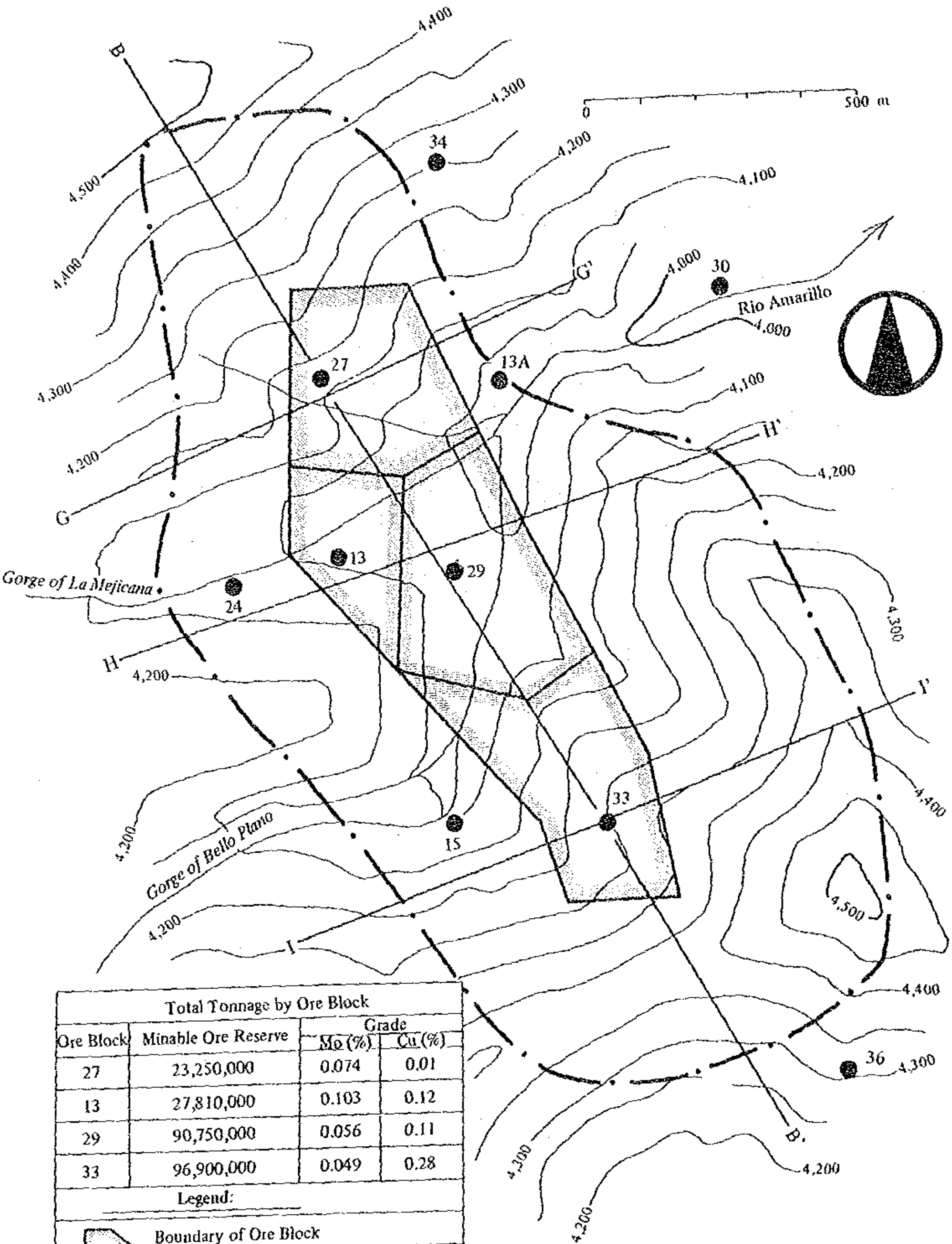
Fig. 2-3. Explanatory Map of the Famatina Minralized Zones (the Rio Amarillo Area)



Legend:

Negro Peinado Formation (Intruded Rock)	Bounds of Mineralized Areas
Dacitic Porphyry Rock Body	Bounds of Ore Block Set for Trial Computation
Bound of I.P. Anomaly Area	No., Location of Drilled Holes

Fig. 2-4. A Plan Figure of Ore Blocks for Computation
(per Drilled Hole Nos. 13, 27, 29 and 33)



Total Tonnage by Ore Block			
Ore Block	Minable Ore Reserve	Grade	
		Mo (%)	Cu (%)
27	23,250,000	0.074	0.01
13	27,810,000	0.103	0.12
29	90,750,000	0.056	0.11
33	96,900,000	0.049	0.28

Legend:

(symbol)	Boundary of Ore Block
(symbol)	Area of Stripping
(symbol)	Location of Drilled Holes

2. Plans

2-1 Mining and Concentration Plan

Planned scale of operations: The quantity of crude ore treated, which constitutes a basis for all planning, is determined based on estimated ore reserves, initial investment outlays and other factors, taking into account actual cases of large-scale mines operating around the world and plans for other mines. A tentative plan has been formulated to treat 30,000 tons of crude ore per day. This is considered the most economically efficient. Another plan for treating 20,000 tons per day has also been formulated for analysis and comparison.

The tentative plans should be reasonable in all aspects, taking due account of the fact that mining and concentration operations are to be carried out at an altitude of approx. 4,000 m.

Mining and concentration model plan: A tentative model for mining and concentration operations is given in Table 2-5. Total production of concentrates is 55,000 tons for copper and 7,500 tons for Molybdenum under an oprating scale of 30,000 tons per day as calculated below.

Cu concentrate:

(30,000 tons	x	0.17% quality of crude ore	x	70% concent-rate recovery rate	÷	20%) quality of con-centrate	x	300 days annual operating days	≒ 55,000 tons

Mo concentrate:

(30,000 tons	x	0.0604% quality of crude ore	x	70% concent-rate	÷	51%) quality of con-centrate	x	300 days annual operating days	≒ 7,500 tons

The figures for recovery rates and qualities of concentrates represent no more than estimates since sufficient data to calculate them more accurately is not available. The quantity of water required for mineral concentration is calculated based on a usagerate of 3 m^3 per tons of crude ore treated and a recycling rate of 50%. Power requirements are calculated as 25 kWh per unit ton of crude ore, assuming all machinery, including loading equipment, is electric-driven. Open-pit mining is to be adopted in consideration of the characteristics of the mining lot, and the waste dump is to be located in the Los Bayos district adjacent to the pit to the south. Bulk floatation is adopted as the concentration method, and the concentration plant is to be constructed at Cueva de Perez. Construction periods for mining and concentration facilities are taken to be three years.

Table 2-5. Tentative Mining Model

Factor \ Operating Scale (tons/day)		30,000	20,000
Minable Ore Reserves (tons)		202,000,000	202,000,000
Grade of Crude Ore (%)		Cu 0.17, Mo 0.0604	Cu 0.17, Mo 0.0604
Working Days (days/year)		300	300
No. of Employees		2,000	1,500
Stripping volume (m^3/day, w/o = 1.28)		15,600	10,400
Recovery Rate of Ore Dressing (%)		Cu 70, Mo 70	Cu 70, Mo 70
Concentrates	Volume (tons/year)	Cu 55,000, MoS_2 7,500	Cu 36,000, MoS_2 5,000
	Grade (%)	Cu 20, MoS_2 85	Cu 20, MoS_2 85
Volume of Water Required (Fresh Feed Only, m^3/day)		45,000	30,000
Power Required (kWh/day)		750,000	500,000
Life of Mine (years)		22	33

Initial investment outleys for development: The total initial investment for mine development is 390,000 million pesos in the case of an operating scale of 30,000 tons/day, which is broken down into the items listed below.

Breakdown of initial investment expenses for mine development

(Unit: Million pesos)

Items	Operating scale (tons/day)	30,000	20,000
Mining operations	Machinery	109,200	81,900
	Civil engineering works	7,800	5,900
	Initial stripping	27,300	19,500
	Others	11,700	9,700
	Sub-total	156,000	117,000
Concentration operations	Machinery	152,100	113,100
	Civil engineering works	58,500	44,800
	Electricity and other works	23,400	17,600
	Sub-total	234,000	175,500
Total		390,000	292,500

Additional investment is necessary in the eleventh year following opening of the mine in the amount 39,000 million pesos for an operating scale of 30,000 tons/day, or 9,750 million pesos respectively in the eleventh and the twenty-first years in the case of 20,000 tons/day. The additional expenses are also included in the estimated initial investment outlays for mine development.

Operating costs: Operating costs of the mine are calculated based on the following unit cost data.

(Unit: pesos)

Sector \ Operating scale (tons/day)	30,000	20,000
Mining operations	3,120	3,900
Concentration operations	4,680	5,460
Total	7,800	9,360

The operating costs include personnel costs, material costs and other expenses. As seen from the above, total operating costs are 70,200 million pesos and 56,160 million pesos annually for respective operating scales of 30,000 tons/day and 20,000 tons/day. The personnel costs were calculated based on wages of mine workers prevailing in Argentina together with consideration of the working conditions of this particular project and the supply-demand situation for mine workers. Total annual personnel costs are estimated to be 57,741 million pesos and 43,303 million pesos respectively for the alternate operating scales of 30,000 tons/day and 20,000 tons/day. The management costs are determined to be 2,437.5 pesos per unit ton of crude ore, making reference to the average unit costs of other mines around the world. The total annual management costs are 21,938 million pesos and 14,625 million pesos for respective operating scales of 30,000 tons/day and 20,000 tons/day. The total operating costs, therefore, are 92,140 million pesos in the case of 30,000 tons/day and 70,790 million pesos for 20,000 tons/day.

<u>Personnel planning:</u> Personnel planning necessary to estimate personnel costs is based on an approx. 25% increase in the number of workers required over the number that would be required for a mine of similar scale situated on flat land. The number of employees required for 30,000 tons per day operation on flat land is 1,440 workers so this figure plus 560 more employees gives a total of 2,000 workers. (see Table 1-1 on the next page.)

The breakdown of employees by class is 55 management level, 50 engineers, 445 clerical employees, 95 foremen and 1,345 workers in the case of 30,000 tons/day operation (Refer to Table 7-3).

Mining is done in two shifts and concentration in three shifts. The annual number of operating days is assumed to be 300, Sundays being holidays.

Table 1-1. Personnel Plan

(Unit: persons)

	Employees		Workers		Total	
Buenos Aires office	30	(20)	20	(15)	50	(35)
La Rioja office	15	(10)	10	(7)	25	(17)
Cilecito office	15	(10)	10	(8)	25	(18)
At the Mine						
Mining	50	(40)	300	(230)	350	(270)
Concentration	50	(40)	200	(150)	250	(190)
Maintenance	100	(80)	500	(370)	600	(450)
Management	300	(220)	400	(300)	700	(520)
Subtotal for mine	500	(380)	1,400	(1,050)	1,900	(1,430)
Total	560	(420)	1,440	(1,080)	2,000	(1,500)

Note: Figures in parentheses represent the case of 20,000 tons/day operation.

2-2 Power Development Plan

Power Demand: The total power requirement for the mine is estimated to be 225,000 MWh (= 25 kWh/ton x 30,000 tons x 300 days) including water pumping requirements. Maximum daily power demand is 42,000 kW. Additionally, about 4,000 kW of power would be required by the mining town, but this can be satisfied by existing power generating facilities.

Regional Demand-supply Balance: There exist in La Rioja Province two separate power systems with steam power plants -- the La Rioja system and the Chilecito systems, neither of which is connected to the central system. Total supply capacity of the region is approximately 50,000 kW, whereas total demand is about 20,000 kW. Demand is expected to reach 35,000 kW by 1985, and additional power supply sources will become necessary if the power demand of the mine of 42,000 kW is added to this increased demand.

Comparison of Alternatives: Among various alternatives, one of constructing an independent generating plant near the existing plant in Chilecito and one of purchasing power from the central system by connecting it with power transmission lines, were selected for comparison. The purchasing alternative was eventually adopted. That is, estimated that the alternative at an independent plant costs 71,080 million pesos for construction, including transmission lines and 22,260 million pesos annually for operation, which make the unit power generating cost to be used for economic analysis 153 pesos/kWh. The purchasing alternative, on the other hand, costs 151 pesos/kWh.

Total annual costs in the case of power purchase are calculated to be 33,980 million pesos (= 151 pesos x 225,000 MWh), but for economic analysis a cost of 34,260 million pesos adjusted by the shadow exchange rate has to be used. Costs are incurred every year for the 22-year period. The actual electricity rate that the mining company would have to pay should be less than 151 pesos/kWh, considering the nature of public utility works, and a unit cost of 101 pesos/kWh was taken from the electricity rate schedule for use in financial analysis. Actual costs to be borne by the mining company include 22,790 million pesos (101 pesos x 225,000 MWh) for purchasing electricity and 3,000 million pesos for constructing power transmission lines between Chilecito and the mine.

2-3 Water Resources Development Plan

Water Requirements: Water requirements for mine development are summarized below.

Item \ Operating scale (tons/day)	30,000	20,000
Concentration plant (ℓ/sec.)	428 (13.5 million m^3/year)	285 (9 million m^3/year)
Mining town (ℓ/sec.)	38	28
Mining camp (ℓ/sec.)	7	5

The most important factor in planning water resources development is how to preserve water for concentration, which accounts for about 90% at the total requirement.

Comparison of Alternatives: The quantity of water that can be extracted from the aquifer in the mining area is estimated to be about 250 ℓ/sec. at most. This is less than the total requirement of the concentration plant, and thus other alternatives were formulated and examined. Of all the alternatives, two appeared more practicle. One is a plan to divert some of the water that will be made available by the Rio Miranda reservoir, which is currently planned by Secretaría de Estado de Recursas Hidricos, La Rioja (SERH) --- the Rio Miranda alternative, and the other is construction of a reservoir on Rio del Oro and to combine it with groundwater near the concentration plant --- the Rio del Oro alternative. These alternatives were analyzed comprehensively from the viewpoints of economic efficiency, effects on the surrounding region and other aspects, and the Rio del Oro alternative was finally adopted.

The Rio del Oro alternative is the most economical among all alternate plans considered, but it still requires considerable investment for construction of a dam at a high altitude site, and same unforeseen technical problems may be involved in such construction. Moreover, operating costs are also relatively high since the water has to be transported about 850 m vertically over a distance of 7.2 km. It is desirable, therefore, that a more precise evaluation be made of the aquifer near the concentration plant in order to utilize the groundwater as fully as possible and to minimize the dam construction costs.

For this purpose, it is imperative that more systematic exploration of groundwater resources be carried out in parallel with further prospecting.

Cost Estimates: Construction and operating costs related to water supply are summarized below.

(Unit: Million pesos)

Items \ Operating scale (tons/day)		30,000	20,000
Construction costs	Dam construction	26,391	26,391
	Water transportation	4,055	4,055
	Groundwater works	872	484
	Total construction costs	31,318	30,930
Operating costs	Personnel costs	60	60
	Electricity costs	1,740	1,610
	Total operating costs	1,800	1,670

Agricultural Water Use: The project area is meteorologically arid to semiarid with annual precipitation being about 200 mm on the eastern plain. Moreover, daily and seasonal variations in precipitation make surface water availability quite unstable. Thus, if water supply is made more stable by water resources development, it will serve not only for agricultural uses but also for domestic purposes and for hydro-power generation. The absolute quantity of water available in the area, however, is small, and a significant quantity is required for the mine. It is difficult, therefore, to provide a stable supply of water for regional development while the mine is in operation.

Salvage Value (Benefits): After the termination of mine operations, however, it is conceived that the Rio del Oro reservoir can be utilized to irrigate a newly developed agricultural area of up to 645 ha. This would potentially contribute to regional development. Benefits associated with this regional development were calculated as the salvage value of the dam and added at the end of the mine operating period. The salvage value was taken to be 6,360 million pesos for economic analysis and 60% of this, or 3,820 million pesos, for financial analysis.

2-4 Mining Town Development Plan

Estimate of Mining Town Scale: Development of the mine makes it necessary to establish a town where mine workers with their families and other service population can live. The estimated population of the town is given below, excluding those working in the city of La Rioja and those commuting from their own homes.

(Unit: persons)

Items \ Operating scale (tons/day)	30,000	20,000
Employees	1,625	1,148
Employee dependents	6,500	4,592
Service population and other	2,875	2,260
Total	11,000	8,000

A total area of 100 ha or 75 ha would be necessary at the minimum to accommodate all the facilities of the town for operating scale of 30,000 tons/day or 20,000 tons/day, respectively.

Commuting Conditions: Necessary conditions for developing the mining town include suitable slope of the land, altitude, commuting time to the mine and land area. Field investigations revealed that there exists no site suitable for the development of the town within commuting distance. Accordingly, a scheme was adopted to develop the town at the foot of the mountains and to provide lodging facilities near the mine where the workers would stay during weekdays. They would then commute 82 km once a week.

Selection of Potential Sites: As potential sites for the mining town, two alternatives were considered — one around the village of Famatina, and the other in Los Sarmientos, near the city of Chilecito. These alternatives were compared qualitatively as to suitability as sites for the town with respect to eleven aspects, including area, shape of the site, land slope, possible threat of flooding, noise and danger from the airport, land ownership, land prices, transportation to the mine, possibility for sharing of existing urban facilities, land use patterns, effects an other economic activities and salvage value of the town. Also, quantitative analysis was made on four of the eleven aspects, including land slope, transportation to the mine, possibility for sharing of existing urban facilities and the salvage value at the town. Both qualitative and quantitative analyses point to the Los Sarmientos alternative as being superior. The quantitative analysis showed that the present discounted value of town salvage is higher by 5,010 million pesos for Los Sarmientos, and thus this alternative was selected as the site for the mining town.

Facilities of the mining town consist of those to be borne by the town itself, others borne publicly and commercial facilities to be developed freely by private sectors. Financial costs to be borne by the mining company correspond to 138,500 million pesos in the case of 30,000 tons/day operation, as shown in the following table.

(Unit: Million pesos)

Cost element	Operating scale (tons/day)	30,000	20,000
Construction costs of mining town	Land acquisition	17	12
	Land preparation	7,924	5,763
	Water and electricity works	2,995	2,178
	Wastewater works	4,113	2,906
	Housing	97,020	69,012
	Facilities for mining company	360	260
Construction costs of lodging facilities	Land preparation	1,441	1,153
	Facilities construction	24,624	18,576
Total		138,494	99,860

Salvage Value: The financial salvage value was assessed based on the assumption that 80% of all houses can be sold at a cost equivalent to 60% and 40% of the housing construction costs respectively for operating scales of 30,000 tons/day and 20,000 tons/day. The total salvage value was calculated to be 46,570 million pesos for an operating scale of 30,000 tons/day and 22,080 million pesos for 20,000 tons/day.

Cost Elements for Economic Analysis: Economic costs of the mining town to be borne by the nation are given below. The economic costs are calculated by subtracting internal transfer elements such as taxes from financial costs.

(Unit: Million pesos)

Items	Operating scale (tons/day)	30,000	20,000
Construction costs of the mining town to be borne by the mining company	Land preparation	7,528	5,475
	Water and electricity works	2,845	2,069
	Wastewater works	3,908	2,761
	Housing for mine workers	92,170	65,562
	Facilities for mining company	342	246
Construction costs of lodging facilities	Land preparation	1,369	1,095
	Facilities construction	23,392	17,648
Construction costs of the mining town to be borne by public organizations and the general public	Transportation infrastructure	5,130	3,848
	Land preparation	3,695	2,943
	Water and electricity works	1,397	1,112
	Wastewater works	1,383	1,087
	Housing for service and other population	34,414	27,052
	Public and commercial facilities	9,282	8,332
	Park facilities improvement	1,672	1,064
Total		188,527	140,294

National economic costs related to the construction of the mining town are as shown in the table above. It is not necessary, however, to total all the costs (in particular, all public sector costs) listed above the project costs. In economic analysis, only additional expenses incurred by the nation are subject to analysis, and only two-thirds of the total economic costs are taken to account for the costs of this project (Refer to Section 2-2 in Chapter 7).

Economic Salvage Value: In a manner similar to that for computation of the financial salvage value, the economic salvage value was computed by taking the physical salvage value to be 60% and 40% of the construction costs of the mining town for respective operating scales of 30,000 tons/day and 20,000 tons/day and by assessing 80% of these values to be the social salvage value. The economic salvage value amounts to 78,610 million pesos in the case of 30,000 tons/day operation and 38,900 million pesos in the case of 20,000 tons/day. As the economic costs associated with the mining town were taken to be tow-thirds of actual costs incurred, the salvage value was also taken to be two-thirds in economic analysis.

2-5 Transportation Plan

Materials to be Transported: Transportation demand generated by mine development is as follows. (1) Transportation of copper and molybdenum concentrates from the concentration plant to the point of delivery (Buenos Aires was assumed for this study in order that the price of the concentrate can be compared with international prices). (2) Transportation of materials and equipment necessary for mining and concentration operation from the point of procurement (i.e., Buenos Aires) to the mine. (3) Transfer of people and materials between the mine and the mining town. As for transportation of the copper concentrate, the possibility of utilizing either the smelting plant expected to be developed by the La Alumbrera mine at Andalgalá or the plant to be developed by the El Pachon mine at Arreal was also taken into account in formulating the transportation plan (Refer to Fig. 1-2).

Transportation Demand Estimates: Transportation demands associated with this project (for copper and molybdenum concentrates, electro-copper, materials and equipment) are summarized in Table 6-1.

Selection of Alternate Transportation Routes: The following alternatives are considered for transportation means and routes.

Section	Transportation Means	Route number in Fig. 1-2	Name of the Route	Distance (km)
The mine – Chilecito	Cableway	(1)		34
	Pipeline	(2)		
	Roads	(3)	Cueva de Noroña route	82
		(4)	Los Ballitos route	110
		(5)	Las Placetas route	37
Chilecito – Buenos Aires	Road or Railway	(6)	Buenos Aires through route	1,217 (1,269)
		(7)	Buenos Aires via Andalgalá route	1,592 (1,879)
		(8)	Buenos Aires via Barreal route	1,974 (1,700)

Note: Figures in parentheses are distances by railway.

Fig. 1-2. Transportation Routes and Distances

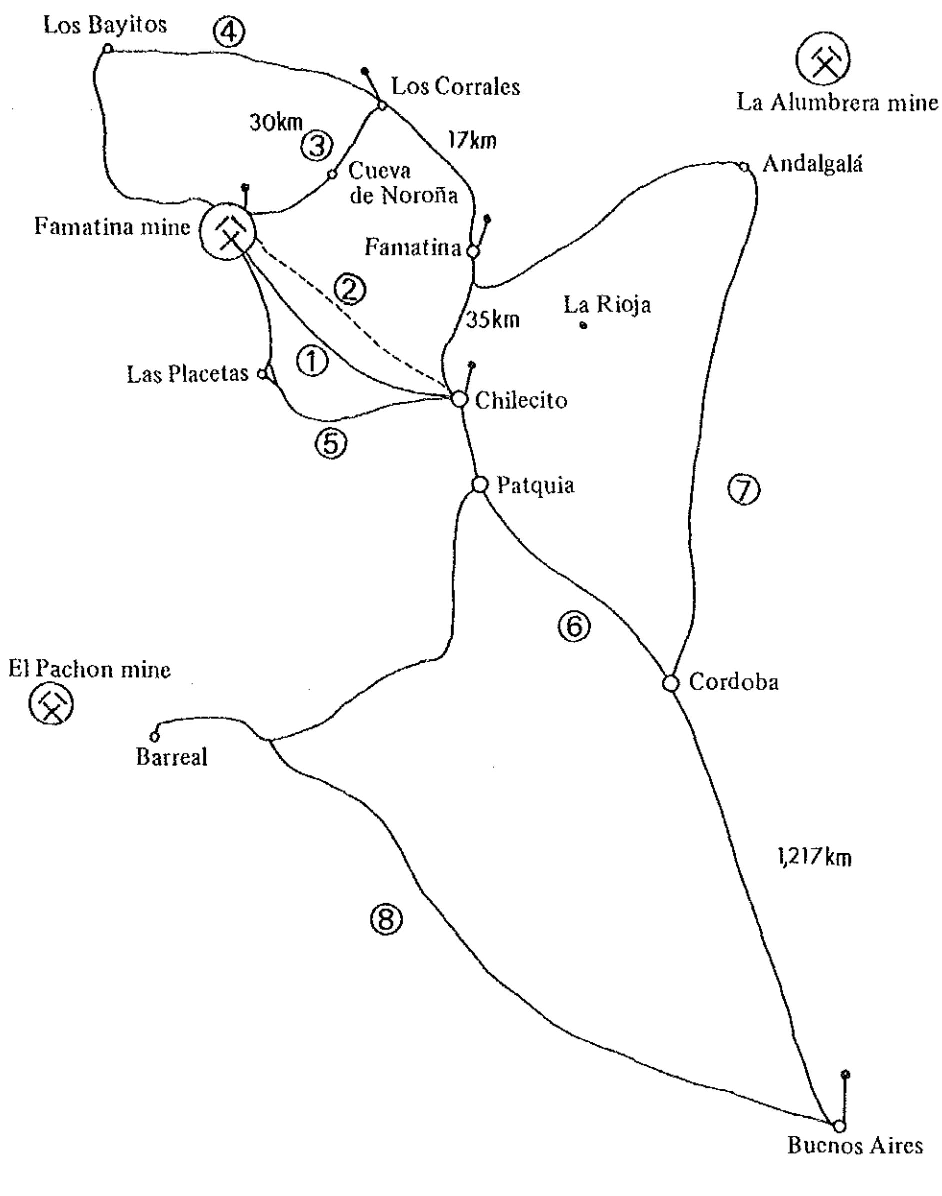


Table 6-1. Generated Transportation Demands (Refined Copper and Molybdenite, Electro-Copper and Materials)

Contents / Operating Scale (tons/day)		30,000		20,000	
Items to be transported	Transportation Section	tons/day	tons/year	tons/day	tons/year
Refined Copper	Dressing Plant → Delivery Point Smelting Plant	200	59,000	130	39,000
Electro-Copper	Smelting Plant → Delivery Point	37	11,000	24	7,200
Refined Molybdenite	Dressing Plant → Delivery Point	27	8,100	18	5,400
Construction Materials	Procurement Point → Mining Site	200	60,000	134	40,000

Note: Refined ore to be transported is assumed to include 8% water as compared to dry ore of copper and molybdenite.

Alternative (1) through (5) are conceivable for the section between the mine and Chilecito. Of these, the cable-way (alternative (1)), constructed in 1913, will not stand up to the transportation demands to be generated by this project since the structure and the mode of operation are out-of-date. Transportation means other than roads, such as pipelines (alternative (2)) are no more than theoretical possibilities because of economic inefficiency. Thus the conclusion was reached that road transportation by 20 ton-truck is the most appropriate means. Three alternatives, (3), (4) and (5), were considered for road transportation. These were compared in a comprehensive way with respect to altitude difference along the respective route, slope of cross-section, geological conditions, total length of road construction and possibilities for capitalizing on existing temporary roads. The Cueva de Noroña route was finally adopted as the most appropriate.

Selection of Transportation Means: Three alternatives are conceivable for the route between Chilecito and Buenos Aires, depending on how and where the copper concentrate is to be smelted. For each route, another choice between roads and railways is involved. Road transportation would be entrusted to a private transport company and railway transportation would be carried out by the National Railways. Financial costs were calculated based on respective tariff schedules, and economic costs were computed as real operating costs incurred to the national economy.

Transportation costs by road and by railway are compared for each route in the case of 30,000 tons/day operation.

(Unit: Million pesos)

Alternatives	Transportation means	Financial costs	Economic costs
(6) Buenos Aires through route	Road	9,220	6,312
	Railway	12,174	23,309
(7) Buenos Aires via Andalgala route	Road	6,522	4,489
	Railway	10,198	18,151
(8) Buenos Aires via Barreal route	Road	7,337	5,293
	Railway	10,653	18,504

Note: These costs do not include transportation costs between the mine and Chilecito.

Road transportation was found to be superior to railway transportation for all routes considered. Thus this option (using 20 ton-trucks) was adopted as the transportation means for the entire distance between the mine and Buenos Aires.

Transportation Costs by Route: Costs involved in transportation are given below for each route. These costs include road maintenance costs and user fees for the port.

(Unit: Million pesos)

Transportation alternatives and routes		Operating scale (tons/day)	Construction costs	Annual operating costs
Mine – Chilecito	Chilecito – Buenos Aires			
(3) Cueva de Noroña route	(6) Buenos Aires through route	30,000	14,257	10,511
		20,000	11,840	7,040
	(7) Buenos Aires via Andalgalá route	30,000	14,257	7,814
		20,000	11,840	5,251
	(8) Buenos Aires via Barreal route	30,000	14,257	8,628
		20,000	11,840	5,789

Of the total construction costs, road construction for the 35 km route between the mine and Los Coralles was assumed to be undertaken by a private enterprise in the basic case of cost estimation (resulting in 5,850 million pesos for road construction costs). If this work is done by the Army, however, only 2,850 million pesos would be required, representing a 3,000 million peso saving.

3. Overall Analysis

3-1. Estimates of Costs Involved (Market Prices)

Costs involved in the development were estimated by sector in Section 2, "Plans." In this section, these sectorwise costs are added to obtain the total costs incurred each year. Market prices herein represent the prices prevailing as of November, 1980 when field investigations were carried out.

Summary of Costs: All project costs, expressed in terms of market prices, are listed below. The total investment costs amount to appropriately 590,000 million pesos, and the annual operating costs are 127,000 million pesos. Of the investment cost, 68% is for the mine and related facilities. The mining town constitutes 24% of the total. (Refer to Table 7-1 on the next page.)

Annual Costs: The exploration period is 1981 through 1982, and construction would take place between 1983 and 1985. Mine operations would be initiated in 1986. The investment costs by year for the construction period are as follows. Substantial investments in mine-related facilities are required in each of three years -- 30% in 1983, 40% in 1984 and another 30% in 1985. Since electric power will be required from the beginning of construction, 80% of the total investment for power development will be made in 1983 and the remaining 20% in 1984. The investments for water resources development will be made over three years, as dam construction will take time. The investments for the mining town consist primarily of housing construction in 1984 and 1985. The investments in the transportation sector will be concentrated in the first year of the construction period since construction materials have to be transported over this route. Investments for other than the essentials are to be made as close to the initiation of the mine as possible to avoid idle facilities. The following table summarizes investment costs for each year. (Refer Table 7-4-(1), (2) on pp. 30, 31.)

3-2 Estimates of Economic Costs (Adjustment of Market Prices)

To compute real costs incurred in developing the Famatina mine, economic costs have to be estimated. The economic costs are calculated based on the financial costs obtained in the previous section for market prices, with necessary adjustments made for real prices.

Method for obtaining economic prices: Cost elements such as taxes and interest representing internal transfer and have to be first subtracted from market prices as the adjustments for real prices. Commodity prices are then divided into domestic currency (domestic goods) and foreign currency (imported goods) portions. The real foreign exchange rate rather than the official rate is applied to the foreign currency portion. Costs obtained in this way are economic costs used as inputs to the economic analysis (Refer to Chapter 1, Section 1. Overall Evaluation Method:).

Domestic and foreign currency portions (domestic and imported goods): As described above, the costs are divided into domestic currency (domestic goods) and foreign currency (imported goods) portions, as more specifically described below.

(1) **Exploration costs:** The exploration costs spent in the past are regarded as 100% domestic costs, as they are the estimated sum of direct costs spent in the field. Future exploration costs are also taken to be 100% domestic.

(2) **The mine:** Of the initial investment expenses for the mine, 40% is considered the domestic currency portion, as the mining requires sophisticated machinery. For additional investment expenses, the domestic currency portion is assumed to constitute 50%, taking account of development of the domestic industries of Argentina.

(3) **Power:** Domestic currency portions constitute 30% of the investment in generation and transformation facilities and 30% in transmission lines. For operation costs,

Table 7-1. Analysis of Financial Costs (Costs of Different Sectors)

30,000 tons/day (Financial Costs)

(Unit: Million pesos)

	Investment (%)		Salvage Value		Annual Operating Costs (%)	
Prospecting	13,669	(2.3)				
Mine	390,000	(66.0)			92,138	(72.4)
Electricity	2,960	(0.5)		1)	24,530	(19.2)
Water	31,318	(5.3)	3,816		60	(0.1)
Mining Town	138,494	(23.5)	46,570			
Transport	14,257	(2.4)			10,511	(8.3)
Total	590,698	(100.0)	50,386		127,239	(100.0)

20,000 tons/day (Financial Costs)

(Unit: Million pesos)

	Investment (%)		Salvage Value		Annual Operating Costs (%)	
Prospecting	13,669	(3.0)				
Mine	292,500	(64.8)			70,785	(74.8)
Electricity	2,960	(0.7)		1)	16,800	(17.7)
Water	30,930	(6.8)	3,816		60	(0.1)
Mining Town	99,860	(22.1)	22,084			
Transport	11,840	(2.6)			7,040	(7.4)
Total	451,759	(100.0)	25,900		94,685	(100.0)

Note: 1) Including the cost of electric energy of water resources (17,400 million pesos).

Table 7-4-(1) Comprehensive Table of Financial Costs by Sector and Year (Operation Scale: 30,000 tons/day)

(Unit: Billion pesos)

Year	Prospecting	Mine	Electricity	Water	Mining Town	Transport	Total
1981	11.25	–	–	–	–	–	11.25
1982	2.41	–	–	–	–	–	2.41
1983	–	93.60	2.37	9.35	9.38	8.26	122.96
1984	–	124.80	0.59	10.61	68.11	3.40	207.51
1985	–	93.60	–	11.36	61.00	2.60	168.56
1986	–	92.14	24.53	0.06	–	10.51	127.24
1987	–	92.14	24.53	0.06	–	10.51	127.24
1988	–	92.14	24.53	0.06	–	10.51	127.24
1989	–	92.14	24.53	0.06	–	10.51	127.24
1990	–	92.14	24.53	0.06	–	10.51	127.24
1991	–	92.14	24.53	0.06	–	10.51	127.24
1992	–	92.14	24.53	0.06	–	10.51	127.24
1993	–	92.14	24.53	0.06	–	10.51	127.24
1994	–	92.14	24.53	0.06	–	10.51	127.24
1995	–	92.14	24.53	0.06	–	10.51	127.24
1996	–	170.14	24.53	0.06	–	10.51	205.24
1997	–	92.14	24.53	0.06	–	10.51	127.24
1998	–	92.14	24.53	0.06	–	10.51	127.24
1999	–	92.14	24.53	0.06	–	10.51	127.24
2000	–	92.14	24.53	0.06	–	10.51	127.24
2001	–	92.14	24.53	0.06	–	10.51	127.24
2002	–	92.14	24.53	0.06	–	10.51	127.24
2003	–	92.14	24.53	0.06	–	10.51	127.24
2004	–	92.14	24.53	0.06	–	10.51	127.24
2005	–	92.14	24.53	0.06	–	10.51	127.24
2006	–	92.14	24.53	0.06	–	10.51	127.24
2007	–	92.14	24.53	0.06	–	10.51	127.24
Salvage Value				3.82	46.57		50.39

Table 7-4-(2) Comprehensive Table of Financial Costs by Sector and Year (Operation Scale: 20,000 tons/day)

(Unit: Billion pesos)

Year	Prospecting	Mine	Electricity	Water	Mining Town	Transport	Total
1981	11.25	–	–	–	–	–	11.25
1982	2.41	–	–	–	–	–	2.41
1983	–	70.20	2.37	9.35	6.93	7.54	96.39
1984	–	93.60	0.59	10.22	49.01	2.43	155.85
1985	–	70.20	–	11.36	43.92	1.87	127.35
1986	–	70.79	16.80	0.06	–	7.04	94.69
1987	–	70.79	16.80	0.06	–	7.04	94.69
1988	–	70.79	16.80	0.06	–	7.04	94.69
1989	–	70.79	16.80	0.06	–	7.04	94.69
1990	–	70.79	16.80	0.06	–	7.04	94.69
1996	–	100.04	16.80	0.06	–	7.04	123.94
1997	–	70.79	16.80	0.06	–	7.04	94.69
2006	–	100.04	16.80	0.06	–	7.04	123.94
2007	–	70.79	16.80	0.06	–	7.04	94.69
2018	–	70.79	16.80	0.06	–	7.04	94.69
Salvage Value				3.82	22.08		25.90

70% is regarded as domestic, since personnel and fuel costs are substantial portions of the total.

(4) **Water resources:** The domestic currency portion of the investment costs for water resources development, including dam construction works, are taken to be 60 to 70%, depending on the specific works involved. The domestic portion constitutes slightly less than 60% of total investment costs.

(5) **Mining town:** Construction costs for the mining town are mostly in domestic currency, but in consideration of some imported machinery that may be required, 90% is assumed as the domestic currency portion.

(6) **Transportation:** The domestic portion of road construction costs is taken to be 70%. Road maintenance costs and construction material transport costs are 100% domestic as they consist primarily of personnel costs.

(7) **Operating costs:** Of total mine operating costs, 98% is considered to be domestic currency-based on the assumption that some managers and technicians are employed on foreign capital. For other operating costs, 30% is assumed to be domestic.

The ratios given above were used to compute the project costs divided into domestic and foreign currencies. Computation shows that the foreign currency portion of total costs is approximately 56% of the investment cost and about 14% of the operating cost.

Real foreign exchange rate (shadow exchange rate): The official exchange rate is 1,950 pesos to 1 U.S. dollar. What is the real foreign exchange rate as reflected in the national economy, however? There are several methods available for calculating the real exchange rate but in this investigation, the one based on real purchasing power was adopted after careful consideration (Refer to Chapter 1, Section 2, sub-section 2-2.). Purchasing parity represents the ratio of normal value of foreign currency to its real purchasing power in the domestic market, the latter being the inverse of the price level. Assuming the foreign exchange market was in equilibrium in 1969, the real exchange rate can be computed by comparing price levels of major trading partners, including the U.S. This method reveals that the Argentine peso is overvalued by 30 to 35% of the official exchange rate. The real foreign exchange rate, therefore, is taken to be 2,600 pesos to one U.S. dollar (corresponding to a 33.3% reduction from the official valuation of peso) and this value is used in computations.

Summary of economic costs: Results of economic cost estimation are as given in Table 7-5. Total economic costs are approximately 643,950 million pesos and annual operating costs are 129,860 million pesos. The mine related expenses and the costs of mining town development represent 70% and 20% of the total cost, respectively. The total economic cost of investments is higher by 53,900 million pesos than the total financial costs, which is 590,000 million pesos. Details are given below.

Table 7-5. Economic Costs

(30,000 tons/day)

(Unit: Million pesos)

	Investment			Salvage Value	Operating Costs
	Portion in pesos	Portion in Foreign currency	Total (%)		
Prospecting	12,302	0	12,302 (1.9)		
Mine	147,420	301,525	448,945 (69.7)		77,399, 8,183, 85,582 (65.9)
Electricity	933	2,563	3,496 (0.5)		22,657, 14,295, 36,952 (28.5)
Water	15,818	20,294	36,112 (5.6)	3,576, 3,711, 7,287	54, 0, 54 (–)
Mining Town	113,109	16,753	129,862 (20.2)	47,161, 6,984, 54,145	
Transportation	10,521	2,714	13,235 (2.1)		7,205, 65, 7,270 (5.6)
Total	300,103	343,849	643,952 (100.0)	50,737, 10,695, 61,432	107,315, 22,543, 129,858 (100.0)

(20,000 tons/day)

(Unit: Million pesos)

	Investment			Salvage Value	Operating Costs
	Portion in pesos	Portion in Foreign currency	Total (%)		
Prospecting	12,302		12,302 (2.5)		
Mine	110,564	226,143	336,707 (68.1)		58,298, 8,010, 66,308 (68.8)
Electricity	933	2,563	3,496 (0.7)		15,420, 9,724, 25,144 (26.1)
Water	15,728	17,956	33,684 (6.8)	3,576, 3,711, 7,287	54, –, 54 (–)
Mining Town	84,176	12,468	96,644 (19.6)	23,338, 3,456, 26,794	
Transportation	8,885	2,714	11,599 (2.3)		4,855, 53, 4,908 (5.1)
Total	232,588	261,844	494,432 (100.0)	26,914, 7,167, 34,081	78,627, 17,787, 96,414 (100.0)

Annual economic costs: Allocation of total economic costs to different years is the same as for financial cost allocation. The total economic costs incurred annually are summarized in Table 7-8 (1), (2) on pp. 35, 36.

3-3 Revenue Estimates

Our view of revenues: Estimated revenues constitute inputs to financial analysis, and for this project the revenues are determined primarily from the sales values of copper and molybdenum. Values of copper and molybdenum concentrates are evaluated by international prices (or FOB prices in Buenos Aires). Since official quotations for copper and molybdenum fluctuate over wide ranges, no attempt was made to forecast long-term transitions in these prices. Average prices in 1980 are used as standard values, and sensitivity analyses are performed for a 40% variation in the price of copper and a 20% variation in the price of molybdenum.

Official quotation of copper concentrate and revenues: The final copper product of this project is copper concentrate. The official quotation is calculated in the following manner.

The copper concentrate has to be smelted to produce electro-copper. Smelting costs are approximately 15 cents per pound. The recovery rate of smelting operations in the case of 20% quality concentrate is about 19% (about 1% is lost during smelting operations). The official quotation for electro-copper was 100 cents on the average in 1980, corresponding to (100 cents – 15 cents) x 2,204.6 pounds x 0.19 = 356 US dollars, where 2,204.6 pounds is equal to one ton. Therefore, the official quotation used in financial analysis is calculated as 356 US$/ton x 1,950 pesos/US$ = 694,000 pesos/ton.

The annual production of copper concentrate is 55,000 tons in the case of 30,000 tons/day operation or 36,000 tons in the case of 20,000 tons/day. Thus, annual revenues derived from copper production used in the financial analysis are calculated as follows:

30,000 tons/day operation:
694,000 pesos x 55,000 tons = 38,170 million pesos

29,000 tons/day operation:
694,000 pesos x 36,000 tons = 24,980 million pesos

Official quotation of molybdenum concentrate and revenues: The Molybdenum price is determined based on the official quotation (FOB price) of American Metal Climax, Inc. (AMAX) in the U.S., and expressed in a unit price per pound of ore with 1% Mo, the standard quality of the final product being 95% in the form MoS_2. Given a quality of 85% MoS_2 and an AMAX quotation of US$10 per pound, the price (FOB) per ton of the ore is calculated as:

US$10/lb x 2,204.6 lbs/ton x 51% = US$11,243.46/ton
or 1,950 pesos/US$ x US$11,243.46 = 21,925,000 pesos,

where 85% MoS_2 corresponds to 51% Mo and one ton is equivalent to 2,204.6 pounds.

Table 7-8-(1) Comprehensive Table of Economic Costs by Sector and Year (Operation Scale: 30,000 tons/day)

(Unit: Billion pesos)

	Prospecting		Mine		Electricity		Water		Mining Town		Transportation		Total	
	A[1]	B[2]	A	B	A	B	A	B	A	B	A	B	A	B
1981	10.13	–	–	–	–	–	–	–	–	–	–	–	10.13	–
1982	2.17	–	–	–	–	–	–	–	–	–	–	–	2.17	–
1983	–	–	33.70	74.86	0.75	2.05	5.19	4.77	10.63	1.57	6.28	2.65	56.55	85.90
1984	–	–	44.92	99.82	0.18	0.51	5.55	7.90	54.10	8.01	2.39	0.03	107.14	116.27
1985	–	–	33.70	74.86	–	–	5.08	7.62	48.38	7.17	1.85	0.03	89.01	89.68
1986	–	–	77.40	8.18	22.66	14.30	0.05	–	–	–	7.21	0.07	107.32	22.55
1987	–	–	77.40	8.18	22.66	14.30	0.05	–	–	–	7.21	0.07	107.32	22.55
1988	–	–	77.40	8.18	22.66	14.30	0.05	–	–	–	7.21	0.07	107.32	22.55
1989	–	–	77.40	8.18	22.66	14.30	0.05	–	–	–	7.21	0.07	107.32	22.55
1990	–	–	77.40	8.18	22.66	14.30	0.05	–	–	–	7.21	0.07	107.32	22.55
1991	–	–	77.40	8.18	22.66	14.30	0.05	–	–	–	7.21	0.07	107.32	22.55
1992	–	–	77.40	8.18	22.66	14.30	0.05	–	–	–	7.21	0.07	107.32	22.55
1993	–	–	77.40	8.18	22.66	14.30	0.05	–	–	–	7.21	0.07	107.32	22.55
1994	–	–	77.40	8.18	22.66	14.30	0.05	–	–	–	7.21	0.07	107.32	22.55
1995	–	–	77.40	8.18	22.66	14.30	0.05	–	–	–	7.21	0.07	107.32	22.55
1996	–	–	112.50	60.17	22.66	14.30	0.05	–	–	–	7.21	0.07	142.42	74.54
1997	–	–	77.40	8.18	22.66	14.30	0.05	–	–	–	7.21	0.07	107.32	22.55
1998	–	–	77.40	8.18	22.66	14.30	0.05	–	–	–	7.21	0.07	107.32	22.55
1999	–	–	77.40	8.18	22.66	14.30	0.05	–	–	–	7.21	0.07	107.32	22.55
2000	–	–	77.40	8.18	22.66	14.30	0.05	–	–	–	7.21	0.07	107.32	22.55
2001	–	–	77.40	8.18	22.66	14.30	0.05	–	–	–	7.21	0.07	107.32	22.55
2002	–	–	77.40	8.18	22.66	14.30	0.05	–	–	–	7.21	0.07	107.32	22.55
2003	–	–	77.40	8.18	22.66	14.30	0.05	–	–	–	7.21	0.07	107.32	22.55
2004	–	–	77.40	8.18	22.66	14.30	0.05	–	–	–	7.21	0.07	107.32	22.55
2005	–	–	77.40	8.18	22.66	14.30	0.05	–	–	–	7.21	0.07	107.32	22.55
2006	–	–	77.40	8.18	22.66	14.30	0.05	–	–	–	7.21	0.07	107.32	22.55
2007	–	–	77.40	8.18	22.66	14.30	0.05	–	–	–	7.21	0.07	107.32	22.55
Salvage Value							3.58	3.71	47.16	6.98			50.74	10.69

Notes: 1) A is Portion in pesos.
2) B is Portion in Foreign Currency.

Table 7-8-(2) Comprehensive Table of Economic Costs by Sector and Year (Operation Scale: 20,000 tons/day)

(Unit: Billion pesos)

	Prospecting		Mine		Electricity		Water		Mining Town		Transportation		Total	
	A[1]	B[2]	A	B	A	B	A	B	A	B	A	B	A	B
1981	10.13	–	–	–	–	–	–	–	–	–	–	–	10.13	–
1982	2.17	–	–	–	–	–	–	–	–	–	–	–	2.17	–
1983	–	–	25.27	56.15	0.75	2.05	5.19	4.77	8.02	1.19	5.79	2.65	45.02	66.81
1984	–	–	33.70	74.86	0.19	0.51	5.46	5.56	40.19	5.95	1.74	0.03	81.28	86.91
1985	–	–	25.27	56.15	–	–	5.08	7.62	35.97	5.33	1.36	0.03	67.68	69.13
1986	–	–	58.30	8.01	15.42	9.72	0.05	–	–	–	4.86	0.05	78.63	17.78
1987	–	–	58.30	8.01	15.42	9.72	0.05	–	–	–	4.86	0.05	78.63	17.78
1988	–	–	58.30	8.01	15.42	9.72	0.05	–	–	–	4.86	0.05	78.63	17.78
1989	–	–	58.30	8.01	15.42	9.72	0.05	–	–	–	4.86	0.05	78.63	17.78
1990	–	–	58.30	8.01	15.42	9.72	0.05	–	–	–	4.86	0.05	78.63	17.78
1996	–	–	71.46	27.51	15.42	9.72	0.05	–	–	–	4.86	0.05	91.79	37.28
1997	–	–	58.30	8.01	15.42	9.72	0.05	–	–	–	4.86	0.05	78.63	17.78
2006	–	–	71.46	27.51	15.42	9.72	0.05	–	–	–	4.86	0.05	91.79	37.28
2007	–	–	58.30	8.01	15.42	9.72	0.05	–	–	–	4.86	0.05	78.63	17.78
2018	–	–	58.30	8.01	15.42	9.72	0.05	–	–	–	4.86	0.05	78.63	17.78
Salvage Value							3.58	3.71	23.34	3.46			26.92	7.17

Notes: 1) A is Portion in pesos.
2) B is Portion in Foreign Exchange.

The annual production of molybdenum concentrate is 7,500 tons in the case of operation scale of 30,000 tons/day or 5,000 tons in the case of 20,000 tons/day. Thus, total annual revenues from the molybdenum are calculated as follows:

30,000 ton/day operation:
21,925,000 pesos x 7,500 tons ≒ 164,440 million pesos

20,000 ton/day operation:
21,925,000 pesos x 7,500 tons ≒ 109,630 million pesos.

Total revenues: The computation results are summarized in Table 7-11.

Table 7-11. Total Annual Revenues

(Unit: Billion pesos)

Operating scale (tons/day) / Items	30,000	20,000
Copper Revenues	38.17	24.98
Molybdenum Revenues	164.44	109.63
Total Revenues	202.61	134.61

3-4. Benefit Estimates

Our view of benefits: Various benefits to the nation of Argentina accrue from development of the mine. These are summarized below as ten items.

1. Development of copper resources to meet various purposes.

2. Provision of copper products for the international market.

3. Acquisition of foreign exchange to enrich the national budget and the financial status of the provincial government, and contribute to improvement of the trade balance and debt repayment ability of the nation.

4. Conversion of mineral resources into valuable goods.

5. Contribution to regional development of La Rioja province by establishing the mine as a center of development.

6. Promotion of technological advances in the field of mine development.

7. Increase in employment opportunities and absorption of surplus labor, which would help in raising income levels and increasing consumption and investment.

8. Multiplier effects on related industries such as construction materials and equipment.

9. Benefits to residents of the region in the form of improved welfare facilities such as a hospital and a playground and secondary benefits derived from water supply, roads and railways.

10. Income distribution effects.

Negative benefits such as pollution from discharge or noise may also be included, but for this project it is considered that they pose no serious problem.

Of those various benefits enumerated above, only quantifiable ones are included in the analysis herein. Of the major quantifiable benefits, one of course is that derived from copper and molybdenum production, which accounts for 90% of the total benefits. Other potential benefits include increased agricultural production using the water supply reservoir after termination of the mine in 22 years. This is certainly a benefit attributable to the mine development, and treated as additional benefit or negative cost that arises after the 22nd year. This and other benefits, however, are minor in comparison with the benefits from copper and molybdenum production.

Benefits from copper and molybdenum production: These products are international goods, and thus their evaluation is usually based on international market prices. The shadow exchange rate in Argentina represents a 33.3% increase in the value of US dollars over the official exchange rate. Therefore, the benefits to the national economy derived from export of the copper and molybdenum products (at standard international prices) are also higher by 33.3% than the revenues used in financial analysis.

30,000 tons/day operation:

(38,170 million pesos + 164,440 million pesos)
revenue form copper revenue from molybdenum

x 1.333 = 270,080 million pesos

20,000 tons/day operation:

(24,980 million pesos + 109,630 million pesos)
revenue form copper revenue from molybdenum

x 1.333 = 179,440 million pesos

As calculated above, the total annual benefits of mineral exportation are 270,080 million pesos in the case of 30,000 ton/day operation or 197,440 million pesos in the case of 20,000 tons/day.

Salvage value: The salvage value of the mining town and water supply facilities is summarized below.

(Unit; Million pesos)

Operating scale (tons/day) / Items	30,000			20,000		
	Domestic Currency	Foreign Currency	Total	Domestic Currency	Foreign Currency	Total
Mining Town	47,161	6,985	54,146	23,338	3,456	26,794
Water Supply Facilities	3,576	3,711	7,287	3,576	3,711	7,287
Total	50,737	10,696	61,433	26,914	7,167	34,081

3-5. Cost-Benefit Analysis

Comparison of costs and benefits (economic analysis): As shown in Table 7-14, the project costs arise starting in 1981 and total costs through the year 2008 amount to 3,500,880 million pesos (investment costs of 643,960 million pesos + operating costs of 2,856,920 million pesos), whereas benefits first accrue in 1986. Total benefits through the year 2008 will be 6,003,190 million pesos (copper, 1,119,360 million pesos + molybdenum, 4,822,400 million pesos + mining town, water supply facilities of 61,430 million pesos). The internal economic rate of return that is used as an index to compare benefits and costs was found to be 20.0% in the case of 30,000 ton/day operation. As stated earlier, the value of the internal economic rate of return is higher than 10%, the opportunity cost of capital, justifies investment from a national viewpoint. The value of 20% obtained for this project implies that the Famatina mine project has high investment priority. (Refer to Table 7-14 on the next page.)

Sensitivity analysis: The result of sensitivity analysis shows that the internal economic rate of return is significantly reduced to 12.3% if the total benefits are reduced by 20%, but the value is still higher than 10%. Even if the highly variable copper price drops by as much as 40%, the internal rate of return is still maintained at 17.3% due to sales of molybdenum. A 20% reduction in the price of molybdenum would bring the rate to 13.9%.

Sensitivity analyses on project costs reveal that increases in investment costs do not significantly affect the viability of the project. Effects of variations in operating costs are more

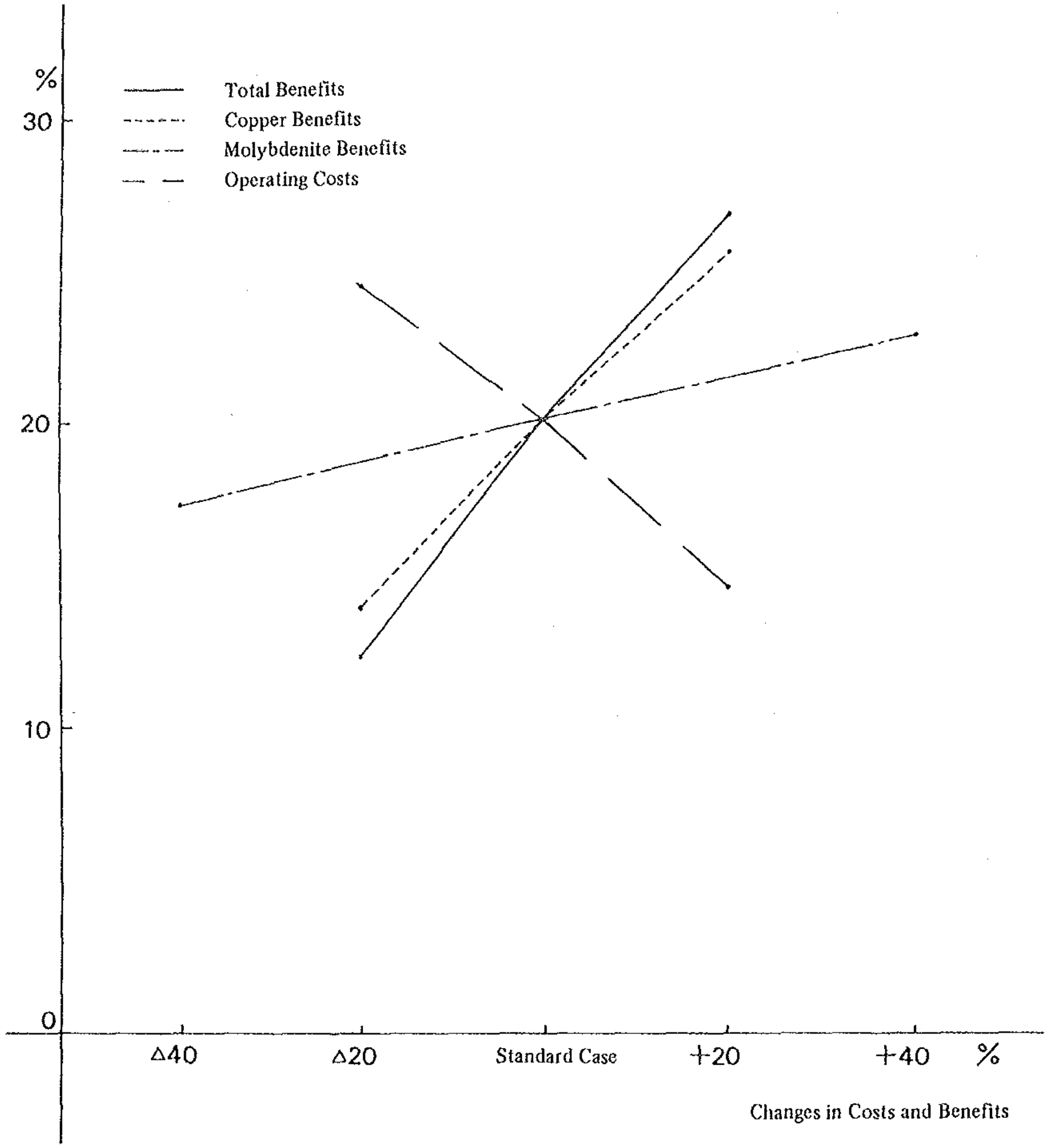
Table 7-14. Calculation of Internal Economic Rate of Return in the Case of an Operating Scale of 30,000 tons/day

(Unit: Billion pesos)

Year	Invest-ment	Bene-fits	Copper	Molyb-denite	Operat-ing Costs	Inflow	Outflow	Net Inflow	Dis-count Rate	Present Value
1981	10.13	–	–	–	–	–	10.13	-10.13	1.000	-10.13
1982	2.17	–	–	–	–	–	2.17	-2.17	0.833	-1.81
1983	142.46	–	–	–	–	–	142.46	-142.46	0.694	-98.87
1984	223.43	–	–	–	–	–	223.43	-223.43	0.579	-129.36
1985	178.68	–	–	–	–	–	178.68	-178.68	0.482	-86.12
1986	–	270.08	50.88	219.20	129.86	270.08	129.86	140.22	0.402	56.37
1987	–	270.08	50.88	219.20	129.86	270.08	129.86	140.22	0.335	46.97
1988	–	270.08	50.88	219.20	129.86	270.08	129.86	140.22	0.279	39.12
1989	–	270.08	50.88	219.20	129.86	270.08	129.86	140.22	0.233	32.67
1990	–	270.08	50.88	219.20	129.86	270.08	129.86	140.22	0.194	27.20
1991	–	270.08	50.88	219.20	129.86	270.08	129.86	140.22	0.162	22.72
1992	–	270.08	50.88	219.20	129.86	270.08	129.86	140.22	0.135	18.93
1993	–	270.08	50.88	219.20	129.86	270.08	129.86	140.22	0.112	15.71
1994	–	270.08	50.88	219.20	129.86	270.08	129.86	140.22	0.093	13.04
1995	–	270.08	50.88	219.20	129.86	270.08	129.86	140.22	0.078	10.94
1996	87.09	270.08	50.88	219.20	129.86	270.08	216.95	53.13	0.065	3.45
1997	–	270.08	50.88	219.20	129.86	270.08	129.86	140.22	0.054	7.57
1998	–	270.08	50.88	219.20	129.86	270.08	129.86	140.22	0.045	6.31
1999	–	270.08	50.88	219.20	129.86	270.08	129.86	140.22	0.038	5.33
2000	–	270.08	50.88	219.20	129.86	270.08	129.86	140.22	0.031	4.35
2001	–	270.08	50.88	219.20	129.86	270.08	129.86	140.22	0.026	3.65
2002	–	270.08	50.88	219.20	129.86	270.08	129.86	140.22	0.022	3.09
2003	–	270.08	50.88	219.20	129.86	270.08	129.86	140.22	0.018	2.52
2004	–	270.08	50.88	219.20	129.86	270.08	129.86	140.22	0.015	2.10
2005	–	270.08	50.88	219.20	129.86	270.08	129.86	140.22	0.013	1.82
2006	–	270.08	50.88	219.20	129.86	270.08	129.86	140.22	0.010	1.40
2007	–	270.08	50.88	219.20	129.86	270.08	129.86	140.22	0.009	1.26
2008	–	61.43	–	–	–	–	–	61.43	0.007	0.43
	643.96	6,003.19	1,119.36	4,822.4	2,856.92	5,941.76	3,500.88	2,502.31		

Fig. 1-3. Sensitivity Analysis on Variations in Costs and Benefits

(Economic Analysis in the Case of an Operating Scale of 30,000 tons/day)



significant, with the internal rate of return being reduced by 4 to 5% as a result of a 20% increase in the operating costs. Even if a 33.3% increase in the value of the peso is assumed, the internal rate of return is computed to be 19.2% (See Fig. 1-3). It is clear from these analyses that decreases in benefits or increases in costs would not seriously undermine the viability of this project, which would contribute significantly to the development of the national economy through efficient utilization of mineral resources, including copper and molybdenum, human resources, including 2,000 mine employees, and capital amounting to 499,000 million pesos (Refer to Table 7-14).

Comparison of revenues and expenses (financial analysis): The internal financial rate of return that equalizes the present discounted values of revenues and expenses was found to be 11.0%. Details are shown in Table 7-13. Depreciation is included in the table but is not regarded as a cost element since it does not represent any outflow of money. Taxes are imposed on the net revenues after interest is subtracted, but interest is separately added later to the total expenses; the net effects are thus zero. This computation shows the relationship between the internal financial rate of return and the prevailing interest rate. (Refer to Table 7-13 on p. 43.)

The 11% value of the internal financial rate of return is not considered very high. An internal financial rate of return of 15% or higher is usually regarded as reasonable for mine development carried out by private enterprise since adequacy of the investment is judged taking into account interest, profits and dividends as well. If the capital can be raised in general money markets at an interest rate of about 8%, this project would be sufficiently profitable.

Sensitivity analyses: An increase in total revenues of 20% makes the internal financial rate of return 17.5%. Although decreases in capital expenses have only minor effect, reduction by 20% in operating costs improves the internal financial rate of return to 15.2% (See Fig. 1-4). Effects on the rate by each item of revenue and cost are given in Table 7-15 on p. 45.

3-6. Overall Evaluation

From the preceding analyses, the following conclusions are drawn concerning how the Famatina mine project should be handled hereafter.

(a) The internal financial rate of return of 11% is not very high, but the internal economic rate of return of 20% is sufficiently high enough to justify proceeding toward development of the 200 million tons copper-molybdenum resources.

(b) A strong point of this investigation is its comprehensive analyses not only of the mine itself but all other aspects of mine development including roads, water resources, power supply and the mining town, although the analyses were based on a very limited number of borings, insufficient hydrologic and other data and very rough estimates of project costs. This is not the usual feasibility study which determines adequacy of investment in mine development. The positive conclusions of this investigation imply only that the next development step should definitely be taken, including further investment in prospecting boring, tests to evaluate ore quality and preparations for international tender.

Table 7-13. Calculation of Internal Financial Rate of Return in the Case of an Operating Scale of 30,000 tons/day

(Unit: Billion pesos)

Year	Invest-ment a	Reve-nues b	Copper	Molyb-denum	Operat-ing Costs c	Depre-ciation d	Interest e	Taxes f	Reve-nues after Taxes b-c-e-f	Net Inflow b-a-(c-d)-f	Dis-count Rate (11%)	Present Value
1981	11.25	–	–	–	–	–	–	–	–	-11.25	1.000	-11.25
1982	2.41	–	–	–	–	–	–	–	–	-2.41	0.901	-2.17
1983	122.96	–	–	–	–	–	–	–	–	-122.96	0.812	-99.84
1984	207.51	–	–	–	–	–	–	–	–	-207.51	0.731	-151.69
1985	168.56	–	–	–	–	–	–	–	–	-168.56	0.659	-111.08
1986	–	202.61	(38.17)	(164.44)	159.84	(32.60)	52.88	–	-10.11	75.37	0.593	44.69
1987	–	202.61	(38.17)	(164.44)	159.84	(32.60)	50.47	–	-7.7	75.37	0.535	40.32
1988	–	202.61	(38.17)	(164.44)	159.84	(32.60)	48.07	–	-5.3	75.37	0.482	36.33
1989	–	202.61	(38.17)	(164.44)	159.84	(32.60)	45.67	–	-2.9	75.37	0.434	32.71
1990	–	202.61	(38.17)	(164.44)	159.84	(32.60)	43.26	–	-0.49	75.37	0.391	29.47
1991	–	202.61	(38.17)	(164.44)	159.84	(32.60)	40.86	–	1.91	75.37	0.352	26.53
1992	–	202.61	(38.17)	(164.44)	159.84	(32.60)	38.46	–	4.31	75.37	0.317	23.89
1993	–	202.61	(38.17)	(164.44)	159.84	(32.60)	36.05	0.44	6.28	74.93	0.286	21.43
1994	–	202.61	(38.17)	(164.44)	159.84	(32.60)	33.65	0.90	8.22	74.47	0.258	19.21
1995	–	202.61	(38.17)	(164.44)	159.84	(32.60)	31.25	1.52	10.00	73.85	0.232	17.13
1996	78.00	202.61	(38.17)	(164.44)	165.04	37.80	28.84	1.44	7.29	-4.07	0.209	-0.85
1997	–	202.61	(38.17)	(164.44)	165.04	37.80	26.44	2.20	8.93	73.17	0.188	13.76
1998	–	202.61	(38.17)	(164.44)	165.04	37.80	24.03	3.13	10.41	72.24	0.170	12.28
1999	–	202.61	(38.17)	(164.44)	165.04	37.80	21.63	4.21	11.73	71.16	0.153	10.89
2000	–	202.61	(38.17)	(164.44)	165.04	37.80	19.23	5.45	12.89	69.92	0.138	9.65
2001	–	202.61	(38.17)	(164.44)	133.86	6.63	16.82	17.14	34.79	58.24	0.124	7.22
2002	–	202.61	(38.17)	(164.44)	133.86	6.62	14.42	17.93	36.40	57.44	0.112	6.43
2003	–	202.61	(38.17)	(164.44)	133.86	6.62	12.02	18.72	38.01	56.65	0.101	5.72
2004	–	202.61	(38.17)	(164.44)	133.86	6.62	9.61	19.51	39.63	55.86	0.091	5.08
2005	–	202.61	(38.17)	(164.44)	133.86	6.62	7.21	20.31	41.23	55.06	0.082	4.52
2006	–	202.61	(38.17)	(164.44)	133.86	6.62	4.81	21.10	42.84	54.27	0.074	4.04
2007	–	202.61	(38.17)	(164.44)	133.86	6.62	2.40	21.89	44.45	53.48	0.066	3.57
2008	–	50.39	–	–	–	–	–	16.63	33.76	33.76	0.060	2.03
	590.69	4,507.81	839.74	3,617.68	3,360.62	561.35	608.08	172.52	366.59	945.33		

Fig. 1-4. Sensitivity Analysis of Variations in Revenues and Expenses

(Financial Analysis in the Case of an Operating Scale of 30,000 tons/day)

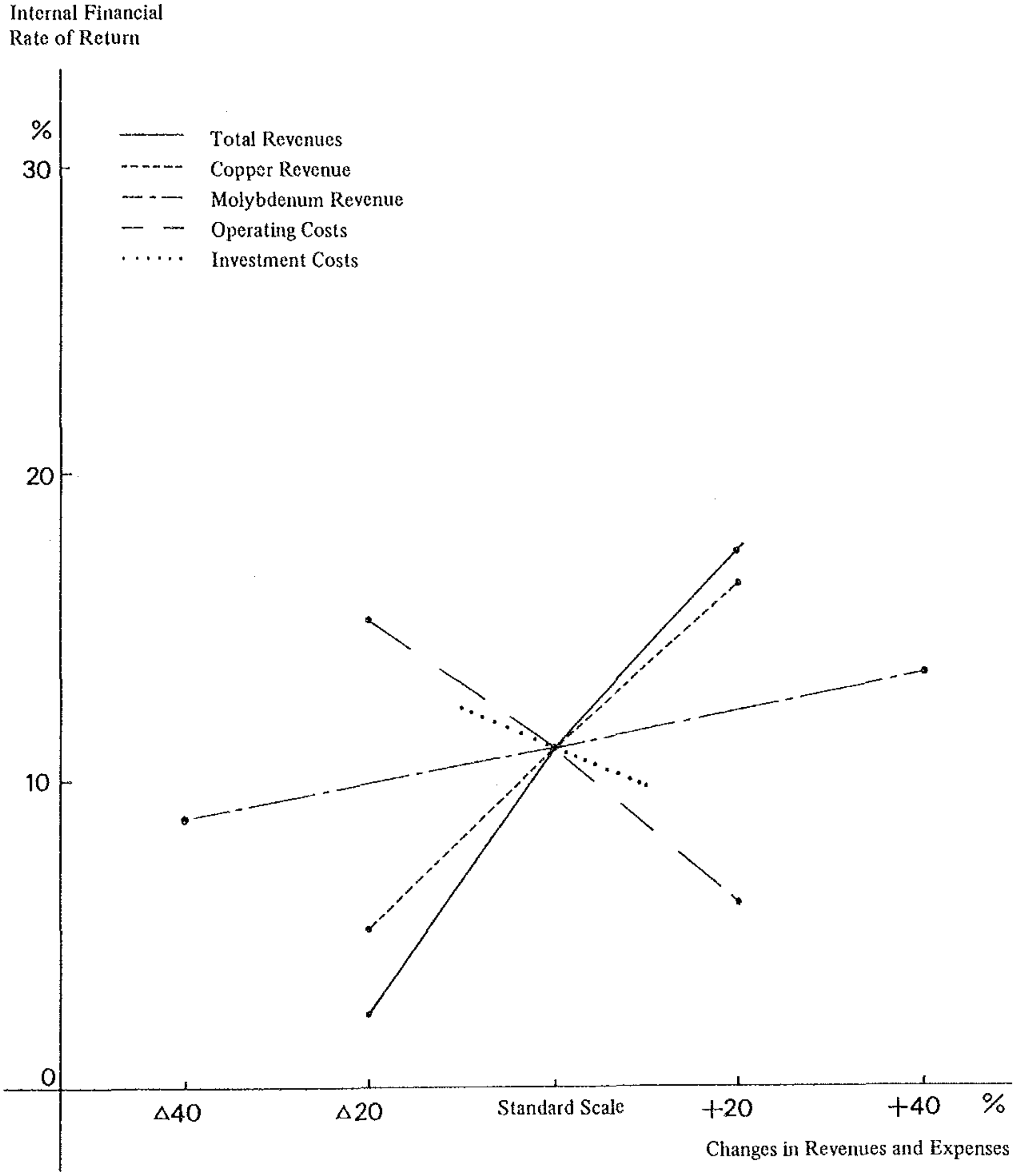


Table 7-15. Summary of Sensitivity Analysis

(Financial Analysis in the Case of an Operating Scale of 30,000 tons/day)

1.	Changes in Total Revenue	20% Decrease	Basic Case	20% Increase	Fig. 7-4-(1)
	Internal Financial Rate of Return	2.4%	11.0%	17.5%	
2.	Changes in Price of Copper Concentrate	40% Decrease	Basic Case	40% Increase	Fig. 7-4-(1)
	Internal Financial Rate of Return	8.8%	11.0%	13.5%	
3.	Changes in Price of Molybdenum Concentrate	20% Decrease	Basic Case	20% Increase	Fig. 7-4-(1)
	Internal Financial Rate of Return	5.1%	11.0%	16.4%	
4.	Changes in Operating	20% Decrease	Basic Case	20% Increase	Fig. 7-4-(2)
	Internal Financial Costs Rate of Return	15.2%	11.0%	6.0%	
5.	Changes in Initial Investment	10% Decrease	Basic Case	10% Increase	Fig. 7-4-(2)
	Internal Financial Rate of Return	12.4%	11.0%	9.8%	

(c) Among various factors to be considered in preparation for development, an important consideration in the case where development is carried out under joint management of private enterprises is that the government should assist in raising low interest capital or in constructing infrastructures, in consideration of the moderate internal financial rate of return of 11%. Such action will be the first step in materialization of the project. Economic analysis revealing a high internal economic rate of return made clear that government aid is certainly justified.

(d) Effects of government aid on the infrastructure, however, do not in fact appear to be so substantial. Possible government grant projects are the construction of the 30 km road, the dam, or the mining town. The effects of reduced initial investment expenses on the internal financial rate of return, however, are not very significant as shown by the sensitivity analyses. More important would be application of a low electricity rate for mine uses or assistance in capital raising by provision of a low interest rate.

(e) The Famatina mine is a molybdenum mine rather than a copper mine. About 80% of the total revenue would be derived from molybdenum, which constitutes one-seventh of the quantity of products generated by the mine. In this sense, the potential for development is higher for this mine than for other copper mines. This is a favorable factor for private enterprises, which make up the moderate internal financial rate of return of 11%.

(f) The large difference between the internal, economic and financial rates of return is primarily attributable to different evaluations of the foreign currency portion. That is, in financial analysis a rate of 1,950 pesos to the dollar was used, white 2,600 pesos to the dollar was used in economic analysis. While the foreign currency portion of the project costs is only half of the total, benefits fall almost entirely in the foreign currency portion. This certainly works in favor of the project in economic analysis. It implies that as the nominal foreign exchange rate approaches the rate that reflects the true value of the peso, the internal financial rate of return will also improve.

(g) Famatina mine development is not simply development of the mine itself, but intrinsically has significantly greater impact on the region. If the population of Chilecito at the foot of the mountains increases to 35,000 from the present level of 24,000, related industries, commercial activities, agricultural production in the surrounding area and cultural levels will be substantially affected. Unfortunately, no methodology has been established to quantity these effects, and thus they are not included in computations of the internal economic and financial rates of return. These aspects, however, should not be neglected in formulating national development policies. It is clear at this moment, however, that the project would have wide spread positive effects.

(h) The various costs and revenues reported herein are all estimates based on the field investigation period, i.e., November, 1980. Possibilities exist that actual values will depart considerably as a result of increases in commodity prices. This will not change the essential results of the investigation, which uses the internal rate of return as judgement criteria, unless same fundamental changes occur in future.

3-7. Comprehensive Measures and Recommendations

The following measures should be taken to insure well-balanced fulfillment of sector-wise plans for development of the mine.

(1) The development scale of the mine should be 30,000 tons per day handling of crude ore. This assures better use of scale economy than 20,000 tons/day operations.

(2) Non-availability of a suitable site for settling about 1,900 mine workers precludes their daily commutation to the mine. Lodging facilities should therefore be provided near the mine site.

(3) The possibility of making use of the army for the construction of the 30 km mountain road to the mine should be pursued, since this would result in a saving in personnel costs and thus reduce construction costs to 2,850 million pesos as compared with the 5,840 million pesos that would otherwise be necessary.

(4) It would be more economical to tap groundwater resources near the concentration plant than to utilize surface water by constructing a dam. As a next step, therefore, systematic exploration of grandwater resources should be performed in parallel with further prospecting activities to determine reserves more accurately.

(5) The estimated dam construction cost of 25,900 million pesos was assumed in this analysis to be borne by private enterprise, but the salvage value of 3,800 million pesos will accrue at the end of the 22-year project life. This is because water in the reservoir can be diverted for agricultural development. Thus the water supply reservoir has some public function in addition to mine service. It is therefore, desirable that government aid be provided for dam construction.

(6) The village of Famatina was at first considered promising as a site for the mining town, but eventually the site near Chilecite, 82 km from the mine, was chosen. This distance is too great for daily commutation, and thus provision of lodging facilities near the mine was recommended. The idea of traveling 82 km once a week to and from the mine is still not very attractive but it is an economically efficient solution.

(7) The total costs associated with the mining town were estimated to be 251,300 million pesos, of which about a half or 138,500 million pesos would be borne by the mining company. Subtracted from this are 26,100 million pesos, corresponding to the cost of lodging facilities, to obtain the costs of the mining town near Chilecito as 112,400 million pesos. Of this, housing construction costs are 97,000 million pesos, equivalent to about 90% of the total. There is much to be done concerning

financing and management of this housing construction work.

(8) It is judged that power purchase is the least costly method of obtaining electricity. It is difficult, however, to estimate the real unit costs per kWh of obtaining electricity from the central system. This study recommends power purchase based on the assumption that low rates would be applied, considering the nature of public utility works. There remain, however, uncertain factors related to whether the connection to the central system can be ensured.

(9) Technical problems in the next phase include determination of the exact route for the 35 km maintain road to the mine, selection of a dam site for the water supply reservoir and the route for the water transportation pipeline, selection of power transmission line routes and better evaluation of grandwater reserves. It is almost impossible to cover the entire area between 2,000 m and 4,300 m altitude by field surveys, but technology is available to examine the area by arial photography or information obtained by satellite.

(10) It was expected at the beginning of the field investigation that the existing cableway of 34 km might be revitalized for this project. This facility, however, is already too old to operate for another 20 years or more for transportation of concentrates amounting to about 220 tons/day. Even if it could be used for the concentrates, another road would be required to transport 200 tons of materials and equipment to the mine. This idea, therefore, was abandoned.

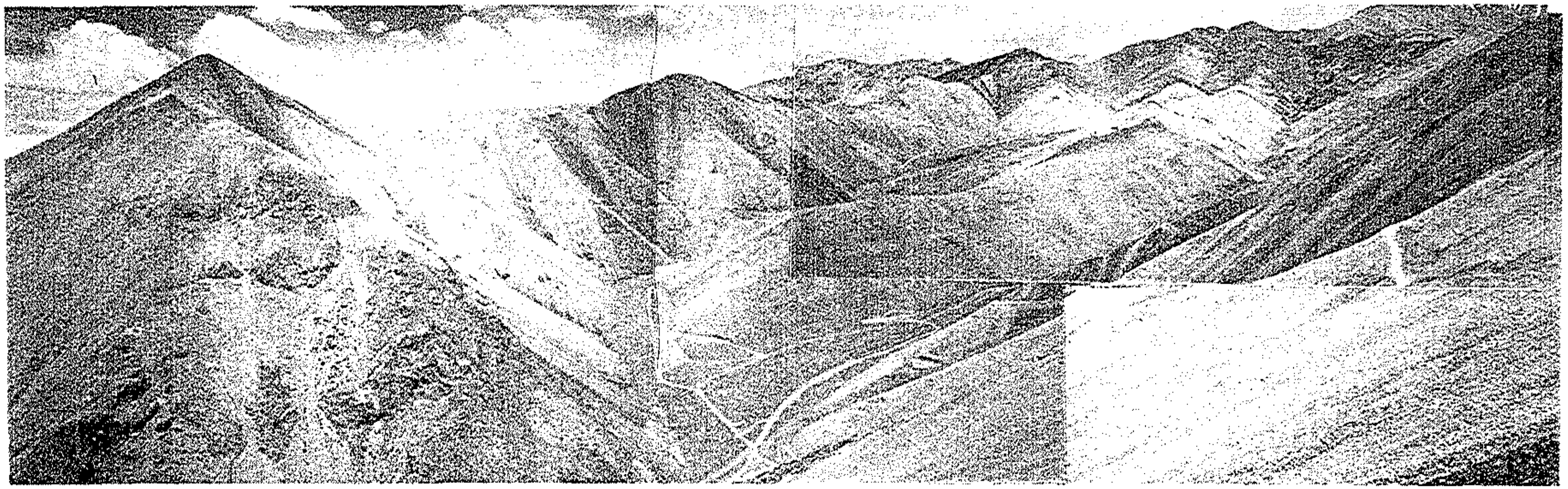
(11) For transportation between Chilecite and Cordoba, the use of trucks was determined to be superior to railway use since the total annual transportation demand related to the mine is only 60,000 tons or less than one-tenth of the quantity that would economically justify the use of railways. Whether this part of the railway system should be abandoned must be examined from other points of view.

(12) Whether the product is to be exported as copper concentrate or electro-copper after smelting depends on the quantities transported and the smelting costs. No investigation was made at this time concerning smelting costs, but if world-average smelting costs of 15 cents per pound can be realized in Argentina, it would be more economical to smelt the copper concentrate domestically rather than export it without smelting.

Chapter 2.

MINE DEVELOPMENT PLAN

The Panoramic View of Famatina Ore Deposits at 4,300 m



CHAPTER 2. *MINE DEVELOPMENT PLAN*

1. The Famatina Mineralized Zone Development Plan

1-1. Outline of the Famatina Mineralized Zone

The Famatina mineralized zone is situated in La Rioja Province in the north-western part of the Republic of Argentina with the coordinates at 29° south latitude and 67°45′ west longitude. The zone lies in a sub-mountainous region of the Andes mountains (Cordillera de Los Andes) which rise 4,000 to 4,500 m above sea level.

Reconnaissance surveys and exploration work have been carried out in this mineralized zone continuously since 1957 under the cooperative efforts of the Govierno Provincial de La Rioja, Secretaría de Estado de Mineria (of the Ministerio de Economia), and the Dirección General de Fabricationes Militares. As the first stage of the project, preliminary exploratory work, including the diamond drilling of 36 holes totalling 10,677 m cumulative depth, was completed in 1980.

It has been confirmed from the exploratory work conducted to date that in the Rio Amarillo area of this mineralized Cu-Mo disseminated ore bodies of the prophyry copper type exist which presumably have a generic relationship with intrusive rocks of the Tertiary period. The latter intrude through sedimentary rocks of the Ordovician period which constitute the principal mother rock in the area.

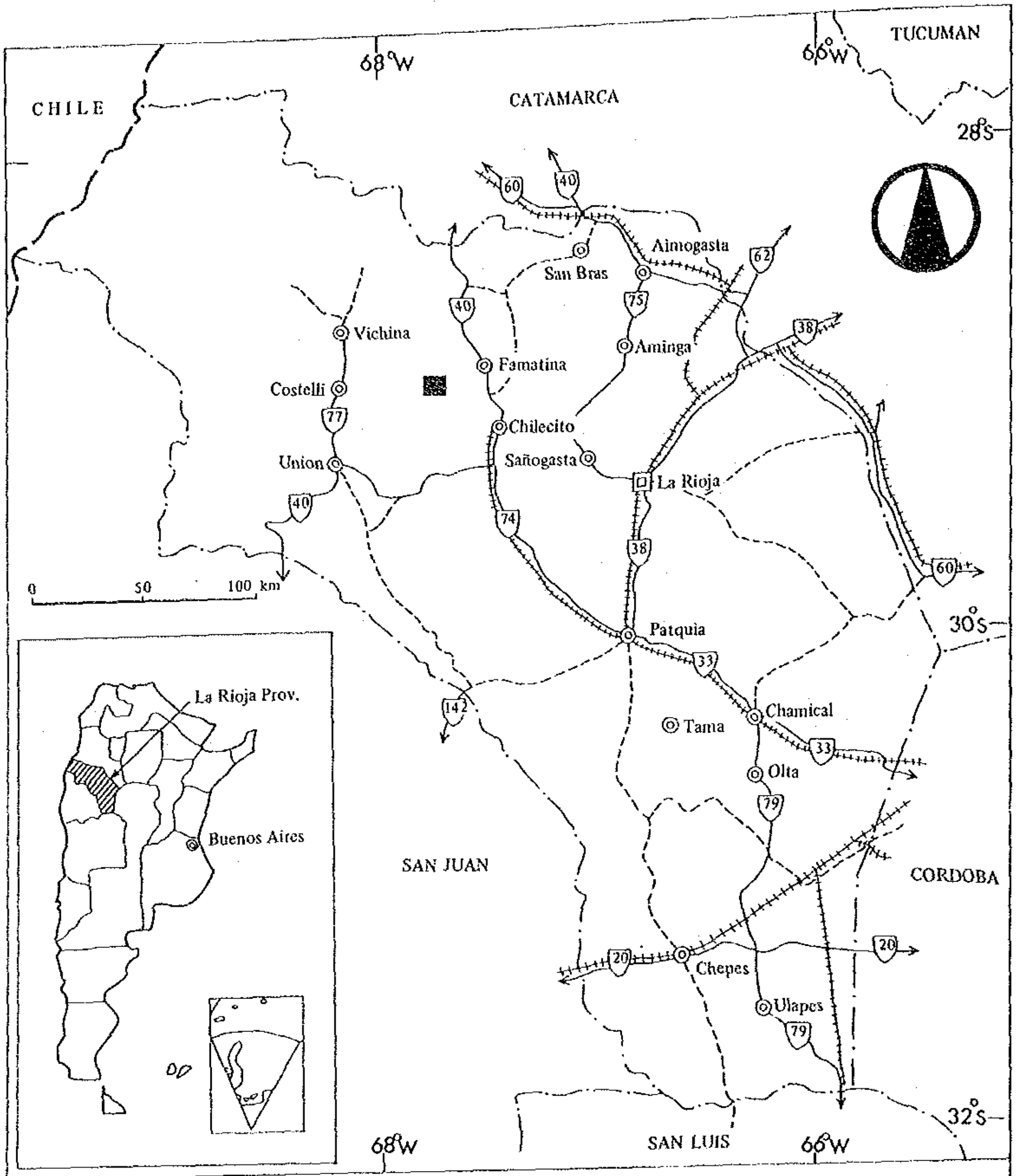
The principal mineralized zone surrounds the intrusive rock body in a horseshoe shape, extending 4,000 m or more in length and 300 m or, in some parts 600 m, maximum depth.

Of all the main ore bodies in the area, only those in the western sector have been taken up in the present study in consideration of various conditions discribed later. A model of the ore deposits was developed for trial calculations with the results sumarized as follows:

Area of ore block:	382,000 sq.m
Average thickness:	250 m
Exploitable ore reserve:	202 Million tons
Average grade of crude ore:	Cu 0.17%, Mo 0.06%

Location: Administratively, the Famatina mineralized zone spreads over the Department of Chilecito and the Department of Famatina in La Rioja Province, about 100 km in rectilineal distance to the northwest by west from La Rioja City, the capital of La Rioja Province (Refer to Fig. 2-1).

Fig. 2-1. Map of the Famatina Mineralized Zone



Legend:

— — —	National Boundary	—▽—	National Route
—·—·—	Provincial Boundary	- - - - - -	Main Provincial Road
▣	Capital of Province	+++++++++	Railway
◎	Capital of Department	■	Famatina Mineralized Zone

Access: The mineralized zone is located only about 100 km from La Rioja City in rectilineal distance, but because of the Velasco sub-mountainous system which lies between two places grounds routes must make a major detour.

From La Rioja City, one must travel 70 km southwards on National Route No. 38 via Patquia village, then 130 km north on National Route No. 74, which branches off from there in the northwest direction, to reach Chilecito City. From there one must go 30 km north on National Route No. 40 as far as Famatina village and take a provincial road 18 km westward to Los Corrales, a small village of Los Corrales, where the base of the explorative prospecting operation for the mineralized zone is located. From there, the prospective mine site can be reached by travelling 30 km up a road along the Rio Amarillo which was built exclusively for explorative operation.

Although the entire lengths of National Routes Nos. 38 and 74 and most of National Route No. 40 are paved, the provincial road is a simple gravel road. The road from Los Corrales to the prospecting site is a steep mountain road which partially utilizes the natural river-bed of the Rio Amarillo. The present condition is such that it can be used only by four-wheel drive vehicles.

There is also a railway along the National Routes, linking the cities of La Rioja, Patquia and Chilecito by an irregular freight service.

Topographic Conditions: The Famatina mineralized zone is situated on the eastern slope near the ridge of the Famatina sub-mountains (Sierra de Famatina) of the Cordillera de Los Andes which runs in north-south direction close to the border between Argentina and Chile. According to the topographical classification of the Cordillera de Los Andes in the north-western part of Argentina, this area belongs to the Sierras Transpampeanas, which is the transitional section between the plains and the mountainous region. There exist in this region a number of steep sub-mountain ranges which run parallel to the principal mountain range of the Andes, and flat semi-basin plains developing between the ranges in association with the water systems running in the north-south direction.

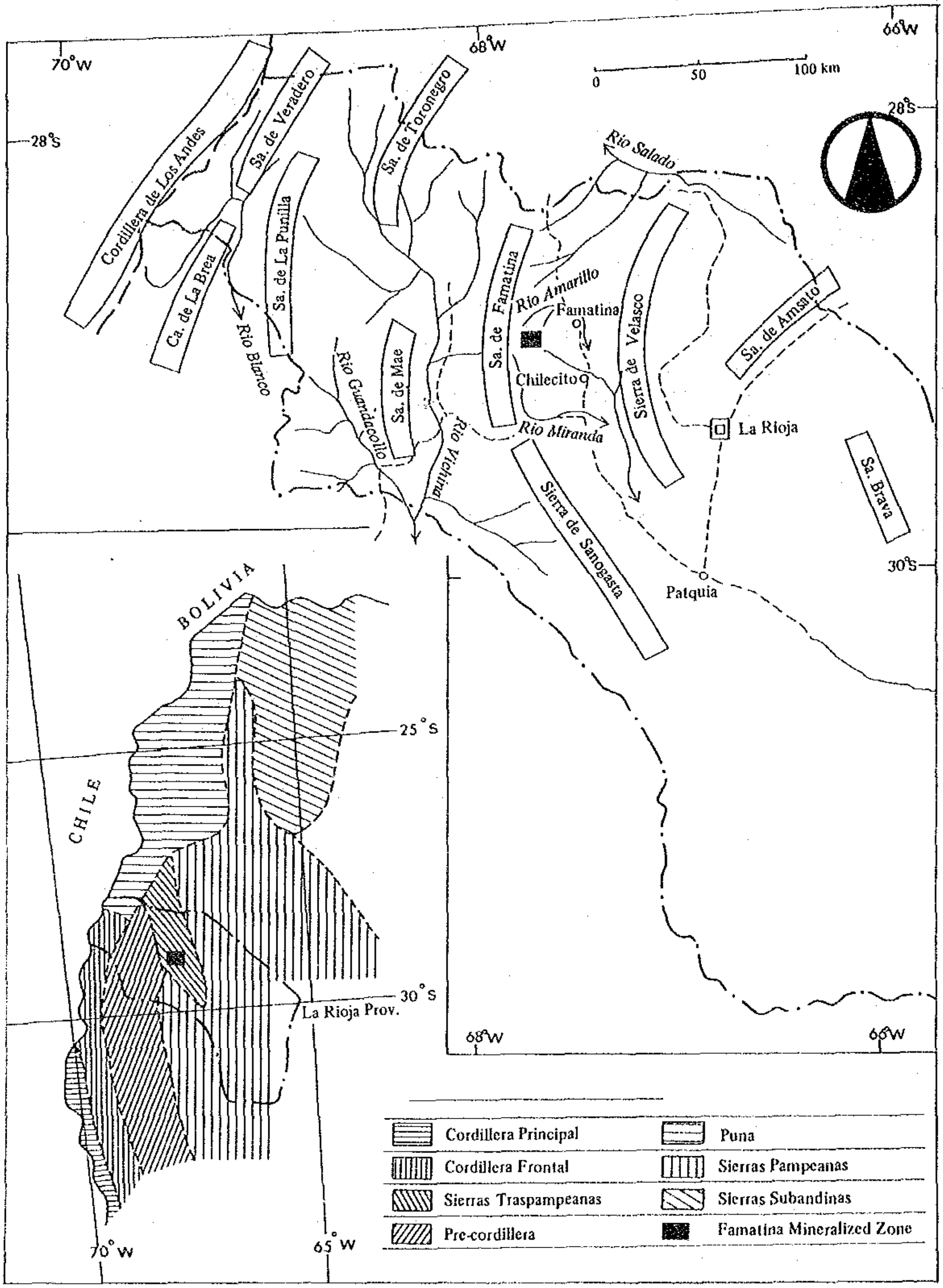
The Famatina sub-mountainous system is an aforested sub-mountain range and some of its peaks tower more than 6,000 m above sea level. The surrounding areas of the mineralized zone exhibit mature topography with steep gradients of 30° or more, and outcroppings of rocks observed widely. Talus sediments are also observed in some parts.

Communities such as Chilecito, Famatina and Los Corrales are located in semi-basin plains along water courses (Refer to Fig. 2-2).

1-2. Explorative Circumstances to Date

Various mining activities have been performed in the neighborhood of this area since the early 19th century. Between the early 1900s and the 1920s, exploration and development of veintype mineral deposits were undertaken intermittently at La Mejicana Mine, Los Vayos Mine and other points locations in the area.

Fig. 2-2. Distribution Map of Main Water and Mountain Systems in Northern Part of La Rioja Province (with Classified Topographical Maps attached)



Active exploration in the Famatina mineralized zone has been carried out from 1957 to the present by the three parties, Gobierno Provincial de La Rioja, Secretaría de Estado de Mineria and Dirección General de Fabricationes Militares. The following is an outline of how circumstances have developed.

1957: The Gobierno Provincial de La Rioja froze a vast area of 1,680 sq.km, inclusive of the subject mineralized zone, and placed it under its direct control (the region was defined as Zona de Reserva No. 1).

1966: The Secretaría de Estado de Mineria established the Organization for the La Rioja Plan (Plan La Rioja) to implement all of activities ranging from preliminary surveys to exploration, aiming at developing the mine in the Province of La Rioja.

1973: In order to promote exploration of the Famatina mineralized zone, the Secretaría de Estado de Mineria commenced developing a road that was to be used exclusively as an access road to the mountain site. Geological and geochemical surveys and geophysical prospecting were also initiated and continue to date.

1974: The plan for exploring the mineralized zone of the Cu-Mo disseminated type in the Famatina area which was drafted by the Secretaría de Estado de Mineria (Plan La Rioja) was authorized as the Famatina Snowclad Mountain Project (Proyecto Nevado del Famatina).

1975: The Secretaría de Estado de Mineria (Plan La Rioja) lanched exploration by drilling.

1976: An agreement for joint work on the project was made by the Gobierno Provincial de La Rioja, Secretaría de Estado de Mineria and Dirección General de Fabricaciones Militares, and as a consulting and coordinating body, the Famatina Committee (Comité del Famatina) was established by the three parties concerned.

1978: The Dirección General de Fabricaciones Militares commenced exploration by drilling, geological survey and geophysical prospecting.

1980: With the completion of the drilling work the first phase field work of exploration was concluded.

The volume of the main exploration works carried out so far is shown in Table 2-1 (Refer to next page).

The cumulative exploration costs spent during the period from 1973, when the explorative activities were begun on a full scale, until today have amounted to 1.95 billion pesos, or 1,884 thousand U.S. dollars, according to data provided by the Secretaría de Estado de

Table 2-1. Volume of Main Explorative Works Implemented to Date

Type of Work	Volume of Work	Remarks
Topographical Survey (with Topographical Mapping)	1 : 10,000 90 km^2 1 : 5,000 3 km^2	Mapping by Aerial Photogrammetry Performed in Parallel and Based on Actual Field Survey
Geological Survey	25 km^2	
Geochemical Survey	940 Samples	Cu, Mo, Pb, Zn; Partly on Au, and Ag
Geophysical Investigation	43.5 km (26 Survey Lines)	I.P. Method
Drilling	10,677 m (36 Holes)	Deepest 639 m, Shallowest 98 m, 300 m on Average

Mineria and the Dirección General de Fabricaciones Militares. However, this amount represents only the approximate total of direct field costs incurred for the subject project by the Secretaría de Estado de Mineria and the Dirección General de Fabricaciones Militares.

The cumulative exploration costs already spent are shown by fiscal year in relation to the progress of exploration works in Table 2-2 (Refer to p. 58).

1-3. Outline of Geology and Mineralization

Geology: The main geological formations around the Famatina mineralized zone consist of, from the lower strata, marine sedimentary rocks that belong to the Negro Peinado formation (Formación Negro Peinado: Ordovician period) which constitute the foundation rock, granitic rocks that belong to the Ñuñorco formation (Formación Ñuñorco: Devonian period), conglomerates and sandstones that belong to the Patquia formation (Formación Patquia: Permian period), and intrusive rocks that belong to the Mogote or Cobre formation (Formación Mogote or Formación de Cobre: Miocene epoch of the Neogene period).

The local geology in the Famatina mineralized zone, particularly around the Rio Amarillo area (Sector Rio Amarillo) where the principal desseminated mineralized zone exists, consists, among the various rocks enumerated above, of sandstone and siltstone of the Negro Peinado formation which has undergone thermal metamorphism to some extent and with rhyolitic and/or dacitic porphyries belonging to the Mogote or Cobre formation. The latter formation is intruding the former at various locations in an irregular form. Also distributed locally are conglomerates of the Quaternary period.

In the Rio Amarillo area, a high angle intrusive rock body of dacitic porphyry of a scale of 2,500 m or more along the major axis and 600 m or more along the minor axis is found outcropping in the middle of the mineralized zone. The mineralized zone of Cu-Mo in this area has a generic relationship to this intrusive rock body, occurs in a half-ring form and is in contact with this intrusive rock body primarily within the Negro Peinado formation the intruded rock.

The prominent tectonic structures recognized within this area are the north-south structure of the Negro Peinado formation itself, the northeast to southwest distributed structure of intrusive rock bodies, and other structures of principal faults running in the southeast to northwest and northnorthwest to sourthsoutheast directions (Fig. 2-3).

Hydrothermal Alteration: The subject area has been subjected extensively to hydrothermal alteration. Particularly in the Rio Amarillo area which constitutes its center, zones having undergone a series of alterations ranging from potashic alteration to silicification, sericitization, argillitization and propylitization are seen distributed in connection with mineralization. Of these, silicification and sericite silicification are predominant in most places, including the central intrusive rock body.

In general, distribution of the various types of altered zones as described above is irregular within the intruded rock. In other words, no distinct banded zonal arrangement is recognizable.

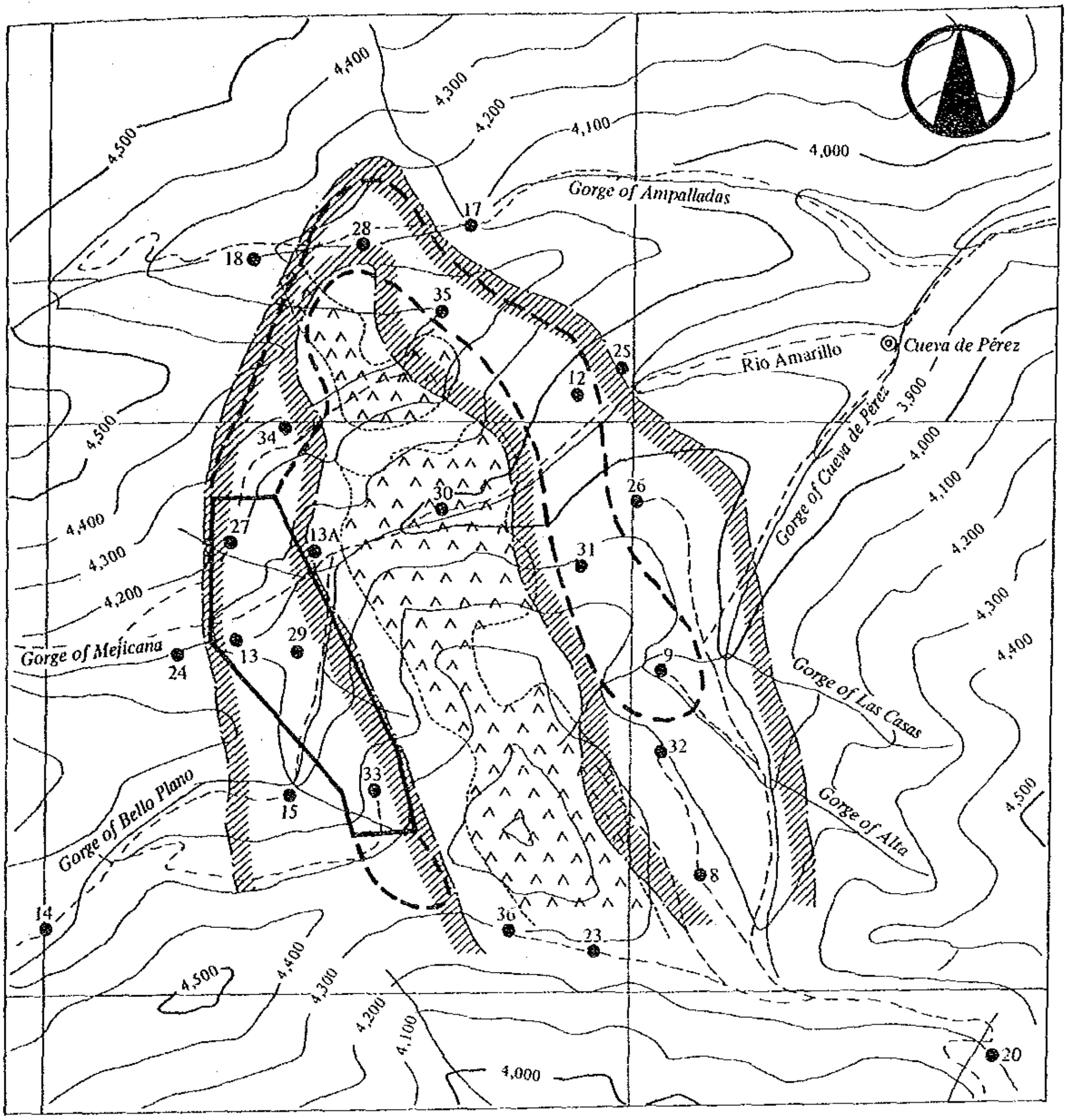
Table 2-2. Summary of Explorative Costs

Fiscal Year	Progress of Work						Explorative Costs	
	Surveying	Geological Survey	Geochemical Survey	Geophysical Investigation	Drilling	Road Building	pesos (thous.)	US$ (thous.)
1973	(1)	(1)	(1)			(1)	508	45
1974				(1)	(1)		1,324	82
1975							3,933	55
1976							11,472	45
1977	(2)	(2)		(2)	(2)	(2)	53,430	131
1978							318,125	394
1979							735,080	711
1980							824,922	421
	Cumulative Total						1,950,794	1,884

Notes: 1) (1) Works by the Secretaría de Estado de Mineria, and
(2) works by the Dirección General de Fabricaciones Militares.

2) Exchange rates at the end of each fiscal year were used for conversion of pesos to U.S. dollars.

Fig. 2-3. Explanatory Map of the Famatina Minralized Zones (the Rio Amarillo Area)



Legend:

	Negro Peinado Formation (Intruded Rock)		Bounds of Mineralized Areas
	Dacitic Porphyry Rock Body		Bounds of Ore Block Set for Trial Computation
	Bound of I.P. Anomaly Area		No., Location of Drilled Holes

Mineralized Ore Body: As stated previously, the Cu-Mo disseminated type ore body in the Rio Amarillo area of the Famatina mineralized zone exists within the silicified-sericitezed zone of the Negro Peinado formation, the intruded rock, in a half-ring or horseshoe shape and in contact with the dacitic porphyric intrusive rock body for about 300 m in width. The dimensions of the mineralized ore body confirmed by minerals found in 10 holes are 4,000 m or more in length along a curve, about 300 m average width and have a maximum depth from surface of 600 m, even more in some parts (as seen in drill hole No. 28).

The ore body is predominated by primary minerals of chalcopyrite, molybdenite and pyrite, but very small amounts of bornite, energite, tetrahedrite, galena, sphalerite, gold, etc. are also evident.

Chalocopyrite and pyrite occur as veinlets or are disseminated, while molybdenite mainly occurs separately within veinlets of quartz.

Besides this disseminated ore body, vetiform deposits of a small scale carrying Au, Ag and Cu are seen distributed in the surrounding areas such as in the La Mejicana and Los Bayos mines.

1-4. Determination of Ore Deposits Model

Results of drilling: Approximate mineral conditions, scale and form of the subject mineralized ore body have been determined grasped from the results of 10 drilling holes-out of the 36 holes of 10,677 m total drilling length drilled over the 1975–1980 period-which have shown minerals in the periphery of the intrusive rock body.

As for the condition of the minerals found in the 10 holes, they show fairly wide dispersions as to width of mineralization and grade. Of the entire mineralized body, divided into several sectors, the west, north and east sectors have relatively high grades.

The drilling works were implemented by the Secretaría de Estado de Mineria (Plan La Rioja) and also by the Dirección General de Fabricaciones Militares (CEGEMIN-I), with average an ore recovery rate of more than 90%.

Of all the drillings, the results of those that are relevant to the main ore bodies are tabulated in Minerals Found in Main Drilled Holes (Table 2-3 on p. 61, 62).

Determination of Ore Block: In developing an ore deposit model from the relevant ore bodies, the following conditions were taken into account:

1) Exploitable ore reserves are large enough to warrant a normal operation of the mine with a low grade and disseminated deposits.

2) The average grade of the deposits is considered as high as possible, judging from the drilling data, including the density of minerals found.

Table 2-3-(1) Minerals Found in Main Drilled Holes (Part 1)

Sector	Western Sector														
Drill Hole No.	27			29			13			33			34		
Depth of Drilled Hole	124.40 m			551.45 m			206.00 m			500.20 m			571.35 m		
Hand of Hole Altitutde	4,162 m			4,067 m			4,086 m			4,240 m			4,276 m		
	Ore Width	Grade		Ore Width	Grade		Ore Width	Grade		Ore Width	Grade		Ore Width	Grade	
		Cu %	Mo %		Cu %	Mo %		Cu %	Mo %		Cu %	Mo %		Cu %	Mo %
above 4,250 m													26	0.015	0.066
~ 4,200										* 40	0.043	0.047	o 50	0.122	0.091
~ 4,150	* 12	0.002	0.120							* 50	0.113	0.047	o 50	0.091	0.046
~ 4,100	* 50	0.006	0.088							* 50	0.292	0.057	o 50	0.446	0.039
~ 4,050	* 50	0.015	0.061	17	0.009	0.043	* 36	0.095	0.002	* 50	0.142	0.039	50	0.087	0.032
~ 4,000	12	0.060	0.041	* 50	0.100	0.044	* 50	0.002	0.106	* 50	0.438	0.050	50	0.070	0.029
~ 3,950				* 50	0.086	0.054	* 50	0.063	0.100	* 50	0.481	0.044	o 50	0.142	0.035
~ 3,900				* 50	0.110	0.065	* 50	0.270	0.113	* 50	0.437	0.059	50	0.129	0.022
~ 3,850				* 50	0.242	0.062	* 20	0.310	0.093	50	0.134	0.025	50	0.116	0.020
~ 3,800				* 50	0.086	0.042				50	0.036	0.021	50	0.034	0.029
~ 3,750				* 50	0.031	0.068				50	0.023	0.026	50	0.025	0.006
~ 3,700				50	0.033	0.031				9	8.960	0.015	55	0.024	0.010
~ 3,650				50	0.022	0.012									
~ 3,600				50	0.019	0.009									
~ 3,550				50	0.012	0.010									
~ 3,500				34	0.015	0.023									
Calculated Grade of All Blocks	112	0.01	0.074	300	0.11	0.056	206	0.12	0.103	340	0.28	0.049			

Notes: 1) within the ore block computed in the ore deposit model.
2) 0.5% or above in terms of others being converted into Cu equivalent.

Table 2-3-(2) Minerals Found in Main Drilled Holes (Part 2)

Sector	Northern Sector			Eastern Sector											
Drill Hole No.	28			35			12			31			9		
Depth of Drilled Hole	639.40 m			463.20 m			273.50 m			455.00 m			279.90 m		
Head of Hole Altitude	4,139 m			4,282 m			3,904 m			4,116 m			4,078 m		
	Ore Width	Grade		Ore Width	Grade		Ore Width	Grade		Ore Width	Grade		Ore Width	Grade	
		Cu %	Mo %		Cu %	Mo %		Cu %	Mo %		Cu %	Mo %		Cu %	Mo %
above 4,250 m				32	0.005	0.029									
~ 4,200				50	0.007	0.042									
~ 4,150				o 50	0.024	0.051									
~ 4,100	39	0.007	0.038	50	0.051	0.041				o 16	0.022	0.051			
~ 4,050	o 50	0.005	0.078	50	0.029	0.040				50	0.001	0.045	28	0.038	0.030
~ 4,000	o 50	0.028	0.108	o 50	0.153	0.053				50	0.003	0.024	o 50	0.242	0.052
~ 3,950	o 50	0.072	0.099	50	0.062	0.034				50	0.017	0.016	o 50	0.244	0.049
~ 3,900	o 50	0.100	0.065	50	0.039	0.033				50	0.052	0.013	o 50	0.269	0.057
~ 3,850	o 50	0.098	0.078	50	0.042	0.033	o 54	0.032	0.060	50	0.096	0.025	o 50	0.242	0.033
~ 3,800	o 50	0.040	0.079	o 31	0.169	0.045	o 50	0.168	0.118	50	0.165	0.019	52	0.050	0.038
~ 3,750	o 50	0.103	0.080				o 50	0.078	0.120	o 50	0.541	0.031			
~ 3,700	o 50	0.006	0.079				o 50	0.137	0.084	o 50	0.301	0.036			
~ 3,650	o 50	0.017	0.090				o 50	0.017	0.078	39	0.100	0.027			
~ 3,600	50	0.024	0.033				o 19	0.013	0.067						
~ 3,550	o 50	0.067	0.052												
~ 3,500	o 50	0.135	0.040												

3) The ore block does not exhibit high variance in grade from part to part.

4) The scale and form of the ore block do not pose serious technical problems in mining operations.

The area of the ore block was determined using data from geological and geophysical prospecting (by I.P. method) as references, and the width of mineralization and ore grade were based on the drilling log.

As a result, from all the mineralized ore bodies, the area represented by drill holes Nos. 13, 27, 29 and 33 was selected as the ore block for the present study. This block satisfies the conditions described above to a reasonable degree.

This block has a major north-south axis of about 1,300 m, an east-west average width of about 300 m and an average ore thickness of 250 m as shown in the attached plane and section maps of the ore block in Fig. 2-4, 2-5-(1), 2-5-(2) on pp. 64, 65, 66.

Ore Reserve and Grade: To compute the exploitable ore reserves and the grade of the blocks represented by the four drill holes mentioned above were analyzed to estimate the approximate ore reserve and the grade of each and the results were added up. The boundaries between ore blocks, were determined by the vertical bisecting method with the drilling holes as centers.

To compute the grade and the ore reserve of each ore block, each drill hole was sliced at depth intervals of 50 m and the average grades of Cu and Mo were computed for each interval with the cut-off grade converted to a Cu equivalent of 0.5% as a rule (Cu : Mo = 1 : 10).

The results of the analysis outlined above are tabulated below (Refer to Table 2-4, on p. 67).

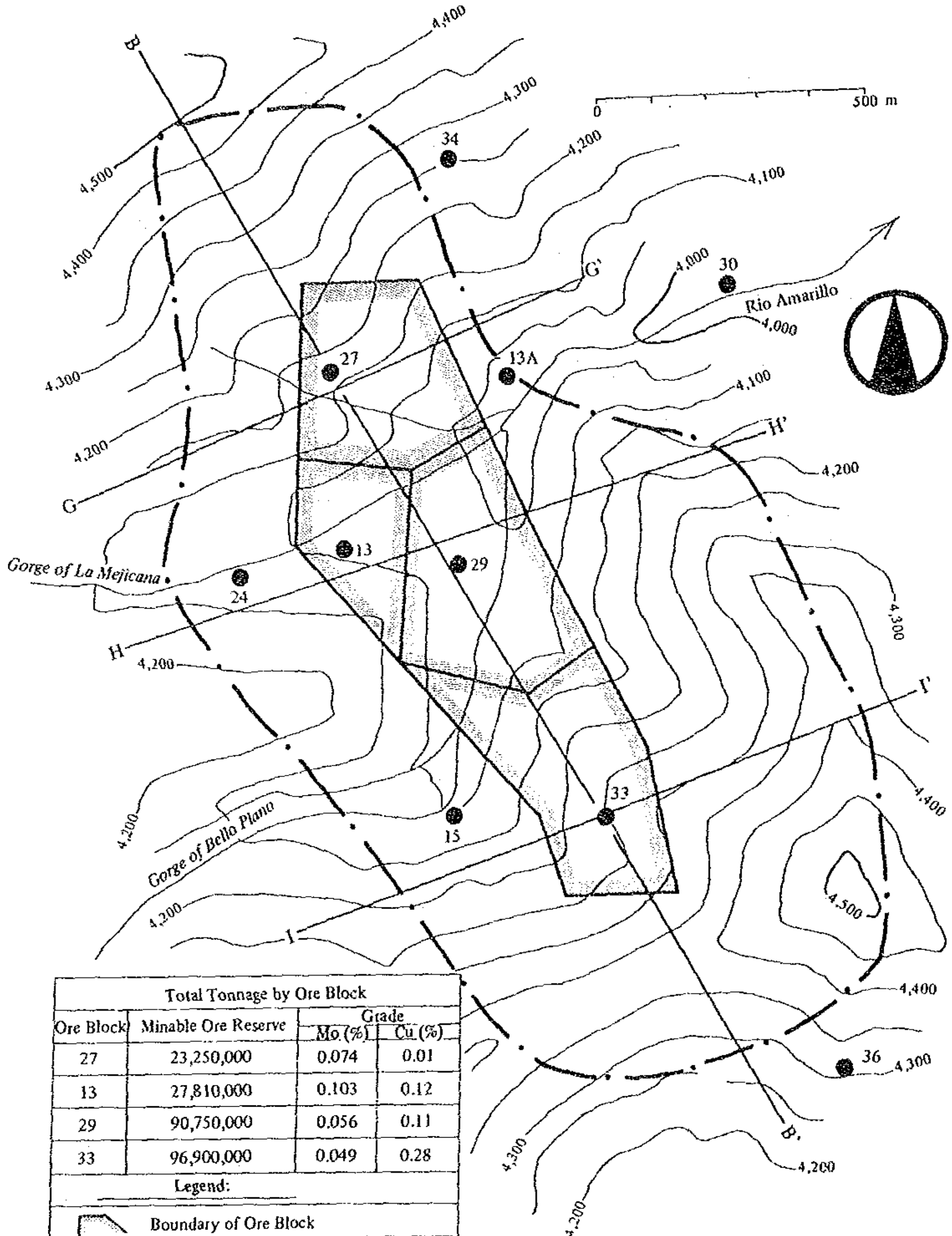
Trial computations using the ore deposit model performed at this time represent only very rough estimates based on the data obtained from the first stage exploration of the mineralized zone. It is anticipated that as a future explorations will be carried out in more detail, to enable better estimates of, and the exploitable reserve and the grade may also improve.

Problem Areas: The following may be pointed out as problem areas of trial computations made with the ore deposit model. These problems require examination and solution during the second stage exploration period.

1) The spacing between drilling holes showing minerals used as bases for defining the ore block was extremely large (ranging between 300 m to 600 m), so that one drilling hole represents an ore reserve of 50 million tons or more on average.

2) The mineralized portions were not distinctly differentiated into the so-called oxidized zone, secondary enriched zone, primary zone, etc., so, for computation, all of them were lumped together.

Fig. 2-4. A Plan Figure of Ore Blocks for Computation (per Drilled Hole Nos. 13, 27, 29 and 33)



Total Tonnage by Ore Block			
Ore Block	Minable Ore Reserve	Grade	
		Mo (%)	Cu (%)
27	23,250,000	0.074	0.01
13	27,810,000	0.103	0.12
29	90,750,000	0.056	0.11
33	96,900,000	0.049	0.28

Legend:

- Boundary of Ore Block
- Area of Stripping
- Location of Drilled Holes

Fig. 2-5-(1) Sectional Plane of Ore Block Hypothesized for Computation (per Drilled Hole Nos. 13, 27, 29 and 33)

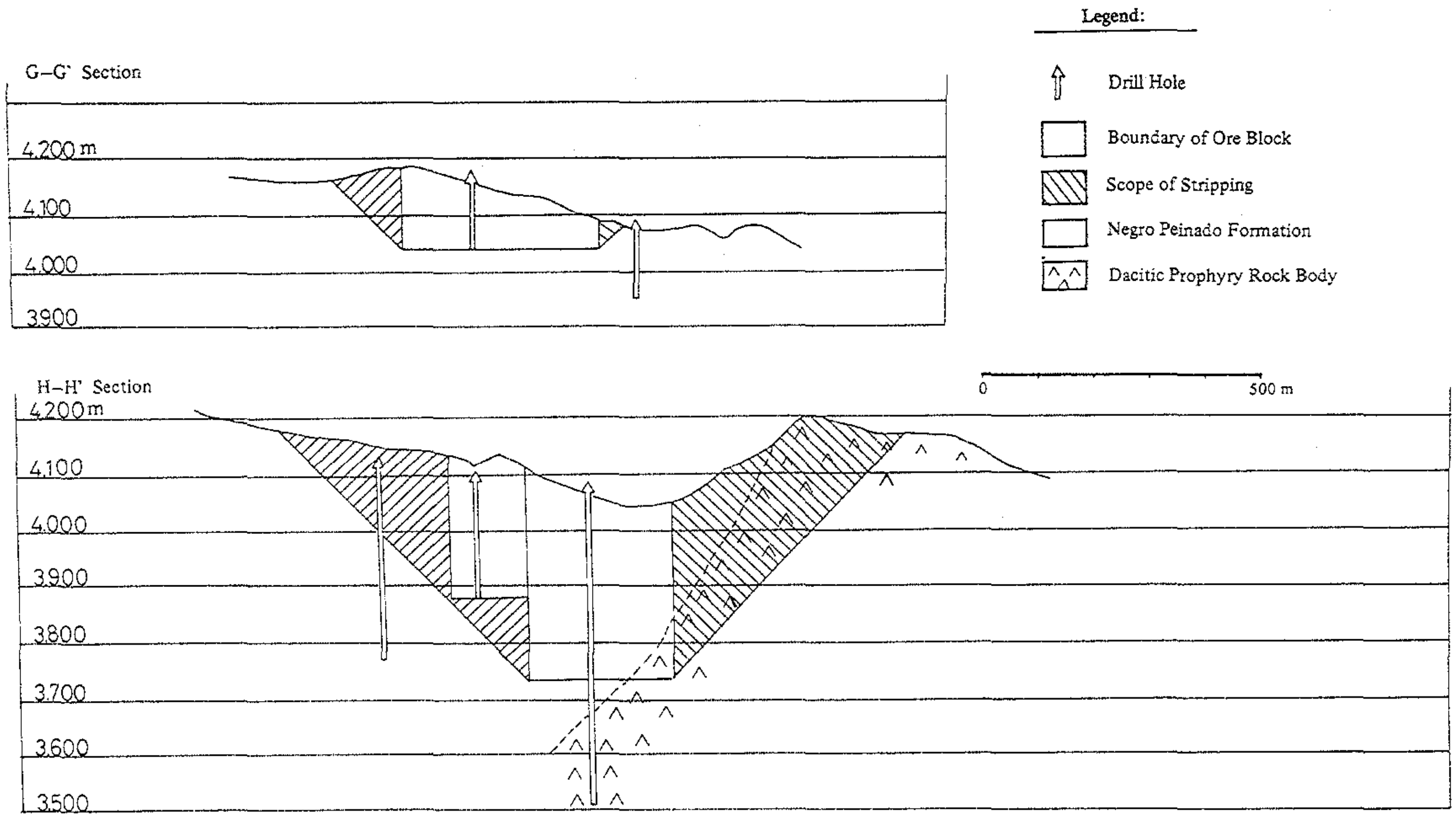
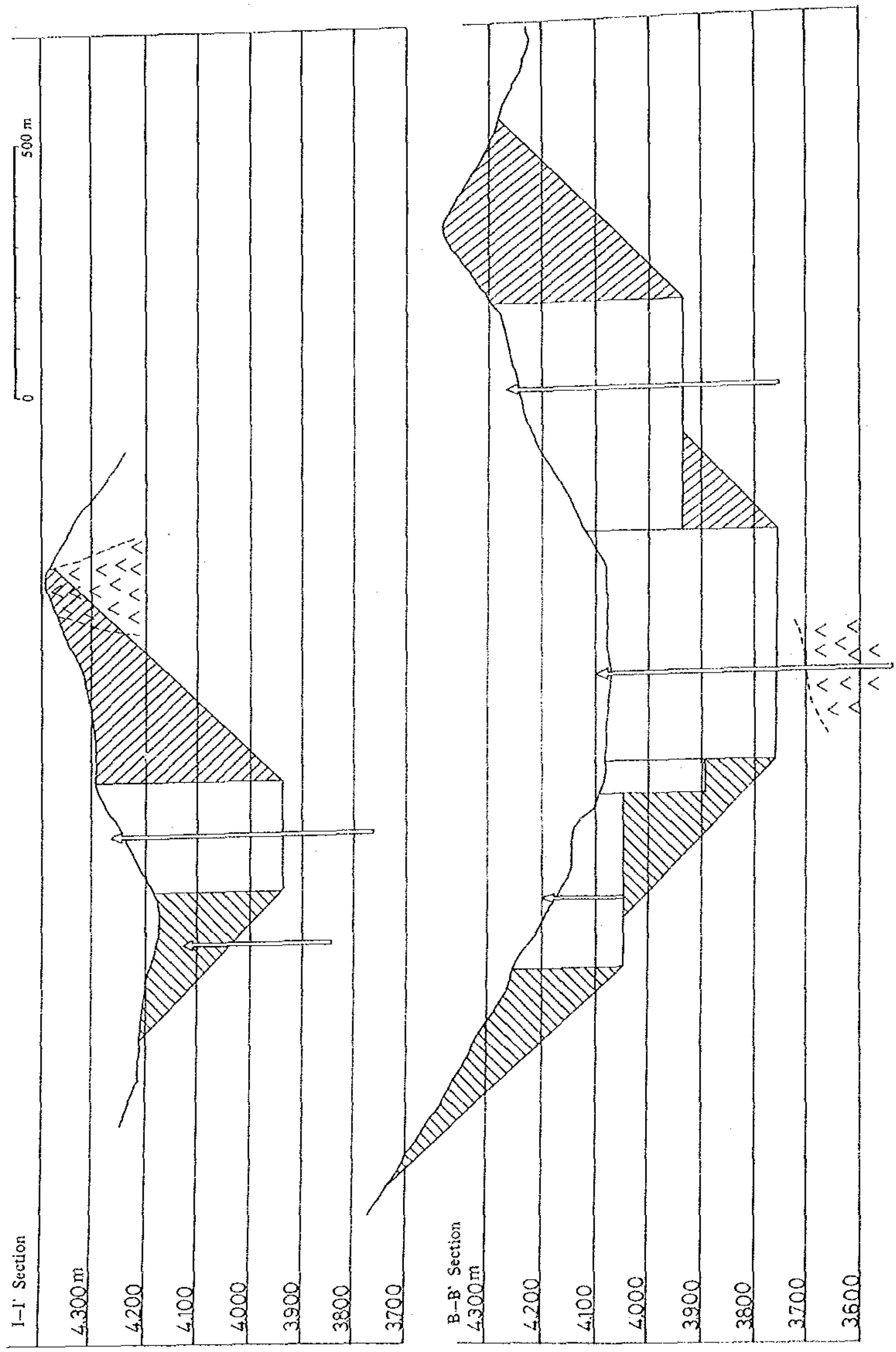


Fig. 2-5-(2)



I–I' Section
4,300m
4,200
4,100
4,000
3,900
3,800
3,700
B–B' Section
4,300m
4,200
4,100
4,000
3,900
3,800
3,700
3,600
0
500 m

Table 2-4. Summary Tabulation of Calculated Ore Reserves
(per Hypothetical Model of Ore Deposit)

Ore Block No.	Area	Width	S.G.	Ore Reserve		Grade	
				Calculated	Exploitable	Cu	Mo
	1,000 m^2	m		10,000 tons	1,000 tons	%	%
27	93	112	2.5	2,325	-	0.01	0.074
13	54	206	2.5	2,781	-	0.12	0.103
29	121	300	2.5	9,075	-	0.11	0.056
33	114	340	2.5	9,690	-	0.28	0.049
		(average)				0.17	0.060
Total	382	250	2.5	23,871	202,000	Cu equivalent 0.77	

Note: 1) The product of existential security x mining yield was assumed as 85%.

2) The conversion ratio of Mo to Cu was assumed to be:
Cu : Mo = 1 : 10

3) Since no data were available on the specific gravity of the ore and existential security, these were arbitrarily assumed as 2.5 and 85% respectively.

1-5. Future Study Required

First stage exploration of the subject ore body has been carried out to date. During the second stage exploration period, the following works are considered necessary. Upon completion of these and other second stage works, the third stage, which includes a feasibility study, will have to be commenced.

Exploration by Detailed Drilling: Since the objective of first stage exploration was to grasp an overall picture of the mineralized zone which extends over a 22 km^2 area in the Rio Amarillo area, the drilling work consisted only of exploration of the potential of the main ore body by bringing up minerals from 10 holes. In order to calculated the ore reserve and prepare a plan for exploitation and also to conduct a feasibility study, it is necessary that more detailed drilling work on all the main minoralized ore bodies in the Rio Amarillo area be carried out in the second stage. Especially, ore bodies of the western sector, which are considered to have the largest potential, should be explored first.

The drilling work required to cover the entire area (1,500 m x 400 m) of the mineralized ore body in the western sector is about 19,600 m in total drilling length with a minimum 100 m grid and an average depth of 400 m.

Chemical and Metallurgical Analysis: Almost all of the samples obtained, mainly by drilling, during the first stage exploration were analyzed at the laboratory of the Plan La Rioja located in La Rioja city. In view of the facts that these samples are ores of relatively low grade and that the main mineral is molybdenum, allowing a certain margin for analytical errors is of critical importance.

Thus, it is necessary that the laboratories be supplied with standard samples and that the samples be analyzed in a multiple number of laboratories for mutual checking, etc.

It is also necessary to determine the soluble Cu grade in the analyses of the ore samples in order to estimate the recovery rate through ore dressing and also to distinguish the oxidized zones and secondary enriched zones of the ore body.

In addition to the normal analytical components, Au, Ag and Sulpher contents must also be systematically analyzed in terms of mode from of occurrence in the ore.

Indoor Flotation Tests: In the investigation carried out this time, the ore dressing recovery rates were assumed to be 70% for Cu and 70% for Mo to estimate the volume of concentrates produced.

In trial computations ore deposit model, however, the Cu grade of crude ore is as low as 0.17% so the assumed recovery rate of ore dressing will critically affect any economic evaluation of the proposed mine. In view of this, indoor flotation tests must be conducted mainly on samples of these two minerals, in drill cores, throughout the second stage exploration period to examine the best possible ore dressing system and to determine the potential recovery rate limit of ore dressing for both of these minerals.

Required Future Exploration Costs: The required future exploration costs estimated from actual costs incurred during first stage exploration, including costs of the various works enumerated above, are anticipated to be as follows:

Direct costs of drilling:
19,600 m x 0.2 million pesos/m = 3.92 billion pesos

Indirect costs for above:
19,600 m x 0.23 million pesos/m = 4.508 billion pesos

When translated into U.S. dollars:

Direct drilling costs:
19,600 m x US$100/m = US$1,960,000

Indirect drilling costs:

19,600 m x US$120/m = US$2,352,000

Total:

19,600 m x US$220/m = US$4,312,000

Total:

19,600 m x 0.43 million pesos/m = 8.428 billion pesos

Note: Indirect costs consist of costs for various analyses, tests and site management.

During the third stage, test mining, flotation process tests using a pilot plant and a feasibility study will be necessary.

2. Tentative Mine Development Model

2-1. Basic Conditions for Planning Infrastructure Development

The following mining model was tentatively formulated to determine conditions for planning infrastructure development:

In determining the volume of crude ore to be treated, actual case histories and development plans of large scale mines around the world were studied while giving special consideration to all aspects of ore reserves, profitability and initial investment outlays and, as a result, two cases have been formulated, one for treating 30,000 tons of crude ore per day and the other for treating 20,000 tons/day.

Because treatment of 30,000 tons/day is obviously more advantageous from the viewpoint of economic development potential, we advise that plans be reviewed primarily on this basis (see Table 2-5 on p. 70).

The above mining model was formulated with due considerations given to the working conditions of a mining site situated 4,000 m above sea level so as not to exert undue strain on the workers.

The number of working days was taken to be 300 days per year, with a day-off every Sunday, with the mine operated in two shifts and ore dressing in three shifts.

The number of employees has been assumed to be about 25% more than would normally be required for the same scale of mine at lower altitude.

Tabld 2-5. Tentative Mining Model

Factor \ Operating Scale (tons/day)		30,000	20,000
Minable Ore Reserves (tons)		202,000,000	202,000,000
Grade of Crude Ore (%)		Cu 0.17, Mo 0.0604	Cu 0.17, Mo 0.0604
Working Days (days/year)		300	300
No. of Employees		2,000	1,500
Stripping volume (m^3/day, w/o = 1.28)		15,600	10,400
Recovery Rate of Ore Dressing (%)		Cu 70, Mo 70	Cu 70, Mo 70
Concentrates	Volume (tons/year)	Cu 55,000 MoS_2 7,500	Cu 36,000 MoS_2 5,000
	Grade (%)	Cu 20, MoS_2 85	Cu 20, MoS_2 85
Volume of Water Required (Fresh Feed Only, m^3/day)		45,000	30,000
Power Required (kWh/day)		750,000	500,000
Life of Mine (years)		22	33

The recovery rate concentrate grade and other performance measures of ore dressing are no more than estimates due to the complete lack of reference data.

The volume of water required was estimated on the basis of 3 m^3 per ton of crude ore treated, with half of this being recycled.

Electric power required was planned on the basis of 25 kWh per ton of crude ore processed, and that all mining and loading equipments, etc. would be motor-driven.

2-2. Mining Model Planning

Stopping method: As for the stopping model, open-cut mining is advisable from the following viewpoints.

(1) The deposit is located relatively close to the surface.

(2) The deposit is spread more horizontally than vertically.

(3) Mass treatment is necessary because the deposit is of large scale and low grade.

(4) The muck bank is located near the pit.

(5) The stripping ratio is economically justifiable.

(6) It is possible to design pits for the use of large scale mining equipment.

(7) The area has low precipitation.

(8) The rate of riverflow within the pit is small so that it can be easily diverted.

In selecting mining equipment it is advisable that the variety, type, size and number of units required be determined by referring to the operating performances at some of the world's large scale mines which are now in operation.

Production volume: As stated previously, two plans are presented, one for processing a crude ore volume of 30,000 tons a day and another for 20,000 tons a day. We considered these to be reasonable after considering all aspects of ore reserves, profitability and initial investment outlays and also upon referring to case histories of large scale mines and mine development programs around the world. However, since the plan for treating 30,000 tons is naturally more advantageous from the standpoint of the life of the mine and profitability, we recommend that this plan be given priority insofar as it does not pose any problem in the course of planning of infrastructure development.

Crude ore production volume:

Stripping ratio: waste/ore = 1.28

In case of treating 30,000 tons/day:

volume of stripping:	38,400 tons/day
volume treated:	68,400 tons/day

In case of treating 20,000 tons/day:

volume of stripping:	25,600 tons/day
volume treated:	45,600 tons/day

In either case, the grade of crude ore is assumed to be 0.17% of Cu and 0.0604% of Mo.

Development: In preparing the mine bench, it is possible to adopt the most popular open-cut mining system and, in the light of the lithology and precipitation, the eventual slope of the pit could be made steeper than 45°.

Muck bank (dumping site for debris): The Los Bayos area which adjoins the southern side of the pit may be cited as the optimum site, being closest to the pit. This area has already been explored by drilling and has been confirmed to have no ore deposits below the surface.

If the Los Bayos area should be considered inappropriate by reason of the possibility of causing problems with water resources downstream then the valley in the area of station No. 7 of the old cableway adjacent to the Los Bayos area may be cited as the second alternative site.

In both cases, the capacity is large enough to accommodate the anticipated volume of muck corresponding to a crude ore volume of 200 million tons, or 170 million cubic meters, but from the viewpoint of hauling muck distance, selection of the first candidate site of the Los Bayos area is recommended, even if it may pose some difficulties.

Road Construction within the Mine: Prior to commencing and during initial stripping work, it will be necessary to build a road for delivering heavy equipment to the pit, a trucking road up to the Los Bayos muck bank and a road for hauling crude ore from the pit to the first stage crushing plant located some 2.5 km down from the pit.

Diversion of riverflow: The Rio Amarillo which flows through the pit may be allowed to flow as it is for the time being, but when the time comes, it will become necessary to divert the river course. Since the flow rate is quite small, however, this will not pose any problem whatsoever.

Ancillary facilities and equipment: A captive repair shop will be built in the Cueva de Perez area for maintenance and repair of heavy mining equipment. This shop will consist of a vehicles shop, a welding shop, an engine shop, a battery shop, a tire shop and an oiling and fueling station, and be equipped with machinery, electrical facilities and inspection facilities capable of coping with any kind of repair work, including overhauls.

A field office for laborers and field supervisors and, as a matter of course, a magazine for powder and explosives must also be constructed.

2-3. Operation

Drilling of holes: For drilling in the bench work, motor-driven rotary drills with bits of around 10" in diameter will be mainly used.

Blasting: AN-FO will be used in the main, but slurry explosives will also be used for