With regard to Somisa Port, three berths of 300 m length out of 980 m of wharfage can be used for this project. However, once the iron foundry is in operation, there is no room for ore transports to use these berths. In case of Rosario Port, vessels would have to navigate up the Parana River for more than 320 km from Buenos Aires. Besides there are several other difficulties in the use of this port such this, the size of vessels cannot be specified until exporting countries and navigation schedules are determined. Other than the three domestic ports, it might be possible to use Copiapó Port in Chile, yet there are several problems with this; (a) the Paso San Francisco pass which would be the main transport route in this case freezes during the winter, making use of this route possible for only five months, a year between November and March, and (b) security is not necessarily guaranteed for this route over the long term due to political problems with Chile. Upon considering the points described about, the transportation plan of this project is formulated on the assumption that the Port of Buenos Aires, which has relatively fewer constraints, is used.

Daily charges for use of the Port of Buenos Aires are estimated to be about 230 pesos/ton·day. Although use largely depends on the operating schedule of the mine, it is necessary to derive costs for pilot boats and tugboats, which are estimated to be 1,140 pesos/ton. Therefore, the total cost for this port which will be used in the succeeding analysis is estimated to be 1,370 pesos/day. Economic costs for use of the port are calculated by deducting 10% of the financial costs as the portion corresponding to internal transfers such as taxes, and the foreign portion of economic costs is assumed to be 30% of the financial costs.

2. Formulation of Alternative Transportation Plans

2-1. Estimation of Generated Transportation Demand

Average daily traffic for the movement of persons and goods between the mining site and Los Sarmientos, a candidate site for the mining town, is estimated to be about 100 vehicles/day including passenger cars, large and small trucks, buses, etc. Also, as mentioned in Chapter 5, this project assumes development of a mining town at Los Sarmientos, with workers at the mining site move between the mine and the town on Friday and Monday when they are likely to spend their weekends in Los Sarmientos. Assuming that they use 50 passenger buses, weekend traffic between the two locations is estimated to be about 200 vehicles. Transportation costs for this movement of workers are included in general management expenses of the mining company.

Transport demand is also generated in order to bring in construction materials of totaling 100,000 tons in the case of an operating capacity is 30,000 tons/day during the first three years of the construction phase starting in 1983. These construction materials will be brought in from Buenos Aires, the procurement point. Contents during the first three years are shown in Table 6-2.

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

Notes:
- Amounts of mining of unrefined ore are (a) 9,000,000 tons/year in case of 30,000 tons/day operating capacity, and (b) 6,000,000 tons/year in case of 20,000 tons/day operating capacity.
- Grades of unrefined ore are assumed to be (a) 0.17% of copper and (b) 0.0604% of molybdenite.
- Recovery rate of ore dressing is assumed to be 70% for copper and molybdenite.
- Grade of refined ore is assumed to be 20% of Cu and 85% of MoS_2.
- Refined ore to be transported is assumed to include 8% water as compared to dry ore of copper and molybdenite.
- Construction materials include spare parts, machinery and equipment, reagents, etc. for mining and dressing. The procurement point is assumed to be Buenos Aires.
- Operaing days per year are assumed to be 300 days.

Table 6-2. Generated Transportation Demands
(Construction Materials)

(Unit: ton)

Operating Scale / Year	30,000 tons/day	20,000 tons/day
First year	30,000	21,000
Second year	40,000	28,000
Third year	30,000	21,000
Total	100,000	70,000

2-2. Alternate Transportation Routes and Means of Transportation

(1) Alternate Transportation Routes

Three alternate transportation routes will be examined in this section, each of which corresponds to the transportation demands mentioned in the previous section.

a) Case I (Direct Transportation to Buenos Aires): This case assumes transport of refined copper and molybdenum from the mining site to Buenos Aires, the delivery point,

b) Case II (Transportation Route via Andalgalá):
In this case refined copper is transported from the mining site to La Alumbrera where the copper ore is electrically smelted. It is then transported to Buenos Aires.

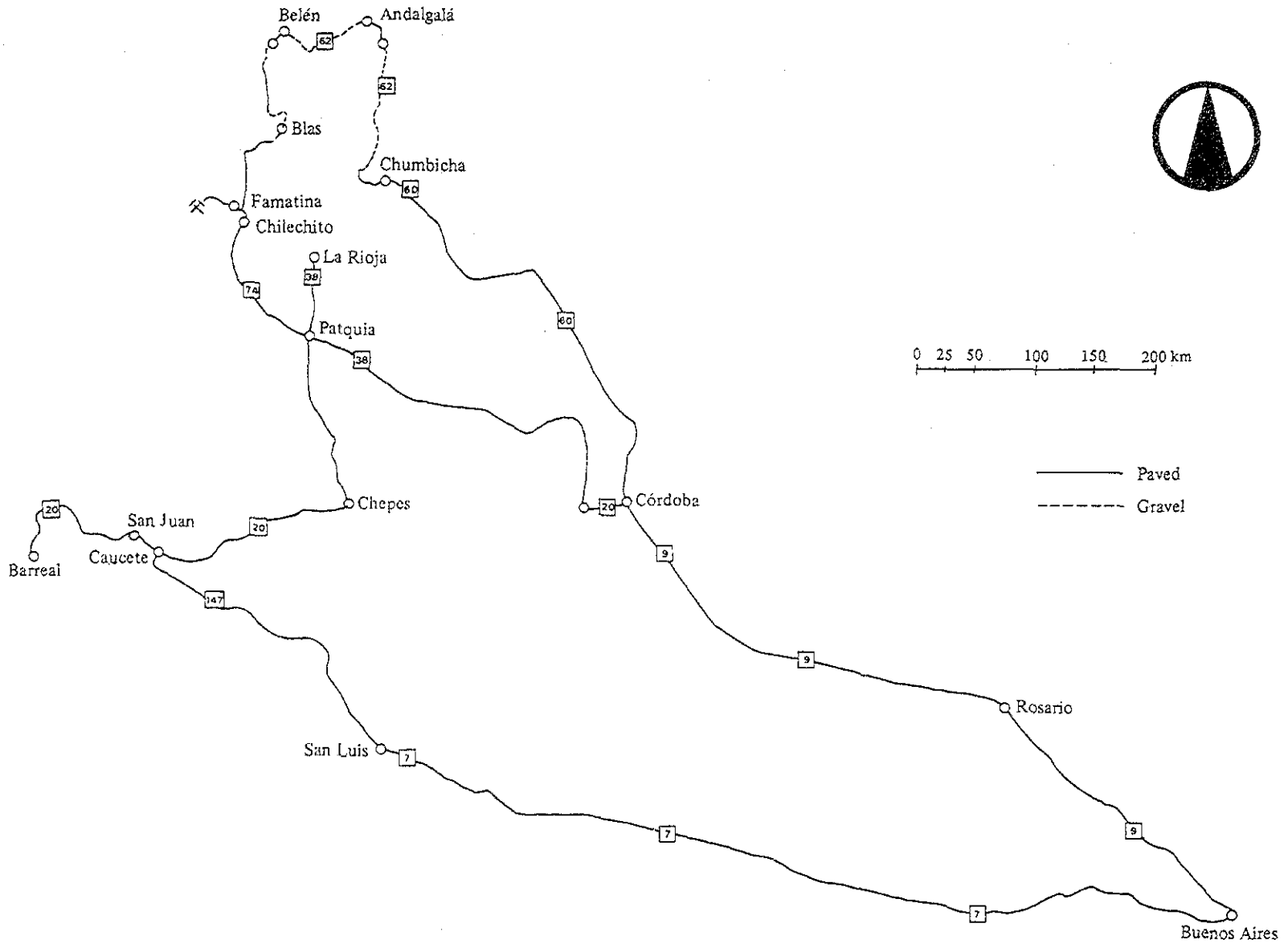
c) Case III (Transportation Route via Barreal):
In this case, refined copper is transported from the mining site to Barreal where the copper ore is electrically smelted. It is then transported to Buenos Aires.

Refined molybdenum is assumed to be transported directly from the mining site to Buenos Aires in Case II and Case III. Also, regardless of the case, materials necessary for operation as well as construction materials and equipment required for the first stages of construction are assumed to be transported directly from Buenos Aires to the mining site. These three alternate cases are shown in Figure 6-3 with a road map.

(2) Alternate Means of Transportation

In addition to the three alternate transportation routes mentioned above, the means of transportation for each alternative, i.e., railway or road, is taken into consideration

Fig. 6-3. Three Alternate Transportation Routes



as follows:

As indicated in the previous section, road transportation by 20 ton capacity semi-trailers will be used as for transport between the mining site and Chilecito in all alternatives. The Los Corrales route is selected as the optimal route for this section (for detailed explanation, refer to the next section). Distances and road conditions following construction are shown in item (1) of Table 6-3. Regardless of the transportation route or means after Chilecito, movement of people and goods must be via road between the mining site and Chilecito. Note)

After passing Chilecito, there remain alternate means of transportation railway and road. Item (2) of Table 6-3 indicates distances and road conditions of each alternate route. By combining item (1) of Table 6-3 to each route in item (2) of the same table, distances and roads conditions of each alternate route from the mining site to Buenos Aires can be derived. The results are indicated in item (3) of Table 6-3. These three cases of road transportation, i.e., the direct route to Buenos Aires, the route via Andalgalá and the route via Barreal, are called, hereafter, Case C-I, Case C-II and Case C-III, respectively. As against these three cases, another three alternate transport routes using the railway after Chilecito are called, hereafter, F-I, F-II and F-III, respectively. Since the station on the G. Belgrano Line closest to the mining site is Chilecito Station, alternate routes are determined to be the minimum distance of each one of the following alternate routes: (a) transport of refined ore from Chilecito to the Port of Buenos Aires, (b) transport of refined ore to the Andalagalá smelting plant and, then, transport of electro-copper from Andalgalá to Buenos Aires, and (c) transport of refined ore to San Juan Station in order to bring in refined ore to the Barreal Smelting Plant nad then transport of electro-copper from Mendoza to Buenos Aires.

The first route goes from Chilecito to Retiro in Buenos Aires via Patoquia, Córdoba and Rosario. The distance totals 1,269 km.

The second route transports refined ore from Chilecito to Andalgalá via Patoquia and Cebollar over 433 km, and transports electfically smelted copper from Andalgalá to Retio in Buenos Aires via Cebollar, Patquia, Cordoba and Rosario over 1,446.3 km.

The third route transports refined ore from Chilecito to San Juan via Patquia and Serrezuela over 651 km, and then transports electrically smelted copper from Mendoza to Retio by San Martín Line over 1,049 km (Refer to Fig. 6-4 on P. 172).

3. Transportation Facilities Improvement Plan

3-1. Road Construction, Improvement and Maintenance Plan

(1) Plant for Road Construction between Mining Site and Los Corrales

Selection of Appropriate Route: There are three alternate road routes which

Note: However, in the case of road transportation via Andalgalá only, trucks go north, away from Chilecito on Route 40 after Famatina.

Table 6-3. Distances and Road Conditions of Alternate Road Transportation Routes

(Unit: km)

(1) Mining Site – Chilecito (Common to all cases)

Transportation Sections \ Road Conditions	Total Distance	Paved Road	Gravel Dirt Road	
			Flat Area	Mountenous Area
Mining Site – Chilecito	82	35	17	30
Mining Site – Los Corrales	30	0	0	30
Los Corrales – Famatina	17	0	17	0
Famatina – Chilecito	35	35	0	0

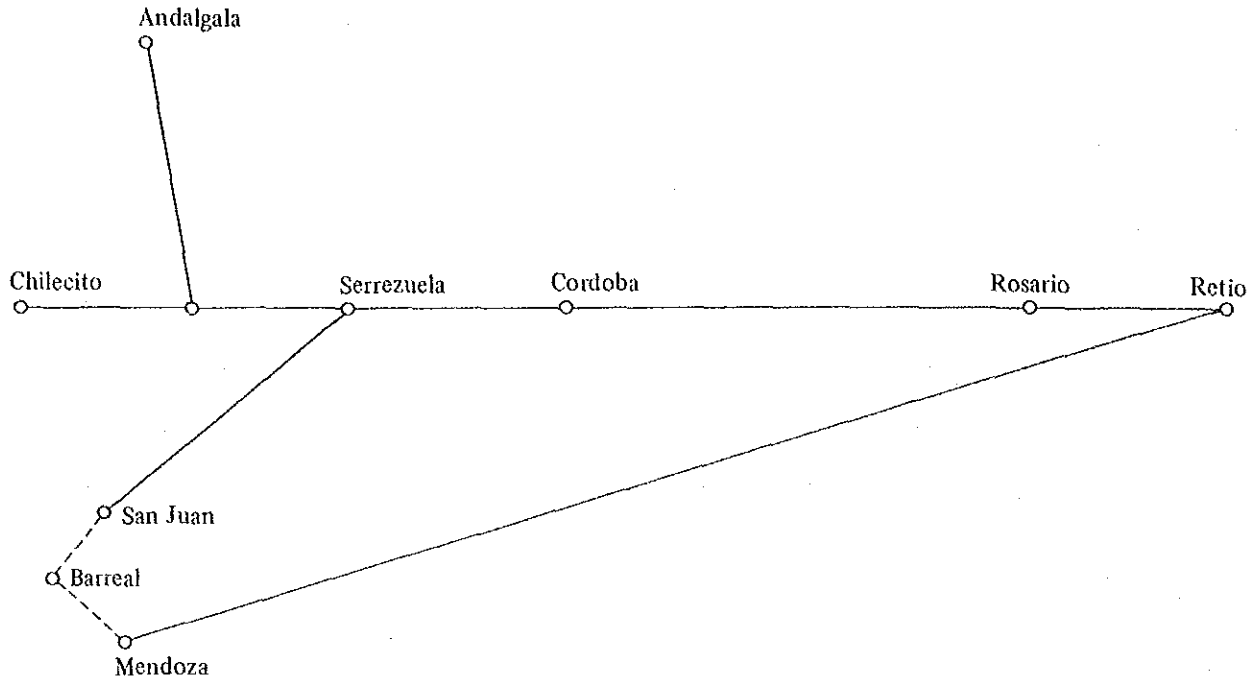
(2) Chilecito – Buenos Aires

	Transportation Sections \ Road Conditions	Total Distance	Paved Road	Gravel Dirt Road	
				Flat Area	Mountenous Area
Case-I	Direct Route to Buenos Aires	1,217	1,217	0	0
	Chilecito – Cordoba	508	508	0	0
	Cordoba – Buenos Aires	709	709	0	0
Case-II	Route Via Andalgalá	1,592	1,358	234	0
	Transportation Distance of Refined Copper	303	175	128	0
	Transportation Distance of Electro-Copper	1,289	1,183	106	0
	Chilecito – Andalgalá	303	175	128	0
	Andalgalá – Cordoba	580	474	106	0
	Cordoba – Buenos Aires	709	709	0	0
Case-III	Route Via Barreal	1,974	1,974	0	0
	Transportation Distance of Relined Copper	673	673	0	0
	Transportation Distance of Electro-Copper	1,301	1,301	0	0
	Chilecito – Barreal	673	673	0	0
	Barreal – San Luis	519	519	0	0
	San Luis – Buenos Aires	782	782	0	0

(3) Mining Site – Buenos Aires

	Transportation Sections \ Road Conditions	Total Distance	Paved Road	Gravel Dirt Road	
				Flat Area	Mountenous Area
Case-I	Direct Route to Buenos Aires	1,299	1,252	17	30
	Mining Site – Cordoba	590	543	17	30
	Cordoba – Buenos Aires	709	709	0	0
Case-II	Route Via Andalgalá	1,604	1,323	251	30
	Transportation Distance of Refined Copper	315	140	145	30
	Transportation Distance of Electro-Copper	1,289	1,183	106	0
	Mining Site – Andalgalá	315	140	145	30
	Andalgalá – Cordoba	580	474	106	0
	Cordoba – Buenos Aires	709	709	0	0
Case-III	Route Via Barreal	2,056	2,009	17	30
	Transportation Distance of Refined Copper	755	708	17	30
	Transportation Distance of Electro-Copper	1,301	1,301	0	0
	Mining Site – Barreal	755	708	17	30
	Barreal – San Luis	519	519	0	0
	San Luis – Buenos Aires	782	782	0	0

Fig. 6-4. Railway Transportation Routes



connect the mining site to the present road network. These routes have a starting point at Cueva de Pérez where the dressing plant will be located, and are indicated in Figure 6-5. In this section, consideration will be given to the conditions of each route with respect to topography, field surveys and cross section, as shown in Figure 6-6.

a) Cueva de Noroña Route: This route connects Cueva de Pérez to the existing provincial road via Cueva de Noroña and Los Corrales, and the total length to be constructed is 30 km. A temporary road has been constructed over this route for prospecting. The slope of the route are relatively gentle and the route has favorable geological conditions. With regard to slopes, the first 7–8 km from Cueva de Pérez has gradients of 6 to 10% with several sections of nearly 15%, and the remaining 22 to 23 km section has gradients of only 4 to 7% with 10% local gradients. From the geological point of view, about 3 km section south of Cueva de Noroña consists of 90% rock (crystalline rock), therefore, construction of the road in that section requires blasting work. On the other hand, an 11 km section further south of this route consists of 80% pudding stone and a 17 km section to the north consists of 90% pudding stone. Construction of these sections appears to be possible only by using bulldozers.

b) Los Bayitos Route: This route goes to Los Corrales via Los Bayitos and is laid down some westward. An attempt was made to develop a temporary road for prospecting, however, this was abandoned because the road is more than 60 km and there are several sections with slopes of 20%. This route is not very appropriate for road construction.

Fig. 6-5. Alternate Routes for Road Construction

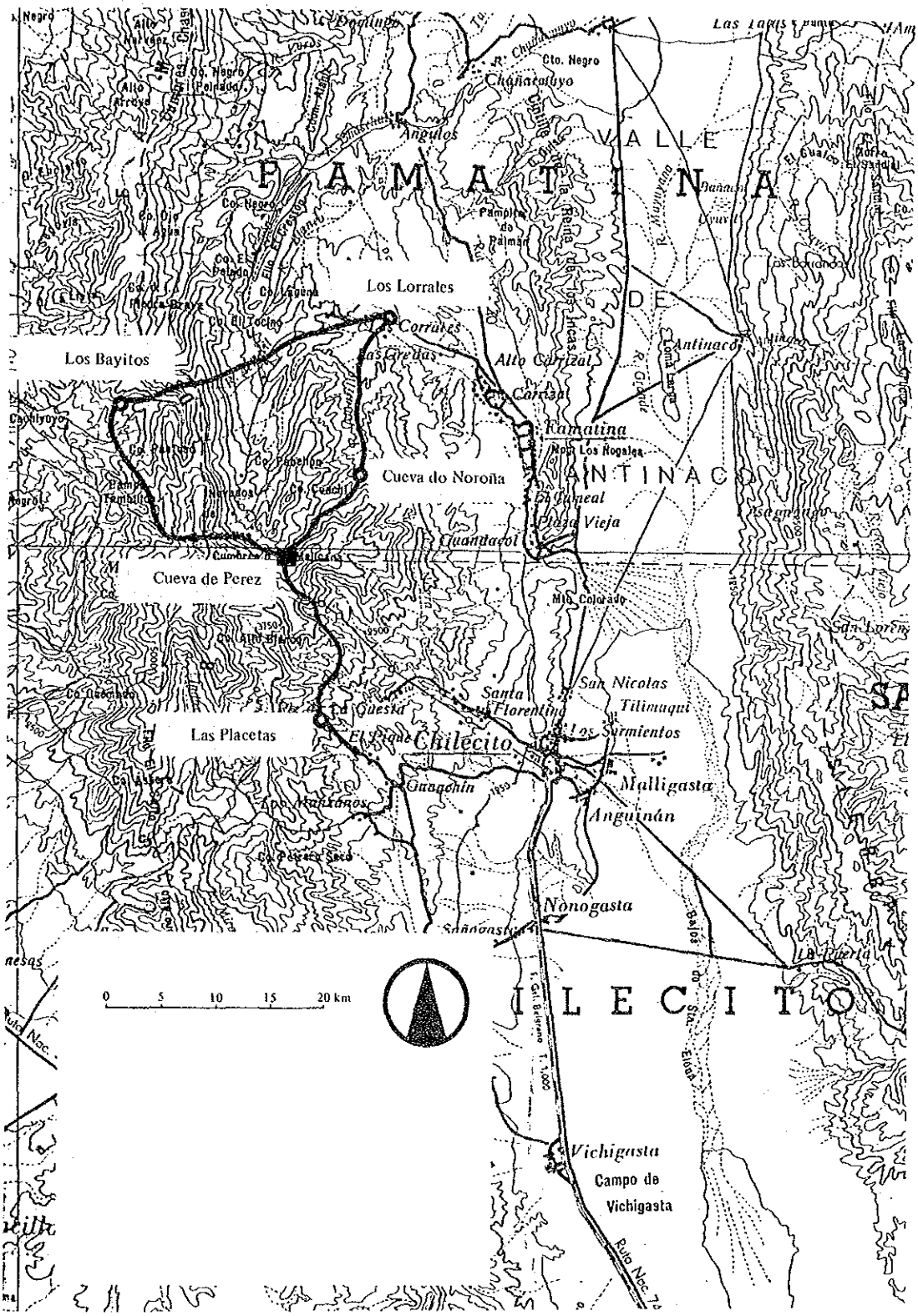
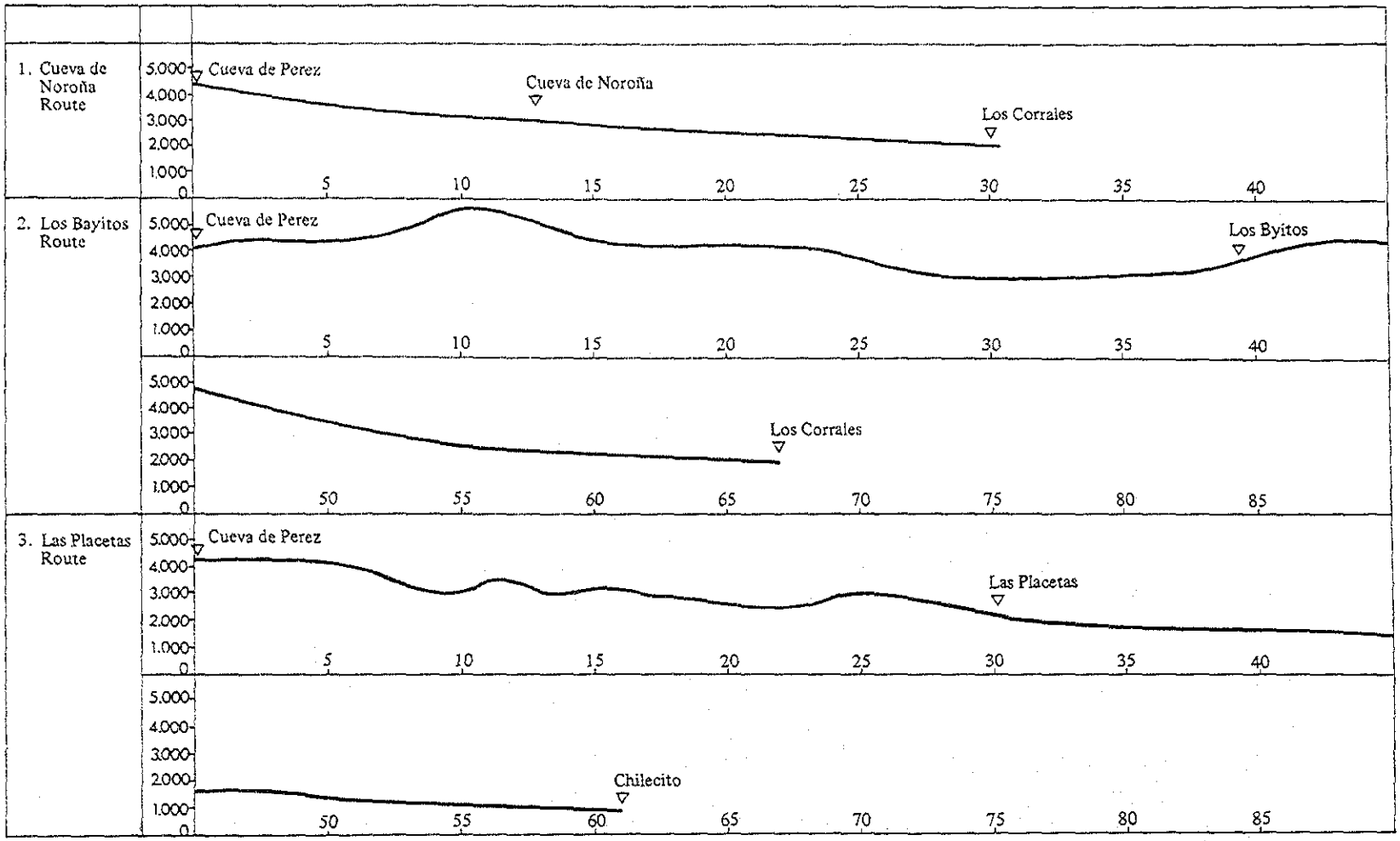


Fig. 6-6. Cross Sections of Alternate Routes between Mining Site and Chilecito



c) Las Placetas Route: The third route travels in a south-east direction from Cueva de Perez via Las Placetas to a point 6 km north-west of Guanchin and links up with the existing provincial road there. This route was investigated by the Dirección Provincial de Vialidad in 1979. Although the length to be constructed is 37 km, there are several problems with respect to slope gradient and geology. First, there are three sections between Cueva de Perez and Las Placetas where the slope is more than 15% over several kilometers. Second, the beginning and ending sections of this route may have to be developed by bulldozers since 80% of these sections consists of pudding stone, but the intermediate section of 8 km between Quebrada del Tigre and Mina del Oro is rock and, therefore, blasting work will be required.

The Los Bayitos route is considered out of question. The following points become clear when the Cueva de Noroña route and Las Placetas route are compared. First, the total length of the Cueva de Noroña route is 82 km between Cueva de Pérez and Chilecito, while the total length of the Las Placetas route is only 61 km. However, there exists a difference of 2,800 m is altitude between the highest point and the lowest point on the Las Placetas route, which would require a considerable amount of detouring in road alignment even if the allowable maximum gradient is taken to be 10%. As a result, the superiority of the shorter distance of the Las Placetas route over Cueva de Noroña route is weakened. Furthermore, if (i) geological conditions, (ii) total length of sections needing to be newly built and (iii) the availability of existing temporary roads, are taken into consideration, it becomes clear that the Cueva de Noroña route is more appropriate for road construction.

Construction Costs: The traffic volume between Cueva de Pérez and Los Corrales is broken down into: (i) average weekday traffic of 100 vehicles and weekend traffic of 200 vehicles; (ii) about 20 semi-trailers of 20 ton capacity for transporting refined ore, materials and equipment, and (iii) other auxiliary traffic generated by visitors, salesman, etc. The total traffic volume is estimated to be less than 200 vehicles per day. This traffic volume is not sufficient to justify construction of paved roads (see Annex 1 of this chapter). Construction of gravel roads is considered economically more efficient. Therefore, 30 km of gravel road with a 4.5 km lane width and 1.0 m shoulder width will be constructed between Cueva de Pérez and Los Corrales. Costs are estimated as follows, given that the entire route is laid through a mountainous region and that a 23.6 km section of the route consists of pudding stone while the remaining 6.4 km consists of rock sections.

Construction costs of gravel road are estimated to be 124 million pesos/km in pudding stone section and 220 million pesos/km in rock sections because of the additional roadbed work required by the latter. By adapting these unit construction costs to this route, the total construction costs become 4,332 million pesos. Further, in the case the military (Batallón de Ingenieros de Construcciones) cooperates in construction of road, construction costs are estimated to be 40% of normal costs, i.e., 2,483 million pesos, as charges only for the use of military machinery and materials and without labor costs.

In addition, some concrete works will be required for construction of retaining walls and at river-beds in the crossing of dry rivers. Although estimation of miscellaneous costs is difficult until horizontal alignment of the road is determined, these are assumed to be 750

million pesos for the entire route. Therefore, the total construction cost is estimated to be 5,082 million pesos in the case of construction by private contractors. If the military undertakes construction, the total cost will be 2,483 million pesos, since the military does not have sufficient skill in concrete works and these must be undertaken by private contractors. Furthermore, it is highly probable in the design of actual road alignment that the construction length will become longer than 30 km because of constraints on allowable gradient, and that some extra works will be required if widening of curved sections for 20 ton semi-trailers or waiting lanes become necessary. Therefore, 15% of the total construction cost is added as contingency.

As a result, the cost of road construction between the mining site and Los Corrales amounts to 5,845 million pesos in case of private construction and 2,854 million pesos in case of execution of the work by the military. These are the financial costs of the mining company, while the economic costs become 5,551 million pesos after deducting 5% of the total cost required by private contractors as internal transfers such as taxes. The expense for machinery is 35% of the economic costs, 85% of which is foreign currency, that is, 30% of the economic costs are assumed to be foreign currency.

Maintenance Costs: The annual maintenance costs of the road between the mining site and Los Corrales are roughly estimated at 5.94 million pesos/km considering the geographical conditions. Therefore, the financial costs of maintaining the 30 km section are 178 million pesos/year. Furthermore, the economic costs for maintenance are assumed to be 169 million pesos/year after deducting 5% of the financial cost as the internal transfer portion. The foreign portion of the economic costs of maintenance is assumed to be 10%.

The construction and maintenance costs for the road between the mining site and Los Corrales are summarized in Table 6-4.

(2) Road Improvement Plan between Los Corrales and Famatina

Road Construction Costs: Improvement works inclusive of widening will be required for 12 km of gravel road section, that is 70% of a 17 km provincial road between Los Corrales and Famatina. The present traffic volume over this section seems to be less than 20 vehicles/day. Traffic volume after completion of this project is estimated to be less than 200 vehicles/day. Since the average daily traffic which justifies an investment for paving should be at least 375 vehicles/day (see Annex 1 of this chapter), and since it is not probable that traffic volume will reach this volume unless there are major changes in the development of the surrounding areas, improvement works in this section should be undertaken on the basis of gravel road work only.

The finanical costs of road improvement are estimated at 103 million pesos/km based on the design standards of 4.5 m lane width, 1.0 m shoulder width, and conditions of the area characterized by pudding stone and flat surface. Total construction costs become 1,424 million pesos with 12 km of improvement plus and 15% for contingencies. These financial costs will be borne by the province and, therefore, are not included in financial analysis of this project. The economic cost becomes 1,353 million pesos by deducting internal transfers such as taxes which make up 5% of the financial cost. As examined in section 1, 80% of the total eco-

Table 6-4. Costs of New Construction, Improvement and Maintenance of Roads

(Unit: Million peso)

			Road Construction between Mining Site and Los Correlas	Road Improvement between Los Correlas and Famatina	Total
Financial Costs	Construction Cost in Case of Private Constractors		5,844	--	5,844
	Construction Cost in Case of Military		2,855	--	2,854
	Yearly Maintenance Cost		178	--	178
Economic Costs	Construction Cost	Domestic portion	3,886	758	4,644
		Foreign portion	1,665	325	1,990
		Total	5,551	1,082	6,634
	Yearly Maintenance Expenses	Domestic portion	152	58	210
		Foreign portion	17	6	23
		Total	169	64	233

Note: Financial cost of road improvement between Los Correlas and Famatina is borne by La Rioja Province and is not included in the financial analysis of the mining company.

nomic cost is regarded as being borne by this project, therefore, the economic cost of the project becomes 1,082 million pesos. In addition, the proportion of foreign currency in the economic costs is assumed to be 30% of the total economic costs, used for road construction between the mining site and Los Corrales.

Maintenance Cost: Annual maintenance expenses for the road between Los Corrales and Famatina are estimated to be 4.95 million pesos/km taking account of topographical conditions. Therefore, the financial costs for maintaining 17 km section become 84.15 million pesos/year. These financial costs are not included in financial analysis of the project since they will be borne by the Province. Economic costs become 79.40 million pesos/year by deducting 5% of the total financial costs as the internal transfer portion. Since 80% of the economic cost is regarded as being borne by the project as done before, annual maintenance expenses which become an input to economic analysis of the project become 63.95 million pesos. Further, it is assumed that the proportion of foreign currency will be 10% of the economic costs just as for costs of road construction between the mining site and Los Corrales.

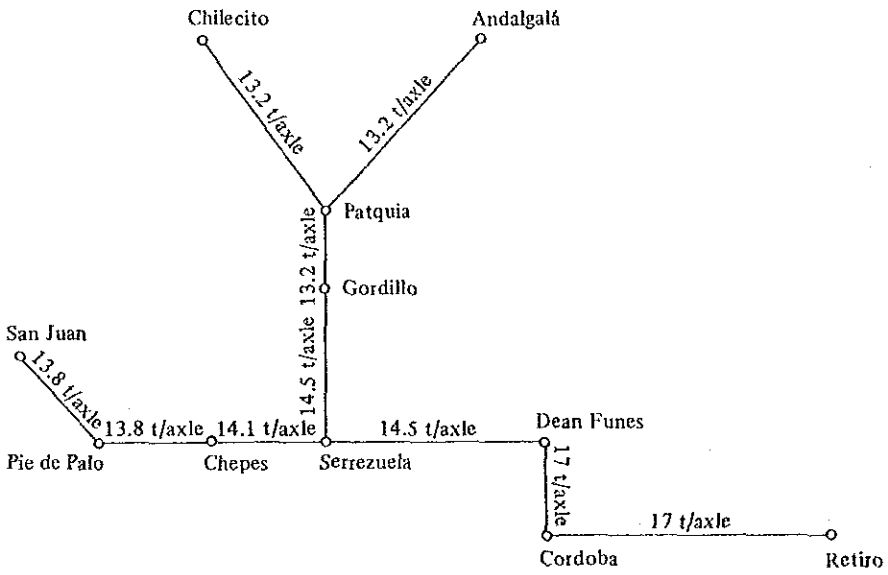
Construction and maintenance costs for the road between Los Corrales and Fama-

tina are summarized in Table 6-4. Furthermore, maintenance expenses are required annually during the entire project life, while 100% of the construction costs are invested in the first year of construction because the road is the basis of all development of this project. Also, the salvage value of the improved road after the project life is assumed to be zero.

3-2. Railway Improvement Plan

It is not necessary to improve major railway infrastructure such as railroad tracks and bridges of the G. Belgrano Line and the San Martín Line for an assumed mine operation scale of 30,000 tons/day. Figure 6-6 shows the track load capacity, including roadbed, bridges and track of the G Belgrano Line which may be used to transport refined ore. Since the weakest portion can still bear loads of 13.2 tons per axle and a freight car has four axles, it has a total load capacity of 52.8 tons per freight car. Assuming that a freight car carries 40 tons of ore and the dead weight is 10 tons per freight car, a total load of 50 tons per freight car is within the load capacity. Therefore, no investment will be required to strengthen and improve the track equipment. Chilecito station needs some improvement for loading of refined ore, shippping and discharging of materials and equipments, etc. These improvement costs, however, will be small if the present equipment is utilized at full scale and so thus will be ignored.

Fig. 6-7. The Track Load Capacity of G. Belgrano Line



4. Estimation of Transportation Costs

4-1. Financial Costs of Road Transportation

Table 6-5 is an excerpt of truck tariffs of the Cordoba Auto-cargo Transportation Federation (FECOTAC – La Federación Cordobesa del Transporte Automotor de Cargas) which can be used as representative tariffs for truck cargo transportation charges. This tariff schedule has been approved by the Directorate of Transportation as well as the Department of Justice (El Departamento Jurídico). However, distortion of transportation charges is often observed in actual contracts. Discounting of transportation charges can be expected in this project since (1) transportation demand will be generated regularly over a long period of time, and (2) two-way long distance transportation demand will be generated by this project.

After examining data on transportation charges in contracts collected by the Mining Department of La Rioja Provincial Government (Secretaría de Estado de Minería), charges for truck transportation are assumed as follows:

(1) The tariff schedule of FECOTAC is taken as the basis in the following analysis.

(2) In addition, the following two items are assumed:

   a) In the case of dirt or gravel roads, and extra charge of 24.25 pesos/ton.km will be added, and
   b) In the case of mountainous areas an extra charge of 48.27 pesos/ton.km will be added.

(3) Based on charges derived from the assumptions in (1) and (2), transportation charges on a contract basis are derived as follows:

   a) For areas in the direction of Buenos Aires, that is the south-eastern parts of Córdoba or San Luis, transportation charges are assumed to be 85% of the charges derived from assumptions (1) and (2), and
   b) For areas in the north-western part of Córdoba or San Luis, 50% of the charges derived from assumptions (1) and (2) will be charged. Although long distance transportation uses the route via Córdoba, distances are measured from Córdoba in each direction, and adjustments will be made based on (a) and (b) above. Total transportation charges for each route are derived by adding charges in both directions and this will be used as the input for financial analysis.

Financial costs of each alternative road transportation plan are computed on the basis of transportation charges mentioned above. These are summarized in Table 6-6. Generated transportation demands are listed in Tables 6-1 and 6-2, and transportation distances and road conditions are listed in Table 6-3.

Table 6-5. Truck Tariffs

Distance (km)	Tariff (peso)	Distance (km)	Tariff (peso)	Distance (km)	Tariff (peso)	Distance (km)	Tariff (peso)
5	4,460	205	24,436	405	41,125	605	54,859
10	5,215	210	24,881	410	41,492	610	55,181
15	5,970	215	25,326	415	41,860	615	55,504
20	6,725	220	25,771	420	42,227	620	55,827
25	7,480	225	26,216	425	42,594	625	56,150
30	8,235	230	26,661	430	42,961	630	56,472
35	8,990	235	27,106	435	43,328	635	56,795
40	9,745	240	27,551	440	43,696	640	57,118
45	10,190	245	27,996	445	44,063	645	57,440
50	10,635	250	28,443	450	44,430	650	57,763
55	11,080	255	28,888	455	44,781	655	58,086
60	11,525	260	29,333	460	45,133	660	58,408
65	11,970	265	29,778	465	45,484	665	58,731
70	12,415	270	30,223	470	45,835	670	59,054
75	12,860	275	30,668	475	46,187	675	59,377
80	13,305	280	31,113	480	46,538	680	59,699
85	13,750	285	31,558	485	46,889	685	60,022
90	14,195	290	32,003	490	47,240	690	60,345
95	14,640	295	32,448	495	47,592	695	60,667
100	15,085	300	32,895	500	47,943	700	60,990
105	15,530	305	33,295	505	48,280	705	61,313
110	15,975	310	33,695	510	48,616	710	61,635
115	16,420	315	34,095	515	48,953	715	61,958
120	16,865	320	34,495	520	49,289	720	62,281
125	17,310	325	34,895	525	49,626	725	62,604
130	17,755	330	35,296	530	49,963	730	62,926
135	18,200	335	35,701	535	50,299	735	63,249
140	18,645	340	36,106	540	50,636	740	63,572
145	19,090	345	36,511	545	50,972	745	63,894
150	19,539	350	36,916	550	51,309	750	64,217
155	19,984	355	37,301	555	51,632	755	64,540
160	20,429	360	37,686	560	51,954	760	64,862
165	20,874	365	38,071	565	52,277	765	65,185
170	21,319	370	38,456	570	52,600	770	65,508
175	21,764	375	38,841	575	52,923	775	65,831
180	22,209	380	39,226	580	53,245	780	66,153
185	22,654	385	39,611	585	53,568	785	66,476
190	23,099	390	39,996	590	53,891	790	66,799
195	23,544	395	40,378	595	54,213	795	67,121
200	23,991	400	40,758	600	54,536	800	67,444

Source: La Federación Cordebesa del Transporte Automotor de Cargas

Table 6-6. Financial Costs of Road Transportation

Case C-I: Direct transport of refined copper as well as molybdenite to Buenos Aires

Case C-II: Direct transport of refined molybdenite to Buenos Aires, while refined copper is transported, first to Andaogala and then electro-copper is transported to Buenos Aires.

Case C-III: Direct transport of refined molybdenite to Buenos Aires, while refined copper is transported, first to Barreal, and then electro-copper is transported to Buenos Aires.

In many cases construction equipment and operating materials are assumed to be transported directly from Buenos Aires to the mining site.

Alternates	Operation Capacity (tons/day)	Construction Equipment			Refined Ore Electro-Copper (1,000 pesos/year)	Materials (1,000 pesos/year)	Total: Refined Ore Electro-Copper Materials (1,000 pesos/year)
		First year (1,000 pesos)	Second year (1,000 pesos)	Third year (1,000 pesos)			
Case C-I	30,000	2,417,250	3,223,000	2,417,250	5,406,580	4,834,500	10,241,080
	20,000	1,692,080	2,256,100	1,692,080	3,577,530	3,223,000	6,800,530
Case C-II	30,000	2,417,250	3,223,000	2,417,250	2,709,080	4,834,500	7,543,580
	20,000	1,692,080	2,256,100	1,692,080	1,788,730	3,223,000	5,011,730
Case C-III	30,000	2,417,250	3,223,000	2,417,250	3,523,460	4,834,500	8,357,960
	20,000	1,692,080	2,256,100	1,692,080	2,327,000	3,223,000	5,550,000

Further, it is possible to create a transportation department within the mining company instead of consigning to a transportation company. In this case, profits which are included in the charges of a transportation company are obviously excluded from the financial costs to the mining company. On the contrary, however, operational efficiency of trucks within the mining company becomes lower than that of a transport company. In addition, if other factors such as road conditions are taken into account, expenses for transportation from the transportation department of the mining company may become similar to the transportation charges of a transport company.

4-2. Economic Costs of Road Transportation

Economic costs for the use of 20 ton semi-trailers are computed for each factor as follows:

(1) Equivalent costs of equipment expenses per traveling hour

$C = 4{,}992$ (basic value of truck) $\times$ 1.29 (adjustment for semi-trailer)
$\fallingdotseq$ 6,400 pesos/hour

(2) General management expenses

$f = 3{,}082$ (basic value of truck) x 1.27 (adjustment for semi-trailer)
$\fallingdotseq$ 3,900 pesos/hour

(3) Maintenance costs for the distance covered (inclusive of tire consumption)

$O = (66 \times 2.51 + 94 \times 1.26) \times r$

(66: basic value of truck; 2.51: adjustment for semi-trailer; 94: basic value of truck; 1.26: adjustment for semi-trailer; r: adjustment for kind of road)

(66 x 2.51: costs for tire consumption; 94 x 1.26: other maintenance costs)

$\fallingdotseq$ { 280 pesos/km for paved road
{ 310 pesos/km for dirt/gravel road

(4) Fuel costs

$P = 0.296$ (unit cost of fuel) x $(a_0 + 989.7\,x^{-1} + 156.7x^2 \times 10^{-5})$ pesos/km

where x indicates speed (km/hour) and a_0 is calculated from the formula:

$a_0 =$ 277 (basic value of truck) + 201 (adjustment for semi-trailer) + a (adjustment for kind of road)

and takes the values as shown in the following table.

	Dirt road	Gravel road	Paved road
Flat area	478.0	467.2	425.6
Mountainous area	547.8	537.0	575.6

(5) Labor costs for drivers

$\ell =$ 4,917 pesos/hour

Economic costs can be derived by adding cost items (1) to (5) using the travel distance or the travel hours (computed from the average speed). Basic assumptions made in the use of these formulae are as follows:

(a) Loading ratio is assumed to be approx. 100%.
(b) Conditions of trucks and maintenance of roads are assumed to be good.
(c) Actual expenses are regarded as crude estimates of economic costs.
(d) Research results of transportation costs carried out by the Ministry of Public Works of the Argentinian Government are used as the basis for cost computation.
(e) One-way transportation does not take place in this project.
(f) Average speeds of 20 ton semi-trailers used in this project are assumed as follows:

Region / Kind of road	North-western region of Córdoba or San Luis	South-eastern region of Córdoba or San Luis
Paved road		
Flat area	60 km/hour	30 km/hour
Dirt/Gravel road		
Flat area	40 km/hour	--
Mountainous area	10 km/hour	--

Based on these assumptions, economic costs for traveling D km by 20 ton semi-trailer are computed as follows:

(1) Paved road in flat area of north-western region of Córdoba or San Luis:

C = 107 D, f = 65 D, O = 280 D, P = 133 D,

($\because a_0$ = 425.6, x = 60) ℓ = 82 D,

$\therefore$ C + f + O + P + ℓ = 667 D.

(2) Paved road in flat area of south-eastern region of Cordoba or San Luis:

C = 213 D, f = 130 D, O = 280 D, P = 136 D,

($\because a_0$ = 425.6, x = 30) ℓ = 164 D,

$\therefore$ C + f + O + P + ℓ = 923 D.

(3) Gravel (dirt) road in flat area:

C = 160 D, f = 98 D, O = 310 D, P = 150 D,

($\because a_0$ = 478.0, x = 40) ℓ = 123 D,

$\therefore$ C + f + O + P + ℓ = 841 D.

(4) Gravel (dirt) road in mountainous area:

C = 640 D, f = 390 D, O = 310 D, P = 191 D,

($\because a_0$ = 547.8, x = 10) ℓ = 492 D,

$\therefore$ C + f + O + P + ℓ = 2,023 D.

Economic costs derived in this manner are summarized in the following table.

Region / Kind of Road	North-western region of Córdoba or San Luis	South-eastern region of Córdoba or San Luis
Paved road		
Flat area	667 peso/km	923 peso/km
Dirt/gravel road		
Flat area	841	—
Mountainous area	2,023	—

Economic costs of each alternative transportation plan are computed on the basis of the formulae given above, and the results are listed in Table 6-7. Generated transportation demands are listed in Table 6-1 and 6-2, and transportation distance and road conditions are listed in Table 6-3. The economic costs in Table 6-7 represent about 70% of the financial costs in Table 6-6. The difference between the financial costs and the economic costs is regarded as corresponding to taxes, profits of the transportation company, etc. In addition, it is assumed that there is no foreign currency portion in the economic costs of road transportation.

4-3. Financial Costs of Railway Transportation

The official railway rates used by Argentine National Railway are adapted as the financial costs of railway transportation, assuming that refined ore as well as electrically smelted copper are transported by block-trains consisting of open cars of 40 ton capacity. However, the rates can be discounted 5% to 10% in reality. These are summarized in Table 6-8. Charges for open-air storage at Retiro are estimated to be 3,100 pesos/m^2 x 2,000 m^2 = 6.2 million pesos/year.

4-4. Economic Costs of Railway Transportation

Tariff revenues of the Argentine National Railway do not cover total operation costs; that is, it is a deficit operation. In the formula (tariff revenue + deficit) = total costs, it is the total costs that are relevant to economic analysis. Since the economic costs are the costs which are substantially spent for transportation, they can be derived by deducting depreciation, taxes, interest, etc. form the total costs. Therefore, the total costs are allocated proportionally to the length of G. Belgrano Line and the length of San Martíne Line by using the data in Table 6-6.

Non-operational costs (General management expenses)

G. Belgrano Line: 23,200 million pesos ..... (1)
San Martín Line: 9,900 million pesos ..... (2)

Table 6-7. Economic Costs of Road Transportation

Case C-I: Direct transport of refined copper as well as molybdenite to Buenos Aires

Case C-II: Direct transport of refined molybdenite to Buenos Aires, while refined copper is transported, first to Andaogala and then electro-copper is transported to Buenos Aires.

Case C-III: Direct transport of refined molybdenite to Buenos Aires, while refined copper is transported, first to Barreal, and then electro-copper is transported to Buenos Aires.

In many cases construction equipment and operating materials are assumed to be transported directly from Buenos Aires to the mining site.

Alternates t	Operation Capacity (tons/day)	Construction Equipment			Refined Ore / Electro-Copper (1,000 pesos/year) Total	Materials (1,000 pesos/year)	Refined Ore / Electro-Copper / Materials (1,000 pesos/year) Total
		First year (1,000 pesos)	Second year (1,000 pesos)	Third year (1,000 pesos)			
Case C-I	30,000	1,637,340	2,183,120	1,637,340	3,662,180	3,274,680	6,936,860
	20,000	1,146,140	1,528,190	1,146,140	2,423,260	2,183,120	4,606,380
Case C-II	30,000	1,637,340	2,183,120	1,637,340	1,839,180	3,274,680	5,113,860
	20,000	1,146,140	1,528,190	1,146,140	1,214,450	2,183,120	3,397,570
Case C-III	30,000	1,637,340	2,183,120	1,637,340	2,643,760	3,274,680	5,918,440
	20,000	1,146,140	1,528,190	1,146,140	1,746,270	2,183,120	3,929,390

Table 6-8. Railway Transportation Tariffs

Section (Distance)	Office Rate		5% Discount		10% Discount		Export Items
	peso/ton	peso/ton	peso/ton	peso/ton	peso/ton	peso/ton	
Chilecito-Retiro (1,269 km)	102,300	80.61	97,185	76.58	92,070	72.55	Refined Ore
Chilecito-Andalgala (433 km)	47,500	109.70	45,125	104.22	42,750	98.73	Refined Ore
Andalgala-Retiro (1,446 km)	114,300	79.03	108,585	75.08	102,870	71.13	Electro-Copper
Chilecito-San Juan (651 km)	60,400	92.78	57,380	88.14	54,360	83.50	Refined Ore
Mendosa-Retiro (1,049 km)	86,500	82.46	82,175	78.34	77,850	74.21	Electro-Copper

Source: Los Ferrocarriles en 1979

Note: Charges for open-air storage at Retiro are estimated to be 3,100 peso/m^3 x 2,000 m^2 = 6.2 million peso/year.

Operational costs

G. Belgrano Line: 13,100 million pesos ..... (3)
San Martín Line: 5,500 million pesos. ..... (4)

Operational costs for Branch Lines

G. Belgrano Line: 136,200 million pesos ..... (5)
San Martín Line: 66,200 million pesos. ..... (6)

Total costs

G. Belgrano Line: (1) + (3) + (5) = 172,500 million pesos ..... (7)
San Martín Line: (2) + (4) + (6) = 81,600 million pesos. ..... (8)

(Refer to Table 6-9 on P. 187 and Table 6-10 on p. 188).

However, the costs determined in this way include costs for freight, passengers, mail, etc. Therefore, it is necessary to substract a portion of the costs attributable to cargo. Costs of cargo transportation are derived by (1) using revenues of cargo, passengers, mail and storage as indicated in Table 6-11, and (2) assuming the raito of revenues is similar to that of costs. First, the following values can be derived from Table 6-11.

	G. Belgrano Line		San Martín Line	
	Revenue (peso)	Ratio	Revenue (peso)	Ratio
Cargo	40.9 billion	67%	38.9 billion	64%
Passengers	15.1 billion	25%	19.3 billion	32%
Mail & storage	2.1 billion	3%	2.2 billion	3%
Others	2.9 billion	5%	0.6 billion	1%
Total	61.0 billion		61.0 billion	

By multipling the ratio of cargo revenues derived above, i.e., 67% and 64%, to the total costs (7) and (8), respectively, costs for cargo transportation become as follows:

G. Belgrano Line: 115,600 million peso
San Martín Line: 52,100 million peso

Actual economic costs of cargo transportation can be calculated by dividing the figures derived above by the cargo transportation volume of each line.

G. Belgrano Line: 34.30 peso/ton·km
San Martín Line: 15.86 peso/ton·km

Since the values derived in this manner are those for 1978, they must be inflated by multiplying the inflation rate of 150% for the year 1979 as well as the inflation rate of 80% from January,

Table 6-9. Comparative Table of the Achievements Corresponding to the Fiscal Year Ended 31/Dec./1977 and 31/Dec./1978

Detail	1977			1978		
	10^9 $		%	10^9 $		%
Service Income						
Results of Operational Activities	111.8			306.1		
Special Bonuses of Freights, Passengers, etc.	∧ 0.6	111.2	76	∧ 2.5	303.6	96
Service Costs						
Operational Expenses	192.7			496.3		
Depreciation	13.3	206.0	142	77.7	574.0	181
Operational Losses		94.8	65		270.4	85
Non Operational Expenses						
Service Free of Charge or Under-Paid	3.5			9.0		
Branch Lines Censidered Anti-Economic	0.3			4.7		
Financial Expenses	10.1	13.9	10	26.2	39.9	13
Results of Ordinary Operations		108.7	75		310.3	98
Other Expenses		26.6	18		34.8	11
Other Incomes		8.8	6		30.9	10
Net Loss of the Fiscal Year		126.5	87		314.2	99
Brought Forward fram the Preceeding Year		19.0	13		2.3	1
Final Account of the Losses		145.5	100		316.5	100

Table 6-10. Operational Expenses per Line and Central Organization – 1978 (per Sector)

(Unit: 10^9 $)

Classification	Lines						Central Organization	Total
	Roca	Mitre	San Martín	Sarmiento	Urquiza	Belgrano		
Maintenance of the Track and Works	10.9	15.1	12.3	6.8	7.0	28.1	–	80.2
Maintenance of the Trains and Rolling Stock	15.3	17.8	12.3	7.2	6.5	24.6	–	83.7
Requirement and Running or Trains and Rolling Stock	16.5	15.5	12.6	6.5	5.8	27.2	–	84.1
Trafic Services	36.4	30.6	22.0	14.7	14.6	44.6	–	162.9
Fruvial Services	–	–	–	–	2.4	–	–	2.4
Administration	4.3	5.7	5.2	3.9	3.5	9.1	42.1	73.8
Procurement	1.2	1.8	1.8	0.9	0.9	2.6	–	9.2
Total Operational Expenses	84.6	86.5	66.2	40.0	40.7	136.2	42.1	496.3

Source: Los Ferrocarriles en 1979

Table 6-11. Operational Revenues Per Line – 1978 (Net Profit)

(Unit: 1,000 million pesos)

Line	Passengers			Cargo	Mail and Storage	Others	Total
	Urban and Suburban	General	Total Passengers				
	1	2	3=2+1	4	5	6	7=3+4+5+6
Roca	13.8	17.4	31.2	24.5	2.0	0.8	58.5
Mitre	13.8	16.7	30.5	31.6	1.8	1.5	65.4
San Martín	11.4	7.9	19.3	38.9	2.2	0.6	61.0
Sarmiento	21.6	1.7	23.3	8.5	1.2	0.3	33.3
Urquila	3.8	4.9	8.7	14.4	0.8	0.5	24.4
Belgrano	8.1	7.0	15.1	40.9	2.1	2.9	61.0
Total	72.5	55.6	128.1	158.8	10.1	6.6	303.6

Source: Los Ferrocarriles en 1979

1980 to October, 1980. Adjusted values as of November, 1980 become as follows:

G. Belgrano Line: 154.35 pesos/ton·km
San Martín Line: 73.37 pesos/ton·km

These values are used as the economic costs of railway transportation for this project.

Table 6-12. Annual Financial Costs of Railway Transportation

(Unit: Million peso)

Section	Operation Capacity of 30,000 tons/day		Operation Capacity of 20,000 tons/day	
	Refined ore or Electro-copper	Materials	Refined ore or Electro-copper	Materials
Chilecito-Retiro (1,269 km)	6,035.7	6,138.0	3,989.7	4,092.0
Chilecito-Andalgala (433 km)	2,802.5	–	1,852.5	–
Andalgala-Retiro (1,446 km)	1,257.3	–	823.0	–
Chilecito-San Juan (651 km)	3,563.6	–	2,355.6	–
Mendoza-Retiro (1,049 km)	951.5	–	622.8	–

Annual Economic Losts of Railway Transportation

(Unit: Million pesos)

Section	Operation Capacity of 30,000 tons/day		Operation Capacity of 20,000 tons/day	
	Refined ore or Electro-copper	Materials	Refined ore or Electro-copper	Materials
Chilecito-Retiro (1,269 km)	11,556.3	11,752.2	7,638.9	7,834.8
Chilecito-Andalgala (433 km)	3,943.2	–	2,606.5	–
Andalgala-Retiro (1,446 km)	2,455.1	–	1,607.0	–
Chilecito-San Juan (651 km)	5,928.4	–	3,918.8	–
Mendoza-Retiro (1,049 km)	823.5	–	539.0	–

5. Formulation of Optimal Transportation Plan

5-1. Selection of Optimal Transportation Alternative

The remaining task for selection of the optimal transportation alternative is the choice between road and railway transportation after Chilecito.

In order to compare the costs of each, firstly, costs associated with road transportation are summarized in Table 6-13. Costs for new road construction, improvement and maintenance mentioned in Section 3 are associated with transportation between the mining site and Chilecito, and, therefore, are not relevant to a comparison of alternate plans. Costs associated with railway transportation are summarized in Table 6-14.

Table 6-13. Annual Road Transportation Costs (Refined Ore, Electro-Copper, Materials) after Chilecito

Alternates	Operation Capacity (tons/day)	Financial Costs (million peso)	Economic Costs (million peso)
Case C-I (Direct Route to Buenos Aires)	30,000 20,000	9,220 6,122	6,312 4,191
Case C-II (Route via Andalgala)	30,000 20,000	6,522 4,333	4,489 2,983
Case C-III (Route via Barreal)	30,000 20,000	7,337 4,872	5,293 3,514

Note: Transportation costs between the mining site and chilecito are deducted from the total cost of each route, since figures in this table indicate transportation costs after Chilecito.

Table 6-14. Annual Railway Transportation Costs (Refined Ore, Electro-Copper, Materials) after Chilecito

Alternates	Operation Capacity (tons/day)	Financial Costs (1,000 peso)	Economic Costs (1,000 peso)
Case F-I (Direct Route to Buenos Aires)	30,000 20,000	12,174 8,082	23,309 15,474
Case F-II (Route via Andalgala)	30,000 20,000	10,198 6,768	18,151 12,048
Case F-III (Route via Barreal)	30,000 20,000	10,653 7,070	18,504 12,293

It becomes clear from a comparison of these costs that road transportation is superior to railway transportation with respect to the financial costs of management of the mining company as well as with respect to economic costs which relate to economic efficieny for the country. In case of railway transportation, additional costs other than the costs listed in Table 6-14 may be required such as those involved in transfer from the railway to trucks at each station. Therefore, road transportation is selected as the optimal means of transport in this project. However, it must be mentioned that when a large discounting of the railway tariff is available or when the economic costs are significantly reduced due to changes in demand for other goods, a new analysis should be undertaken.

5-2. Summary of Costs Associated with Transportation Plan

Costs associated with the transportation plan under the selected optimal transportation alternative are summarized in Table 6-15. These costs become inputs for financial and economic analyses of this project and, further, will be used as input data for determining alternatives of operation scale of the mine in the comprehensive evaluation of the project. As to the alternate transportation routes, they will also be used as inputs for formulation of a utilization plan for the smelting plants.

Table 6-15. Summary of Costs Assisted with Transportation Planning

(Unit: 1,000 pesos)

Investment Period		1st Year of Construction					2nd Year of Construction				3rd Year of Construction				Operation Period			
Cost Element		Types of Costs / Operating Scale	Financial Costs	Economic Costs			Financial Costs	Economic Costs			Financial Costs	Economic Costs			Financial Costs	Economic Costs		
				D [5]	F [6]	Total		D	F	Total		D	F	Total		D	F	Total
Road Construction Costs		30,000	5,844	4,644	1,990	6,634	–	–	–	–	–	–	–	–	–	–	–	–
		20,000	5,844	4,644	1,990	6,634	–	–	–	–	–	–	–	–	–	–	–	–
Road Maintenance Costs		30,000	–	–	–	–	178	200	23	233	178	210	23	233	178	210	23	233
		20,000	–	–	–	–	178	210	23	233	178	210	23	233	178	210	23	233
Transportation Costs of Construction Materials		30,000	2,417	1,637		1,637	3,223	2,183		2,183	2,417	1,637		1,637	–	–	–	–
		20,000	1,692	1,146		1,146	2,256	1,528		1,528	1,692	1,146		1,146	–	–	–	–
Transportation Costs of Refined Copper, Electro-Copper, and Materials [2]	Case C-I	30,000	–	–	–	–	–	–	–	–	–	–	–	–	10,241	6,937	0	6,937
		20,000	–	–	–	–	–	–	–	–	–	–	–	–	6,801	4,606	0	4,606
	Case C-II	30,000	–	–	–	–	–	–	–	–	–	–	–	–	7,544	5,114	0	5,114
		20,000	–	–	–	–	–	–	–	–	–	–	–	–	5,012	3,398	0	3,398
	Case C-III	30,000	–	–	–	–	–	–	–	–	–	–	–	–	8,358	5,918	0	5,918
		20,000	–	–	–	–	–	–	–	–	–	–	–	–	5,550	3,929	0	3,929
User Fees for Port		30,000	–	–	–	–	–	–	–	–	–	–	–	–	92	58	25	83
		20,000	–	–	–	–	–	–	–	–	–	–	–	–	61	38	16	55
Total Costs Associated Transportation	Case C-I	30,000	8,261 [3]	6,281	1,990	8,271	3,401	2,393	23	2,416	2,595	1,847	23	1,871	10,511	7,205	49	7,253
		20,000	7,536 [4]	5,790	1,990	7,780	2,434	1,739	23	1,761	1,870	1,356	23	1,379	7,040	4,855	40	4,894
	Case C-II	30,000	8,261 [3]	6,281	1,990	8,271	3,401	2,393	23	2,416	2,595	1,847	23	1,871	7,814	5,382	48	5,430
		20,000	7,536 [4]	5,790	1,990	7,780	2,434	1,738	23	1,761	1,870	1,356	23	1,379	5,251	3,646	40	3,686
	Case C-III	30,000	8,261 [3]	6,281	1,990	8,271	3,401	2,393	23	2,416	2,595	1,847	23	1,871	8,628	6,186	48	6,234
		20,000	7,536 [4]	5,790	1,990	7,780	2,434	1,738	23	1,761	1,870	1,356	23	1,379	5,789	4,178	40	4,217

Notes:
1) 2,854,940 thousand pesos in the case of implementation by armies.
2) Case C-I Buenos Aires through Route, Case C-II Buenos Aires by Andalgala route, C-III Buenos Aires by Barreal route
3) 5,272,190 thousand pesos in the case of implementation by armies.
4) 4,547,020 thousand pesos in the case of implementation by armies.
5) D is domestic currency.
6) F is foreign currency.

Annex. Traffic Volume Justifying Investments in Road Pavement Works

In order to determine the minimum traffic volume which justifies investment for pavement works for dirt/gravel roads, an average daily traffic volume which makes the benefit-cost ratio 1.0, is examined for road pavement projects, as shown in Figure 6-8. Table 6-16 shows the results. The following assumptions are used for this purpose and computation was undertaken by the Ministry of Public Works.

(1) The traffic consists of 40% trucks, 5% buses and 55% passenger cars.

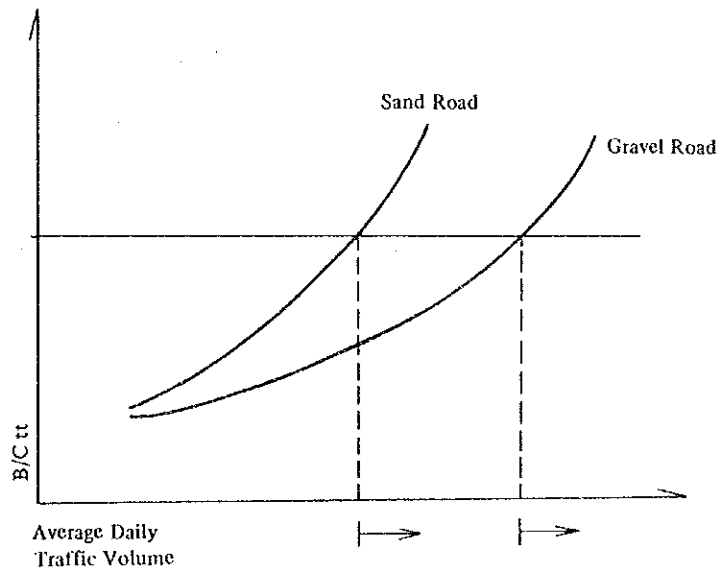
(2) An average annual growth rate of traffic volume is 4%.

(3) The discount rate for computation of the present value is 10%.

(4) The project life is 20 years, and

(5) Savings in travel expenses such as fuel costs and labor costs as well as time savings are counted as benefits, while construction costs, normal maintenance expenses for large scale repair works are included in cost calculation.

Fig. 6-8. The Minimum Traffic Volume Which Justifies Investment for Pavement Works for Sand/Gravel Roads



The Minimum Traffic Volume Which Justifies Investment for Pavement Works for Sand/Gravel Roads

Table 6-16. Traffic Volume for the Justification of Investments for Pavement Works of Roads

Existing Conditions		Minimum Traffic Volume for Pavement Works
Kinds of Roads	Conditions	
Sand Road	Bad	250
	Normal	280
	Good	375
Gravel Road	Bad	300
	Normal	350
	Good	500

Chapter 7.

OVERALL EVALUATION

CHAPTER 7. OVERALL EVALUATION

1. Overall Evaluation Techniques

Economic Evaluation: For development of the Famatina Mine, it is necessary to determine approximately what the total cost will really be as well as the total profits (or benefits) that will actually be derived from development. Further, it must be demonstrated that the net benefit of this project is sufficiently high to justify implementation. Only by means of such analysis is it possible to achieve optimum allocation of all necessary domestic resources. Such analysis is usually termed "economic analysis."

Internal Rate of Economic Return: With this project, both costs and benefits will accrue over a full 25-year period from 1981 to 2006. By the year 2000, a million pesos at 1981 prices might not be worth more than a hundred thousand pesos, hence the need to discount both future costs and benefits at a particular discount rate in order to determine their values in terms of 1981 prices and then to determine which is greater. By trying out different discount rate values, one should be able to determine a discount rate which makes the present value of the costs discounted to 1981 equal to the present value of the benefits. This rate is called the economic internal rate of return and, depending on what the percentage is, one can draw conclusions as to whether or not the Famatina Mine project should be implemented.

Here we shall assume that the internal economic rate of return should be approximately 10% in order to justify implementation of the Famatina Mine Project. It is extremely difficult to judge whether 10% is the best figure or a lower figure such as 7% or a higher figure such as 15% should be used. Most international agencies usually use values in the range of 8–12% as the standard for granting project loans. In the case of the Famatina Mine project, the figure of 10% has been adopted on the basis of various considerations. Accordingly, the figure of 10% for the internal economic rate of return provides the threshold for whether or not the project can be implemented. It should be noted that this economic evaluation is to serve as a standard for determination of whether or not the Famatina Mine project should be carried out in preference to a variety of other projects that could be implemented in Argentina (the 10% is sometimes referred to as the opportunity cost of capital).

Economic Price: In calculating the internal economic rate of return, a comparison is made between the real cost (economic cost) and the real benefits (real return or real economic benefits). The point here is what "real" means. This survey was carried out in October, 1980 and the cost and benefits are therefore expressed in terms of prices prevailing at that time. In other words, they are expressed in terms of general market prices. In order to determine the real prices, we must first subtract taxes from the market prices. This is because taxes are assessed *ex post* and thus constitute a transfer item in the national economy and no consumption of resources is involved. In other words, taxes have nothing to do with resources that are actually used in implementing the project. Secondly, interest should be excluded. Although interest accrues from use of the capital necessary to carry out the project, it merely represents a transfer

within the national economy in the same manner as taxes. Accordingly, in economic evaluation, interest is not considered as a cost element. Thirdly, a portion of the costs and benefits in the form of foreign exchange must be adjusted to actual exchange rates. Imports of mining equipment purchased on international markets and the international price of copper are usually expressed in U.S. dollars, but in order to compare the costs and benefits of mining development, they must be expressed consistently in pesos, and this involves evaluation of real prices (how this is done is explained later). Besides these three considerations, there are many other special considerations involved in economic evaluation, including the concept of salvage value and the question of the scope of costs and benefits which should be considered. These are explained later as actual computation is carried out.

Financial Evaluation: Income and expenditures are compared in terms of ordinary prices, i.e., market prices, but there are some differences compared to the calculation methods employed by private enterprise. In a manner similar to that for calculation of the internal economic rate of return in economic analysis, a discount rate is adopted that makes the present value of income equal to the present value of expenditures over a period of 25 years, both being expressed in market prices. This is called the internal financial rate of return. For instance, if the internal financial rate of return is calculated as 5%, this means that income and expenditures will be equal if an interest rate of 5% is applied. In other words, if the project is implemented on the basis of funds borrowed at 3% interest, there would be a profit rate of 2% (5% – 3%).

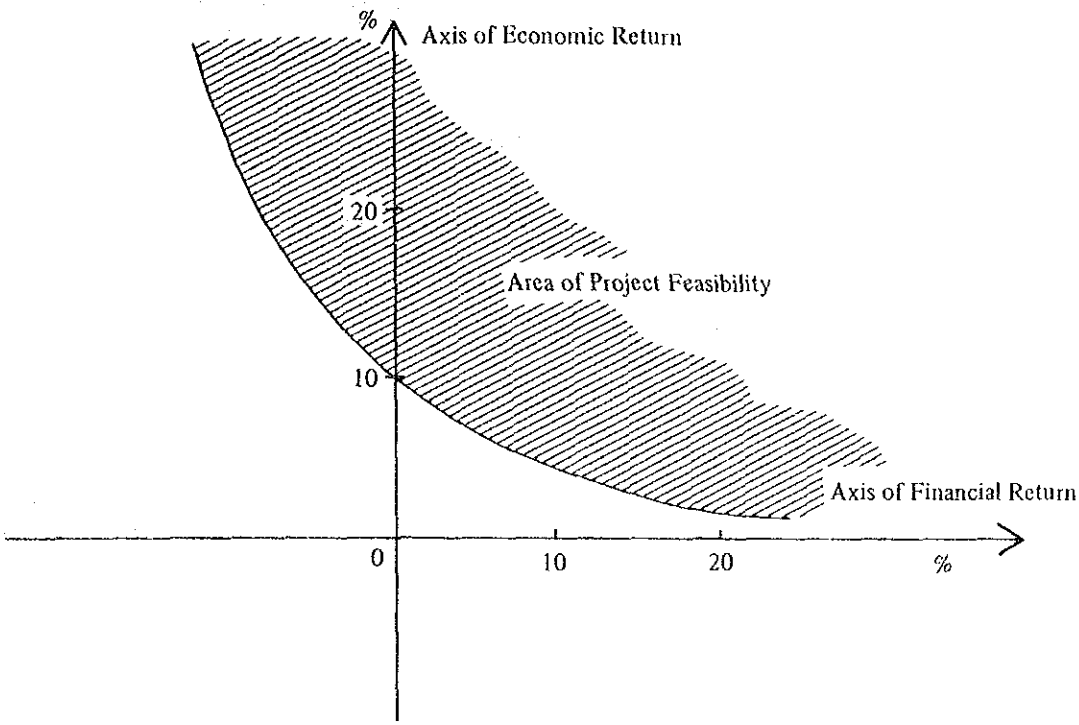
Project Selection Criteria: As we have seen, there is considerable difference between economic evaluation and financial evaluation. It is desirable in evaluation of the project that both be favorable. What happens, then, if one is favorable and the other is not? Generally speaking, in project selection, economic evaluation is of primary importance; financial evaluation assuming importance at the stage when a decision must be made as to whether or not to implement individual projects that have been selected as candidates. Accordingly, no matter how favorable the financial evaluation, the project cannot be selected if the internal economic rate of return determined in the economic evaluation is below 10%. Conversely, if the economic evaluation is favorable but the financial evaluation is not, it is still possible to attempt to redesign the project with the aid of national or local governments, which could, for instance, shoulder some portion of the project costs (see Fig. 7-1 on next page).

2. Analysis of Overall Costs

2-1. Calculation of Financial Costs

The estimated financial costs are given in Table 7-1, the total investment cost being approximately 590,000 million pesos and the annual operating costs 127,000 million pesos. Of the investment costs, 92% are accounted for by the mine itself (68%) and the mining town (24%). All of these financial costs have been calculated on the basis of market prices as of October, 1980. The calculation criteria and the breakdown for different sectors are as follows (Refer to Table 7-1 on p. 200).

Fig. 7-1. Synthesis of Evaluation on the Basis of Economic and Financial Rates of Return



Prospecting Costs: The prospecting costs prior to 1981 (see Table 7-2) were converted to 1981 prices and future capital costs have been discounted to represent current prices on the basis of a capital opportunity cost of 10% per annum, the total amount of this item coming to 8,842 million pesos (1981 prices). Prior prospecting costs could be excluded from financial costs, but in this project they have been included in the basic case. The variation in the financial rate of return that would result from exclusion is to be determined on the basis of a sensitivity analysis of the initial investment outlays, i.e., reduction in initial investment in this case.

Mine: The initial expenses for the mine would be 390,000 million pesos in the case of a crude ore treatment capacity of 30,000 tons/day and 292,500 million pesos in the case of 20,000 tons/day. These expenses constitute 66% and 65% of the total initial investment for the respective mining scales. Of the initial expenses for the mine, 40% is for mine operation itself and 60% for ore dressing. Another breakdown of initial expenses for the mine by item shows that machinery and equipment and for civil engineering and construction works account for 67% and 17% respectively. Operating costs of the mine constitute 72.4% of the total operation costs, of which 62.7% is accounted for by personnel costs (personnel costs account for 45.4% of total operating 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 7-2. Prospecting Costs to Date

	Annual Prospecting Expenditures	Wholesale Price Index 1960 : 100	Prospecting Cost to Date in Real Terms 1980 Prices	Discount Rate 10%	Prospecting Costs at Current 1981 Prices
1973	508	2,103.4	294,126	2,141	629,724
1974	1,324	2,524.5	638,710	1,949	1,244,846
1975	3,933	7,384.0	648,670	1,773	1,150,092
1976	11,472	44,233.7	315,847	1,610	508,514
1977	55,430	110,338	611,802	1,464	895,678
1978	318,125	271,079.2	1,429,200	1,332	1,903,694
1979	735,080	676,579.7	1,323,144	1,211	1,602,327
1980	824,922	1,217,843.4[1)]	824,922	1,100	907,414
1981				1,000	
Total	1,950,794		6,086,421		8,842,289

Note: 1) Projected.

Personnel and General Management Costs: Personnel and general management costs are included in operating costs. The total for direct personnel costs is given in Table 7-3. The monthly payments per person include not only basic salaries but also various allowances and social security benefits. Taking the following considerations into account, the level of wages was set slightly higher than the level currently prevailing: (1) labor conditions are unfavorable because most of the work is at high altitudes; (2) a large number of technicians and workers have to be recruited from a wide area; (3) since most mines (particularly nonferrous mines) in Argentina and particularly those in La Rioja Province are of small scale and have only a small number of workers, the labor market for quality technicians and workers may become tight in future (Table 7-3). As for management class personnel expenses, all personnel of the management level are included.

General Management Costs: General management costs are normally about 1 to 1.5 dollars per ton of crude ore. In this report they have been calculated at 1.25 dollars (2,437.5 pesos) per ton.

Electricity: Since it is assumed as the basic case of power development that power is to be purchased, the initial investment includes only 2,960 million pesos for a power transmission line between the mine and Chilecito. The operating costs come to 24,530 million pesos per year, or 19% of total operating costs. The unit cost for purchased electricity (101 pesos/kWh) used as the financial cost was calculated from electricity rate schedules. The electric power cost involved

Table 7-3. Direct Personnel Expenses

(Unit: Million pesos)

Personnel Expenses / Type of Work	Monthly Salary per Person	Direct Annual Personnel Expenses per Person	Overall Direct Personnel		Personnel Expenses	
			Number of Persons	in the Case of 30,000 tons/day	Number of Persons	in the Case of 20,000 tons/day
Management	5.9	76.7	55	4,219	43	3,298
Engineers and Technicians	3.9	50.7	50	2,535	35	1,775
Office Staff	2.9	37.7	455	17,154	342	12,893
Foremen and Team Leaders	2.9	37.7	95	3,582	70	2,639
Unskilled Laborers	2.1	27.3	350	9,555	260	7,098
Office Workers	1.6	20.8	815	16,952	620	12,896
Total	1.6	20.8	180	3,744	130	2,704
	-	-	2,000	57,741	1,500	43,303

in bringing water to the mine is also included.

Water: The initial investment for water is 31,318 million pesos, the breakdown being 84% for dam construction, 13% for water conveyance construction works, and 3% for underground water works. As for operating costs relating to water, these will mainly be personnel costs for maintenance and repairs.

Mining Town: The investment for the mining town is 138,494 million pesos in the case of a crude ore treatment capacity of 30,000 tons/day and 99,860 million pesos in the case of a capacity of 20,000 tons/day, corresponding to as high as 23.5% and 22.1% of the total investments for the respective mining scales. If the salvage value is subtracted, however, this percentage will be only 16%. Salvage value is explained in the section on economic cost. Approximately 19% of the investment for the mining city is accounted for by the cost of constructing accommodation facilities. In the case of financial costs, only those directly connected with the mining company have been considered, and not those to be borne by local government.

Transportation: Transportation constitutes only 2.4% of total investment. The reason why this figure is so low is that it has been assumed that a transport company will handle the mine's transportation needs for the most part. Approximately 38% of the initial investment for transportation, or 5,844 million pesos, represents road construction costs, the remaining being the cost of transport of construction materials, etc. If road construction is carried out by the military, the initial investment will be reduced by 2,989 million pesos. Later we shall attempt sensitivity analysis with respect to this point.

Table 7-4 gives yearly totals for the costs by sector that we have considered above, the figures for 1981–1985 representing investment costs and those for 1986 and subsequent years representing operating costs. For the years of additional investment (1996 in the case of operating scale of 30,000 tons/day and 1996 and 2000 in the case of 20,000 tons/day) the figures represent the total for investment and operating costs. (Refer to Table 7-4-(1), (2) on pp. 204, 205).

Calculation of the economic cost is as per Table 7-5 in the case of an operating scale of 30,000 tons/day. The overall economic cost comes to approximately 643,950 million pesos, and the annual operating costs come to 129,860 million pesos, the breakdown being 70% for the mine itself and 20% for the mining town. The economic cost exceeds the total investment for the financial cost of 590,000 million by 53.9 million pesos, the reason and breakdown being as Table 7-5 on p. 206.

2-2. Economic Costs

Internal Transfer Costs: As already stated, the difference between financial analysis and economic analysis lies in how benefits and costs are assessed. In each case economic analysis is necessary to identify the real costs that are to be borne by the country. Accordingly, items such as taxes, which only represent a transfer within the country, must be excluded from the economic costs. Since capital goods to be imported for implementation of the present project are exempted from customs duties, taxes are included only in the costs of equipment or materials

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

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)		77,399,	8,183,	85,582	(65.9)
Mine	147,420	301,525	448,945	(69.7)		22,657,	14,295,	36,952	(28.5)
Electricity	933	2,563	3,496	(0.5)		54,	0,	54	(--)
Water	15,818	20,294	36,112	(5.6)	3,576, 3,711, 7,287				
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)

purchase in local currency. Although we do not know the exact tax rates imposed on different products, a tax rate of 5–10% has been assumed, based on a study of the Argentine tax structure, and this percentage has been deducted from the different sectors. Table 7-4 gives the figures resulting from this calculation of the internal-transfer portion of the financial costs considered earlier.

Labor Costs: As in the case of evaluation of other resources, the principle of opportunity cost is applied in the economic evaluation of labor. With regard to skilled labor, it can be assumed that the market mechanism functions and therefore the wages that are actually paid in the market can be used. In the case of unskilled labor, however, some adjustment will be necessary if a surplus exists. That is, even if workers are taken away from their present jobs, this may not represent any substantial consumption of human resources from a national viewpoint because of their very marginal productivity. This being the case, the economic cost of unskilled labor is generally considered to be very small. In Argentina, however, the unemployment rate is so low (1.9% in October, 1979) that practically full employment may be assumed. There is also a minimum wage law, which makes it possible to consider the market wage rates of unskilled workers as well to be an approximate representation of opportunity costs. Accoridngly, in the economic costs the same figures have been adopted as for personnel costs in fignancial cost analysis.

Mining Town: In estimating the economic costs, all cost elements relating to this project must be taken into account, regardless of who must bear them. Accordingly, the portion of the cost of the mining town that is to be borne by local government has also been included (Table 5-15). However, a part of the cost of constructing the new mining town, relating mainly to public facilities, is treated in a different manner based on considerations given below concerning the national economy. When people gather together to form a town or city, it becomes necessary to build public facilities. The larger the city becomes, the greater the scale of public facilities required. Accoridngly, if the people working for the mine were to live in other towns in the country rather than in the mining town, additional investment in public facilities would be necessary in those towns. However, construction costs would be somewhat lower in this case, since only marginal investment would be necessary in those existing towns, whereas in the case of the mining town, new public facilities must be provided. For this reason, it would not be appropriate to consider the entire amount given in Table 5-15 as the cost of the present project, nor would it be right to consider that the portion relating mainly to public facilities should be assessed as a zero economic cost. Based on this reasoning, we have taken the economic cost of the mining town to be two-thirds of the figure given in Table 5-15 and the salvage value has also been calculated as two-thirds of the figure given in the table.

Water: The economic costs for water were also calculated for the different items. Since the dam can be converted to irrigation use after completion of the project, the salvage value of the dam has been calculated and included in the benefits starting from the year following the final year of the project. First, net benefits derived from conversion of the dam to irrigation use were calculated. Since in general the capital opportunity cost is about 10%, an internal rate of return of about 10% was assumed and an initial investment of 6,360 million pesos was calculated as the amount necessary in order to derive the amount of net benefits calculated. In other words, since the dam is economically feasible even with that amount of investment, at the end of the

project life the salvage value of the dam is assessed as 6,360 million pesos. As for the salvage value in terms of financial analysis, it has been set at 60% of that for economic analysis, or 3,816 million pesos. This financial salvage value is the price at which the enterprise would be able to sell the dam. Since the dam would be used for public purposes, it would be sold to the local government. It is clear that the financial salvage value would be less than the economic salvage value, but just what price it could be sold for depends on negotiations with the buyer. Here we have assumed that it could be sold for 60% of the economic salvage value.

Electricity: The cost of purchase of electricity is 101 pesos per kWh in terms of financial cost and 151 pesos per kWh in terms of economic cost. The financial cost of the electricity is a kind of policy rate taken from the schedule of electricity rates, whereas the economic cost of electricity is obtained by dividing the actual costs of the power company by the number of kWh sold.

Calculation (using shadow exchange rate) of Economic Cost of Equipment and Materials Procured with Foreign Exchange: The official exchange rate was 1,950 pesos to the dollar as of but it is said the actual exchange rate is more like 5,000 or even 7,000 pesos to the dollar. This difference is the result of the fact that whereas inflation has been 100–150 percent per annum, the peso has been devalued against the dollar by only 10–20% per year; that is, adjustments of the official exchange rate have not kept step with the inflation rate. Should, for instance, a generator that cost 5 million dollars be considered to cost 5 million x 1,950 pesos = 9,750 million pesos or 5 million x 5,000 pesos = 25,000 million pesos? The cost of the mine would, of course, vary considerably depending on the answer to this question. For the purpose of economic analysis, therefore, it is necessary to use a real exchange rate (shadow exchange rate) rather than the official exchange rate in order to obtain the real prices of imported goods so as to be able to compare the costs and benefits.

Generally, the following formula is used to calculate real prices in pesos:

$$R' = \frac{f \times (1-S)R + mM(1+T)R}{fX + mM}$$

X: Exports
M: Imports
S: Export taxes
T: Import taxes
R: Official exchange rate
f: Exchange rate elasticity of foreign exchange supply
m: Price elasticity of domestic demand for imported goods

Since, it is difficult to calculate the price elasticity of demand and supply, however, price elasticity is generally ignored (assumed to be 1), and the following simplified formula is used.

$$R' = \frac{(M+T) + (X-D)}{M + X}$$

Using this formula, the shadow exchange rate (SER) for 1979 is calculated as follows:

Official exchange rate

1978. 12. 31.	1 US$	=	1,003.50 pesos
1979. 12. 31.	1 US$	=	1,618.50 pesos
Average	1 US$	=	1,311 pesos

Exports: X = 1,311 x 7,746 million $ = 10,155,000 million pesos

Import: M = 1,311 x 6,300 million $ = 8,259,300 million pesos

Import Taxes: T = 1,294,600 million pesos

Export Taxes: D = 42,100 million pesos

$$\frac{(8,259,300 + 1,294,600) + (10,155,000 - 42,100)}{10,155,000 + 8,259,300}$$

= 106.8

In other words, the peso is overvaluated by 6.8%.

Since, however, Argentina's import duties in 1979 were extremely high (Table 7-6), there is a strong possibility that the price elasticity of demand is quite high. The simplified formula above is effective when duties are low enough to allow for ignoring the elasticity. When duties are extremely high, however, as is the case of Argentina, the use of this simplified formula cannot be justified (Refer to Table 7-6 on p. 210).

In this analysis, we have used a method based on evaluation of purchasing power to determine the SER in Argentina. Selecting a time in the past when both trade and the domestic economy were in a state of equilibrium and assuming that the exchange rates, too, were at an equilibrium at that time, the real exchange rates at any other time can be determined by measuring the amount of change since the time when the price levels in both countries were at an equilibrium. First of all, Argentina's trade is divided into exports and imports. The wholesale price indices of Argentina's trade partners are weighted according to the amount of trade and averaged out in order to calculate the average wholesale price index for these countries. If this index is compared with Argentina's domestic wholesale price index, it is possible to surmise the real exchange rate. The World Bank also uses this method in determining the real exchange rate.

Table 7-6. Import Tax Rate and Items

Import Tax Rate (%)	As of Jan., 1979	Import Tax Rate (%)	As of Jan., 1979
85	15	29	7
80	-	27	-
75	5	25	155
70	-	24	-
65	46	23	-
60	24	21	79
55	8	20	164
50	183	18	-
48	670	17	-
46	787	15	-
45	24	14	-
44	679	12	-
42	129	10	-
40	224	5	-
39	254	0	-
36	463	Total Number of Items	8,285
35	167	Average Tax Rate (%)	25.5
30	99		

Source: JETRO, "Trade Information", Feb. 15, 1979.

Note: In spite of the fact that, judging from the duty schedule, many import items have an import tax rate of 30–50%, the average tax rate is only 25.5%. What this means is that a high import tax is imposed on only a few import items.

Table 7-7 gives the figures obtained by deflating the nominal exchange rate with the rates of increase in prices in Argentina and also in international prices. By using this method it is estimated that as of the end of 1979 the Argentine peso was evaluated about 20% higher than the real exchange rate. Assuming that the peso was overvaluated by 20% in 1979, the present SER can be calculated roughly as follows:

End of December 1979:	
Official rate (against US$):	1,615 pesos
End of October 1980:	
Official rate (against US$):	1,949 pesos
Rate of wholesale price increase, January–October, 1980:	80%
Rate of increase in wholesale prices of main trading countries:	20–30%
Decline in official exchange rate between end of December, 1979 and October, 1980:	Approximately 21%
Difference between Argentine's and trade partners' rates of increase in wholesale prices:	50–60%

As of October, 1980 it would appear that the official exchange rate was overvaluated by 30–40% in comparison to the real exchange rate, although the data available is not really sufficiently complete to draw a definite conclusion.

On the basis of the above considerations, a real exchange rate of 2,600 pesos to the US dollar (a 33.3% lower evaluation of the peso than the official rate of 1,950 pesos to the dollar) was assumed as the basic value for use in economic analysis. Furthermore, a sensitivity analysis was made by varying the SER between 1,950 pesos to the US dollar and 3,250 pesos to the US dollar.

Breakdown into Foreign and Domestic Currencies: Before applying the shadow exchange rate to foreign currency components of the costs, the costs are divided first into domestic currency (domestic products) and foreign currency (imported goods) based on estimated financial costs.

Table 7-7. Argentine Foreign Exchange Rate, 1976–1980

	Nominal Exchange Rate	Real Exchange Rate (Dec., 1969 = 10)		
		Export Weighted[1)]	Import Weighted[1)]	Adjusted by US Wholesale Prices with Argentine Weights[2)]
1976 Average	224.3	110.8	107.1	125.2
June	189.3	116.3	108.8	131.5
Sept.	216.2	108.5	102.4	119.7
Dec.	267.6	110.7	114.8	124.5
1977 Average	417.8	106.1	109.4	125.5
Mar.	336.5	108.6	112.6	132.6
June	390.5	108.6	112.1	127.1
Sept.	473.5	103.5	106.1	120.9
Dec.	597.5	110.6	112.6	121.5
1978 Average	795.8	102.8	103.1	105.4
Mar.	721.0	113.4	112.8	121.1
June	788.5	102.9	103.6	110.8
Sept.	849.3	96.8	97.6	98.4
Dec.	978.6	91.3	91.6	91.4
1979 Average	1,317.0	78.6	77.8	83.4
Mar.	1,136.7	84.9	84.5	90.2
June	1,292.0	77.2	76.7	84.7
Sept.	1,449.8	71.0	69.9	76.8
Dec.	1,596.9	75.1	73.5	81.7
1980 Mar.	1,724.7	75.5	73.9	82.4

Source: World Bank, Economic Memorandom on Argentina.

Notes: 1) Calculation of the real exchange rate on the basis of import/export weighting was done by deflating the nominal exchange rate by the Argentine wholesale price index and further adjustment on the basis of wholesale prices of Argentina's trading partners in accordance with the relative weight of Argentine imports from the exports to them.

2) Deflated exchange adjusted by US$ wholesale prices weighted according to Argentine wholesale price index.

(1) Prospecting costs:
Since prior prospecting costs were estimated only in terms of direct expenses at the mining site, this item involves only pesos. The same assumption has been made for future prospecting costs.

(2) Mine:
Since sophisticated equipment and machinery will be needed in initial investment relating to start up of the mine, it has been assumed that only 40% of the cost of this item will be in pesos in the initial stage. Considering, however, the development of Argentina's domestic industry, this percentage is assumed to rise to 50% with respect to additional investment made in future.

(3) Electricity:
Domestic currency components of plant and equipment investment for power generation and transformation are taken to be 30%, and for transmission lines 35%. As for operating costs, 70% is taken to be domestic, considering the high percentage of personnel and fuel costs.

(4) Water:
The portion in pesos for initial investment relating to water resources and the main dam works has been set at between 60% to 70% for the different items involved. Overall, it has been set at slightly under 60%.

(5) Mining town:
Most of the costs of the mining town will be in pesos but, considering the fact that some imported machinery will be used, the portion in pesos has been set at 90%.

(6) Transportation:
For road construction costs, the portion in pesos has been set at 70%. Since the cost of road maintenance and transportation of construction materials consists almost entirely of personnel costs, this cost element is assumed to be 100% domestic.

(7) Operating costs:
Considering the fact that there will be some foreign personnel involved in management and technical aspects of operation, the peso portion of personnel costs of the mine operating costs has been set at 98%. For the remainder of the operating costs, the portion in pesos has been set at 30%.

Domestic and foreign currency components were estimated as described above, and the latter was multiplied by the shadow exchange rate of 2,600 pesos to one US dollar. Table 7-7 gives the total economic costs estimated, with adjustments for internal transfer items such as taxes. The table shows that approximately 56% of the total investment costs and about 14% of the operating costs are foreign currency components. The sectorwise costs estimated for each year are summarized in Table 7-8. The format of the table is comparable to the table for financial costs given before.

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.

3. Analysis of Revenues and Benefits

3-1. Estimation of Supply and Demand, Price and Revenues with Respect to Copper

Copper Prices and Supply/Demand Situation: Copper being a typical market commodity, the price fluctuates over a very wide range. Looking back at the price of copper over the past twenty years, in terms of 1979 prices the highest price per ton was 4,845 dollars, and the lowest price 1,547 dollars, the average being 2,968 dollars (Fig. 7-2). In order to estimate future transitions of copper prices, it is necessary that we take a look at the world supply and demand situation with respect to copper over the medium to a long term. Demand for copper is showing a tendency to increase gradually. It should increase at an annual rate of about 3% in the 1980's, judging from World Bank reports and world-wide trends with respect to supply of and demand for copper. Assuming this to be the case, the estimated demand of 7.5 million tons in 1979 will increase to 9.9 million tons by 1990.

Such increase in the supply of copper will be due to such factors as increase in the supply of recycled copper, rises in the operating rates of existing copper mines, and development of new copper resources. In the medium to long term, however, the development of new copper mines will have the greatest effect on supply. Considering new mining investments in Argentina, Chile, Mexico, Panama, Peru, Brazil and other countries, one can expect the supply to increase at about the same rate as demand; i.e., increase to 7.7 million tons by 1985 and to 9 million tons by 1990. Accordingly, over the medium to long term the estimated costs of new copper mines provide a fairly good basis for estimating future prices of copper. The average cost of mine development in the 1980's should be about 2,000 dollars per ton in terms of 1977 prices. By the end of the 1980's the cost of mine development should still be about 2,100 dollars per ton at 1977 prices, even if gold, silver and other by-products are taken into account. Considering these circumstances, it appears that copper prices will rise very gradually over the long term.

Outlook for Copper Supply and Demand in Argentina: Per-capita copper consumption in Argentina is still extremely low. As industrialization progresses in the 1980's, demand for copper is expected to exhibit a strong trend, with increases at a rate of 6–7% per year (see Table 7-9 and 7-10 on p. 218). As for supply, 6,665 tons of copper concentrate were produced in Argentina in 1978, and 34,172 tons imported (total for electrolytic copper, crude copper, scrap copper, copper wire, copper rods, plate copper, copper alloys, etc.). In other words, at the present stage there is almost complete reliance on imports to meet copper needs. Looking at the development plans of existing large-scale disseminated type copper deposits, one sees that in addition to the present project there are plans for supply of 100,000 tons and 60,000 tons per year, respectively, of electrolytic copper at Pachon and at La Alumbrera. If these projects are implemented as planned, an oversupply of copper will result in Argentina, but considering the fact that copper is an international market commodity, it is unlikely that the domestic supply and demand situation will push the price down in Argentina.

Estimated Revenues from Copper: Although the international price of copper is expected to exhibit a strong tone over the long term, as already noted, copper is a typical market commodity and as such the price can fluctuate widely in the short term due to various factors. Thus uncertainties are involved in forecasting price transitions over the long term on the basis

Fig. 7-2. Transition of Copper Prices (US$/ton)

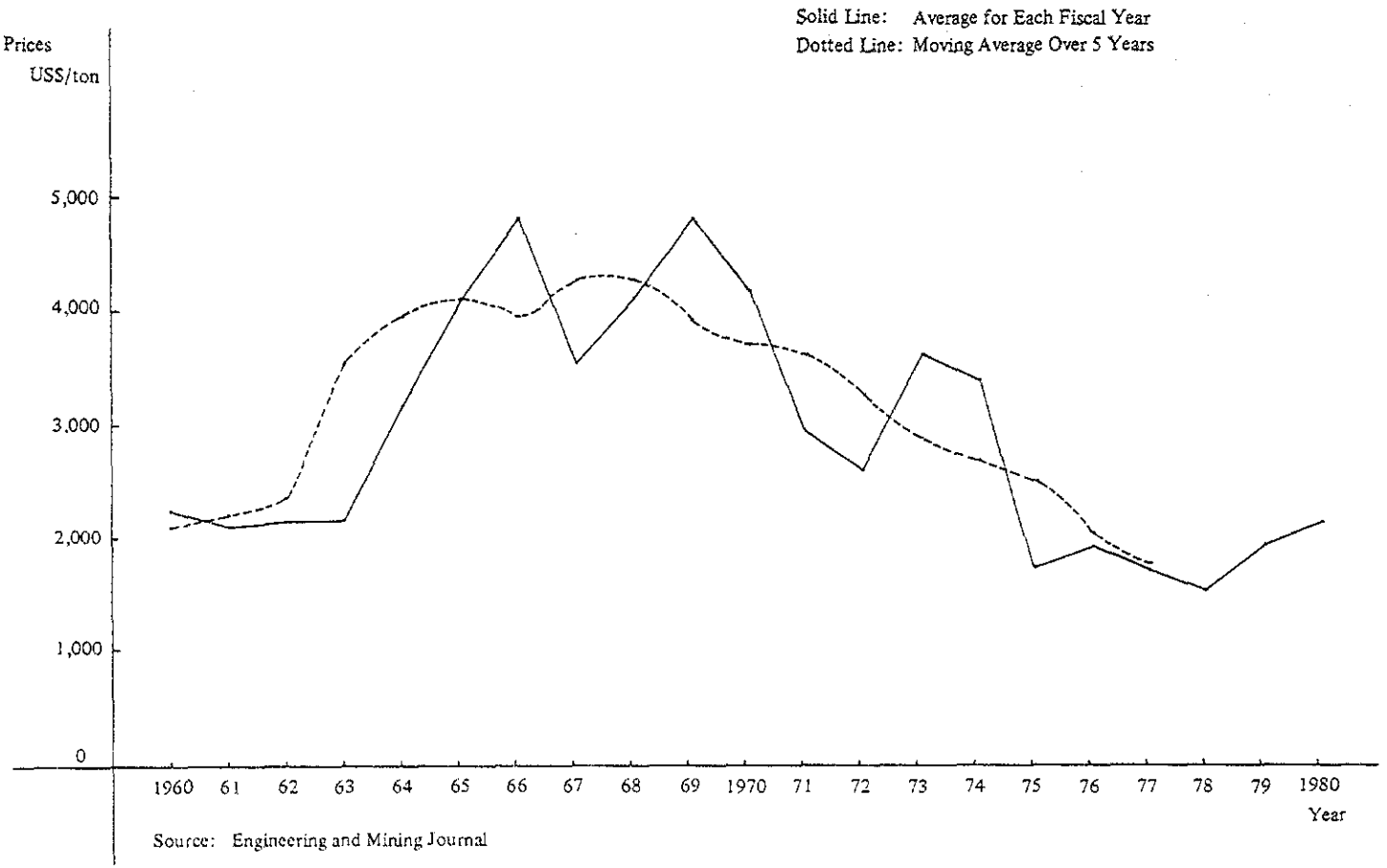


Table 7-9. Per Capita Consumption of Copper in Selected Countries

Nation	Annual per Capita Consumption of Copper
F.R.R.	12.0 kg
Switzerland	11.0
Japan	9.3
Canada	9.3
North America	8.3
Australia	8.0
France	6.9
Italy	5.6
Chile	4.6
Argentina	2.1

Source: SEM Brochure based on Panorama Minero

Table 7-10. Demand Projections for Copper in Argentina

Fiscal Year	Total Annual Demand
1977	54,800 tons
1978	58,100
1979	61,600
1980	65,300
1985	87,300
1990	116,900
1995	156,400

Source: Panorama Minero (SEM)

of the apparent outlook, and it is almost meaningless to do so. Accordingly, for the purpose of the present project, we have adopted as the standard price for copper the average price per pound in 1980 of 100 cents (1,950 pesos) and have carried out sensitivity analysis on price changes.

The Market Price of Copper Concentrate and Revenues: The final product of the present project, copper concentrate, is calculated as follows.

In order to manufacture electrolytic copper it is necessary to smelt the copper concentrate. Smelting costs are usually around 15 cents (293 pesos) per pound of concentrate. Furthermore, the actual yield from such smelting is approximately 19% when the grade of the copper concentrate is 20% (in order words, 1% is lost in smelting). In 1980 the average market price of electrolytic copper was 100 cents per pound, the price per ton of copper concentrate coming to 356 dollars on the basis of the following calculation: (100 cents – 15 cents) x 2,204.6 x 0.19 = 356 dollars

Smelting cost Lbs. ton: Smelting yield rate

The price per ton of copper to be used in financial evaluation comes to 694,000 pesos at an exchange rate of 1,950 pesos to the US dollar.

Since the annual production of copper concentrate will be 55,000 tons in the case of an operating scale of 30,000 tons/day and 36,000 tons in the case of an operating scale of 20,000 tons/day, the annual income from copper for the purpose of financial evaluation will be as follows:

In the case of an operating scale of 30,000 tons/day

694,000 pesos x 55,000 tons = 38,170 million pesos

In the case of an operating scale of 20,000 tons/day

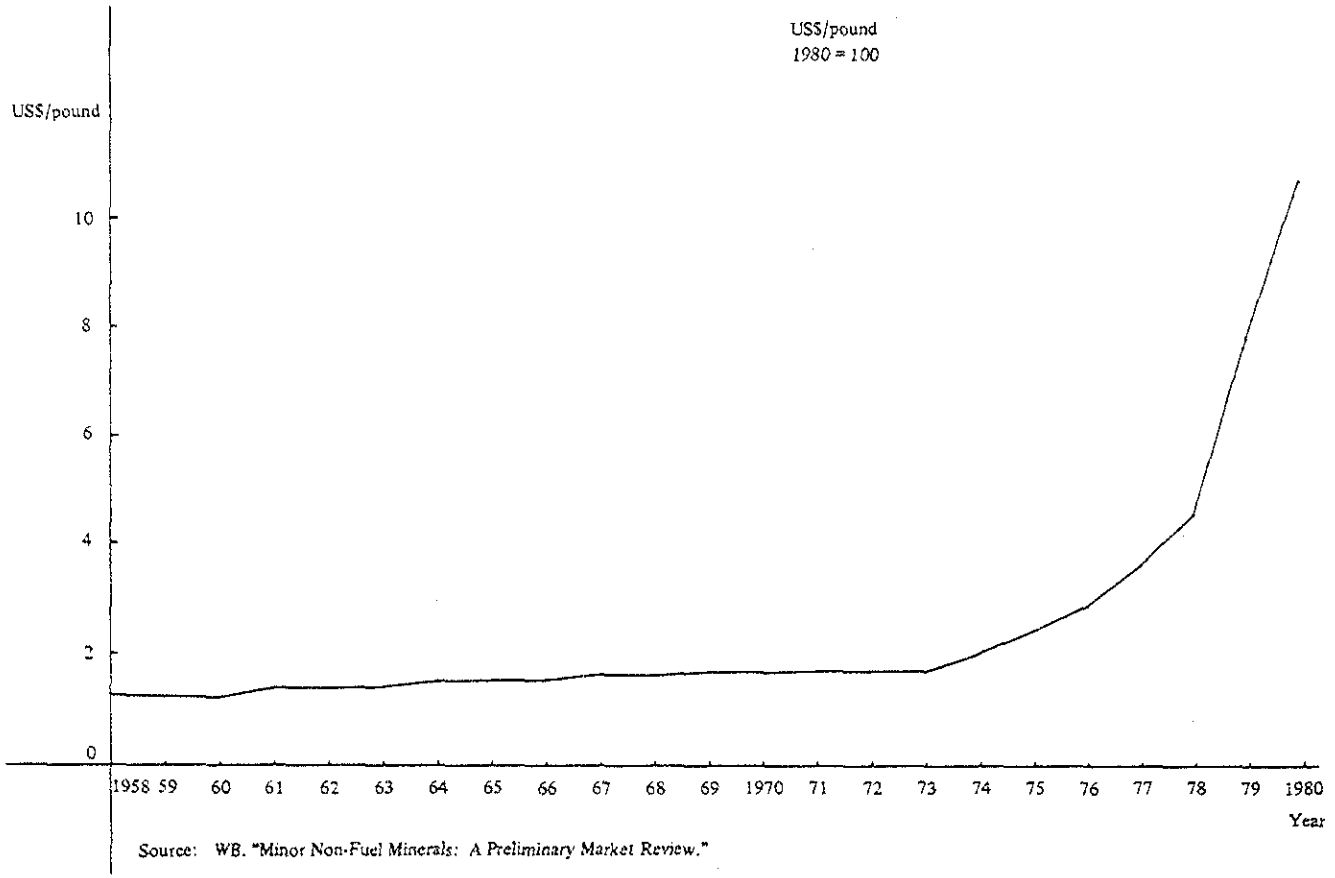
694,000 pesos x 36,000 tons = 24,980 million pesos

3-2. Estimation of Supply and Demand, Price and Revenues with Respect to Molybdenum

Molybdenum has a wide range of metallurgical uses, particularly in steel alloys. Considering that a substitute is not likely to be found and also considering the future outlook for steel demand, demand for molybdenum is expected to be rather strong over the medium to long term. Furthermore, owing to excessive market demand for molybdenum in recent years, the price rose from an average of 2.02 dollars a pound in 1974 to an average of 7.93 dollars a pound in 1979, and the average price in 1980 was about 10 dollars a pound (Refer to Fig. 7-3 on p. 220).

According to a World Bank forecast, demand for molybdenum will increase at an annual rate of approximately 4.8% up to the end of the century. Since the supply from existing mines is not sufficient to meet such an increase, it will be necessary to undertake new prospecting. Such prospecting for molybdenum deposits is presently underway but one cannot expect

Fig. 7-3. Transition of Molybdenite Price



Source: WB. "Minor Non-Fuel Minerals: A Preliminary Market Review."

production from new mines during the first half of the 1980's. The medium to long term outlook with respect to supply and demand will depend largely on the extent to which supply can keep pace with the increase in demand.

Outlook for Molybdenum Supply and Demand in Argentina: At the present time there is hardly any production of molybdenum in Argentina and virtually no imports either. Since molybdenum is mainly used for steel, domestic demand could very well increase in future if Argentina's steel industry develops, but for the time being, the entire amount produced will be exported.

Estimate of Revenues from Molybdenum: As already mentioned, owing to excessive demand for molybdenum over the past ten years or so, the price level has been pushed upward considerably. Furthermore, since it is very likely that demand will be fairly strong in comparison to supply in international markets over the medium to long term, the price, too, can be expected to remain at a high level. Nevertheless, as in the case of copper prices, uncertainties are involved in forecasting price trends over the long term on the basis of the outlook at a particular point in time. Accordingly, we have again taken the average price of molybdenum in 1980 (10 dollars per pound) as the standard price and have undertaken sensitivity analysis as well.

Price of and Revenue from Molybdenum Concentrate: The price quoted by the American Climax Company in the U.S. (FOB) serves as the basis for the price of molybdenum ore. This price is quoted per pound with respect to 1% Mo with a standard MoS_2 grade of 95%. Accordingly, the price per ton (FOB) of 85%MoS_2 ore at the Climax price of 10 dollars per ton is as follows:

10 US$ x 2,204.6 x 51% = 11,243.46 US$

1,950 pesos x 11,243.46 US$ = 21,925,000 pesos

The figure of 51% was used in the above calculation because ore with a MoS_2 content of 85% has an Mo content of 51%. Furthermore, there are 2,204.6 pounds to a ton.

Since the annual amount of production of molybdenum concentrate will be 7,500 tons in the case of an operating scale of 30,000 tons/day and 5,000 tons in the case of 20,000 tons/day operation, the annual income from molybdenum for the purpose of financial analysis will be as follows:

In the case of an operating rate of 30,000 tons/day

21,925,000 pesos x 7,500 tons = 164,440 million pesos

In the case of an operating rate of 20,000 tons/day

21,925,000 pesos x 5,000 tons = 109,630 million pesos

Total Revenues: The above results are given in Table 7-11.

Table 7-11. Total Annual Revenues

(Unit: 10^9 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

3-3 Calculation of Benefits

Argentina will receive a number of benefits through development of the mine. Such benefits are summarized in terms of the following ten items:

1. Development of mineral resources and their conversion to usable form.

2. Provision of mineral resources for international markets.

3. Improvement of national budget and provincial government finances and contribution to international balance of payments and liability redemption capacity through foreign exchange earnings.

4. Conversion of mineral resources to economically valuable goods.

5. Promotion of development of La Rioja Province through mine development.

6. Development of technology in the field of mining through development of mineral resources.

7. Higher income through the employment and labor absorption effects of mine development and stimulation of consumption and investment.

8. Promotion of related sectors, including industries supplying materials and equipment, through indirect effects of mine development.

9. Benefits to inhabitants of the region; secondary benefits such as hospitals, sports grounds and other welfare facilities, water supply facilities, roads and railways, etc.

10. Income distribution effect.

In addition to these positive benefits, there are potential negative benefits such as contaminated drainage water, noise, etc., but in this case there are no such problems.

Of the various benefits listed above, those that can be quantitatively evaluated will be taken into account, and of them, over 90% are accounted for by copper and molybdenum production. In addition, for instance, after completion of the life of the mine, the water supply dam can be used for irrigation water supply. This, too, is therefore a benefit deriving from development of the mine, and it is therefore to be taken into account in terms of the salvage value of the dam the year after termination of the project. The main benefits of the project, however, are derived from copper and molybdenum production.

Benefits Derived from Copper and Molybdenum Production: Since the products are international commodities, the prices at which they are normally traded on international markets have been taken as the standard. Since the calculated shadow exchange rate represents a 33.3% reduction in the value of the peso from the official exchange rate, the benefits that the national economy receives through the export of copper and molybdenum (at international prices) is 33.3% higher than the income calculated for the purpose of financial evaluation.

In the case of an operating scale of 30,000 tons/day

(38,170 million pesos + 164,440 million pesos) x 1.333
Copper income Molybdenum income

= 270,000 million pesos

In the case of an operating scale of 20,000 tons/day

(24,980 million pesos + 109,630 million pesos) x 1.333
Copper income Molybdenum income

= 179,440 million pesos

The annual benefits derived from the export of the ores therefore comes to 270,080 million pesos in th case of an operating scale of 30,000 tons/day and 197,440 million pesos in the case of 20,000 tons/day.

Salvage Value: The total of the salvage values of the mining town and the water resource facilities will be as follows.

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 Resources 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

4. Calculation of Internal Rate of Return

In this section financial and economic evaluations are carried out on the basis of the revenues, benefits and costs calculated in sections 2 and 3. The evaluation criteria are the internal rates of return as calculated on the basis of the discount flow method.

The calculations are carried out for the two scales of operation of 30,000 tons/day and 20,000 tons/day, using the revenues, benefits and costs calculated for the different sectors. Sensitivity analyses are then carried out for the revenue and cost items.

4-1. Calculation of Internal Financial Rate of Return

Method of Calculation: As already stated, the internal financial rate of return is the discount rate that makes the total of annual net inflow (amount of net inflow = amount of inflow – amount of outflow) zero. Let us first determine the amounts of inflow and outflow. If investment is excluded from the revenue and cost figures in Table 7-13, the following formula generally holds:

Revenues – Operational costs (General operational costs + Depreciation) – Interest – Taxes = Amount of inflow,

and if investment is included,

General operational costs + Taxes + Investment = Amount of outflow.

Since depreciation is a cost that does not involve outflow, it is not considered as a part of the outflow. Furthermore, interest is not included in the amount of outflow because of the definition of the internal financial rate of return. Whereas the internal economic rate of return is for comparison with capital opportunity costs, the internal financial rate of return is for comparison with market interest rates. This means that if the internal rate of financial return is 11.0% and the funds needed for the project can be procured at an average interest rate of

11.0%, income and expenditures will be exactly balanced throughout the period of the project. Therefore, if funds can be procured at interest rates below the internal rate of financial return, there will be a profit, and if they can only be procured at interest rates above the internal financial rate of return, there will be a cumulative deficit. Accordingly, a comparison is made between the results obtained after excluding interest from the outflow (internal financial rate of return) and the market rate of interest. Since in the calculation of the internal financial rate of return the amount of tax varies according to depreciation and interest rates, an effort has been made to assume a depreciation method, interest rate for procured funds, taxes and other factors as close to reality as possible.

Premises: The premises for calculation have been set as follows:

(a) Project life: 1981 has been set as the base year for the project, the first two years being the period of investigation and the next two years being the period of investment. Operations are to start in 1986, and it has been assumed that they will terminate in the year 2007 in the case of an operation scale of 30,000 tons/day (period of operation being 22 years) and in 2018 (period of operation being 33 years) in the case of 20,000 tons/day.

(b) Amount of investment per year: The prospecting costs for 1981 and 1982 and the amounts of investment for 1983, 1984 and 1985 are totals of the annual investment figures for each of the sectors. As already stated, the prospecting costs for 1980 and preceding years (see Table 2-2) have been converted to 1981 prices and to present values as of 1981 on the basis of an annual capital opportunity cost of 10%. The calculated figures were added to the prospecting costs for 1981 and then shown as the total amount of investment for that year. In addition to the initial investment, further investment of 78,000 million pesos will be necessary in the 11th year of operation in the case of an operation rate of 30,000 tons/day and a further investment of 29,250 million pesos will be necessary in each of the 11th and 21st years of operation in the case of 20,000 tons/day.

(c) Operating costs: The operating costs were determined by adding the variable costs, general management costs and depreciation for each of the sectors to the basic operating costs.

(d) Depreciation: The period of depreciation has been set as the project life in the case of the dam and fifteen years in the case of all other facilities, the method of depreciation being the fixed-amount method.

(e) Salvage values: The salvage values resulting in the different sectors were totaled and entered as income for the year following the final year of operation, the salvage value of equipment and machinery being set as zero.

Capital Raising Plans: Capital raising plans have been set as follows:

(a) Amount required: The amount of capital required for execution of the project is

the sum of the construction costs and the operating expenses. The operating expenses include general management costs during the construction period (approximately 10% of construction costs) and marginal expenses accounting for sales credits, product inventories, raw material inventories and others (each assumed as representing about one month's worth of sales). Including all of these, the necessary operating expenses have been set at 20% the construction costs.

(b) Breakdown of capital raising: Capital raising is to be on the basis of external capital (borrwoing) and the project's internal capital (equity), the debt/equity ratio having been set at 70:30 as the generally valid ratio for international projects at the present time.

(c) Breakdown of equity: It has been assumed that the project's equity will be based on a 51% contribution by domestic Argentine capital and a 49% contribution by foreign capital. In case of the amount provided by Argentine capital, past prospecting costs and mining rights have been assumed to replace actual cash contributions.

(d) Demand for capital in different years: It has been assumed that the demand for capital will occur in proportion to the annual amount of plant and equipment investment for the years 1983, 1984 and 1985.

(e) Amount of money to be borrowed each year: It has been assumed that the equity will be paid in 1983. Accordingly, the equity paid in at that time is first to be used for plant and equipment investment in 1983, the remaining amount to be borrowed. In 1984 and 1985 the amounts borrowed will depend on the amount of plant and equipment investment.

(f) Breakdown of amounts borrowed and interest: It has been assumed that 20% of the amount to be borrowed will be borrowed from the Development Bank of Argentina at an annual interest rate of 3% and that the rest will be borrowed in U.S. dollars at an annual interest rate of 10%. Accordingly, the average interest rate per annum has been set at 8.6%.

(g) Plan for payment of interest and repayment of principal: It has been assumed that both payment of interest and repayment of principal will commence in 1986, the year when operations begin. Accordingly, the interest for 1983–1985 has been assumed to be compound interest. The amount of external capital at the end of 1985 has been assumed to be the initial amount borrowed plus this interest. This amount has been set as the final amount borrowed for the project, which is to be paid back evenly over the entire life of the project. It has been assumed that the interest will be 8.6% per year on the balance of the amount borrowed as of the end of the preceding year.

Taxes: In calculating taxes, tax breaks are provided for by the Mining Promotion Law, promulgated October 26, 1979.

(a) Income tax: The tax rate applicable to taxable income is 33%. In this connection, the Mining Promotion Law recognizes declining income tax deductions of from 100% to 10% over a maximum period of 15 years (Table 7-12). In this project tax deductions have been made accordingly.

Table 7-12. Tax Reduction Schedule for Income Taxes

Year	Percentage Reduction
1	100
2	100
3	100
4	100
5	100
6	100
7	100
8	80
9	70
10	60
11	50
12	40
13	30
14	20
15	10

(b) Import customs duties and import fees: As a special preferential measure stipulated by the Mining Promotion Law, the capital goods, accessories and spare parts that are needed for implementation of the project and have been approved for import will be exempted from import customs duties and import fees. Accordingly, no import custom duties or import fees have been taken into account with respect to the imports related to this project.

(c) Value-added tax: There is no value-added tax on exports. Since all of the production of the present project is to be exported, there will be no value-added tax involved.

(d) Other preferential measures: It has also been assumed that all other taxes (stamp duties, net property taxes, etc.) will be exempted. No other preferential measures, however, have been taken into account.

4-2. Calculation of Internal Economic Rate of Return

Basically, the method of calculation is the same as for the internal financial rate of return. Since, as stated in section 1, interest and taxes are not included as costs in the calculation

of the economic rate of return, they have been excluded from the economic flow chart. Furthermore, although depreciation has been included in operating costs in the financial flow chart, it has been excluded in the economic flow chart. The portion in pesos and the portion in foreign currency have been indicated separately in the flow charts involved in calculation of the economic rate of return.

4-3. Results of Calculation (Operating Scale: 30,000 tons/day)

Financial Evaluation: As indicated in Table 7-13, in the basic case the internal financial rate of return comes to 11.0%. This is the discount rate at which the total present value of income and expenditures as discounted on the basis of a computer program, comes to zero. From this financial flow chart the following points are evident.

(a) Net inflow: The net inflow will be negative up to the fifth year, when the investment period will end, but once operations begin, net inflow will be positive for all years except those in which additional investment is made.

(b) Operational profit: There will be a positive operating profit starting from the year that operations begin, such operating profit being 21.1% of sales for the first year of operation.

(c) Current profit: Current profit, which is the operating profit minus interest, will be negative to the amount of 10,110 million pesos in the first year, and will not become positive until the sixth year of operation.

(d) Taxes: Since current profits will not be positive until the sixth year of operation, income tax will not be levied until that year. Actually, however, because of exemptions allowed by the Mining Promotion Law, it will not be until the eight year of operation that any income taxes are actually levied. Furthermore, because of the gradually declining percentage of exemption, it will not be until the sixteenth year of operation that the entire amount of the current profit is subject to income tax.

(e) Profit after taxes: Totaling the profit after taxes each year, it is apparent that there will be a surplus over the entire period of the project.

(f) Cost per ton: The cost per ton for concentrate (Cu 55,000 tons, MoS_2 7,500 tons) will be as follows, the cost of copper and molybdenum having been divided in the ratio of their respective incomes.

(Unit: 1,000 pesos)

	Cost per ton, depreciation included	Cost per ton, depreciation excluded
Copper	623	496
Molybdenum	16,740	13,326

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	Investment a	Revenues b	Copper	Molybdenum	Operating Costs c	Depreciation d	Interest e	Taxes f	Revenues after Taxes b-c-e-f	Net Inflow b-a-(c-d)-f	Discount 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		

Economic Evaluation: As indicated in Table 7-17, the internal economic rate of return is a relatively high 20.0%. Since the capital opportunity cost is 10%, this project can be considered one of rather high priority from the standpoint of the national economy.

(a) Benefits: The benefits are almost entirely those derived from the sale of copper and molybdenum. Since it has been assumed that all of the copper and molybdenum produced in this project is to be exported, the calculated benefits are higher if the real exchange rate rather than the official exchange rate is applied.

(b) Costs: The costs are as calculated in Section 2. The ratio of annual costs to annual benefits is approximately 48%.

(c) Net inflow: The economic cost during the investment period is somewhat greater than the financial cost. However, as a result of the higher benefits, the net inflow during the period of operations is nearly twice the net inflow in the financial evaluation (Refer to Table 7-14 on p. 231).

4-4. Results of Calculation (Operating Scale: 20,000 tons/day)

Financial Evaluation: The internal financial rate of return for the basic case comes to 7.9%.

(a) Current profit: The operational profit will be a positive figure starting from the first year of operations, but the current profit will be -24,480 million pesos in the first year of and will not become positive until the sixteenth year of operations.

(b) Profit after taxes: Totaling the profits after taxes for each of the years, it is evident that there will be a surplus over the entire period of the project.

(c) Cost per ton: The cost per ton of concentrate (Cu 36,000 tons, MoS_2 5,000 tons) is calculated by allocating the total costs, the cost of copper and molybdenum in proportion to the revenues derived from each.

(Unit: 1,000 pesos)

	Cost per ton, including depreciation	Cost per ton, excluding depreciation
Copper	698	534
Molybdenum	18,743	14,932

(d) *Comparison with the case in which the rate of operation is 30,000 tons/day:* Since scale economy is not realized to the same degree in this case as in the case of 30,000 tons/day operations, the efficiency is extremely low. Assigning an index number of 100 for 30,000 tons/day operations, the following comparison can be made.

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		

	Operating Scale of 30,000 tons/day	Operating Scale of 20,000 tons/day
Initial investment	100.0	76.7
Income	100.0	66.4
Operational costs	100.0	74.4

Although income is only 66.4% of what is realized in the case of 30,000 tons/day operations, the initial investment and the operating costs are 76.7% and 74.4%, respectively, of what they are in that case.

Economic Evaluation: The internal economic rate of return is 16.1%. Since the capital opportunity cost is 10%, even in this case the project is very feasible from the viewpoint of the national economy. Assigning an index number of 100 in the case of a rate of operation of 30,000 tons/day, the following comparison can be made.

	Operating Scale of 30,000 tons/day	Operating Scale of 20,000 tons/day
Initial investment	100.0	77.1
Annual benefits during period of operation	100.0	66.4
Annual costs during period of operation	100.0	74.2

4-5. Sensitivity Analysis

The income and costs used in calculation of the internal rate of return in the preceding section were carefully estimated. Nevertheless, since there are uncertain elements with respect to the accuracy and future changes in the cost and price data used in calculating revenues and costs, it is quite possible that these figures will change when the present project reaches the stage of implementation. Furthermore, it is necessary to identify key variables that significantly affect the internal rate of return of the present project in order to enhance the reliability of the plan. Accordingly, in the present section a sensitivity analysis will be made with respect to the main variables (prices of copper and molybdenum, amount of investment, operating costs, and SER). This sensitivity analysis is made with respect to both the financial evaluation and the economic evaluation.

Financial Evaluation: The basic case is as follows.

Rate of operation:

30,000 tons/day

Annual production of copper concentrate:

Cu 55,000 tons

Annual production of molybdenum concentrate:

MoS_2 7,500 tons

Price of copper:

694,000 pesos per ton of concentrate (equivalent to 100 cents/pound of electrolytic copper)

Price of molybdenum:

21,925,000 pesos per ton of concentrate (MoS_2 grade 85%, 10 dollars/pound)

General operating costs (excluding depreciation):

127,239 million pesos

Initial investment (1983–1985):

499,029 million pesos

In sensitivity analysis calculations, only one variable at a time is changed in the basic case:

(a) Variation in total revenues: As indicated in Table 7-15 and Fig. 7-1-(1), variation in total revenues has the greatest effect on the internal financial rate of return. What is meant by total revenues is the total income from copper and from molybdenum. Irrespective of the individual prices of copper and molybdenum, a 20% increase in total revenues (i.e. an increase from 202,610 million to 243, 130 million pesos) will result in a 6.5% increase in the internal financial rate of return to 17.5% (Refer to Table 7-15 on p. 234, and Fig. 7-4-(1) on P. 235).

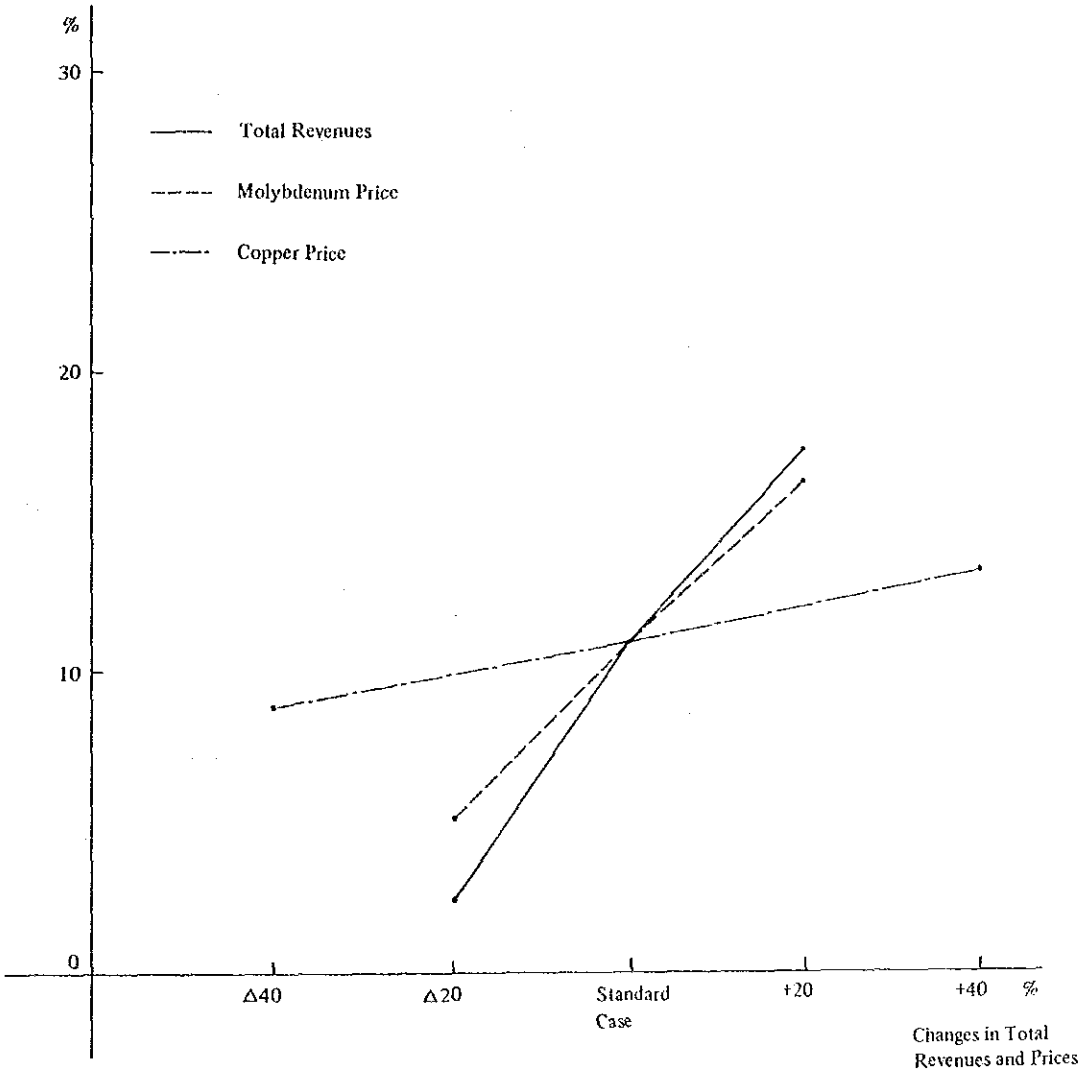
(b) Variation in the price of copper concentrate: Since in the basic case the percentage of total revenues represented by copper is only about 21%, variations in the price of copper will not have much effect on the financial internal rate of return. A 40% increase in the price of copper would result in only a 2.5% increase in the financial internal rate of return. This 40% increase represents an increase from 6,944 pesos to 9,724 pesos per ton of concentrate. This is the variation in the price of copper concentrate. As for variation in the price of electrolytic copper, it would be as follows.

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%	

Fig. 7-4-(1) Sensitivity Analysis for Changes in Revenues (Financial Analysis in the Case of an Operating Scale of 30,000 tons/day)



	-40	Standard price	+40	Unit %
Price of Concentrate	416,000	694,000	972,000	pesos/ton
Price of Electrolytic Copper	66	100	119	cents/pound

In other words, a 40% decrease in the price of copper concentrate would mean a 34% decrease in the price of electrolytic copper, and a 40% increase in the price of copper concentrate would mean a 19% increase in the price of electrolytic copper.

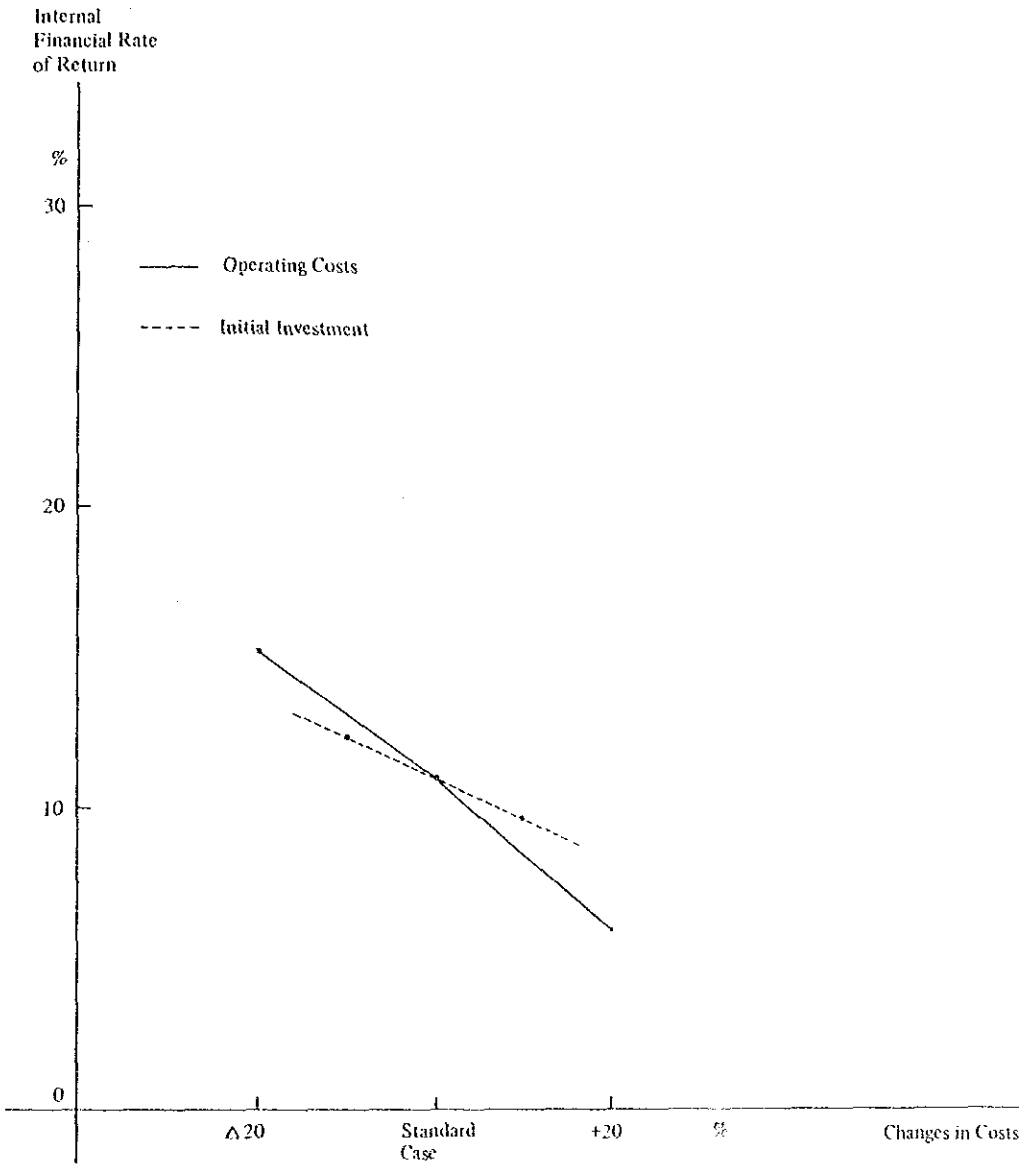
(c) Variations in the price of molybdenum concentrate: Since in the basic case the percentage of total income represented by molybdenum is the very high figure of approximately 81%, variations in the price would have a considerable effect on the financial internal rate of return. A 20% increase in the price of molybdenum would result in a 5.4% increase in the financial internal rate of return, a 20% increase in the price of molybdenum meaning an increase from 21,925,000 pesos per ton of concentrate to 26,310,000 pesos per ton.

(d) Variations in operating cost: Variations in operating costs would also have a considerable influence on the internal financial rate of return. A 20% decrease in operating costs would result in a 4.2% increase in the internal financial rate of return to 15.2%, and a 20% increase would result in a 5% decrease in the internal financial rate of return to 6% (Refer to Fig. 7-4-(2) on p. 237).

(e) Variations in capital costs: Effects of variations in capital costs are not as great as effects from price changes. A 10% decrease in capital costs would result in a 1.4% increase in the internal financial rate of return, and a 10% increase would result in a 1.2% decrease. In other words, if capital costs (excluding prospecting costs) of 577,000 million pesos were to decrease by 55,700 million pesos, the internal financial rate of return would increase to 12.4%, and likewise, if there were to be an increase of 57,700 million pesos in capital costs, the financial internal rate of return would decline to 9.8%.

(f) Effects of different variables: The degree of influence on the internal financial rate of return of variations in the different variables are as follows. Assigning an index number of 100 to variations in the internal financial rate of return resulting from a 20% variation in total income, the variation in the internal financial rate of return resulting from a 20% variation in each of the other variables is indicated as an index number, the 20% variation being a 20% increase in the case of income and a 20% decrease in the case of costs. The degree of influence of the variables on the internal financial rate of return is as follows.

Fig. 7-4-(2) Sensitivity Analysis for Changes in Costs (Financial Analysis in the Case of an Operating Scale of 30,000 tons/day)



Total income	Price of copper	Price of molybdenum	Operational costs
100	38	83	65

Economic Evaluation: The basic case is as follows:

Rate of operation:

30,000 tons/day

Annual production of copper concentrate:

Cu 55,000 tons

Annual production of molybdenum concentrate:

MoS_2 7,500 tons

Price of copper (per ton of crude ore):

925,000 pesos

Price of molybdenum (per ton of crude ore):

29,226,000 pesos

Annual personnel expenses:

58,122 million pesos

Operating costs:

129,860 million pesos

Initial investment:

544,570 million pesos

(a) As indicated in Table 7-16 and Fig. 7-5, variations in total benefits would have the greatest effect on the internal economic rate of return. A 20% variation in total benefits would result in a 6–7% variation in the internal economic rate of return. Since in the basic case the internal economic rate of return is high, it would be possible to achieve an internal economic rate of return of higher than 10%, which is the capital opportunity cost, even with an increase of 20% in total benefits.

(b) Variation in the price of copper: The price of copper does not have a very great bearing on the internal economic rate of return. Even with a 40% decrease in the price of copper, the internal economic rate of return would be 17.3%.

(c) Variation in the price of molybdenum: Since the percentage of total benefits for each year represented by molybdenum is a high 81% or so, variations in the price of molybdenum would have a substantial influence on the internal economic rate of return. A 20% decrease in the price, for instance, would result in a 6.1% decrease in the internal economic rate of return to 13.9%.

(d) Variation in operating costs: Operating costs also have a considerable bearing on the internal economic rate of return. A 20% variation in operating costs would result in a 4–5% variation in the internal economic rate of return. If costs were to increase by 20%, the internal economic rate of return would decline to 14.5%.

(e) Variation of SER: Almost all benefits evaluated in the economic analysis of the project come from the export of concentrates. Accordingly, an increase in the SER (provided that the Argentine peso has a lower value at the SER than at the official exchange rate) would result in an increase in the internal economic rate of return. If the variation in the SER were approximately 33%, the variation in the internal economic rate of return would be approximately 5–7% (Refer to Table 7-16 on p. 240, Fig. 7-5-(1), (2), (3) on p. 241, 242, 243).

Operating Scale of 20,000 tons/day: The results of sensitivity analysis for an operating scale of 20,000 tons/day are summarized in Tables 7-17 and 7-18 and Fig. 7-6 and 7-7 (Refer to Table 7-17, on p. 244, Fig. 7-6-(1), (2) on p. 245, 246, and Table 7-18 on p. 247, and Fig. 7-7-(1), (2), (3) on p. 248, 249, 250).

5. Overall Evaluation

5-1. Adequacy of Investment in Mine Development

From the preceding analysis, the following conclusions is 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 ton copper-molybdenum resources.

(b) A strong point of this investigation is in its comprehensive analysis 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 analysis was 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 deter-

Table 7-16. Summary of Sensitivity Analysis

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

1.	Changes in Total Benefits	20% Decrease	Basic Case	20% Increase	Fig. 7-5-(1)
	Internal Economic Rate of Return	12.3%	20.0%	26.6%	
2.	Changes in Price of Copper Concentrate	40% Decrease	Basic Case	40% Increase	Fig. 7-5-(1)
	Internal Economic Rate of Return	17.3%	20.0%	22.6%	
3.	Changes in Price of Molybdenum Concentrate	20% Decrease	Basic Case	20% Increase	Fig. 7-5-(1)
	Internal Economic Rate of Return	13.9%	20.0%	25.4%	
4.	Changes in Operating Costs	20% Decrease	Basic Case	20% Increase	Fig. 7-5-(2)
	Internal Economic Rate of Return	24.4%	20.0%	14.5%	
5.	Changes in SER	33.3% Decrease	Basic Case	33.3% Increase	Fig. 7-5-(3)
	Internal Economic Rate of Return	12.9%	20.0%	24.8%	

Fig. 7-5-(1) Sensitivity Analysis for Changes in Benefits (Economic Analysis in the Case of an Operating Scale of 30,000 tons/day)

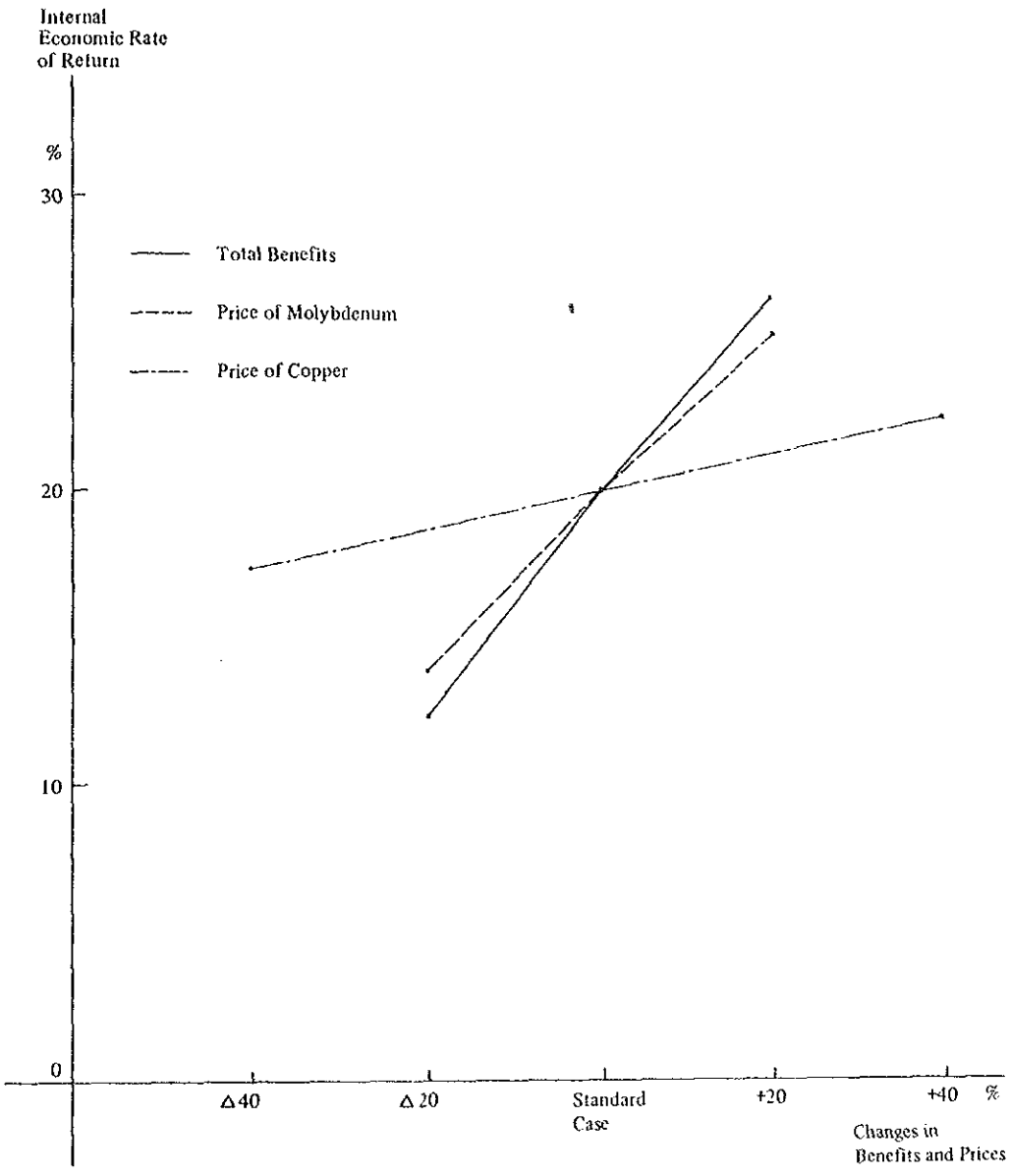


Fig. 7-5-(2) Sensitivity Analysis for Changes in Operating Costs (Economic Analysis in the Case of an Operating Scale of 30,000 tons/day)

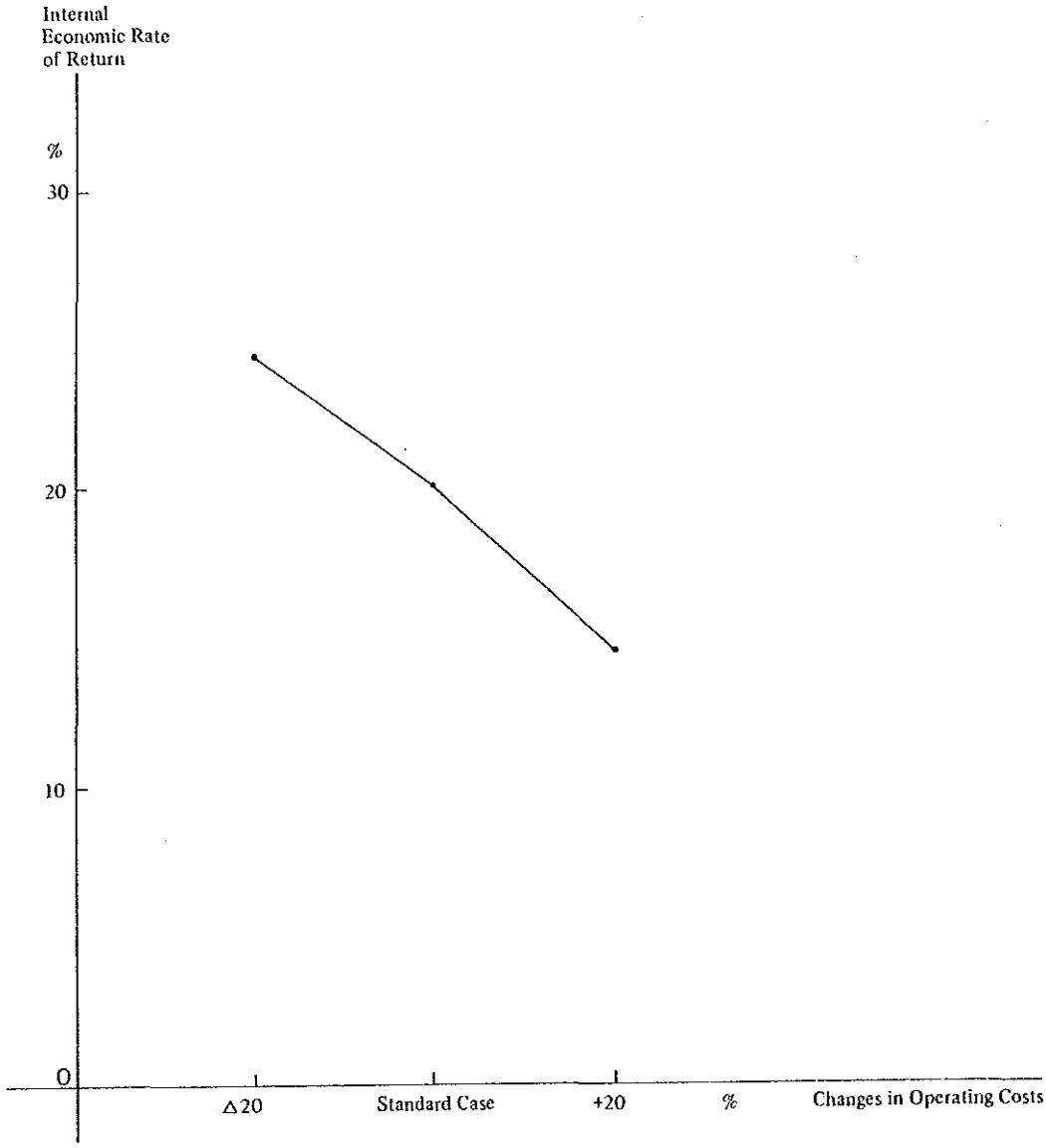


Fig. 7-5-(3) Sensitivity Analysis for Changes in the Shadow Exchange Rate (Economic Analysis in the Case of an Operating Scale of 30,000 tons/day)

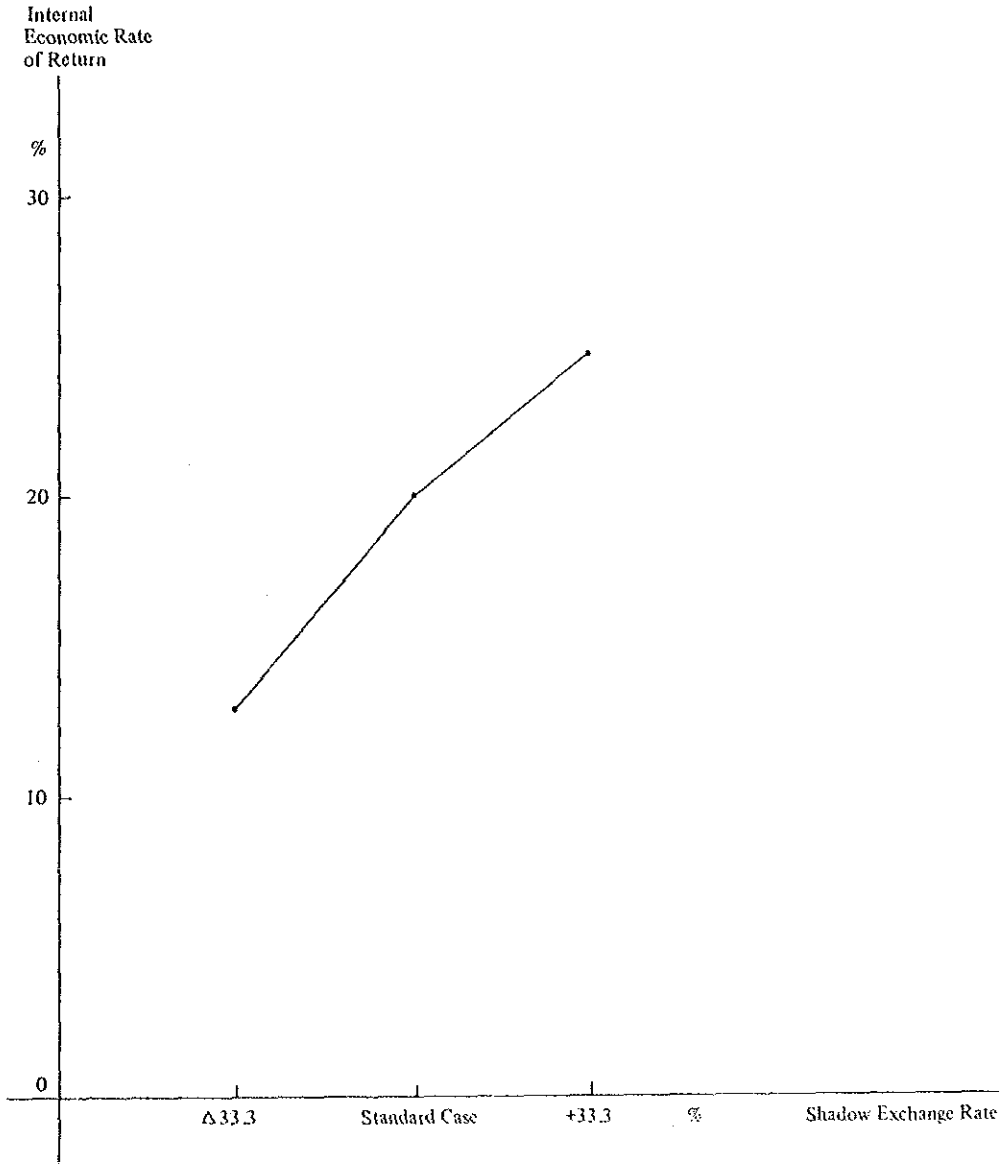


Table 7-17. Summary of Sensitivity Analysis

(Financial Analysis in the Case of an Operating Scale of 20,000 tons/day)

1.	Changes in Total Revenue	20% Decrease	Basic Case	20% Increase
	Internal Financial Rate of Return	0.6%	7.9%	13.4%
2.	Changes in Price of Copper Concentrate	40% Decrease	Basic Case	40% Increase
	Internal Financial Rate of Return	5.3%	7.9%	10.2%
3.	Changes in Price of Molybdenum Concentrate	20% Decrease	Basic Case	20% Increase
	Internal Financial Rate of Return	1.7%	7.9%	12.7%
4.	Changes in Operating Costs	20% Decrease	Basic Case	20% Increase
	Internal Financial Rate of Return	12.1%	7.9%	2.7%
5.	Changes in Initial Investment	10% Decrease	Basic Case	10% Increase
	Internal Financial Rate of Return	8.8%	7.9%	6.4%

Fig. 7-6-(1) Sensitivity Analysis for Changes in Revenues (Financial Analysis in the Case of an Operating Scale of 20,000 tons/day)

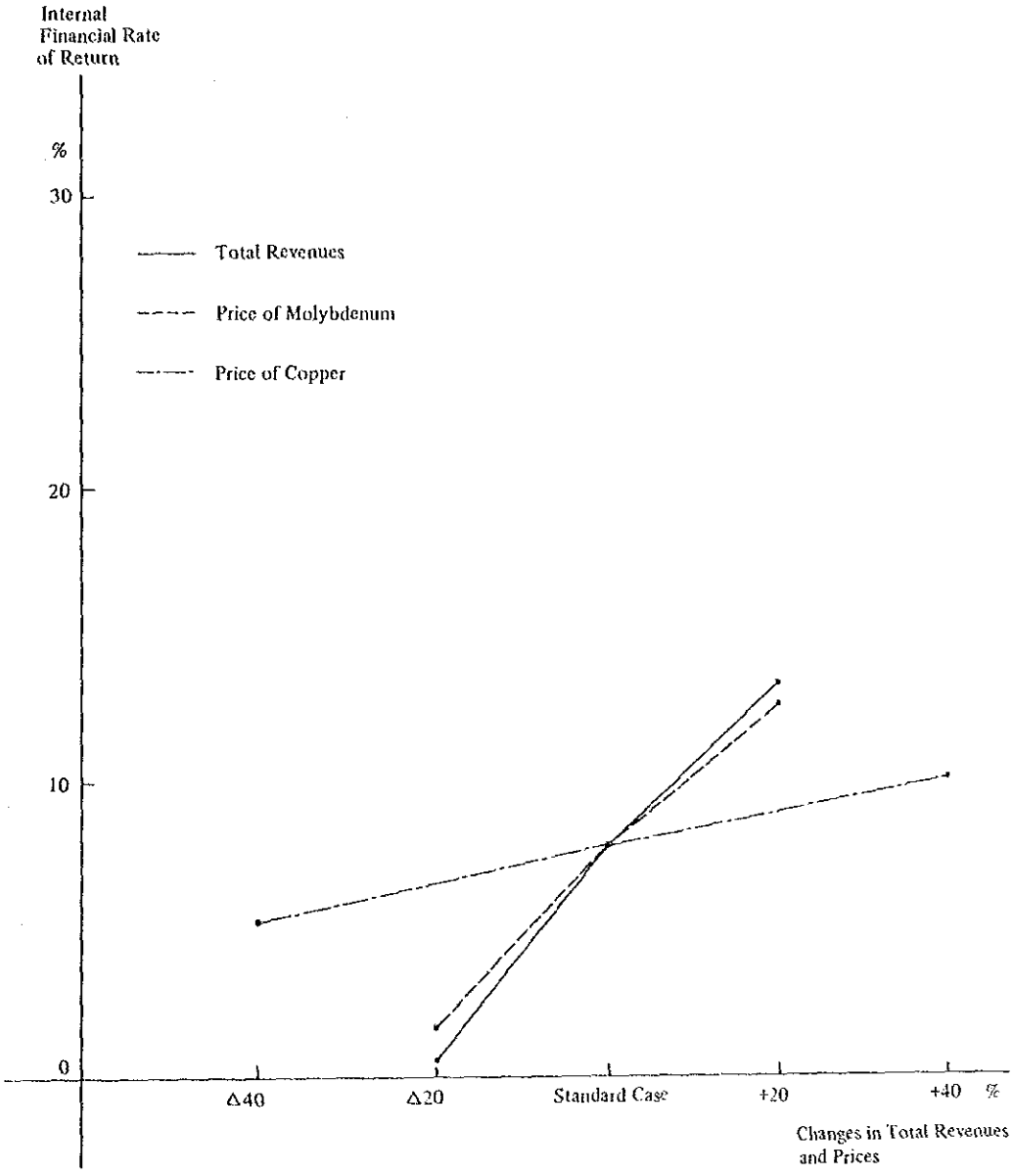


Fig. 7-6-(2) Sensitivity Analysis for Changes in Costs (Financial Analysis in the Case of an Operating Scale of 20,000 tons/day)

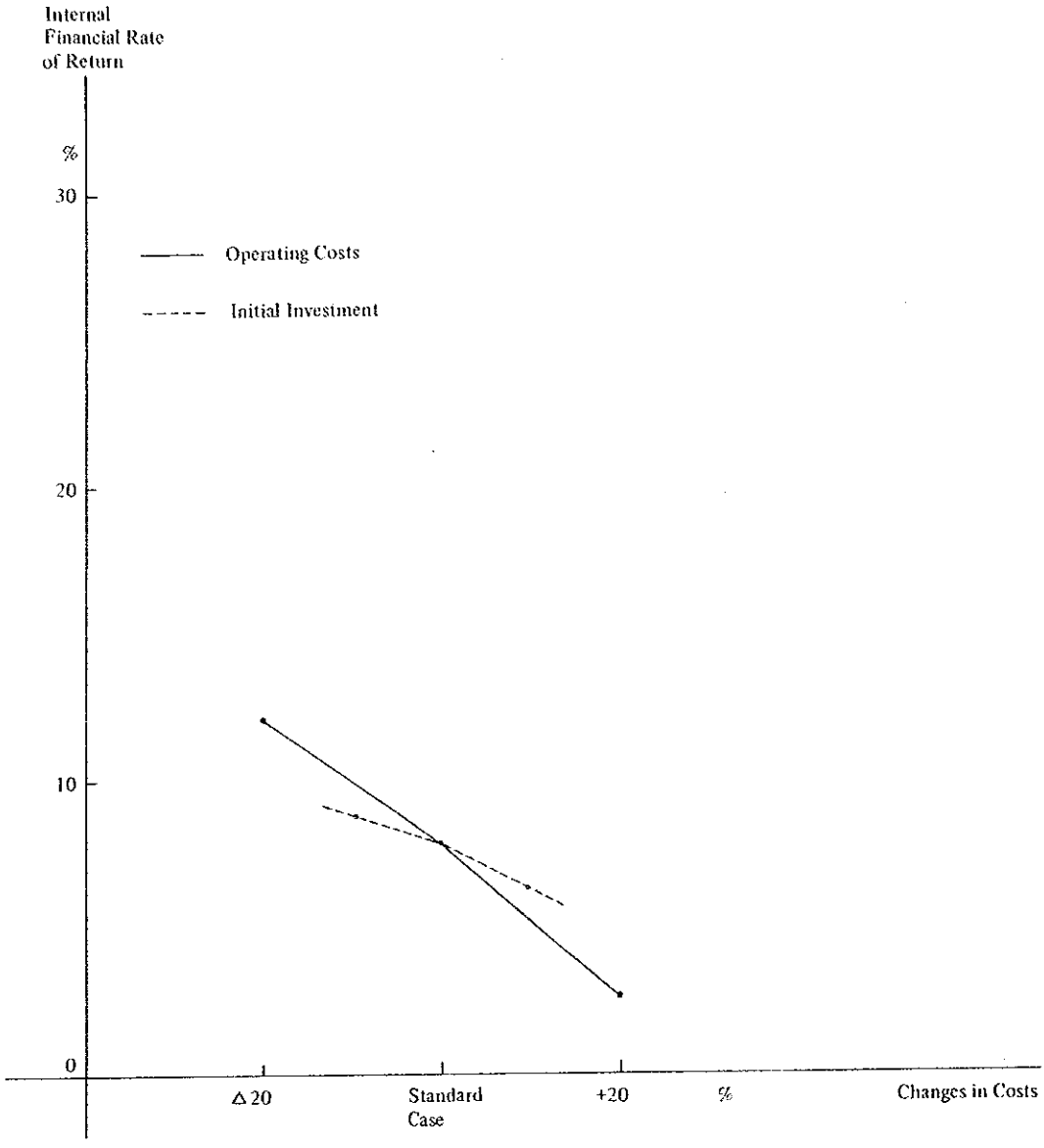


Table 7-18. Summary of Sensitivity Analysis

(Economic Analysis in the Case of an Operating Scale of 20,000 tons/day)

1.	Changes in Total Benefits	20% Decrease	Basic Case	20% Increase
	Internal Economic Rate of Return	9.1%	16.1%	22.0%
2.	Changes in Price of Copper Concentrate	40% Decrease	Basic Case	40% Increase
	Internal Economic Rate of Return	13.7%	16.1%	18.4%
3.	Changes in Price of Molybdenum Concentrate	20% Decrease	Basic Case	20% Increase
	Internal Economic Rate of Return	10.6%	16.1%	21.0%
4.	Changes in Operating Costs	20% Decrease	Basic Case	20% Decrease
	Internal Economic Rate of Return	20.5%	16.1%	10.4%
5.	Changes in SER	33.3% Decrease	Basic Case	33.3% Increase
	Internal Economic Rate of Return	9.6%	16.1%	20.5%

Fig. 7-7-(1) Sensitivity Analysis for Changes in Benefits (Economic Analysis in the Case of an Operating Scale of 20,000 tons/day)

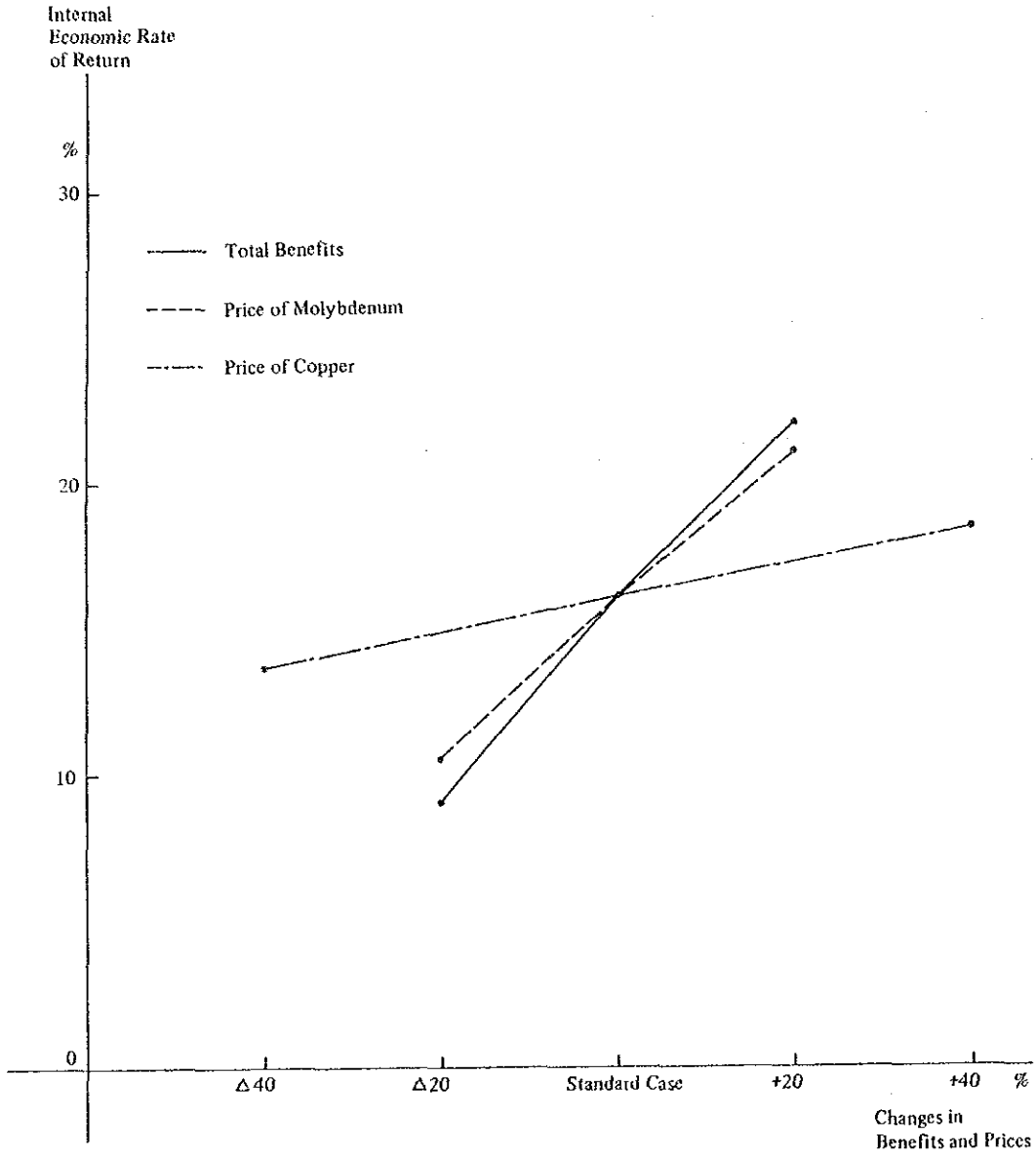


Table 7-7-(2) Sensitivity Analysis for Changes in Operating Costs (Economic Analysis in the Case of an Operating Scale of 20,000 tons/day)

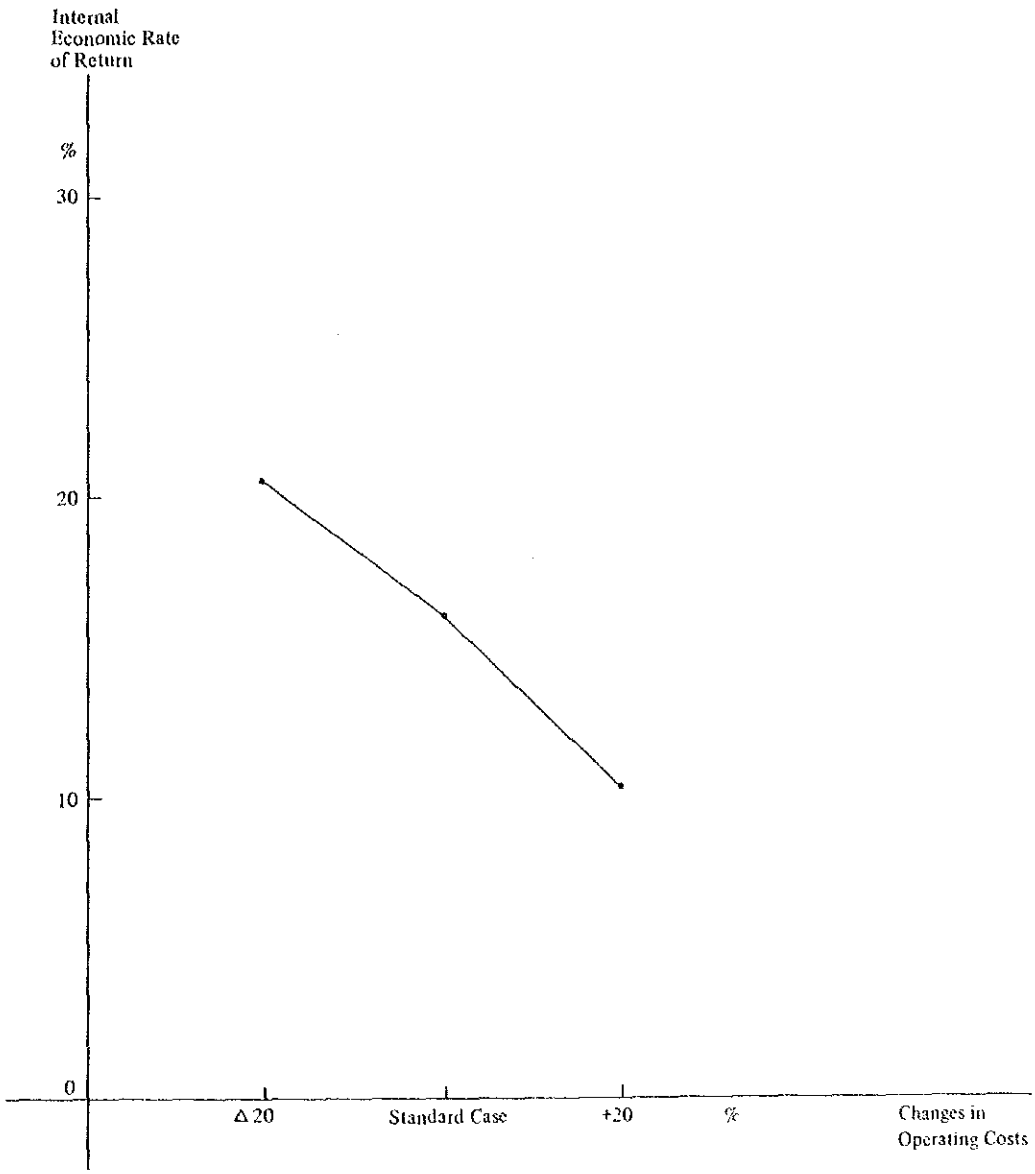
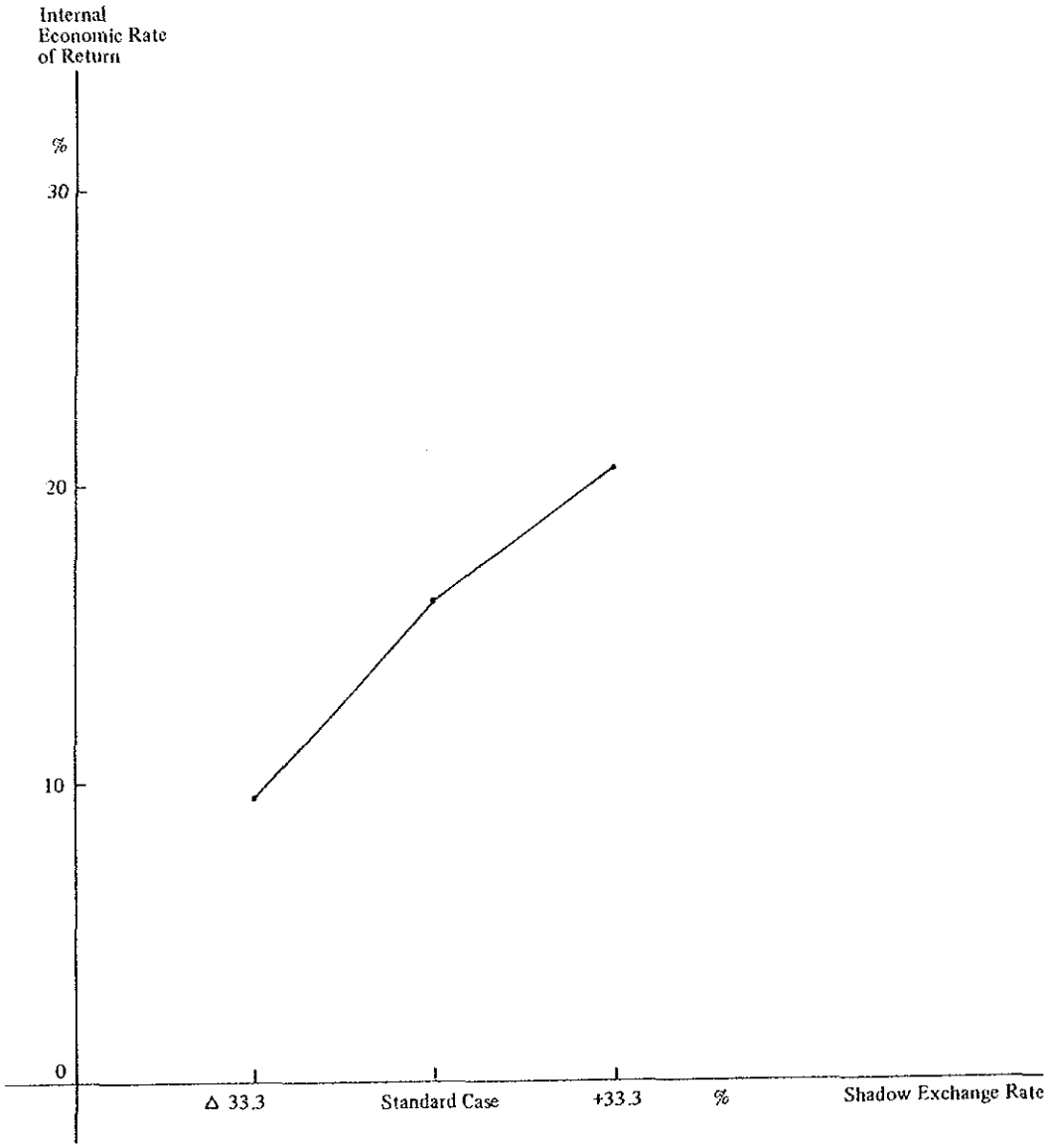


Fig. 7-7-(3) Sensitivity Analysis for Changes in the Shadow Exchange Rate (Economic Analysis in the Case of an Operating Scale of 20,000 tons/day)



mines adequacy of investment into mine development. The positive conclusions of this investigation imply only that the next of development step should definitely be taken, including further investment in prospecting boring, expenses for tests to evaluate the ore quality and preparations for international tender.

(c) Among various factors to be considered in preparation for development, an important consideration in the case where the 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 an 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 aids on the infrastructure, however, do not in fact appear to be so substantial. Possible government grant projects are 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 analysis. More important would be application of a low electricity rate for mine uses or assistence 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 revenues would be derived from the molybdenum, which constitutes one-seventh of the product by quantity. 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 partly compensates 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, while 2,600 pesos to the dollar was used in the 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 the 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 quantify 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 develop-

ment policies. It is clear at this moment, however, that the project would have widespread 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.

5-2. 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 enterprises, 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 to the mine. 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 Chilecito, 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 groundwater 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 using aerial 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 the 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 Chilecito 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.

NOTE: **Question of Whether Copper should be exported as Concentrate or as Electrolytic Copper**

Smelting is necessary in order to convert concentrate to electrolytic copper. Considering the amount of concentrate that is to be produced in the present project (55,000 tons per year), it would be extremely inefficient to build a smelter solely for this purpose. Accordingly, the method of transporting concentrate to another smelter for smelting should be adopted. There are two possibilities; one is the smelter planned for the La Alumbrera Mine at Andalgala; and the other is the one planned for the El Pachon Mine at Barreal. Let us compare these two alternatives with the alternative of exporting the copper as a concentrate.

Comparison of transportation costs: Transportation cost comparison of the three alternatives is as follows (see Chapter 6 for details concerning calculation of individual transportation costs).

			Annual total cost of transportation
Mine	concentrate →	Buenos Aires	10,511 M pesos (Electrolytic copper)
Mine	concentrate →	Andalgala smelter	Buenos Aires 7,814 M pesos (Electrolytic copper)
Mine	concentrate →	Barreal smelter	Buenos Aires 8,628 M pesos

If the concentrate is smelted at Andalgada or at Barreal, there will be a savings of 2,697 million pesos or 1,883 million pesos a year in transportation costs respectively.

The reduced transportation costs will be as follows per ton of electrolytic copper.

Annual production of electrolytic copper at a mine scale allowing for an operating scale of 30,000 tons/day

Annual production of concentrate: 55,000 tons

Copper concentrate grade: 20%

Yield rate for copper smelting: 20% – 1% = 19% (concentrate grade)

Electrolytic copper production:

55,000 tons x 0.19 = 10,450 tons
22,046 x 10,450 = 23,040,000 pounds

Cost reduction in terms of electrolytic copper:

2,697 million pesos/23,040,000 pounds = 117 pesos/pound
1,883 million pesos/23,040,000 pounds = 81 pesos/pound

Accordingly, if the concentrate is smelted at the Andalgala smelter instead of being transported to Buenos Aires as concentrate, there will be a reduction in cost of 117 pesos/pound of electrolytic copper. The reduction in the case of smelting at the Barreal smelter will be 82 pesos/pound.

In general, the cost of smelting prevailing in the world is 293 pesos (15 cents) per pound. Accordingly, in international markets the price of electrolytic copper is 1,950 pesos (100 cents) per pound, and that of concentrate, as claculated in terms of electrolytic copper, comes to 1,657 pesos (1,950 – 293) per pound. Since the transportation costs will be lower via a smelter than for direct export as concentrate, it will still be economical to smelt the concentrate even if the cost of smelting at the smelter rises above the general cost of smelting of 293 pesos/pound but not by more than the amount of reduction in transportation costs. In other words, the permissible smelting costs per pound are as follows:

Andalgala smeltery:
293 pesos + 117 pesos = 410 pesos

Barreal smeltery:
293 pesos + 82 pesos = 375 pesos

These permissible smelting costs per pound are respectively 40% and 28% higher than the international level of smelting costs. If the concentrate can be smelted at a cost of less that these figures, it will be more economical to export the copper as electrolytic copper than as concentrate. If the smelting cost is greater than these figures, it will be more economical to export the concentrate without smelting. So far, we have assumed that all production of the mine will be exported, but what about the possibility of partial domestic consumption? Even in the case of domestic consumption, the above considerations with respect to transportation costs and smelting costs are applicable since the main consumption area is in the vicinity of Buenos Aires. Accordingly, if the cost of smelting at the Andalgala and Barreal smelters is more than 410 pesos or 375 pesos, respectively, per pound, it will be more economical to export the copper as concentrate and import electrolytic copper separately. If the smelting cost is below those figures, it will be possible to convert the concentrate to electrolytic copper for domestic supply and export the surplus. The basic criterion for determining whether the copper should be exported as concentrate or smelted is as described above. Since this question has only been considered here purely in terms of economic effect, it would, of course, be an entirely different question if the smelters were necessary from the standpoint of state policy. In any case, if con-

sideration is to be given to smelting, it will be necessary to undertake a separate detailed feasibility study.