companies will be utilized as the existing mines have been doing the same in the Ribeira area.

As for the long-distance transport of zinc concentrates, considering the existence of railway facilities from Apiaí to São Paulo and Rio de Janeiro, available at a lower cost than road transport, the concentrates will be carried by truck for the distance of 67 km from the Perau mine to Apiaí and switched to railway transport for the 957 km to Juiz de Fora in Minas Gerais, via São Paulo and Rio de Janeiro. The estimated volumes of the three kinds of concentrates to be transported are as shown in Table III–1.

Table III–1 Volume of Concentrates to be Transported

Concentrate	Route	Distance[1] (km)	Means	Volume ton/day
Lead	Perau → Panelas	30	Road	17
Zinc	Perau → Apiaí	67	Road	9
	Apiaí → Juiz de Fora	957	Railway	"
Barite	Perau → Paranaguá	183	Road	35

1) Edidra Abril, "Guia Rodoviário do Brasil 1984," and Geomapas, "Paraná, Rodoviário e Politico 1984."

1–3 Cost Estimation

1–3–1 Road Improvement

Municipal Road No. 4 does not require a long-section improvement for the new transportation demand from Perau mine. However, the road conditions worsen when it rains because of poor drainage, therefore, some portions need gravel pavement. Also, about 1.5 km of the road at Perau mine requires gravels on certain portions. The gravelling expenses for the municipal road will be shared by the Adrianópolis municipal government and the mining company, and those for the road at Perau mine will be borne by the mining company alone. Such expenditure will not come from a special account but will be covered by the municipality's routine road repair funds and the mining company's expenses. The gravelling work on the road at Perau mine will be done with the mining company's construction machinery, such as a bulldozer, shovel loader and truck.

1–3–2 Transportation Costs for Concentrates

The estimation of haulage costs for concentrates will be made, based on the transport tariffs currently paid by the mining companies in the Ribeira area; the tariffs from Perau mine to Panelas mine (lead concentrate) and from Perau mine to Apiaí (zinc concentrate) are estimated at US$0.0633/t per km, and from Perau mine to Paranaguá Port (barite concentrate) at US$0.0708/t per km.

For the export of barite concentrate, port charges at Paranaguá are also required. These charges are tentatively estimated to be US$6/t including all expenses such as unloading, storage, handling, loading and other indirect expenses such as the rental of the concentrate storage yard. The estimated annual costs of the overland transport of concentrates are shown in Table III–2.[4)]

Table III–2 Annual Costs of Concentrate Transport

(unit: US$)

Concentrate	Distance (km)	Volume (ton/year)	Unit Cost	Cost
Lead	30	5,088	$\frac{6.14}{100}$ /t · km	9,372
Zinc	67	2,796	$\frac{6.14}{100}$ /t · km	11,502
"	957	"	21.59/t (Freight) 0.65/t (Tax)	62,183
Barite	183	10,368	$\frac{6.86}{100}$ /t · km	130,158
"		"	6 /t (port)	62,208

Section 2. Water Resources

2–1 Background of Water Utilization

In order to utilize water resources for mine development in the Ribeira area, it is necessary to know the precipitation, river discharge and present situation of water utilization in the upstream basin of the Rio Ribeira do Iguape, where many mines are located. There follows a description of the government organizations concerned, the volumes of discharge of the rivers such as the Rio Ribeira do Iguape, Rio Ribeirão Grande and Rio do Perau, the present water utilization situation, and the government's water quality standards.

2–1–1 Water Resources in the Ribeira Area

(1) Water Utilization in the River Basin

The Federal Government agency concerned with the management of water resources is the Divisão de Controle de Recursos Hídricos (DCRH) which belongs to Departamento Nacional de Aguas e Energia Eléctrica (DNAEE) of Ministério das Minas e Energia (MME). For water utilization of rivers under the control of the Federal Government, approval is required from DNAEE under the Water Law (Código de Aguas). The Rio Ribeira do Iguape, which runs through two states, is managed by the Federal Government (DNAEE 2° Distrito). On the other hand, the Ribeira river's tributaries such as Rio Ribeirão Grande and iits branch Rio do Perau, running

only within the State of Paraná, are under the control of the state government. The state government's agency in charge is Superintendéncia dos Recursos Hídricos e Meio Ambiente (SUREHMA). The utilization of water on the rivers under the control of the state government also needs approval of SUREHMA pursuant to the Federal Government's law. The basin of the Rio Ribeira do Iguape extends over the two states of Paraná (western) and São Paulo (eastern) almost parallel to the Atlantic Coast. Fig. III–3 shows basin of the Rio Ribeira do Iguape, and the basin of the Rio do Perau.

The Rio Ribeira do Iguape basin has an overall area of 24,980 km^2, is populated by 357,600 people and thus has a low population density of fourteen people per km^2. Along the river are several medium and small cities such as Cerro Azul, Adrianópolis, Ribeira, Iporanpa, Eldorado, Registro and Iguape. For the development of mines in the Ribeira area, the resultant influences, particularly of the mine effluents, on the cities in the downstream area cannot be ignored.

Although river water utilization is presently at a low level, there is a plan to supply water to Curitiba from the southwestern upper reach of the river, and to São Paulo from the northeastern upper reach. If this plan is implemented, it will affect the discharge of this river.

(2) Hydrological Characteristics of the River Basin

The planning of water utilization and flood control in the Rio Ribeira do Iguape basin (including the Rio do Perau) requires information of the hydrological characteristics of the drainage area. Indicated in Table III–3 are the rainfall statistics for forty-five years (1939–1983) at Adrianópolis (180 m above sea level) which is close to the Perau area, at the junction of the Rio Ribeirão Grande and the Rio Ribeira do Iguape, although the statistics do not represent the whole upper stream area of the Ribeira.

Table III–3 Rainfall Statistics of Capela da Ribeira Station, Adrianópolis

(unit: mm)

Statistics	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Daily Max.
Average	144.6	122.3	96.2	61.9	65.8	74.4	59.3	46.5	86.6	97.4	80.2	104.4	1040.3	53.4
Max.	364.6	391.0	285.6	174.3	273.7	298.4	362.2	172.4	364.0	221.2	314.5	237.6	2028.1	112.0
Min.	10.6	3.5	1.5	1.2	0.0	0.9	0.6	0.0	3.5	21.1	5.7	14.9	207.0	10.6
Standard Deviation	79.1	82.3	58.5	45.8	61.7	63.8	59.8	38.1	73.0	49.7	72.1	58.2	410.4	25.5

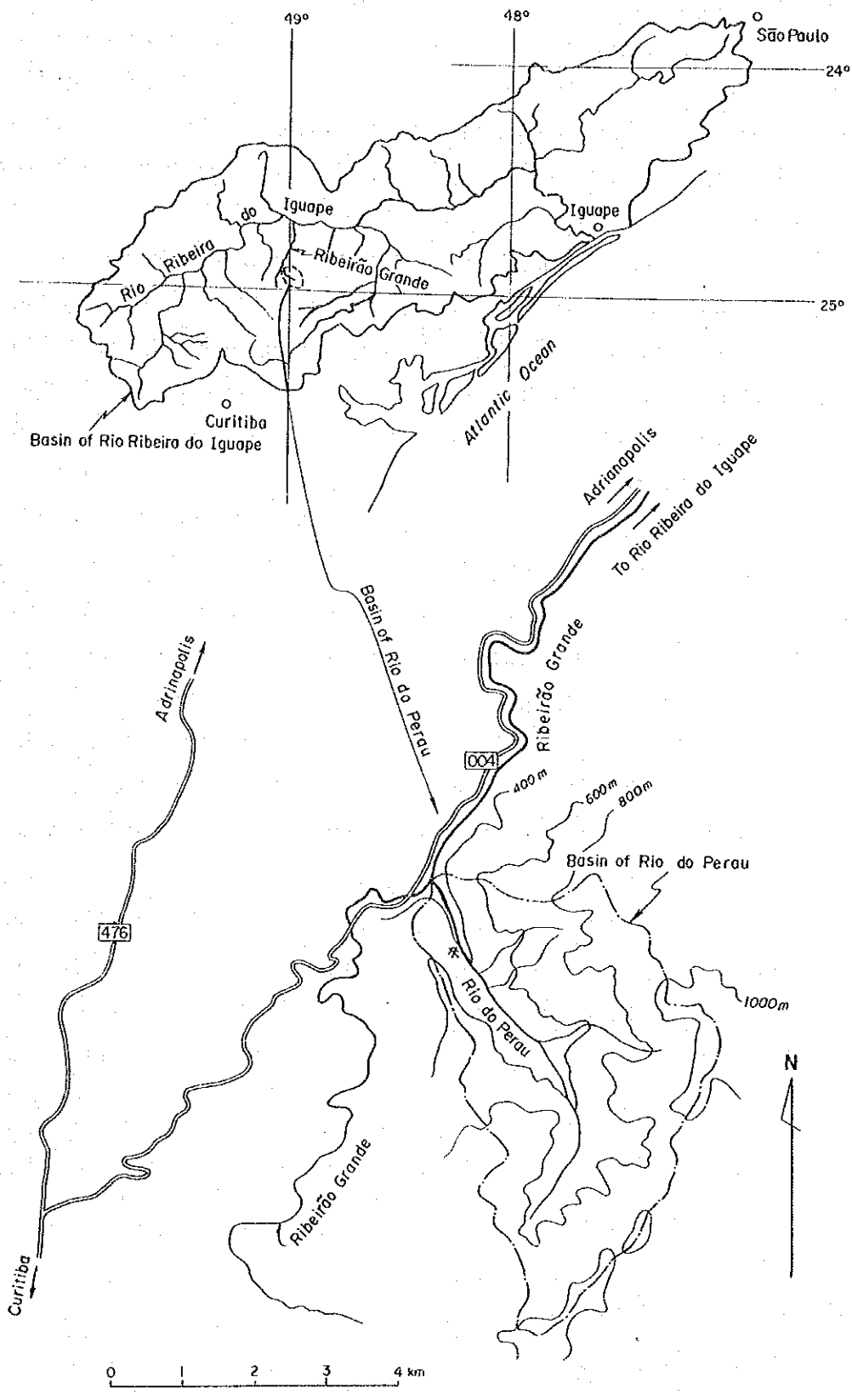

Fig. III–3 Basin of Rio Ribeira do Iguape and Rio do Perau

According to the table, the annual average rainfall amounts to 1,040 mm, which is smaller than the figure for the upper reaches of the Ribeira in the rainfall hyetograph, which gives 1,400 mm. The monthly average rainfall is small during winter from April to August, and large during summer from December to March. The maximum daily rainfall for the past forty-five years is 112 mm, followed by 100 mm, 100 mm, 96 mm and 94 mm according to year, with an average of 53 mm.

There are 19 discharge gaging stations on the main stream and tributaries of the Rio Ribeira do Iguape including seven stations on the upstream of Upper Ribeira area. Since no gaging station exists either on the Rio do Perau or on the upper stream of the Rio Ribeirão Grande, the statistical discharge data of the Rio Ribeira do Iguape recorded at the Capela da Ribeira gaging station for forty-three years (1936–1978) are shown in Table III–4 as an indicator of the hydrological characteristics of the river basin.

The basin area, where the said gaging station is located, is 7,252 km^2, and the basin areas of the Rio Ribeirão Grande and Rio do Perau are 348 km^2 and 15 km^2, respectively; the smaller the basin area, the larger the fluctuations of discharge. The monthly mean value of discharge variation is the highest in February and the lowest in August, but the variation ratio stands at 1.57, which is considerably smaller than that for rainfall, which is 2.63 (122.3 mm/46.5 mm). The annual average and minimum specific discharges are, 13.7 ℓ/sec.km^2 and 7.08 ℓ/sec.km^2, respectively. There is a discharge of more than 57.2 m^3/sec (7.89 ℓ/sec.km^2) for 96 % (347 days) of a year. If this statistical value is applied, it follows that the discharge of the Rio do Perau is more than 118 ℓ/sec for 96 % of year.

Table III–4 Discharge Statistics of Rio Ribeira do Iguape at Capela da Ribeira Station

Monthly Discharge (unit: m^3/sec)

Statistics	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Average	Max.	Min.
Average	121	133	110	86.8	89.9	95.1	92.4	84.5	94.4	99.1	96.1	92.9	99.4	728	51.3
Max.	268	331	183	183	264	210	272	229	379	234	278	212	167	2620	90.5
Min.	39.8	54.7	61.7	45.3	39.0	52.2	45.8	39.6	42.6	39.5	42.0	40.2	51.4	135	30.8
Standard Deviation	49.5	59.9	32.3	27.8	44.7	37.5	43.7	40.1	58.8	43.4	43.8	39.2	27.2	418	13.5

Average Annual Characteristics

Maximum		Average	Intermediate				Minimum		Annual Runoff	
			25%	50%	75%	95%				
m^3/s	ℓ/s·km^2	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	ℓ/s·km^2	$10^6 m^3$	mm
728	100	99.4	105	80.6	67.4	57.2	51.3	7.08	3138	433

(3) Water Quality Standards

The conceivable causes of water pollution from mine development are mine ground water, water seepage from the waste dump, effluents from the processing mill, runoffs from the tailing dam and so on. Sufficient anti-pollution measures have not yet been taken at the mines in the Ribeira area.

The water quality standards in Brazil are set by the Ministério do Interior, Secretaria Especial do Meio Ambiente. Waters are classified into four groups by the kind of water utilization, and for each, regulations are prescribed. The Rio do Ribeirão Grande, the discharge area for Perau mine, is regarded as a class No. 2 water. The water quality standards for a class No. 2 water are described as follows:

1) Floating materials, including non-natural scums, must be virtually absent.
2) Oils and greases, to be virtually absent.
3) Substances that can give taste or smell to water, to be absent.
4) Artificial dyes that cannot be removed by coagulation, sedimentation and filtration, to be absent.
5) The 100 mℓ limit of 1,000 faecal coliforms shall not be exceeded in 80 % of a minimum of five monthly samples collected at any time during a year.
6) BOD/5 days to be 5 mg/ℓ maximum.
7) DO to be not less than 5 mg/ℓ.
8) Harmful substances (maximum contents)
   - Ammonia 0.5 mg/ℓ
   - Arsenic 0.1 "
   - Barium 1.0 "
   - Cadmium 0.01 "
   - Chromium 0.05 "
   - Cyanides 0.2 "
   - Copper 1.0 "
   - Lead 0.1 "
   - Tin 2 "
   - Phenol 0.001 "
   - Fluorine 1.4 "
   - Mercury 0.002 "
   - Nitrate 10 mg/ℓ of N
   - Nitrite 1 mg/ℓ of N

- Selenium 0.01 mg/ℓ
- Zinc 5 mg/ℓ

2–2 Water Requirements at the Mine

The major water requirements at Perau mine are, the water for the processing mill and domestic water for the mine camp. The ore processing needs water of a suitable quality in respect of pH and dissolved elements and in sufficient quantity. Domestic water must be fit to drink. Ore processing requires 1.5 m^3/min. of water, and water can be recycled in the event of a shortage. As for the domestic water requirements, assuming that about 200 persons will live at the mine camp, the required amount of water per capita is tentatively estimated at 200ℓ/day including the water supply to school and other facilities. Consequently, the amount of water required for the mine area is as shown below.

Processing	25 ℓ/sec (= 1.5 m^3/min = 2,160 m^3/day)
Mine Camp	0.5 ℓ/sec (= 28 ℓ/min = 40 m^3/day)

2–3 Cost Estimation for Water Supply Facilities

In view of the proximity and water quality, utilization of the Rio do Perau running through the mine area is advisable for water supply to Perau mine. The Rio do Perau joins the Rio Ribeirão Grande at about 1.5 km downstream from the mine facilities. The latter has a basin area of tens of square kilometers at the confluence point, where 2–3 m^3/sec discharge was measured at the time of our inspection in November 1984. However, the quality of water is not high due to contamination by agricultural/stock-farming activities, sewage from houses and soil errosion. To utilize this river, therefore, sedimentation facilities will be required.

As for the Rio do Perau, 120 ℓ/sec discharge or more should be available for 95 % of a year, as already mentioned. In fact, at the time of our inspection in November, during the season having a discharge rate close to the annual average, approx. 150 ℓ/sec discharge rate was observed. As the river is considered capable of providing the 25 ℓ/sec of water required for ore dressing, water from the Rio do Perau will be used for the processing mill.

For the intake of river water, a small intake weir will be built at the site, 400 m above sea level, where the existing intake facilities are located, to augment the capacity of the present facilities. The water will be carried over a distance of about 500 m from the intake to the existing receiving tank, located at 390 m above sea level (the lowest point on the processing site), through a 6" steel pipe line utilizing the 10-m head. The discharge is computed, as shown below, by

the Hazen-Williams formula:

$$Q = AV = A^{0.85} C R^{0.63} S^{0.54}$$

Where; Q = Discharge (m^3/sec)

A = Pipe cross section area (m^2)

C = Roughness coefficient (approx. 110 in this case)

R = Hydraulic radius (m)

S = Energy gradient

Consequently,

$$Q = \pi \left(\frac{1}{2} \frac{6 \times 2.54}{100}\right)^2 0.85 \times 110 \times \left(\frac{1}{4} \frac{6 \times 2.54}{100}\right)^{0.63} \left(\frac{10}{500}\right)^{0.54}$$

$= 0.026\ m^3$/sec

A mine camp will be set up at a area about 1 km upstream from the confluence point of the Rio do Perau and Rio Ribeirão Grande, along the latter. The domestic water for the camp will be taken from the creek running from the hillside, east of the camp. In order to avoid the polluted water, discharged from the neighboring houses and pastures, the water will be taken in at a point more than 700 m above sea level and conveyed over a distance of about 1,000 m using 2" steel pipe to a receiving tank, which will be set up at a place 400 m above sea level for domestic water distribution in the camp.

The cost estimation for the construction of water supply facilities for the ore processing and camp is as shown in Table III–5.

To utilize the water required for the mine development, an application for a licence must be filed with SUREHMA in Paraná State[5]. The application must be accompanied by information regarding the products of the mine, intake sources of water for both domestic and mining use, in-

Table III–5 Cost of Water Supply Facilities

unit: US$

Facility	Size	Quantity	Unit Cost	Cost
Processing				
Intake weir	3 m width	1.6 m^3 concrete	230 /m^3	368
Transmission pipeline	6 "ϕ	500 m	34.42/m	17,210
Tank	180 m^3	47 m^3 concrete	153 /m^3	7,191
Mining camp				
Intake box	125 ℓ	0.1 m^3 concrete	230 /m^3	23
Transmission pipeline	2" ϕ	1,000 m	7.09/m	7,090
Tank	10 m^3	5 m^3 concrete	153 /m^3	765

take volume, the volume and quality of waste water to be discharged, effluent treatment method, destination of discharged water, volume of solid waste and its disposal methods, and so on.

Section 3. Electric Power

3–1 Background of Electric Supply

Mining is the key industry for the development of the Ribeira area. Infrastructure such as power supply facilities is of particular importance to the mining project which consumes a relatively large amount of electric power. The following description covers the electric power situation in Southern Brazil and in the Ribeira area and the plans of the organizations concerned with electric power supply.

3–1–1 Power Supply in the Southern Area of Brazil

The government organization responsible for the electric power industry is Departamento Nacional de Aguas e Energia Eléctrica (DNAEE). ELETROBRAS undertakes projects such as power generation, transmission and distribution throughout the nation. It has several regional subsidiary organizations. For the three states of Paraná, Santa Catarina and Rio Grande do Sul in Southern Brazil, ELETROSUL is responsible for power generation and transmission beyond the jurisdiction of state governments. Independent from these projects, under the management of the Federal Government, there exist certain power companies run by state governments, such as Companhia Energetica de São Paulo (CESP) in São Paulo State and Companhia Paranaense de Energia (COPEL) in Paraná State. The state-run power companies are mostly engaged in power transmission and distribution although they are also undertaking power generation, while the Federal Government's entities are mainly engaged in power generation and transmission.

The Government of Brazil places emphasis on hydro-power generation with the aim of saving foreign exchange on oil imports. Of the nation's installed total power generating capacity of 40,097 MW, as of 1983, 85 % consisted of hydro-power and 15 % thermal power.

In Paraná State which is included in the Ribeira area, there are already hydropower generating plants, such as Salto Santiago (1,998 MW) run by ELETROSUL and Foz do Areia (1,674 MW) run by COPEL, which have been in operation on the Rio Iguaçu since 1980. In addition, on the Rio Paraná at the western end of Paraná State, Itaipú Hydropower Plant with an installed total capacity of 12,600 MW is now under construction by ELETROBRAS as a joint project with the Federative Republic of Paraguay, and its No. 1 generator (700 MW) was put into operation at the end of 1984.

On the whole, the power generated in the southern states such as Paraná is supplied to the

high consumption southeastern area of Brazil. From the Itaipú Power Station, 500 kV and 750 kV transmission lines are scheduled to be constructed, however, the present situation is that investment in power generating facilities has been ahead of the construction of power transmission facilities. Such investment, with its financing heavily dependent on the international money market, is causing a problem of accumulated debts.

Electric power consumption in Brazil grew at the high annual rate of 10 to 14 % from 1970 to 1980, but it fell sharply to 2.7 % in 1981 and 6.1 % in 1982, affected by the economic recession of recent years. Power requirements are expected to grow again along with the recovery of the economy and the construction of transmission lines from Itaipú. Since the revenue from power tariffs does not cover even half the investment costs, the government is trying to revise the tariff system to match the costs.

3–1–2 Power Supply and Demand in the Ribeira Area

COPEL of Paraná State does not transmit the electric power to the Ribeira area from its power plant but buys the power from CESP of São Paulo State for supply to the region. This is, however, not because there is a shortage of electricity in the state but because the state has no adequate transmission system. The existing transmission facilities[6] and construction plans in the Ribeira Region are indicated in Fig. III–4[7].

The power consumption in the municipalities of Adrianópolis and Cerro Azul of the Ribeira area is shown in Table III–6. According to the table, the industrial consumption of electricity in Adrianópolis stands at 7,494 MWh/year. Twelve establishments account for 92 % of the total requirement of the municipality, and presumably most of it is consumed by the mining industry. The percapita consumption in Adrianópolis and Cerro Azul is 743 kWh and 54 kWh a year, respectively, which is at a low level compared with the national average of 1,000 kWh.

Table III–6 Electricity Consumption in Ribeira Area (1982)

Municipality		Residence	Commercial	Industry	Others	Total
Adrionópolis						
Consumers	(No.)	400	71	12	29	512
Consumption	(MWh)	305	184	7,494	187	8,170
Cerro Azul						
Consumers	(No.)	479	95	16	21	611
Consumption	(MWh)	346	275	128	278	1,027

Source: Departamento Estadual de Estatística, "Anuário Estatístico do Paraná – 1983," Curitiba, 1984.

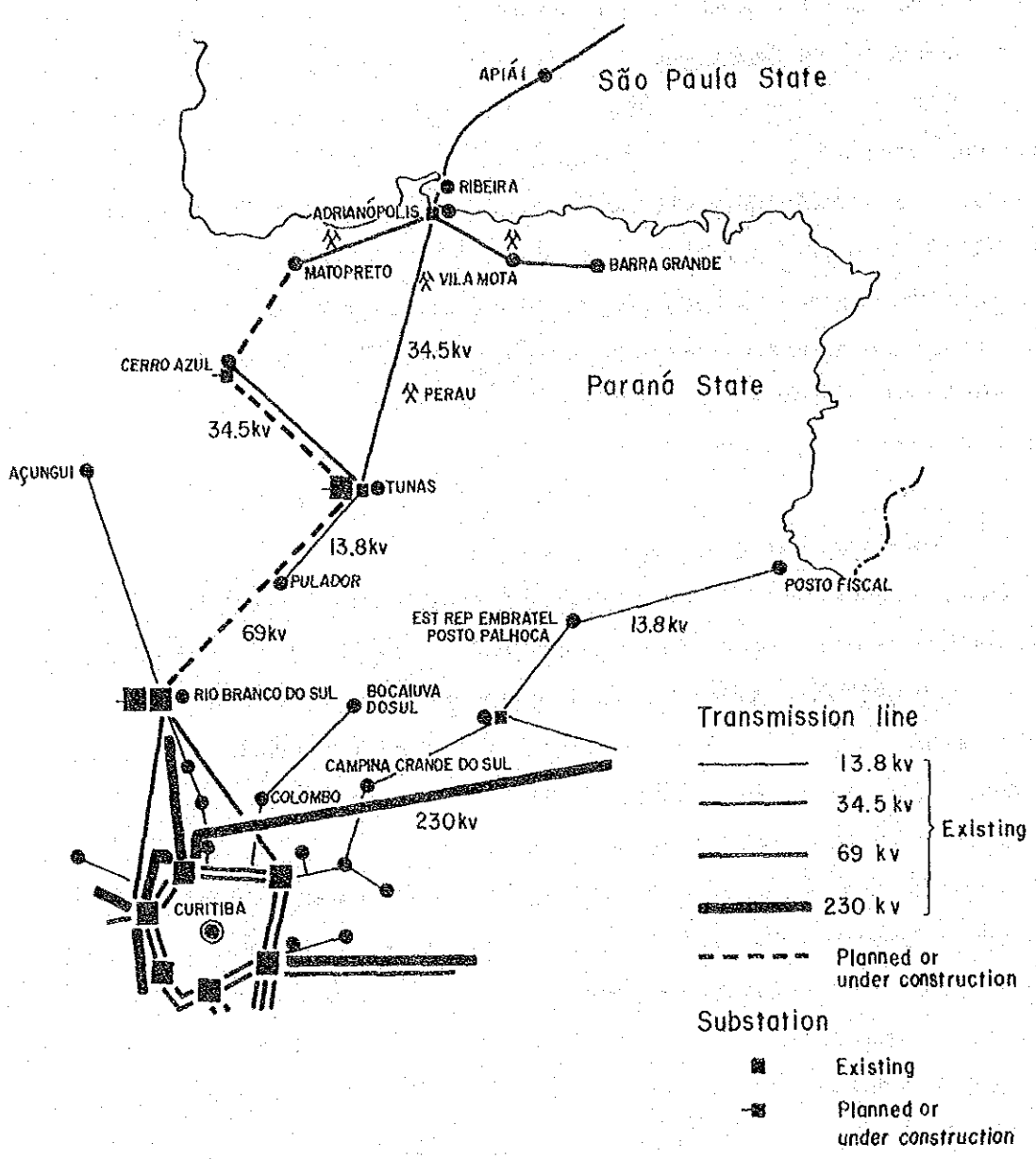

Fig. III–4 Transmission System in the Ribeira Region Area

In the Ribeira area there are five major mines,[8] Furnas (Iporanga Municipality), Perau, Barrinha, Panelas (these three are in Adrianópolis Municipality) and Rocha (Cerro Azul Municipality). These mines receive power supply from São Paulo State through the existing transmission lines (refer to Fig. III–4).

COPEL plans to construct a 69 kV transmission line from Rio Branco do Sul to Tunas by 1986. Meanwhile, Du Pont and MINEROPAR (Minerais do Paraná S.A.) are now developing mines at Mato Preto and in the neighborhood of Cerro Azul, and they are planning to construct transmission lines (34.5 kV) from Tunas to their respective mine sites, without relying on the power supply from São Paulo State.

The planned construction of transmission lines to Mato Preto from Tunas indicates that São Paulo State has no surplus capacity to meet additional power requirement in the Ribeira area. The five mines in the Ribeira area require power of about 1,000 kW maximum, and the new requirement from Perau mine (approx. 2,000 kW) cannot be satisfied by the existing transmission facilities. For this reason, augmentation of the transmission system is necessary for mining and other regional development in the Ribeira area.

3–2 Electricity Requirement of the Mine

In the development of Perau mine, electric power is required for mining and processing operations, and also for the repair shop, mine camp, and other purposes. More specifically electricity is needed for hoists, drainage pumps, ventilation fans, compressors, etc. in the mining operation; for the crusher, classifiers, etc. in the processing operation; for lathes, welding machines, etc. in the repair shop (where the power consumption is relatively small); and for domestic use in the mine camp. The power requirement for each section is shown in Table III–7. As indicated in the table, the entire operation of the mine will need 2,000 kW of electric power and an annual energy consumption of 9,150 MWh.

Table III–7 Electricity Demand

Sector	Demand kW	Energy MWh/day
Mining	903	15,092
Processing	966	15,000
Repair shop etc. [1]	60	400

Note : This includes demand of the office and mining camp.

3–3 Cost Estimation for Electricity Supply Facilities

Since the existing power transmission facilities and substations do not have sufficient capacity to handle the electricity demand of the mine, it will be necessary to secure a new source of electric power, by either buying it from an electric power company or by installing a power generator at the mine. Independent power generation requires a license from the Government under the regulations of the Federative Republic of Brazil. It is, however, quite difficult at present to obtain such a license because of the Government's foreign-exchange saving policy.[9] Consequently, the cost estimates below are only for the case of purchase of electricity from a power company.

The existing 34.5 kV transmission system from Adrianópolis to Tunas does not have the capacity to provide the required additional 2,000 kW of power for the mine. However, the construction by COPEL of the 69 kV transmission facilities to Tunas (18 km south of Perau mine) will be completed in 1986. In addition to completing this new line, the existing line between Adrianópolis and Tunas is assumed to be upgraded. Therefore, a service line will be constructed by the mining company from a point 3.7 km west of Perau to the mine site. The transmission line will have a capacity of 34.5 kV using aluminium cable. A substation, for exclusive use of the mine, is also to be set up on behalf of the mining company. The estimated cost of electric supply facilities[10] is shown in Table III–8 below.

Table III–8 Cost of Electric Supply Facilities

Facility	Capacity	Quantity	Unit Cost	Cost
Transmission line	34.5 kV	3.7 km	9,000 /km	33,300
Substation	2000 kVA	1	–	150,000

The above-mentioned estimation is for the total electric power supply facilities (transmission line and substation) for all activities of the mine including processing plant, repair shop and mine camp.

The costs of transformers, distribution facilities and electric fees for individual activities such as mining operation, ore processing and supporting facilities are included in the investments of each section.

Section 4. Telecommunications

The nationwide telephone services in Brazil are undertaken by TELEBRAS under the supervision of the Ministry of Telecommunications. Under the wing of TELEBRAS, are public

telephone corporations in their respective states. In Paraná State, Companhia de Telecomunicacoes do Paraná (TELEPAR) is in charge of telephone services. As for the Ribeira area, there are 84 terminals/144 telephones in Adrianópolis Municipality and 94 terminals/165 telephones in Cerro Azul Municipality.[11]

The Perau mine has no telephone facilities at present. The most suitable method of communications from the mine to other cities is supposed to be the "MONOCANAL" system, which involves a radio link between the mine and Adrianópolis connected directly to the Adrianópolis and national telephone network. The installation cost of telephone facilities will have to be borne by the mining company, and the facilities will belong to and be maintained by TELEPAR. The cost of setting up MONOCANAL[12] is indicated in Table III–9.

Table III–9 Cost of Communication Facilities

(unit: US$)

Facility	Cost
Radio and Anthena	6,123
Terminal and Telephone	451
Design	22
Total	6,596
Annual Maintenance and Rental Fee	166

Section 5. Mine Camp

5–1 Labor Potentials in the Vicinity of the Mine

Labor availability in the area should be looked into in the planning of mine development. The populations of Adrianópolis and Cerro Azul Municipios are 11,000 and 19,000, respectively, with the central town areas having 2,900 and 5,000 respectively. Most of the population of this area are engaged in agricultural farming. The ratio of the population of agricultural workers to the total working population (ten or more years old) in the two municipalities is 64 % and 94 %, respectively, showing a high potentiality for available labor power.

This area, being mountainous and having poor soil, has little prospect of expanding agricultural production. People are engaged mostly in small scale cropping and pasturing on the mountainsides. It is presumed, therefore, that there is little possibility of agriculture absorbing surplus labor. Furthermore, in Adrianópolis there have been some 200 unemployed mine workers for the last two years with many skilled laborers among them. The town of Apiaí, 37 km from Adrianópolis, is larger than the latter and must have a still larger labor potential.

Mining and processing engineers are available from Curitiba, the capital of Paraná State, 122 km from Adrianópolis. Engineers can also be brought in from São Paulo. Thus, the development of the Ribeira area is likely to absorb some surplus labor particularly in the mining sector.

5–2 Necessity of a Mine Camp

The number of employees needed for development of the Perau mine is 150 persons, besides several school teachers and a nurse. The village of Epitácio Pessoa, which is closest to Perau (8 km), has only a few dozen of residents, and the town of Adrianópolis which has surplus labor is 30 km from the mine. It is, therefore, unrealistic to assume that all the mine workers will commute from Adrianópolis and neighboring villages for the ten years of mine operation. Furthermore, in view of the three-shift operation proposed for the mine, it is preferable for the workers residences to be as close as possible to the mine. Therefore, the construction of lodgings and mine camp facilities will be necessary.

Not all the employees will stay in the mine camp as some of them will be residents living within commutable distances. Also, most employees will not have their families with them in the mine camp. It is normal practice in this area that workers live alone in the camp and return to their families in Adrianópolis, Apiaí or neighboring towns and villages, at weekends.

5–3 Cost Estimation for Mine Camp Facilities

Relatively flat land with areas around 1 ha and within walking distance from the mine, are available at several places along the Rio do Ribeirão Grande. There are three relatively flat places within about 1.5 km upstream from the confluence point of the river and the Rio do Perau. Giving consideration to the possibility of floods, a place on the left bank of the river, about 1,200 m upstream from the confluence point, with relatively high elevation has been chosen as the mine camp site. The location and approximate bounds of the site are shown in Fig. III–5.

This area is 360 to 376 m above sea level, and is 70 m wide and 220 m long with an area of 15,400 m^2. If the site needs to be cleared of vegetation, an application must be filed with ITC (Instituto de Terrase e Cartografia) of Paraná State for permission.

With regard to domestic water, as mentioned in Section 2, water will be taken from about 1,000 m upstream of the creek running 150 m west of the camp, for piping to the camp. Electricity will be transmitted over a distance of about 1,300 m from the substation located near the confluence point of the Rio do Perau and Rio do Ribeirão Grande, for distribution in the camp.

In the determination of the camp scale, the following assumptions are made: 1) about half (80 persons) of the mine workers and service personnel will commute from residences out-

side the camp, 2) about one fourth (20 persons) of the camp resident employees will be unmarried and 3) about one half (30 persons) of the married resident employees will live at the camp, separate from their families (similar proportions have been found at neighboring mines). Consequently, the number of single camp resident employees will be 50 persons and the number of employees with families will be 50. Assuming that each family has an average of five members, the total population of the camp is estimated at 200 persons. The employees living with families will have one-family houses with an area of 50 m^2 each and single residents will stay in communal houses accommodating five persons each. The camp facilities will include a school (100 m^2) for 90 pupils, a church (60 m^2) and a clinic (60 m^2). The cost estimation for these camp facilities is as indicated in Table III–10.

Table III–10 Cost of Mine Camp Facilities

(unit: US$)

Item	Size	Quantity	Unit Cost	Cost
Land	1.54 ha	1	280/ha	431
House				
With family	50 m^2	3	96/m^2	14,400
"	50 m^2	27	36/m^2	48,600
Without family	60 m^2	1	96/m^2	5,760
"	60 m^2	9	36/m^2	19,440
School	100 m^2	1	36/m^2	3,600
Church	60 m^2	1	36/m^2	2,160
Clinic	60 m^2	1	96/m^2	5,760
Water supply pipeline		1000 m	3.57/m	3,570
Electricity supply				
Transmission and distribution	1" ϕ	1500 m	230/50m	6,900
Transformer	20 KVA	1	767	767

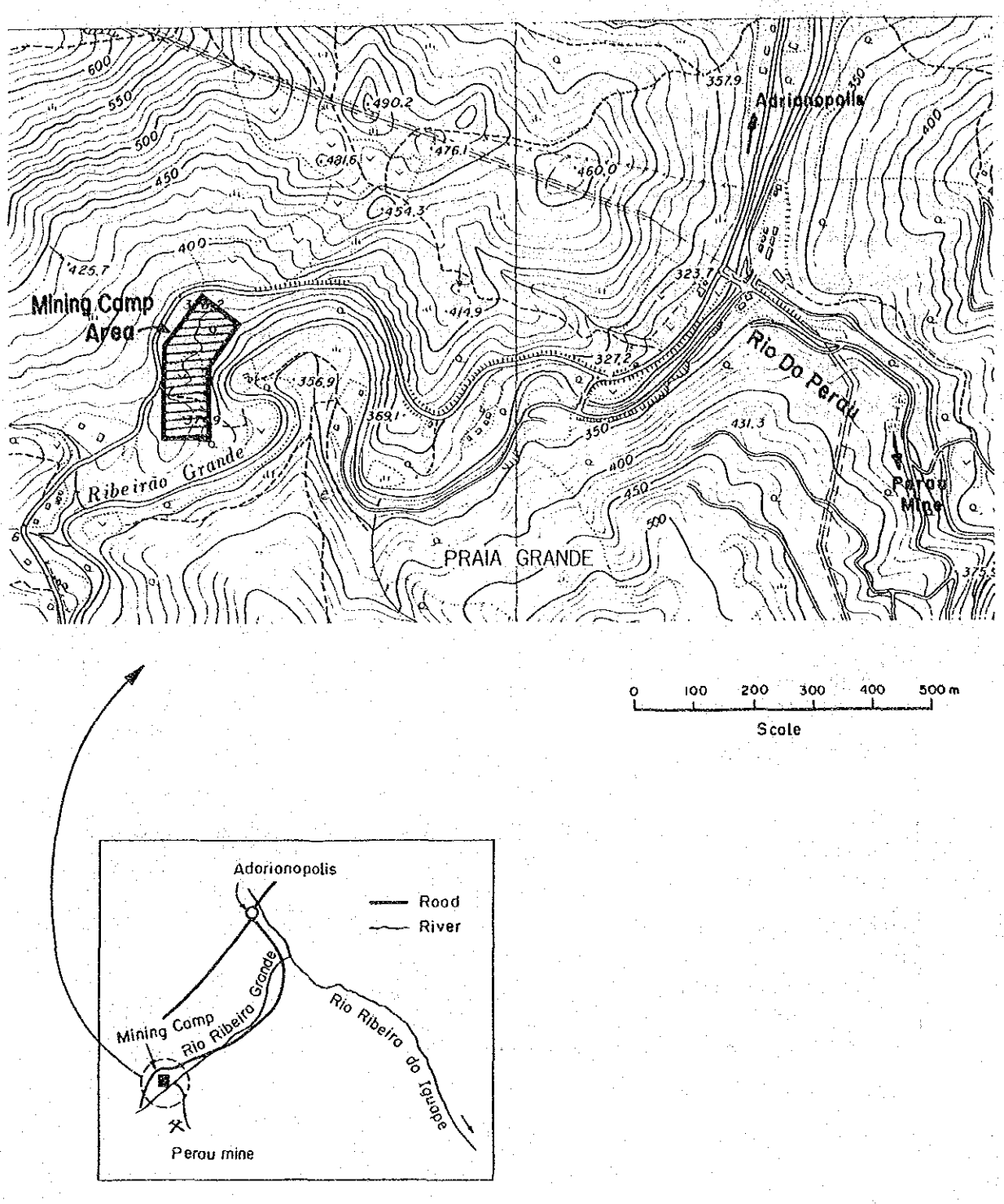

Fig. III–5 Location of Mine Camp

Notes

1) It is assumed that a part of municipal road No. 4 south of Perau mine will be improved.

2) Administração dos Portos de Paranaguá e Antonina, "Porto de Paranaguá, Estatistica 1984".

3) Secretaria dos Transportes, "Porto de Paranaguá, Dossie de Informações Assessoria de Controle de Resultados," Março 1984.

4) Economic costs are estimated assuming that 7 % of land transportation costs represents taxes and 12 % is the foreign exchange portion. 20 % of transportation costs represents fuel costs and a further 20 % is treated as profits of a transportation company. This is based on the following estimation: 25 % of the profits and 12 % of fuel costs are considered to represent the tax portion; 70 % of the cost of producing petroleum products represents the cost of crude oil, therefore 70 % of the balance obtained by deducting taxes from fuel costs are treated as the foreign exchange portion. The unit freight tax for railway tranportation of US$0.65/t, is known as Taxa de baldeio.

5) The form of "Cadastro Industrial" can be used for the application.

6) The transmission lines in the Ribeira area were constructed by CESP.

7) COPEL. "Sistema Electrico do Paraná 1984."

8) The pwer requirements of these five mines are 225 kVA, 1,000 kVA, 250 kVA, 1,130 kVA and 875 kVA, respectively, including the capacities of substantions under construction.

9) As a matter of fact, Rocha mine had a diesel power generator in the past but switched to the buying electric power. The cost of constructing the transmission line was shared between COPEL, CNP (Program for Substitution of Imported Oil) and Rocha mine.

10) 85 %of the cost of the transmission line is accounted for by equipment and materials and 15 % by labour. As for the cost of the substation, labour, equipment and construction materials account for 20 % 70 %and 10 % respectively. The equipment and materials required for the transmission line and substation can all be produced in Brazil, hence no foreign exchange will be expended. Of the construction costs, 5 % of the labour cost and 22 % of equipment/materials costs will be for tax.

11) Department Estadual de Estatistica, "Anuário Estatîstico do Paraná – 1983"

12) The facilities will all be of domestic manufacture, requiring no foreign exchange, 95 % of the expenses are for antennas and other equipment and out of this 22 % goes to tax payment. All the cost of telephones and terminals is included in the equipment expenses, and 22 % of this also goes to tax.

CHAPTER IV OVERALL EVALUATION

CHAPTER IV OVERALL EVALUATION

Section 1 Objectives and Assumptions

This chapter aims at an overall evaluation of the feasibility for development of the lead and zinc ore deposit newly discovered at Perau mine in the Ribeira area, in the Federative Republic of Brazil. The analysis consists of two parts. The first part is a financial analysis which is made to investigate whether a corporation can gain adequate profit from investing in the project. The second part is an economic analysis which is made from the standpoint of the Brazilian national economy to determine if investment in this project is superior to other investment opportunities in terms of its possible contribution to economic growth. These two analyses should have great importance in the feasibility study of this project. That is to say, if the conclusion of the financial analysis is negative, there will probably be little incentive for the investor to be engaged in the development as it is presently envisaged, and there should be a review of the method of development, and/or introduction of new accelerative or protective measures by the government, in order to promote this development. Also, if the conclusion from the economic analysis is negative, it means that, under the existing conditions, the development should not be recommended to the Brazilian government unless there are special political considerations.

The financial and economic analyses made in this chapter are based on the following assumptions together with the technical and concrete plans, and the estimated costs for development and operation which have both been described in the previous chapters:

(1) Concentrates produced and sold by this project are composed of lead (containing silver), zinc and barite. The lead and zinc will substitute for imports to meet domestic demand, and the barite is for export.

(2) The lead concentrates (containing silver) will be sold to Panelas Smelter in Libera district; the zinc concentrates, to a smelter at Juis de Fora in Minas Gerais State; and the barite concentrates will be exported to South American countries via Paranaguá Port.

(3) The main developing entity is a private enterprise which is financed mainly by Brazilian capital and whose management right is held by Brazilians, but the concrete corporation type is not specified. For the use of the land owned by the Perau Mine and roads in the site, and developing the new ore deposit area, no fee is anticipated. Accordingly, it is assumed that the owner of these properties is one of investors in the development.

(4) The development fund will be raised by making use of the governmental finance programmes, FINAME and BNDES/POC, within the existing limit amount, and using the developing entity's own fund for any portion over the limit. Although the survey team has found by investi-

gation that loans over the limit amount have been made through negotiation, the possibility of an additional loan is not taken into account herein for the present.

(5) The concentrate price was determined using domestic and international prices. The price of barite was determined using that in Japan because a local price was not available.

(6) The existing tax system, as investigated by the survey team will not be changed in future (See Appendix 1 for detail).

(7) Taking the present high inflation rate into account, the analyses are made using the U.S. Dollar other than the domestic currency, the Cruzeiro. The inflation rate of the Cruzeiro to the U.S. Dollar is 10% monthly, and the rise in prices in terms of U.S. Dollars depends on the inflation rate of the U.S. Dollar.

(8) In order to perform estimates in U.S. Dollars, the ordinary financial accounting system is used, rather than the Brazilian system. Since government financing is made on the basis of ORTN, which is almost tied to the U.S. Dollar, it is felt that the difference between the two accounting systems will exert little influence on the results of the analysis.

(9) Conclusions in the financial and economic analyses are shown respectively in terms of financial internal rate of return and of economic internal rate of return.

In the following paragraphs, an outline of the financial and economic analyses under the above-mentioned assumptions will be shown. Furthermore, the cash flow for the financial and economic costs and benefits of this development plan will be presented. Finally, the estimates of the financial internal rate of return and economic internal rate of return will be shown. In addition, a sensitivity analysis was made to assess impacts of changes in future concentrate prices on the feasibility of the plan. The results of this analysis will also be presented.

Section 2 Methods of Financial and Economic Analyses

2–1 Financial Analysis

The method of financial analysis used in this report is the DCF (Discounted Cash Flow) method, which is commonly used by international financing agencies such as the World Bank, in examining lending to an investment project. This method is characterized by the two concepts of "discount" and "cash flow" as shown in the title.

The first concept "discount" is based purely on time preference without reference to inflation. Therefore, it must be noted that the analyses use the market prices at the time of the investigation. The financial internal rate of return calculated in this report is the discount rate at which the discounted present value of financial costs for various fiscal years becomes just equal to the discounted present value of the cash flows of the financial benefits for the same fiscal

years – i.e. the present value of the net benefits falls to zero. If the financial internal rate of return calculated is higher than the rate of time preference (a general commercial interest rate minus an inflation rate) in Brazil, this project can be executed from a financial standpoint. (Financial costs and benefits will be described later.)

The second concept, "cash flow", means the inflow or outflow of cash for an investor. Attention should be paid to the fact that depreciation costs and depletion allowances do not constitute a cash flow because they are not an actual outflow of cash. The depreciation costs are booked as costs in business accounting, and the depletion allowance is allowed to count in mining development in Brazil. If a lender is also considered as an investor, interest charges and repayments, which are accounted as costs in business accounting, do not constitute cash (out) flow. It should also be noted that, in this report, the lender is taken as the investor to make this analysis in line with the usual examination procedures for lending used by the international banking facilities. Thus, the internal financial rate of return calculated in this way becomes lower than a rate of return to the equity capital if the former rate is higher than the lending interest rate – i.e. the rate of return to the equity capital exceeds the internal financial rate of return, – which should also be noted.

Financial costs and benefits can be described as follows. Since the financial analysis is made fundamentally to judge the profitability of the business, the two concepts correspond to each item of expenses and revenues in terms of domestic market price, as counted in normal business accounting. However, as far as the above-mentioned depreciation, depletion allowance, interest charges, and repayment, do not constitute cash flow, they are not considered as the financial costs and benefits.

The calculating formula of the internal rate of return in the DCF method is shown herein as follows:

$$\sum_{t=0}^{T} \frac{(\text{Cash Inflow})_t - (\text{Cash Outflow})_t}{(1+r)^t} = 0$$

where; t = The number of years passed since the investment started.

T = Total project life.

r = Internal rate of return.

It will become the financial internal rate of return by using financial costs and benefits in terms of domestic market prices for the cash inflows and outlows. It will become the economic internal rate of return by summing the two in terms of the under-mentioned shadow prices.

2–2 Economic Analysis

The economic analysis is made by using the economic costs and benefits in terms of "Shadow Prices" (also called accounting prices), instead of domestic market prices for cash inflows and outflows in the DCF method. It is also called the (social) costs and benefit analysis. Shadow prices are calculated especially from the national economic viewpoint. The usual cost and benefit analysis is performed to maximize overall consumer's surplus. This surplus is measured by the consumers' willingness-to-pay, which is considered as personal utility level on the basis of the theory of welfare economics. However, in this report, the analysis is performed to maximize the value of national products, instead of the consumer's surplus, in accordance with methods usually used by international banking facilities such as the World Bank.

This method analyzes whether or not a higher level of national products (national income) will occur with the implementation of the project. If the economic internal rate of return exceeds the opportunity cost of national economic capital, then the proposed projects can be executed from an economic standpoint. Although there are different opinions about estimating opportunity cost (also called social discount rate), the same rate used for the financial analysis can also be used.

The economic benefits of the present project, from the national economic viewpoint, compared to the situation without the project, are conservation of foreign currency (by replacing imports with domestically produced lead and zinc concentrates) and acquisition of foreign currency (by export of barite concentrate). Since all these materials are internationally traded goods, benefits should be calculated in international prices in a foreign currency (US$ herein), Therefore, international prices in US$ instead of Brazilian Cruzeiro are the shadow prices used for calculating economic benefits. The international price, in US$ is also used as the shadow price in calculating economic costs of imported materials and machines to be used for this project. Foreign exchange conversion rate – shadow exchange rate – will be described in detail, later.

Costs, used in cost and benefit analysis must be the "opportunity costs", not financial costs. "Opportunity cost" means the benefit foregone by making a choice. For this project, it means the benefits which will not be lost if development didn't occur. In concrete terms it is the decreased value in national products caused by employing the materials, machines, and labor in this project. Aforesaid economic costs of imported materials and machines, in the international price

(shadow price) in US$, are one example of opportunity costs from a national economic viewpoint.

It is clear that the opportunity cost for imported materials and machines is measurable by the foreign currency leaving the Brazilian national economy. However, in other less clear cases, it is not always easy to find the shadow price (also called the real price).[1] Accordingly, in the economic analysis of this report, adjustments will be made for the following three items only, in order to close the gap between financial and economic costs and to make better estimates of shadow or real prices.

The three items considered to exert an influence on results of the analysis are (1) tax, (2) wages for unskilled labor, and (3) foreign currency costs or foreign exchange rate.

Tax is a financial cost for a corporation, but a benefit for a government. From a national economic standpoint, which includes corporations and government, these costs and benefits offset each other. Therefore, opportunity cost or economic cost of any tax is zero. Although market prices of materials and machines to be used in this project are added to taxes, such as ICM and IPI, the price of taxes deducted from the market price is used as the shadow price in the analysis.

In the Ribeira area, where this development is envisaged, there is a substantial surplus of unskilled labor, due to reduction of mining operations in the Ribeira area. Accordingly, the wage rate to be paid to the workers in this project is considered far greater than their contribution to national products than the case without this project. In other words, the opportunity cost of this unskilled labor should be considered far smaller than wages counted as financial costs. Of course, they have to make a living, even if the project is not implemented and will be employed in jobs (perhaps occasional) for income and we cannot account this opportunity cost to be zero. Accordingly, half of the wage rate counted as the financial cost is applied to opportunity costs (shadow wages) of unskilled labor in this report. There is no surplus of engineers and skilled workers, so that the opportunity cost (shadow wage) of their labor is equal to the financial cost.

The opportunity cost (shadow exchange rate) of the foreign currency (US$), from the national economic viewpoint, shows the amount of Cruzeiro necessary to get one US$. In other words, the opportunity cost of foreign exchange is a foreign exchange rate at which imports and exports, priced in US$, balance, without protective measures such as custom duties. To calculate it, it is necessary to investigate, not only statistics of import and export custom duties, but also price elasticities of import and export. However, these data could not be obtained for this study.[2]

As a foreign currency market exists in parallel to the official exchange rate in Brazil, it is plainly unreasonable to apply the official rate to the economic analysis. Therefore, in this economic analysis the effect of the 25% IOF tax, imposed on domestic/foreign currency is taken into account. This means that the shadow exchange rate is estimated by considering the fact that people have to pay 25% more Cruzeiros, than the official exchange rate to get one US$. Of course, more Cruzeiros are necessary for payment of custom duties to get imported goods, so that a 25% adjustment seems to be a conservative estimate. A 25% increase adjustment is used to convert Cruzeiro into US$, while a 20% decrease adjustment is used to convert US$ into Cruzeiro. Since prices in this report are indicated in US$, the application of exchange rate means that all expenses paid in domestic currency should be decreased by 20% to give economic costs (indicated in US$).[3)]

Section 3 Benefits

3–1 Financial Benefits

3–1–1 Financial Price of Lead Concentrate

The financial price of lead (containing silver) concentrate is based on the condition by which Panelas Smelter is presently purchasing lead concentrate from the existing five mines in the Ribeira area. The price per ton of the lead (containing silver) concentrate is calculated using the following formula with payment being made at the end of following month and 15% IUM tax added to the purchase price being paid by the mine.

$$V = (T \times t \times P) + (T_1 \times t_1 \times P_1)$$

where,
- V = Purchasing price per ton of concentrate
- T = Percentage specified, depending on grade of lead contained in the concentrate. (In this project, percentage is specified at 65 % for the grade of concentrate containing 67.18% lead.)
- T_1 = Percentage specified, depending on grade of silver contained in the concentrate. (In this plan, percentage is specified at 70 % for the grade of concentrate containing 1,213 g silver/ton)
- t = Lead content in concentrate (67.18 kg/ton)
- t_1 = Silver content in concentrate (1.213 g/ton)
- P = Domestic price of lead (780 US$/ton)[4)]
- P_1 = Domestic price of silver (349 US$/kg)[5)]

The price of the concentrate sold to the Panelas Smelter, using the above-mentioned formula, is estimated at US$636.9 per ton. Since actual payment (in Cruzeiro) is delayed by an average of 1.5 months, sales revenue of the lead concentrate (containing silver) becomes US$552.1 for the

mine, taking account of a monthly inflation rate of 10%. The substantial financial price is calculated to be US$ 480.3/ton after deducting the 15% IUM tax (actually 13% if inflation until tax payment is taken into account).

3–1–2 Financial Price of Zinc Concentrate

To calculate the financial price of zinc concentrate, it is assumed that the smelter in Juise de Fora is now following the purchasing condition of zinc concentrate from the Boquira mine. The price of zinc concentrate, containing about 52% zinc, from the Boquira mine is US$ 234. IUM tax will be paid by the smelter. The grade of zinc in this project is assumed to be 53.3%, giving a substantial financial price of US$ 208.57 assuming that the price is US$ 240/ton with payment made at the end of the following month.

3–1–3 Financial Price of Barite Concentrate

The price per ton of barite (96% grade) in Japan is US$ 44. If it is also assumed that the CIF price at foreign ports is US$ 44 per ton, and freight from Paranagua Port is US$ 18 per ton, then the financial price is estimated to be US$ 26 per ton.

3–1–4 Annual Financial Benefits

This project assumes that operations will start from the sixth year, with monthly outputs of lead, zinc and barite concentrates being 382, 210 and 778 tons, respectively. Annual outputs are calculated at 4,584, 2,520 and 9,336 tons respectively. Annual revenues, calculated by multiplying these outputs by the aforesaid financial prices, will be US$ 2,201,695 (lead concentrate), US$ 525,420 (zinc concentrate), and US$ 242,736 (barite concentrate). The total annual financial benefit amounts to US$ 2,969,852.

3–2 Economic Benefits

3–2–1 Economic Prices of Lead, Zinc and Barite Concentrates

International prices of lead (containing silver) concentrate and zinc concentrate are assumed to be US$ 409.6 and US$ 244 per ton, respectively (based on data presented by DNPM)[6]. As the barite concentrate is assumed to be exported, its price is calculated to be US$ 26 per ton (same as financial price).

3–2–2 Annual Economic Benefits

Annual economic benefits are calculated, on the basis of the above-mentioned economic prices, at US$ 1,877,606 (lead concentrate), US$ 614,880 (zinc concentrate), and US$ 242,736 (barite concentrate), totalling US$ 2,735,222. These annual economic benefits compared with annual financial benefits are shown in Table IV–1. Economic salvage values of facilities and equipment at the termination of this project are ignored.[7]

Table IV–1 Annual Financial & Economic Benefits (for Years 6th to 15th)

(Unit: US$ at Nov. 1984 price)

	Lead Conc.	Zinc Conc.	Barite Conc.	Total
Annual Production (ton)	4,584	2,520	9,336	16,440
Financial Price (per/ton)	480.3	208.5	26.0	
Annual Financial Benefits	2,201,695	525,420	242,736	2,969,852
Economic Price (per/ton)	409.6	244.0	26.0	
Annual Economic Benefits	1,877,606	614,880	242,736	2,735,222

Section 4 Costs

4–1 Financial Costs

The estimation of the financial costs in US$ was made by using the official exchange rate and domestic market prices at the time of the field survey (November 1984). Although efforts were made to obtain the domestic market prices of all related items during the field survey, the prices of some products could not be adequately investigated because of the limited survey time, and consequently Japanese domestic market prices were used and adjusted in terms of the Brazilian taxation system (especially for the ore dressing equipment and the tailing dam). In the calculation of the on-site financial costs in this development project, domestic transportation costs and the rate of such indirect taxes as ICM and IPI (IOF is imposed on imported materials at the time of conversion into foreign currency, and a custom duty is also imposed on materials competitive with domestic products) should be taken into account. Financial costs for mining and dressing are shown in Tables IV–2 and IV–3 respectively. These data will be necessary for calculation of the economic costs.[8]

The overall summary of the financial costs are shown in Table IV–4 together with the working capital.[9] In this table, machinery and equipment to be financed by FINAME and others to be financed by BNDES/POC are shown separately.

Table IV–5 shows schedules of depreciation, and borrowing, repayment, and interest charges

Table IV–2 Annual Financial Costs for Mining

(Unit: US$ at Nov. 1984 price)

Item \ Year	1st	2nd	3rd	4th	5th	6th (1)	7th (2)	8th (3)	9th (4)	10th (5)	11th (6)	12th (7)	13th (8)	14th (9)	15th (10)
Machinery & Equipment (Brasilian Made) of which,	158,260	25,134	16,472	24,877	250,514	–	–	–	41,116	31,870	–	–	–	–	–
ICM	27,197	4,384	2,911	4,339	42,603	–	–	–	7,059	5,421	–	–	–	–	–
IPI	10,327	1,778	1,267	1,680	17,542	–	–	–	2,408	2,640	–	–	–	–	–
Transport Costs	7,013	795	137	570	13,322	–	–	–	686	599	–	–	–	–	–
Total	202,797	32,091	20,787	31,466	323,981	–	–	–	51,269	40,530	–	–	–	–	–
Machinery & Equipment (Imp orted) of which,	117,545	16,324	–	–	96,656	–	–	–	–	–	–	–	–	–	–
ICM	21,581	2,996	–	–	17,749	–	–	–	–	–	–	–	–	–	–
IPI	9,403	1,306	–	–	7,729	–	–	–	–	–	–	–	–	–	–
IOF	29,387	4,082	–	–	24,163	–	–	–	–	–	–	–	–	–	–
Transport Costs	12,326	36	–	–	225	–	–	–	–	–	–	–	–	–	–
Total	190,242	24,744	–	–	146,522	–	–	–	–	–	–	–	–	–	–
Materials for *Facilities* of which,	22,846	–	–	13,885	1,934	–	–	–	–	–	–	–	–	–	–
ICM	3,883	–	–	2,361	329	–	–	–	–	–	–	–	–	–	–
IPI	1,337	–	–	812	113	–	–	–	–	–	–	–	–	–	–
Total	28,066	–	–	17,058	2,376	–	–	–	–	–	–	–	–	–	–
Materials for Development & Operation of which,	32,560	56,980	56,980	56,980	116,390	390,960	390,960	390,960	390,960	390,960	390,960	390,960	390,960	390,960	390,960
ICM	5,535	9,687	9,687	9,687	19,786	66,468	66,468	66,468	66,468	66,468	66,468	66,468	66,468	66,468	66,468
IPI	1,905	3,333	3,333	3,333	6,809	22,860	22,860	22,860	22,860	22,860	22,860	22,860	22,860	22,860	22,860
Total	40,000	70,000	70,000	70,000	142,985	480,288	480,288	480,288	480,288	480,288	480,288	480,288	480,288	480,288	480,288
Total of Machinery, Equipment & Materials	331,211	98,438	73,452	95,742	465,494	390,960	390,960	390,960	432,076	422,830	390,960	390,960	390,960	390,960	390,960
Total of Transport Costs	19,339	831	137	570	13,547	–	–	–	686	599	–	–	–	–	–
Total of ICM, IPI and IOF	110,555	27,566	17,198	22,212	136,823	89,328	89,328	89,328	98,795	97,389	89,328	89,328	89,328	89,328	89,328
Labour Costs (Staff)	23,232	34,320	34,320	34,320	34,320	45,408	45,408	45,408	45,408	45,408	45,408	45,408	45,408	45,408	45,408
Labour Costs (General)	40,078	56,407	56,407	61,224	92,535	193,644	193,644	193,644	193,644	193,644	193,644	193,644	193,644	193,644	193,644
Labour Costs (Unskilled)	11,583	13,510	13,510	16,721	33,840	54,624	54,624	54,624	54,624	54,624	54,624	54,624	54,624	54,624	54,624
Total	74,893	104,237	104,237	112,265	160,695	293,676	293,676	293,676	293,676	293,676	293,676	293,676	293,676	293,676	293,676
Electricity	13,620	22,610	35,412	47,670	51,070	104,880	104,880	104,880	104,880	104,880	104,880	104,880	104,880	104,880	104,880
Other Expences	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800
Contingency	3,000	5,000	4,000	4,000	4,000	–	–	–	–	–	–	–	–	–	–
Sub-total	566,418	272,482	248,235	296,260	854,429	892,644	892,644	892,644	943,913	933,174	892,644	892,644	892,644	892,644	892,644
Depreciation	–	–	–	–	–	265,548	256,236	255,192	250,176	250,176	214,176	214,176	209,352	196,536	196,536
Total	566,418	272,482	248,235	296,260	854,429	1,158,192	1,148,880	1,147,836	1,194,089	1,183,350	1,106,820	1,106,820	1,101,996	1,089,180	1,089,180

N.B. : The years in parenthesis are for the operation which starts from 6th year.

Table IV–3 Annual Financial Cost for Dressing

(Unit: US$ at Nov. 1984 price)

Item \ Year	1st	2nd	3rd	4th	5th	6th (1)	7th (2)	8th (3)	9th (4)	10th (5)	11th (6)	12th (7)	13th (8)	14th (9)	15th (10)
Machinery & Equipment (Brazilian made) of which,	–	–	278,478	417,716	691,194										
ICM	–	–	47,371	71,056	117,524										
IPI	–	–	19,858	29,787	49,331										
Transport Costs	–	–	1,910	2,864	4,775										
Total	–	–	347,617	521,423	862,824										
Materials for Construction & Operation of which,	–	–	164,652	333,437	328,477	276,710	276,710	276,710	276,710	276,710	276,710	276,710	276,710	276,710	276,710
ICM	–	–	27,991	56,685	55,841	47,039	47,039	47,039	47,039	47,039	47,039	47,039	47,039	47,039	47,039
IPI	–	–	15,411	31,209	30,746	32,375	32,375	32,375	32,375	32,375	32,375	32,375	32,375	32,375	32,375
Transport Costs	–	–	649	1,334	1,314	10,773	10,773	10,773	10,773	10,773	10,773	10,773	10,773	10,773	10,773
Total	–	–	208,703	422,665	416,378	366,897	366,897	366,897	366,897	366,897	366,897	366,897	366,897	366,897	366,897
Imported Machinery & Materials of which,	–	–	–	–	5,000	12,375	12,375	12,375	12,375	12,375	12,375	12,375	12,375	12,375	12,375
ICM	–	–	–	–	903	3,008	3,008	3,008	3,008	3,008	3,008	3,008	3,008	3,008	3,008
IPI	–	–	–	–	313	1,609	1,609	1,609	1,609	1,609	1,609	1,609	1,609	1,609	1,609
IOF	–	–	–	–	1,250	3,094	3,094	3,094	3,094	3,094	3,094	3,094	3,094	3,094	3,094
Import Tax	–	–	–	–	0	3,713	3,713	3,713	3,713	3,713	3,713	3,713	3,713	3,713	3,713
Transport Cost	–	–	–	–	123	244	244	244	244	244	244	244	244	244	244
Total	–	–	–	–	7,589	24,043	24,043	24,043	24,043	24,043	24,043	24,043	24,043	24,043	24,043
Total of Machinery, Equipment & Materials	–	–	443,130	751,153	1,024,671	289,085	289,085	289,085	289,085	289,085	289,085	289,085	289,085	289,085	289,085
Total of Transport Costs	–	–	2,569	4,198	6,212	11,017	11,017	11,017	11,017	11,017	11,017	11,017	11,017	11,017	11,017
Total of ICM, IPI, IOF & Import Tax	–	–	110,631	188,737	255,908	90,838	90,838	90,838	90,838	90,838	90,838	90,838	90,838	90,838	90,838
Labour Costs (Staff)	–	–	0	0	0	15,600	15,600	15,600	15,600	15,600	15,600	15,600	15,600	15,600	15,600
Labour Cost (General)	–	–	127,816	247,951	141,687		51,004	51,004	51,004	51,004	51,004	51,004	51,004	51,004	51,004
Labour Cost (Unskilled)	–	–	73,703	130,732	98,018	21,860	21,860	21,860	21,860	21,860	21,860	21,860	21,860	21,860	21,860
Total	–	–	201,519	378,683	239,705	88,464	88,464	88,464	88,464	88,464	88,464	88,464	88,464	88,464	88,464
Electricity	–	–	–	–	–	102,150	102,150	102,150	102,150	102,150	102,150	102,150	102,150	102,150	102,150
Analysis	–	–	–	–	–	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000
Other Expenses	–	–	28,019	94,822	112,216	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600
Contingency	–	–	3,000	3,000	6,000	–	–	–	–	–	–	–	–	–	–
Sub-total	–	–	31,019	97,822	118,216	663,154	663,154	663,154	663,154	663,154	663,154	663,154	663,154	663,154	663,154
Depreciation	–	–	–	–	–	372,834	372,834	372,834	372,834	372,834	372,834	372,834	372,834	372,834	372,834
Total			788,858	1,420,593	1,644,712	1,035,988	1,035,988	1,035,988	1,035,988	1,035,988	1,035,988	1,035,988	1,035,988	1,035,988	1,035,988

Table IV–4 Annual Financial Costs (Summary Sheet)

(Unit : US$ at Nov. 1984 price)

Item \ Year	1st	2nd	3rd	4th	5th	6th (1)	7th (2)	8th (3)	9th (4)	10th (5)	11th (6)	12th (7)	13th (8)	14th (9)	15th (10)
Machinery & Equipment															
o Mining	393,039	56,835	20,787	31,466	470,503	–	–	–	51,269	40,530	–	–	–	–	–
o Dressing	–	–	347,617	521,423	862,824	–	–	–	–	–	–	–	–	–	–
o Supporting	266,400	–	–	–	7,904	5,000	–	–	–	–	5,880	–	–	–	–
o Total	659,439	56,835	368,404	552,889	1,341,231	5,000	–	–	51,269	40,530	5,880	–	–	–	–
Others															
o Mining	173,379	215,647	227,448	267,794	383,926	892,644	892,644	892,644	892,644	892,644	892,644	892,644	892,644	892,644	892,644
o Dressing	–	–	441,241	899,170	781,888	663,154	663,154	663,154	663,154	663,154	663,154	663,154	663,154	663,154	663,154
o Tailing Dam	–	–	478,720	478,720	478,720	–	–	–	–	–	–	–	–	–	–
o Supporting	80,100	9,600	9,600	10,031	162,122	63,891	63,891	63,891	63,891	63,891	63,891	63,891	63,891	63,891	63,891
o Transport of Ore	–	–	–	–	–	337,606	337,606	337,606	337,606	337,606	337,606	337,606	337,606	337,606	337,606
o Total	253,479	225,247	1,157,009	1,655,715	1,805,656	1,957,295	1,957,295	1,957,295	1,957,295	1,957,295	1,957,295	1,957,295	1,957,295	1,957,295	1,957,295
Working Capital (+/–)	–	–	–	–	233,604	–	–	–	–	–	–	–	–	–	Δ233,604
Total	912,918	282,082	1,525,413	2,208,604	3,381,491	1,962,295	1,957,295	1,957,295	2,008,564	1,997,825	1,963,175	1,957,295	1,957,295	1,957,295	1,723,691

Table IV–5 Schedules of Depreciation, Borrowing, Repayment & Interest Charges

(Unit: US$ at Nov. 1984 price)

Item \ Year	1st	2nd	3rd	4th	5th	6th (1)	7th (2)	8th (3)	9th (4)	10th (5)	11th (6)	12th (7)	13th (8)	14th (9)	15th (10)
Depreciation (Current Terms)															
o Mining	–	–	–	–	–	265,548	256,236	255,192	250,176	250,176	214,176	214,176	209,352	196,536	196,536
o Dressing	–	–	–	–	–	372,834	372,834	372,834	372,834	372,834	372,834	372,834	372,834	372,834	372,834
o Tailing Dam	–	–	–	–	–	143,616	143,616	143,616	143,616	143,616	143,616	143,616	143,616	143,616	143,616
o Supporting	–	–	–	–	–	63,398	63,398	63,398	63,398	63,398	35,611	35,805	34,805	34,805	34,805
o Total	–	–	–	–	–	845,396	836,084	835,040	830,024	830,024	766,237	766,431	760,607	747,791	747,791
Depreciation (Real Terms)	–	–	–	–	–	563,034	535,415	514,180	491,434	475,884	426,020	410,376	391,645	370,346	356,102
Borrowing															
o FINAME	527,551	45,468	303,889	456,063	1,100,877	–	–	–	–	–	–	–	–	–	–
o BNDES/POC	126,740	112,624	572,776	819,263	885,896	–	–	–	–	–	–	–	–	–	–
o Total	654,291	158,092	876,665	1,275,326	1,986,773	–	–	–	–	–	–	–	–	–	–
Repayment (Current Terms)															
o FINAME	–	–	–	87,925	95,503	146,151	222,162	405,642	405,641	317,717	310,139	259,490	183,478	–	–
o BNDES/POC	–	–	–	–	18,106	34,193	116,020	233,057	359,613	359,613	359,614	341,507	325,419	243,594	126,561
o Total	–	–	–	87,925	113,609	180,346	338,182	638,699	765,254	677,330	669,753	600,997	508,897	243,594	126,561
Repayment (Real Terms)	–	–	–	78,159	97,363	152,388	284,033	528,080	623,779	538,014	511,992	444,952	363,988	167,966	85,490
Interest Charges (Current Terms)															
o FINAME	–	–	–	82,298	78,752	114,603	174,193	312,919	263,836	196,289	156,256	108,092	60,733	–	–
o BNDES/POC	–	–	–	–	22,862	40,768	139,537	271,878	400,661	352,798	304,933	251,074	200,295	129,898	58,736
o Total	–	–	–	82,298	101,614	155,371	313,730	584,797	664,497	549,087	461,189	359,166	261,028	129,898	58,736
Interest Charges (Real Terms)	–	–	–	73,152	87,095	131,742	260,211	494,953	547,874	437,945	353,957	266,246	186,664	89,787	39,676

related to FINAME and BNDES/POS, financing programmes. [10] In FINAME, the financing sum (limited to 90% of the total costs) for machinery and equipment is assumed to include the costs prior to operation in addition to the costs of purchasing machinery and equipment. Accordingly, attention should be paid to the fact that there is a little difference between Tables IV–4 and IV–5.

Depreciation, repayment, and interest charges are also calculated in real terms by taking the inflation rate (assumed to be 4% annually) of the US$ used for prices in the present analysis. This is because the inflation rate of the US$ (which mostly corresponds to ORTN) will raise annual prices (that is, no rise in constant prices) for both benefits and costs, but will not alter the annual costs of depreciation, repayment and interest charges (i.e. relative decrease in the constant prices through the inflation). The yearly rises of U.S. consumer prices from 1981 to 1983 were 10.4%, 6.07%, and 3.25% respectively.

The forecasted financial position of the project is shown in the income and fund flow statements in Table IV–6 (depreciation, repayment, and interest charges are expressed in real terms). The income statement is necessary for calculating the business income tax, which is a component of cash–outflow in the financial analysis. On the other hand, the fund flow statement is necessary for the calculation of the rate of return to the equity capital; because the rate of return to the equity capital is especially important for a developer in determining the feasibility of an investment. In order to write the fund flow statement, it is assumed that the annual net cash-inflow (= cash-inflow – cash-outflow) is appropriated for dividends with a necessary cash balance being kept, and when there is a cash shortage, a corresponding amount of additional equity is invested.

4–2 Economic Costs

The calculation of economic costs was made in accordance with the method described in Section 2. This means that the followng three procedures are made for the economic costs:

(1) All taxes are excluded from financial costs.

(2) The opportunity cost of unskilled labor is estimated at 50% of the market wage. wage.

(3) The dollar equivalent for all items to be paid in Brazilian currency (i.e. excluding imported materials and machinery under C.I.F. terms) is multiplied by 0.8 (shadow exchange rate).

The annual economic costs are shown in Table IV–7.

Table IV–6 Income Statement & Fund Flow Statement

(Unit: US$ at Nov. 1984 price)

	Item \ Year	1st	2nd	3rd	4th	5th	6th (1)	7th (2)	8th (3)	9th (4)	10th (5)	11th (6)	12th (7)	13th (8)	14th (9)	15th (10)
Income Statement	Sales Revenue						2,969,852	2,969,852	2,969,852	2,969,852	2,969,852	2,969,852	2,969,852	2,969,852	2,969,852	2,969,852
	Operating Expenditure[1/]						1,957,295	1,957,295	1,957,295	1,957,295	1,957,295	1,957,295	1,957,295	1,957,295	1,957,295	1,697,735
	Depreciation						563,034	535,415	514,180	491,434	475,884	426,020	410,376	391,695	370,346	356,102
	Depletion Allowance						593,970	593,970	593,970	593,970	593,970	593,970	593,970	593,970	593,970	593,970
	Interest Charges						131,742	260,211	494,953	547,874	437,945	353,957	266,246	186,664	89,787	39,676
	Profit Before Tax						Δ276,189	Δ377,039	Δ590,546	Δ620,721	Δ495,242	Δ361,390	Δ258,035	Δ159,722	Δ 41,546	282,369
	Income Tax (35%)						0	0	0	0	0	0	0	0	0	98,829
	Profit After Tax						Δ276,189	Δ377,039	Δ590,546	Δ620,721	Δ495,242	Δ361,390	Δ258,035	Δ159,722	Δ 41,546	183,540
Fund Flow Statement	Cash Outstanding from Previous Year	0	0	0	0	0	25,956	25,956	25,956	25,956	25,956	25,956	25,956	25,956	25,956	25,956
	Sales Revenue	0	0	0	0	0	2,969,852	2,969,852	2,969,852	2,969,852	2,969,852	2,969,852	2,969,852	2,969,852	2,969,852	2,969,852
	Capital	258,627	123,990	648,748	1,084,589	1,838,736	–	–	10,446	210,365	3,932	–	–	–	–	–
	Borrowing	654,291	158,092	876,665	1,275,326	1,986,773	–	–	–	–	–	–	–	–	–	–
	Total Revenue	912,918	282,082	1,525,413	2,359,915	3,825,509	2,969,852	2,969,852	2,980,298	3,180,217	2,973,784	2,969,852	2,969,852	2,969,852	2,969,852	2,969,852
	Operating Expenditure	0	0	0	0	0	1,957,295	1,957,295	1,957,295	1,957,295	1,957,295	1,957,295	1,957,295	1,957,295	1,957,295	1,957,295
	Interest Charges	–	–	–	73,152	87,095	131,742	260,211	494,953	547,874	437,945	353,957	266,246	186,664	89,787	39,676
	Income Tax	–	–	–	–	–	0	0	0	0	0	0	0	0	0	183,540
	Dividents	–	–	–	–	–	723,427	468,313	0	0	0	140,731	301,359	461,905	738,382	963,411
	Investment (Fixed Capital)	912,918	282,082	1,525,413	2,208,604	3,381,491	5,000	–	–	–	–	–	–	–	–	–
	Investment (Working Capital)	–	–	–	–	233,604	–	–	–	–	–	–	–	–	–	Δ233,604
	Repayment	–	–	–	78,159	97,363	152,388	284,033	528,050	623,779	538,014	511,992	444,952	363,988	167,966	85,490
	Total Expenditure	912,918	282,082	1,525,413	2,359,915	3,799,553	2,969,852	2,969,852	2,980,298	3,180,217	2,973,784	2,969,852	2,969,852	2,969,852	2,969,852	2,995,808
	Net Revenue	0	0	0	0	25,956	0	0	0	0	0	0	0	0	0	Δ 25,956
	Cash Outstanding in Current Year	0	0	0	0	25,956	25,956	25,956	25,956	25,956	25,956	25,956	25,956	25,956	25,956	0

1/ The figure for the last year includes recovery of working capital and cash outstanding.

Table IV–7 Annual Economic Costs (Summary Sheet)

(Unit: US$ at Nov. 1984 price)

Item \ Year	1st	2nd	3rd	4th	5th	6th (1)	7th (2)	8th (3)	9th (4)	10th (5)	11th (6)	12th (7)	13th (8)	14th (9)	15th (10)
Imported Machinery & Equipment (Foreign Currency Costs)															
o Mining	117,545	16,234	–	–	96,656	–	–	–	–	–	–	–	–	–	–
o Dressing	–	–	–	–	5,000	12,375	12,375	12,375	12,375	12,375	12,375	12,375	12,375	12,375	12,375
o Total	117,545	16,234	–	–	101,656	12,375	12,375	12,375	12,375	12,375	12,375	12,375	12,375	12,375	12,375
Unskilled Labour															
o Mining	4,633	5,404	5,404	6,688	13,536	21,850	21,850	21,850	21,850	21,850	21,850	21,850	21,850	21,850	21,850
o Dressing	–	–	29,481	52,293	39,207	8,744	8,744	8,744	8,744	8,744	8,744	8,744	8,744	8,744	8,744
o Tailing Dam	–	–	127,148	127,148	127,148	–	–	–	–	–	–	–	–	–	–
o Supporting	7,863	–	–	–	10,803	7,215	7,215	7,215	7,215	7,215	7,215	7,215	7,215	7,215	7,215
o Total	12,496	5,404	162,033	186,129	190,694	37,809	37,809	37,809	37,809	37,809	37,809	37,809	37,809	37,809	37,809
Others															
o Mining	261,338	172,066	174,022	205,862	462,488	598,954	598,954	598,954	632,395	624,929	598,954	598,954	598,954	598,954	598,954
o Dressing	–	–	418,186	714,928	934,175	430,465	430,465	430,465	430,465	430,465	430,465	430,465	430,465	430,465	430,465
o Tailing Dam			128,680	128,680	128,680	–	–	–	–	–	–	–	–	–	–
o Supporting	234,787	6,758	6,758	7,108	103,463	40,524	37,404	37,404	37,404	37,404	41,073	37,404	37,404	37,404	37,404
o Transport of Ore	–	–	–	–	–	260,174	260,174	260,174	260,174	260,174	260,174	260,174	260,174	260,174	260,174
o Total	496,125	178,824	727,646	1,056,578	1,628,806	1,330,117	1,326,997	1,326,997	1,360,438	1,352,972	1,330,666	1,326,997	1,326,997	1,326,997	1,326,997
Working Capital (+/–)	–	–	–	–	186,883	–	–	–	–	–	–	–	–	–	Δ186,883
Total	626,166	200,462	889,679	1,242,707	2,108,039	1,380,301	1,377,181	1,377,181	1,410,622	1,403,156	1,380,850	1,377,181	1,377,181	1,377,181	1,190,298

Section 5 ESTIMATION OF INTERNAL RATE OF RETURN

5–1 Financial Internal Rate of Return

The financial internal rate of return (FIRR) for a project life of 15 years is shown in Table IV–8 together with yearly cash-inflow, cash-outflow and net cash-inflow. The cash-inflow corresponds to the annual financial benefits outlined in Table IV–1, and the cash-outflow corresponds to the total annual financial costs in Table IV–4 plus the amount of annual income tax. The figures in parentheses in Table IV–8 represent the cash flow and FIRR to equity. The cash-inflow and cash-outflow correspond to the annual dividends and invested equity in the fund flow statement in Table IV–6 respectively.

The calculated financial internal rate of return is as low as 2.01% for total capital and negative for equity capital (that is, the invested capital cannot be recovered); in other words, the project has no attraction to investors under the existing conditions.

5–2 Economic Internal Rate of Return

The economic internal rate of return (EIRR) during the period of the project life is shown in Table IV–9 together with yearly economic benefits, costs and net benefits. The benefits are the sums of the annual economic benefits in Table IV–1, and those of costs are the corresponding sums of the figures in Table IV–7.

The economic internal rate of return is estimated at 17.18% and seems to fulfill the decision criteria (compared with the normal commercial interest rate and inflation rate). For instance, the criteria for a World Bank finance is 12%, and that for USAID only 8%. Thus, it seems that the present project will be beneficial to the Brazilian economy.

Section 6 SENSITIVITY ANALYSIS

The internal rate of return estimated in the previous section was determined on the basis of the prices of concentrates at the time of the field survey. However, these prices fluctuate greatly along with changes in world production and consumption. In addition, since no starting date for the project has yet been determined, there is obviously some concern about using current prices for the future concentrate prices. In fact, the current prices are at an extremely low level, reflecting the serious supply-demand imbalance due to the world-wide business recession that is leading many mines to bankruptcy.

In future, the supply-demand imbalance will be adjusted by curtailing production, with the world-wide business recovery being expected to bring about an increase in consumption of con-

Table IV–9 Financial Internal Rate of Return

(Unit: US$ at Nov. 1984 price)

Year	Cash Inflow	Cash Outflow	Net Cash Inflow
1st		912,918	Δ912,918
		(256,627)	(Δ256,627)
2nd		282,082	Δ282,082
		(123,990)	(Δ123,990)
3rd		1,525,413	Δ1,525,413
		(648,748)	(Δ648,748)
4th		2,359,915	Δ2,359,915
		(1,084,589)	(Δ1,084,589)
5th		3,825,509	Δ3,825,509
		(1,838,736)	(Δ1,838,736)
6th (1)	2,969,852	1,962,295	1,007,557
	(723,427)	(0)	(723,427)
7th (2)	2,969,852	1,957,295	1,012,557
	(468,313)	(0)	(468,313)
8th (3)	2,969,852	1,957,295	1,012,557
	(0)	(10,446)	(Δ10,446)
9th (4)	2,969,852	2,008,564	961,288
	(0)	(210,365)	(Δ210,365)
10th (5)	2,969,852	1,997,825	972,027
	(0)	(3,932)	(Δ3,932)
11th (6)	2,969,852	1,963,175	1,006,677
	(140,731)	(0)	(140,731)
12th (7)	2,969,852	1,957,295	1,012,557
	(301,359)	(0)	(301,359)
13th (8)	2,969,852	1,957,295	1,012,557
	(461,905)	(0)	(461,905)
14th (9)	2,969,852	1,957,295	1,012,557
	(738,388)	(0)	(738,388)
15th (10)	2,969,852	1,822,520	1,147,332
	(963,382)	(0)	(963,382)
F.I.R.R = 2.01% (Negative)			

N.B. : Figures in parentheses are for the equity capital.

Table IV–8 Economic Internal Rate of Return

(Unit: US$ at Nov. 1984 price)

Year	Benefits	Costs	Net Benefits
1st		626,166	Δ626,166
2nd		200,462	Δ200,462
3rd		889,678	Δ889,678
4th		1,242,707	Δ1,242,707
5th		2,108,039	Δ2,108,039
6th (1)	2,735,222	1,380,301	1,354,921
7th (2)	2,735,222	1,377,181	1,358,041
8th (3)	2,735,222	1,377,181	1,358,041
9th (4)	2,735,222	1,410,622	1,324,600
10th (5)	2,735,222	1,403,156	1,332,066
11th (6)	2,735,222	1,380,850	1,354,372
12th (7)	2,735,222	1,377,181	1,358,041
13th (8)	2,735,222	1,377,181	1,358,041
14th (9)	2,735,222	1,377,181	1,358,041
15th (10)	2,735,222	1,190,298	1,544,924
E.I.R.R = 17.18%			

centrates. Therefore, the possibility of a rise in the price of concentrates (of course, the possibility of the price falling cannot be denied) seems to be considerable. Taking into consideration this uncertainty in the future prices of concentrates, a sensitivity analysis has been made herein by estimating the financial and economic rates of return in the case of a decrease of 10%, and increases of 10% and 20% in prices (i.e. 10% decrease, 10% and 20% increases in the sales revenue of the project). Further, in this sensitivity analysis, estimations have also been made for the case that a tailing treatment plant is not constructed to reduce development costs. This estimation was made for additional reference, because it seems that developers tend to reduce their costs in this way. In fact, tailing treatment is not being carried out at present in ore dressing plants of the mines in the Ribeira area. The results of an economic analysis of this case are also shown, but attention should be paid to the fact that the social cost caused by contamination with effluents from the tailing has not been included in the analysis.

In the sensitivity analysis, the income and fund flow statements differ from those of the basic case, due mainly to decrease in depreciation (when the tailing treatment plant is not built) and increase in corporate income tax which is minimal in the basic case (using the current prices of concentrates) but occurs in most years in the case of the increased corporate earnings (in the 10% and 20% increases in prices of the concentrates). However, in this report we will omit assumed financial statements and annual cash flows in all cases and present only the internal rates of return in Table IV–10.

The result of the sensitivity analysis shows that, if the prices of the concentrates increase by 20% in the future, the project will become attractive to investors, and even if the prices fall by up to 10%, the criteria will be fulfilled for the Brazilian economy.

This analysis shows that the rate of return without the tailing treatment plant is considerably high for the equity capital when prices of the concentrates rise. (Of course, this is partly because the amount of the government financing is left unchanged even in the case when tailing treatment is not introduced.) As a result of the analysis, it is considered that omitting the tailing treatment plant has great attraction to the developer. However, from the viewpoint of preventing pollution, it seems desirable that the government will take measures to counteract such a tendency.

Table IV–10 Sensitivity Analysis for Sales Revenue

	Revenue 10% Less	Basic Case	Revenue 10% More	Revenue 20% More
Financial Rate of Return				
o Basic Case	Negative	2.01%	5.92%	8.75%
	(Negative)	(Negative)	(7.29%)	(13.17%)
o Without Tailing Treatment	Negative	4.96%	9.10%	12.08%
	(Negative)	(5.36%)	(16.41%)	(23.62%)
Economic Rate of Return				
o Basic Case	12.82%	17.18%	21.00%	24.40%
o Without Tailing Treatment	16.02%	20.56%	24.53%	28.07%

N.B.: Figures in parentheses are for the equity capital. Same amount of borrowing is assumed for the case without tailing treatment.

Section 7 OVERALL EVALUATION

(1) According to the results of the economic analysis undertaken from the standpoint of the impact of the project on Brazilian economy, even if the overseas prices of the concentrates decrease by 10% compared with the prices at the time of the field survey (November 1984), producing them domestically is preferable to importing them (barite is not exported), and the project can be said to be feasible. In this sense, it is desirable for the Brazilian government to promote the project.

(2) However, looking at the financial analysis from the standpoint of the developer, there will be no incentive to private investment unless future prices of the concentrates increase by about at least 20%.

(3) Meanwhile, because of the present low price of concentrates, it seems very likely that the real present prices of concentrates will increase by about 20% in the near future, so it will be possible to execute the project under the existing system and policy.

(4) In order to execute the project on the basis of actual prices below those of the concentrates mentioned above, the present system and policy will have to be somewhat modified to facilitate the investment (for instance, to repay the indirect tax on materials and machinery, to reduce IUM, and to reduce interest or increase the ceiling amount of the government financing).

(5) Although it will be more profitable to private developers to omit the tailing treatment plant, this omission is undesirable from the environmental point of view, and the government will be required to take measures regarding the matter.

(6) In the Ribeira area, many mines are now curtailing operations and causing increase in unemployment. The execution of the project is expected to provide jobs for 150 workers as a direct effect, and further 200 or more jobs as a result of indirect effects. This will make a great contribution to the economic and social development in the area.

(7) However, there is no complete picture of the extent of ore deposits because of the few number of trial drillings and full-scale prospecting will have to be carried out. If the ore reserves exceed the anticipated scale, the project will have greater and more desirable effects in both financial and economic terms, as well as on the employment situation of the area.

(8) The conclusions for the present project seem to be true also for the existing five mines in the area. That is, for the benefit of the Brazilian national economy, it will be more profitable to expand the production of lead concentrate in the existing five mines instead of importing the concentrate. One issue is the higher financial profitability, anticipated for the Panelas smelter, of using imported rather than domestic concentrate (see Note 6). It is desirable that, by carefully examining this matter, the Brazilian authorities will adopt necessary measures (e.g. imposing

custom duties on the import of the lead concentrate and introducing incentives in tax and financing for production expansion of existing mines), because these measures will also promote development in the area.

Notes:

1) For instance, consideration of Brazilian home-produced machinery, clarifies matters. Without this project, will home-produced materials be used for other purposes, or be exported, or not produced? For each case, opportunity cost would vary considerably, but it was difficult to find the variation during a short survey such as this. Therefore, this analysis assumed that all home-produced materials will be used for other domestic purposes, if the project does not proceed.

2) In Brazil, trade is carried out under quantitative controls such as import quota and foreign exchange allocations. Accordingly, even if these materials could have been obtained, it would have been very difficult to estimate the shadow exchange rate accurately.

3) If imported raw materials or intermediate materials are used in home-produced machinery, purchased with the domestic currency, then a portion of foreign currency should be involved. However, since the 25% IOF tax has been imposed on the foreign currency portion, application of the shadow exchange rate means that the IOF tax is removed. Accordingly, even if the calculation is made either by dividing the two portions of domestic and foreign currencies, or by considering the total as domestic currency, each calculated economic cost will equal the other. Consequently, in this report, all home-produced materials are summed in the domestic currency. Since custom duties are not imposed on foreign-produced materials for which no local suppliers exist, they can be ignored for imported raw materials and parts. Double taxation by the ICM tax on intermediate goods is prohibited, making it unnecessary to take the portion of foreign currency into account, for the total amount of ICM tax.

4) CIP price (October 19, 1984) quoted from Afrante Inormativo Geral.

5) Price quoted from Boletim de Precos No. 50, DNPM. There is no CIP price for silver, so an amount calculated by adding the 25% IOF tax to the international silver price, was used.

6) According to the DNPM, the present import price of lead concentrate is US$ 400 per ton, but silver content is unknown. Therefore, the international price of the lead concentrate was calculated by applying international prices of lead and silver to the same formula as that for calculation of financial price. The international price of the zinc concentrate is the 1983 average import price. The economic price has no relation to inflation in terms of Cruzeiro. Since custom duties are imposed on the imported concentrate, if we therefore, examine the purchasing price of the concentrate for smelters (taking the IOF tax and domestic freight into account), results

are as follows: Imported concentrate is estimated to be cheaper than home-produced by about US$ 30 per ton for a lead smelter, while it is about US$ 100 per ton more expensive for a zinc smelter.

7) When the survey team inspected existing mines, old equipment was abandoned. Economic salvage value seems very small, if any. Discount calculation is made in the analysis, so that salvage value can be regarded as zero.

8) The data for the tailing dam, supporting management, and infrastructure were omitted bacause of their complexity.

9) In this table, the costs of carrying out the feasibility study (F/S) was not taken into account. The working capital (including some cash reserves) is assumed to be about 1.5 months of the operating costs.

10) Finances are not anticipated for replacement of machinery and equipment.

NOTE : BRAZILIAN TAX SYSTEM

The five tax systems related to the present project in the current Brazilian tax system (as of November 1984) can be briefly described as follows:

(1) IPI (Tax on industrial products)

(2) ICM (Tax on circuation of goods)

(3) IOF (Tax on financial transactions)

(4) IUM (Tax on sales of minerals)

(5) Corporate Income Tax

(IPI and ICM)

IPI and ICM are paid at the time of material purchase. ICM (17%) is imposed on all materials, and IPI (usually 5 – 8%) is imposed on most industrial products. These taxes are also imposed on raw materials and intermediate goods. The payment of the taxes is entered on the credit side of the tax ledger to offset the amount of the tax imposed (debit side) at the time of the sale of finished goods. Since the taxes are in form of value added tax, amounts of IPI and ICM imposed on the finished goods include those on the raw materials and intermediate goods as well. ICM is imposed first, being considered a part of the commodity price. IPI is added to the price at the time of sale.

Knowledge on this tax system is important in the compilation of tax deductions in the economic analyses, as well as in the estimation of material prices in the study. Since the taxes are in form of value added tax, the total amount of IPI and ICM can be calculated by deducting the total tax at the time of material purchase.

(IOF)

Although this is called a tax on financial transactions, the meaning of IOF is actually much broader. Related to the present project is the function of the foreign exchange tax (25%), imposed when the domestic currency is converted into a foreign currency in order to pay for imported goods.

If the imported goods are industrial products, the sequence of imposing tax on the import price (CIF) is as follows: IOF, custom duties, IPI, and ICM.

(IUM)

This is the federal tax (15%) imposed at the time of sale on prices of ores and concentrates produced in mines. Conerning this tax, it is important that the 15% amount is added to the prices of the ores and concentrates, so that the portion to be paid as the tax from the sales amount (including the tax) becomes less than 15%.

Corporate Income Tax

Corporate income tax is commonly imposed on pre-tax profit, but for Brazilian mining companies, the depletion allowance can be treated as a cost item in corporate accounting – different point from the usual system. The depletion allowance is 20% of revenue (excluding the amount deducted as IUM). In the financial analysis in this study, the amount excluding IUM is treated as revenue (financial benefit).

CHAPTER V FIVE MINES UNDER OPERATION IN RIBEIRA AREA

CHAPTER V FIVE MINES UNDER OPERATION IN RIBEIRA AREA

Section 1 Lead and Zinc Deposits in Ribeira

In the project area (Fig. II–1–2), many lead and zinc deposits are emplaced in the limestone of the Açungui formation.

A zone of a 20-km width, between a line running ENE from the west of Ribeira through Apiai for 80 km and another line extending in the same direction passing through the vicinity through the vicinity of Iporanga, which is the southern limit, is shown in figure known as the area of metallic ore deposits. Fig. V–1 shows the location of the mines developed in the area. Those marked O are the five surveyed mines.

Section 2 Result of the Survey of Each Mine

The five mines, Perau, Frunas, Panelas, Barrinha and Rocha in the Vale do Ribeira area were surveyed, and the results are shown in Table V–1.

The survey was conducted in detail on ore reserve, ore, mining method, production, productivity, transportation, materials, water, employees, electric power, ventilation and mineral dressing.

The mines are backward in exploration in general, and those, in which a reasonable quantity of ore reserve has been confirmed, are limited in number.

Few mines adopt systematic mining and are less productive.

Dressing plants which have fallen into disuse are found everywhere and the flow sheets are not likely to relate to systematic production. More research and development seems to be required.

However, since each mine maintains a profit with the present form of management, it is thought that to be entirely wrong to force the type modernization we are thinking about.

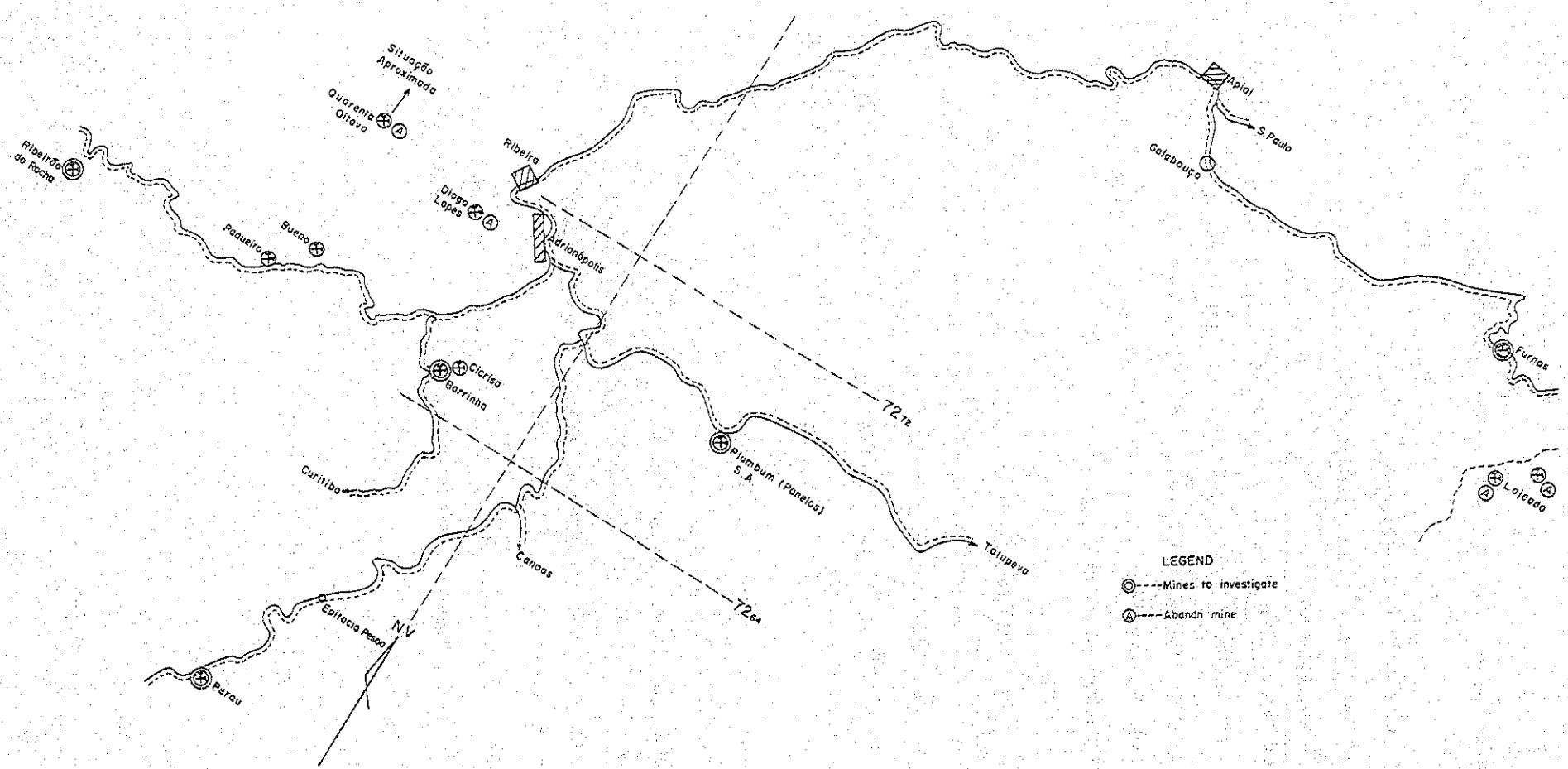

Fig. V–1 Map of Mines in Ribeira Area

Table V–1 Summary Table of Mining Facilities

Name of mine	PERAU	TURNAS	PANELAS	BARRINHA	ROCHA
Name of company	São Marco S.A. Condutores Elétricos	CAF - Agentidera Furnas Mineração Indústria Com. LTDA	Paranibuna S.A.	Mineração São Bras S.A.	Rocha Exploração Industrial Comércio Demolições LTDA
Ore reserve (t)					
Measured	383,056	3,334	86,000	10,000	105,447
Probable	315,462	3,057	–	10,000	69,060
Possible	91,020	5,062	150,000	–	15,165
Total	689,538	11,453	236,000	20,000	193,672
Location of mine (km from Panelas mine)	30	60	0	15	43 (New mine)
Ore minerals	Galena (Zinc blend, Bornite, Pyrite, Cerussite, Rutile, Chalcopyrite)	Galena, Cerussite (Pyrite, Limonite, Hematite)	Galena, Cerussite (Pyrite)	Galena, Cerussite (Pyrite)	Galena, Cerussite (Pyrite)
Gangue minerals	Limestone, Schist, Quartz	Limestone	Limestone	Limestone, Quartz	Limestone, Dolomite
Grade of ore					
Ag : g/t	Ag Pb PbO Zn ZnO Fe FeO Cu S		Ag Pb PbO Zn ZnO Fe FeO Cu S	Ag Pb PbO Zn ZnO Fe FeO Cu S	Ag Pb PbO Zn ZnO Fe FeO Cu S
Others : %	58 5.99 1.33 3.1 1.4 7.1 9.2 0.16 3.8	4.5 % Pb 60.0 g/t Ag	83 5.13 3.27 3.1 1.4 6.4 8.2 0.03 3.0	150 8.51 1.07 0.6 0.7 2.1 9.2 0.13 4.6	149 6.14 1.73 1.4 3.8 4.5 5.8 0.19 3.9 125 6.89 6.73 0.6 0.6 8.5 7.2 0.01 0.4
Mining method	Room and pillar	Room and pillar	Room and pillar	Sub-level stopping	Sub-level stopping
Production (t/M)	1,500	350	1,100	1,000	5,000
Operation shift	2	2	1	3	2
Working hours (hr)	6	6	6	6	7
Number of working place	6	3	10	2	30
Efficiency of Mining per one worker per month (t/man)	42	15	37	20.8	67
Number of drill holes per one blasting	25	25	26	25	33
Metrage of advance per one blasting	1.3	1.3	1.0	0.9 ~ 1.2	1.3
Efficiency of advance per one worker per month (m/man)	0.85	9.0	0.52	–	–
Transportation in mine					
Rail gauge (mm)	600	508	600	610	600
Capacity of minecar (m^3 or kg)	0.6 m^3	0.6 m^3	7000 kg, 1000 kg	1000 kg, 150 kg	1000 kg, 500 kg, 150 kg
Loading method	Hand	Hand	Loader and hand	–	Loader and hand
max. transportation distance (m)	350	800	1000	330	1,300
Quantity per ton of crude ore					
Timber (m^3/t)	0.005	–	0.032	–	–
Explosive (kg/t)	0.63	0.5	0.91	0.74	0.9
Detonator (piece/t)	1.1		3.45	3.5	2.4
Bit (m/piece)	300	200	180	200	200
Transportation fee of ore (Cr$/km/t)	59.3	167	191	160	167
Water Supply (m^3/D)	from tire water 0.03 m^3/min (pH 6.3)	60 (from river water)	40 m^3/h	24 60 ~ 80 m^3/D	– (from river water) 0.3 m^3/min (from mine) 0.5 m^3/min (from dressing plant)
Drainage		15			
Number of employee					
Under ground	40 64	23	Mining 58	54 84	114 240
Surface	24	22	Dressing 27 269 Refining 69 Others 135	30	126
Electric power					
Max use of power (kVA)	1,000	225	1,130	100 + 150 (increase at the end of 1984)	–
Use of electric power (kWH/M)	–	12,240 (Oct. 1984)	520,800	–	156,800
Cycle (Hz)	60	60	60	60	60
Quantity per ton of crude ore (kWH/t)		35	–	–	–
Ventilation	Natural	Natural	Natural	Natural	Natural
Mineral dressing	Test plant (2t/H)	Dressing plant (10 t/H)	Dressing plant (10 t/H)	Test plant (2 t/H)	Dressing plant (5 t/H)
Flowsheet of dressing	Crushing Screening Table / Jigger (Not use in present)	Crushing Screening Jigger Screening Table (Not use in present)	Crushing Grinding Classifier Flotation	Crushing Hydro separation Jigger / Table (Not use in present)	Crushing Screening Jigger Slime (1 t/H) Flotation
Grade of concentrate	Ag Pb PbO Zn ZnO Fe FeO Cu S		Ag Pb PbO Zn ZnO Fe FeO Cu S	Ag Pb PbO Zn ZnO Fe FeO Cu S	Ag Pb PbO Zn ZnO Fe FeO Cu S
Ag : g/t	811 53.3 – 6.9 1.1 10.7 13.9 0.83 17.5	836 51.06 – 3.5 2.0 14.7 19.0 1.33 20.1	761 55.5 – 1.0 1.2 9.2 11.9 0.93 26.8	903 42.15 – 3.7 4.7 11.7 15.1 1.06 27.6
Others : %				1,035 64.03 – 1.3 1.6 6.7 8.5 0.36 7.3
Remarks	1 Mining • Recovering of residual pillar by filling method • Mining of below G-4 by skip winding 2 Dressing • Dressing planning will be needed in near future	1 Mining • Strengthen of compressor Power • Use of large diameter compressor pipe line 2 Dressing • Dressing planning will be needed in near future	o Dressing and Refining • Better to adopt the pollution control system both air and water	o Mining • Strengthen of compressor power • Use of large diameter compressor pipe line • Improvement of mining method	o Mining • Shrinkage method is better than sublevel stopping method working in present • Take care of handling of explosive • Better to use electric blasting • Better to adopt the treatment of tailing in dressing plant

Improvement measures suitable for natural the features of Brazil would be necessary, and the curtailment of employees by mechanization, for example, would have to be reconsidered.

An idea to collectively redevelop the existing five mines might not be practical, because these mines are managed separately and operated by the different companies. There are also big differences in the ore reserves as well as in mining and dressing technologies among the mines.

It is thought that it will greatly contribute to the regional development of the district and improvement of the life and welfare of the residents if the mines remain open with the target of maintaining a reasonable quantity of ore reserve by promoting exploration. Mining operation should be stabilized by introducing all techniques, necessary to their own standpoint.

Therefore, in terms of this proposal for the mines only the matters to be taken into consideration for redevelopment have been proposed, in addition to the description of the present situation of each mine.

2–1 *Results of the Survey of Each Mine*

2–1–1 Perau Mine

(1) Present Situation

The ore reserve of this mine amounts to 690,000 tons, which is more plentiful than the other mines. The mining method is the "room and pillar" method and production is 1,500 tons per month. The productivity per person per month is 43 tons, which is relatively higher than that of other mines.

Possession of a disused dressing plant, makes it possible to investigate the development of dressing at the mine site.

(2) Proposal for Redevelopment

Prospecting : Because of many uncertain factors in respect to the ore reserve of the new deposit, it is necessary to drill fill-in holes between the existing drill holes and the northeast of hole AG–02 at intervals of 30 to 50 m in order to accurately estimate the ore reserve.

It is desirable to drift the tunnels and to perform underground drilling to prospect the northern extension of the Perau deposit now in operation.

Mining : While cut and fill method is being used for mining of the Perau ore, it will be possible to recover ore of considerably higher quality if the pillars are recovered by the cut and fill method because the wall rocks are compact and hard, being composed of calc-silicate rock and limestone.

For the mining of ore below the G–2 level in future, it is desirable to sink inclined shafts along the ore bed and to use skip haulage for transportation of ore.

Dressing : While the hand-picking system being used at present could be continued for the time being, it will be necessary to investigate a system of feeding ore to the new dressing plant which may be built in future when the development of the new deposit is realized.

2–1–2 Furnas Mine

(1) Present Situation

The ore reserve of the mine is little more than 10,000 tons, which is very santy, and promotion of exploration is desired. The productivity is also as 15 tons per person per month, and the production is 350 tons per month. Separation of ore is being done by hand picking and washing.

(2) Proposal for Redevelopment

Prospecting : It is desirable to elucidate the chute of the ore veins by investigating the fissure system relating to formation of the veins and to apply it to the exploration (underground drilling) of the downward extension.

It is also desirable to conduct geochemical prospecting along the horizon (soil and rock), trenching of the showings and drill surveys, because the ore horizon continues in a northwest direction. It will be necessary to carry out geophysical surveys (IP and SIP) over a dense area in future.

The present mining method of waste piling appears to be appropriate since the ore bodies are small in scale and the wall rock is soft and weak.

Enlargement of the diameter of the pipe from 1.5″ to 3.0″, for more effective use of compressed air will lead to the possibility of increasing the size of rock drills used.

Introduction of small-size pick hammers for mining at narrow working faces or near the ore chute instead of work by hand with chisel and hammer will lead to an efficient working.

Dressing : The dressing method for oxide ore, which occupies the most part of the Furnas ore, should be investigated by the special organizations (such as CETEM and IPT) to improve the recovery rate.

2–1–3 Panelas Mine

(1) Present Situation

Although the mine is the most modern one among the five, it is in a stage of sealing down production because of decreased ore reserves. It is worthy, in the mining, because trackless mining is being used. The productivity is 40 tons per capita per month, which is higher than other

mines. Both the dressing plant and refining plant have been considerably modernized.

(2) Proposal for Redevelopment

Prospecting : It will be difficult to increase the ore reserve within the area of the known deposit since the geological survey has almost been exhausted. Therefore, exploration efforts should be directed to other areas.

The mine has explored the strata-bound Pb-Zn-Ba deposit similar to the Perau new deposit in the Canoas area, and has confirmed the presence of an ore deposit, though small in scale. Therefore, the ore reserve should be confirmed by detailed drill survey.

It is also recommended to carry out a drill survey in the area surrounding the Itaoca granite mass in the vicinity of the known ore deposit to establish the possible existence of a contact metasomatic deposit.

Mining : Because the mining system is well organized and the operation is systematically managed, there is no particular point recommended for improvement.

Dressing and Refining : The lead concentrate is recovered at the dressing plant, and refined at the refinery. There is no particular comment on the equipment and technique of these operations except for the point of pollution control by proper treatment of the tailings from dressing and stack gas refining.

2-1-4 Barrinha Mine

(1) Present Situation

The ore reserve of this mine amounts to 20,000 tons, which is very small in quantity. The characteristic of the ore is a high content of silver, compared with that of other mines, being as high as 160 g/t on average. The dressing test plant is not operating and mining has not been systematized. There is danger every where.

(2) Proposal for Redevelopment

Prospecting : It is necessary to confirm the "down-chute" of the deposit by continuing the effort of exploration (drilling) of the lower extension of the Quatro deposit being operated. It is recommended that a drill survey, for the SIP anomaly detected to the southwest of the deposit, be carried out.

Mining: While mining is operated by sublevel stopping at 5-m intervals, the working environment underground is very dangerous because of irregular setting of working faces. It should be well organized as soon as possible. It is also necessary to enlarge the diameter of the pipeline to improve the efficiency of compressed air drills.

average. A new dressing plant is under

Dressing : New installation of mechanical dressing facilities will not be required if the mine continues to produce the high-grade ore in a small quantity.

2–1–5 Rocha Mine

(1) Present Situation

The ore is high in silver content, being 150 g/t on average. A new dressing plan is under construction, and a road for transportation of concentrate to the Panelas refining plant is being constructed. The dressing plant, mainly for gravity concentration, is operated in relatively favorable way. The production is 5,000 tons per month, which is the largest in the Ribeira area.

(2) Proposal for Redevelopment

Prospecting : It was found from the survey of the Anta Gorda project that the veins of the mine are dominant in dolomite, and underground mapping was made. Although the geological maps thus made are being used, the data from the area newly developed have not yet been supplemented. It is recommended that the underground mapping be continued to follow the distribution of dolomite and that an effective exploration (drilling and tunneling) be continued to follow.

Mining : Although the mining is being performed by sublevel stopping, it is necessary that introduction of the shrinkage method be investigated since the shape of the vein is suitable for this method.

It is necessary to consider measures for safety of the workers by preparing a manway in the raise when a high raise is being developed, electric detonators for balsting should be used in such a place.

Dressing : While new dressing plant is being constructed, necessary pollution control systems for treatment of the tailings should be considered.

In connection with the tailings pond, it is recommended to refer to the plans of the dressing plant and the tailings pond for the development of the new deposit described in this report.

Section 3 Effect of the Project on Regional Development and Local Residents

Fig. V–2 shows a flow chart composed of the development of the new ore deposit and the promotion of the existing five mines centering on the "Regional development and the influence on local residents".

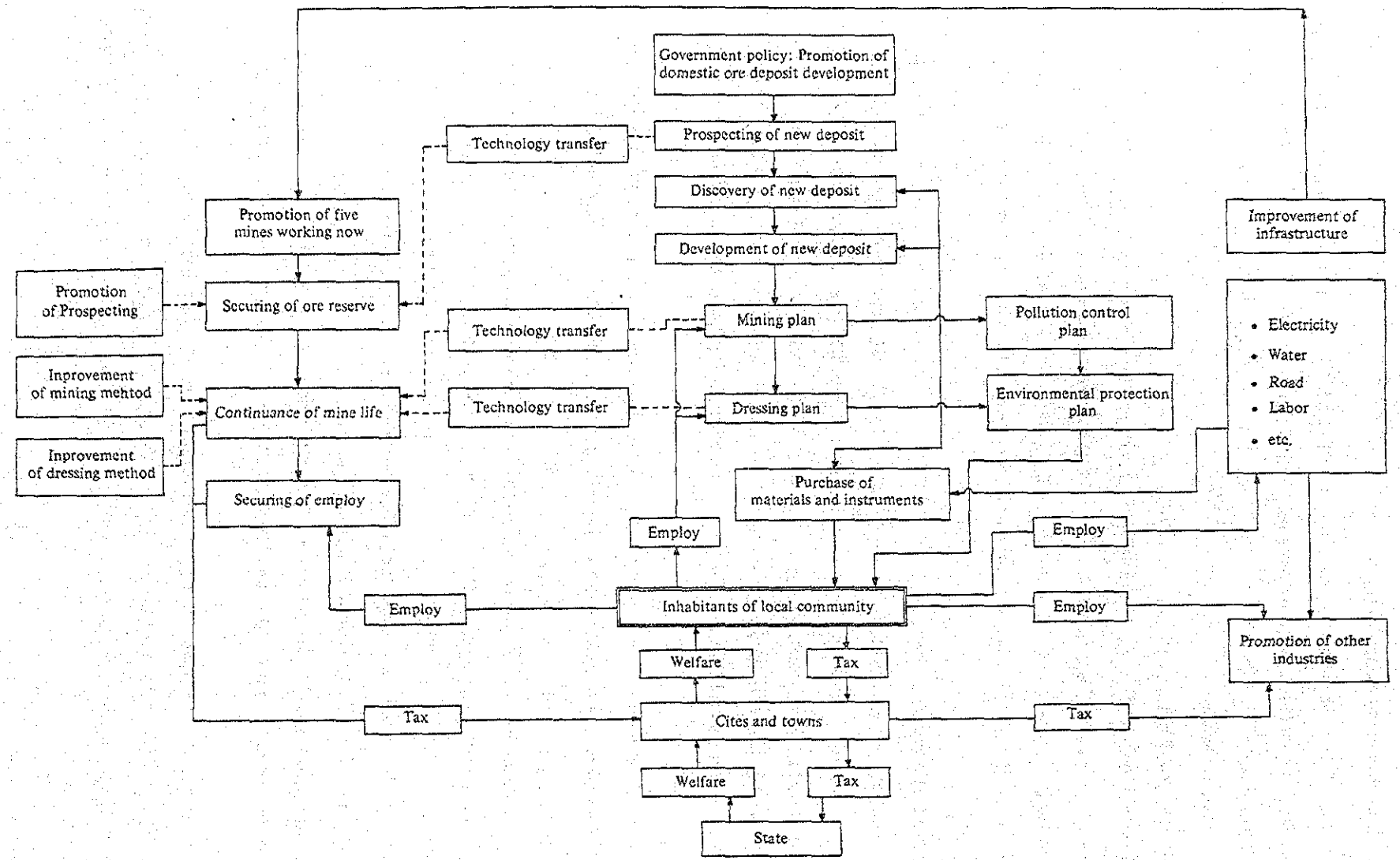

Fig. V–2 Flow Chart of Development of Ribeira Communities

At first, the development of the new ore deposit begins with promotion of a plan for mining of ore and dressing. These works are accompanied by "promotion of employment" and "purchase of materials", which will contribute to the regional development and make local residents prosperous. "Environmental protection" using antipollution measures will secure the safety of the life of local residents.

"Improvement and amplification of infrastructure" will result in a better standard of life for local residents, and further, these amplifications of infrastructure will lead to the "promotion of other industries (such as forestry and livestock farming)", related to the "promotion of employment".

In regard to the existing five mines, although it is urgent to promote their operation, "promotion of exploration" and "security of ore reserve" will be essential in preparation for the shortage of ore reserves. The discovery of the new deposit gives great incentive to the development in the area in that sense. The technology of the development of the new deposit and the development of a dressing method will give a technological lead to the five mines in the area in future, and will pave the way for technology transfer.

Security of ore reserves of these five mines and the technological innovation will provide success in processing low-grade ores and stability of the mines, which will relate to the "promotion of employment" and welfare of local residents.

Economical development of the district will result in the increase of tax, which will provide the residents with a form of "welfare".

The compilation of the above, centering on the regional development and local residents, is expressed as follows:

(1) Promotion of employment
  (i) Redevelopment of the existing five mines
  (ii) Development of the new deposit
  (iii) Improvement of infrastructure
  (iv) Promotion of other industries
(2) Purchase of materials
  (i) Redevelopment of the existing five mines
  (ii) Development of the new deposit
  (iii) Improvement of infrastructure
  (iv) Promotion of other industries
(3) Replacement of tax

  Amplification of welfare by replacement of tax.

(4) Environmental protection

Protection of the environment by antipollution measures for the new deposit.

(5) Promotion of other industries

Promotion of other industries by amplification of infrastructure.