REPORT ON MINING DEVELOPMENT PLAN

OF

VALE DO RIBEIRA AREA

BRAZIL

MARCH 1985

JAPAN INTERNATIONAL COOPERATION AGENCY METAL MINING AGENCY OF JAPAN

> M* R N **555** 85778

No. 1 39

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PRÉFACE

The Government of Japan, in response to the request of the Government of the Federative Republic of Brazil, decided to conduct the investigation in relation to the feasibility and strategy for the development of the Perau new ore deposit and evaluate the other mines in the Vale do Ribeira Area located in the southern part of that country, and entrusted its execution to the Japan International Cooperation Agency (JICA). JICA consigned the project to the Metal Mining Agency of Japan (MMAJ). Because of its essential qualities in that it belongs to a special field involved in the mineral resources development, mining, dressing and infrastracture.

The investigation was conducted in fiscal 1984, and accomplished as scheduled under close cooperation with the Government of the Federative Republic of Brazil and its various agencies, especially the Departamento Nacional da Produção Mineral (DNPM) of the Ministry of Mining.

This report is the compilation of the results of the investigation of this year.

We wish to express our heartful gratitude to the Government of the Federative Republic of Brazil and its appropriate agencies and organizations concerned, as well as the Ministry of Foregin Affairs, the Ministry of International Trade and Industry, the Embassy of Japan in the Federative Republic of Brazil and the companies concerned for the operation and support extended to the Japanese survey team.

March 1985

Anita Rigaha

Keisuke Arita President Japan International Cooperation Agency

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Masayuki Nishiie President Metal Mining Agency of Japan

ACKNOWLEDGMENTS

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

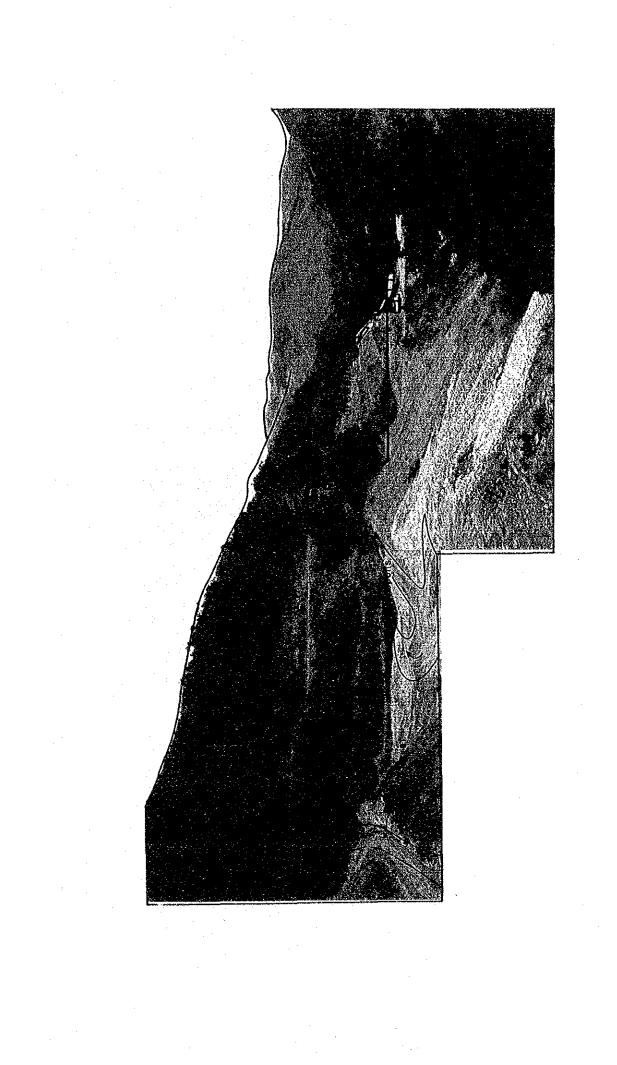
The objective of the study was to formulate a mining development plan for Vale do Ribeira Area, located in southern part of the Federative Republic of Brazil, and to study the feasibility related to implementation of the Plan. The dressing test for this study was performed by the cooperation of the Bishimetal Exploration Corporation.

It is my sincere wish that this study will contribute to the regional development around the Area and further to the economic development of the Federative Republic of Brazil, and that it will also help strengthening the friendly and cooperative relationships between the Federative Republic of Brazil and Japan.

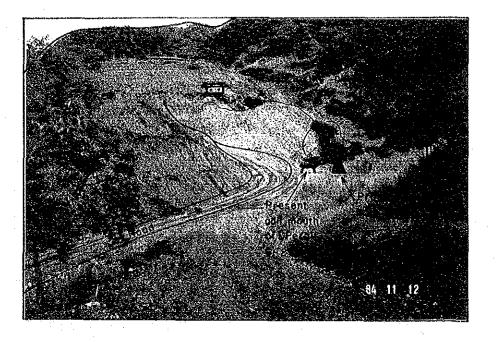
I would like to express my gratitude to government organization of Brazil, particularly Departamento Nacional da Producão Mineral, for their strong supports in all aspects, and also to the Japanese Embassy. The dressing test was performed by the cooperation of the Bishimetal Exploration Corporation.

My deep appreciation is extended also to the Ministry of Foreign Affairs, the Ministry of International Trade and Industry, the Japan International Cooperation Agency, the Metal Mining Agency of Japan. March 1985

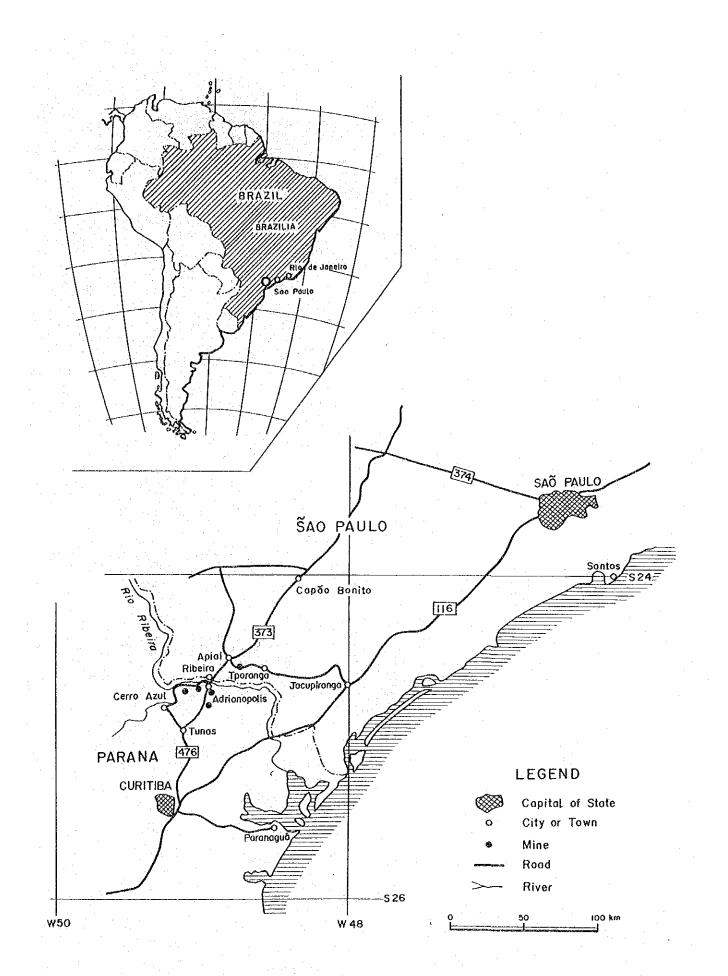
Saburo Kawai President International Development Center of Japan



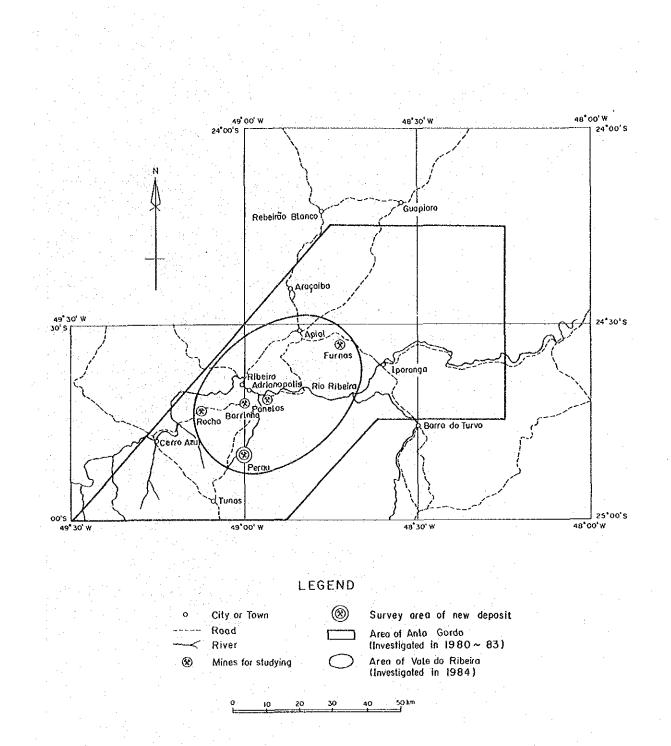
Proposed area for new dressing plant



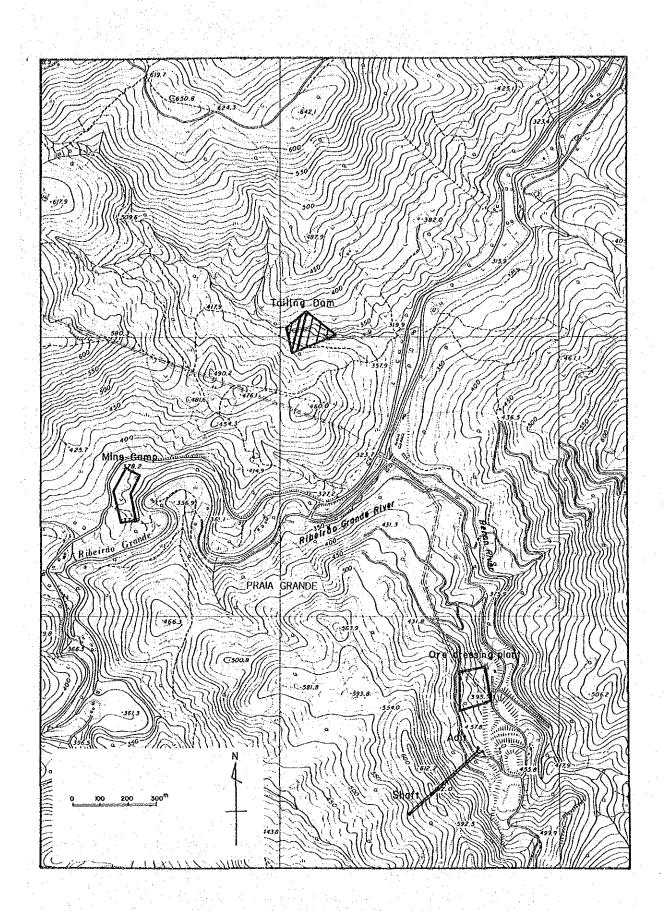
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Location Map of Project Area



Location Map of the Investion Area



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Flow Chart of Development of Ribeira Communities

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ABSTRACT

(1) It was decided to investigate the possibility of developing the new deposit, discovered in the Perau area, with inferred (1984) ore reserves of one million tons, in response to a request of the Brazilian Government, on the basis of survey results of ore deposit carried out at the end of the previous year. Moreover, the direction of a comprehensive development of the whole area was proposed.

(2) The field investigation was carried out by cooperation between six specialists in every sector, despatched by the Japan International Cooperation Agency and the Metal Mining Agency of Japan, and counterparts from Brazil, during the period from November 2 to December 5, 1984.

(3) The ore reserve of the new deposit in the Perau area has been confirmed as follows.

Ore reserve (ton) Pb (%) Zn (%) Ag (g/t) BaSO₄ (%) Au (g/t)

1,000,000 4.0 2.0 80 18 Below 0.5

The ore consists of a combination of barite and sulfide. The new deposit is dominated by barite and sphalerite when compared with the existing Perau deposit. The ore minerals are concentrated in a certain horizon in a disseminated form. Average grades of the ore are shown above and only traces of gold are found.

(4) Mining Plan of New Deposit

The following conditions were set as the draft mining plan for the operation:

| Period of mine life 10 yea | | | |
|----------------------------|--------------|--|--|
| Minable ore reserve | 924,000 tons | | |
| Annual production | 90,000 tons | | |
| Monthly production | 7,500 tons | | |

The development will begin with the excavation of a cross cut, extending 400 m from the surface, close to the adit mouth of the G-2 level. A vertical shaft will be sunk at a point 350 m from the adit mouth of the cross cut.

The vertical shaft will be 325 m in total length by sinking 300 m deep with a raise of 25 m. The shaft winding is to be established through the raise.

Nine exploitation levels will be excavated from the shaft at vertical intervals of 20 m.

Upward pillar stoping is planned for mining the ore at the thick bed part and upward stoping with timbering or waste piling at the thin bed part.

The estimate for the mining cost per ton was set at US\$13.00 in the draft plan because ample cheap manpower can be used in place of mechanization.

(5) Dressing Plan

The dressing plan was drawn up by considering the result of the dressing test conducted in Japan, the dressing operated at the Panelas mine and the operational results of lead and zinc dressing plants in Japan. All the ore feed will be processed by the flotation method and differential flotation of lead, zinc and barite will be adopted.

The flotation targets for each concentrate are as follows:

Lead concentrate : 67 % lead grade and 94% recovery and 1200 g/t silver grade and 85 % recovery.

Zinc concentrate : 53 % zinc grade and 83 % recovery.

Barite concentrate : 63 % BaO grade and 40 % recovery.

The construction cost was calculated to be US\$ 3.73 per ton of ore processed, and the operation cost US\$7.3 per ton of ore (depreciation not included).

Regarding the prevention of environmental pollution, consideration was given for discharging waste water, and deposition of all the flotation tailings at the tailings dam.

(6) Infrastructure

For the transportation plan, existing roads were suitable for mine construction and operation. It was planned that lead and zinc concentrates will be transported to a refinery, while barite concentrate will be exported from the port of Paranaguá.

There were no special problems regarding water resources.

However, a new electric power source was required, because the existing power transmission and receiving facilities are insufficient. A 69 kV power line is planned to be built to Tunas, 18 km south of the mine will be extended Adrianópolis in 1986. Therefore, it will be possible to supply electricity if the mine side pays the expenses for a service line and receiving facilities.

The manpower in the operations stage totals 156 comprised of 115 for mining, 25 for dressing plant and 16 for administration and service. The mine camp is planned to be built within an easily accessible walking distance of the mine. A school, church and dispensary will be installed to provide health and education.

(7) Redevelopment of Existing Five Mines

Redevelopment of the existing five mines Furnas, Panelas, Barrinha, Rocha and Perau now operating, will greatly contribute to the development of the district and improve the life and welfare of the residents. The future of the mines will be ensured by promoting exploration

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and location of reasonable quantity of ore reserves.

Development of the new mine will give new technological incentive to these five mines as well as stimulate management, and will also profit local resisdents by the promotion of employment, purchase of materials, improvement of infrastructure and furtherance of other industries.

(8) Overall Evaluation

The result of the economic analysis shows that the development of the new deposit will be advantageous for the Brazilian economy even if the international price of concentrates goes down by 10% from the time of the field survey; which leads to the conclusion that it warrant to proceed with development. However, according to the financial analysis, the development of the mine will not be attractive for private investors, unless the domestic price of concentrates goes up by 20% of the current prices.

Since the Government of Brazil is aiming at the self-sufficiency in supply of non-ferrous metals, it may be recommended for the Government to facilitate private investments by taking such measures as refund of indirect taxes on materials and machinery, mitigation of IUM (tax on mineral sales), reduction of interest rate or increase in the ceiling amount of the government financing.

In view of the fact that the new deposit is the largest in the Area where mineral production is being reduced, the development of the deposit will make significant contributions to the economic and social development of the Area.

CHAPTER I INTRODUCTION

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CHAPTER I INTRODUCTION

1. Forword

It is said that the 21st century will be an era of Brazil. The extensiveness of the land and the rich occurrence of mineral resources produced are pointed as one of the reasons.

Among the abundant resources, vast ore reserves such as iron ore, bauxite, manganese ore, phosphorus ore, magnesium ore, nickel ore, uranium ore and potasium ore are picked up (Table I-1).

Among the mineral products in 1981, iron ore far outnumbered the others in quantity in the metallic sector having reached 123 million tons, which occupied 70% of the export of mineral commodities and 8% of the total amount of exports (Table I-2).

The Brazilian Government has drawn the mineral resource development plan (1981 to 1990), in which it is planned to invest 7 million USS within these ten years for development centering on aluminium, copper and iron ores.

The production of lead and zinc ores in Brazil, which have been taken up by this project, is small in quantity, and will be described in detail in Section 5. The production of lead ore in Brazil in 1983 was 20,000 tons of concentrate (60.5 % Pb) and that of zinc ore was 120,000 tons of concentrate (18 % Zn).

It seems that these low figures do not mean that the lead and zinc ores are poor in their reserves, but that the planning of the exploration has been delayed in territories of Brazil.

The Ribeira area, which is the object of the survey, has been well known as one of the main areas of production of lead in Brazil.

The departamento Nacional da Producão Mineral (DNPM) of the Government of the Federative Republic of Brazil noticed the potentiality of the lead deposit of the area, and requested collaborative investigation of the area with the Government of Japan for the purpose of finding new deposits and studying effective survey techniques on the 4th of August 1980. In response to the request, the Japan International Cooperative Agency (JICA) and the Metal Mining Agency of Japan (MMIJ) despatched the survey team to Brazil in 1980 to select the area for technical survey.

As the result of the survey and negotiations, the Scope of Work of the Anta Gorda region was agreed between Japan and Brazil as the target area. Surveys were then conducted for four years from 1980.

The survey method consisted of geological survey, geochemical survey, geophysical survey and drill survey, which were executed step by step. The amount of work in each year is

-1-

| | Ore reserve (million ton) |
|------------------|------------------------------|
| Metallic ore | |
| Bauxite | 3,268 |
| [ron ore | 16,694 |
| Manganese ore | 208 |
| Copper ore | 13 |
| Non metallic ore | |
| Kaolin | 998 |
| Phosphorous ore | 218 |
| Limestone | 594 |
| Magnesium ore | 168 |

Ore reserves in Brazil (1982) Table I-1

Source : Ministério das Minas e Energia, Sumário Mineral 1983

| | · · · · · · · · · · · · · · · · · · · | (unit: ton) | | |
|--|---------------------------------------|-------------------------|-------------|--|
| | 1979 | 1980 | 1981 | |
| Asbestos | 2,422,420 | 2,602,501 | 1,992,766 | |
| Sand | 17,958,925 | 24,743,536 | 35,876,151 | |
| Clav | 3,900,119 | 5,581,826 | 21,601,433 | |
| Limestone Kaolin Doromite Phosphorous ore | 45,055,723 | 50,170,037 | 52,065,725 | |
| Kaolin | 1,343,005 | 1,156,447 | 1,063,480 | |
| Doromite | 1,711,612 | 1,354,042 | 1,960,783 | |
| Phosphorous ore | 12,477,699 | 16,532,858 | 16,441,359 | |
| Granite | 42,684,237 | 47,031,817 | 49,225,056 | |
| Bauxite | 2,883,745 | 6,688,015 | 6,969,140 | |
| Cupper ore | 599,687 | 3,699,735 | 4,345,195 | |
| Chromium ore | 891,543 | 833,935 | 926,413 | |
| Iron ore Manganese ore | 117,502,304 | 139,699,735 | 122,709,441 | |
| Manganese ore | 2,809,167 | 3,044,320 | 3,165,744 | |
| Titanium ore | 6,688,748 | a the - base | 2,910,420 | |
| Zinc ore | 545,142 | 1,153,114 | 721,041 | |

of main ore in Brazil

Source: Ministério das Minas e Energia, Departamento Nacional da Produção Mineral

shown in Table I-3.

The outcome of these survey is as described in the following.

(1) The stratigraphy and geologic structure of the area have been clarified, and the Açungui group, particularly, was subdivided.

(2) The existing deposits were classified into the Perau-type, stratabound lead deposit, and the Roca-type, which is a vein to irregularly massive, lead deposit.

(3) The geochemical survey, showed a promising anomaly in the Furnas area and two promising geophysical anomalies of IP and SIP were detected in the other areas.

(4) A new ore deposit accompanying zinc and barite was confirmed by the drill survey in the Perau area.

(5) The efficiency of the geophysical method of SIP was found to detect sulphide ore deposits in the survey area.

Among those clauses in the above, the clause (4) which the confirmation of the new ore deposit in the Perau area, particularly, is worthy and one million tons of ore reserve with average grade of 4.0 % Pb, 2.0 % Zn, 85 g/t Ag and 14 % BaO have been assumed.

On the basis of these results, the Government of Brazil requested the Government of Japan to collaborate in the execution of preliminary investigation for the possible, development plan of the Perau ore deposit in the Ribeira area including the infrastructure and the economical evaluation.

The Japan International Cooperation Agency and the Metal Mining Agency of Japan concluded a Scope of Work on 27th of September 1984 with DNPM. The collaborative investigation called the Ribeira area development project survey was performed, based on the Scope of Work mentioned above.

2. Purpose and Scope of the Survey

2-1 Purpose of the Survey

The survey aimed to investigate the possibility of development of the lead-zinc-barite deposit, together with the ore reserves of about one million tons confirmed in the Anta Gorda area, which bestrides the two states of São Paulo and Parana, under present optimum conditions. Furthermore, it was, to propose the direction of mine development and regional development of the area by comprehensively investigating and analyzing the whole area which includes the mines such as Perau, Rocha, Panelas, Furnas and Barrinha.

The main theme is shown in the following three items.

 To investigate the adaptability of the deposit in the vicinity of the Perau mine containing lead, zinc and barite, which reaches up to one million tons in reserve, by estimating the balance between incomings and outgoings and by planning optimum utilization on the national basis.
 To propose the points for redevelopment, by investigating the mines such as Perau, Rocha, Barrinha, and Furnas further to the north, for ore reserves, productivity of mining, mining

method and dressing method.

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

2-2 Scope of the Survey

(1) Mining Development

To draw up the optimum development plan by collecting the data required for the mining plan and further, for the dressing plan of the lead-zinc-barite deposit in the area, by investigating the possibilities for development of the deposit.

(2) Transportation

To work out a suitable improvement plan for the transportation of materials, shipment of concentrate and commuting of workers, by investigating transportation facilities and especially improvement of the roads.

Not only the mining development but also effects on the local residents are to be taken into account in the plan.

(3) Electric Power

To plan the source and the optimum method for supplying electric power required for the mining development, by investigating the situation of supply and demand for power in the Anta Gorda region.

(4) Water

To work out the optimum supply plan for industrial water required for the mining operation and potable water.

(5) Employees

To draw up the plan for securing manpower by investigating the working force in the surrounding area of the mine, the labor policy of the Government, the custom of labor and the wage system.

The plan of the townsite for employees and their families is also to be worked out,

(6) Total Evaluation

To present a plan for mining development by evaluationg internal economy, rate of return

_ 4

for judgement, on a national basis and evaluation of internal finance rate of return for judgement on a private basis, and investigate the scale and the period of the development,

The flow chart of the mining development is shown in Fig. I-1 with the items compiled above.

Outline of Survey Area

3.

3-1 Access and Transportation

The survey area is situated about 200 km to the southwest of São Paulo (approximately 10 million in population), the largest city in Brazil, and spread over the two states of São Paulo and Paraná with the Ribeira River between them.

The state highways (São Paulo State Highway 373 and Paraná State Highway 476) run almost through the center of the survey area. Apiaí city (8,000 in population) is the largest city in the survey area. It is about 320 km from São Paulo and it takes five hours by car to drive between these cities. From Curitiba city (1,000,000 in population), the capital city of Paranaá State to Apiaí through Tunas takes four hours by car over a distance of 170 km. Adrianópolis, where the base camp was set up, is about 40 km from Apiaí, mentioned above, and it is a one hour drive by car. The road between Adianópolis and Curitiba is unpaved.

A truck road (Federal Highway 116), connecting São Paulo city and Curitiba city, extends to the east of the survey area. Jacupiranga, situated midway of the highway, and Apiai are connected by an unpaved road which passes through Iporanga, which takes three hours to drive along (115 km).

Several regular bus services operate every day to São Paulo and Curitiba from Ribeira, which is situated along the border between the two states of São Paulo and Parana. Several air services are also operated every day between São Paulo and Curitiba.

3-2 Topography and Drainage System

A trend of geologic structure, in parallel with the eastern coast line of Brazil, predominates in the Precambrian shield in the eastern part of the country. The structure of the NE-SW system is notable in the neighborhood of the survey area, and is well reflected in the topography.

Both the Mar mountain range (Coast Range) 1,000 to 1,500 m in altitude, extending along the east of the survey area, and the Paranaplacaba range on the west, are composed of granitic

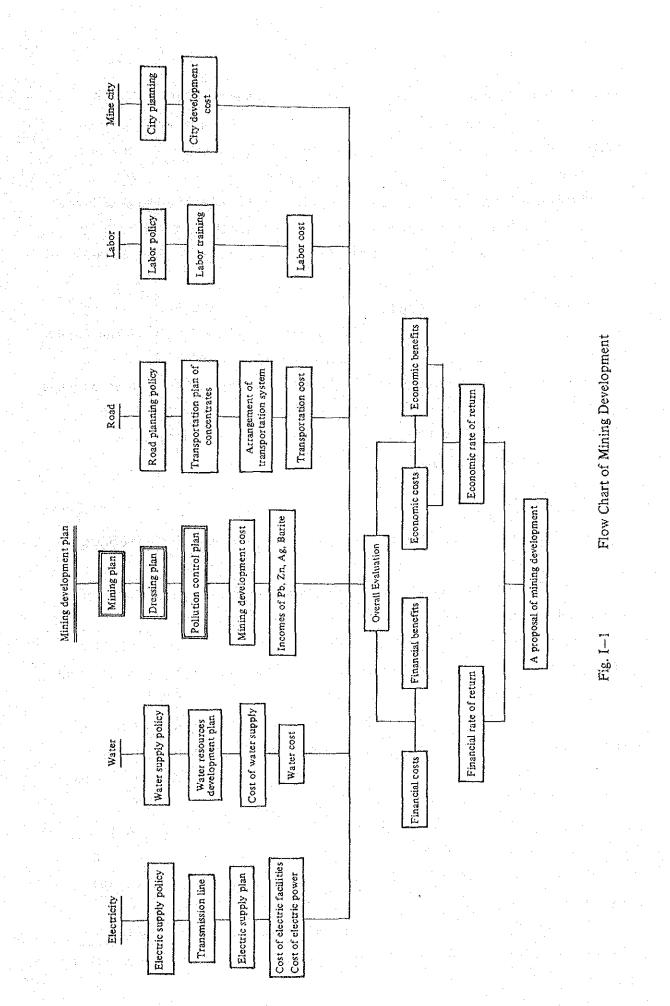
- 5 -

Table I-3 Out Line of the Field Survey and Laboratory Works in 1980 \sim 1983

| | | Phase II (1981) | Phase III (1982) | Phase IV (1983) |
|--|------------------------|-----------------------|---------------------------------------|--|
| Item | Phase I (1980) | | | Aug. 26, 1983~ |
| Period | Jan. 12 ~ Apr. 4, 1981 | Jul. 3~Oct. 22, 1981 | Jul. 2~Oct. 21, 1982 | Feb. 7, 1984 |
| Geological Survey (km ²) | | | | |
| Reconnaissance Survey | 5,800 | - | | |
| Semi-detailed Survey | _ | 1,200(Southern Part) | 1,000(Northern Part) | tom |
| Detailed Survey | | 10(Perau) | 2(Perau) | 10(Furnas) |
| | | 4(Rocha) | 8(Barrinha) | |
| Photo-interpretation (km ²) | 5,800 | | | - |
| Topographic Mapping (km ²) | | 1,200(1:25,000) | 1,000(1:25,000) | Alter and Alter and |
| | | 100(1:10,000) | | |
| Geochemical Survey | | | · · · · · · · · · · · · · · · · · · · | |
| Interpretation of Existing Data | 5,800 km ² | | | en de la companya de La companya de la comp |
| Detailed Survey | - | On the Perau | | - |
| | 학교 가격 문화 | ore Horizon | | |
| Geophysical Survey | | | | |
| Acromagnetic Interpretation | 6,750 km ² | 3,250 km ² | | _ |
| Gravity Survey | | 100 km^2 | | - |
| IP Method | - | 30.2 km (Perau) | 10 km (Perau) | 12 km (Furnas) |
| | | | 14 km (Barrinha) | |
| Spectral IP Method | un en attende service | 5 km (Perau) | 6 km (Barrinha) | 4.5 km (Furnas) |
| | _ | | 912.20m (3 holes) | 931.6m (3 holes in Perau) |
| Drilling | | | | |
| Diming | | | | 600m (2 holes in Barrinha) |
| | | 100 | 90 | 26 |
| Thin Section Polished Section | 61 51 | 50 | 53 | 32 |
| A stay (ore) | 108 | 52 | 81 (37)* | 44 (22)* |
| Assay (ore) do. (rock) X-ray Soil Pb Isotopic A nalysis Forceil | 103 | 51 | 120 | -, |
| S X-ray | 54 | 56 | | n the new group high first Receiver an the second |
| g Soil | - | 113 | eta - Litera Alpa | |
| Pb Isotopic A nalysis | | 4 | 20 | - |
| Fossil | 11 | · · · · · | - | |
| Physical Property Measurement | Magnetic | Density 58 | PFE. Resistivity 49 | 2000 - 100 - |
| | susceptibility 56 | PFE. Resistivity 30 | | |

* Samples from Drilling

- 6.-



- 7 -

rocks which have intruded under the control of the geologic structure of the NE-SW system.

The survey area forms a basin-like mountain mass (600 to 1,000 m above sea level) surrounded by these two ranges and shows a tendency to higher altitude in the west, becoming lower toward the east.

All the drainage systems belong to the Ribeira River, and the main stream flows eastward showing marked meandering. Since the altitude of the river bed of the main stream is between 100 and 200 m above sea level, the relative height of the highland reaches 500 to 1,000 m.

In the granite zone (eastern margin of the Paranapiacaba range), distributed at the western end of the survey area, the topography is relatively gentle with a dendritic drainage system, while the limestone zone to the east forms a plateau with karst topography, characterized by deep V-shaped valleys. In the phyllite-schist zone, further east of the above, valleys of trellis to parallel pattern, formed in relation to the geologic structure are dominantly observed. In the area of the southeastern part distributed by quartzite, mountain ranges with a characteristic feature formed by folding, run in parallel.

3-3 Climate and Vegetation

Most of the territories of Brazil belong to the tropics and subtropics. The tropic of Capricron at Latitude 23.5°S passes through São Paulo.

Only the two states of Santa Catarina and Rio Grande do Sul belong to the Temperate Zone geographically.

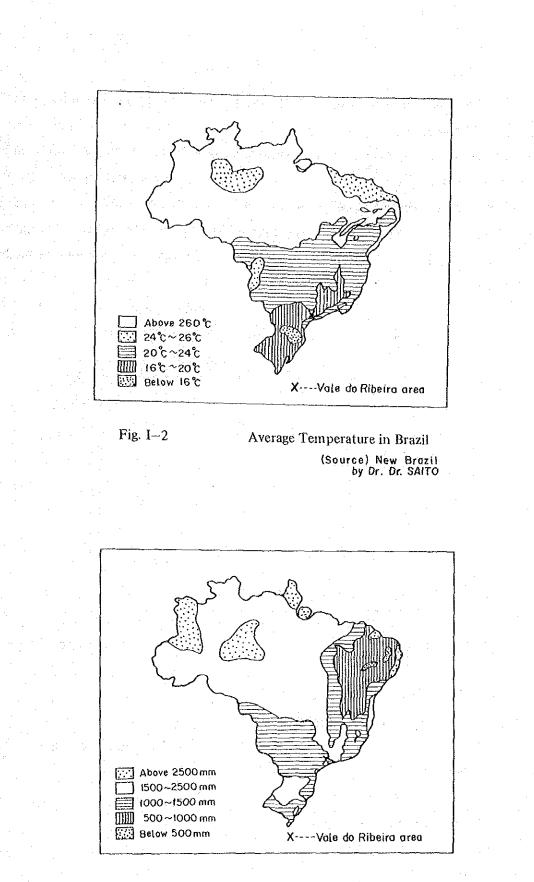
As shown by the annual mean temperature (Fig. I-2) and the annual precipitation (Fig. I-3), the territories extend from the Amazon basin of high temperature with tropical rain to the cold southern mountainous district.

While the Anta Gorda region is situated on the border between São Paulo State and Paraná State, the temperature often falls below freezing point in the both states in the period from June to August, with several frosts. The coffee plantations in northern Paraná States sometimes fuffer from heavy frost. The average temperature of the region is about 16° to 20°C.

Although the annual precipitation is more than 2,500 mm in some part of the Amazon district, it is in the range of 1,500 to 2,000 mm in most parts of the country. About 1,300 mm falls in southern São Paulo State, where it is rainy in summer from December to March and drier in winter from June to August.

Critiba, the capital city of Paraná State, is situated 170 km to the south of the Anta Gorda region, where the highest mean temperature of 22.7°C, the lowest mean temperature of

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Rainfall in Brazil

(Source) New Brazil by Dr. SAITO 12.9°C, the annual mean temperature of 18.9°C, and the annual precipitation of 1,600 mm are shown in the Table 1-4.

Vegetation is generally thick, and the mountains are covered with thickly wooded conifers and miscellaneous trees. In most of the area, however, the trees have been cut down nearly to the hilltop, and the cutovers are utilized as plowed fields and ranches. Beside these conifers and miscellaneous trees, shrubs and samambarias are thickly wooded. Among them samambaria grows thickly on the terrains of granite and metamorphic rocks, but it does not gorw on the limestone terrain.

| | 7 | emp. (°C |) | Rainfall (mm) |
|----------------|------|----------|---------|---------------|
| Main city | max. | min. | average | |
| Belem | 31.5 | 22.3 | 26.0 | 3,281 |
| Recife | 28.8 | 21.0 | 25.4 | 2,253 |
| Bahia | 28.0 | 23.4 | 25.2 | 1,563 |
| Belo Horizonte | 27.5 | 16.9 | 21.5 | 1,543 |
| Rio de Janeiro | 27.6 | 21.3 | 24.2 | 1,055 |
| São Paulo | 25.4 | 15.6 | 19.6 | 1,302 |
| Brasilia | 26.6 | 15.9 | 20.5 | 1,796 |
| Critiba | 22.7 | 12.9 | 18.9 | 1,607 |
| Porto Alegre | 24.7 | 15.5 | 19.5 | 1,330 |

Table 1–4 Temp. and Rainfalls in Main City

4. Outline of Survey Method

(1) Advance Investigation from Existing Data (in Tokyo)

(2) Collection of Information from the Government Office and the Authorities Concerned in the Cities such as Brasilia, São Paulo and Critiba

(3) Investigation in Anta Gorda Region

1) Investigation in the Perau area

Investigation for the development plan of the Perau mine and the new deposit (leadzinc-barite deposit).

2) Investigation at the Barrinha mine and the Furnas mine

To investigate the ore reserve, productivity, production, grade of ore and employees at

the Barrinha and Furnas mines.

3) Investigation at the Panelas mine and the Rocha mine

To investigate especially the actual circumstances of ore dressing and lead refining at the Panelas mine in addition to mining, and also the actual circumstances of ore dressing at the Rocha mine in addition to mining,

4) Investigation of zinc refining plant

To investigate the real condition for refining of zinc concentrate which is expected to be produced from the new deposit.

(4) To obtain the ore samples used for the dressing test at the Perau mine, which will used for an experimental dressing test in Japan.

(5) To investigate the following items for the development plan.

- 1) Ore reserve and probable crude ore
- 2) Mining plan
- 3) Dressing plan
- 4) Production of crude ore by year
- 5) Production of concentrate
- 6) Electric power
- 7) Water
- 8) Transportation
- 9) Labor force
- 10) Mine camp plan
- 11) Finance rate of return
- 12) Economy rate of return
- 13) Others

(6) Investigation Meeting in the Field (in Brazil)

To round off the day's work and discuss matters every day after completion of work.

(7) Investigation Meeting after Returning to Japan (in Tokyo)

To hold a meeting once a week, after returning to Japan, for the preparation of the report,

to arrange the data and coordinate opinion.

Members and Schedule 5.

5 - 1Members

Members Engaged in Negotiation for Survey Plan 5 - 1 - 1

Japanese Counterparts

Toshio Sakasegawa

Tsunekazu Ajiki

Takashi Kamiki

Hideyuki Ueda

Brazilian Counterparts

Carlos Oiti Berbert

Frederico Lopes Meira Barboza

Manoel da Rededenção e Siloa

Kiomaru Oguino

Maria Helena P. Teixeira Mendes

Roberto Mamiti Akinaga

5 - 1 - 2

Survey Team

(1) Japanese Counterparts

Name Work responsibilities Toru Ishihara Leader Tsuyoshi Suzuki Geology Hideyasu Wasawa Mining Takanari Kusumoto Dressing Masahiro Nakashima Infrastructure Yutaka Inoue Economics

(2) Brazilian Counterparts Work responsibilities

Leader

Geology

Mining Dressing Economics

Name

Elias Carneiro Daitx Fernando Mendes Valverde Luis Eraldo de Mattos Clovis Calestino de SA Carlos Eduardo R. Simoes Salvador Luiz Matos de Almeida Milton Akira Kiyotani

MMAJ MMAJ (Rio de Janeiro) MMAJ

JICA

DNPM

,, ,,

DNPM São Paulo

Belonging to

IDC

Belonging to

DNPM São Paulo

CETEM **DNPM São Paulo**

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5-2 Schedule of Survey Team

| Date | Journey and Object of Visit | Participant | Content |
|--------------------------|-----------------------------|---|----------------------------------|
| Nov. 2 Fri. | Lv. Narita | Ishihara, Suzuki, Inoue | Over night |
| 3 Sat, | Ar. Rio de Janeiro | | |
| 5 Sal, | AI. KIU de Janeiro | | |
| 4 Sun. | ММАЈ | | Courtesy Call |
| | | | |
| 5 Mon. | Rio → Brasilia | - " | |
| | Japanese Embassy JICA | | Courtesy Call |
| | DNPM | | |
| ан 1917 - Эл | Lv. Narita | Wasawa, Kusumoto, | •• |
| | | Nakashima | |
| | | racasinina | |
| 6 Tue. | Ar. São Paulo | 11 | Meeting |
| | Brasilia → Sao | Ishihara, Suzuki, | |
| 4. 1911 - 1919 - 1919 | | Inoue | |
| 7 Wed. | DNPM São Paulo Branch | All Members | Convertience Civili |
| i noa. | | All Members | Courtesy Call Chief of Branch |
| | | | Introduction of Survey |
| | | | Team |
| | · · · · · | | Consultation of Survey |
| · · · · · · | | | Plan |
| · · · · | Consulate General Japan | | Courtesy Call |
| | JETRO | | " |
| 8 Thu. | DNPM São Paulo | | Consultation of Sur- |
| o inu. | | | Consultation of Survey Plan |
| 9 Fri. | São Paulo → Apiai | 11 | Move for Mine Survey |
| | | | more for mile baryey |
| 10 Sat. | Furnas Mine | $\mathbf{D} = \mathbf{D} + \mathbf{D}$ | Survey of Mine |
| · · · · · · | | | |
| 11 Sun. | | 17 | Meeting |
| 12 Mon. | Perau Mine | | Engran of Mine |
| 12 Mon. | | | Survey of Mine |
| 13 Tue. | | | 11 |
| | | | |
| 14 Wed. | Rocha Mine | " | |
| * 4 A A | | · · | |
| 15 Thu. | | 11 I | Meeting Nationa |
| | | , , , , , , , , , , , , , , , , , , , | Holiday |
| 16 Fri. | Barrinha Mine | | Survey of Mine |
| 17 Sat. | | ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,, | Meeting |
| 17 Sat. | | | MeetIIB |
| 18 Sun. | | | Visit Old Apiai Gold |
| 10 Juli. | | | Mine |
| | Apiai → Curitiba | Nakashima | Move |

- 1,3 -

1 1 1

| | a she an a she a she a | | |
|---|-----------------------------|---|--|
| | | | |
| Date | Journey and Object of Visit | Participant | Content |
| Nov.19 Mon. | Panelas Mine | All Members | Survey of Mine |
| | | (except Nakajima) | |
| | Apiai → Curitiba | Inoue | Move |
| | DNPM Curitiba Branch | Nakajima | Survey of Infrastructure |
| | MATER | 11 | " (Construction) |
| | COPEL | n j | " (Electric Power) |
| | | | " (Hydrology) |
| | DNAEE | | (11) (11-5-55) / |
| | | 4 11 X (| Survey of Mine |
| 20 Tue. | Panelas Mine | All Members | Out toy or mino |
| · · · · · | | (except Nakashima and | |
| | | Inoue) | 0 |
| | DNPM Curitiba Branch | Nakashima, Inoue | Survey of Infrastructure |
| | DER | Nakashima | " (Road) |
| | DNER | 1 · · · · · · · · · · · · · · · · · · · | · · · () |
| | TELEPAR | " | " (Communication) |
| | PARANAGUE PORT OFFICE | | " (Port) |
| | BADEP | Inoue | " (Finance) |
| i en | Headman of Adrianopolis | All Members | " |
| | | (except Nakashima and | |
| : | | Inoue) | |
| | | 1110000 | |
| 21 Wed. | Apiai →Critiba | All Members | Move |
| | | (except Nakajima and | |
| | | Inoue) | |
| ÷ | Curitiba – São Paulo | Inoue | 11 - 11 - 12 - 12 - 12 - 12 - 12 - 12 - |
| | SUREHMA, ITC | Nakajima | " (Water Environment) |
| | | | (Land) |
| | PLANE JAMENTO | | Survey of Infrastructure |
| | 1 LARCE STRUCKTO | | (Regional Plan) |
| | DNPM Critiba Branch | All Members | Courtesy Call |
| 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - | DIM M CIRICA Dialich | (except Inoue) | Courtosy can |
| | COBRI | (except mode) | Survey of Infrastructure |
| | COPEL | | Survey of Immastructure |
| 00 ml | On della - A São Devilo | ., | |
| 22 Thu. | Curitiba → São Paulo | | Move |
| 1 | DNPM São Paulo Branch | | Meeting for Survey |
| | | | |
| 23 Fri. | " | All Members | Collection of Information |
| an a | | | |
| 24 Sat. | II | | |
| | | | |
| 25 Sun | ## 1 | (· · · · · · · · · · · · · · · · · · · | Arrangement of Information |
| | | | |
| 26 Mon. | DNPM São Paulo Branch | ** | Collection of Information |
| | HOECHST | Kusumoto | " (Dressing Reagent) |
| | | | (Pressing reagenry |
| 27 Tue. | DNPM São Paulo Branch | All Members | a di seconda di second |
| 2,7 100, | VILLARES | Wasawa, Kusumoto | " (Mining Equipment) |
| | TINNU | 1 HASAWA, N USHIDOLO | I (Mining Hollinmont) |

- 14 -

| | | | н | · |
|--------|--|--|--|--|
| • • | | | | |
| | Date | Journey and Object of Visit | Participant | Content |
| | 28 Wed. 29 Thu. | DNPM São Paulo MINERAL MAQ CESP JETRO, TOKYO BANK Consulate General Japan JETRO São Paulo → Brasilia Japanese Embassy JICA DNPM | All Members Kusumoto Nakashima Inoue Ishihara, Suzuki '' All Menbers | " (Dressing Equipment) Survey of Infrastructure (Electric Power) Collection of Information (Tax, Finance) Greeting " Move Greeting " Greeting and Report |
| | 30 Fri. Dec. 1 Sat. 2 Sun. 3 Mon. 4 Tue. 5 Wed. | Brasilia → Rio de Janeiro CETEN Inga Zinc Smelter Lv. Rio de Janeiro Ar. Los Angeles Lv. " Ar. Narita | 11 11 11 11 11 11 11 11 11 11 11 11 11 | Move Visit and ,, Over Night Return Home |

| | NOTES: | DNPM | ; MINISTERIO DAS MINAS E ENERGIA DEPARTAMENTO NACIONAL PRODUCÃO MINERAL | DA |
|-----|--------------------|--------------|--|-----|
| | | JETRO | ; JAPAN EXTERNAL TRADE ORGANIZATION | |
| | | ММАЈ | ; METAL MINING AGENCY OF JAPAN | |
| • | i Tari | JICA | ; JAPAN EXTERNAL TRADE ORGANIZATION | |
| | | MATER | ; COMPANY NAME | |
| | | COPEL | ; COMPANHIA PARANAENSE DE ENERGIA | |
| | | DNAEE | ; DEPARTAMENTO NACIONAL DE ÁGUAS DE ENERGIA ELÉCTRICA | |
| | | DNER | ; DEPARTAMENTO NACIONAL DE ESTRADAS DE RODAGEM | |
| | | DER | ; DEPARTAMENTO DE ESTRADAS DE RODAGEM | |
| | ан сайта. Алган | TELEPAR | ; TELECOMUNICACOES DO PARANA | |
| | 11 | SUREHMA | ; SUPERINTENDENCIA DOS RECURSOS HÍDRICOS E MEIO AMBIEN | NTE |
| | | 1TC | ; INSTITUTÓ DE TERRASE E CARTOGRAFIA | |
| | | PLANEJAMENTC | ; SECRETARIA DO PLANEJAMENTO | |
| | | BADEP | ; BANCO DE DESENVOL VIENTO DO RAPANÃ S.A. | |
| | | HOECHST | ; COMPANY NAME | |
| | · · · · | VILLARES | ; COMPANY NAME | |
| | • • | ATLAS COPCO | ; COMPANY NAME | |
| | | MINERAU MAQ | ; COMPANY NAME | · · |
| | | CESP | ; COMPANHIA ENERGETICA DE SÃO PAULO | |
| | | INGA | ; COMPANY NAME | |
| | | CETEN | ; CENTRO DE TECNOLOGIA MINERAL | |
| | | | | |
| | | | | |
| . * | | | 15 | |

Section 6. Status of Supply and Demand, and Deposit of Lead, Zinc and Silver in Brazil

6-1 Supply and Demand This project aimed to clarify the supply and demand of lead, zinc, silver, metals and ores in

Brazil, which were investigated.

The source of the data described in this section is based on the following remarks.

Samario Mineral : 1982 ~ 1984

Annual Report DNPM: 1983

6-1-1 Production, Consumption, and Import and Export of Lead and Zinc in Brazil
(1) Production of Lead Ore and Zinc Ore

The production of both lead ore and zinc ore is stable as shown in Table I-5.

(2) Production of Metallic Lead and Metallic Zinc

Table I-6 shows the production of metallic lead and metallic zinc. The amounts in 1983 were 50,000 tons per year of lead and 110,000 tons per year of zinc.

(3) Quantity of Ore Processed and Metal Consumed

Table I-7 shows the quantity of lead and zinc concentrate (including the imported ore) processed and consumed quantity of the metals. The consumption of these metals was 50,143 tons (49,520 tons in production) of lead and 112,479 tons (110,958 tons in production) of zinc. Domestic production (including the imported concentrate) covers 98 % of lead and 99 % of zinc.

(4) Amount of Export and Import of Ore and Metal

Table I-8 and Table I-9 show the record of the export and import of lead and zinc in Brazil. Import amounts of both are not outstanding.

It can be read from the above tables that the production and consumption of lead and zinc are well balanced in Brazil. Supply and demand are about 50,000 tons of metallic lead and about 110,000 tons of metallic zinc. Imports of zinc, are therefore, 30,000 tons of concentrate and 36,000 tons of metal, and of lead, 4,000 tons of concentrate and 3,500 tons of metal.

6-1-2 Production, Consumption, and Import and Export of Silver in Brazil

(1) Production of Silver

Table I-10 shows the production of silver in Brazil from 1980 to 1983. The total output in 1983 was about 55 tons.

| | Zinc (t/y) | | Lead (t/y) | | 1 |
|------|--|---|-------------|---------------------------------|-----------------------|
| | RUN OF MINE | CONS ORE | RUN OF MINE | CONS ORE | |
| 1980 | 1,153,114 | 105,000 6) | 327,515 | 21,754 5) | - |
| 1981 | 721,041 | 96,582 2) | 334,450 | 21,650 1) | 1 |
| 1982 | 738,958 | 111,882 3) | 305,953 | 19,360 1) | 1 |
| 1983 | 861,965 | 119,843 4) | 311,091 | 18,821 1) | |
| | 1) 60,5 % Pb 2) 24 % Zn 3) 19 % Zn | 4) 18 % Z 5) 60,0 % 6) 20 % Z | Pb Samario | mineral : 19 Report DNPM: 19 |) 82 — 1984 983 |

 Table 1--5
 Production of zinc and lead ore

 Table I-6
 Production of zinc and lead metal

| | Zinc (t/y) | | Lead (t/y) | |
|------|-------------|--------------|-------------|--------------|
| | PRIM, METAL | SECON. METAL | PRIM. METAL | SECON. METAL |
| 1980 | 78,303 | 17,666 | 44,519 | 40,431 |
| 1981 | 91,944 | 19,000 | 34,657 | 31,100 |
| 1982 | 95,528 | 14,400 | 21,943 | 26,299 |
| 1983 | 99,913 | 11,045 | 20,581 | 28,939 |

Samario mineral: 1982 - 1984Annual Report DNPM: 1983

 Table 1–7
 Consumption of zinc and lead

| | Zinc (t/y) | | Lead (t/y) | |
|------|------------|---------|------------|--------|
| | CONS. ORE | METAL | CONS. ORE | METAL |
| 1980 | 155,243 | 90,000 | 46,115 | 84,138 |
| 1981 | 122,582 | 126,662 | 31,665 | 67,242 |
| 1982 | 140,830 | 114,944 | 19,360 | 48,850 |
| 1983 | 150,364 | 112,479 | 23,002 | 50,143 |

Samario mineral : 1982 – 1984 Annual Report DNPM : 1983

| | Zinc (t/y) | | Lead (t/y) | |
|------|------------|--------|------------|-------|
| | CONS, ORE | METAL | CONS. ORE | METAL |
| 1980 | 18,500 2) | 59,580 | 24,361 3) | 1,422 |
| 1981 | 26,000 2) | 27,510 | 10,015 1) | 1,925 |
| 1982 | 28,948 2) | 7,609 | | 0,617 |
| 1983 | 30,521 2) | 3,675 | 4,181 1) | 3,504 |

Zinc and lead imported Table I-8

65 % Pb 3) 2) Average 52 % Zn 1) 63,5 % Pb Notes : 1982 - 1984 Samario mineral

Annual Report DNPM 1983

Table I-9 Zinc and lead exported

| | Zinc Metal (t/y) | Lead Metal (t/y) |
|------|------------------|------------------|
| 1980 | 0.230 | 2.230 |
| 1981 | 11.792 | 0.440 |
| 1982 | 2.593 | 0.009 |
| 1983 | 2.154 | 0.032 |

: 1982 - 1984 Samario mineral Annual Report DNPM : 1983

Table I-10 Production of silver

| | Lead Metallugy (t) | Gold Metallugy (t) | Secondary (t) | Total (t) |
|------|-----------------------|-----------------------|------------------|--------------|
| 1980 | 22.432 | 0.487 | 18,600 | 41.519 |
| 1981 | 23.249 | 0.531 | 39.300 | 63.080 |
| 1982 | 19.303 | 0.500 | 33.000 | 52.803 |
| 1983 | 14.718 | 0.508 | 40.000 | 55.426 |

: 1982 - 1984 Samario mineral Annual Report DNPM : 1983

(2) Consumption of Silver

Table I-11 shows the consumption of silver in Brazil. It shows that the consumption is about 150 tons a year.

(3) Export and Import of Silver

Since the production of silver is 55 tons and the consumption is 151 tons, the difference of about 100 tons of silver is imported. (Table I-12)

6-2 Lead and Zinc Deposits in Brazil

The producing districts of lead and zinc ores in Brazil are, as shown in Fig. 1-4, located in relatively limited areas. These include the following.

(1) Boquira Mine in Bahia State.

(2) Vale do Ribeira Area along the border between Sao Paulo State and Parana State.

(3) Mines such as Varante, Paracatu, Unai and Morro Aqudo in the northwestern part of Minas Gerais State.

(4) Promising deposits under exploration in the vicinity of Camaquá Mine in Rio Grande Sur State and in the vicinity of Palmeiropolis in the central eastern part of Goias State.

| | Appearance Consumption (t) | Estimated Consumption (t) | | |
|------|-------------------------------|------------------------------|--|--|
| 1980 | 145.373 | | | |
| 1981 | 103.994 | 131.000 132.500 | | |
| 1982 | 136.995 | | | |
| 1983 | 151.644 | 112.560 | | |

Table I-11 Consumption of silver

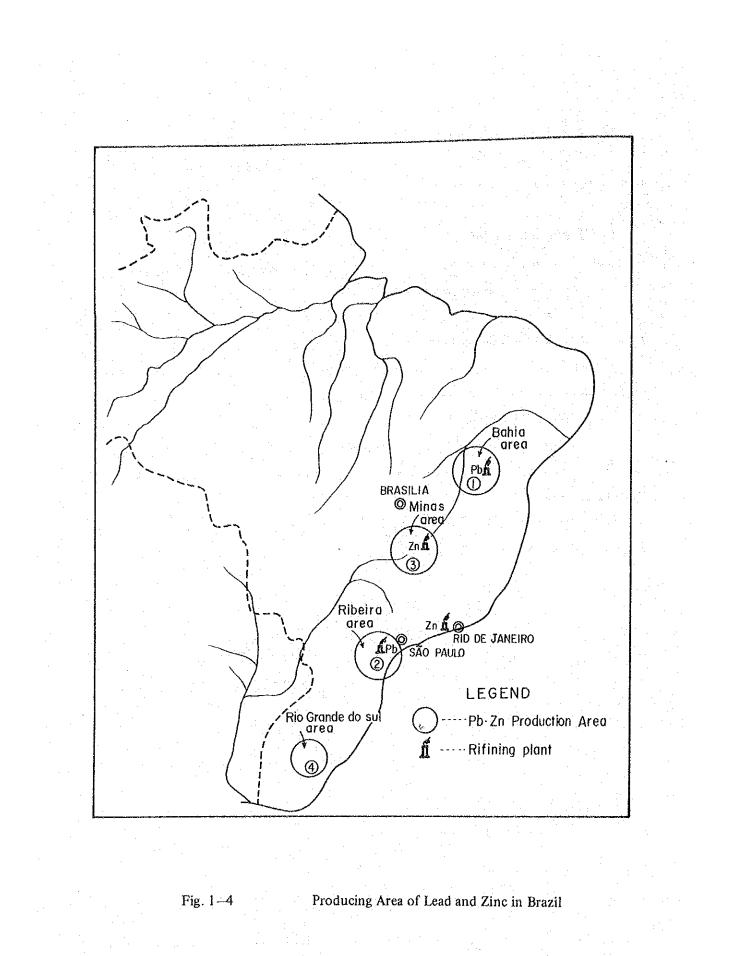
Samario mineral : 1982 - 1984 Annual Report DNPM : 1983

Table I-12Silver, imported or exported

| | Imported (t) | Exported (t) | | |
|------|--------------|--------------|--|--|
| 1980 | 41.519 | 4.328 | | |
| 1981 | 45.438 | 4.524 | | |
| 1982 | 87.477 | 3,285 | | |
| 1983 | 97.229 | 1.011 | | |

Samario mineral : 1982 - 1984 Annual Report DNPM : 1983

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Section 7. List of Mining Companies and Smelters in Brazil Related to Lead, and Zinc

- (1) Lead Ore Mining Company
 - Vale do Ribeira area
 - Mineração Boquira S/A
 - Cia Minera de Metais
 - Mineração Jussara Ltda.
 - João Ricardo de Souza
- (2) Zinc Ore Mining Company
 - Cia Mineira de Metais (CMM)
 - Mineração Areiense S/A
 - Mineração Boquira S/A
 - Mineração Jussara Ltda
 - Mineração Morro Agudo S/A
 - Mineração São Barz S/A

Plumbum SA Industria Brasileira de Mineração

Rocha Exploração e Comércio de Mineração Ltda. (Cerro Azul · Parana state

(Panelas, Perau, Rocha · Perana state)
(Boquira · Bahia state)
(Vazante · Minas Gerais state)
(Hacaranbi · Minas Gerais state)
(Lavas do sul · Rio Grande do sul)

(Vazante · Minas Gerais state)
(Vazante · Minas Gerais state)
(Boquira · Bahia state)
(Itacaranb'i · Minas Gerais state)
(Vazante · Minas Gerais state)
(Barrinha · Parana state)
(Panelas · Parana state)
(Cerro Azul · Parana state)
: Rocha · Parana state)

(3) Zinc Smelter Company

- Cia Minera de Metatis (CMM) Capacity Cia Paraibuna de Metais Capacity
- Cia Mercatil e Industrial Inga

Capacity

(4) Lead Smelter Company

- Mineração Boquirá
 Capacity
 PLUMBUM
 - Capacity
 - Mineração Morro Velho
 - Caraiba (Project)

Barreiro Grande · Minas Gerais state 72,000 t/y (1983)
Juiz de Forão · Minas Gerais state 34,000 t/y (1983)
Itaguai · Rio de Janeiro state 13,000 t/y (1983)

Santo Amro · Bahia state 22,000 t/y (1983) Panelas · Parana state 19,000 t/y (1983) Morro Velho · Minas Gerais state Caraiba · Bahia state

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Eluma Metais (Project)
 Silver refining plant

- PLUMBIUM
- Mineração Morro Velho
- Caraiba Metal (Project)
- Eluma Metais (Project)

Rio Grande · Rio Grande do Sul state

Panelas · Parana state

Morro Velho · Minas Gerais state

Caraiba · Bahia state

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Rio Grande · Rio Grande do Sul state

CHAPTER I MINING DEVELOPMENT

CHAPTER II. MINING DEVELOPMENT

Section 1 Geology, Ore Deposit and Ore Reserve

1-1 Outline of Geology

1-1-1 Outline of Regional Geology

The Precambrian Group is assumed to occupy two-thirds of the whole land of Brazil. As shown in Fig. II-1-1, it can be divided broadly into three regions of Guianas, Brazil Central and Atlantico. The survey area belongs to the southern mountain massif in Atlantico. On the east side of this massif runs a coast range which is composed of crystalline complex and is considered to have formed in the Transamazonian Orogeney (2,200 ~ 1,800 m.y.).

The Anta Gorda area lies on the west side of the range and consists of the Precambrian rocks of the Setuva formation and the Açungui group in an ascending order, into which, metabasic and granitic rocks of Brazilian Orogeny (750 \sim 500 m.y.) and dykes of Cretaceous diabasic rocks have intruded.

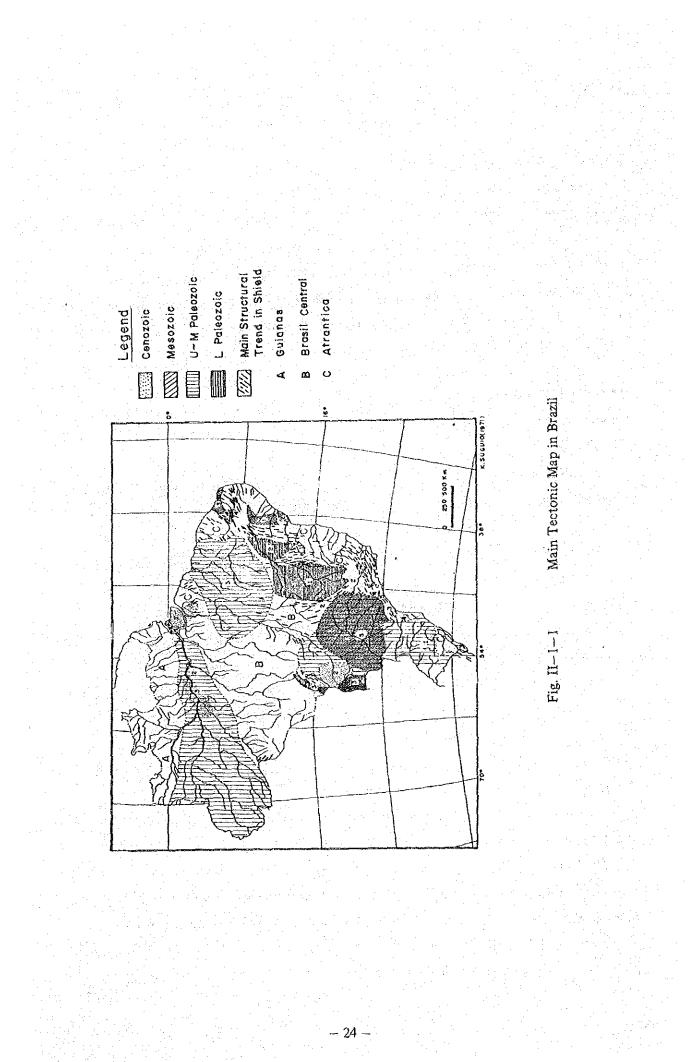
As shown in Fig. II-1-2 and Table II-1-1, the Setuva formation is mainly composed of gneiss and is narrowly distributed as a core of anticlinal structure in the southern part of the survey area, showing the NE-SW direction.

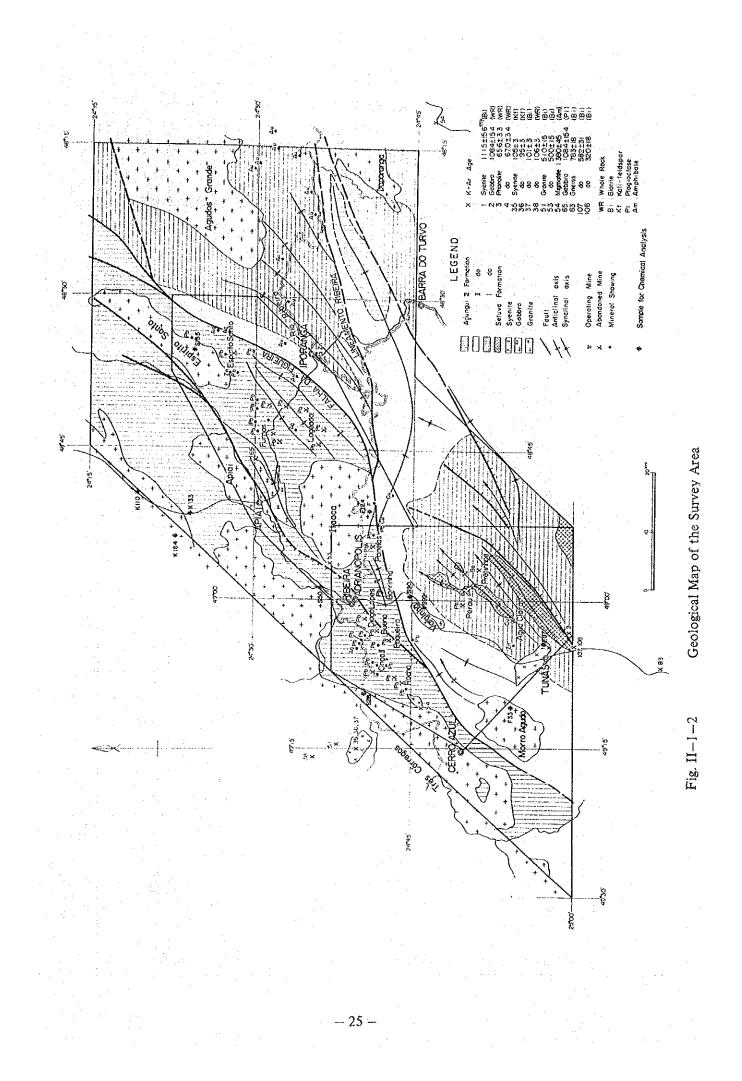
The Açungui group is mainly composed of mica-schist \sim phyllite with some amphibolite and limestone, distributed around almost the whole survey area. It can be divided from the rock facies into 3 formations, viz., Açungui I, II and III.

The ore deposits, or mineral showings of lead, occur in the Açungui I and III formations and are classified from their occurrences into 2 types, viz., Perau and Rocha.

The Perau type deposit is a strata-bound deposit emplaced in limestone to calc-silicate rocks which are developed in a lenticular form in the lower section of the Açungui I formation. The Perau mine (Pb-Ag) in operation at present, the new ore deposit (Pb-Zn-Ag-Ba) in the western part of the Perau mine which was encountered by drilling of the Anta Gorda project, the Agua Clara mine (Pb-Cu-Ba) which is out of operation, the Pretinho mine (Ba) which is under preparation for development and the Canoas deposit (Pb-Zn-Ag-Ba) which is under exploration, belong to this type.

The Rocha type deposit is a vein-type to an irregular, massive deposit emplaced in calcareous rocks in the Açungui III formation. The typical operating mines are the Rocha mine, the Barrinha mine, the Furnas mine and the Paneras mine, and resting mines such as the Lageado-Serra deposits, the Espirito Santo mine, the Paqueiro mine, the Bueno mine and the Diago Lopas mine. Other showings are known in the area.





| Gr | | roup, | | Columnar | Columnar | | ectonic | Igneous | Mineralizatio |
|---------------------------------|-------------|---------------|-----------------|---|--|----------|----------------------|----------|---------------|
| Geological Age Format Mambe | ber | 1 OL | Section | | | lovement | Activity | ļ | |
| Quaternary | | | ~~ | | gravel, sand | | | | |
| Cretaceous | | | | | | | 1 | abbro, d | |
| Jurassic | | | • | | | | ł | • | |
| Cambrion | | • | | | | . 1 | Brazilian Orogeny | grante | |
| | | 2 . | | | | | Bra | gdbbro | |
| | | \sim | <u>ب</u> ر ا | | AUSy meta sondstone-quartzite with mica schist | 1 | ? | | |
| | - - - | | member | | AML3 limestone-colc-schist | | | | |
| | | | Upper | | ANL sps intercalation of mica schist | | | | |
| | | A∐F | er. | | AWS2 phyllite~ mica schist | | · · | | |
| | | | member | | | | | | |
| | | 5,500± m | Middle | | A狙Szés intercalation of limestone~calc-schist A狙Lz limestone, dolomite & calc-schist | | | | |
| Pre – Combrian | | 194 | her hber | | ANSı mica schist | | | | Ň |
| н 1917 - 1913 1917 - 1913 | G . | : | Lowe | | AEL 1 limestone - calc - schist | | • | | |
| | п 0 | . , | | | Allss intercalation of meta sandstone | | Orogeny | | |
| | Gr | AI | F | | Allps 'phyllite – mica schist Allss intercalation of meta sandstone Allcs intercalation of catc – schist | | | | |
| | n b | • • . |)0 ± | ~ ~ ~ | Allam intercalation of amphibolite~cmphibole schist | | CCOD | | |
| | . u . n | 5,51 | m | <u>ా సినిమా సంగా</u> గ్రామానికి గ్రామానికి | Allps phyllite~mica schist Allss intercolation of meta sandstone | | Urua | | |
| | ΡÇ | | | | Allss meta sondstone ~ quartzite | | ل ہ | | : |
| | | | | ~ | Allos mica schist | | | | · . |
| · | | | | | Alles colc-schist~limestone | | | Å | |
| | | | | ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~ | AIam amphibolite~amphibole schist AIps mica schist | | | | |
| | · . | ΑI | F | <u>vvvv</u> ~ | | | | | |
| | | • | | \sim \sim \sim \sim | Alss intercalation of calo-schist | | | basalt | |
| | | | | V | AIps mica schist AIam amphibolite~amphibole schist | | | | be |
| | | 3,50 ~ 4,0 | 0 00 m | 3 3 3 3 3 | AI& limestone, dolomite & calc-silicate rock (Peray horizon) AIqt quartzite | | | | Perau type |
| | Setu | va I | - | ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~ | Sgn gneiss ~ mica schist | | | | |
| | | 500 | n ± | 1 11115 | Sqt quartzite | | | | |

Table II-1-1 Generalized Stratigraphic Column

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The main ore deposits and the mineral showings swarm in $AIIIL_2$ and $AIIIL_3$ members of the calcareous rocks in the Açungui III formation.

Regarding the genesis of the ore deposits, it is thought that in the Perau deposit, the sulfide minerals were syngenetically deposited in calc-silicate rocks of the Açungui I formation in a reducing environment from low-temperature hydrothermal solution which ascended in association with a basic igneous activity. In the Rocha type deposits, the sulfide minerals which had been deposited in the calcareous rocks of the Açungui III formation were removed to, and concent-rated in the vein fractures which were formed by the later Brazilian Orogeny.

1-1-2 Outline Geology of Perau Area

The geology of the surrounding area of the Perau mine consists of the Setuva formation and the Açungui I formation (Fig. II-1-3). The Setuva formation is composed of gneissose rocks (Sgn) and is distributed in the axial parts of the Perau and the Agua Clara anticlines.

The Açungui I formation conformably overlies the Setuva formation, and consists of quartzite (AIqt), limestone and dolomite to carbonate schist (AIIs) (where the Perau deposit and thin layers of graphite schist (AIgp) and dolomite (AIdo) are intercalated), mica schist (AIps), amphibolite to amphibole schist (AIam), calc-schist (AIcs) and graphite schist (AIgs) in an ascending order. Among these, limestone and dolomite to carbonate schist, in which the Perau deposit is emplaced, are distributed in an "S" shape, with the Perau mine at the center. The thin bed of graphite schist in the footwall of the ore deposit and the "magnetite zone" in the hanging wall, form effective key beds of the ore horizon.

The main geologic structure of the surroundings of the Perau mine is controlled by the Perau anticline and the Faria syncline of the NE-SW system. The Ribeirão Grande fault running to the northeast of the Perau mine is known as a provinent fault.

The Perau anticline and the Faria syncline are distributed almost parallel with the axes in the direction of N30°E to N50°E, and plunger toward the southwest. The Perau ore horizon (Alls) and the beds of the hanging wall and footwall are distributed in form as "S" shape affected both by the Perau anticline and the Faria syncline. The Perau horizon pinches out in the southern part of the mine.

The Perau mine is located in the northwestern limb of the Perau anticline. Structures such as minor folding and microfolding are often observed underground. In addition, it is known that the ore shoot and the directions of these microstructures are consistent with each other.

The minor folding and microfolding are often observed in mica schist and carbonate schist

