No. 39

REPORT ON MINING DEVELOPMENT PLAN

OF

VALE DO RIBEIRA AREA

BRAZIL

MARCH 1985

JAPAN INTERNATIONAL COOPERATION AGENCY

METAL MINING AGENCY OF JAPAN

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PREFACE

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 Producão 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

Keisuke Arita

Keisuke Arita
President
Japan International Cooperation Agency

Masayuki Nishiie

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.

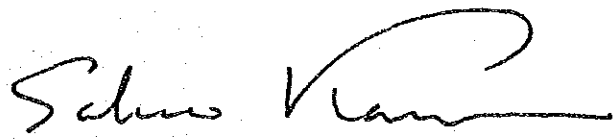
The objective of the study was to formulate a mining development plan for Vale do Ribeira Area, located in southern part of the Federative Republic of Brazil, and to study the feasibility related to implementation of the Plan. The dressing test for this study was performed by the cooperation of the Bishimetal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

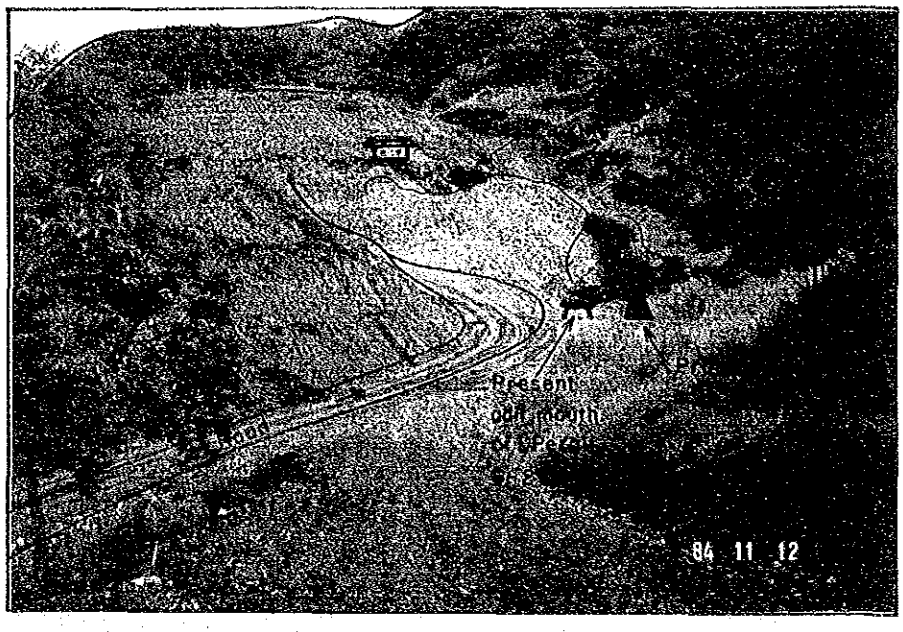
My deep appreciation is extended also to the Ministry of Foreign Affairs, the Ministry of International Trade and Industry, the Japan International Cooperation Agency, the Metal Mining Agency of Japan.

March 1985

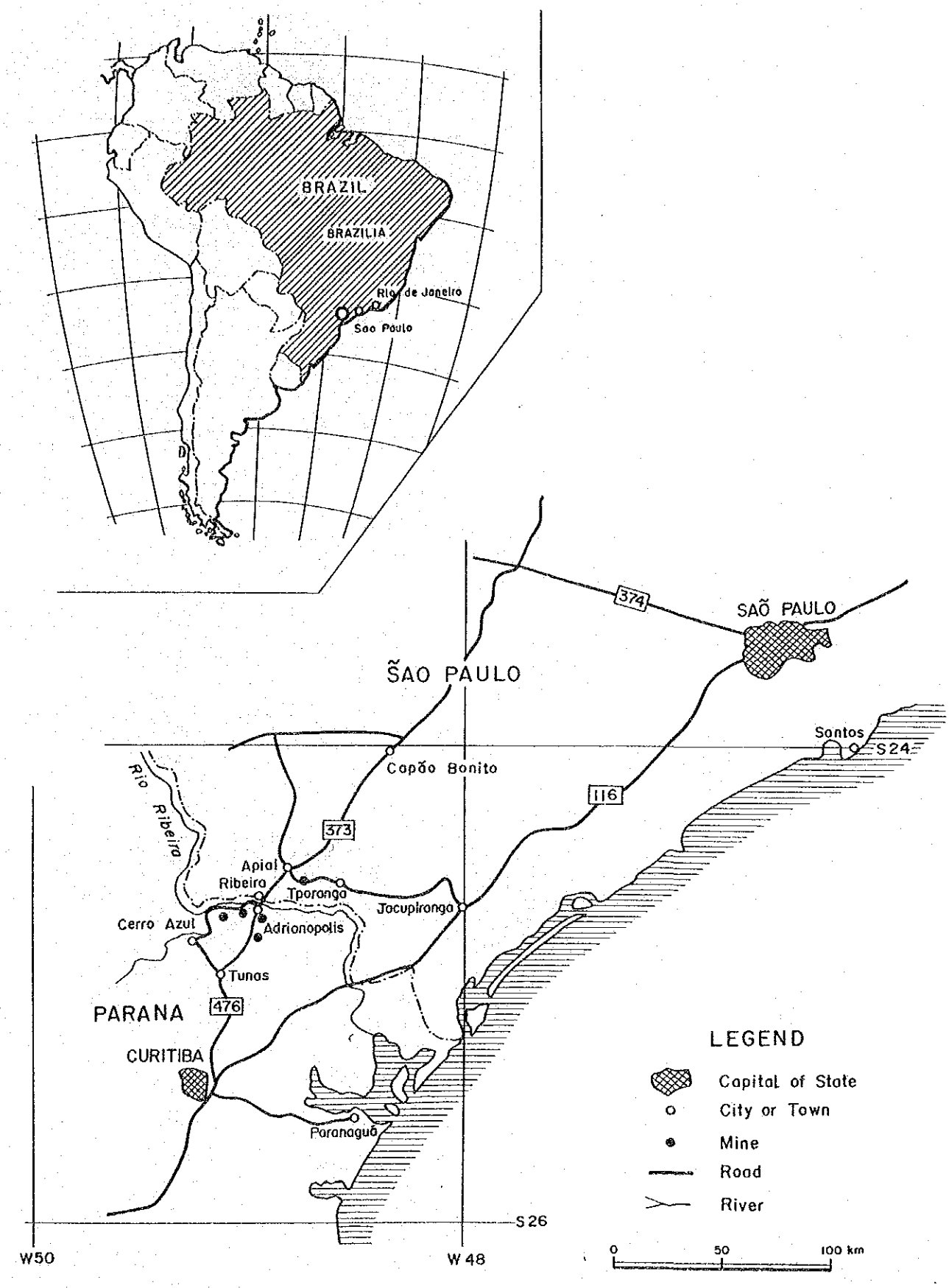


Saburo Kawai
President
International Development Center
of Japan

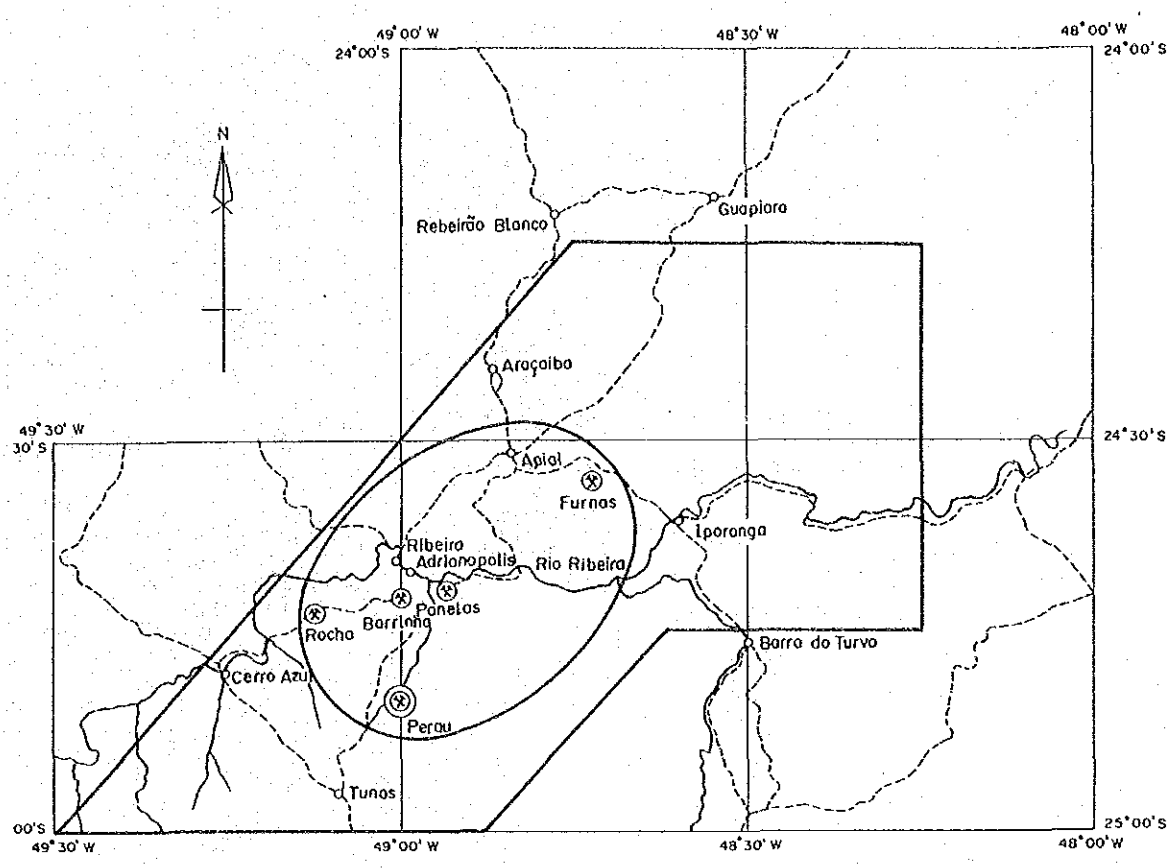
Proposed area for new dressing plant



Proposed adit mouth for new deposit



Location Map of Project Area

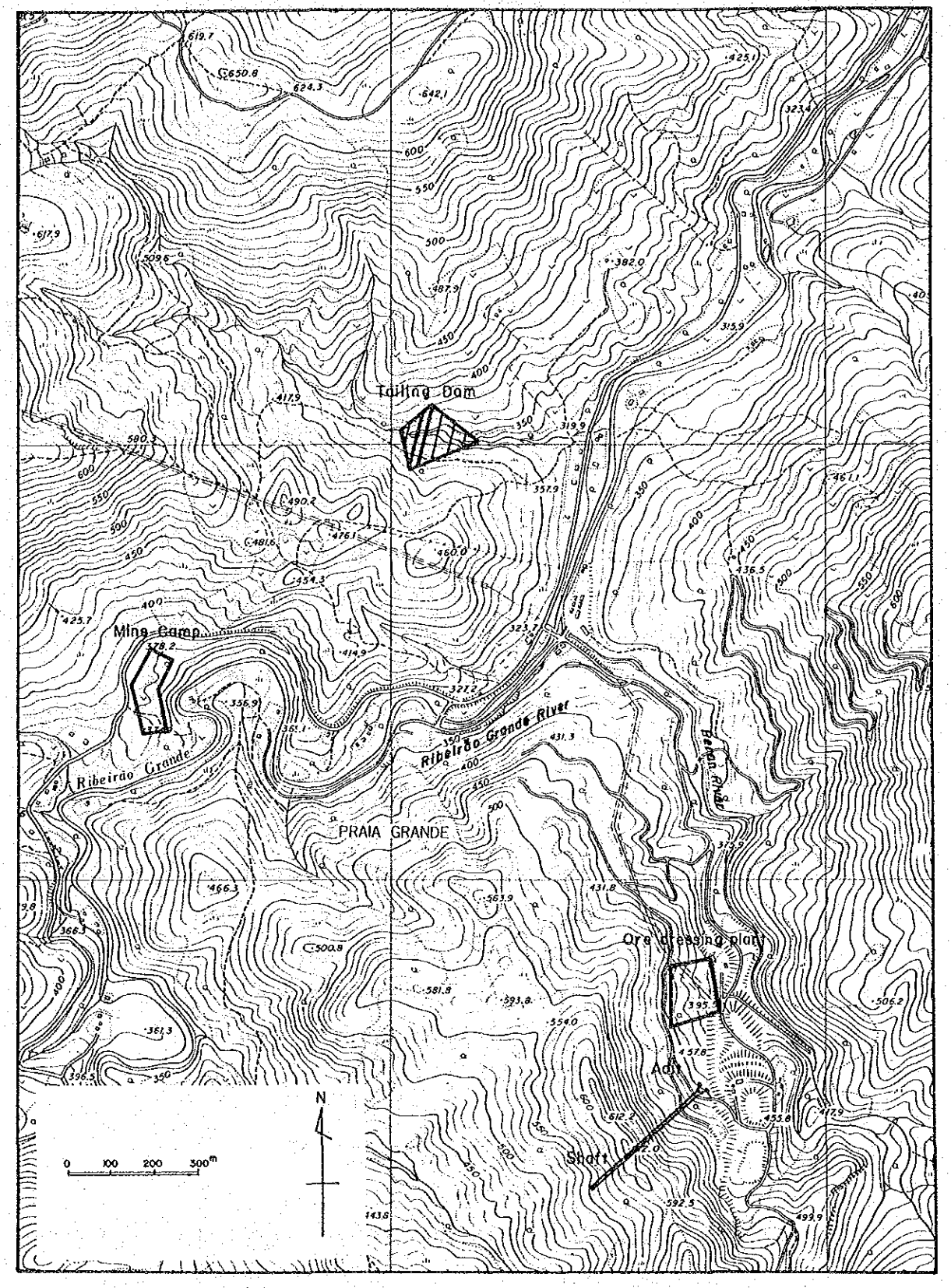


LEGEND

- City or Town
- Road
- River
- Mines for studying
- Survey area of new deposit
- Area of Anta Gordo (Investigated in 1980 ~ 83)
- Area of Vale do Ribeira (Investigated in 1984)

0 10 20 30 40 50 km

Location Map of the Investion Area



Map of Propossed Facilities in Perau Area

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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)	$BaSO_4$ (%)	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 years
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

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

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 US$ 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

Table I–1 Ore reserves in Brazil (1982)

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

Source : Ministério das Minas e Energia, Sumário Mineral 1983

Table I–2 Production of main ore in Brazil

(unit: ton)

		1979	1980	1981
Non metallic	Asbestos	2,422,420	2,602,501	1,992,766
	Sand	17,958,925	24,743,536	35,876,151
	Clay	3,900,119	5,581,826	21,601,433
	Limestone	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
Metallic	Cupper ore	599,687	3,699,735	4,345,195
	Chromium ore	891,543	833,935	926,413
	Iron 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	–	2,910,420
	Zinc ore	545,142	1,153,114	721,041

Source: Ministério das Minas e Energia, Departamento Nacional da Producão 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.

(1) 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.

(2) 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

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.

3. Outline of Survey Area

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 Paraná. 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 Paranapiacaba range on the west, are composed of granitic

Table I–3 Out Line of the Field Survey and Laboratory Works in 1980 ∿ 1983

Item		Phase I (1980)	Phase II (1981)	Phase III (1982)	Phase IV (1983)
Period		Jan. 12 ∿ Apr. 4, 1981	Jul. 3∿Oct. 22, 1981	Jul. 2∿Oct. 21, 1982	Aug. 26, 1983 ∿ Feb. 7, 1984
Geological Survey (km^2)					
Reconnaissance Survey		5,800	–	–	–
Semi-detailed Survey		–	1,200(Southern Part)	1,000(Northern Part)	–
Detailed Survey		–	10(Perau) 4(Rocha)	2(Perau) 8(Barrinha)	10(Furnas)
Photo-interpretation (km^2)		5,800	–	–	–
Topographic Mapping (km^2)		–	1,200(1 : 25,000) 100(1 : 10,000)	1,000(1 : 25,000)	–
Geochemical Survey					
Interpretation of Existing Data		5,800 km^2	–	–	–
Detailed Survey		–	On the Perau ore Horizon	–	–
Geophysical Survey					
Aeromagnetic Interpretation		6,750 km^2	3,250 km^2	–	–
Gravity Survey		–	100 km^2	–	–
IP Method		–	30.2 km (Perau)	10 km (Perau) 14 km (Barrinha)	12 km (Furnas)
Spectral IP Method		–	5 km (Perau)	6 km (Barrinha)	4.5 km (Furnas)
Drilling		–	–	912.20m (3 holes)	931.6m (3 holes in Perau) 600m (2 holes in Barrinha)
Laboratory Work	Thin Section	61	100	90	26
	Polished Section	51	50	53	32
	Assay (ore)	108	52	81 (37)*	44 (22)*
	do. (rock)	12	51	120	–
	X-ray	54	56	–	–
	Soil	–	113	–	–
	Pb Isotopic Analysis	–	4	20	–
	Fossil	11	–	–	–
	Physical Property Measurement	Magnetic susceptibility 56	Density 58 PFE. Resistivity 30	PFE. Resistivity 49	–

* Samples from Drilling

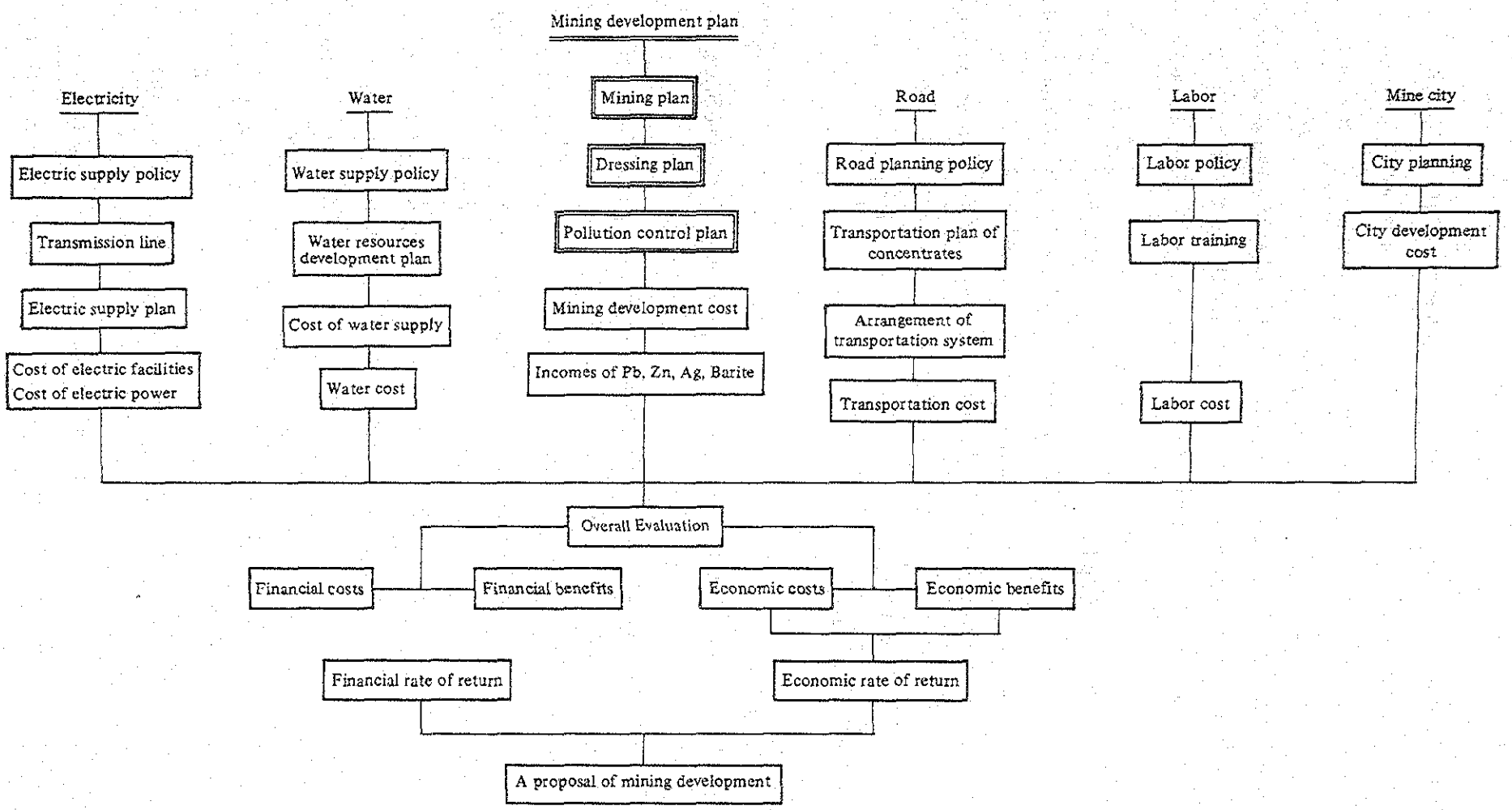


Fig. I–1 Flow Chart of Mining Development

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

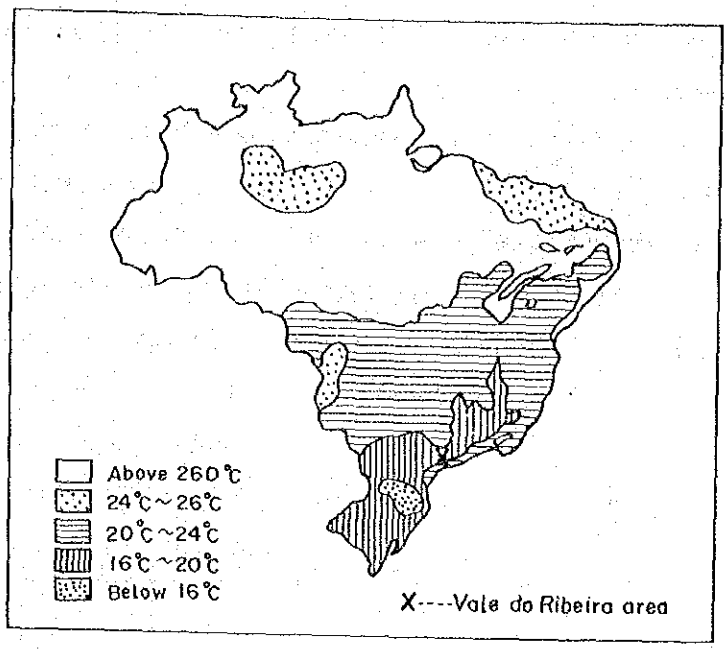


Fig. I–2 Average Temperature in Brazil

(Source) New Brazil
by Dr. Dr. SAITO

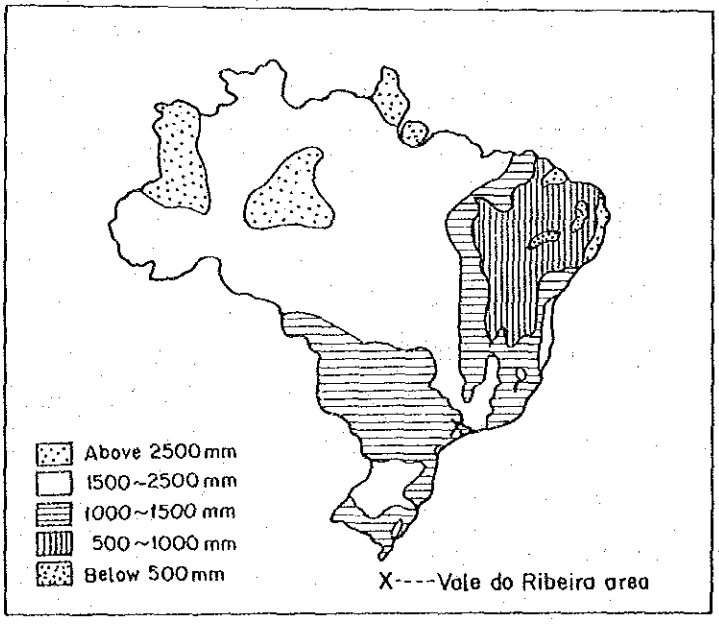


Fig. I–3 Rainfall in Brazil

(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 I–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 lime-stone terrain.

Table I–4 Temp. and Rainfalls in Main City

Main city	Temp. (°C)			Rainfall (mm)
	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

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 (lead-zinc-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.

5. Members and Schedule

5–1 Members

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

Japanese Counterparts

Toshio Sakasegawa	MMAJ
Tsunekazu Ajiki	MMAJ (Rio de Janeiro)
Takashi Kamiki	MMAJ
Hideyuki Ueda	JICA

Brazilian Counterparts

Carlos Oiti Berbert	DNPM
Frederico Lopes Meira Barboza	"
Manoel da Rededenção e Siloa	"
Kiomaru Oguino	"
Maria Helena P. Teixeira Mendes	DNPM São Paulo
Roberto Mamiti Akinaga	"

5–1–2 Survey Team

(1) Japanese Counterparts

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

(2) Brazilian Counterparts

Work responsibilities	Name	Belonging to
Leader	Elias Carneiro Daitx	DNPM São Paulo
Geology	Fernando Mendes Valverde	"
	Luis Eraldo de Mattos	"
	Clovis Calestino de SA	"
Mining	Carlos Eduardo R. Simoes	"
Dressing	Salvador Luiz Matos de Almeida	CETEM
Economics	Milton Akira Kiyotani	DNPM São Paulo

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	"		
4 Sun.	MMAJ	"	Courtesy Call	
5 Mon.	Rio → Brasilia	"		
	Japanese Embassy	"	Courtesy Call	
	JICA	"	"	
	DNPM	"	"	
	Lv. Narita	Wasawa, Kusumoto, Nakashima		
6 Tue.	Ar. São Paulo	"	Meeting	
	Brasilia → Sao	Ishihara, Suzuki, Inoue		
7 Wed.	DNPM São Paulo Branch	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 Survey Plan	
9 Fri.	São Paulo → Apiai	"	Move for Mine Survey	
10 Sat.	Furnas Mine	"	Survey of Mine	
11 Sun.		"	Meeting	
12 Mon.	Perau Mine	"	Survey of Mine	
13 Tue.	"	"	"	
14 Wed.	Rocha Mine	"	"	
15 Thu.		"	Meeting	National Holiday
16 Fri.	Barrinha Mine	"	Survey of Mine	
17 Sat.		"	Meeting	
18 Sun.		"	Visit Old Apiai Gold Mine	
	Apiai → Curitiba	Nakashima	Move	

Date	Journey and Object of Visit	Participant	Content
Nov.19 Mon.	Panelas Mine	All Members (except Nakajima)	Survey of Mine
	Apiai → Curitiba	Inoue	Move
	DNPM Curitiba Branch	Nakajima	Survey of Infrastructure
	MATER	"	" (Construction)
	COPEL	"	" (Electric Power)
	DNAEE	"	" (Hydrology)
20 Tue.	Panelas Mine	All Members (except Nakashima and Inoue)	Survey of Mine
	DNPM Curitiba Branch	Nakashima, Inoue	Survey of Infrastructure
	DER	Nakashima	" (Road)
	DNER	"	" (")
	TELEPAR	"	" (Communication)
	PARANAGUE PORT OFFICE	"	" (Port)
	BADEP	Inoue	" (Finance)
	Headman of Adrianopolis	All Members (except Nakashima and Inoue)	"
21 Wed.	Apiai →Critiba	All Members (except Nakajima and Inoue)	Move
	Curitiba – São Paulo	Inoue	"
	SUREHMA. ITC	Nakajima	" (Water Environment) (Land)
	PLANE JAMENTO	"	Survey of Infrastructure (Regional Plan)
	DNPM Critiba Branch	All Members (except Inoue)	Courtesy Call
	COPEL	"	Survey of Infrastructure
22 Thu.	Curitiba → São Paulo	"	Move
	DNPM São Paulo Branch		Meeting for Survey
23 Fri.	"	All Members	Collection of Information
24 Sat.	"	"	"
25 Sun	"	"	Arrangement of Information
26 Mon.	DNPM São Paulo Branch	"	Collection of Information
	HOECHST	Kusumoto	" (Dressing Reagent)
27 Tue.	DNPM São Paulo Branch	All Members	"
	VILLARES	Wasawa, Kusumoto	" (Mining Equipment)
	ATLAS. COPCO	Wasawa	" (")

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

NOTES:

DNPM	;	MINISTERIO DAS MINAS E ENERGIA DEPARTAMENTO NACIONAL DA PRODUCÃO MINERAL
JETRO	;	JAPAN EXTERNAL TRADE ORGANIZATION
MMAJ	;	METAL MINING AGENCY OF JAPAN
JICA	;	JAPAN EXTERNAL TRADE ORGANIZATION
MATER	;	COMPANY NAME
COPEL	;	COMPANHIA PARANAENSE DE ENERGIA
DNAEE	;	DEPARTAMENTO NACIONAL DE ÃGUAS DE ENERGIA ELÉCTRICA
DNER	;	DEPARTAMENTO NACIONAL DE ESTRADAS DE RODAGEM
DER	;	DEPARTAMENTO DE ESTRADAS DE RODAGEM
TELEPAR	;	TELECOMUNICACÕES DO PARANA
SUREHMA	;	SUPERINTENDÉNCIA DOS RECURSOS HÍDRICOS E MEIO AMBIENTE
ITC	;	INSTITUTÓ DE TERRASE E CARTOGRAFIA
PLANEJAMENTO	;	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

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.

Table I–5 Production of zinc and lead ore

	Zinc (t/y)		Lead (t/y)	
	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)
1982	738,958	111,882 3)	305,953	19,360 1)
1983	861,965	119,843 4)	311,091	18,821 1)

Notes
1) 60,5 % Pb
2) 24 % Zn
3) 19 % Zn
4) 18 % Zn
5) 60,0 % Pb
6) 20 % Zn

Samario mineral : 1982 – 1984
Annual Report DNPM: 1983

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 – 1984
Annual Report DNPM : 1983

Table I–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

Table I–8 Zinc and lead imported

	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

Notes 1) 63,5 % Pb 2) Average 52 % Zn 3) 65 % Pb

Samario mineral : 1982 – 1984
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

Samario mineral : 1982 – 1984
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

Samario mineral : 1982 – 1984
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. I--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.

Table I--11 Consumption of silver

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

Samario mineral : 1982 – 1984
Annual Report DNPM : 1983

Table I--12 Silver, 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

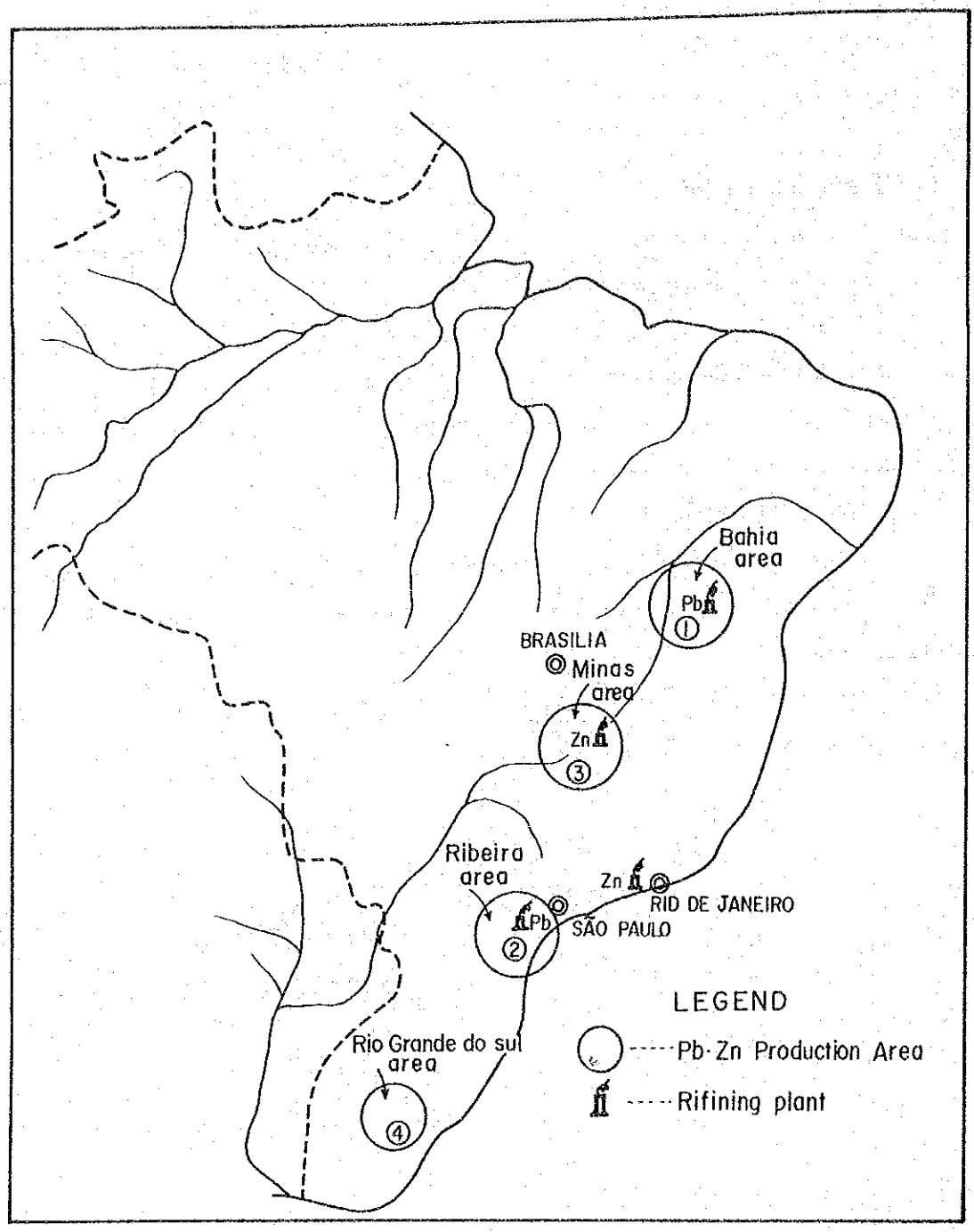


Fig. 1–4 Producing Area of Lead and Zinc in Brazil

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

(1) Lead Ore Mining Company

- Vale do Ribeira area (Panelas, Perau, Rocha · Perana state)
- Mineração Boquira S/A (Boquira · Bahia state)
- Cia Minera de Metais (Vazante · Minas Gerais state)
- Mineração Jussara Ltda. (Hacaranbi · Minas Gerais state)
- João Ricardo de Souza (Lavas do sul · Rio Grande do sul)

(2) Zinc Ore Mining Company

- Cia Mineira de Metais (CMM) (Vazante · Minas Gerais state)
- Mineração Areiense S/A (Vazante · Minas Gerais state)
- Mineração Boquira S/A (Boquira · Bahia state)
- Mineração Jussara Ltda (Itacaranb'i · Minas Gerais state)
- Mineração Morro Agudo S/A (Vazante · Minas Gerais state)
- Mineração São Barz S/A (Barrinha · Parana state)
- Plumbum SA Industria Brasileira de Mineração (Panelas · Parana state)
- Rocha Exploração e Comércio de Mineração Ltda. (Cerro Azul · Parana state : Rocha · Parana state)

(3) Zinc Smelter Company

- Cia Minera de Metatis (CMM) Barreiro Grande · Minas Gerais state
  Capacity 72,000 t/y (1983)
- Cia Paraibuna de Metais Juiz de Forão · Minas Gerais state
  Capacity 34,000 t/y (1983)
- Cia Mercatil e Industrial Inga Itaguai · Rio de Janeiro state
  Capacity 13,000 t/y (1983)

(4) Lead Smelter Company

- Mineração Boquirá Santo Amro · Bahia state
  Capacity 22,000 t/y (1983)
- PLUMBUM Panelas · Parana state
  Capacity 19,000 t/y (1983)
- Mineração Morro Velho Morro Velho · Minas Gerais state
- Caraiba (Project) Caraiba · Bahia state

• Eluma Metais (Project)	Rio Grande · Rio Grande do Sul state
Silver refining plant	
• PLUMBIUM	Panelas · Parana state
• Mineração Morro Velho	Morro Velho · Minas Gerais state
• Caraiba Metal (Project)	Caraiba · Bahia state
• Eluma Metais (Project)	Rio Grande · Rio Grande do Sul state

CHAPTER Ⅱ 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 ~ 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 ~ 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.

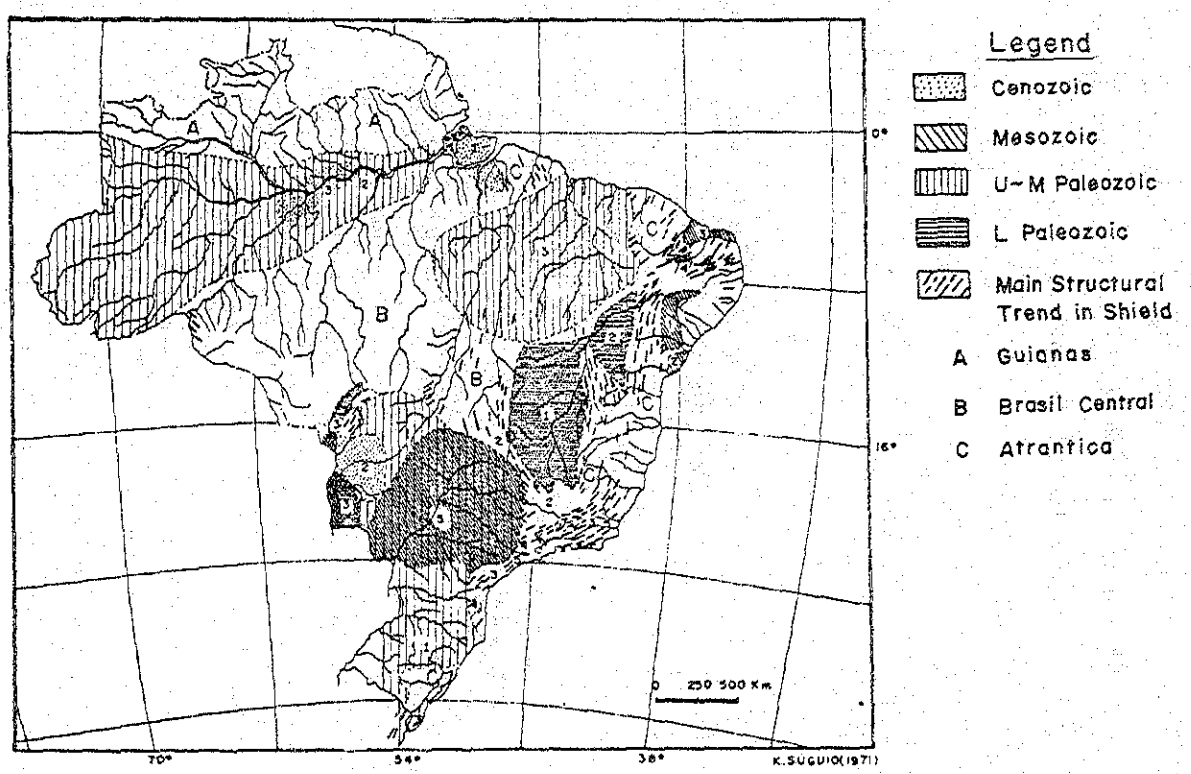


Fig. II–1–1 Main Tectonic Map in Brazil

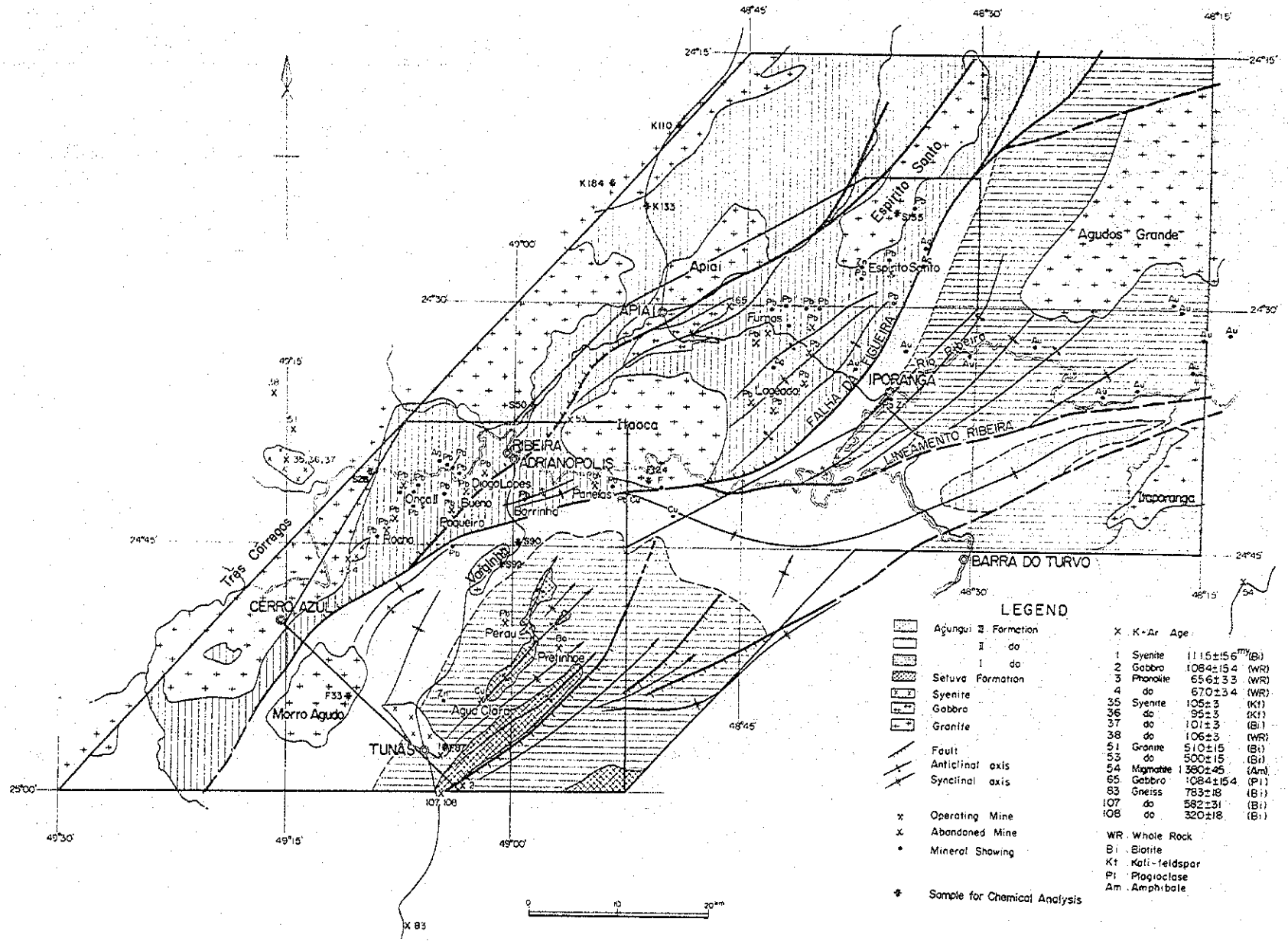
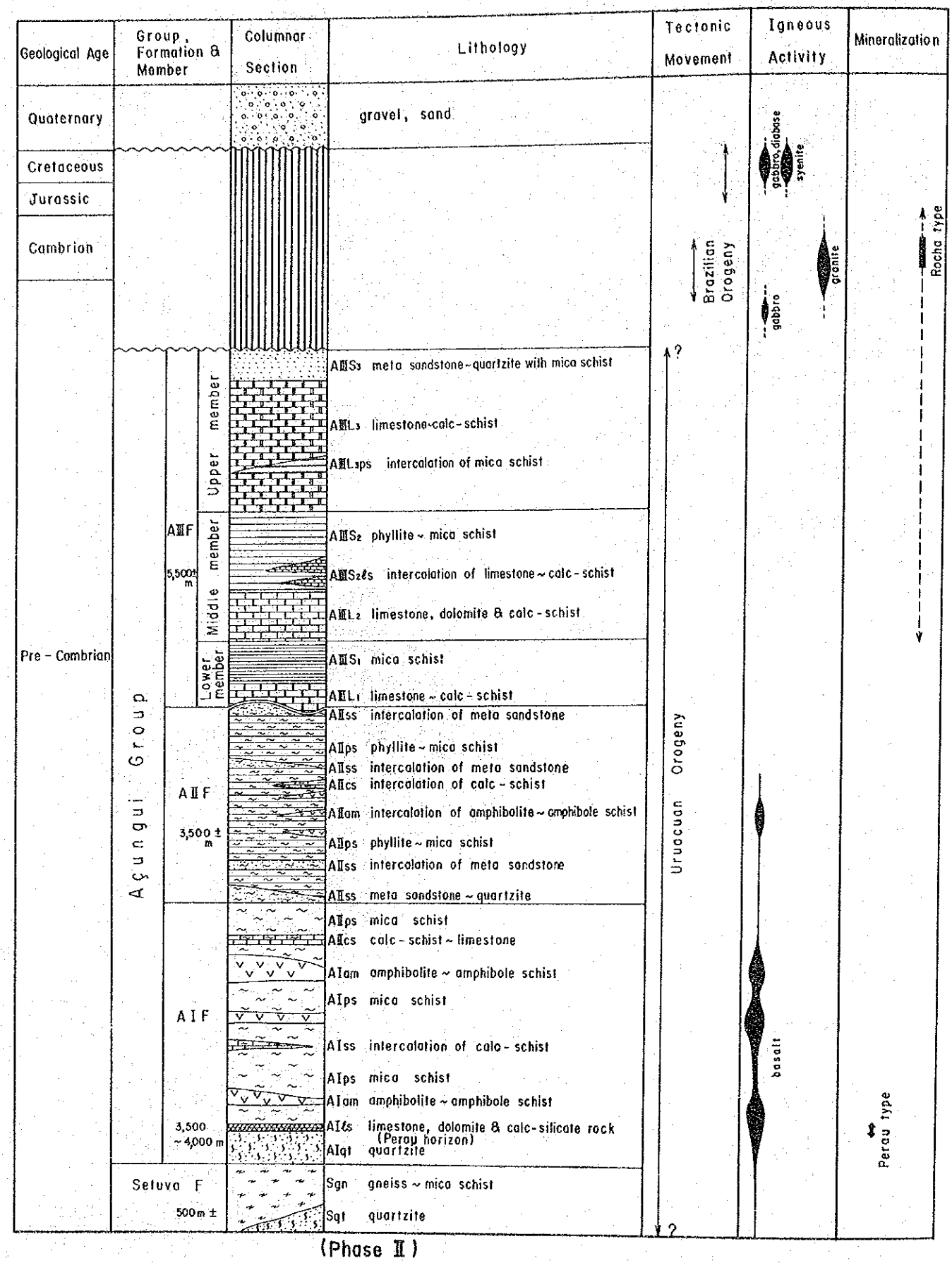


Fig. II–1–2 Geological Map of the Survey Area

Table II–1–1 Generalized Stratigraphic Column



(Phase II)

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 concentrated 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.

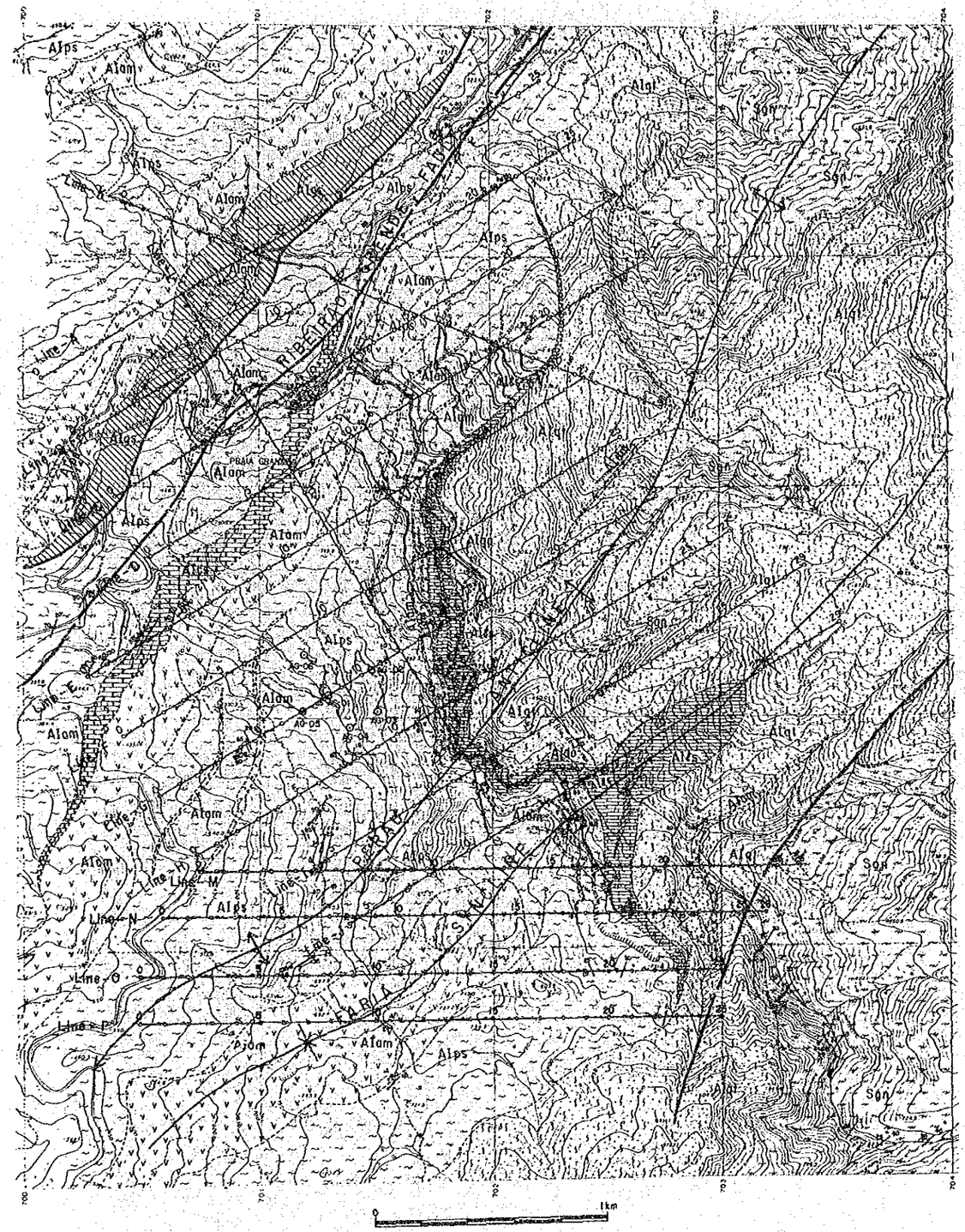
The Açungui I formation conformably overlies the Setuva formation, and consists of quartzite (AIqt), limestone and dolomite to carbonate schist (AIls) (where the Perau deposit and thin layers of graphite schist (AIgp) and dolomite (AIdo) are intercalated), mica schist (AIps), amphibolite to amphibole 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.

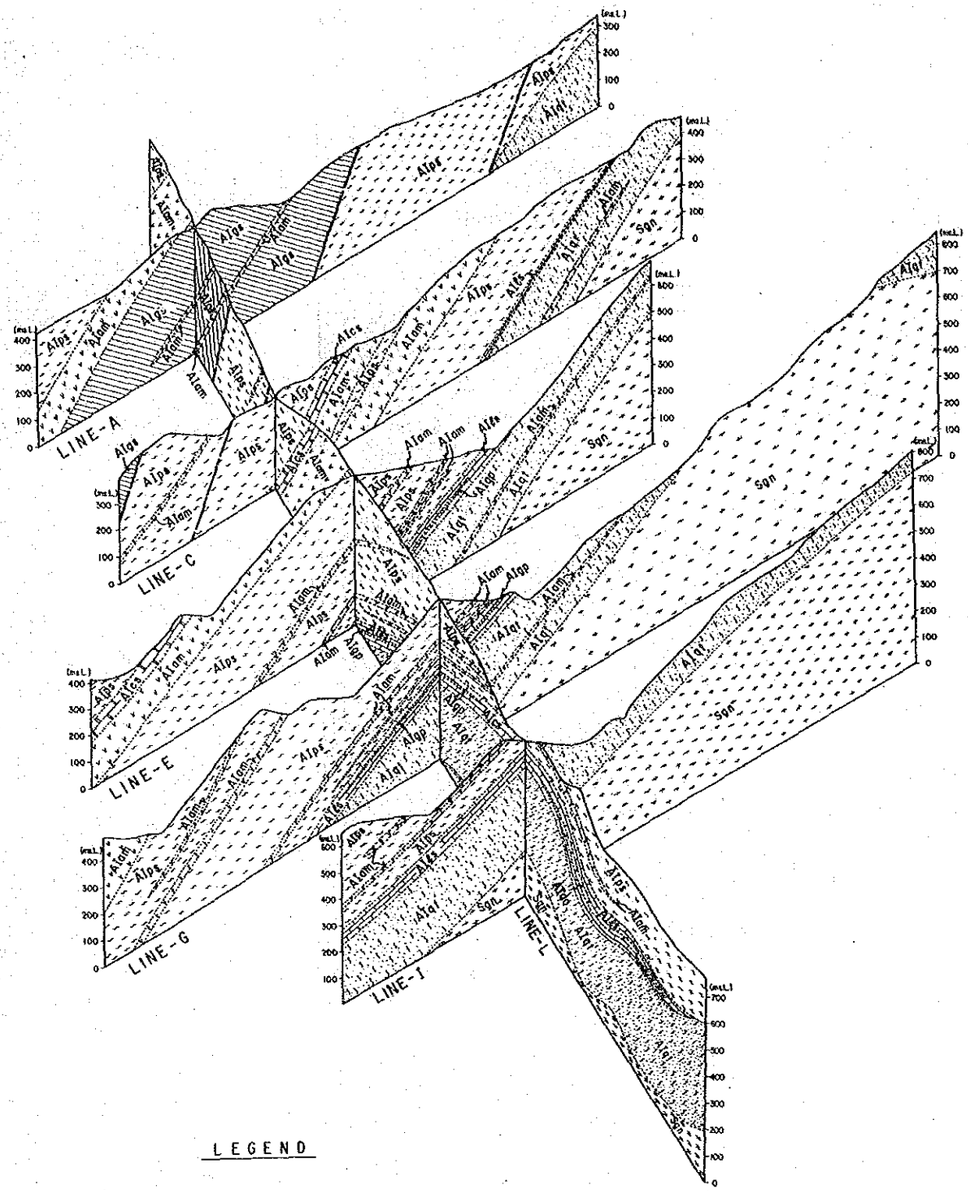
The main geologic structure of the surroundings of the Perau mine is controlled by the Perau anticline and the Faria syncline of the NE–SW system. The Ribeirão Grande fault running to the northeast of the Perau mine is known as a prominent fault.

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 (AIls) 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





LEGEND

Açungui Formation I

- Algs — Graphite schist
- Alcs — calc – schist
- Alam — Amphibolite , amphybole schist
- Alps — Mica schist
- Aldo — Dolomite layer
- Alap — Graphite schist, phyllite layer
- Alfs — Limestone, dolomite, calc-silicate rock, barite and sulphides. "Perau horizon"
- Alqt — Quartzite, with amphibolite

Setuva Formation

- Sgn — Gneiss with minor amphibolite

- Anticlinal axis
- Synclinal axis
- Fault
- Bedding
- Schistosity
- Lineation
- Plunge of fold

Fig. II–1–3 Geological Map and Geological Profile of Perau Area