

140 tons.

(2) Geology in the Surrounding Area of the Deposit

Quartzite (Alqt), the bottom of the Açungui I formation, calc-schist (Alcs) and mica schist (Alps) are distributed in the neighboring area of the deposit. Entirely the same rock facies as the vicinity of the Perau mine is repeated on account of the presence of the Agua Clara anticline extending northeastward from Agua Clara. The general strike and dip of this area are N40°E and 30° to 40°S respectively.

Mica schist has been chloritized to display dark greenish color, and contains a considerable amount of porphyroblasts of garnet. The schist is intercalated with thin layers of magnetite dissemination and pelitic limestone.

(3) Ore Deposit

The barite bed is emplaced in calc-schist, being 0.80 to 1.50 m wide. Since the position of the ore bed is 50 m apart from quartzite in the lower part and 5 m apart from biotite schist in the upper part, it can be said that the deposit is entirely in the same horizon as that of the Perau deposit. A band of chalcopryite and several millimeters wide is sometimes found in the barite bed.

Assay result are shown as follow.

Sample No.	Width	BaSO ₄	S	Cu	Pb	Zn
F-113	0.80 m	85.48%	0.51%	812 ppm	54 ppm	61 ppm

The lateral extension of the ore bed reaches up to 1,000 m as the result of removal of the overburden.

3-3 Rocha Type Deposit

3-3-1 Rocha Deposit

(1) Outline of Rocha Mine

The rocka mine is situated about 24 km to the southwest of Adrianopolis, and the mine office of Rocha Exploração e Comercio de Minerio Ltda is located in a valley 230 m above sea level surrounded by the steep mountains in the upper reaches of Rocha River, a tributary of Ribeira River.

The main working faces are found on the 308 m level and a sublevel above the 403 m level, and in additon, the works to reopen the old tunnel of 227 m level are under way.

The crude ore of 1,020 t/m, 5.89% Pb and 100 ~ 300 g/t Ag is mined and dressed by 150 workers, and all the concentrates 41.75% in lead grade are sold to the Panelas smelter of Plumbum S.A.

(2) Geology

Geology of the surrounding area of the Rocha mine consists of mica schist (AIII_{S1}), calcareous rocks (AIII_{L2}) and mica schists (AIII_{S2}), of the Açungui III formation from the base upward, which have been intruded by basic rock and diabasic dykes (Fig. II-11). Among these, the calcareous rocks in which the ore deposit is emplaced are subdivided, from the base upward, into calc-schist (L_{2cs}), limestone (L_{2ls}) and dolomite (L_{2dol}), which are further classified into the rocks in the underground such as limestone (L), alternating beds of limestone and dolomite (A) and dolomite (D), where the dolomite is the favorable country rock of the ore deposit (Fig. II-12).

The strata show an isoclinal structure striking 25° ~ 40° E and dipping 40° ~ 80° SE.

The geologic structure in the underground is characterized by frequent occurrence of drag folds, vein fractures and faults. These relations are shown in the typical cross section (Fig. II-13).

The faults and vein fractures seem to have been formed in relatively competent dolomite (D₂) by the same stress as that of folding in the latest stage of folding.

(3) Ore Deposit

(a) Outline of Ore Deposit

The deposit of the Rocha mine is a vein-type lead deposit emplaced in dolomite in the calcareous rocks (AIII_{L2}) of the Açungui III formation.

The veins are roughly divided into two types such as the one showing NNW-SSE system and the other emplaced in the faults of N-S system (Fig. II-14, Table II-7).

The type 1 is divided into the vein groups from south to north such as São Francisco, Bassetti, Egara and Matão, and the veins emplaced in the Bassetti fault and the Esperança fault belong to the type 2.

(b) Assemblage of Ore Minerals

The main ore minerals constituting the veins of the Rocha deposit to be observable with the naked eye are galena, pyrite and small amount of chalcopyrite and sphalerite. Under the microscope, other sulphide minerals such as tetrahedrite, arsenopyrite, marcasite and pyrrhotite, and the secondary minerals such as chalcocite and covellite are observed.

Gangue minerals consist mainly of dolomite and calcite, and small amount of quartz.

(c) Chemical Analysis of Wall Rocks

The wall rocks of the Rocha mine are divided into four kinds such as limestone, dolomitic limestone, calcareous dolomite and dolomite.

As the result of analysis of heavy metals (Au, Ag, Cu, Pb and Zn) in the country rocks, the

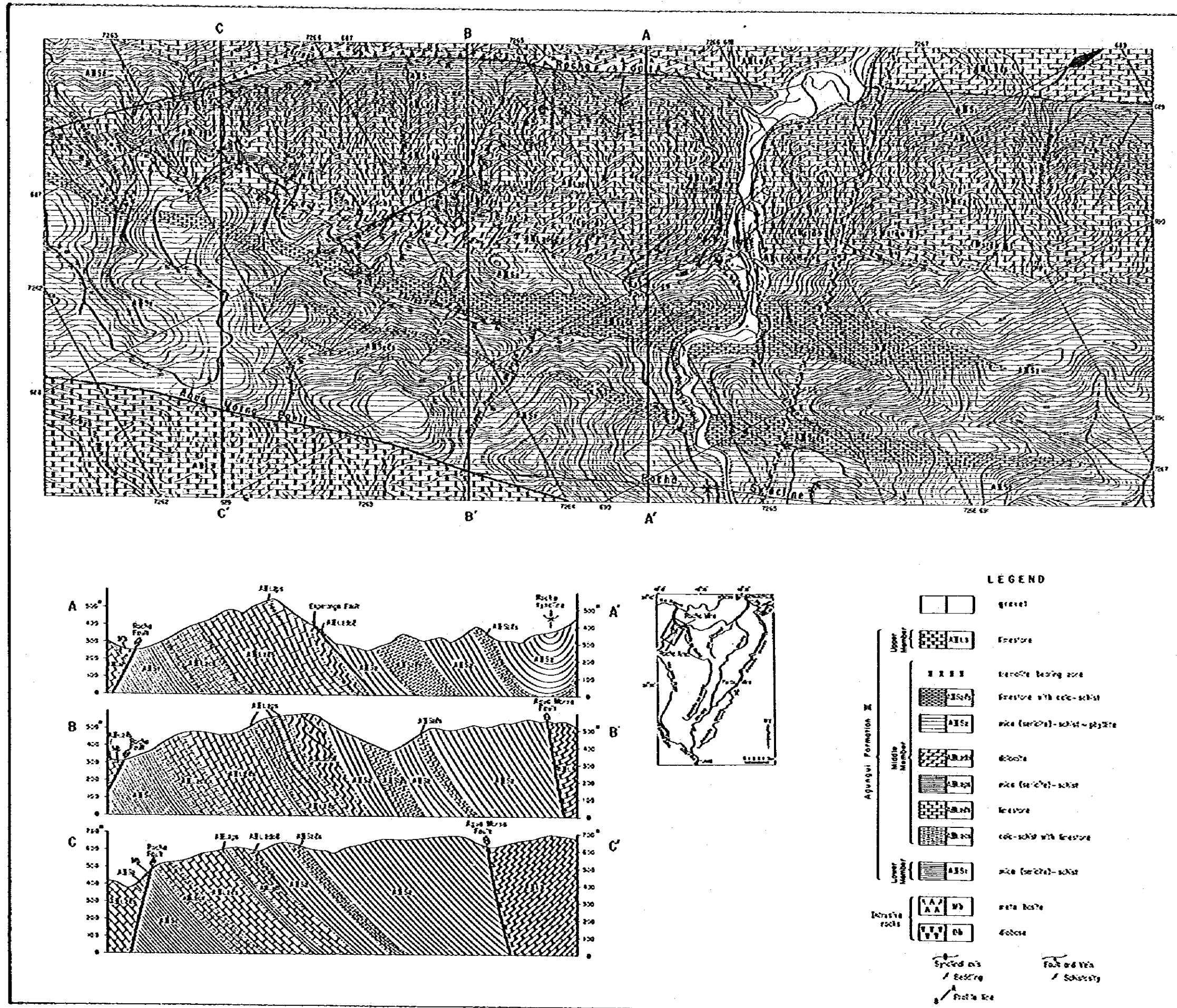


Fig. II-11 Geological Map and Geological Profile of Rocha Area

(a) Stratigraphic Section in Rocha Area

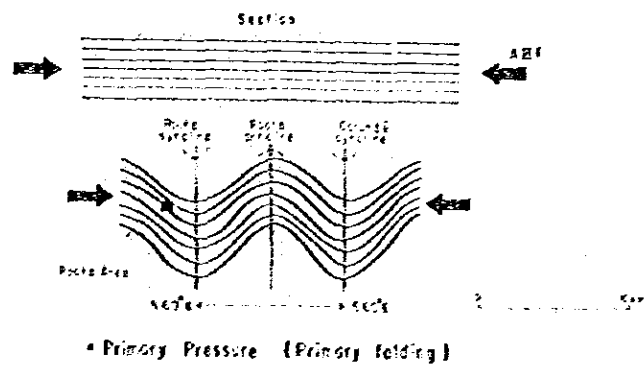
Formation & Member	Columnar Section	Lithology	Thickness (m)
Açungui Formation III	Middle M	AMS ₂	west : sandy mica (sericite) schist east : mica (sericite) schist
			350 550
			900 1100
		AMS ₂	
		AMS ₂ ls	limestone with calc - schist
			50
		AMS ₂	mica (sericite) schist
			160
		x x x x x	tremonite bearing zone
		AMS ₂ ls	limestone with calc - schist
			260
			0
			200
		AMS ₂	mica (sericite) schist ~ phyllite
			200
	Low. M	AMS ₂ ls	dolomite
			0
			200
		AMS ₂ ls	limestone
			140
			5
		AMS ₂ ls	intercolation of mica (sericite) schist
			200
		AMS ₂ ls	limestone with calc - schist
			200
	Low. M	AMS ₂ ls	mica (sericite) schist
			0-40
			500
			200
	Low. M	AMS ₂ ls	limestone
			200
			800
			400
	Low. M	AMS ₂ ls	calc - schist with limestone
			100
			200
	Low. M	AMS ₁	mica (sericite) schist
			+200

(b) Underground Stratigraphic Section in Roche Mine

Columnar Section	Lithology
S ₂	S ₂ : sericite schist
S ₂	S ₂ l: intercolation of limestone
S ₂ l	S ₂ d: sericite schist with intercolation of dolomite
D	D ₁ : massive dolomite grey, fine ~ medium grained size
D	D ₀ : intercolation of alternation of dolomite & limestone
D	D ₁ : Intercolation of limestone
D	D ₂ : bedded dolomite light grey, medium grained size
A	A ₂ : alternation of dolomite > limestone A ₁ : alternation of limestone > dolomite dolomite - block, fine grained size limestone - light grey, medium grained size
L	L: limestone light grey ~ white, medium grained size

Fig. II-12 Generalized Stratigraphic Columnar Section in Rocha Area

A) Regional shema



B) Structural shema in Roche Area

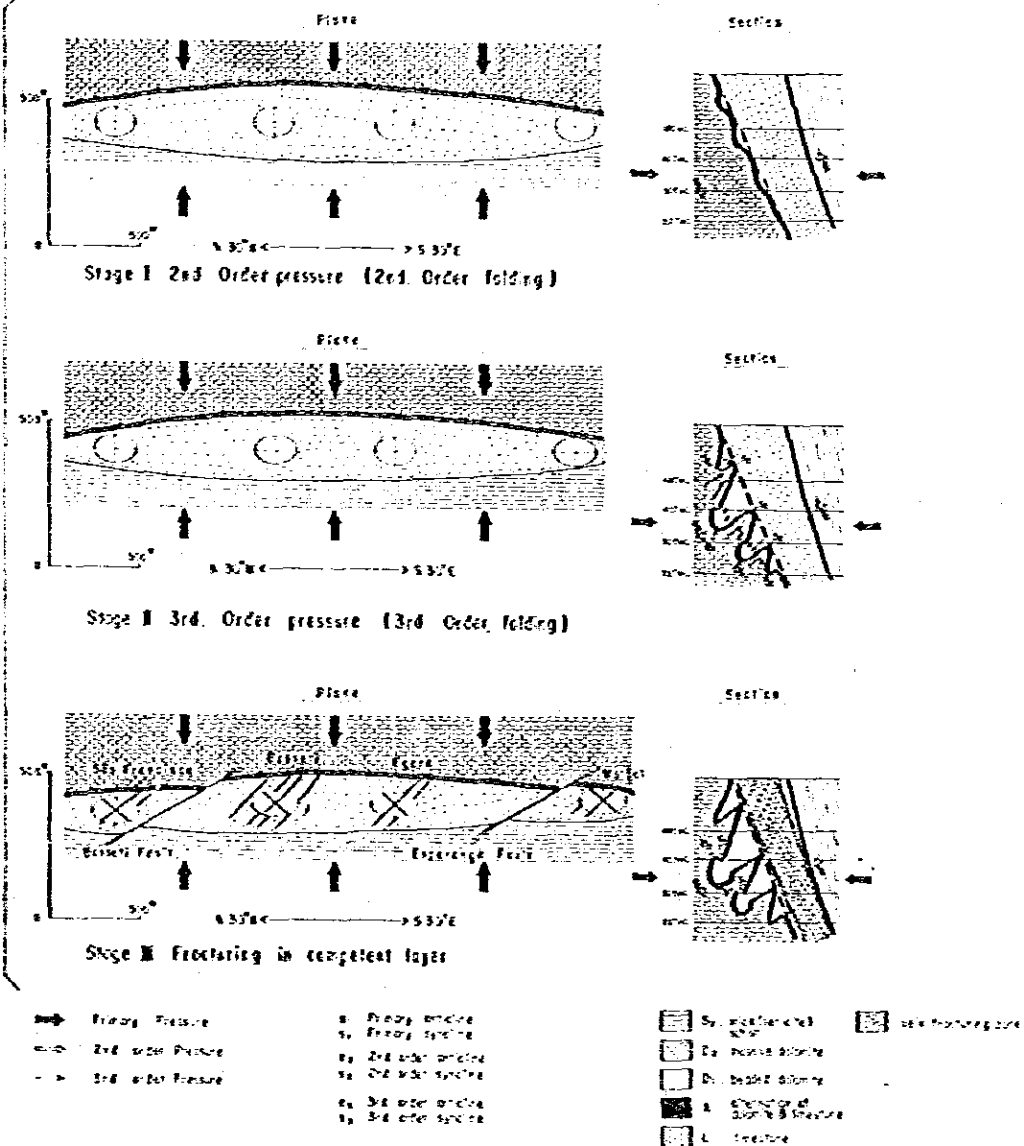


Fig. II-13 Relation of Stress against Folding and Fracturing

Table II-7 List of Ore Veins in Rocha Mine

type & group		Vein Name	Strike of vein	Dip of vein	length of vein (m)	mean wide of vein (cm)
TYPE I	São Francisco	São Francisco III	N 20°W	55°E	30	30
		São Francisco II	N 20°W	74°E	100	20
		São Francisco I	N 10°W	60°E	50	10
	Basseli	Basseli II - sul	N - S	68°E	100	20
		Basseli I - Bis	N 15°W	60°E	100	20
		Basseli I	N 20°W	65°E	120	50
		Basseli O	N5°W-20°W	65°W	180	60
		Gaveta III	N 20°W	70°W	160	30
		Gaveta II	N 15°W	60°W	80	5
		C	N 25°W	68°E	110	30
		D	N 25°W	70°E	70	15
	Egoro	Nova Esperança	N 65°W	60°SW	40	20
		Egoro	N 40°W	80°NE	70	20
	Matão	Matão I	N 10°W N 35°W	75°E 80°W	70 40	5 50
		Matão II	N 75°W	50°N	40	1
TYPE 2		Basseli II	N - S	74°E	400	30
		Esperança	N - S	58°E	200	50

following facts were made clear.

- (i) In the part of alternating beds of limestone and dolomite (A), Ag is high in limestone and Pb in dolomite, and
- (ii) Ag is highest in limestone (L), becoming lower through the alternation (A) toward dolomite (D₁, D₂). Pb showed the adverse behavior to that of Ag, and Zn showed similar behavior as Pb. Cu does not show any notable change.

It is a characteristic that Ag content is very high in the country rocks of the Rocha mine, although Cu, Pb and Zn show only an average content. Although the direct relationship between this and mineralization of the deposit has not been made clear, it seems to be an important characteristic for indicating the country rock in the case of exploration of the ore deposit.

A sample of the grades of the vein is as follows:

Sample No.	Au	Ag	Cu	Pb	Zn
S-113	1.8 g/t	470 g/t	0.49 %	26.95 %	0.02 %

3-3-2 Barrinha Deposit

(1) Outline of Barrinha Mine

The Barrinha mine is situated 10 km to the south of Adrianopolis. Several old pits and outcrops are found on the hill side at an altitude of 500 to 600 m above sea level.

The Quatro deposit is the main ore deposit, which is currently worked by underground mining underneath the old open pit. Beside it, outcrops and old pits such as Oito and São Joaquim on the north of Quatro, and Cecrisa and Laranjal on the east of Quatro are distributed.

Drill survey is currently being carried out by the Barrinha mine itself in the adjacent area of Oito, and a small-size mineralized zone containing galena.

(2) Geology

Geology of the Barrinha mine consists of, from the lower upward, mica schist (AIHS₁), limestone to carbonate schist (AIHL₂) and phyllite to mica schist (AIHS₂) (Fig. II-15, II-16).

While limestone to carbonate schist (AIHL₂), which forms the country rock of the ore deposit is composed of a portion consisting mainly of limestone (AIHL₂ls) and another portion mainly of carbonate schist or calc-schist (AIHL₂cs), they are in a interfingering relationship. It is likely that the latter was formed from an impure components as compared with the former.

Since the surrounding area of the mine is situated on the northern side of the Ribeira fault close to it, the geology shows a complicated structures by folds and faults.

(3) Ore Deposit

(a) Outline of Ore Deposit

Among many ore deposits or showings found in the Barrinha mine area, Quatro, Oito, São

LEGEND

Out Line of IP Amomoty



surface to shallow



deep

Outline of SIP Anomaly

A,8,C. type of phase spectrum

Upper Pre-Cambrian

Agungi Formation II

AMS2 33 ps
AEL2
AMS1

sericite schist ~ phyllite (ps)
meta quartz sandstone (ss)
graphite schist (gs)

AEL2
 AES1

carbonate schist ~ calc ~ schist
limestone (ls)

ANSI

sericite schist

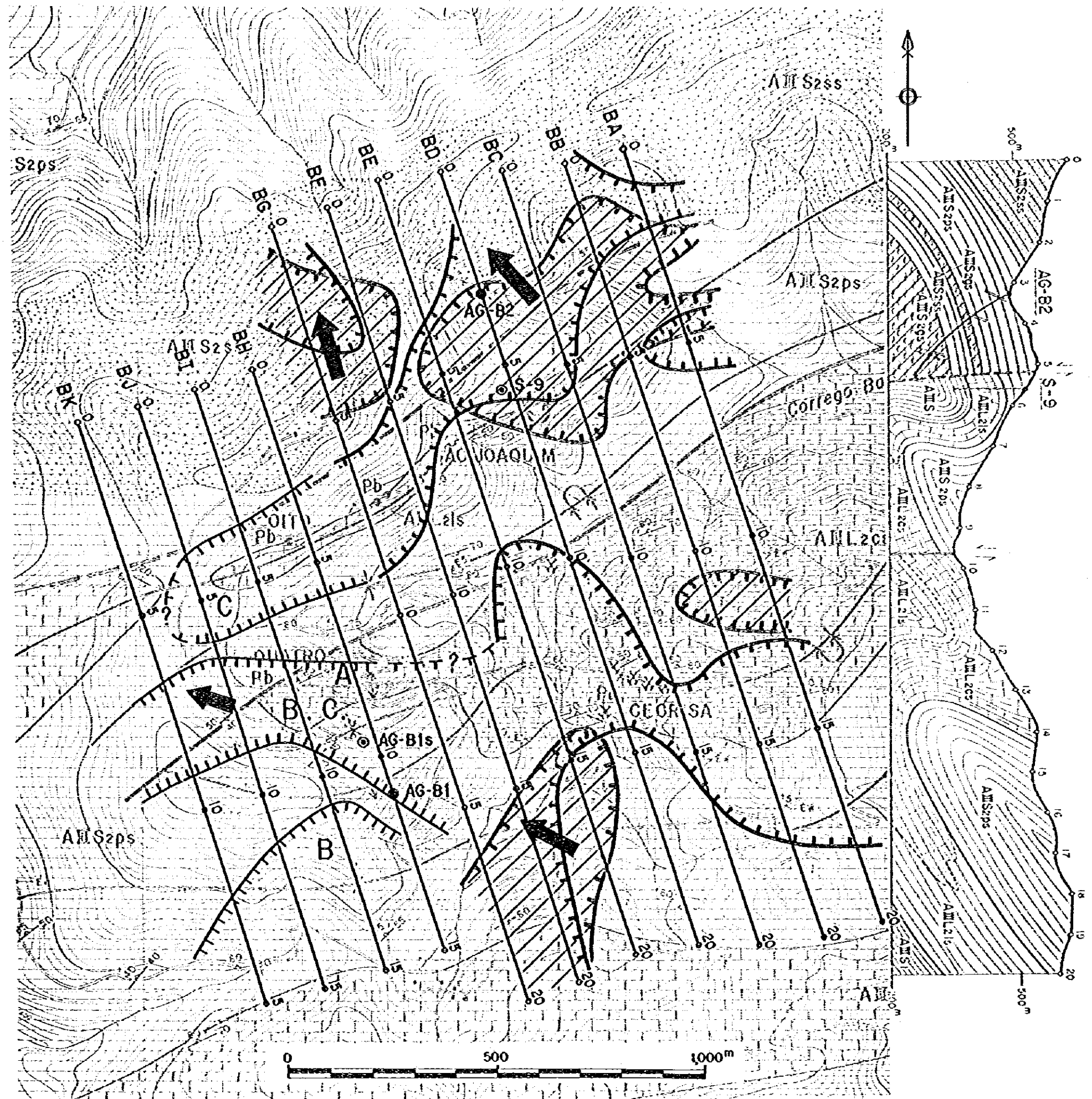
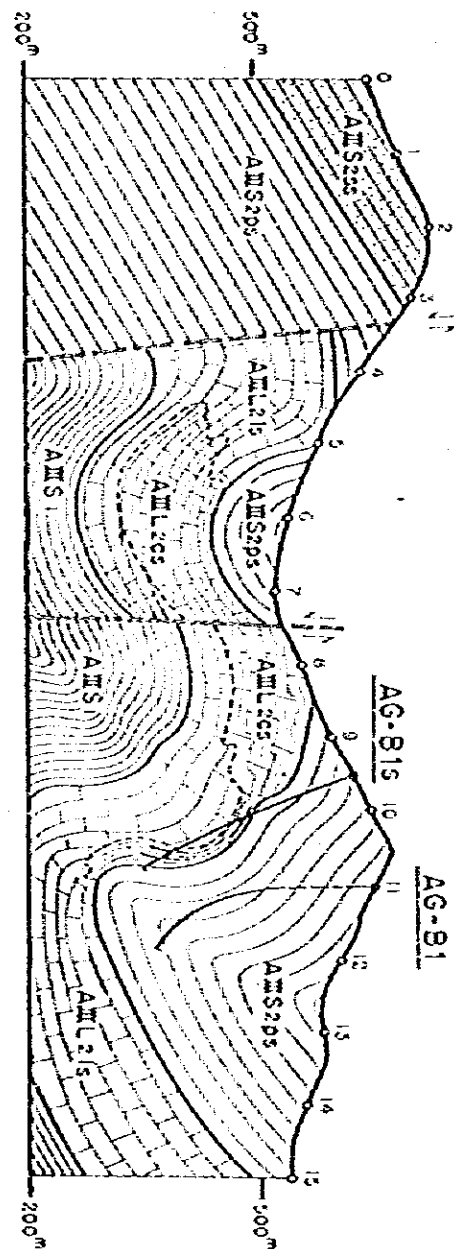


Fig. II-15 Geological Map and Geological Profile of Barrinha Area

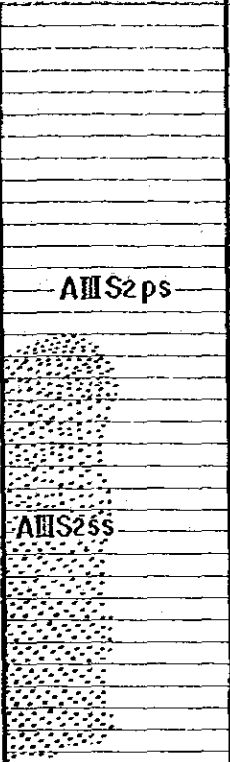
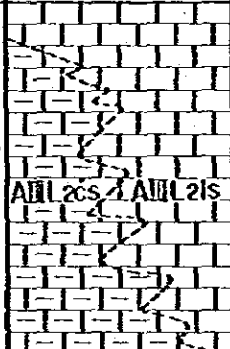
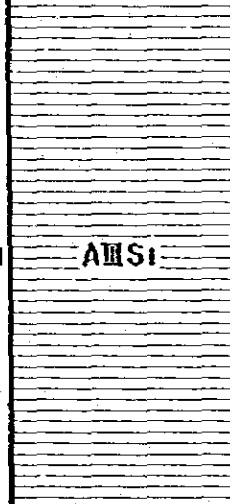
Formation	Columnar section	Lithology	Thickness
Açungui Formation III		<p>AIII S2ss : mélo quartz sandstone with mélo conglomerate</p> <p>AIII S2ps : quartz-sericite schist-phyllite</p>	+ 700 ^m
		<p>AIII L2ls : limestone with calc-schist</p> <p>AIII L2cs : carbonate schist ~ calc - schist with sericite schist</p>	± 200 ^m
		<p>AIII S1 : sericite schist with sericite - biotite schist</p>	+ 600 ^m

Fig. II -16 Generalized Stratigraphic Columnar Section in Barrinha Area

Joaquim, Cecrisa and Laranjal are the main ones. These deposits and showings have been prospected by tunneling, trenching and drilling, among which only the Quatro deposit has been the object of economic operation.

The Quatro deposit and other deposits and showings are all emplaced in limestone (ls) of $AlHIL_2$ and carbonate schist to calc-schist (cs).

In terms of shape of the ore deposit, the Quatro deposit is positioned in the axial part of the limestone bed showing irregular massive to bedded form, and Cecrisa shows a form of vein cutting the bed of carbonate schist.

(b) Assemblage of Ore Minerals

Ore minerals consist mainly of galena and pyrite, accompanied with small amount of sphalerite and chalcopryrite. Cerussite and pyromorphite are observed in abundance in the oxidized zone on the surface. Microscopic observation of the ore samples from the Quatro deposit shows that the ore minerals are mainly composed of galena and pyrite, with subordinate amount of sphalerite, chalcopryrite, tetrahedrite and magnetite.

All the deposits of the Barrinha mine are vein-type to irregular and massive lead ore deposits emplaced in $AlHIL_2$, and are positioned in the apex to the limb of the fold. In addition, these show a tendency to be concentrated at the boundary with $AlHS_2$. This tendency seems to be an effective guidance for ore finding in future exploration in the area.

(c) Assay Result of Ore

		Au _{g/t}	Ag _{g/t}	Cu _%	Pb _%	Zn _%
Quatro	S-78	0.0	153.3	0.08	30.61	0.04
Quatro	A-576	0.9	480.8	0.73	15.12	0.09
Oito	S-72	0.7	199.5	0.26	15.20	0.05
São Joaquim	S-75	3.9	164.3	0.10	8.30	2.98
Laranjal	S-85	0.8	222.9	0.58	17.38	0.06
Cecrisa	S-82	0.1	187.1	0.09	7.86	0.01

(d) Relationship between the Results of Geophysical Survey and Mineralization

The result of electric survey (IP, SIP) shows that the contrast of apparent resistivity is strong on every survey line, and the geologic structure is well reflected in it.

The FE anomalous zones detected in this survey are roughly divided into the northern anomalous zone and the southern anomalous zone bounded by Barrinha da Forquilha Creek which runs eastward approximately in the central part of the survey area. The northern anomalous zone is distributed from the apex to the northern limb of an anticline which extends on the east of São Joaquim, and the anomalous zones are continuous, being distributed harmoniously

with the upper part of the limestone bed. This is well consistent with the geological position of the main ore deposit and other showings, which leads to the expectation of occurrence of any strata-bound or irregular and massive mineralized zone, and the drill survey carried out on the survey line BD resulted in to make clear that IP anomalies are combined by graphite and pyrite in graphitic mica schist and pyrite-galena mineralized zone in carbonate rock.

SIP anomalies have been detected at the Quatro deposit and to the south-southeast of it. The Quatro deposit currently in operation is an irregular and massive lead deposit in limestone, of which the extension on all sides still remains unconfirmed.

Occurrence of anomalies detected to the south-southeast of the Quatro deposit leads to the expectation of occurrence of any similar mineralized zone, and the drill survey carried out on the line BH resulted in to make clear that the SIP anomalies are caused by the pyritization zone in carbonate rocks.

3-3-3 Fumas Deposit

(1) Outline of Fumas Mine

The Fumas mine is situated about 17 km to the east of Apiaí, along the São Paulo State Highway 165. The mine is currently in operation for exploration and mining mainly at the Santa Barbara 2 level, and produces 20 t/m of sulphide ore (50% Pb) and 150 t/m of oxide ore (15 % Pb), all of which are sold to Plumbun S.A. Beside it, several old tunnel in the Maxial level, and numerous open pits and trenches are found in Santo Antônio, Três Bocas and Laranjeiras area.

(2) Geology

The geology in the surrounding area of the mine consists of, from the base upward, AIII_L₂ member, AIII_S₂ member, AIII_L₃ member and AIII_S₃ member of the Açungui III formation (Fig. II-17, II-18).

The Fumas deposit is emplaced in limestone (AIII_L₃lsA) and dolomite (AIII_L₃dol/A₁-A₂) of the lower part of AIII_L₃, and the combination of these geology with sericite schist of hanging wall of ore horizon continues to the west of the mine as an effective key bed of ore bearing horizon.

The area lies between the Calabouço syncline and the Serra Manduri anticline, the structures of the first order in the area, and the general strike and dip are N60°E and 49°NW respectively.

(3) Ore Deposit

(a) Outline of Ore Deposit

The ore deposit consists of lead deposits filling the cracks along the bedding plane and the fractures of E-W system intersecting the bedding plane, and a tendency is shown that the ore

Formation	Columnar Section	Lithology	Thickness (m)
Agungui Formation III	AHS3	meta quartz sandstone with meta siltstone (AES3)	220 ⁺
	AEL3dolC	dolomite	350
	AEL3s1C	limestone	450
	AEL3s1B	interbedding of sericite schist, sericite-quartz schist and meta sandstone	980
	AEL3dolB	dolomite	1090
	AEL3s5	interbedding of sericite schist	230
	AEL3s1B	limestone	340
	AEL3s5	interbedding of meta quartz sandstone	
	AEL3s5A	sericite schist	40
	AEL3dolA2	dolomite with lime part	110
	AEL3dolA1	bedded white dolomite and black limestone	185
	AEL3s1A	limestone with dolomite part	100
	AES2ss	interbedding of sericite-quartz schist ~ meta sandstone	150
	AES2ps	sericite schist ~ phyllite	260
	AEL2	limestone with dolomitic part, very rare sericite schist	280 ⁺

Fig. II-18 Generalized Stratigraphic Columnar Section
in Furnas Area

swells at the intersection of these fractures. While seven ore pipes have been mined out, all the objects of mining were the intersections mentioned above, and the direction of the "chute" of the bonanza is consistent with the line of intersection of the two fractures, which plunges 45° westward in general. The new ore body currently being explored and mined is of the same kind, in which the size is up to several tens meters laterally and more than 100 m vertically.

It is assumed that the fractures parallel to the bedding plane and that of NNW-SEE system constitute a conjugate set, and it is considered that these fractures were formed by the Brazilian Orogeny which formed the fold structure of NE-SW system predominantly found in the area (Fig. II-19). It should be an important guidance for ore finding in the area to estimate the distribution of the intersections. As the result of electric survey (IP, SIP), although the apparent resistivity showed a pattern well reflecting the geologic structure, no marked IP and SIP anomalous zones were detected within the ore-bearing horizon.

(b) Assemblage of Ore Minerals

The ore minerals consist mainly of abundant galena, accompanied by sphalerite, pyrite, cerussite and tetrahedrite. Considerable amount of gossan is found on the surface having resulted from marked oxidation.

(c) Assay Result of Ore

As shown in the following, the lead value shows more than 10 % in average. The maximum value of silver showed 2,586 g/t, showing positive correlationship with lead grade. Although silver minerals can not be observed microscopically, it is considered that silver is present in a form of solid solution in sulphide minerals such as galena and tetrahedrite. While zinc shows high values locally, gold and copper are very low in general. Therefore, the ore to be economically mined is Pb-Ag (-Zn) ore.

Sample No.	Location	Occurrence	Au g/t	Ag g/t	Cu %	Pb %	Zn %
E-643	Furnas Mins	Pyrite-Galena vein	0.3	1540.0	0.02	12.81	0.13
E-644	do.	Sphalerite-Galena vein	0.2	2586.0	0.11	12.60	3.82
E-645	do.	do.	0.0	1891.0	0.13	11.28	17.75
N ₁ -18	do.	float of Galena-Pb oxide	—	1036.0	0.03	51.17	0.44
N ₁ -24	do.	Galena-Pb oxide vein (N: 1.0m)	—	2404.0	0.03	68.75	1.93
N ₁ -52	do.	float of Galena	—	1339.0	0.01	72.12	0.60
E-544a	Gruta de Santana	Pb-calcite network	0.0	7.9	0.02	5.92	2.79

Location	Lageado deposits, Santana Nova G5	Furnas Mine, Santa Barbara
Set of Fractures	f1: N65°E65°S (fracture of vein) f2: N50°E10°N (bedding fissility)	f1: N60°W80°S (fracture of vein) f2: N40°E45°W (bedding fissility)
Sketch		
Stereonet Projection		
PRINCIPAL STRESS AXIS (CONPRESSIONAL)	MAX(σ_1): S27°E27°, MED (σ_2): S64°W2°, MIN(σ_3): N23°W63°, SHEAR PLANE ANGLE: 103°	MAX(σ_1): S2°E23°, MED (σ_2): N69°W42°, MIN(σ_3): N68°E39°, SHEAR PLANE ANGLE: 91°

Fig. II-19 Fracture Analysis of Furnas-Lageado Area

3-3-4 Panelas Deposit

(1) Outline of the Mine

The Panelas mine is a lead mine situated about 14 km to the east of Adrianopolis and operated by Plumbum SA. Industria Brasileira do Mineraçao, which operates a smelter in the mine site. The deposit was discovered in 1936, and the mill plant was constructed in 1954. The amount of ore mined up to date is 1,200,000 t, and the production of lead reached 84.5 t. The main part of the deposit has been almost mined out, and the monthly production is maintained at a level of 1,000 t of crude ore (5.4% Pb, 100 g/t Ag). Among the total of 380 laborers, 150 work for mining and 130 for milling and smelting.

The mill plant has a capacity of 6,000 t/m, processes 3,700 t of ore a month including those purposed from the mines in the surrounding area as of 1983. The breakdown is as follows:

Name of Mine	low-grade ore		high-grade ore	
Rocha mine	1,020 t	5.89% Pb	171 t	41.75% Pb
Perau mine	850 t	5.63% Pb	10.5t	29.75% Pb
Barrinha mine	630 t	15.36% Pb	16.9t	37.45% Pb
Furnas mine	150 t	15.36% Pb	19.8t	48.64% Pb
Panelas mine	1,000 t	5.40% Pb	—	—
Paqueiro mine	50 t	7.92% Pb	—	—
Total	3,700 t	8.7% Pb	218.4t	41.41% Pb

The smelter has a capacity of 1,600 t/m of lead, which also treats the imported ore in addition to the ore mentioned above.

(2) Geology of the Surrounding Area of the Mine

The rocks distributed in the surrounding area of the mine consist of limestone (AIII_{L2}) and mica schist (AIII_{S1}, AIII_{S2}) which belong to Açungui III formation and Itaoca granite which intruded into these rocks. While the general strike and dip of limestone and mica schist are NE-SW and 50°N respectively, they are NW-SE and 50°S on the western side.

Limestone in the mine area can be divided into black limestone and grayish white limestone, locally showing a remarkable flor folding.

(3) Ore Deposit

According to Odan Y. (1978), 90 ore bodies have been found in the Panelas deposit, and the occurrence of them can be divided into three zones such as A, B and C. Zone A consists of black limestone in which 68 ore bodies are included, showing a notable contrast to Zone B of grayish white limestone (20 ore bodies) and Zone C (two ore bodies).

A unit ore body is narrow and rectangular in shape, showing a tendency to extend along the chute. The average width is 0.30 m. Although the ore bodies are generally conformable to the surrounding strata, it is sometimes obviously oblique to the bedding.

According to Odan Y., black limestone (Zone A) is rich in graphite which seems to have had an influence upon the deposition of ore minerals, and assemblage of the ore minerals consists mainly of galena and pyrrhotite whilst galena and pyrite are dominant in grayish white limestone (Zone B).

Most of the pyrite grains have been replaced by pyrrhotite. When taking into account the contact metamorphism of the country rocks (Melcher G.C. 1968), it is likely that it has been caused by thermal metamorphism of Itioca granite.

The sequence of crystallization of ore minerals is pyrite → pyrrhotite → chalcopyrite → tetrahedrite → galena.

The examples of analysis of ore minerals in Zone A and Zone B are as follows:

		Width _m	Au _{g/t}	Ag _{g/t}	Cu _%	Pb _%	Zn _%
Zone A	219 mL G-27 (F-207)	0.10	0.0	0.9	0.20	24.46	0.04
Zone B	150 mL B-41 (F-221)	0.10	0.4	270	0.80	28.85	0.02

3-3-5 Lageado-Serra Deposits

The ore deposits and showings have been known at 23 localities in the Lageado area and eight in the Serra area (Fig. II-20). Beside these, a lead deposit (Santo Antonio do Pavão) is known in limestone (AIII_{L2}) of the Açungui III formation.

(1) Lageado Deposits

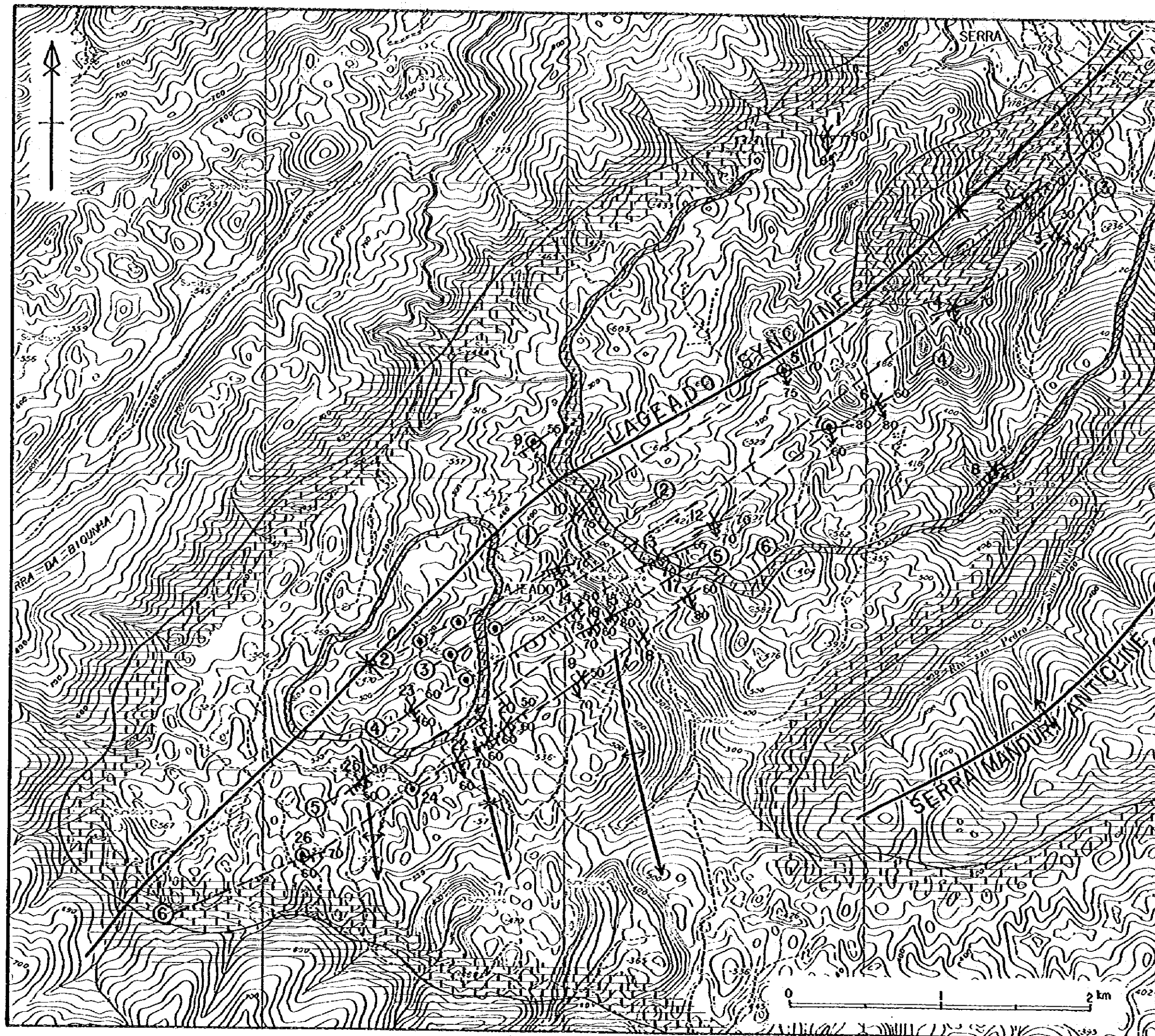
(a) Outline of Ore Deposit

The deposits are found at 5 km to the southwest of the Furnas mine, and 23 deposits and showings are concentrated within an area of 1.5 km by 4 km. Although these were operated during the period from 1944 to 1968, they were all small in scale and produced only a small amount of ore. To reach the old mine area, an unpaved road branches off from São Paulo State Highway 165 for about 9 km.

According to a record, the Santana Nova deposit, the largest one among the deposits of the area (600 m in strike length and 200 m along the chute) produced several thousand tons of ore at the grades 5 to 50% Pb.

(b) Geology

Geology of the surrounding area consists of meta-sedimentary rocks (AIII_{S1}) and calcareous rocks (AIII_{L2}) of the Açungui III formation. AIII_{L2}, the host rock of the ore deposit, consists mainly of limestone (AIII_{L2ls}) interbedded with dolomite (AIII_{L2dol}) and meta-sedimentary



LEGEND

- | | |
|--|---|
| | dolomite |
| | limestone |
| | mica schist ~ phyllite,
meta conglomerate ~ meta sandstone |
| | dip and strike of vein (surveyed) |
| | do. (by reference) |
| | synclinal axis |
| | anticlinal axis |
| | underground |
| | trench or/oc outcrop of vein |
| | line number of vein |

- 1 Macaquinho
- 2 Jaguairica
- 3 Berto Funda
- 4 Alto do Bento or Descanso
- 5 Sete Alqueires
- 6 Casa Velha
- 7 Sítio Novo
- 8 Aberto do Leão
- 9 Cu showing
- 10 Lourenço Velho
- 11 Santana Velha
- 12 Parco do Mato
- 13 Momongabe
- 14 Santana Nova
- 15 São Francisco
- 16 Nova Esperança
- 17 Coqueiro
- 18 I.G.G.
- 19 Bugios
- 20 Jardim II
- 21 Jardim I
- 22 São Rafael
- 23 Santana F
- 24 Sebastião Gabriel
- 25 São Vicente
- 26 Boa Ventura

rocks (AHL₂ps). The country rock of the deposit is gray to dark gray pelitic limestone, interbedded with very thin layers of calc-schist to calcareous phyllite which show a crenulation structure. The deposits are found in relatively lower part of the Açungui III formation.

The deposits are positioned on the northwestern limb of the Serra Manduri anticline which is of the first order in the area, and at the same time, most of the deposits and showings are concentrated to the southeastern limb of the Lageado syncline of the second order.

(c) Ore Deposit

The deposits are vein-type lead ore deposits, a copper showing is included, and the vein fractures strike N45° ~ 75°E, dipping 50° ~ 80° SE. The veins have an average width of 0.30 m, but they often swell and pinch, showing a maximum width of 1.5 m. Barren shear zones are found in some part. Lead oxide containing galena are the main ore minerals, which is accompanied by a small amount of pyrite. Beside these, small amount of chalcopyrite, covellite, hematite and goethite are observed under the microscope.

The assay results of ore minerals of the deposits are as follows:

Sample No.	Location	Occurrence	Au g/t	Ag g/t	Cu %	Pb %	Zn %
D-521	Santa Nova G ₃	Galena vein	0.8	157.0	0.05	11.58	0.18
D-523	do.	G3 Galena vein	1.1	218.0	0.04	11.28	0.29
D-581	do.	do.	0.1	1073.0	0.05	11.84	0.27
D-583	do.	Pb oxide ore -Galena vein	0.1	619.0	0.07	12.24	0.04
D-584	Sao Vicente	do.	0.5	496.0	0.08	12.04	0.22
D-586	Jardim G2	do.	0.4	2150.0	0.58	12.14	0.08
d-588	Nova Esperanca	do.	0.5	1891.0	0.08	12.04	0.01
D-590	Santana Nova G5	Galena vein	0.3	1874.0	0.08	12.24	0.01
D-593	Copper showing	Chalcopyrite and Galena impregnation	1.5	100.7	1.33	0.50	11.50

(2) Serra Deposits

Eight deposits and showings of this group are positioned on the northeastern extension of the Lageado deposits. Geology and ore deposit, and ore genesis of this group are the same as those of the Lageado deposits, but the ore horizon is positioned in a little supper horizon.

The assay results are as follows:

Sample No.	Location	Occurrence	Au _{g/t}	Ag _{g/t}	Cu _%	Pb _%	Zn _%
D-595	Juguatirica	Pb oxide- Galena vein	0.0	1200.0	0.14	13.32	0.27
D-596	do.	do.	0.0	1054.0	0.08	11.53	0.92
D-597	do.	do.	0.1	835.0	0.16	10.56	5.37
I-508	Aberta do Leao	Galena	0.0	1131.0	0.01	12.86	0.27

3-3-6 Espirito Santo Deposit

(1) Outline of Ore Deposit

The deposits are situated about 24 km to the east of Apiai. Although two limonite veins are observed in an old tunnel which is about 80 m long, no lead ore can be found. Beside it, a trench and a tunnel are found, which seems to have explored galena-quartz veins. Although galena-quartz veins several centimeters wide can be observed in each trench and tunnel, these are not the workable ones, and the operation has been suspended. The total amount of ore so far produced is several hundred tons (C.P.R.M. 1975).

4 km to the east-southeast of the Espirito Santo deposit, the Monjolinho de Sebastiao deposit is found, and further one to 2 km on the east, occurrence of the showings such as Agua da Limeira, Braço da Pescaria, Figueira and Paciencia are known.

(2) Geology

Geology in the surrounding area of the deposit consists of calcareous rocks (AIII_L) of the Açungui III formation. The calcareous rocks consist mainly of calcareous dolomite to dolomite (AIII_L,dol), which is about 1,000 m thick.

The ore deposit is emplaced in limestone which is intercalated in the dolomitic rocks, and is positioned about 620 m above the bottom of AIIII_L, stratigraphically.

The area is situated between the Calabouço syncline and the Serra Manduri anticline which are of the first order in the area, and at the same time, it is positioned at the northwestern limb of the Espirito Santo anticline of the third order, where the general strike and dip of N50°E and 50° ~ 80° NW are shown.

(3) Ore Deposit

The ore deposit is composed of a vein emplaced in a shear zone in limestone, striking N65°E and dipping 80°NW. Several pyrite-galena-quartz veins one to 1.5 cm wide are observed in a limonite-stained shear zone which is almost parallel to the bedding of limestone. Gray silicified zone 3 to 5 cm wide are found on both sides of the quartz vein, in which small druses are found.

Ore minerals are mainly galena and hematite accompanied by cerussite and subordinate amount of pyrite and covellite.

The assay results are as follows:

Sample No.	Location	Occurrence	Au _{g/t}	Ag _{g/t}	Cu _%	Pb _%	Zn _%
C-518	Espirito Santo Mine	Galena-Quartz vein	0.0	85.9	0.05	8.57	0.66
C-580	Monjolinho de Sebastião	Galena-Dolomite Quartz vein	0.8	204.0	0.00	7.70	0.00
C-591	Agua da Limeira	Galena-Quartz vein	0.4	554.0	0.06	12.09	0.00

3-3-7 Paqueiro Deposit

(1) Outline of the Mine

The Paqueiro mine lies almost midway of Adrianopolis and the Rocha mine. It was developed in 1953 and operated during the period from 1957 to 1971 by Plumbum SA, and re-open at present. The total production is 16,300 t of ore at the grade of 9% in lead until 1971.

(2) Geology in the Surrounding Area of the Deposit

Limestone (AlIII_{L3}) and mica schist (AlIII_{L3}ps) are distributed in long and narrow zones showing repeated folding in the direction of NE-SW system. Strike faults are dominantly found.

(3) Ore Deposit

The ore deposit consists of veins formed at the boundary between limestone and mica schist and also in limestone. Although four ore bodies such as A, B, C and D are known, the D ore body, the largest one, could not be investigated because of flooding. Ore minerals are galena and pyrite, accompanied by quartz and calcite.

The scale and assay results of the ore bodies are as follows:

Ore body	Scale	Sample No.	Au _{g/t}	Ag _{g/t}	Cu _%	Pb _%	Zn _%
A	L=6, W=0.3	S-63 (W=0.2 m)	0.1	6.4	0.01	1.61	0.45
B	Lens (0.2 x 0.05m)	S-65 (W=0.2 m)	0.1	84.5	0.06	5.95	0.01
C	L=700m echelon	S-62 (W=1.2 m)	2.5	110.0	0.03	8.91	0.01
D	L=200m echelon	S-69 (W=0.2 m)	0.4	656.5	0.09	21.83	0.01

3-3-8 Bueno Deposit

(1) Outline of the Mine

The mine is situated 2 km on the northeastern extension of the Paqueiro mine. The deposit is prospected at these levels located at 550 m, 572 m and 600 m above sea level. Although the time of start of the mine can not be known, the operation has been suspended since 1971.

(2) Geology in the Vicinity of Ore Deposit

The ore deposit is a vein along a fault found at the contact between limestone and mica

schist. The ore body shows a lenticular form 15 m in lateral extension and 1.5 m in width.

The ore minerals are galena and pyrite, accompanied by the gangue minerals such as quartz and calcite. Under the microscope, chalcopyrite and galena penetrate pyrite in a form of vein (S-54).

The assay result of the ore samples from the ore pile is as follows:

Sample No.	Au g/t	Ag g/t	Cu %	Pb %	Zn %
S-55	0.5	70.2	0.18	23.45	0.01
E-648	0.3	1506.0	0.09	12.96	0.01

3-3-9 Diago Lopes Mine

(1) Outline of the Mine

The mine is situated 2 km to the west-southwest of Adrianopolis, where three prospecting levels are found at 445 m, 468 m and 470 m above sea level. It is not known when the mine was opened, and the operation has been suspended since 1975. The total production is 144 t of ore at the grade of 9.72% Pb.

(2) Geology in the Vicinity of the Deposit

The geology is similar to those of the Paqueiro and the Bueno mines. Regionally, the deposit is positioned at the point where the geologic structure of NE-SW system turns its direction to E-W. Three systems of faults are found, such as E-W (Diago Lopes Fault), NW-SW and NW-SE.

(3) Ore Deposit

The deposits of the mine consist of the vein-type deposits emplaced at the contact between limestone and mica schist (along the Diago Lopes Fault) and in fractures in limestone, and the strata-bound deposit in limestone.

Vein-type deposit:

The deposits are found in the 468 m level and the 445 m level. The former is 50 m in lateral extension having a width of 0.1 to 0.5 m, and shows a notable swell and pinch. The latter also have a lateral extension of 50 m with the width of 0.1 to 0.3 m, showing a lenticular form.

Strata-bound deposit:

It is found in the 470 m level, showing a lenticular form with the lateral length of 10 m and the width of 0.1 to 0.3 m.

The assemblage of ore minerals are the same in both types, which are composed of galena and pyrite accompanied by gangue minerals such as calcite and quartz.

The typical grades of ores of the 470 m level and the 468 m level are as follows:

Sample No.	Location	Width	Au g/t	Ag g/t	Cu %	Pb %	Zn %
S-68	470 m L	0.50 m	0.9	424.9	0.07	31.83	0.38
S-71	468 m L	0.40	0.0	18.0	0.07	0.41	0.01

3-4 The Result of Lead Isotope Measurement

In the survey of Phase I in which the lead ore zone in the Ribeira valley were comprehended, they were roughly classified into two types, such as the Perau type which is emplaced in limestone and silicate rock of the Açungui I formation in a stratiform and the Rocha type which is emplaced in carbonate rock of the Açungui III formation (JICA and MMAJ, 1981).

In the survey of Phase II in which those in the southern Ribeira valley were comprehended, Pb isotopic dating was carried out on galena ore samples taken from the typical mines (two samples from each mine) in order to know the time of formation of these deposits.

As the result of plotting these values of Pb isotopic dating on the ore lead growth curve of Cumming and Richards (1976), it became clear that the Perau type and the Rocha type were clearly distinguished even from the standpoint of isotopics (JICA and MMAJ, 1982). That is, the isotopic age of the Perau deposit is about 1,400 m.y. and that of the Rocha deposit is about 1,000 ~ 1,200 m.y.

The survey area of Phase III comprehends the northern part of the lead ore province in the Ribeira valley, and the Rocha-type lead deposits such as Furnas, Lageado and Espírito Santo are located in the area.

In the survey of Phase III, Pb isotopic dating was carried out on 20 galena ore samples taken from the deposits in the survey areas of Phase II and Phase III in order to summarize the ore deposits of the Perau type and the Rocha type (Fig. II-4). The result of these values of Pb isotopic dating (Table II-8) on the ore lead growth curve of Cumming and Richards (1976), as shown in Fig. II-21, is coincident with the result obtained up to Phase II of the project.

A good agreement of the age of the Perau deposit and its country rocks is not contradictory to the conception that the Perau deposit was formed syngenetically. The age of the Rocha deposit is older than the activity of granitic rocks, but approximately similar to the age of the country rocks, and it is not contradictory to the hypothesis that heavy metals had originally been deposited in the host rocks and concentrated in the fractures of the country rocks.

Table II-8 Results of Pb Isotopic Analysis

Deposit Type	No.	Sample No.	Location	Ore Name	Isotopic Relation		Isotopic Age (m.y.)
					Pb 207/Pb 204	Pb 206/Pb 204	Cumming and Richards (1975)
Peraiu type	1	A-574	Peraiu Mine G2+8-S	Pyrite-Galena Ore	15.49	16.20	1440
	2	A-571	Canoas	Galena Ore	15.51	16.24	1420
	*A	P-1	Peraiu Mine	Galena Ore	15.51	16.24	1420
	*B	P-2	Peraiu Mine	Galena Ore	15.56	16.31	1380
Rocha type	3	A-572	Panelas Mine 110+26 mL	Galena Ore	15.48	16.66	1180
	4	A-573	Panelas Mine 110+34 mL	Galena Ore	15.47	16.66	1180
	5	A-576	Barrinha Mine	Pyrite-Galena Ore	15.54	17.09	950
	6	A-577	Barrinha Mine	Pyrite-Galena Ore	15.51	17.04	980
	7	C-518	Espírito Santo	Hematite-Galena Ore	15.49	16.52	1260
	8	C-580	Monjolinho de Sebastião	Galena Ore	15.57	17.20	890
	9	C-591	Agua da Limeira	Galena Ore	15.53	16.89	1060
	10	D-581	Boa Ventura	Galena Ore	15.55	16.91	1050
	11	D-583	Nova Esperança	Pyrite-Galena Ore	15.54	16.99	1010
	12	D-590	Santa Nova G-5	Pyrite-Galena Ore	15.51	16.93	1030
	13	D-595	Jaguatirica	Serussite-Galena Ore	15.53	16.97	1020
	14	I-508	Aberto do Leão	Galena Ore	15.54	16.97	1020
	15	E-643	Furnas Mine	Pyrite-Galena Ore	15.57	17.27	850
	16	E-644	Furnas Mine	Galena Ore	15.51	16.95	1030
	17	E-646	Diogo Lopes Mine	Serussite-Galena Ore	15.45	16.62	1210
	18	E-647	Paqueta Mine	Galena Ore	15.52	16.87	1070
	19	E-648	Bueno Mine	Galena Ore	15.50	16.61	1210
	20	E-649	Onça II	Galena Ore	15.51	16.85	1080
	*C	R-1	Rocha Mine	Galena Ore	15.54	16.91	1050
	*D	R-2	Rocha Mine	Galena Ore	15.51	16.84	1080

*A ~ D after Phase II

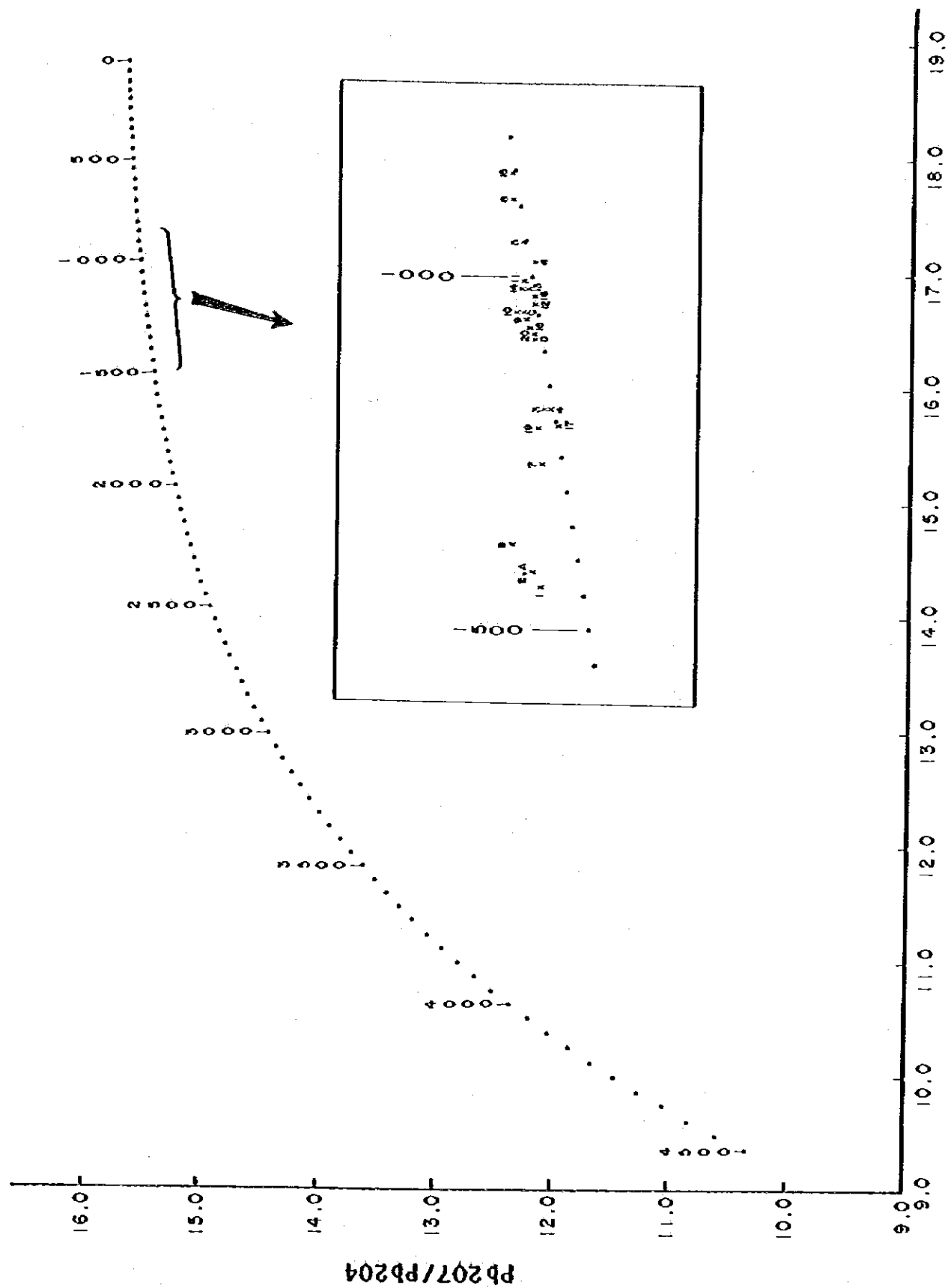


Fig. II-21 Pb Isotopic Age by Ore Lead Growth Curve of Cumming and Richards (1976)

CHAPTER 4 GEOCHEMICAL SURVEY

4-1 Reanalysis of Existing Data

In connection with the geochemical survey of the area, reanalysis of the existing basic data of regional geochemical survey (DNPM, CPRM), soil geochemical survey in the Perau area and chemical analysis of limestone of the Açungui III formation were conducted.

As for the systematic data of regional geochemical survey by stream sediment, Projeto Sudelpa (1975) by CPRM and Projeto Geoquímica no Vale do Ribeira which was planned and performed by CPRM, have been made public (Fig. II-22). In these reports, anomalies for each element of Cu, Pb and Zn had been extracted.

Effective sampling positions of stream sediment among these data were selected, and the data were statistically processed, which were correlated to the geological units.

In Projeto Geoquímica no Vale do Ribeira, the geological units were classified into, from the base upward, as follows: composite gneiss to migmatites (10), the Setuva formation (9), quartzite (8), the Açungui formation composed of metabasite and amphibolite (7), the Açungui formation composed of schist and amphibolite (6), the middle Açungui formation consisting of the clastic rocks (5), the upper Açungui formation consisting of the clastic rocks (4), the Açungui formation composed of chemical precipitation rocks (3), granitic rocks (2) and basic rocks (1).

In this survey, they were divided into the following four units: (2) granitic rocks (3) limestone formation of the Açungui III formation, (4) to (8) schist and phyllite of the Açungui formation, Açungui II formation + Açungui I formation, and (9) the Setuva formation. Table II-9 shows the mean and standard deviation on Cu, Pb and Zn, and Table II-10 the correlation coefficient. In the correlation coefficient among the three elements, those of Pb-Zn and Zn-Cu are high, while correlativity between Cu and Pb is low excepting those in the limestone zone (geological unit (3)).

Correlation between the distribution of the anomalous area of each element and the geological units resulted in to show the following tendency: in terms of the anomalous areas of copper, five are found in the zone (2) of the granitic rocks, three in the zone (3) of limestone in the surrounding area of the Furnas mine and three in the zone (4) to (8) on the eastern side of the Setuva formation, in the horizon which seems to be the same as the Perau deposit.

As for the anomalous areas of lead, 12 are found in the zone (2) of granitic rocks, six in the zone (3) of limestone being consistent with the typical known deposits such as Furnas, Barrinha and Rocha and three in the zone (4) to (8) including a place 3 km to the south of Iporanga.

The anomalous areas of zinc are present almost overlapping with those of lead.

Fig. II-22 Location Map of the Recent Project Area for Geochemical Survey

Table II-9 Mean and Standard Deviation of Stream Sediment Samples by Lithology

Element	Lithology	Number	Max (ppm)	Min. (ppm)	Mean 10^x	S.D. 10^y	$10^{\bar{x}+\sigma}$	$10^{\bar{x}+2\sigma}$
Cu	2	217	82	3	9.27	1.91	17.71	33.85
	3	99	120	4	19.23	2.23	17.71	33.85
	4-8	351	340	3	27.23	2.06	43.00	96.15
	9-10	67	75	6	20.09	1.69	34.04	57.64
	1-10	741	340	3	18.49	2.31	42.74	98.78
Pb	2	217	230	4	11.97	1.93	23.14	44.72
	3	99	1,000	3	17.46	3.30	57.53	189.78
	4-8	351	1,000	3	16.11	2.19	35.24	77.04
	9-10	67	45	4	11.78	1.76	20.71	36.38
	1-10	741	1,000	3	14.52	2.26	32.80	74.09
Zn	2	217	380	10	41.30	1.60	66.09	105.87
	3	99	770	15	52.48	1.99	104.41	207.74
	4-8	351	390	5	61.38	1.76	108.36	191.08
	9-10	67	110	4	52.36	1.60	83.94	134.43
	1-10	741	770	4	52.84	1.77	93.72	166.36

Table II-10 Correlation Coefficient among Three Elements

Lithology N Element	2	3	4-8	9-10	1-10
	217	99	351	67	741
Cu - Pb	0.35	0.61	0.28	-0.02	0.36
Pb - Zn	0.59	0.71	0.49	0.43	0.59
Zn - Cu	0.58	0.79	0.65	0.22	0.65

4-2 Result of Geochemical Survey of Soil in Perau Area

In the survey of Phase II, soil geochemical survey was carried out in the limestone horizon in the surrounding area of the Perau deposit. One hundred and thirteen samples were analyzed for six components such as Cu, Pb, Zn, Co, Ni and Mn by the atomic absorption method, in which simple component analysis and factor analysis among the multi-variate analysis were made.

Table II-11 shows the mean and standard deviation on each component. The anomalous zones on Cu, Pb and Zn are harmonious with the distribution of the Perau ore horizon, particularly along Line-G in the vicinity of the Perau deposit. To the contrary, the anomalous zones of Co and Ni are distributed on a small scale centering on Line-G, and Mn anomalous zone is distributed along A11s on the south of Line-II.

As the result of factor analysis, varimax method, of the six components of 113 samples thus obtained by using computer (NEC8801), two factors (factor 1: Co-Mn-Ni-Zn, factor 2: Pb-Cu-Zn) (Table II-12) were extracted. Factor 1 shows the zones high in factor mark which are consistent with the distribution of A11s and Alam, and factor 2 the zones high in factor mark between Line-E and Line-I along A11s (Fig. II-23). It is interpreted that factor 1 reflects the properties of rock of the country rock and amphibolite, and it seems that factor 2 is in close association with mineralization of the Perau deposit.

4-3 Result of Chemical Analysis of Limestone

4-3-1 Purpose of Analysis

Numerous lead ore deposits are found in calcareous rocks of the Aqungui III formation distributed in the area, which had been considered that these are due to repetition of the same horizon by folding. As the result of survey of this project, stratigraphical classification of the calcareous rocks and geological positioning of the lead deposits were made clear.

In the survey of Phase II, as the result of analysis of heavy metals (Cu, Pb, Zn and Ag) in the country rock of the ore deposit (A11L₂), an important characteristic that the rock is very high in silver content as compared with the average value of the common calcareous rocks, indicating that such rock is the country rock of ore deposit, was obtained.

In the survey of Phase III, microelements of the calcareous rocks were analyzed in order to make clear the index elements of mineralization in calcareous rocks, sedimentary environment of the country rock and the field of emplacement of metallic ore deposit.

4-3-2 Method of Sampling, Component of Analysis and Method of Analysis

The Aqungui III formation in the survey are of Phase III is intercalated with three horizons of calcareous rocks of L₂, L₃ and L₄, among which L₂ and L₃ are the important country rocks

**Table II-11 Mean and Standard Deviation of
Geochemical Data in Perau Area**

Element	Max (ppm)	Min (ppm)	Mean 10x	S.D 10 σ	10 x+ σ	10 x+2 σ
Cu	2400	8	52.12	2.48	129.4	322.1
Pb	10000	5	25.18	2.77	69.8	193.2
Zn	4500	6	41.88	2.40	100.5	241.5
Co	440	3	14.09	2.60	36.6	95.5
Ni	290	3	16.39	1.03	38.0	88.3
Mn	5700	28	707.95	3.93	2779.7	10914.4

**Table II-12 Factor Loading of Geochemical Data
in Perau Area**

	Factor 1	Factor 2
Element	Factor Loading	Factor Loading
Cu	0.28992	0.70405
Pb	-0.01332	0.92004
Zn	0.69207	0.54181
Co	0.91388	0.20020
Ni	0.85397	0.24562
Mn	0.90075	-0.02068

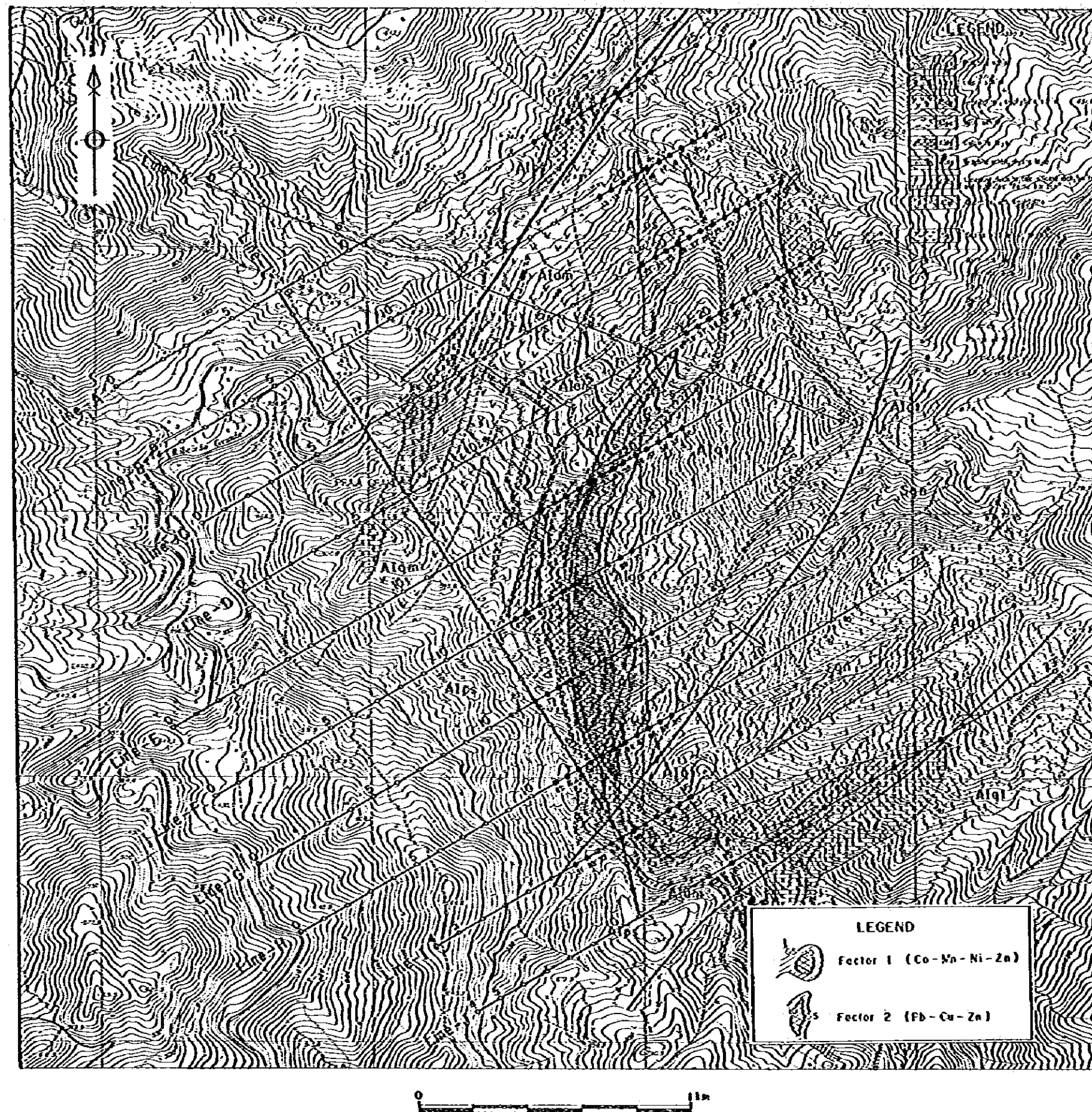


Fig. II-23 Geochemical Factor Map of Soil Samples in Perau Area

of lead deposits. One hundred and 20 samples were taken homogeneously from the area of distribution of all the calcareous rocks, and analysis was made on 15 elements such as Cu, Pb, Zn, Ag, Co, Ni, Mn, Ba, Sr, F, CaO, MgO, Na, K and I.R. (insoluble residue) by atomic absorption method and wet analysis.

4-3-3 Interpretation of Assay Result

Histograms were produced on each analytical data obtained, and multivariate analysis was made in order to assume the mineralization and depositional environment. Simple component analysis of elements considered to be important from the result of multi-variate analysis was fed back, and the anomalous zones related to lead mineralization were extracted.

Table II-13 shows mean and standard deviation of each element. The histograms obtained are composed of plural populations compounded by various factors.

Although there are various method of multi-variate analysis, factor analysis was carried out together with cluster analysis in order to make clear the mutual relation between each component.

Table II-14 shows the correlation coefficient between each element, and Table II-15 shows factor loading of each element of four factors obtained by factor analysis (varimax method).

When the factors of more than 0.4 in factor loading are extracted, factor 1 becomes I.R.-K-Ba-Na-Cu-Zn-Ni-F-Mn, factor 2 Pb-Ag-Zn, factor 3 Sr-Ca and factor 4 Mg-F. It is understood that, among these factors, factor 1 and factor 4 as well as factor 2 and factor 3 are connected together in a short distance as shown in dendrogram (Ward's method) obtained by cluster analysis (Fig. II-24). Also relative comparison was made on a part of elements for each horizon of L₂, L₃ and L₄.

The characters of the factors are as follows:

Factor 1 (I.R.-K-Ba-Na-Cu-Zn-Ni-F-Mn)

Factor marks of 0 ~ 0.5 are observed discontinuously in all the horizons of L₂, L₃ and L₄, and it is especially distributed collectedly in L₂ and L₃. It is likely that this factor suggests the reducing sedimentary environment with abundant impurities.

While Ba and Na are approximately equal in amount in L₂ and L₃, though a little high in L₄, K and Mn show no great difference between the horizons.

Factor 2 (Pb-Ag-Zn)

The areas high in factor marks are observed overlapped with those distributed by factor 1, and also they are collectedly distributed in the surrounding areas of the known deposits. This factor suggests the mineralization.

**Table II-13 Mean and Standard Deviation of
Geochemical Data of Carbonate Rocks in the Phase II Area**

Element	Max	Min	Mean 10 ^x	S.D 10 ^y	10 ^{x10}	10 ^{x120}	Unit
Cu	240	3	6.10	2.63	16.0	42.2	ppm
Pb	5400	5	17.10	2.49	42.6	105.9	
Zn	920	3	10.52	3.05	32.1	98.2	
Ag	12.0	0.5	0.53	1.44	0.76	1.10	
Co	20	3	3.62	1.51	5.5	8.3	
Ni	55	3	5.06	2.17	11.0	23.9	
Mn	7400	6	183.23	4.51	826.0	3723.9	
Ba	2400	10	124.74	2.81	349.9	981.7	
Sr	2300	5	553.35	2.74	1517.1	4159.1	
F	2750	50	328.85	2.62	861.0	2254.2	
CaO	55.4	0.1	33.88	2.12	71.8	152.1	%
MgO	19.3	0.3	2.71	3.39	9.2	31.1	
Na	0.75	0.03	0.07	2.45	0.17	0.42	
K	1.80	0.03	0.16	3.24	0.52	1.68	
I.R.	97.1	0.3	8.07	3.54	28.6	101.2	

I.R. : Insoluble residues

Table II-14 Correlation Matrix

	Cu	Pb	Zn	Ag	Co	Ni	Mn	Ba	K	IR	Na	F	Mg	Sr	Ca
Cu	0.718														
Pb	0.353	0.722													
Zn	0.671	0.359	0.705												
Ag	0.278	0.222	0.343	0.722											
Co	0.478	-0.033	0.454	-0.070	0.613										
Ni	0.714	-0.167	0.689	0.670	0.643	0.643									
Mn	0.557	0.167	0.705	0.241	0.655	0.614	0.755								
Ba	0.549	0.007	0.504	0.560	0.527	0.582	0.644	0.711							
K	-0.354	0.108	-0.274	-0.631	-0.234	-0.269	-0.288	-0.191	0.465						
IR	0.299	-0.009	0.415	0.037	0.326	0.429	0.193	0.425	-0.069	0.629					
Na	-0.479	0.171	-0.343	0.654	0.318	0.432	0.221	0.328	0.444	-0.228	0.485				
F	0.222	-0.074	0.431	-0.141	0.355	0.522	0.353	0.127	-0.442	0.508	-0.234	0.518			
Mg	0.451	-0.073	0.456	-0.121	0.462	0.556	0.352	0.127	-0.442	0.508	-0.234	0.518	0.518		
Sr	0.648	0.089	0.488	0.666	0.560	0.714	0.555	0.711	-0.129	0.609	-0.340	0.312	0.413	0.613	
Ca	0.566	-0.050	0.636	0.626	0.612	0.612	0.627	0.672	-0.153	0.476	-0.547	0.312	0.413	0.613	0.513

IR = insoluble residues

Table II-15 Factor Loading of Geochemical Data of Carbonate Rocks in the Phase II Area

Element	Factor Loading			
	Factor 1	Factor 2	Factor 3	Factor 4
Cu	0.450	0.365	-0.272	0.055
Pb	-0.030	0.813	0.143	0.001
Zn	0.458	0.474	-0.220	0.350
Ag	0.021	0.842	-0.030	-0.099
Co	0.327	-0.658	-0.126	0.123
Ni	0.457	-0.016	-0.180	0.377
Mn	0.404	0.340	-0.231	0.241
Ba	0.761	0.026	-0.033	0.035
Sr	0.005	-0.008	0.803	-0.196
F	0.466	-0.031	0.056	0.599
CaO	0.367	0.073	0.715	-0.011
MgO	0.075	-0.062	-0.276	0.682
Na	0.602	-0.112	-0.125	0.149
K	0.509	0.112	-0.057	0.285
IR	0.537	0.051	-0.300	0.202

IR = insoluble residues

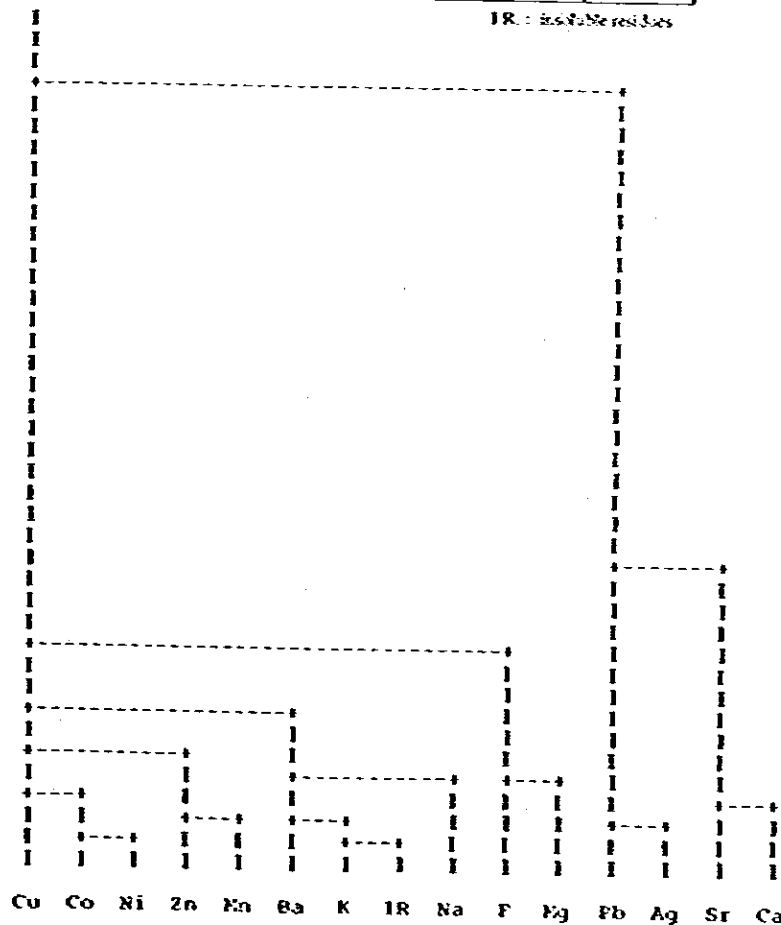


Fig. II-24 Dendrogram by Cluster Analysis of Geochemical Data of Carbonate Rocks

The anomalous zones of Pb and Zn are consistent with those in L_2 and L_3 among the areas distributed by the factor 2.

Thus a simplified map of the areas which will have the potential of occurrence of lead mineralization was produced by synthesizing the Pb anomalous zones and factor 2 as shown in Fig. II-25, which shows a distribution to be consistent with the known ore deposits such as Furnas, Lageado and Espirito Santo.

Factor 3 (Sr-Ca)

The samples high in factor marks are found more in L_2 and L_3 than in L_4 . This factor seems to characterize dolomite with impure materials, and it is assumed that a part of dolomite was primarily deposited in a reducing environment because factor 4 is shown to be in correlation with factor 1 by cluster analysis.

While F content is equal in L_2 and L_3 , and low in L_4 , this is not contradictory to the fact that dolomite is preponderantly small in amount in L_4 as compared with L_2 and L_3 .

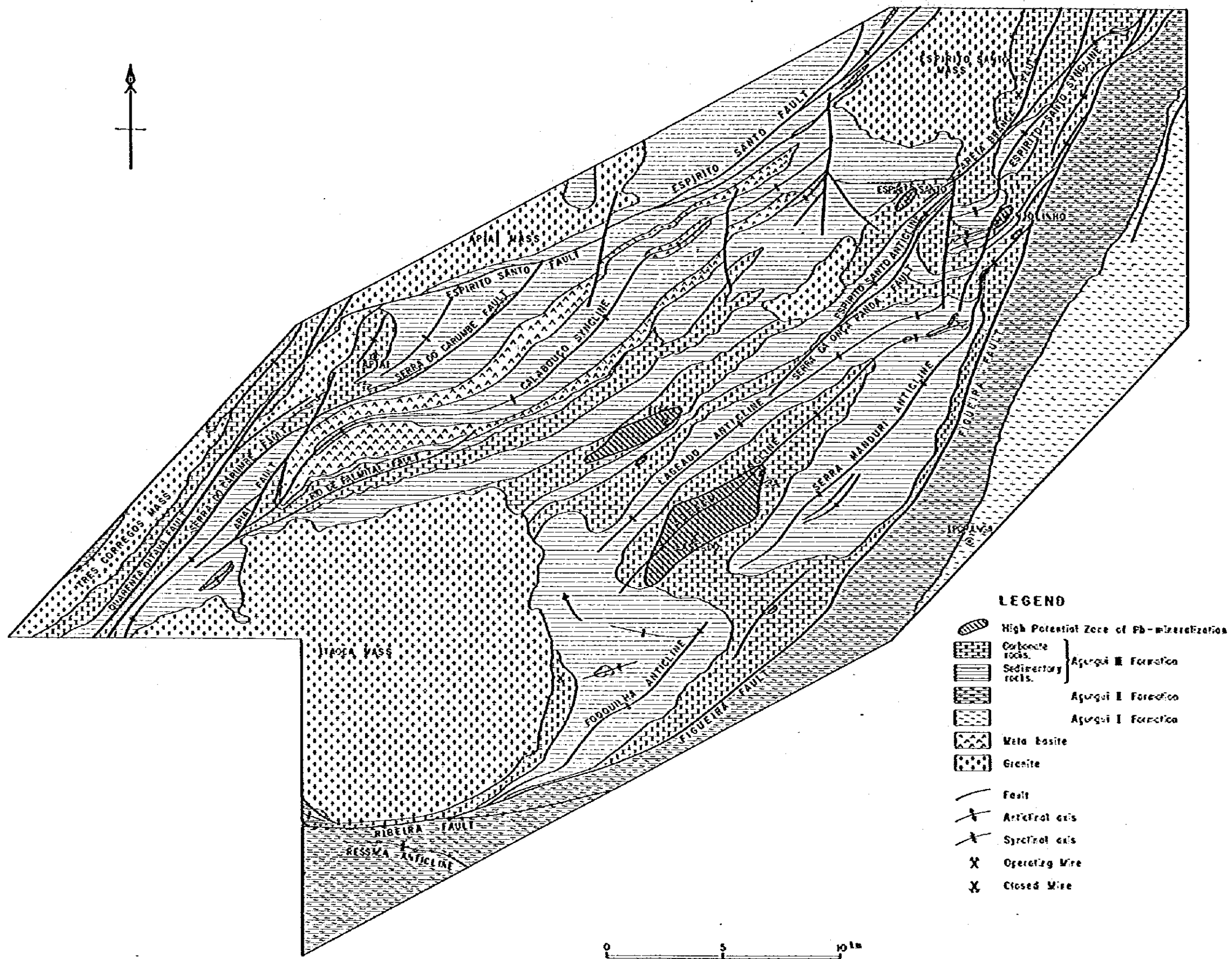


Fig. II-25 High Potential Zone of Pb-Mineralization in the Phase II Area

III. GEOPHYSICAL SURVEY

CHAPTER 1 GENERAL REMARKS

Throughout four phases, four kinds of geophysical methods such as aeromagnetic interpretation, gravity, IP (Induced Polarization) and SIP (Spectral IP) methods were conducted in the Anta Gorda area.

Aeromagnetic interpretation was applied to clarify the magnetic underground structure of the whole area at Phases I and II.

Gravity survey was carried out to clarify the underground structure of the area of 100 km² in the province of the Perau mine at Phase II.

IP and SIP surveys were conducted to clarify the distribution of the ore horizon and to locate the possible drilling sites at the Perau, Barrinha and Furnas mines at Phases II, III and IV.

CHAPTER 2 AEROMAGNETIC INTERPRETATION

There can be seen many kinds of magnetic anomalies on the aeromagnetic map of the Anta Gorda area.

Magnetic anomalies observed are classified into four ranks, I, II, III and IV, which are thought to be caused by the outcropped or concealed magnetic sources of Rank I (strong), Rank II (intermediate), Rank III (weak) and Rank IV (very weak), respectively.

The results of the susceptibility measurements of rock samples, collected within the survey area, suggest that gabbro, diabase and syenite belong to Rank I, granite to Rank II, amphibolite and gneiss to Rank III, and pelitic rocks, psammitic rocks and limestone to Rank IV.

And the survey area is divided into seven zones, i.e., Zone A to G, from the magnetic features as follows:

(1) Zone A

This zone is located in the southwestern corner of the survey area and is characterized by a group of Rank I magnetic anomalies of short wavelength and high amplitude with NW–SE trend.

According to the geological information, granite (Rank II magnetic rock) is broadly distributed within this zone, but it is difficult to delineate its distribution from aeromagnetic map because magnetic anomalies due to granite are overlapped by above-mentioned magnetic anomalies due to Rank I magnetic rocks (diabase). It is suggested that geotectonic lineaments, trending NW–SE direction, may reflect narrow dykes of Rank I magnetic rocks.

(2) Zone B

This zone is a zonal area with a width of about 30 km, running from the northern-central edge to central-western edge, and is characterized by a very little magnetic variation.

A little variation suggests that the Rank II magnetic body (granite) is dominantly distributed in this zone, and its western and eastern sides are limited by geotectonic lineaments.

At the northern and central parts within this body, there are Rank I magnetic bodies (diabase and syenite) as intrusive rocks, within which B–1 and B–3 are cropped out but other B–2, B–4 and small magnetic bodies near B–3 are concealed. Also, narrow dykes of Rank I magnetic rock are expressed as the magnetic discontinuities (geotectonic lineaments) of the NW–SE direction.

(3) Zone C

This zone occupies the central part of the survey area, and is characterized by a very little magnetic variation of long wavelength. This variation may reflect the predominant distribution of Rank IV magnetic bodies and also suggests the direction of the major geotectonic lineaments is

NE-SW.

At the northern part of Zone C, Rank I (gabbro) and Rank III (amphibolite) magnetic bodies exist as intrusive rocks and those distribution are controlled by NE-SW trending geotectonic lineaments. And at the central-western part of Zone C, narrow dykes of Rank III magnetic rock (amphibolite) are distributed in the direction of NE-SW to E-W.

Rank I magnetic bodies (gabbro and/or syenite) are distributed near the Rocha mine (B-5), at the south of Ribeira (C-1), near Tunas (C-4) and at the east of the Perau mine. By analysis of aeromagnetic data, any relation between these intrusive rocks and mines cannot be seen.

(4) Zone D

This zone is located in the northwestern corner. The direction of the dominant magnetic discontinuity line in this zone is a NE-SW.

(5) Zone E

A triangular zone with its apexes at Piloes River, at Pardo River and at Barra da Balatal in the eastern side of Zone C corresponds to Zone E. In this zone, magnetic anomalies with small relief, which may be due to Rank III magnetic bodies (amphibolite or metabasalt), are distributed in the direction of NE-SW, and major geotectonic lineaments run in this direction.

(6) Zone F

This zone is located in the northeastern edge of the survey area and is characterized by a group of magnetic anomalies with NW-SE trend.

Although Rank II (granite) and Rank IV magnetic rocks are dominantly distributed in this zone on the geological map, it is impossible to delineate such rocks because of the above-mentioned magnetic anomalies caused by diabase (Rank I).

(7) Zone G

In the southeastern part of the survey area there exists magnetic anomalies with the anomaly axes of N75°E. Concealed Rank III magnetic rocks causing those anomalies are distributed along the geotectonic lineaments with a trend of N75°E.

Based on the above-mentioned considerations, the following conclusions were derived:

The geological lineation runs in a NE-SW direction. This tendency is consistent with the magnetic geotectonic lineament. The distribution of granite, gabbro, diabase and syenite are mostly delineated.

Mines in the area are located within the magnetic body of Rank IV and are apparently distributed near the Rank I, II and III magnetic bodies. Any relations between these mines and these magnetic rocks can not be seen.

CHAPTER 3 GRAVITY SURVEY

Gravity survey was conducted to clarify the underground structure in the vicinity of Perau mine with an area of 100 km². The number of gravity stations was 274, and the station spacing was principally 400 m.

The Bouguer anomaly map is characterized by the dominant contour distribution with northeast trending gravity contour which may reflect to the major geological structure with NE–SW trend in this area.

Seluva formation, which is, considered as basement rock and exposed at Serra do Cadeado, showing northeast striking anticlinal structure, dips gently to its both wings. To northwest, it increases its depth with 30 degree dip gradually, repeating a minor folding towards a major north-east-striking fault which runs from Epitacio Pessoa to Quilometro Quarenta and its downthrown is 1500 m on northwest. And at the northwest side of this fault, gneiss group of Seluva formation has its depth of 2500 m.

Gravity high with NE–SW trend at the central part on the Bouguer anomaly map reflects the intrusive rocks, considered as gabbro, which are assumed to intrude at the northwest side of above-mentioned fault. And at the northeastern corner of the survey area, the gravity low is consistent with granitic rock. On the fifth order residual map, this gravity low is detected as positive anomaly zone. And also positive anomalies are detected where the Açungui I formation seems to be thick.

Perau mine locates on the hill of the positive anomaly and around dense rocks.

CHAPTER 4 SIP & IP METHOD

4-1 Perau Area

In Phase II (1981), IP and SIP methods were carried out in order to clarify the distribution of the ore horizon and to locate the drilling site. Line length of both surveys were 30.2 km and 5 km respectively.

Following the Phase II, in Phase III (1982) IP survey was conducted to check the southern limits of the IP anomalous zone detected at Phase II survey. Its line length was 10 km.

As a results of IP and SIP surveys through two Phases, three remarkable IP anomalous zones were detected as follows:

(1) Anomalous zone A

This anomalous zone, having a low apparent resistivity and a strong IP effect, is distributed from the surface to the depth in the northern part, and shows an NE-SW trend. This zone is inferred to be due to graphite schist. Phase spectra of this zone show horizontal or right-side-up curve in the frequency range of lower than 1 Hz. On the other hand, strong negative coupling are detected around this zone, which are thought to be caused by the contact between graphite schist of low resistivity and pelitic schist of high resistivity.

(2) Anomalous zone B

This anomalous zone shows an NE-SW trend which reflects the major geological structure in this area. And this zone may be caused by the Perau ore horizon which extends to the depth dipping western from the Perau mine, and continues to the south and to the southeast. This zone is distributed above anomalous zone A and also affected by strong IP effect of it so that the feature of this zone shows very vague in IP survey results.

The Perau ore horizon being thought as anomalous source has a resistivity of about 300 Ω m and its phase spectrum shows a horizontal or right-side-down curve in the frequency range of lower than 1 Hz. This type of spectrum is thought to be caused by the lead and zinc minerals associating with pyrite bearing in calcschist-limestone being a host rock.

This anomalous zone disappears near Line-L. And this zone is more affected southward by anomalous zone C which overlies zone B.

(3) Anomalous zone C

This anomalous zone, distributed broadly in the western part of the area, shows a similar characteristics with anomalous zone A, and its IP effect is very strong.

This zone exists under the same geological situation as the zone A, and is thought to be caused by graphite schist associating with pyrite, being an upper layer of the Perau ore horizon,

judging from its resistivity.

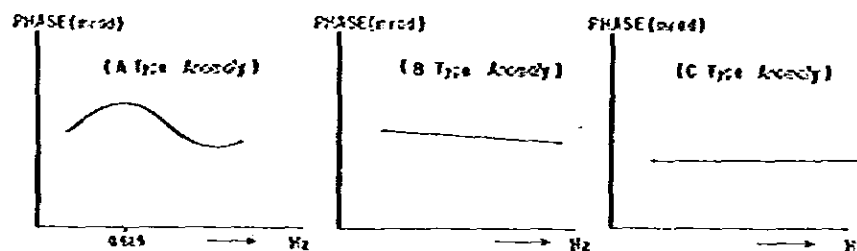
Differences between anomalous zones A and C, are described below:

- (i) Though both anomalous zones A and C reflect graphite schist, graphite schist causing anomalous zone C is more disseminated by pyrite than one causing the zone A.
- (ii) Graphite schist in the zone A is loose, graphite schist in the zone C shows a very clear schistosity. So, graphite schist in the zone C is thought to be more conductive than that in the zone A.
- (iii) The phase spectra of the zone C show a horizontal or right-side-down curve in the frequency range of lower than 1 Hz. This spectral type is very similar to that of the zone B, and is distributed broadly southwestward and/or southwest-southward.

4-2 Barrinha Area

In the Barrinha area, there are two major deposits, Quatro and Oito deposits, being now under exploration.

In Phase III (1982), IP method was applied to clarify the distribution of both ore deposits and those extensions. And also SIP method was carried in the same Phase out to understand the spectral type of both ore deposits. As the results of both surveys, three remarkable spectral type were observed as shown below:



And three anomalous zones, A, B and C, are classified, corresponding to above-mentioned three spectral types.

(1) Type A anomalous zone

Spectral type A belonging to this zone shows the phase response which takes a peak around 0.625 Hz to 0.875 Hz. And in this zone, IP effect becomes stronger as the depth increases.

Generally, it is thought that this spectral type A is caused by pyrite. This type is seen only near No. 7 on Line BH and two ore deposits usually accompany abundant pyrite so that this anomaly may correspond to a local anomaly and/or an anomaly due to vein type or massive ore

deposit.

(2) Type B anomalous zone

Spectral type B in this zone shows the phase spectrum of a right-side-down curve in the frequency range of lower than 1 Hz. This spectral type B is thought to be due to sulphide because this anomaly shows strong IP effect similarly as type A anomalous zone.

And also, this anomaly shows very similar anomaly pattern with the so-called pipeline effect.

(3) Type C anomalous zone

Spectral type C in this zone shows the phase spectrum of a horizontal and/or slightly right-side-up curve. Anomalies of this type are observed near the Quatro and Oito ore deposits so these anomalies may be due to both ore deposits.

SIP anomaly, being thought due to Quatro ore deposit, is distributed at the depth of the southeastern part and may not continue to the southern IP anomaly detected by conventional IP method, because the depth of anomalous source and the geological circumstance, these two anomalies may be caused by the different anomalous source.

On the other hand, another IP anomaly due to the Oito ore deposit may extend towards southeast and continue to the northern anomaly detected by the conventional IP method.

Apparent resistivity shows extremely low below Lines D and E, so there is a possibility that this low resistivity may be caused by graphite schist and/or strongly mineralized rocks.

Therefore, it is recommendable to conduct the detailed survey to confirm the origin of this low resistivity zone in the future.

In both Barrinha and Perau areas, it is extremely difficult to understand a true response due to the ore deposit and/or mineralization because of the effect of the pyritization.

The distribution of apparent resistivity in both areas reflects the dominant geological structure with a NE-SW trend.

4-3 Furnas Area

In the Phase IV (1983), both IP and SIP methods were carried out in Furnas area, but failed in to detect the remarkable IP anomaly caused by the ore deposit.

But, the distribution of apparent resistivity is coincident with the geological structure in the area, and the spectral type characteristics of rocks in each horizon could be observed.

Two IP anomalies with an NE-SW trend, were revealed.

One is observed below No. 3 to No. 8 each line and continues from the surface to the depth showing north dipping. Anomalous source is thought to be dolomite associating with pyrite

within limestone, sericite-schist or pyritization within limestone, SIP anomaly of more than -40 mrad, being thought as a center of anomaly, may correspond to dolomite.

Another one is detected below No. 12 to No. 14 on each line and continues to the depth showing north dipping. This anomaly is caused by a simple source different with above-mentioned anomaly. The anomalous source may correspond to filmy graphite which is borne along schistosity within schist.

Judging from the spectral type, this anomaly is thought to be affected by rare pyrite.

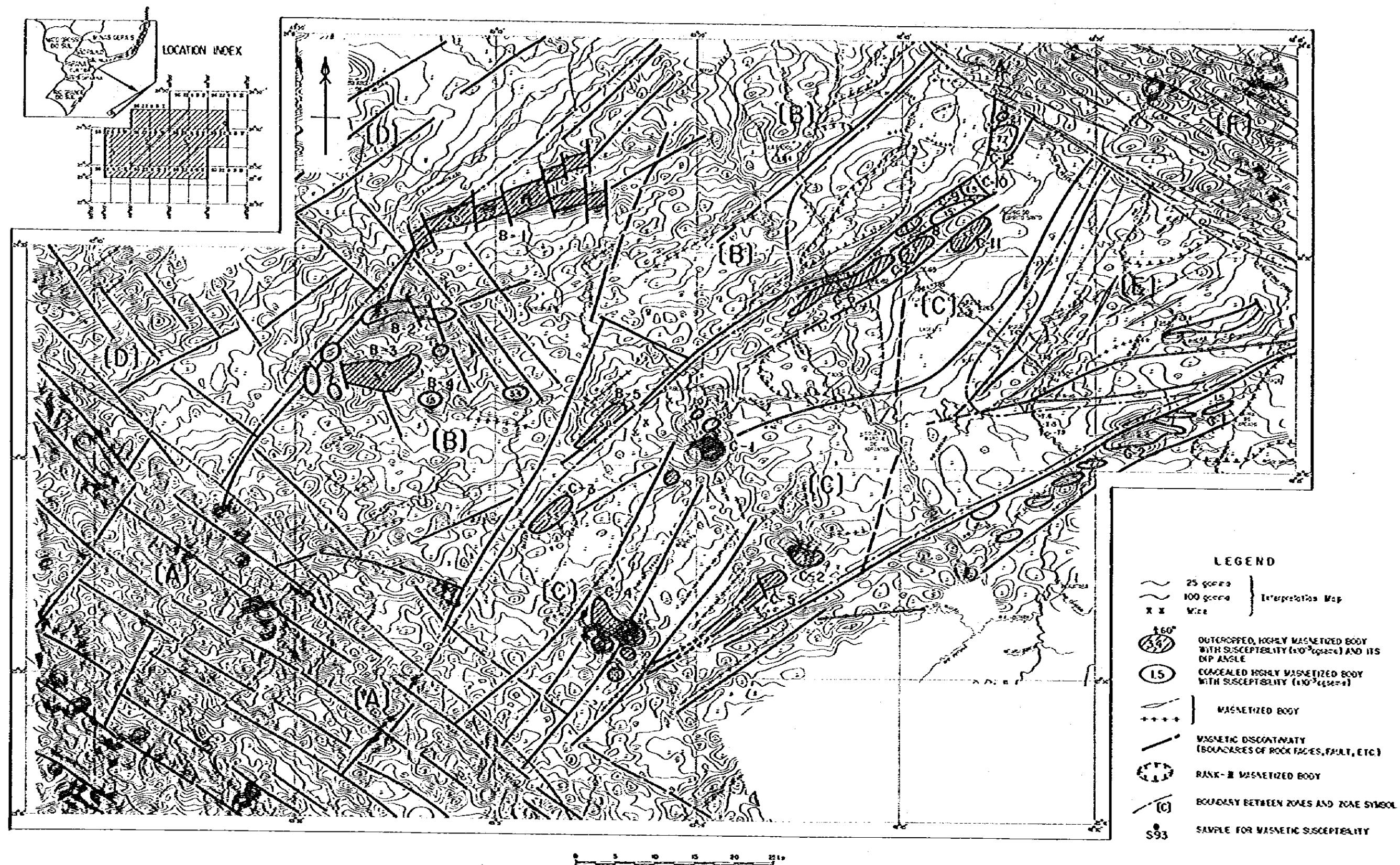


Fig. 1-1 Aeromagnetic Interpretation Map

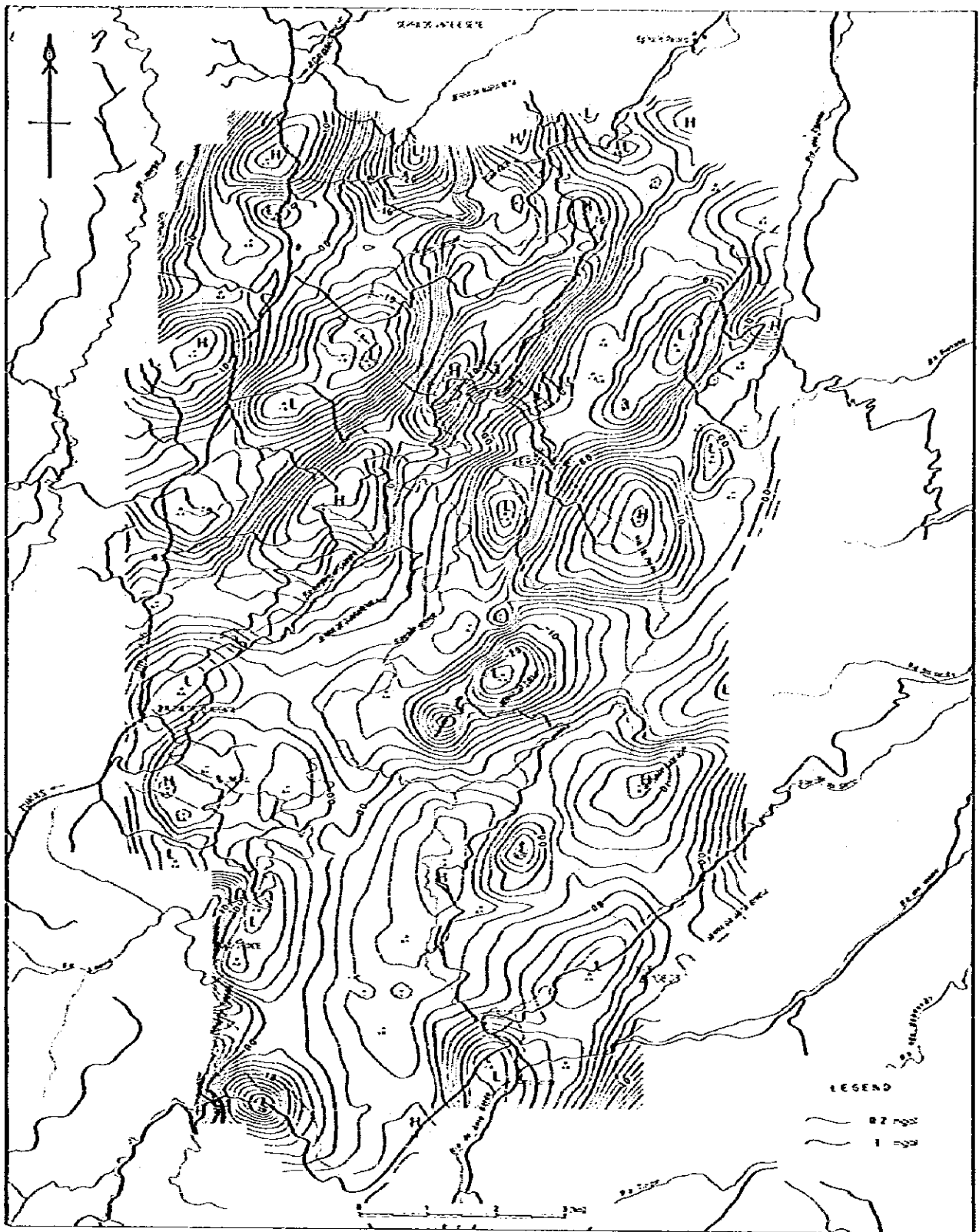


Fig. ■-2 Fifth Order Residual Gravity Map

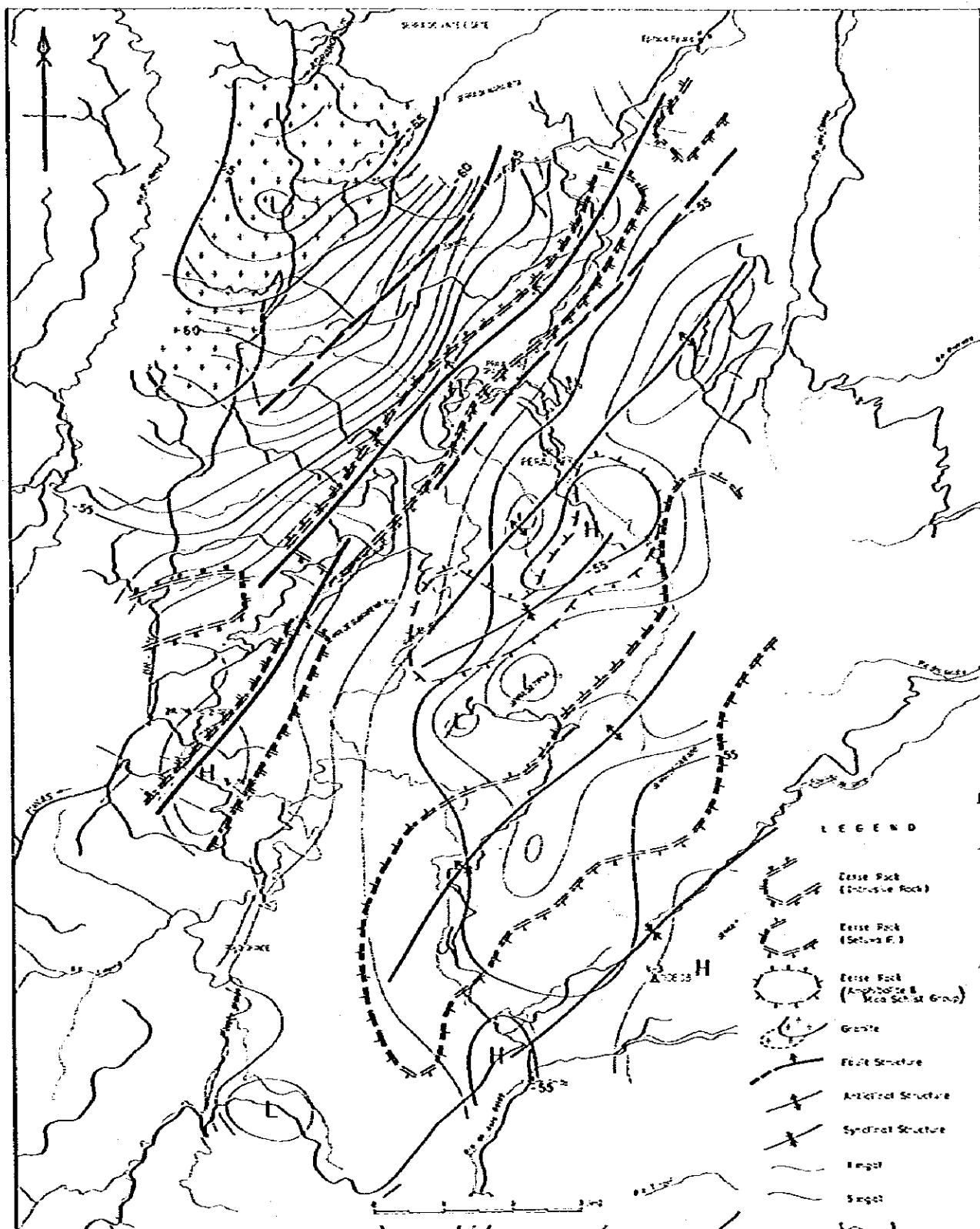


Fig. 3 Gravity Structural Map

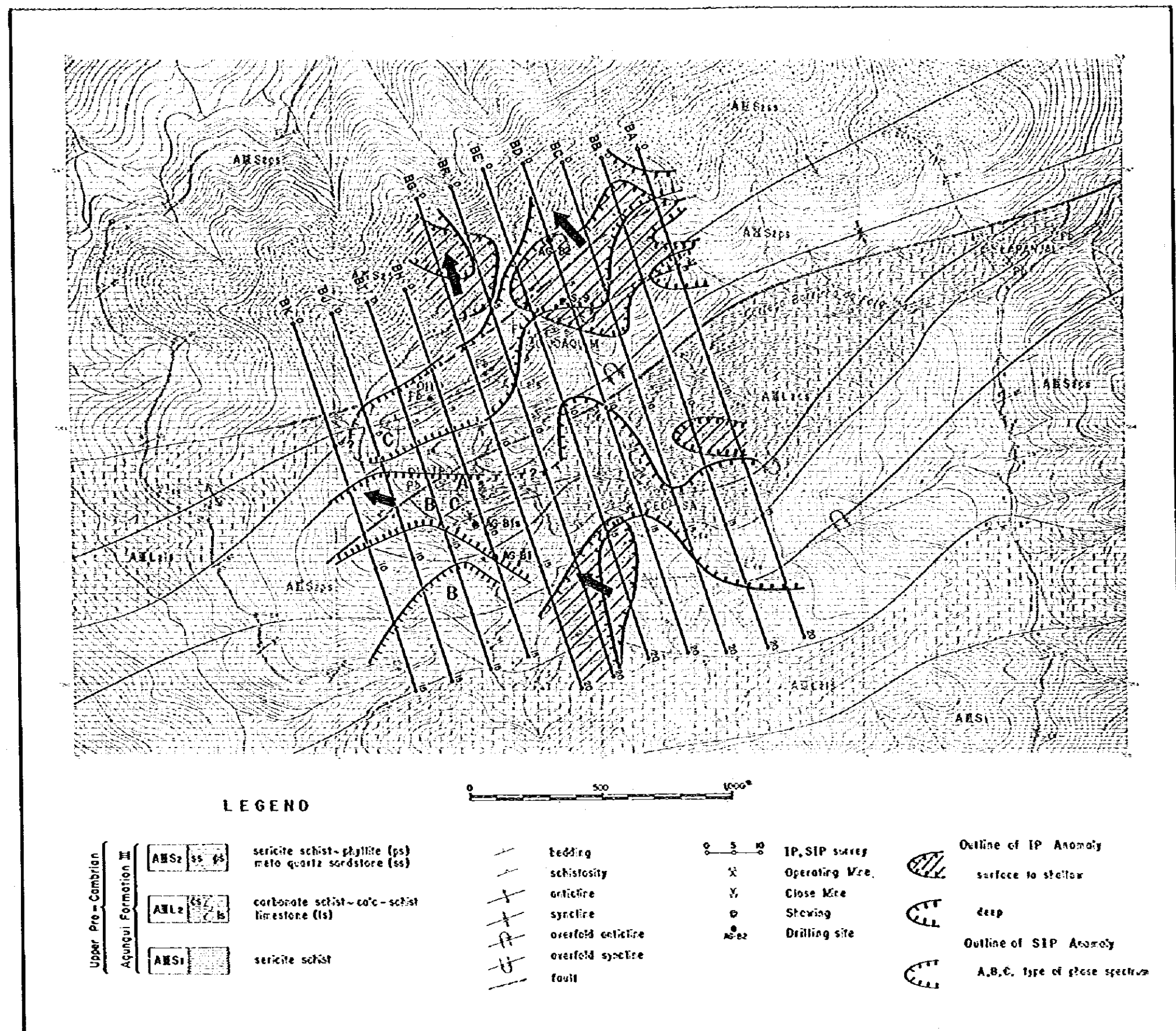


Fig. 1-5 IP and SIP Interpretation Map in Barrinha Area

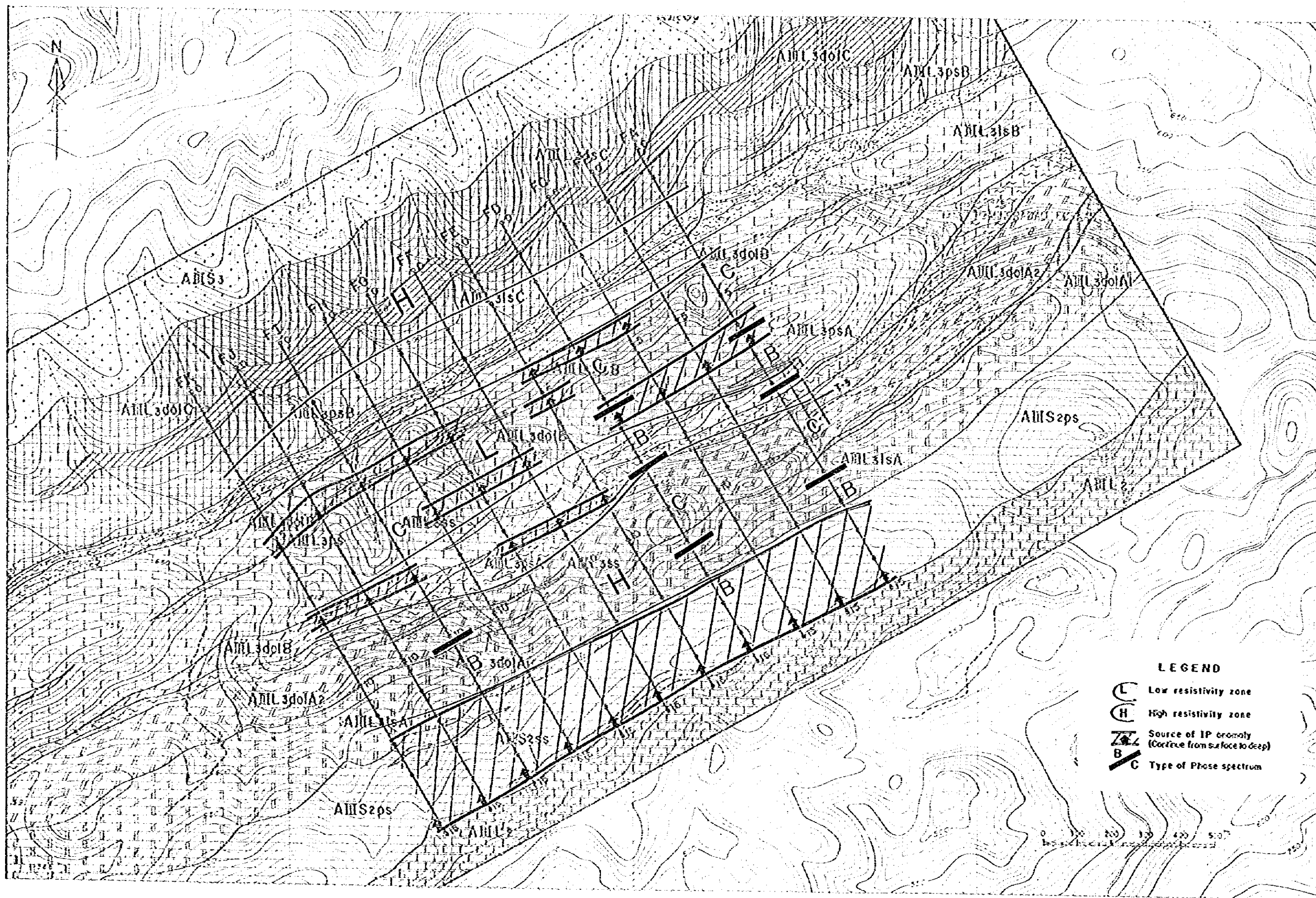


Fig. 1-6 IP and SIP Interpretation Map in Furnas Area

IV. DRILLING SURVEY

CHAPTER 1 GENERAL REMARKS

In the drill survey in the Anta Gorda region, eight holes with the total length of 2,443.8 m were drilled in the Perau area and the Barrinha area.

In the Perau area, as the result of drill survey in Phase III consisting of three holes with the total length of 912.20 m drilled at the place extracted on the basis of the study of the data of geological survey and geophysical survey. A stratiform lead and zinc deposit accompanied by barite was discovered in the same horizon of the Perau lead deposit. In Phase IV, the drill survey consisting of three holes with the total length of 1,531.6 m consecutively conducted to confirm the form of distribution, the scale and grade of the ore deposit.

Geology of the Perau area is composed of metamorphic rocks of the Precambrian Açungui I formation mainly consisting of mica schist, amphibolite, carbonate schist, graphite schist, limestone and quartzite. The ore deposit is a stratiform deposit emplaced in carbonate schist as the host rock, and the main ore minerals are composed of barite, galena, sphalerite, pyrite and pyrrhotite.

The core recovery was more than 95%, and almost 100% in the ore horizon.

The assay results of the main ore sections in each hole are shown in the following.

Nole No.	Depth of ore section (m)	Length of ore section (m)	Pb %	Zn %	Cu ppm	Ag ppm
AG-01	255.95~263.45	7.5	4.36	2.96	214	95
	263.45~265.90	2.45	2.56	0.56	236	56
AG-02	242.85~247.85	5.0	4.7	0.48	162	86
	251.40~252.50	1.1	4.5	4.5	60	68
	253.35~253.60	0.25	5.7	5.6	40	110
AG-03	194.30~196.20	1.9	2.5	0.9	293	35
AG-04	196.95~197.15	0.20	1.6	0.46	330	26
AG-05	354.65~355.65	1.0	2.5	2.9	100	75
	357.85~358.35	0.5	4.9	2.8	160	185
AG-06	327.55~328.05	0.5	2.2	0.04	22	38
	328.60~329.40	0.8	1.8	4.4	70	38
	330.15~330.60	0.45	1.3	1.1	30	38

The ore deposit is most predominant in the vicinity of the two holes such as AG-01 and AG-02. It shows a shape of distribution elongated in the direction of NE-SW along Hole AG-01 and Hole AG-02, and it seems that the southern limit is in around Hole AG-03 and Hole AG-04, while the northern limit is in the vicinity of Hole AG-06. The scale of deposit becomes inferior toward Hole AG-05. The areas for future exploration remains on the north and the northeast of Hole AG-02.

In the Barrinha area, the drill survey consisting of two holes with the total length of 600 m conducted in Phase IV at the place extracted on the basis of the result of analysis of data of geological survey and geophysical survey in Phase III resulted in to make clear the relationship between the geologic structure on the southeast of the Quatro deposit as well as in the northeastern part of the survey area and the anomalous zones of geophysical survey. In addition, the areas to warrant future exploration were selected.

CHAPTER 2 THE RESULT OF DRILL SURVEY

2-1 AG-01

The bed rock was encountered at the depth of 0.55m. The rocks below that down to 236.20 m consist of graphitic mica schist, mica schist and amphibolite to amphibole schist. Graphitic mica schist is distributed in the upper part, in which pyrite is found in a form of film along the schistosity plane and the cracks. The interbedded strata of amphibolite to amphibole schist are seemingly harmonious with graphitic mica schist., both of which grade into each other.

The section between 236.20 m and 305.50 m is composed of carbonate schist, graphite schist to phyllite, limestone and dolomite to carbonate schist of the Perau Horizon. The main sections among those are as follows.

- 236.20 ~ 241.00 m "Magnetite Zone", the key bed indicating the hanging wall of the ore deposit.
- 255.95 ~ 265.90 m Stratiform lead and zinc deposit accompanied by barite
- 265.90 ~ 271.50 m Graphite schist, the key bed indicating the footwall of ore deposit.
- 271.50 ~ 305.50 m The main rocks are limestone and dolomite, being interbedded with carbonate schist.

The ore section shows a characteristic of the mineralization of barite sulphide minerals. Galena, sphalerite and pyrite are contained in barite zone as the main ore minerals, accompanied by a small amount of chalcopyrite and rare amount of pyrrhotite.

- 305.50 ~ 331.15 m Alternating beds of limestone and quartzite, which are included in quartzite stratigraphically.

2-2 AG-02

The bed rock was encountered at 19.00 m. The rocks from there down to 226.30 m consist mainly of graphitic mica schist and mica schist interbedded with amphibolite to amphibole schist. Pyrite is found in graphitic mica schist along the schistosity plane forming film.

The section between 226.30 m and 298.60 m is distributed by the rock facies of the Perau Horizon. The main sections among those are as follows.

- 228.10 ~ 231.05 m "Magnetite Zone"
- 242.85 ~ 252.50 m Stratiform lead and zinc deposit accompanied by barite.
- 256.20 ~ 267.00 m Graphite schist to phyllite

276.00 ~ 298.60 m Limestone, dolomite and carbonate schist.

The ore section shows a characteristic of the mineralization of barite-sulphide minerals. Galena, sphalerite and pyrite are contained in barite zone in a form of dissemination. The main ore portions were intersected at three places, among which zinc is low in grade in the section from 242.85 m to 247.85 m.

298.60 ~ 330.55 m Alternating beds of limestone and quartzite in the quartzite horizon are distributed.

2-3 AG-03

The bed rock was encountered at 9.00 m. The rocks from there down to 185.80 m consist of graphitic mica schist, mica schist and amphibolite to amphibole schist. Graphitic mica schist is dominant in the upper part, in which pyritization is often found.

The section between 185.80 m and 250.50 m consists of carbonate schist, graphite schist to phyllite and limestone-dolomite of the Perau Horizon. The main sections among these are as follows.

185.80 ~ 187.60 m "Magnetite Zone"

194.30 ~ 196.20 m Lead and zinc deposit accompanied by barite

198.25 ~ 205.05 m Graphite schist to phyllite

205.05 ~ 250.50 m Limestone-dolomite

In the ore section, galena and sphalerite are contained in the alternating beds of cherty schist and carbonate schist in a form of bed to network. The scale of mineralized zone is inferior to those of Hole AG-01 and Hole AG-02. Barite is low in content, and lead and zinc are low in grade. Thus an aspect of the tail end of ore deposit is shown.

2-4 AG-04

The bed rock was encountered at 3.80 m. The rocks below that point down to 187.35 m consist of graphitic mica schist, mica schist and amphibolite to amphibole schist. Graphitic mica schist is dominant in the upper part, in which pyrite occurs in a form of film.

The section between 187.35 m and 220.00 m consists of carbonate schist, graphite schist to phyllite and limestone-dolomite to carbonate schist of the Perau Horizon. The main portions of it are as follows:

187.35 ~ 190.30 m "Magnetite Zone"

196.95 ~ 200.75 m Lead and zinc mineralized zone at three places

205.55 ~ 212.55 m Graphite schist to phyllite

212.55 ~ 220.00 m Limestone-dolomite, interbedded with carbonate schist

The ore section includes the separate three portions as shown in the following.

196.95 ~ 197.15 m (0.20 m) ... Lead and zinc mineralization accompanied by barite

199.80 ~ 199.90 m (0.10 m) ... Galena is disseminated in the alternation beds of cherty

200.65 ~ 200.75 m (0.10 m) ... Schist and carbonate schist

Both the scale and grade of the mineralized zone show an aspect of the marginal facies of the ore deposit.

2-5 AG-05

The section between 0 m and 341.55 m consists of graphitic mica schist, mica schist and amphibolite to amphibole schist. Graphitic mica schist is found in the upper part from the collar down to 224.20 m, in which pyrite occurs along schistosity plane and fractures in a form of film.

The section between 341.55 m and 361.60 m consists of carbonate schist and graphite schist to phyllite of the Perau Horizon. The main section among these are as follows.

343.00 ~ 351.50 m "Magnetite Zone"

354.65 ~ 358.35 m Lead and zinc deposit accompanied by barite

359.50 ~ 361.60 m Graphite schist or phyllite

The ore section shows a characteristic of the mineralization of barite-sulphide mineral, and galena, sphalerite and pyrite are contained in barite zone in a form of dissemination. The high grade portions are in the upper part (1.0 m) and the lower part (0.5 m) of the mineralized zone, and the middle part forms a weakly mineralized zone mainly containing pyrite. The scale of mineralized zone is inferior to that of AG-01, and it shows an aspect to be close to the marginal part of the deposit.

2-6 AG-06

The bed rock was encountered at 4.00 m. The rocks below that point down to 174.30 m are composed of graphitic mica schist, mica schist and amphibolite to amphibole schist, and diabase penetrates these rocks. Graphitic mica schist is found in the upper part accompanied by pyritization.

The section between 304.30 m and 350.00 m consists of carbonate schist, graphite schist to phyllite and limestone to carbonate schist of the Perau horizon. The main sections are as follows.

299.00 ~ 312.50 m "Magnetite Zone"

327.55 ~ 329.40 m Lead and zinc deposit accompanied by barite

329.40 ~ 346.50 m Graphite schist to phyllite

346.50 ~ 350.00 m Limestone to carbonate schist

The ore section shows a characteristic of the mineralization of barite-sulphide minerals, and the ore minerals such as galena, pyrite and pyrrhotite, and small amount of sphalerite are disseminated in barite zone.

The scale and grade of the mineralized zone are markedly inferior to those of AG-01, and it is likely that the tail end of a stratiform deposit of barite-sulphide minerals is indicated.

2-7 AG-B1

The bed rock was encountered at 45.80 m, showing that the overburden is thick in this part. The rocks below that point down to 300.00 m consist mainly of chlorite-mica schist, locally intercalated with dolomite to carbonate schist and chlorite-amphibole schist.

The section between 57.00 m and 80.00 m consists of silicified mica schist, in which quartz-pyrite veinlets are often found.

Although quartz veins accompanied by patchy to massive pyrite were encountered, no other mineralization was observed.

2-8 AG-B2

The bed rock was encountered at 11.70 m. The rocks below that point down to 113.20 m consist mainly of mica schist interbedded with quartzose schist and graphitic mica schist.

The section between 113.20 m and 300.00 m consists mainly of graphitic mica schist, in which the apparent content of graphite increases downward. It is intercalated with quartzose schist from 132.05 m to 190.20 m. Although pyrite is contained in the portion where graphitic mica schist is dominant, in a form of film along the schistosity plane and the fractures, no other notable mineralization can be observed.

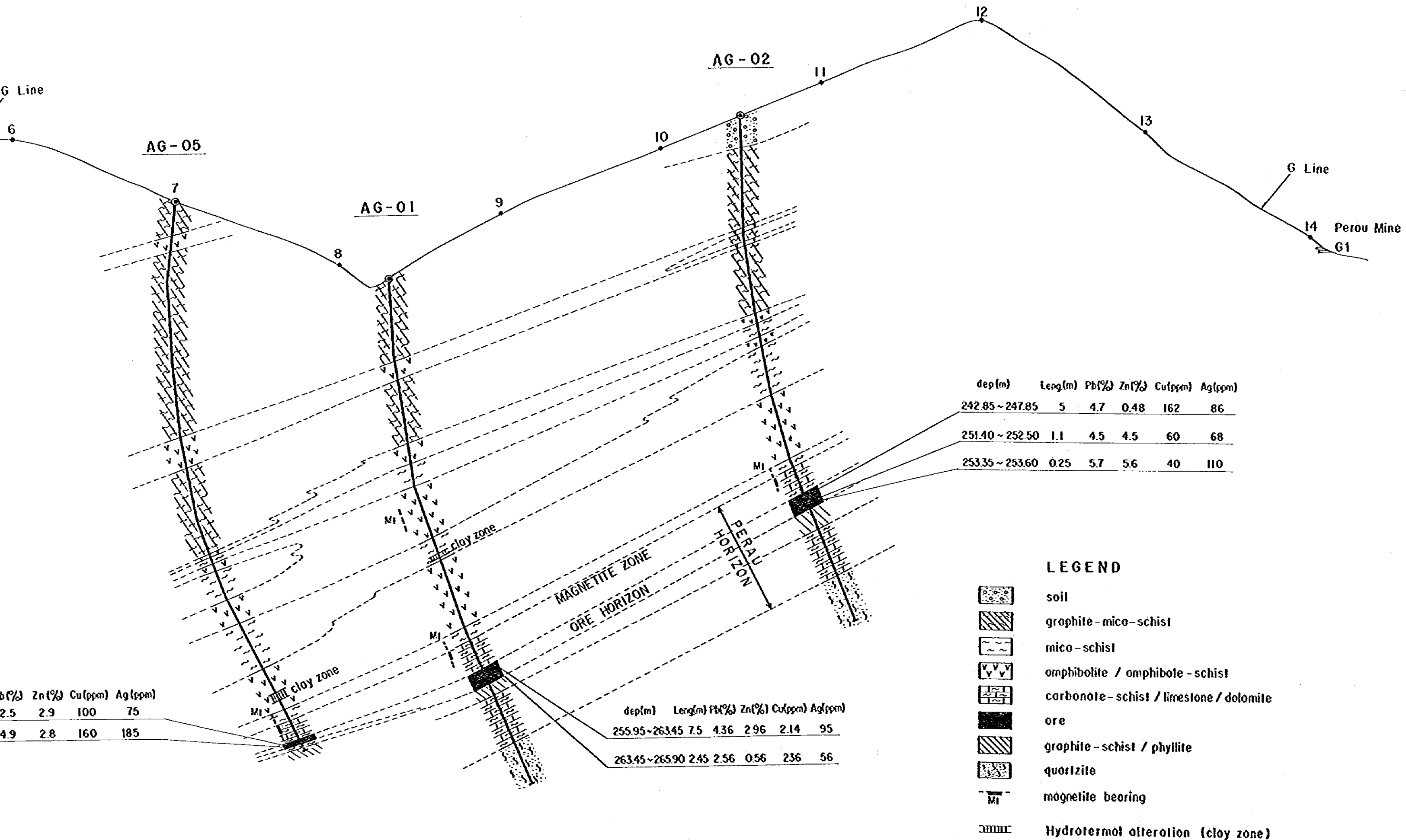


Fig. N-1 Geological Profile for AG-01, AG-02 and AG-05

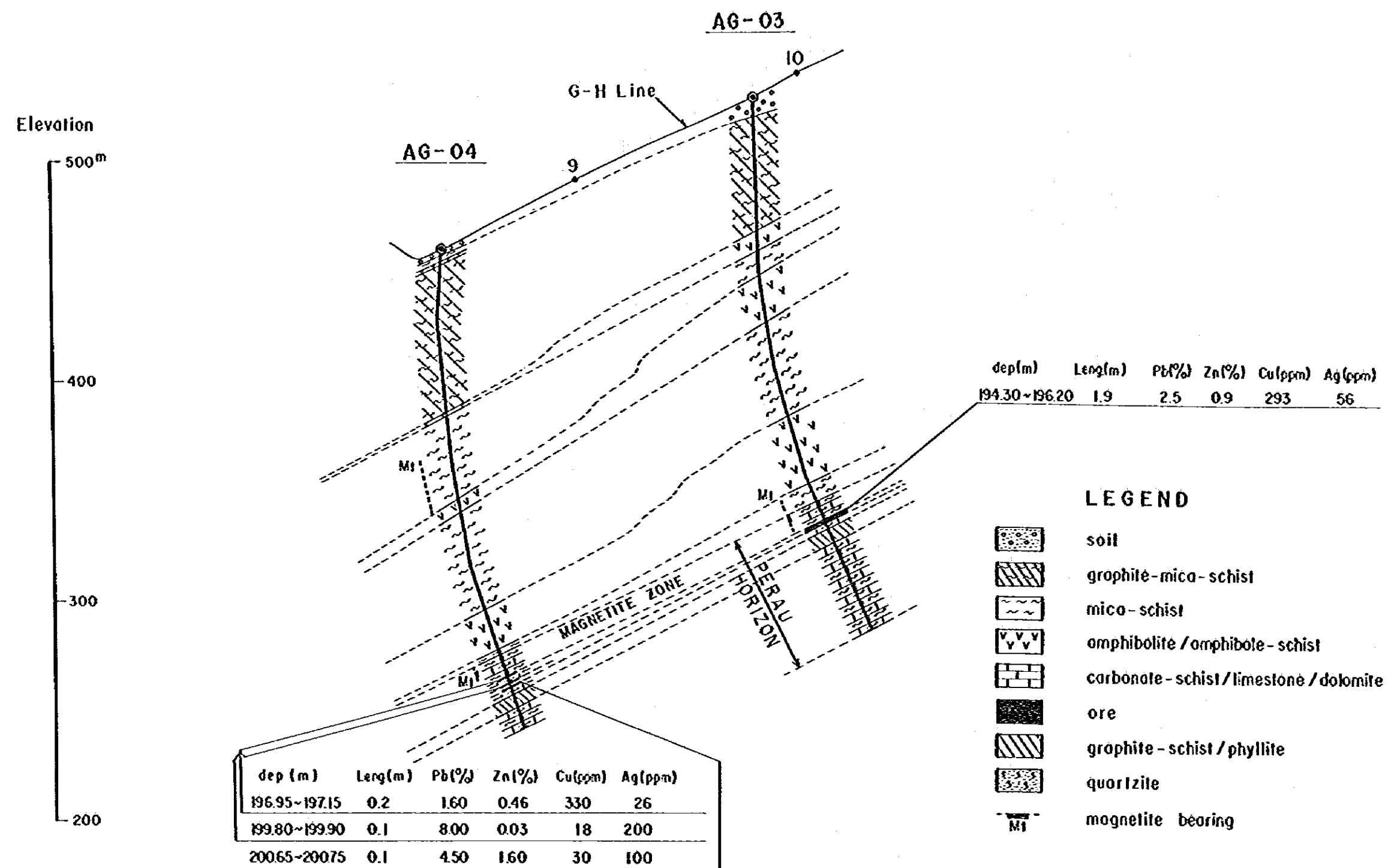


Fig. IV-2 Geological Profile for AG-03 and AG-04

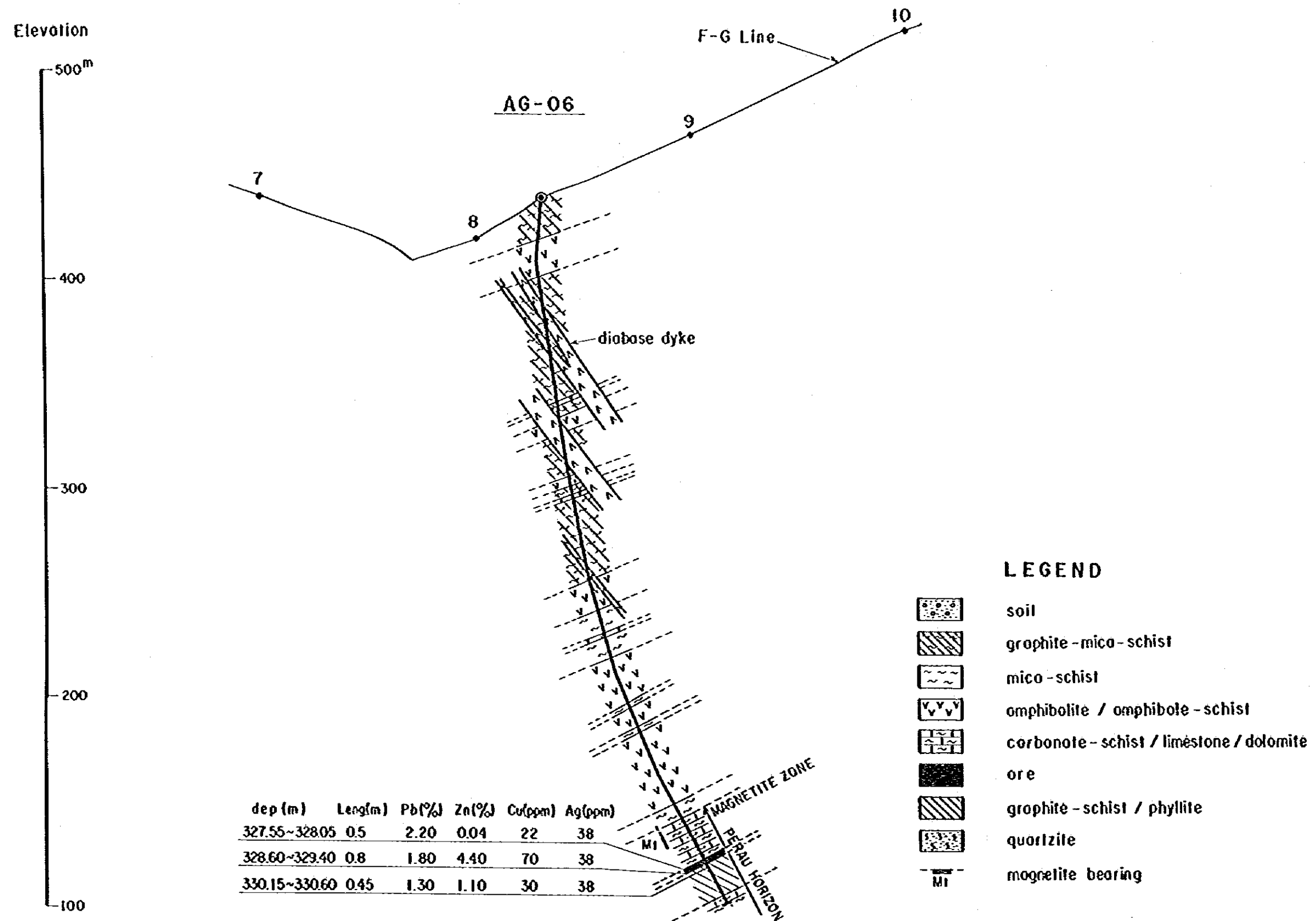


Fig. IV-3 Geological Profile for AG-06

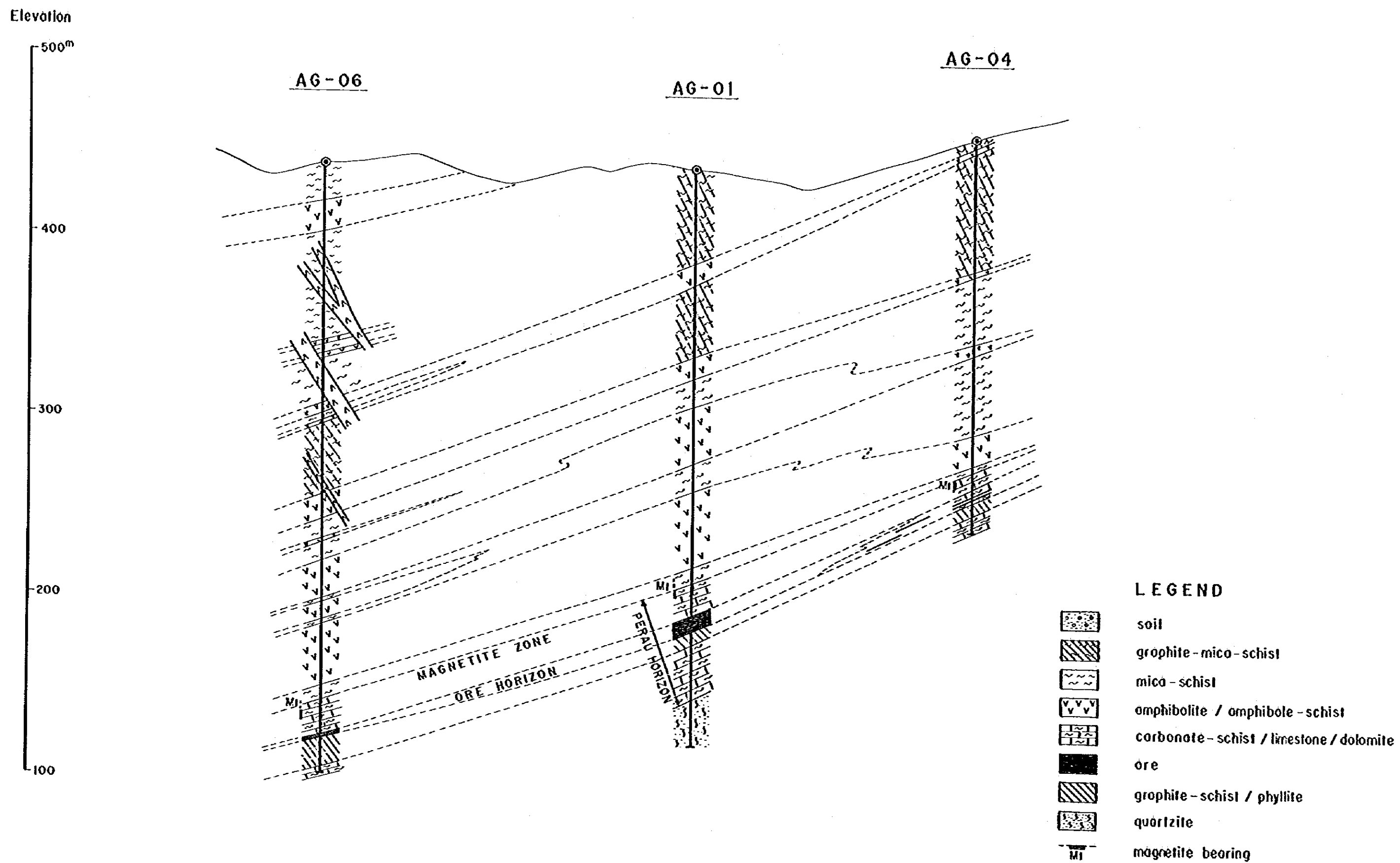


Fig. N-1 Geological Profile for AG-6, AG-01 and AG-01

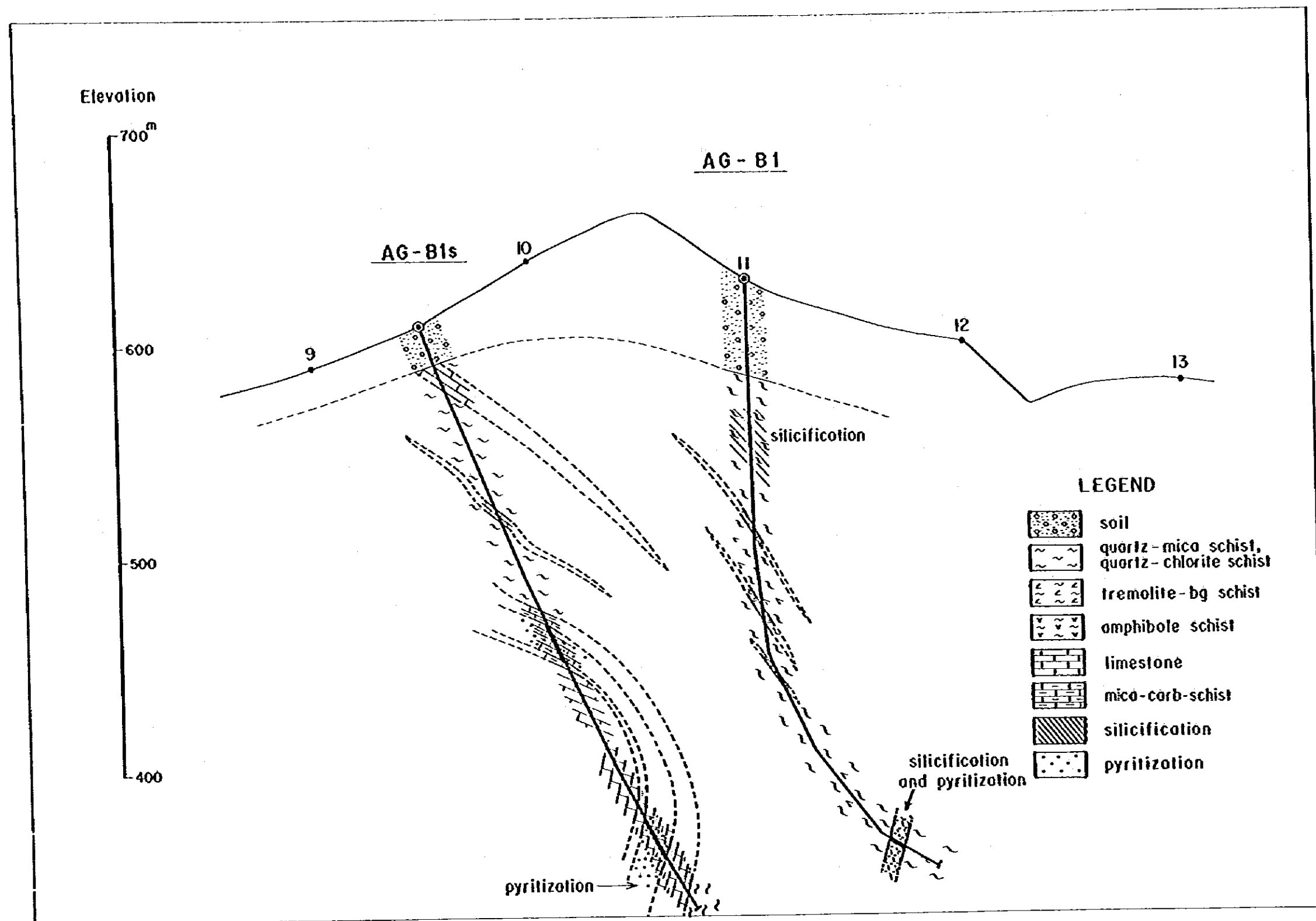


Fig. W-5 Geological Profile for AG-B1

V. CONCLUSION AND RECOMMENDATION

CHAPTER I CONCLUSION

- (1) The stratigraphy of the surveyed area was established, and the geologic structure as well as the ore-bearing horizon of the main ore deposits were made clear. The geology distributed in the area is composed of the Precambrian Setuva formation and the Açungui group, among which the Açungui group in which the ore deposits are emplaced was subdivided.
- (2) The main ore deposits distributed in the survey area are roughly divided into the Perau-type strata-bound lead (zinc) deposits and the Rocha-type vein-type to irregular massive silver bearing lead deposits. The Perau-type deposits are emplaced in carbonate rocks in the lower part of the Açungui I formation and the Rocha-type deposits in the carbonate rocks in the middle to upper part of the Açungui III formation.
- (3) In the Rocha area, although no lateral extension of the ore-bearing horizon can be expected, the room for exploration toward the depth remains untouched.
- (4) In the Furnas area, the ore-bearing horizon was clarified, and confirmed its extension. The electric survey result showed the existence of strata in both the hanging wall and foot-wall, which show a strong IP effect caused by the occurrence of graphite and pyrite. The detection of IP anomaly in the ore-bearing horizon was difficult because of small mineralized zone and unpolarizable and high resistivity host rock.
- (5) In the Barrinha area, as the result of drill survey in the northeastern part of the area among the anomalous zones detected by the geophysical survey (IP and SIP), existence of a fault zone of E-W system has become to be assumed, and it was proved that the IP anomalies in the area was caused by the combined effect of pyrite-graphite in graphite-mica schist and pyrite-galena in carbonate rocks. It also became clear that the SIP anomalies detected on the south of the Quatro deposit was caused by pyrite in carbonate rocks.
- (6) In the Perau area, the drill survey conducted on the basis of comprehensive analysis of the results of geological survey, geochemical survey and geophysical survey, the strata-bound lead and zinc deposit accompany with barite has been discovered on the western side of the Perau deposit in the same horizon.

CHAPTER 2 RECOMMENDATION

While the technological collaborative project by the Japanese Government started in fiscal 1980 is to be completed by the end of fiscal 1983, the following items are to be proposed as recommendation for the Brazil would continue the survey.

- (1) At the Perau area it is recommended that the possibility of development of mine including the existing Perau mine would have to be examined by making clear comprehensively the whole aspect of the deposit by performing drill survey for the barite-lead and zinc deposit discovered as the result of this survey.
- (2) Because the vein fracture system is dominant in dolomite in the Rocha area, it will be needed to trace the dolomite horizon, and at the same time, to conduct exploration in the lower part of the known deposit.
- (3) At the Barrinha area, performance of drill survey is recommended because of possibility of occurrence of massive lead deposit in limestone-dolomite strata located to the south of the Quatro deposit, which is similar to that deposit.

It is desirable that exploration on the north and north-east of the Barrinha area is to be made for the limestone-dolomite strata as a target, which is distributed on the southern side of the fault of E-W system, the occurrence of which was made clear in the survey.

- (4) At the Furnace area, it is recommended that a detailed geochemical survey (soil and rock) for the ore bearing horizon is to be conducted, together with trenching and drilling, if necessary. It is also desired that the exploration for the lower part of the known deposit would have to be made by scrutinizing the "chute" of the bonanza.