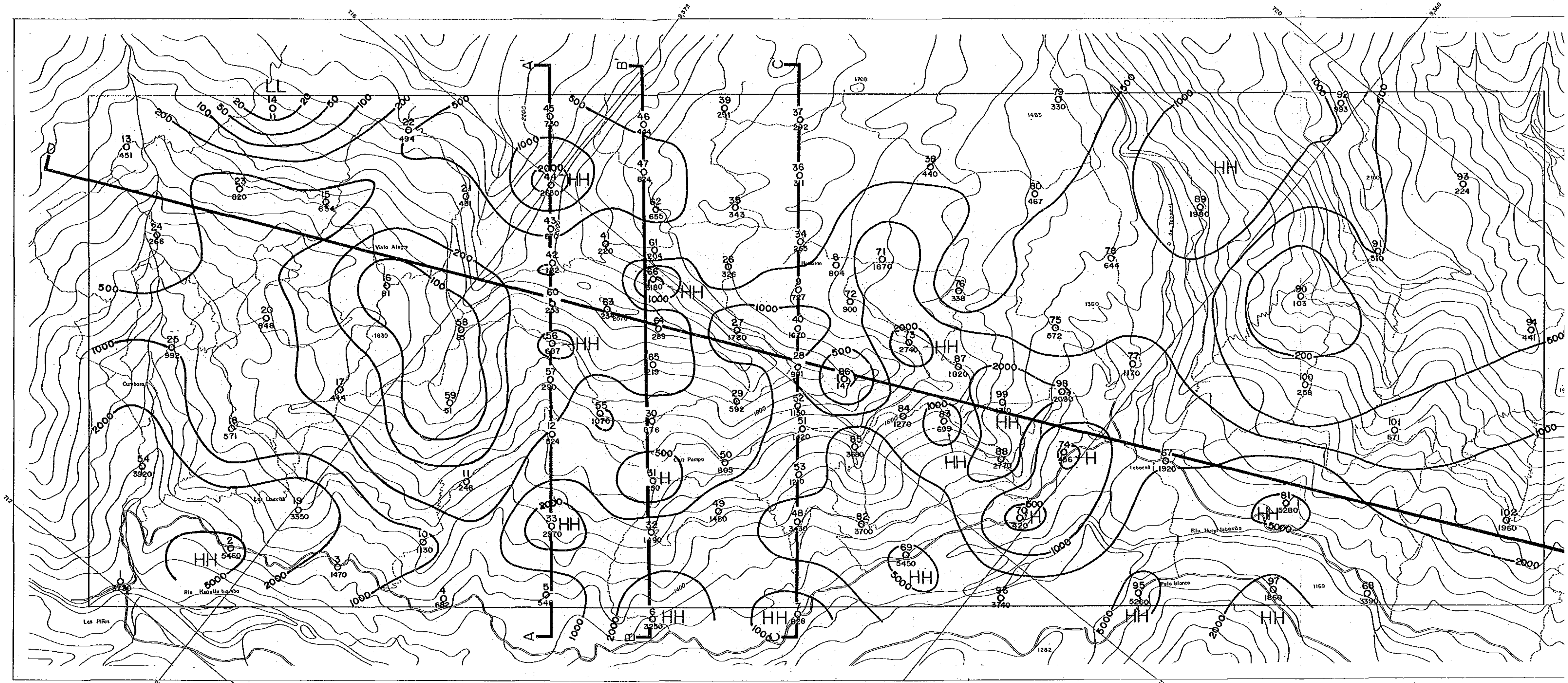
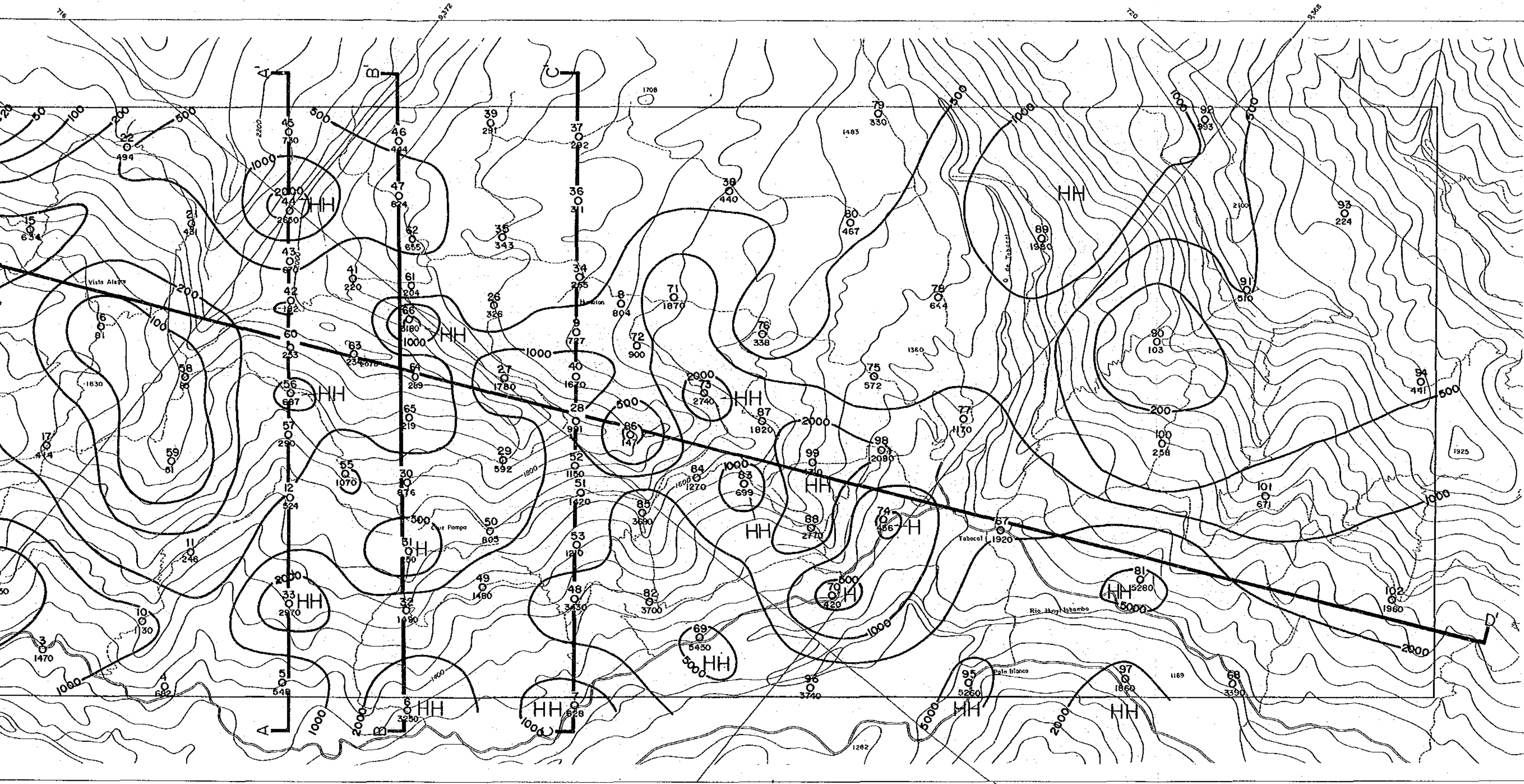
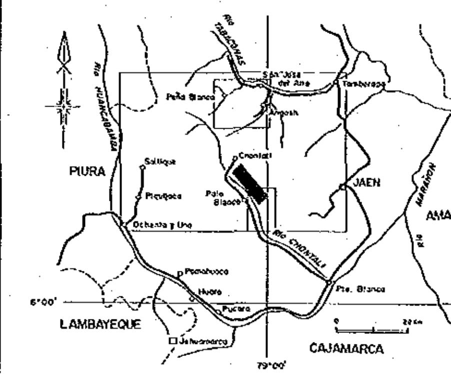




THE MINERAL EXPLORATION
IN
THE PACHAPIRIANA AREA, REPUBLIC OF PERU
(PHASE II)

Fig. II-12 (4) Apparent Resistivity Map
of the chontali Area (4 Hz)



JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN
FEBRUARY 1990

Prepared by MINDECO

LEGEND

45 Station number
O CSAMT Station
202 Apparent Resistivity (Ω·m)

A A' Cross Section

Division of Apparent Resistivity
20 50 200 500 (Ω·m)
LL L H HH

10 Apparent
20 Resistivity
50 Contour (Ω·m)

0 500 1000 m
Scale = 1 : 10,000

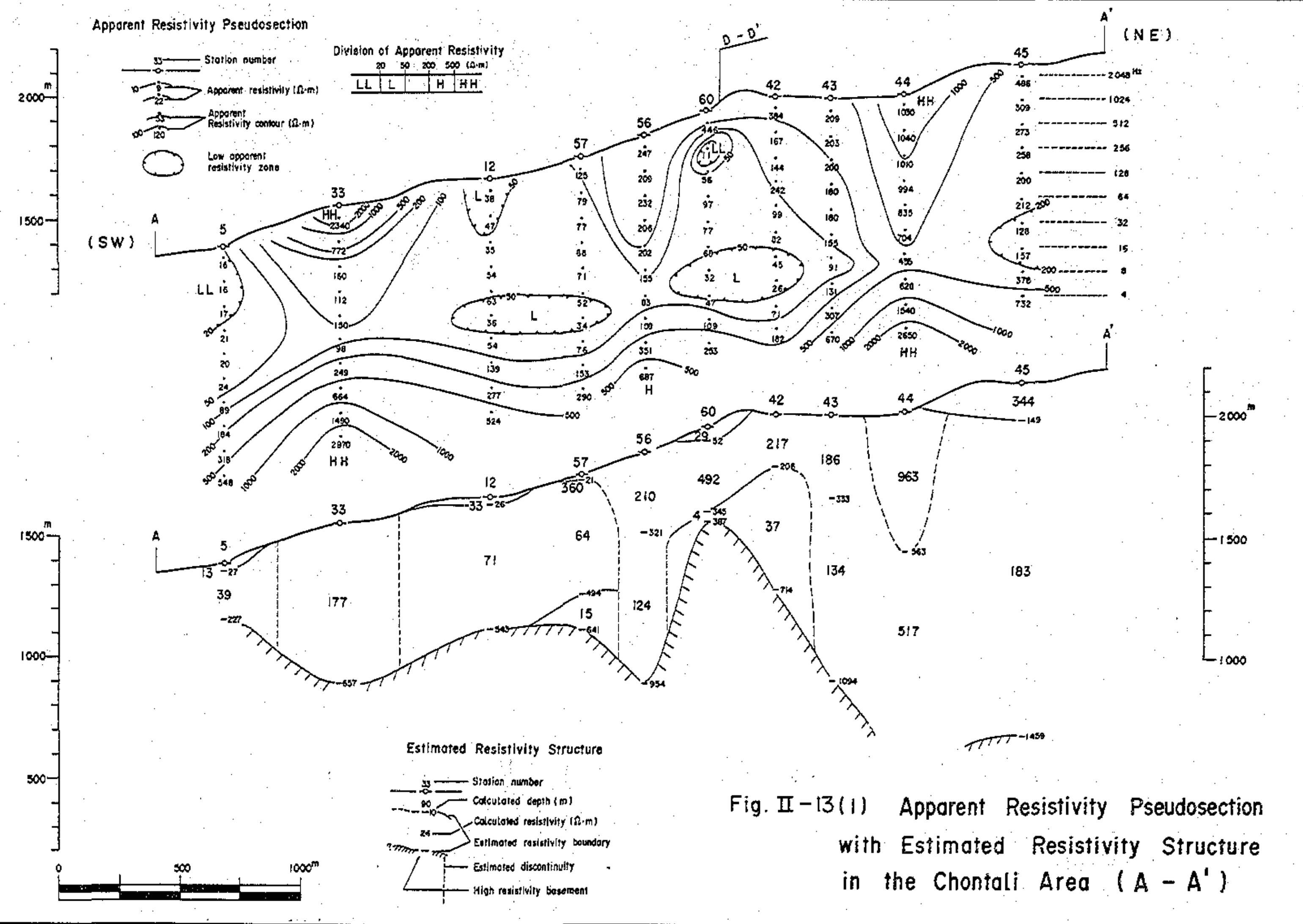


Fig. II-13(1) Apparent Resistivity Pseudosection with Estimated Resistivity Structure in the Chontali Area (A - A')

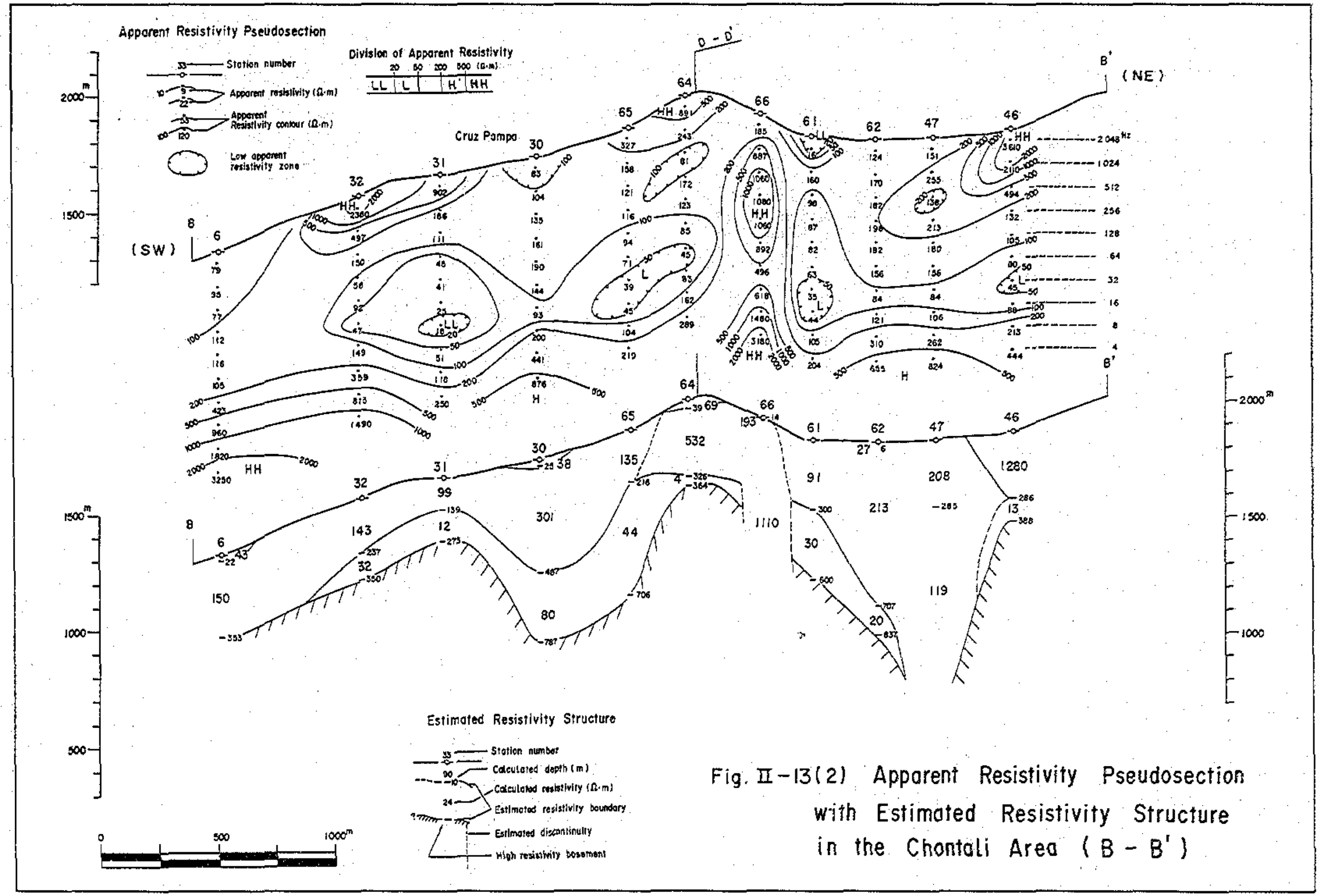


Fig. II-13(2) Apparent Resistivity Pseudosection with Estimated Resistivity Structure in the Chontali Area (B - B')

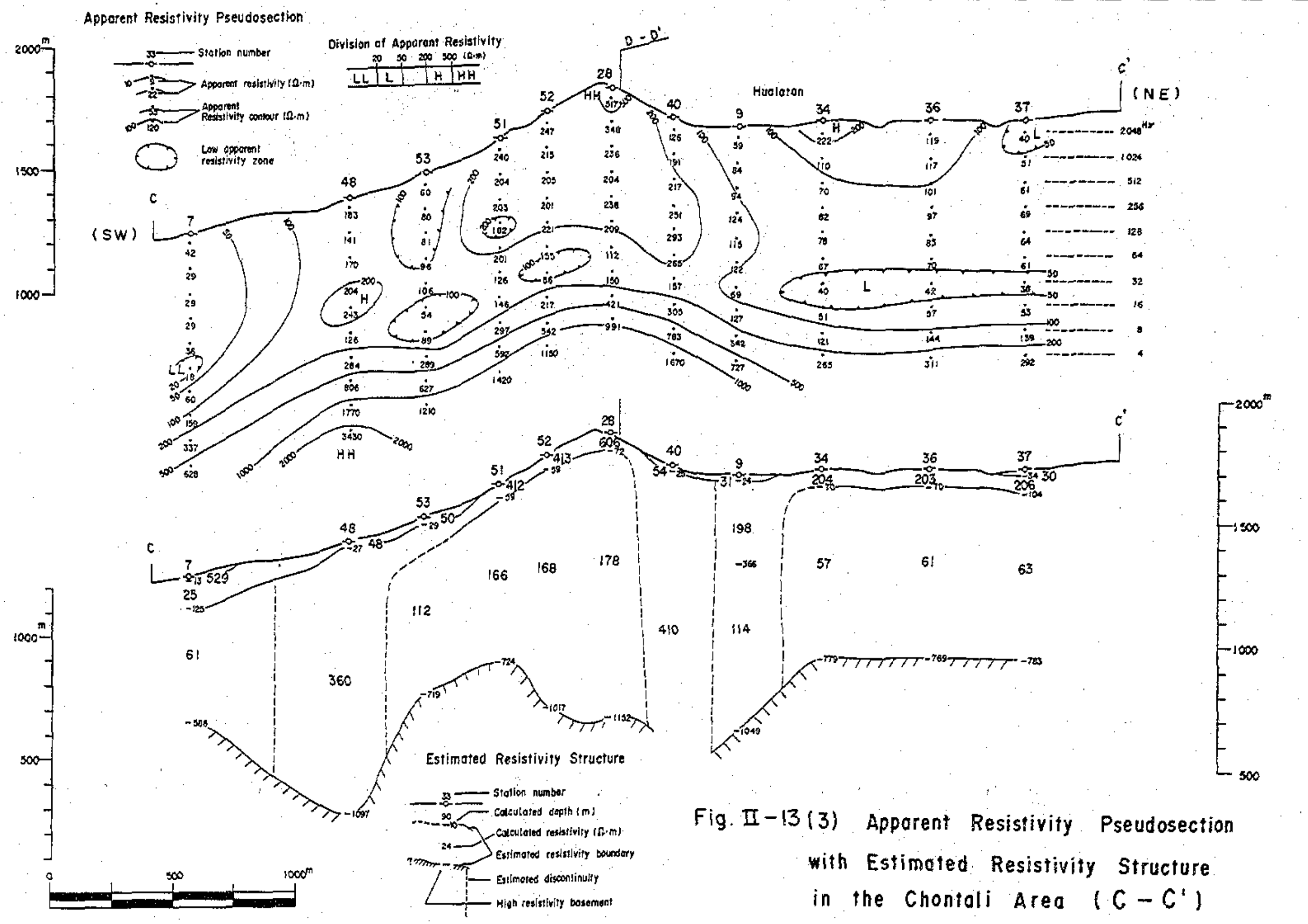


Fig. II-13(3) Apparent Resistivity Pseudosection with Estimated Resistivity Structure in the Chontali Area (C - C')

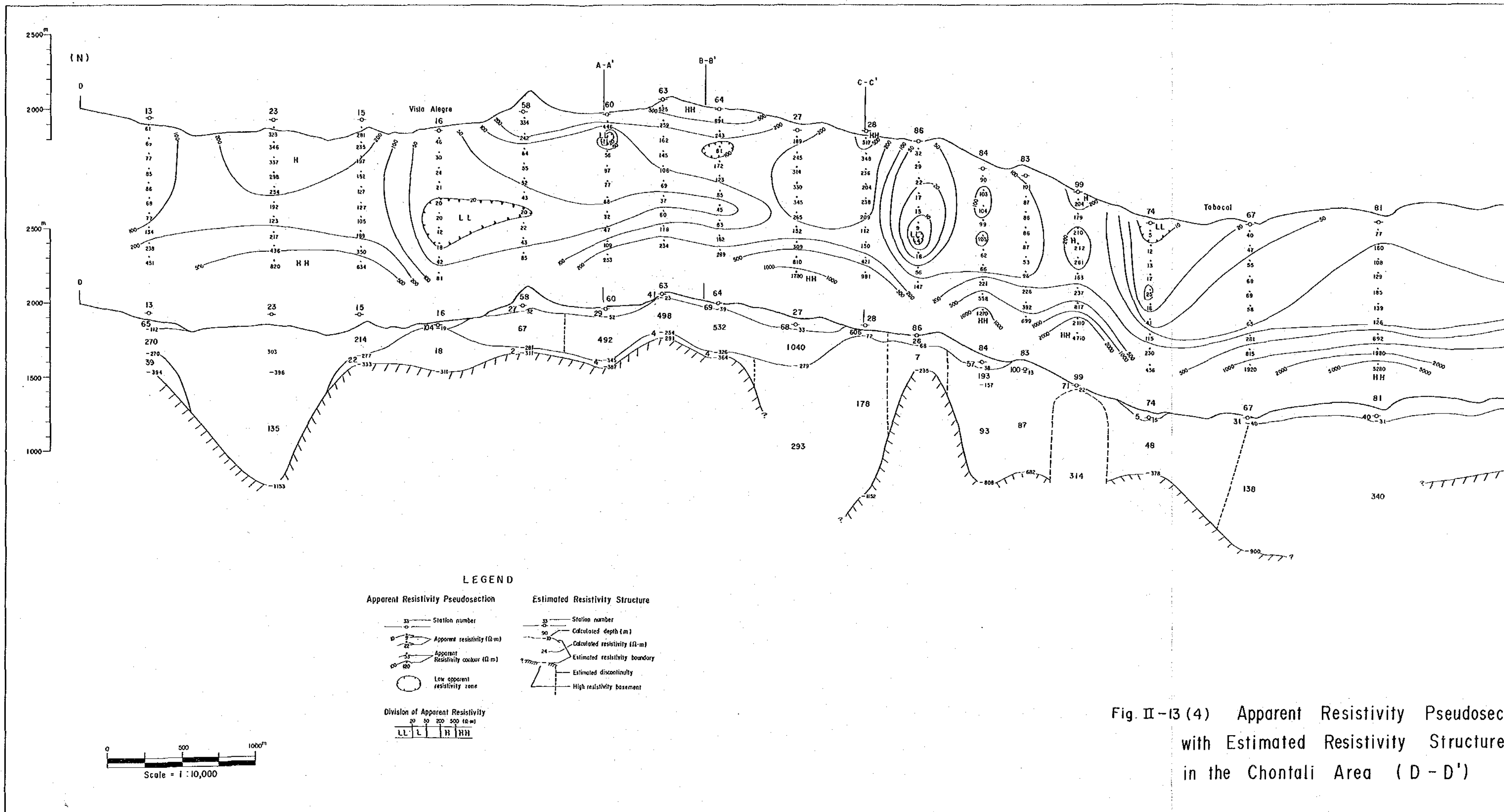


Fig. II-13 (4) Apparent Resistivity Pseudosection with Estimated Resistivity Structure in the Chontali Area (D - D')

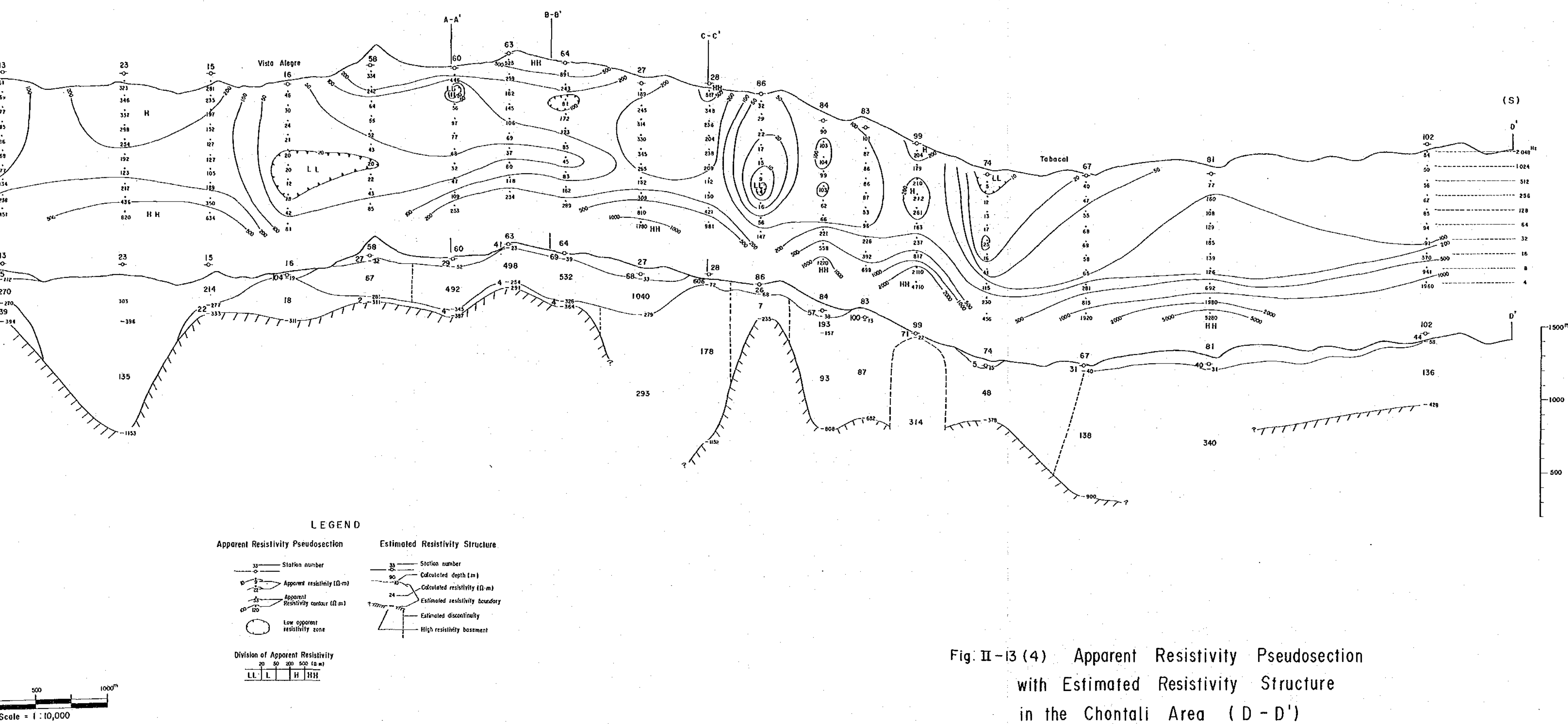


Fig. II-13 (4) Apparent Resistivity Pseudosection with Estimated Resistivity Structure in the Chontali Area (D-D')

ture does not continue laterally. Along the sections, B-B' and C-C', resistive layer is near the surface of the ground as if the basement outcropping and it makes resistivity structure discontinuous. The upheaval of the basement with conductive layer on top and resistivity structure discontinuity are common to the three sections and it is inferred to be a continuous feature for the three sections. Along the section D-D', there is a large upheaval of the basement from Vista Alegre to the intersection with the section B-B', and local upheavals of the basement with resistivity structure discontinuity at the intersection with the section C-C' and north of Tabacal. Resistive layer is thick and continuous to depths at the center of the section, from the station No. 60 to the station No. 64. At the stations No. 86 and No. 99, conductive layer is at and around upheavals of the basement.

Around known mineralized zones, the basement upheaves and resistivity structure differs from surroundings at the station No. 64 of the section B-B', the stations Nos. 28 and 51 of the section C-C', and the stations Nos. 64, 27, 28, 86, and 99. Therefore, we assume there exist close relation between upheaval of the basement and mineralization.

② Resistivity Structure Map
(Fig. II-14(1) and (2), and PL.-11(1) and (2))

The resistivity structure map of 1,600m above sea level is very similar to the distribution of high (apparent) resistivity zones and low (apparent) resistivity zones of the apparent resistivity map of 256 Hz. High resistivity zones over 500 Ω m extend N-S direction in the west of Hualatan and are surrounded by conductive zones under 50 Ω m. Major mineralized zones in Chontali area are in these resistive zones extending N-S direction. Conductive zones under 50 Ω m are in the southwest of Vista Alegre. Intruded monzonite and alteration is at near the station No. 59, and the conductive zones are assumed to be caused by the intrusion and alteration.

On the resistivity structure map of 1,200 m above sea level a resistive zone of over 500 Ω m is in the southwest of Hualatan which also is seen slightly south of it in the resistivity structure map of 1,600 m above sea level and show upheaval of the basement. A resistive zone of over 500 Ω m is also around Cruz Pampa. There are relatively low resistivity zones of 100 Ω m are between those two resistive zones. A high resistivity zone extends widely from Vista Alegre to Los Laureles in the northwestern part of the survey area. There is no conductive zone from Vista Alegre to southeast which is seen on the resistivity structure map of 1,600 m. A conductive strip extending from Palo Blanco through Tabacal toward N45° E direction is assumed to reflect extension of an inferred fault in depths.

③ 3 Dimensional Resistivity Map (Fig. II -14(3))

In order to understand resistivity structure easily, we made a three dimensional representation of resistivity structure in color. The three dimensional resistivity map is a compilation of resistivity structure planes at 1,600m, 1,400m, 1,200m, 1,000m and 800m above sea level. It is summarized as follows:

i) A resistive zone expands in depths of the center to the north western part of the survey area. It reaches vertically to the level 1,400 m with corn-shape and outcrops at Cruz Pampa and Hualatan. Interpreting from relation between this resistive zone and mineralized alteration zone on the surface of the ground, mineralization in Chontali area is closely related to this upheaval of the resistive basement.

ii) There are conductive zones above and around the upheaval of the resistive basement. Some of them may be a reflection of alteration zones.

iii) A conductive to medium resistivity strip extends to depths along a inferred fault through Palo Blanco and Tabacal.

1-3 Consideration

This survey area consists of the Oyotun Volcanics as basement, the Goyllarisquizga Group overlying it and granodiorite, monzonite porphyry, quartz porphyry-rhyolite and andesite intruded into them. Silicified and combined silicified-argillized zones are widely developed in the Oyotun Volcanics, and among them those closely connected with geochemical anomaly are found at Hualatan west in the detailed survey area.

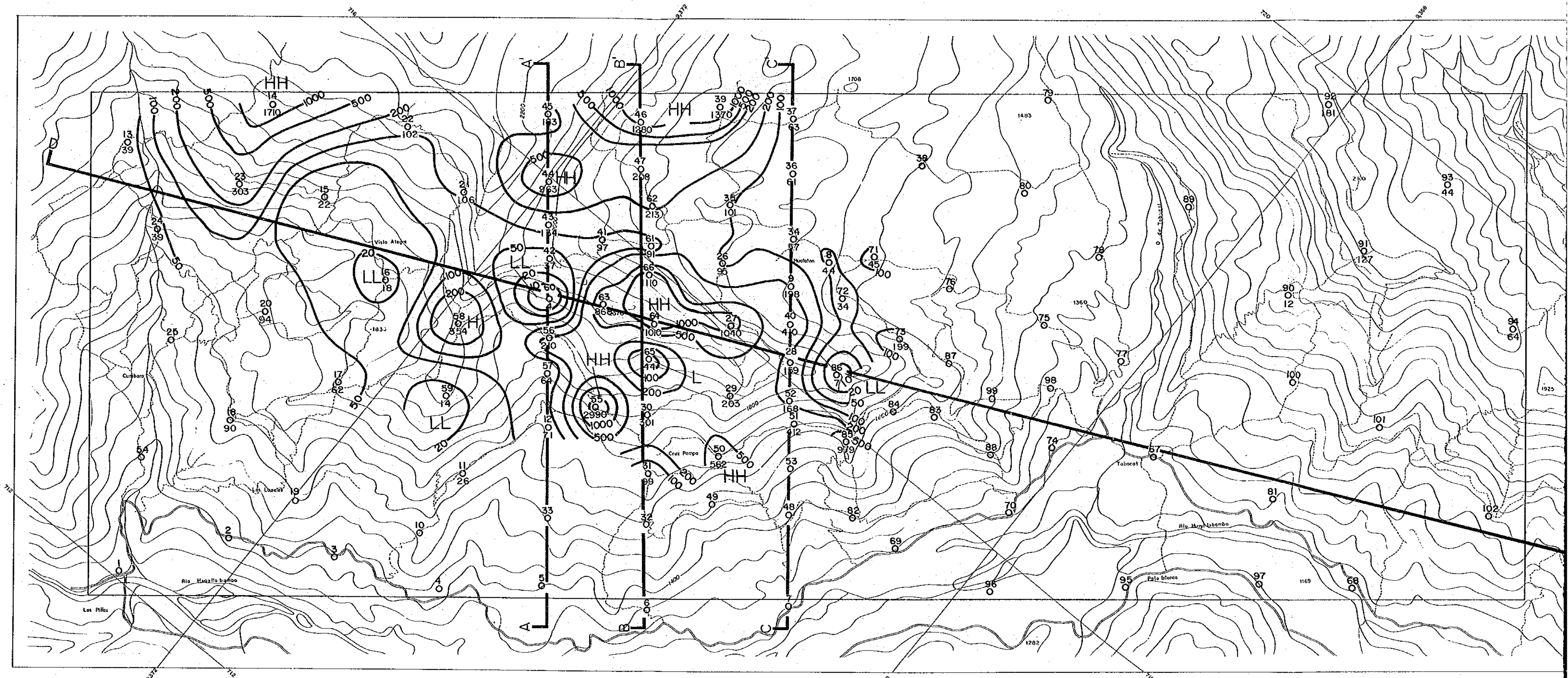
Geophysical survey implemented in Chontali area revealed that in the central part of the alteration zone there exists a rise of resistivity basement extracted as high resistivity zones. As a result of the phase I survey, it is clarified that the Oyotun Volcanics cover the Salas group schist or phyllite. According to the laboratory tests, the resistivity of schist is as low as 180 Ω m suggesting that the schist is not the member constituting the high resistivity basement, but that of granite and diorite-granodiorite developed in the western part is 1000 Ω m suggesting that the rise can reflect the intrusion structure of these intrusive rocks.

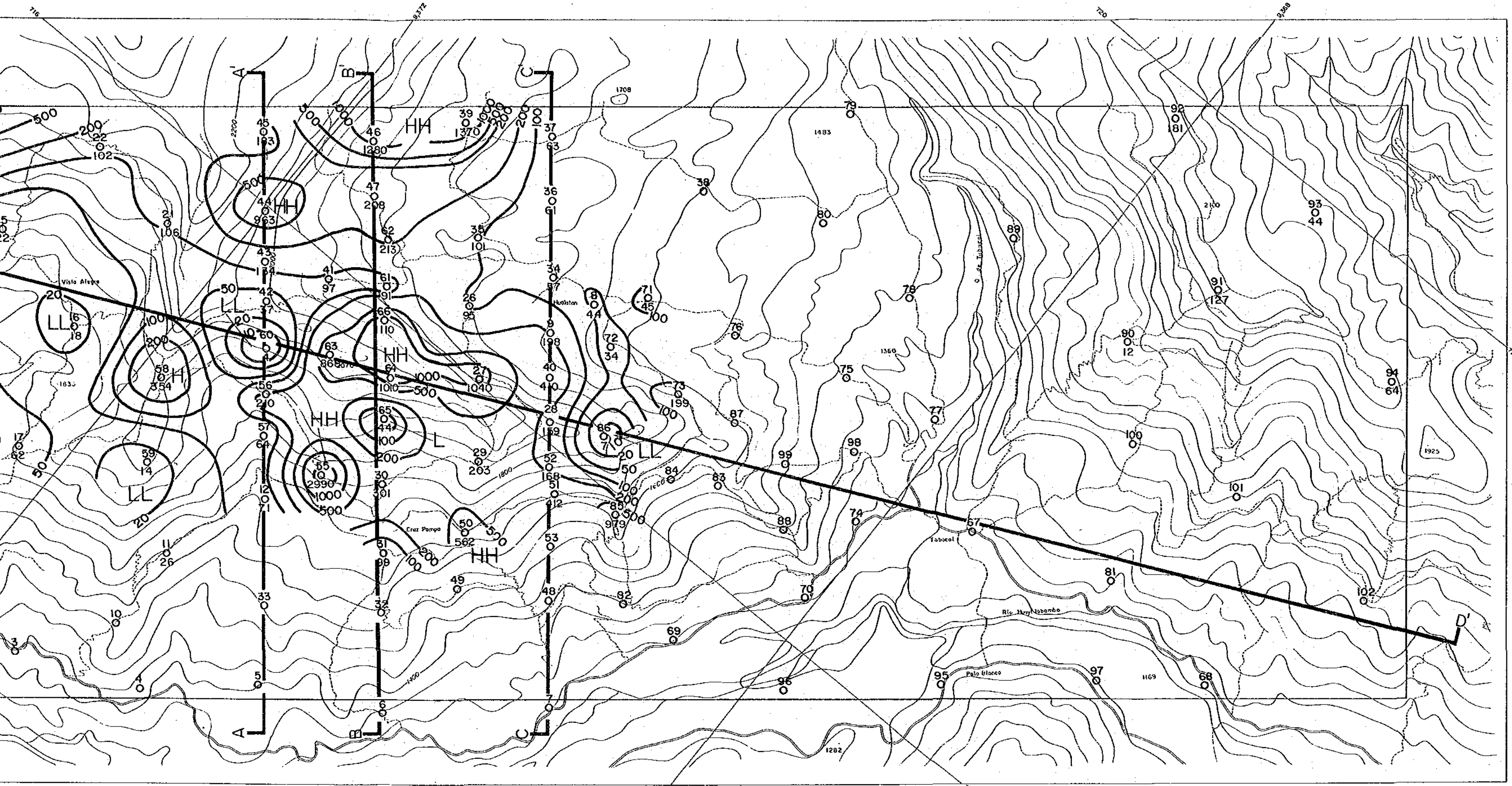
The analyzed results by homogeneous temperature for fluid inclusions in quartz veins of the alteration zones show that the value is higher in the western part close to the area with granite intrusions and lower on the mountains in Hualatan west. The low temperature area, however, was extracted in the lowland in the northern and southern ends of the detailed survey area and the high temperature area extends to the higher altitude part on the slope of mountains in Hualatan west. Therefore, it is possible to consider that beneath the mountains of Hualatan west there exists the highest temperature center.

It can be assumed that there exists a heat source beneath the mountains of Hualatan west and be concluded that the rise of high resistivity basement reflect the intrusion structure of granitic rocks.

The analyzed values by homogeneous temperature for fluid inclusions from 30 samples range from 96℃ to 271℃ , arithmetic means of which is 155℃ , suggesting that the low temperature value is relatively dominant. Most distinct geochemical anomaly is found for gold and the grade at the outcrop is confirmed as high as 16.15 g/ton Au or 12.95 g/ton Au, for example. As the mineralization temperature most adequate for epithermal Au-Ag vein type ore deposits is around 180-230℃ , it is concluded that there is high potentiality for higher graded Au ore deposits to exist toward the granitic intrusive body (heat source) inferred to occur deep underground.

In Tabacal south, galena-bearing quartz veins occurs in the silicified alteration zones and geochemical anomaly for Au and Ag overlaps there. The scale, however, is so small that it is impossible the zones continue to the large scaled mineralization zone, although small scaled auri-argentiferous base metal ore deposits can exist.


A
A'
B
B'
C
C'
D
Cruz Pampa
Tabacal



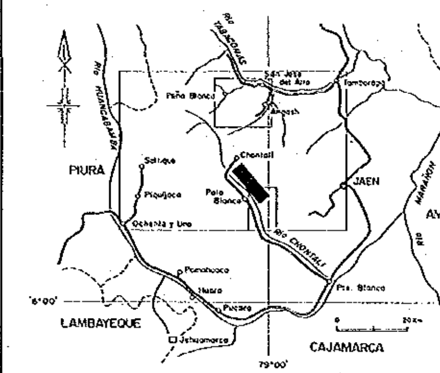
THE MINERAL EXPLORATION

IN

THE PACHAPIRIANA AREA, REPUBLIC OF PERU

(PHASE II)

Fig. II-14 (I) Resistivity Structure Map of the Chontali Area (+1,600m)



JAPAN INTERNATIONAL COOPERATION AGENCY

METAL MINING AGENCY OF JAPAN

FEBRUARY 1990

Prepared by MINDECO

LEGEND

45 Station number
O CSAMT Station
202 Caluclated Resisivity (Ω·m)

A A' Cross Section

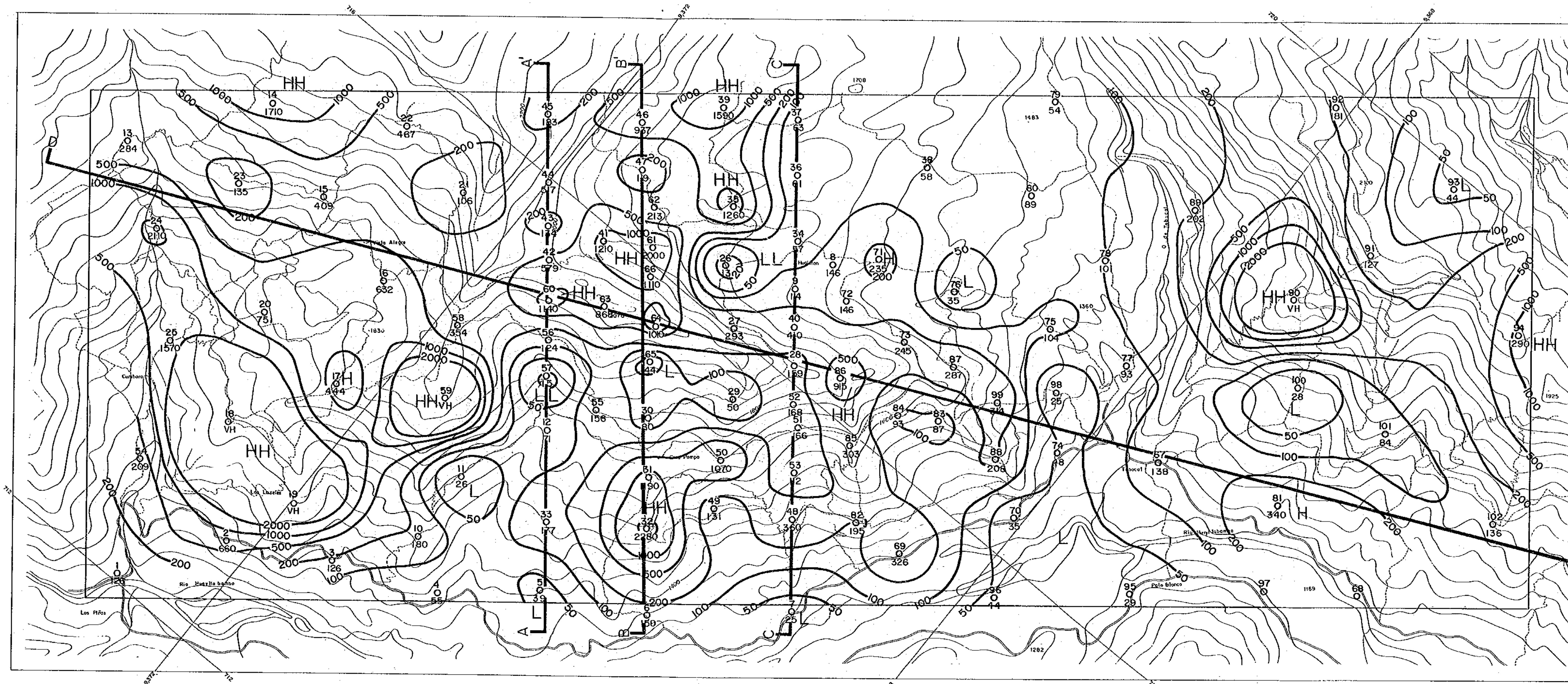
Division of Apparent Resistivity

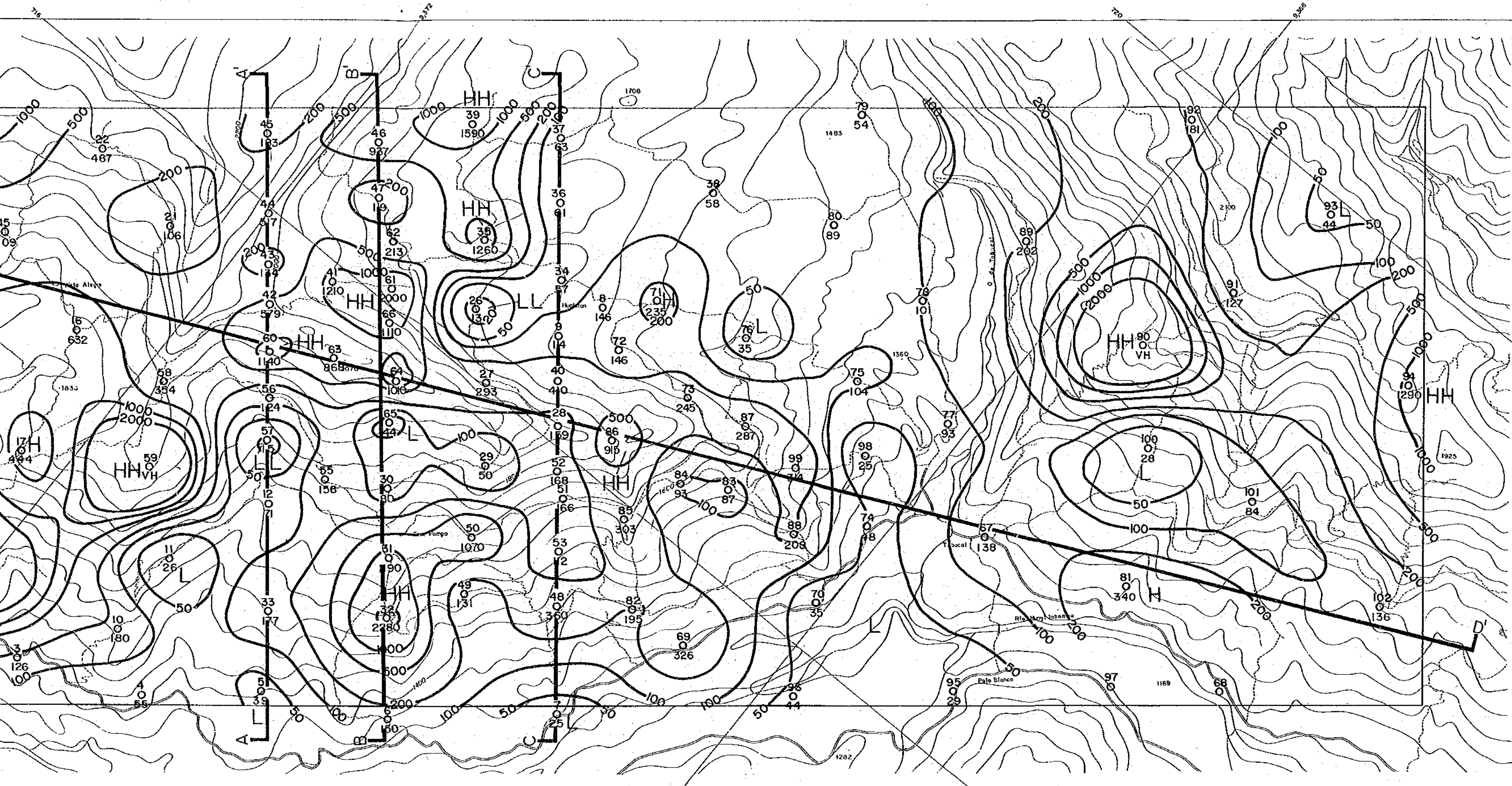
LL	L		H	HH
	20	50	200	500 (Ω·m)

10, 20, 50 Resistivity Contour (Ω·m)

0 500 1000m

Scale = 1 : 10,000





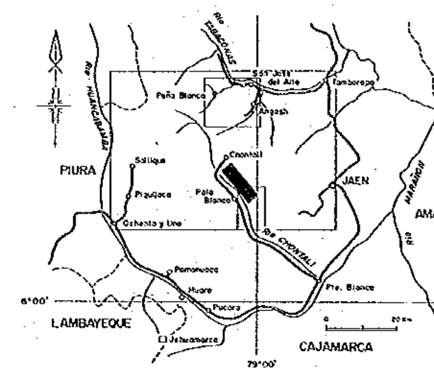
THE MINERAL EXPLORATION

IN

THE PACHAPIRIANA AREA, REPUBLIC OF PERU

(PHASE II)

Fig. II-14 (2) Resistivity Structure Map of the Chontali Area (+1,200m)



JAPAN INTERNATIONAL COOPERATION AGENCY

METAL MINING AGENCY OF JAPAN

FEBRUARY 1990

Prepared by MINDECO

LEGEND

N

45 Station number
O CSAMT Station
202 Caluclated Resistivity (Ω·m)

A A' Cross Section

Division of Apparent Resistivity

	20	50	200	500 (Ω·m)
LL	L		H	HH

10, 20, 50 Resistivity Contour (Ω·m)

VH: > 5000 Ω·m

0 500 1000m

Scale = 1 : 10,000

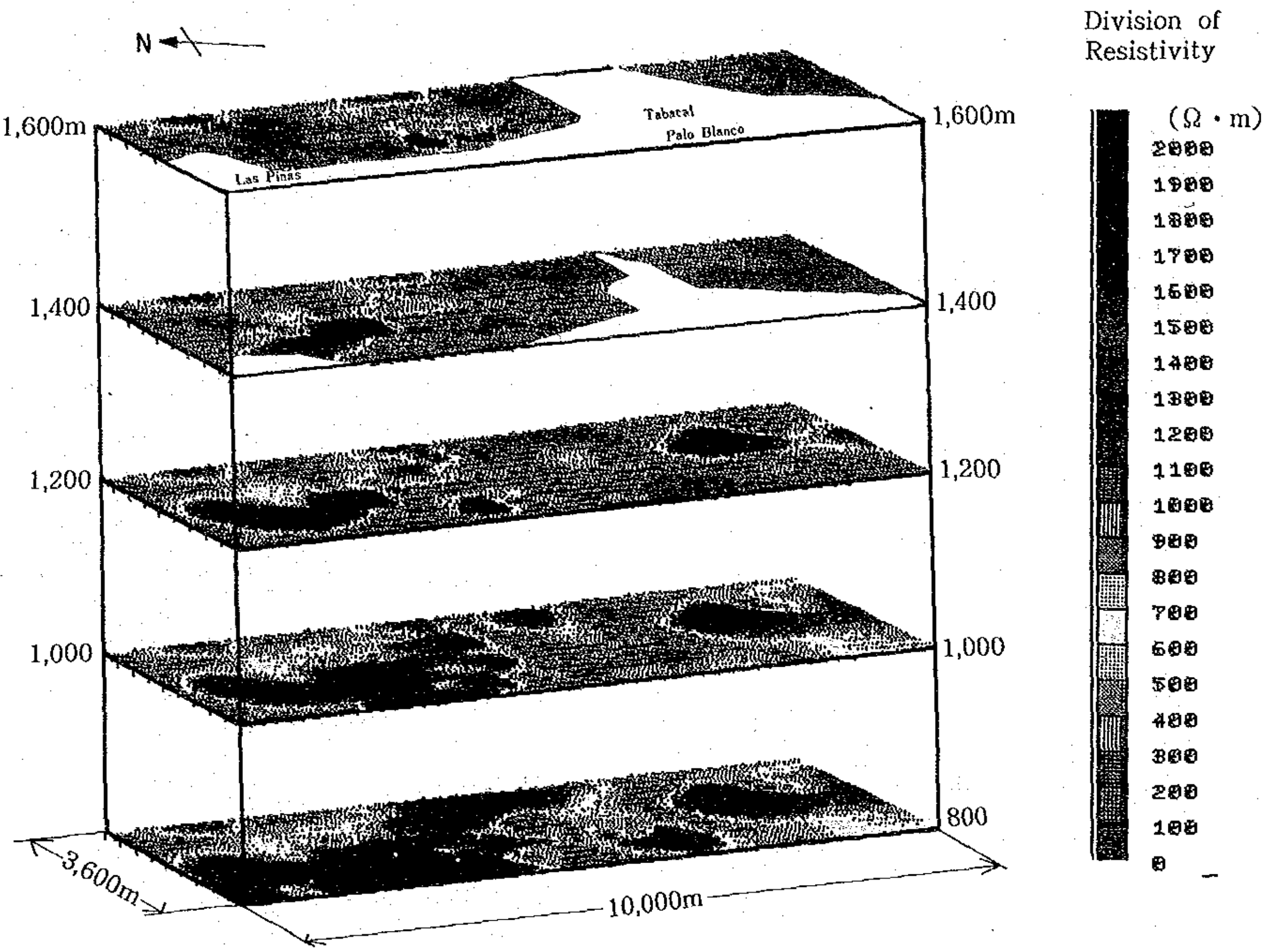


Fig. II-14 (3) 3-D Resistivity Map of the Chontali Area

CHAPTER 2 JEHUAMARCA AREA

2-1 Purpose of the Survey

The Jehuamarca area includes the mineralized zone extracted by the follow-up study for the anomalies found out by geochemical prospecting in the "Proyecto Geoquimico del Norte". The study was advanced by INGEMMET up to the phase of detailed survey on a scale of 1/2500. The phase I survey was carried out by adopting a detailed geological survey with the geochemical survey of rock samples to re-evaluate the results obtained by INGEMMET. Moreover geophysical survey using the CSAMT method was conducted to clarify resistivity structure deep underground and the possibility that silicified alteration zone, which was closely related with the mineralization as concluded from the geological survey, exists with a mushroomed structure.

During the phase II survey, drilling survey was performed to verify the mineralized conditions in underground silicified mineralization zone with a mushroomed structure. The other purpose of drilling is to verify the mineralized conditions not only in fissures through which the mineralization solution passed but in the silicified alteration zone with highest anomalous value in the survey area.

The propose of drilling at each site is as follows (Fig. II - 15):

MJPJ-1; to verify the mineralized conditions of the central part of the deeply seated underground silicified zone inferred to show a mushrooming structure and to verify those in the deep underground extension of the silicified veins exposed at the surface

MJPJ-2; to verify the mineralized conditions of the southeastern limb of the deeply seated underground silicified zone inferred to show a mushrooming structure and to verify those in the deep underground extension of the silicified veins exposed at the surface

MJPJ-3; to verify the mineralized conditions of the northwestern margin of the deeply seated underground silicified zone inferred to show a mushrooming structure and to verify those in the silicified rocks with the highest value of geochemical anomaly of gold (4.03 g/ton) in the area

2-2 Method of the Survey

2-2-1 Outline of the Survey

Drilling was performed assigning a local drilling company into employment, under the direction of a drilling engineer sent from Japan. Drilling was conducted at three sites using one set of rigs, model L-38 with maximum capacity of up to 725 m deep(BQ), to gain total hole length of 816.25 m.

Operations were conducted in three shifts of 8 hours each. A party of each shift is constituted by one local foreman and five operators. The wire-line method was adopted to get high core recovery and high operation efficiency.

Drilling covers 165 days, from July 17 to December 29, 1989 and content of the drilling at each site is as follows:

Drilling site	Hole length(m)	Core length(m)	Core recovery(%)
MJPJ-1	316.25	311.75	98.58
MJPJ-2	300.00	296.30	98.77
MJPJ-3	200.00	189.45	64.27

2-2-2 Drilling Procedure

1) Transportation of rigs and materials

Drilling rigs and materials were transported from Lima to Pucara by trucks, and from Pucara to the survey area by helicopter. Transportation of rigs was finished September 24. Oil fuel and muddy materials were transported from Pucara by horses, taking two days.

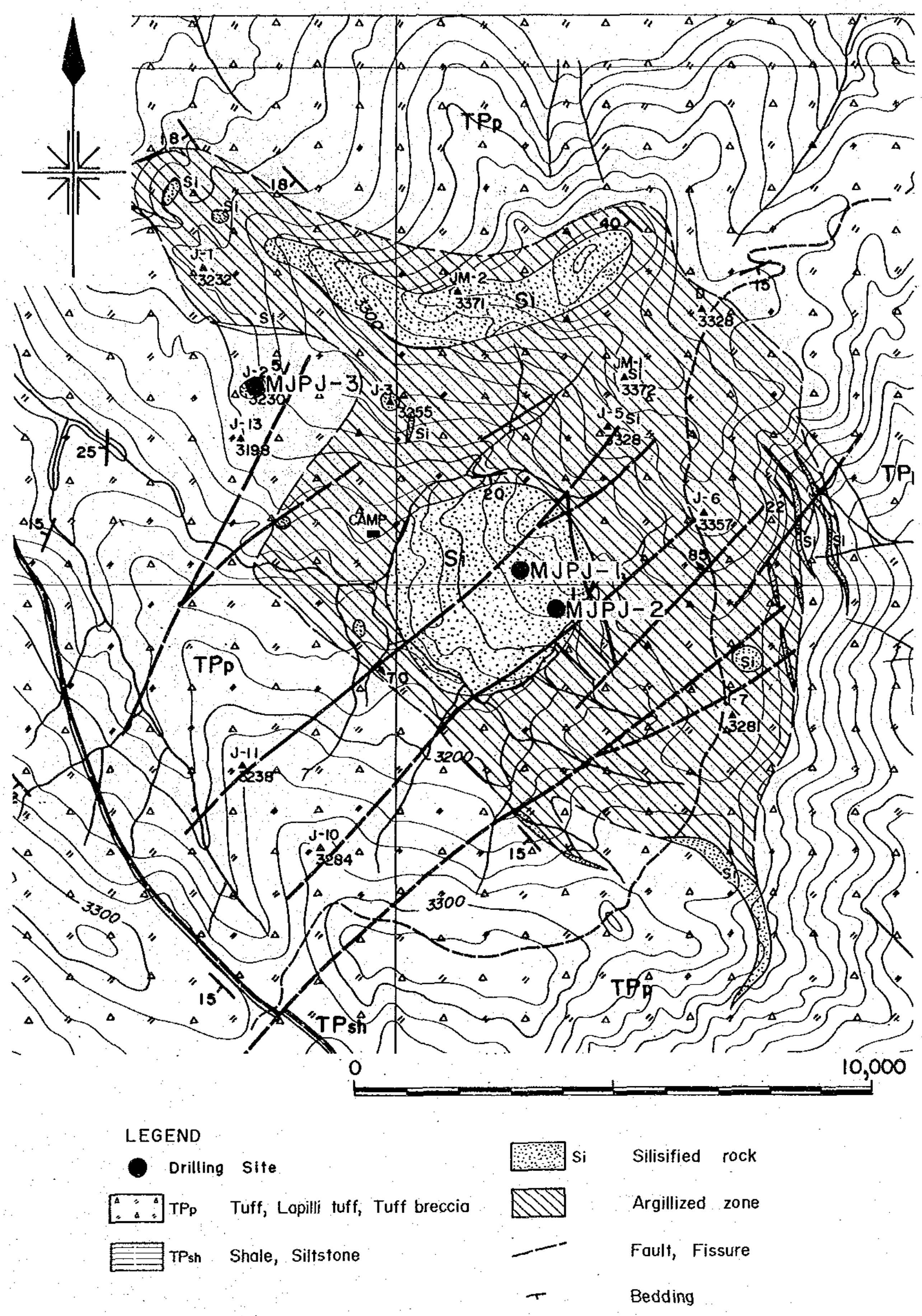


Fig. II-15 Location of the Drilling Site in the Jehuamarca Area

2) Construction of routes, heliport and land adjustment around each site

Construction of routes, heliport and land adjustment around each site was performed by human power.

3) Setting up

Setting up of rigs and drilling operations was made in the following order of site number, MJPJ-2, MJPJ-1 and MJPJ-3.

4) Water transportation

Water was transported from a stream, downward from the camp site, to each site using pumps and delivery hoses of 1 inch in diameter and pumps.

5) Drilling operation

(1) MJPJ-1 site inclination -90°

period	:	from October 22 to November 7, 1989
hole length	:	316.25 m
core length	:	311.75 m
core recovery	:	98.58 %

0.00- 2.95 m

Drilling through surface soil was performed using diamond bit(116mm in diameter) with bentonite muddy water, and after reaching hard rock, casing pipe was set.

2.95-150.25 m

Drilling was performed using HQ diamond bit with bentonite muddy water. Through the fracture zone between 2.95 m to 10.85m, HW casing shoe was used to extend the hole and HW casing pipe was set. The rock is lapilli tuff. Mineralized zones were found in between 61.00m and 66.50 m and between 81.70 m and 87.20 m. After reaching 150.25 m, NW casing pipe was installed.

150.25-245.65 m

Drilling was performed using NQ diamond bit with bentonite muddy water. The rock is mainly lapilli tuff, with fault breccia between 215.05 m and 241.55m and between 248.25 m and 250.75 m. After reaching 245.65 m, BW casing pipe was set.

245.65-316.25 m

Drilling was performed using BQ diamond bit with bentonite muddy water. The rock is lapilli tuff. At 267.40 m, lost circulation occurred and resumed operation after injecting grease. At 316.25 m the drilling operation was successfully finished.

(2) MJPJ-2 site direction 135° due north, inclination -90°

period	:	from September 24 to October 21, 1989
hole length	:	300.00 m
core length	:	296.30 m
core recovery	:	98.77 %

0.00-104.40 m

Drilling was performed using HQ diamond bit with bentonite muddy water, and through the fracture zone until 7.40 m HW casing shoe was used to extend the hole and HW casing pipe was set. The rock is lapilli tuff. Mineralized zones were intersected between 43.10 m and 47.15 m. At 43.10 m, all muddy materials were lost, failed to stop the lost, and the drilling was continued after injecting grease. After reaching 104.40 m, NW casing pipe was set.

104.40-226.05 m

Drilling was performed using HQ diamond bit with bentonite muddy water. The rock is mainly lapilli tuff, and mineralized zones were sometimes found. After reaching 226.05 m, BW casing pipe was set.

226.05-300.00 m

Drilling was performed using BQ diamond bit with bentonite muddy water. The rock is tuff. At 267.40 m, no muddy materials were lost and at 300.00 m the drilling operation was successfully finished.

(3) MJPJ-3 site inclination -90°

period	:	from December 8 to December 23, 1989

hole length : 200.00 m
core length : 189.45 m
core recovery : 94.72 %

0.00-110.60 m

Drilling was performed using HQ diamond bit with bentonite muddy water, and through the fracture zone until 4.50 m HW casing shoe was used to extend the hole and HW casing pipe was set. The rock is mainly silicified tuff. Mineralized zones were frequently found. At 20.50 m, 50 % of muddy materials, and then at 30.00 m all of them were lost, failed to stop the lost, and the drilling was continued after injecting grease. After reaching 110.60 m, NW casing pipe was set.

110.60-169.65 m

Drilling was performed using HQ diamond bit with bentonite muddy water. The rock is mainly tuff, and mineralized zones were sometimes found. At 117.85 m, all muddy materials were lost, failed to stop the lost, and the drilling was continued after injecting grease. After reaching 169.65 m, BW casing pipe was set.

169.65-200.00 m

Drilling was performed using BQ diamond bit with bentonite muddy water. The rock is tuff. At 170.00 m, all muddy materials were lost, failed to stop the lost, and the drilling was continued after injecting grease and at 200.00 m the drilling operation was successfully finished.

6) Transportation between each site and withdrawing

(1) Transportation

From site to site, drilling rigs were transported using their own mechanical power, and other materials by human power.

(2) Withdrawing

It is left to the employed drilling company.

2-2-3 Core Observation and Sampling

Through the observation of drilling cores, the character and intensity of mineralization and alteration were focused. As for the mineralization, relative abundance of such visible minerals inferred to be primary as pyrite, sphalerite, galena, chalcopyrite and tetrahedrite were confirmed combined with the geological horizons. As for the alteration, the intensity mainly of silicification, argillization and chloritization was described combined with the geological horizons. The relative intensity (frequency of occurrence) of capillarity veinlets, which are too small to show on the columnar section, was described combined with the geological horizons.

In the case of the survey area where the low graded mineralization has undergone, it is desirable to get samples systematically from the whole core, but as the planned numbers of samples for analysis were limited in the phase II survey, 125 samples were selected and split by core splitter. These are 117 samples taken from the part where the total content of Cu, Pb and Zn is estimated with naked eye to be more than 1 %, 5 samples from porous intensely-silicified rock near the bottom of MJPJ-1 which can undergo Au mineralization and 3 samples from at oxidized-leached zone in MJPJ-3.

After the sampling, cores were preserved at the temporary camp of INGEMMET in Jehuamarca.

2-3 Geology

Regionally, this survey area consists of the Oyotún Volcanics as basement and Porculla Volcanics unconformably covering it (Wilson, 1984). The area consists mainly of andesitic to dacitic tuff breccia and lapilli tuff, and characterized by the development of tuff, welded tuff and pyroclastic rocks intercalated with tuffaceous shale or tuffaceous silt. These pyroclastic rocks has the gently waved structure but generally trend in NW-SE direction, showing a monoclinal structure dipping gently toward southwest.

The distinct fault fissure system trends NE-SW with dipping steeply and is intersecting perpendicular with sedimentary structure. Additionally, minor branched fissures trending NNW-SSE to NW-SE are also observed, bridging between the main NE-SW system. These fissure systems scarcely disturb the sedimentary structure, therefore, they are concluded to be the secondary systems.

Alteration in this area may have developed taking the said fissures as passage. The central part concentrated by fissures are surrounded by the following zonal alteration zones: silicification-argillization, argillization and/or propylization from center outward. In the periphery of the alteration zone, a small scale silicification zone in harmony with the sedimentary structure was often observed in the argillization zone, suggesting that these alteration zones would have developed preferentially in the specific horizons. Judged from the results of geochemical survey, the mineralization in this area developed through the NE-SW fissures as the passage and especially occur in a significant scale in the silicification stage and Au mineralization is the representative one.

2-4 Survey Results

2-4-1 MJPJ-1 (Location 9'326,058N, 695,205E: altitude 3227.32 m)

1) Geology and alteration (Apx. 16 (1))

The constituent rock in this hole is Porculla Volcanics, composed mainly of lapilli tuff intercalated with tuff, tuffaceous shale and dacite.

0.00- 15.95m	weathered lapilli tuff with yellow brown tint colored by limonite
15.95- 52.50m	weakly silicified lapilli tuff with relatively abundant quartz veinlets
52.50- 60.9m	weakly argillized tuffaceous shale intercalated with thin bed of tuff
60.90- 65.55m	drusy quartz intercalated with well-stratified tuffaceous shale
65.55-105.30m	silicified lapilli tuff intercalated with thin

	bed of tuff
105.30-112.30m	silicified tuff associated with clay veins
112.30-119.50m	silicified lapilli tuff with welded tuff-like elongated fragments
119.50-131.40m	silicified tuff associated with quartz veinlets and clay veinlets
131.40-140.85m	silicified lapilli tuff
140.85-149.10m	relatively fresh lapilli tuff
149.10-151.90m	silicified lapilli tuff, rather intensely fractured
151.90-158.20m	argillized zone with fault breccia, mainly of lapilli tuff
158.20-178.45m	silicified lapilli tuff
178.45-184.80m	silicified tuff associated with clay veinlets, rather intensely fractured
184.80-193.80m	silicified lapilli tuff, rather intensely fractured
193.80-194.80m	argillized zone with fault breccia
194.80-215.05m	silicified lapilli tuff, intensely fractured
215.05-241.55m	argillized zone with fault breccia
241.55-248.25m	relatively fresh hornblende dacite
248.25-250.70m	argillized zone with fault breccia
250.70-297.05m	silicified lapilli tuff
297.05-316.10m	intensely silicified lapilli tuff
316.10-316.25m	dark gray clay

Throughout the core in this hole, relatively intense silicification is observed. Argillization is also observed throughout the core, though relatively weak. Chloritization is observed mainly in shallower part, but discontinuous.

Under the microscope, the specimen (MJPJ-1 247.6 m) of fresh dacite (241.55-248.25 m) has undergone intense sericitization, chloritization and carbonatization (Apx.1) and it is impossible to discriminate mafic minerals. Judged from the mode of occurrence, the rock may be a dyke intruding along the fissure, but it can not be confirmed through the microscopic observation.

It has been clarified through the X-ray diffractive analysis (Apx. 6) that the specimen (MJPJ-1 309.00 m) of intensely silicified lapilli tuff (297.05-316.10 m) near the bottom contains diaspore and pyrophyllite, suggesting the formation under the condition of acidic and relatively high temperature.

2) Mineralization

The core of this hole underwent mineralization of sulphide minerals, except for the leached zone of 0.00-15.95 m. The sulphide minerals are composed mainly of pyrite, associated with visible sphalerite, galena, chalcopyrite, tetrahedrite. Pyrite is observed throughout the core, though the amount is variable. Galena occurs in the shallow part (shallower than 215.05 m) and chalcopyrite in the deeper part (253.60-278.00 m). The occurrence of tetrahedrite is localized to the quartz veins developed between 82.60 and 82.85 m.

Under the microscope, high grade ore (Apx. 8; 61.95 m) from quartz zone (60.90-65.55 m) is composed mainly of pyrite, with subordinate sphalerite and a few tennantite. Additionally, chalcopyrite occurs included in pyrite and sphalerite, and pyrrhotite occurs as an exsolved phase from sphalerite.

The specimen (Apx. 8; 82.7 m) from silicified-argillized lapilli tuff with small quartz veins is composed mainly of sphalerite, with subordinate pyrite and galena and a few chalcopyrite and tetrahedrite. Tennantite and magnetite are included in sphalerite.

Results of chemical analysis of ore samples are as follows:

Depth (m)	Core length (m)	Au (g/t)	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)	Mo (ppm)
60.90- 65.55 (quartz zone)	4.65	1.593	95	0.05	2.2	7.9	12
65.55- 69.50 (silicified-chloritized lapilli tuff)	3.95	0.518	27	0.03	0.7	2.7	6
81.50- 82.85 (silicified-argillized lapilli tuff in quartz zone)	1.35	0.267	87	0.52	0.07	0.14	9
87.05- 89.30 (silicified-chloritized lapilli tuff)	2.25	0.102	13	0.04	0.05	0.21	8

128.50-133.80	5.50	0.035	7	0.03	0.07	0.43	8
(silicified lapilli tuff)							
172.55-178.45	5.90	0.132	10	0.03	0.23	1.1	3
(silicified-argillized lapilli tuff)							
184.80-193.80	9.00	0.182	8	0.04	0.18	0.6	3
(silicified lapilli tuff)							
209.05-215.05	5.20	0.182	6	0.04	0.40	1.2	6
(silicified lapilli tuff)							
289.70-297.05	7.53	0.061	28	0.04	0.04	0.27	10
(silicified lapilli tuff)							
306.80-313.80	7.00	0.133	23	0.07	0.03	0.04	9
(intensely silicified lapilli tuff)							

2-4-2 MJPJ-2 (Location 9'325,980N, 695,274E: altitude 3229.39 m)

1) Geology and alteration (Apx. 16 (2))

The constituent rock in this hole is Porculla Volcanics, composed mainly of tuff intercalated with relatively thick beds of lapilli tuff and thin beds of tuff breccia and tuffaceous shale.

0.00- 19.30m	weathered lapilli tuff with yellow brown tint colored by limonite
19.30- 21.15m	weathered tuffaceous shale intercalated with lapilli tuff
21.15- 28.75m	weathered lapilli tuff intercalated with tuff
28.75- 35.80m	weathered tuffaceous shale intercalated with tuff and tuff breccia
35.80- 38.00m	argillized lapilli tuff
38.00- 42.00m	chloritized shaly tuff
42.00- 43.10m	silicified lapilli tuff
43.10- 47.15m	drusy quartz (core from 45.9m to 47.15m was lost)
47.15- 76.75m	lapilli tuff intercalated with argillized thin bed of tuff breccia
76.75-105.05m	silicified lapilli tuff
105.05-114.90m	intensely silicified tuff, with abundant veinlets of drusy quartz in deeper part

114.90-120.30m intensely silicified lapilli tuff, weakly brecciated in part

120.30-203.70m silicified or intensely silicified tuff, weakly brecciated

203.70-254.60m silicified or intensely silicified lapilli tuff, intensely brecciated

254.60-300.00m relatively fresh dacitic tuff

The core from 0.00 m to 254.60 m has undergone relatively intense silicification. Argillization is relatively intense in the shallower part, though observable throughout the whole core. Chloritization is weak and also observed throughout the whole core. Relatively fresh tuff deeper than 254.60 m has undergone epidotization and is discriminated as the propylite zone. Carbonate minerals with pale pink tint occur in veinlets or patches between 87.00 m and 166.00 m.

Under the microscope, the sample (MJPJ-2 35.60 m) from tuffaceous shale intercalated with pyroclastic rocks (28.75-35.80 m) has a clastic texture, with microfossils (Apx. 1). It contains hydromica and microcrystalline felsic clay minerals, though the alteration effect is not visible, to suggest that it has undergone mineralized-alteration by high grade ore deposits formed just underneath. The sample (Apx. 1; MJPJ-2 258.70 m) from very weakly silicified dacitic tuff (254.60-300.00 m) assumed to belong to the propylite zone contains secondary epidote, chlorite and carbonate minerals and traversed by veinlets of these minerals. Therefore, it is reasonable to consider that the rock belongs to the propylite zone. Aforementioned veinlets contain sphalerite associated with opaque minerals (perhaps pyrite), suggesting that the propylite zone has undergone mineralization.

As a result of X-ray diffractive analysis (Apx. 6), it is clarified that aforementioned pink carbonate mineral (93.90 m) is rhodochrosite and that silicified zone contains mainly of quartz and sericite associated with a few anatase.

2) Mineralization

The core of this hole underwent mineralization of sulphide minerals, except for the oxidized-leached zone of 0.00-35.80 m. The sulphide minerals are visible, composed mainly of pyrite, associated with sphalerite, galena, tetrahedrite and chalcopyrite. Pyrite is observed throughout the core. Sphalerite occurs throughout the whole core except for the oxidized-leached zone and the propylite zone deeper than 254.6 m. Galena occurs in the quartz zone (43.10-47.15 m), 76.75-94.55 m and 204.25-254.60 m. Tetrahedrite is observed in the depth of 103.55-138.30 m. The occurrence of chalcopyrite localized to the quartz veins developed between 43.10 and 47.15 m and in the depth of 106.00-150.10 m, associated with quartz veinlets.

Under the microscope, high grade ore (Apx. 8; MJPJ-2 43.70 m) from quartz zone (43.10-47.15 m) is composed mainly of pyrite, with subordinate sphalerite and chalcopyrite. Chalcopyrite is replaced by vast amounts of chalcocite and covelline. Chalcocite and covelline are observed only below the oxidized-leached zone, suggesting that these minerals were formed through the secondary enrichment by meteoric water.

Results of chemical analysis of ore samples are as follows:

Depth (m)	Core length (m)	Au (g/t)	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)	Mo (ppm)
43.10- 47.15 (quartz zone)	4.50	1.172	342	2.30	0.5	0.5	13
47.15- 50.30 (silicified lapilli tuff)	3.15	0.602	19	0.05	0.27	0.81	13
64.85- 66.10 (silicified-argillized tuff)	1.25	0.100	9	0.05	0.39	0.7	15
76.75- 94.55 (silicified-weakly argillized lapilli tuff)	17.80	0.440	8	0.01	0.20	0.48	5
127.55-138.30 (intensely silicified tuff)	10.75	0.180	13	0.40	0.07	0.37	3
150.10-166.40 (silicified or intensely silicified-argillized tuff)	16.30	0.112	9	0.01	0.23	1.6	5
175.10-182.70 (silicified or intensely silicified tuff)	7.60	-	9	0.01	0.48	1.9	5

187.45-189.80	2.35	0.167	9	0.01	0.45	1.0	9
(intensely silicified tuff)							
208.35-211.65	3.30	0.250	5	-	0.06	1.0	5
(intensely silicified lapilli tuff)							

2-4-3 MJPJ-3 (Location 9'326,373N, 694,727E: altitude 3224.08 m)

1) Geology and alteration (Apx. 16 (3))

The constituent rock in this hole is Porculla Volcanics, composed of alternation of tuff intercalated with thin beds of tuff breccia and lapilli tuff. Brecciated rock developed between 0 m and 114.25 m is considered to be formed by a tectonic movement after the sedimentation.

0.00- 4.55m	weathered breccia agglutinated by limonite
4.55- 11.15m	weathered tuff and lapilli tuff with limonite
11.15- 13.50m	weathered breccia agglutinated by limonite
13.50- 19.15m	silicified tuff
19.15- 24.15m	weathered breccia agglutinated by limonite
24.15- 27.25m	weathered lapilli tuff with limonite
27.25- 36.25m	weathered breccia agglutinated by limonite, intercalated with weathered lapilli tuff
36.25-114.25m	silicified or intensely silicified breccia, intercalated with thin beds of silicified lapilli tuff
114.25-134.35m	silicified lapilli tuff
134.35-176.15m	silicified or intensely silicified tuff
176.15-200.00m	silicified lapilli tuff, intercalated with thin beds of tuff and tuff breccia

The whole core has undergone relatively intense silicification. Argillization is relatively intense in the shallower part, though observable throughout the whole core. Chloritization appears deeper than 63.85 m and becomes more intense with increasing depth. Carbonate minerals with pale pink tint occur in veinlets between 170 m and 187 m.

Under the microscope, the sample of silicified tuff (Apx. 1;

154.25 m) has preserved its original eutaxitic texture, although intense silicification, argillization (sericite and montmorillonite) and chloritization makes an original texture unclear. Fragments of quartz are observed. It is an altered tuff and contains relatively abundant opaque minerals, associated with anatase and sphalerite. By X-ray diffractive analysis (Apx. 6; MJPJ-3 154.25 m), it is clarified that anatase exists and the opaque mineral is pyrite. The results of X-ray diffractive analysis for other altered samples (Apx. 6; MJPJ-3 70.35 m and MJPJ-3 104.25 m) show that they contain quartz, sericite and a few anatase. It is noteworthy that the sample at 104.25 m contains sericite of 2M1 polytype in contrast to other samples containing 1M polytype.

As a result of X-ray diffractive analysis, it is clarified that aforementioned pink carbonate mineral (MJPJ-3 183.60 m) is rhodochrosite, as in the case of sample from MJPJ-2 (MJPJ-2 93.90 m).

2) Mineralization

The core of this hole underwent mineralization of sulphide minerals including the weathered-leached zone of 0-36.25 m.The sulphide minerals are visible, composed mainly of pyrite, sphalerite, galena, chalcopyrite and tetrahedrite. Pyrite is rather abundant, observed throughout the core. Sphalerite occurs deeper than 48.4 m as dissemination or veinlets. Galena occurs in quartz veinlets deeper than 114.25 m. Chalcopyrite occurs locally in pyrite which agglutinates breccias in the depth between 36.25 and 62.0 m. Tetrahedrite is observed in the depth of 96.1-104.75 m, scattered in pyrite druse.

Under the microscope, silicified breccia (Apx. 8; 43.65 m) is composed mainly of pyrite, with subordinate chalcopyrite and sphalerite. Chalcopyrite and pyrite are replaced by chalcocite and covelline. These copper minerals were inferred to be formed through the secondary enrichment by meteoric water, as in the case of the sample from MJPJ-2 (43.7 m).

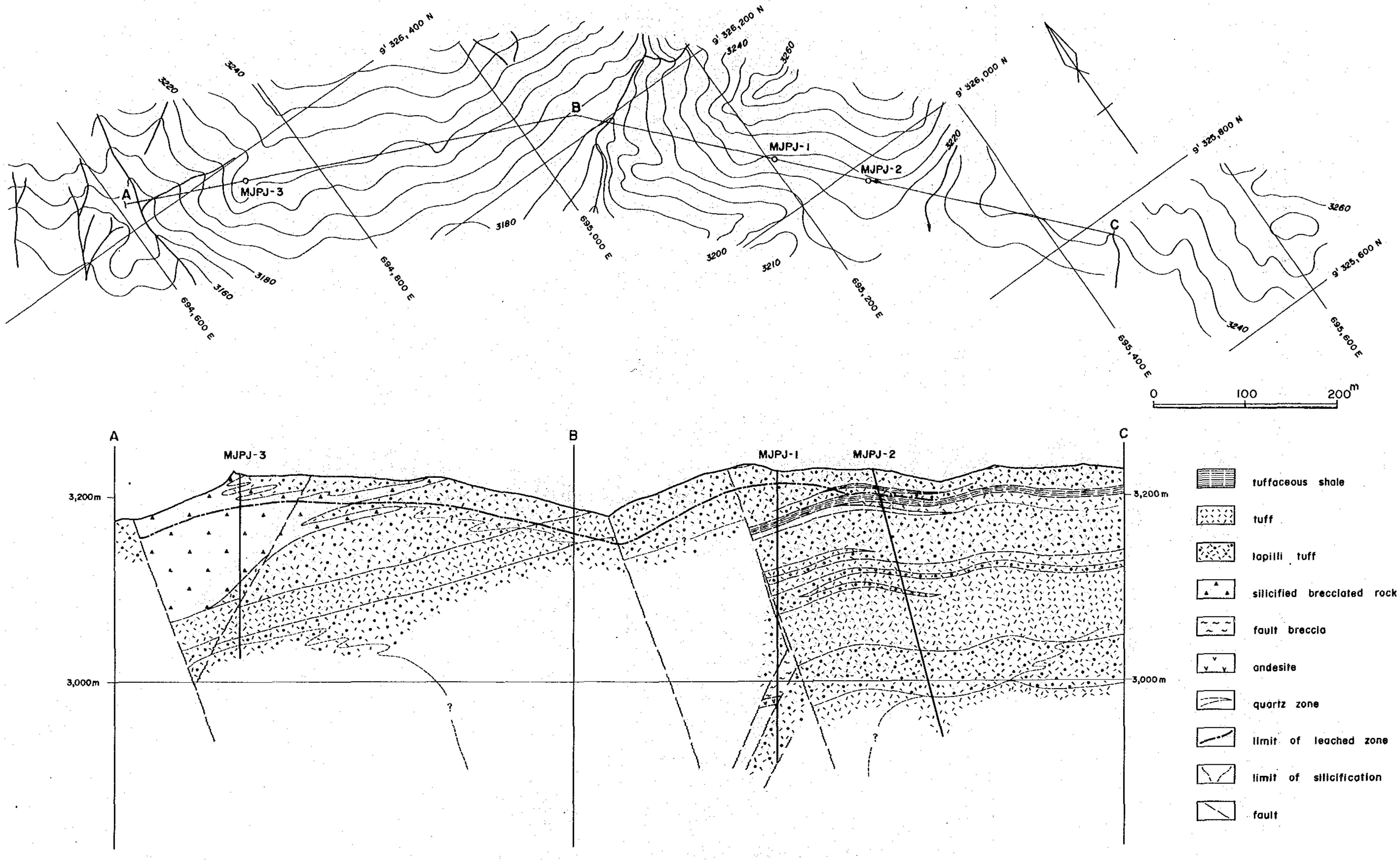


Fig. II-16(1) Interpretative Profile of the Drillings in the Jehuamarca Area

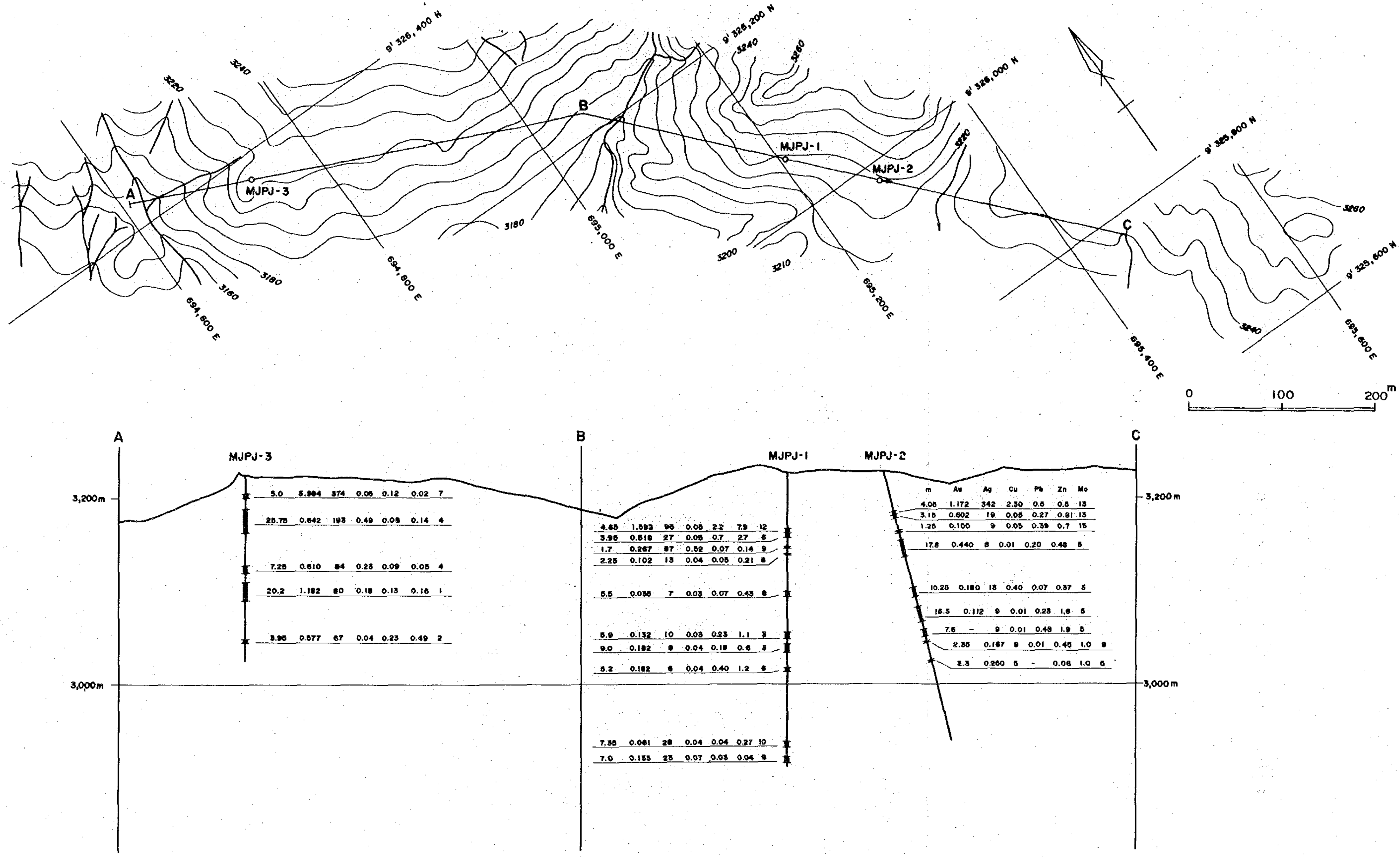


Fig. II-16(2) Assay Results on the Profile of the Drillings in the Jehuamarca Area

Results of chemical analysis of ore samples are as follows:

Depth (m)	Core length (m)	Au (g/t)	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)	Mo (ppm)
19.15- 24.15	5.00	3.994	374	0.05	0.12	0.02	7
(oxidized-leached breccia)							
25.75- 62.00	25.75	0.642	193	0.49	0.08	0.14	4
(silicified breccia)							
97.50-104.75	7.25	0.610	84	0.23	0.09	0.05	4
(silicified-argillized breccia)							
114.25-134.35	20.20	1.181	80	0.18	0.13	0.16	1
(silicified lapilli tuff)							
176.15-180.10	3.95	0.577	67	0.04	0.23	0.49	2
(silicified lapilli tuff)							

2-5 Consideration

It was concluded by the phase I survey that the geological structure of this area is the gently waved structure but generally trends in NW-SE direction, showing a monoclinal structure dipping gently toward southwest. It is affirmed through the structural analysis of two beds of tuffaceous shale found in the drilling holes of MJPJ-1 and MJPJ-2 through the phase II survey. Based on the geophysical survey, it was concluded that the silicified zone formed a mushroom-like shape. It is also affirmed by the drilling survey, namely in the hole at MJPJ-1, bored near the center of the alteration zone, silicification is observed until the bottom but in the holes at MJPJ-2 and MJPJ-3, bored in the outer margins of the zone, the drilling holes reach to the surrounding propylite zone through the silicified zone. The mineralization is concluded to be closely associated with the silicification. At every drilling hole of phase II, mineralization of gold, silver, copper, lead and zinc is commonly observed, though the intensity of mineralization is variable, closely associated with the silicified zone.

Thus the geological and ore-formation models constituted through the phase I survey is affirmed.

Meanwhile, the fault fissure system in this area was concluded to be secondary one, because it tended to scarcely disturb the geological structure at the surface. Through phase II drilling survey, however, it is clarified that the area has undergone intense structural disturbance, because fault breccia zones with clay are found at MJPJ-1 (151.9-250.7 m) and silicified breccia at MJPJ-3 (0-114.25 m). At the fault breccia-clay zone found in MJPJ-1, breccia is mineralized with pyrite, sphalerite, and rarely galena and chalcopyrite, but clay in matrix contains no sulphide minerals except for a few pyrite. Therefore, the fault could be formed after the mineralization. Meanwhile, in the case of silicified breccia found in MJPJ-3, not only the breccias but the matrix is mineralized with sulphide minerals. The minerals sometimes agglutinate the breccia. Therefore, the brecciation was taken place by the tectonic movement before the mineralization. By the drilling survey, the underground continuation of the NE-SW trending fissure systems, which were considered to be the fissures opened before the mineralization, can not be traced. All things considered, based on available data, many questions and problems on the fault fissure system in this area remain unsolved. It is necessary to conduct regional geological survey to re-examine the geological and structural settings of this area and to conduct more detailed geological survey (on a scale of 1/2000, for example) in the area where the drilling survey is conducted, to clarify the geological meaning of drilling cores.

Silicified breccia tends to develop on the mountain summits at the surface and was concluded to develop preferentially in the specific horizons by the phase I survey. At MJPJ-3, however, it occurs with an obtuse angle against the cores and concordantly with the bedding plane. Therefore, it is formed as bed but the thickness is too thick to consider that it develops in the specific horizons. The breccia should be re-examined on the viewpoint of tectonic origin.

On the viewpoint of structural control, the quartz zones with abundant sulphide minerals found at MJPJ-1 and MJPJ-2 occupy the same horizon, because they occur just below the tuffaceous shale. The country rock of the quartz zone can be tuff bed, because at MJPJ-2 thin bed of tuff is preserved between shale and quartz zone, and at MJPJ-1 tuff is preserved without mineralization, and it develops the layer of sulphide concordantly to the bedding. Therefore, it can be said that the shale bed occupying above the quartz zone is a cap rock.

As a general view of distribution of ore minerals in cores by naked eye observation, chalcopyrite is abundant in the central part (MJPJ-1) and tetrahedrite in the outer margin (MJPJ-2 and MJPJ-3). Sphalerite and galena have not any distinct tendency as they occur throughout the whole cores at three sites. As for the vertical change, chalcopyrite is abundant in the shallower part and tetrahedrite in the deeper. Sphalerite and galena have not any distinct tendency of distribution as in the case of horizontal one. Such two types of sphalerite can be discriminated, however, as dark-colored and light brown colored ones. Roughly speaking, the former tends to occur in the shallower part and the latter in the deeper part. Moreover, the former occurs surrounding the latter, suggesting the poly-stage mineralization.

Judged from the result of chemical analysis of ores, gold and silver are relatively concentrated in near the surface and the outer margin of the mushroomed structure (MJPJ-3) and less concentrated in the deeper part and the central part of the mushroomed structure (MJPJ-1 and MJPJ-2). Copper, lead, zinc and molybdenum have no distinct tendency of distribution. The analyzed result for silicified breccia from oxidized-leached zone (MJPJ-3) coincides with that of geochemical samples taken from the outcrop through the phase I survey(K11803, 4.030 g/ton Au, 238 g/ton Ag, 420 ppm Cu, 600 ppm Pb, 150 ppm Zn and 5 ppm Mo), suggesting that gold and silver can be concentrated in the oxidized-leached zone.

It was concluded that the alteration environment is relatively uniform neutral to alkaline, because the polytype of sericite is only of 1M. Judged from the observation of ores, diaspore and pyrophyllite are found in the silicified rock at the bottom of MJPJ-1, the environment can be rather high temperature and acidic. Moreover, at the base of silicified breccia in MJPJ-3, high-temperature type 2M1 polytype is found. Therefore, the hydrothermal alteration condition of the area is different not only in temperature but in chemical environment between the surface area and deeper part. As 2M1 polytype of sericite is found at the base of silicified breccia in MJPJ-3, though 1M type is found both in its hanging and foot walls, it is concluded that mineralized-alteration has been progressed through the base of the breccia as passage.

The result of microscopic observation of ore minerals coincides with that with naked eye, and the aforementioned zonal arrangement of ore minerals is affirmed. The difference between the two types of sphalerite discriminated with naked eye can not be confirmed and left for further study (by EPMA, for example).

CHAPTER 3 PENA BLANCA AREA

3-1 Purpose of the Survey and Procedure Used

The Pena Blanca area concerns the zones where anomalies were extracted through geochemical survey using the stream sediments by INGEMMET as a part of the "Proyecto Integral Chinchipe". The area includes the Pena Blanca geochemically anomalous zone extracted at the upper stream part of Pena Blanca as well as the Angash anomalous zone extracted at the upper stream part of Angash. The occurrences of alteration zone or mineralized zone closely associated with the mineralization have been verified by the phase I survey for the geochemical anomaly based on the stream sediments by INGEMMET. Through the phase II survey, Semi-detailed geological survey combined with geochemical survey was conducted for the area (220 km2) to extract the mineralization zones as well as to find the source of said anomalies.

As no topographic maps had yet been published by IGN for the area, SLAR image on the scale of 1/100,000 compiled by ONERN are enlarged to the scale of 1/25,000 to be used as the base map. On the image, were shown no indication for villages, roads, mountains and so on but only the UTM co-ordinates, latitude and longitude. Therefore, the cardinal point for the survey was set at San Jose del Alto village, only the locality of which is shown on the map on the scale of 1/250,000, composed using LANDSAT images and published by ONERN. However, the locality of the village, read as 712,200E and 9,402,000N on UTM co-ordinates, must be revised to 719,600E and 9395,800N for fitting the villages, summits and drainages to those on the SLAR images. Moreover, the UTM co-ordinates shown on the SLAR images must be moved 1300m eastward and 300m southward, based on the distribution of rivers in the Chontali area. The locality of the survey area is described using the UTM co-ordinates with aforementioned revision.

As shown before, the locality of the cardinal point is inaccurate and shadows reflecting the topographic unevenness on the SLAR images and real topography in the field do not coincide with each other. Therefore, the survey was conducted through the drawing of schematic survey routes on field note, measuring by pace, clinometers and/or clinocompasses. Altitude is measured by barometer at important points. At main villages or summits, the direction to the visible village and summits were measured to specify their localities on the maps. The main survey roads are for riding on horseback connecting the villages. Toward Mt. Huayanche and Mt. Collota, which are the important points for the specification of location, we organize path cleaning groups to obtain survey routes up to or near the summits. The base camp was set up at Angash. and the advanced camp is positioned at Porvenir. At least three survey teams were organized and six teams were organized if needed.

3-2 Geology

According to Reyes et al. (1987), this survey area consists of Paleozoic Salas Group as basement, and Mesozoic Leche Formation and Oyotun Volcanics unconformably covering it and dioritic rocks intrude the former rocks. The Salas Group and the Leche formation occupy the central north of the area, and dioritic rocks northeastern flange (Fig. I-3 in the report of the phase I survey).

3-3 Survey Results

3-3-1 Geological Survey

The survey area consists of such weakly metamorphosed rocks as schist, phyllite, meta-pyroclastic rocks, micaceous sandstone, as basement. They are unconformably covered by calcareous formation. The former rocks are in fault contact with pyroclastic rocks including andesite to dacite. All of these rocks are intruded by diorite-granodiorite, granite, monzonite-monzonite porphyry, quartz porphyry-rhyolite and andesite (Fig.Ⅱ-17).

Weakly metamorphosed rocks are widely distributed in the central part of the area, showing a general extension trend of NE-SW. Phyllite mainly occupies the western and meta-pyroclastic rocks and micaceous sandstone the eastern parts. Schist is found only on the river bed of the Nueva Esperanza, flowing in the south of Angash. Micaceous sandstone sometimes has schistose structure. Under the microscope, it (Apx. 1; H091508) is characterized by the foliated structure with quartz, plagioclase, sericite and chlorite. Meta-pyroclastic rocks occur intercalated with micaceous sandstone. These are correlative with the Salas Group, because they are weakly metamorphosed. Total thickness of the rocks is more than 1,400 m.

Calcareous formation occupies the mountains in the eastern part of this area, showing a general extension trend of N-S or NE-SW. Rock facies range from limestone to dolomite, partly changed to marble by metamorphism (Apx.1, Apx. 5). Moreover, the rock close to the fissures contains such skarn minerals as diopside, grossular and vesuvianite, suggesting that it has undergone silicification or Mg-addition (Apx. 6; H091202). The formation is in contact with underlying Salas Group parallel unconformably. The surface of unconformity contains paleosoil-like brown clay zone with the thickness of 20 to 30 cm (at Vista Alegre west). This calcareous formation is correlative with the Leche Formation, because it covers parallel-unconformably the underlying rocks and have undergone metamorphism. Total thickness of the formation is more than 100 m.

Pyroclastic rock is found in the eastern flange and the southern part of this area, being in fault contact with the former two geological units. The fault trends N-S and NE-SW. Southern extension of this rock continues to the pyroclastic rocks surveyed during the phase I in the Chontali area, thus the rock is correlative to the Oyotun Volcanics. It is noteworthy that the rock in this area contains the autobrecciated basaltic lava (Apx.1; A090701). It is found on the routes from Cochalan to Angash and from Cochalan to San Jose del Alto. Under the microscope, it (Apx. 1; A090701) has undergone such alteration as albitization, carbonatization, sericitization and chloritization to disturb the original texture. As the rock is porous with hyalopilitic and autobrecciated textures, it can be formed by the underwater eruption. It is correlative to the upper Oyotun Volcanics. Pyroclastic rock composed mainly of dacitic lapilli tuff intercalated with andesitic thin lava is correlative to the lower

Oyotun Volcanics, as in the case in the Chontali area.

Among the intrusive rocks, diorite-granodiorite is found as a large body trending NE-SW in the western part of this area and as a body constituting Mt. Huayanche in the southeastern part. It is also found as small bodies trending NE-SW along the Angash River. Under the microscope, the rock of the western part (Apx. 1; Y092311) is composed mainly of plagioclase, quartz, orthoclase and common hornblende, with accessory sphene and opaque minerals. Alteration minerals are sericite, chlorite and epidote. Modal composition is plotted in the area of quartz diorite. The absolute age determined by K/Ar method gives 122± 6 million years (early Cretaceous, Apx.4), which is the oldest age in this area. The rock on Mt. Huayanche (Apx.1; H091602) is composed mainly of plagioclase, quartz, orthoclase, hornblende and biotite, with alteration minerals of opaque minerals, chlorite and epidote. Modal composition is plotted in the area of granodiorite. The rock along the Angash River (Apx.1; Y092010, A090904) is composed mainly of plagioclase, quartz, orthoclase and hornblende, with accessory biotite, opaque minerals, sphene and apatite. Alteration minerals are chlorite and sericite. Modal composition is plotted in the area of quartz monzonite to tonalite. The absolute age determined for the sample Y092010 by K/Ar method gives 16.4± 0.8 million years (middle Miocene, Apx.4), which is the youngest age in this area. The age is inconsistent with the intrusion series stated through the phase I survey and left for the future study. In fact, the body intrudes in contact with the great fault trending NE-SW confirmed by the phase I survey, thus it is reasonable to consider that the relatively young igneous activity occurs in this area.

Granite is found around Angash in the northeastern part of the area. Under the microscope, it (Apx. 1; Y092220) is composed mainly of orthoclase, plagioclase, quartz and hornblende, with accessory opaque minerals, apatite, sphene and zircon. Alteration minerals are sericite, chlorite and epidote. Modal composition is plotted in the area of granite. The absolute age determined by K/Ar method gives 102± 5 million years (early Cretaceous, Apx.4), which is the oldest age for granite in this area. The body constitutes a part of the intrusive body traversing N-S in the east-

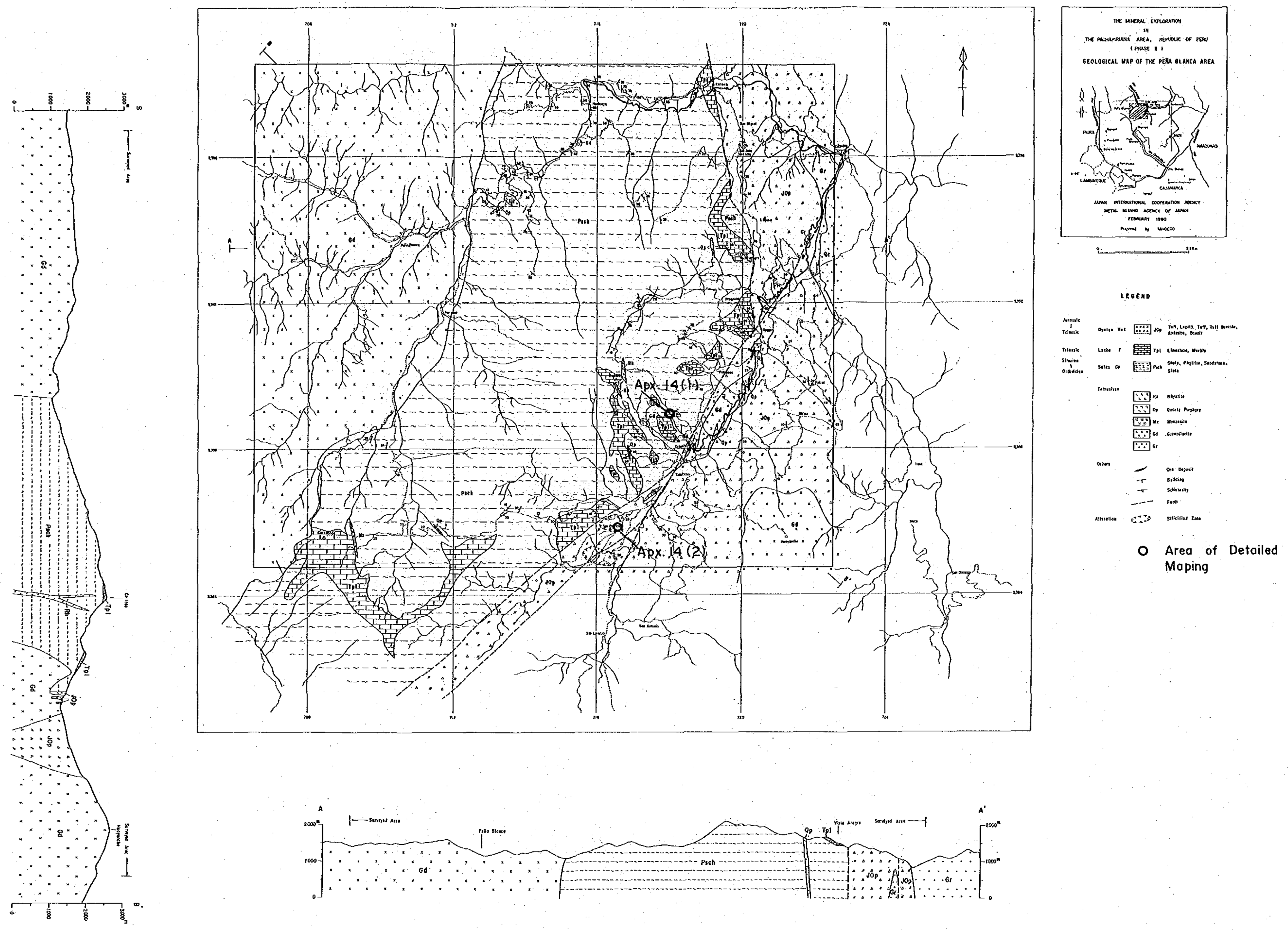


Fig. II-17 Geological Map and Profiles of the Peña Blanca Area

ern part of the area. The N-S trending body is composed mainly of granodiorite. It (Apx.1; H091910) is plotted in the area of quartz monzonite diorite. The absolute age determined by K/Ar method gives 88.4± 4.4 million years (late Cretaceous, Apx.4), which is inconsistent with the conclusion of the phase I that the granite is younger than dioritic rocks. Therefore the intrusion stage must be further studied along with the field survey. Monzonitic rocks is found only as very small dykes in this area. Monzonite porphyry (Apx. 1; Y090501) intruding around Mt. Corcobado is plotted, through the microscopic modal analysis, in the area of quartz monzonite diorite.

Quartz porphyry and rhyolite occurs frequently as small-scaled dykes, and the frequency of occurrence is relatively higher in the eastern part of this area. Rhyolite on Mt. Collota is partly brecciated. Under the microscope, it (Apx. 1; H091304) is composed of rhyolitic fragments constituted by microcrystalline aggregate of felsic minerals, embedded in a matrix of quartz dominant felsic minerals agglutinating the fragments. Chemical analysis data (Apx. 3) shows that SiO_2 content is higher than 95 %, suggesting that it has undergone silicification as well as brecciation. Andesite occurs frequently as small-scaled dykes, and the frequency of occurrence is relatively lower than the dykes of quartz porphyry and rhyolite.

Three fault fissure systems trending NE-SW, ENE-WSW and N-S to NNW-SSE are developed in the eastern and southern parts of this area. Among them, NE-SW trending one is inferred to be great, continued to the fault fissure system trending NE-SW assumed in the semi-detailed surveyed area of Chontali in phase I. The latter two are assumed to be the subsidiary systems being originated from the great one.

Alteration in this area occurs mainly in the calcareous rocks of the Leche Formation and in the Oyotun Volcanics. That in the former is related mainly to the contact metamorphism and pneumatolytic alteration, associated with hydrothermal alteration. Namely, as shown in the description of the Leche Formation in this section, calcareous rocks contains skarn minerals and silicified limestone (Apx. 6; H091202) has undergone Mg-addition as well as quartz addition to give ankerite. Therefore, there is a possibility that a small-scaled dolomite has been formed also through the alteration by Mg-rich hydrothermal solution(Apx. 6; 091206). The alteration in the Oyotun Volcanics is hydrothermal one, showing the occurrence similar, with naked eye, to that of the other areas. In the alteration zones in this area, however, development of quartz veins is poor and silicified zone is small in scale, characterized by argillization.

3-3-2 Geochemical Survey

Comparing the results on the average basis with the semi-detailed survey area in Chontali (Table Ⅱ -1), this area is characterized by its rather high grade of copper, zinc and lead.

Analyzing the distribution of anomalous values per each element (Fig.Ⅱ -18), that of copper is on a small scale, without continuity but seems to concentrate near the intrusive rocks, which intrude along the NE-SW trending fault system and its surrounding. Zinc distribution is on a small scale with good continuity, having the tendency to gather around the calcareous rocks along the NE-SW trending fault. Distribution of lead occurs on a small scale and without continuity, having the tendency to gather near the intrusive rocks intruded along the NE-SW fault. The anomalous zones of gold, silver and molybdenum are scattered, without continuity.

Relationship of geochemical anomalies of each element is extremely irregular, but it is recognized that above-mentioned anomalous zones on a small scale tend to concentrate near the NE-SW trending fault. Relationship between geochemical anomalies and aforementioned alteration zones is also irregular, but in the skarn type alteration zones it is observed such a zonal patterns as copper and zinc anomalous zones as core, are surrounded by small-scaled silver and lead anomalous zones without continuity. While, in the hydrothermal alteration zones gold and lead anomalous zones tend to be surrounded by copper and zinc anomalous zones.

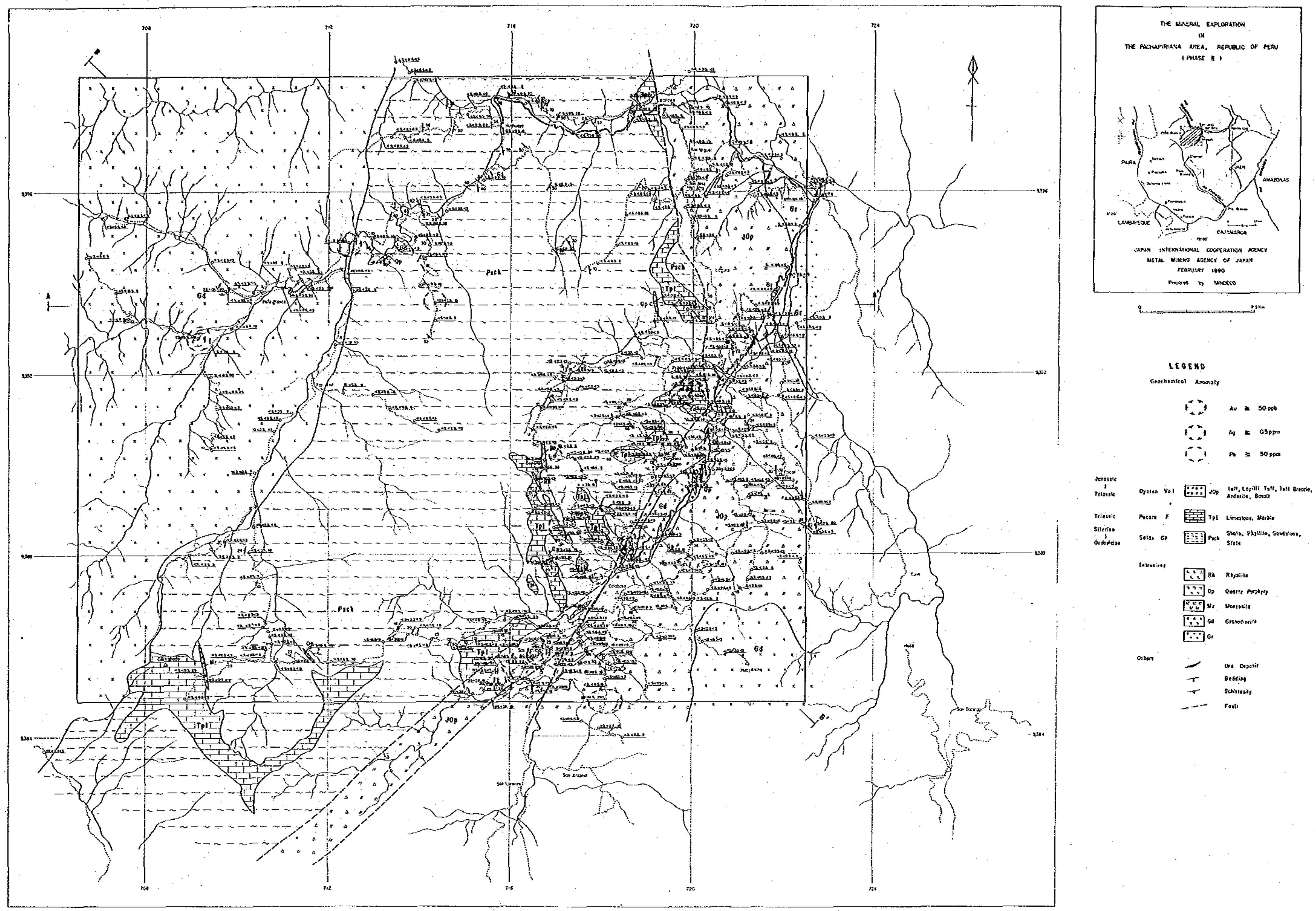


Fig. Ⅱ-18(1) Distribution of Geochemical Anomaly in the Peña Blanca Area (Au,Ag and Pb)

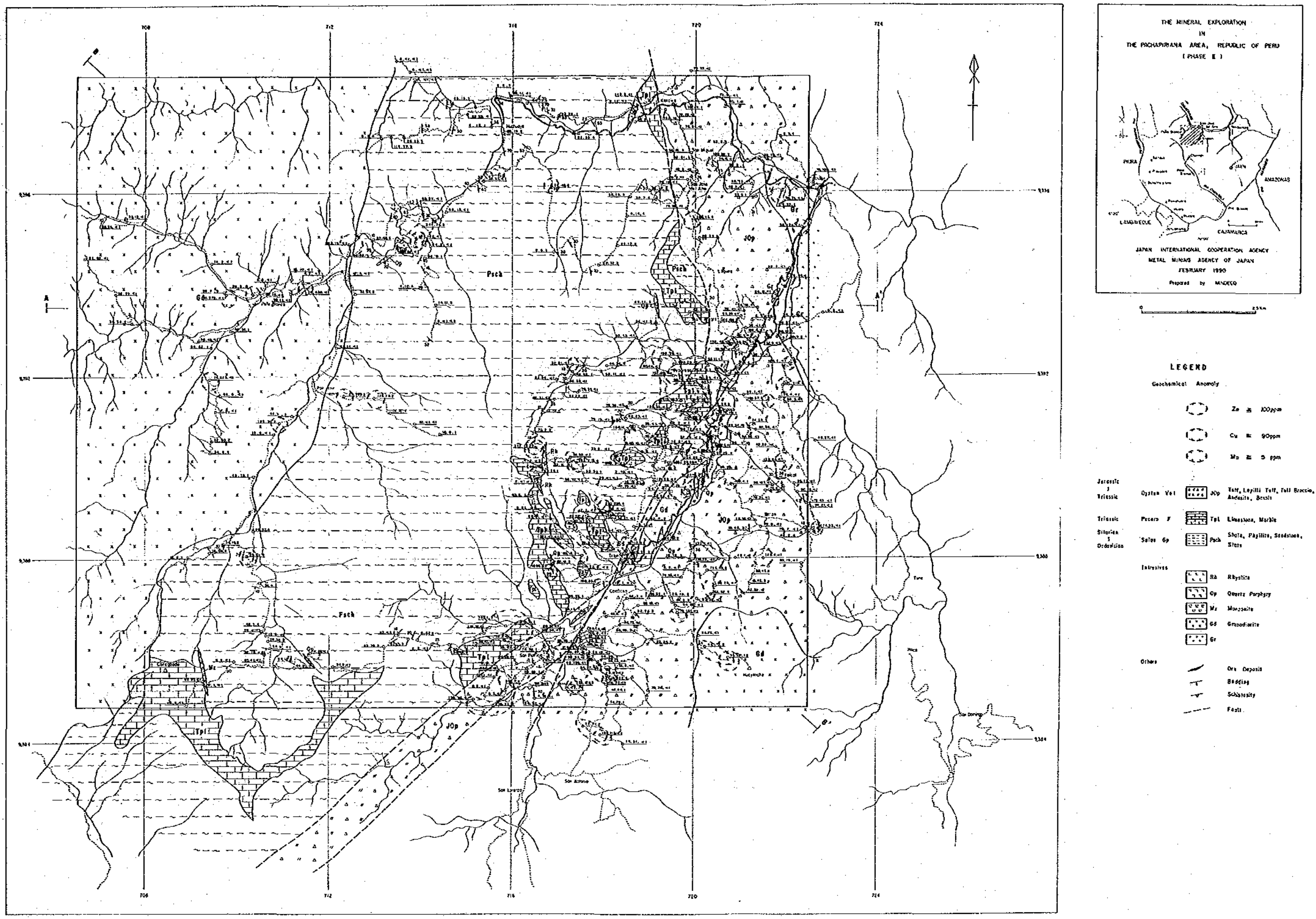


Fig. Ⅱ-18(2) Distribution of Geochemical Anomaly in the Peña Blanca Area (Zn,Cu and Mo)

3-4 Results of Chemical Analysis of Ore

The skarn zone developed in the calcareous formation of the Leche Formation in this area has been mineralized by sulphide minerals composed mainly of pyrite. Massive sulphide deposit is sometimes found in the zone(Apx. 14-(1)). Grades of two samples from this massive deposit by weighted means were 1.25 m in width, 0.19 g/ton Au, 11 g/ton Ag, 1164 ppm Cu, 100 ppm Pb, 258 ppm Zn and 19 ppm Mo, thus providing evidence that gold, silver and copper mineralization is predominant in the area. Under the microscope, these samples (Apx. 8; A092204, A092208) are composed mainly of pyrite, associated by chalcopyrite with magnetite and sphalerite as an exsolved phase, suggesting that the copper mineralization has occurred.

The result for a silicified rock (Apx. 14-(2) from silicified-alteration zone in the Oyotun Volcanics is 0.25 g/ton Au, 7 g/ton Ag, 5 ppm Cu, 300 ppm Pb, 150 ppm Zn and 13 ppm Mo. A geochemical sample from another silicified zone situated about 1 km south of above-mentioned silicified zone gives the result(Apx. 13; H090907) of 165 ppb Au, <5 ppm Ag, 7 ppm Cu, 230 ppm Pb, 366 ppm Zn and 1 ppm Mo, with a tendency to coincide with that of above-mentioned rock. Namely, these rocks suggest the existence of gold, lead and zinc mineralization.

3-5 Consideration

The Pena Blanca area consists of the Salas Group weakly metamorphosed rocks as basement, the Leche Formation, Oyotun Volcanics and intrusive rocks intruding into the formers. Structurally, lineament in a NE-SW direction is predominant, corresponding to the fault between the basement rocks and the Oyotun Volcanics in the eastern part, and to the boundary of intrusive bodies which intruded into the basement.

Along the NE-SW trending fault, a small-scaled granodiorite body intruded. It has altered the calcareous Leche Formation which unconformably overlies the basement, to form skarn zone and to carry sulphide mineralization in the zone. The southwestern extension of the fault continues to the NE-SW trending fault running to the south of Chontali, which is assumed to play an important role for the formation of mineralized alteration zones in the Chontali area. Additionally, silicified-alteration zone is found in the Oyotun Volcanics between the fault and its subsidiary fault trending ENE-WSW, which traverse to the north of San Patricio.

As a result of chemical analysis for ores from skarn zone and silicified zone, it has been clarified that the former is characterized by gold, silver and copper mineralization and the latter by gold, lead and zinc one. The distribution of geochemical anomalies is not inconsistent with above-shown result.

In the Chontali area, mineralized alteration zones detected in the Oyotun Volcanics are genetically related with granitic rocks, which occupies the western part of the Chontali area. If it is assumed that the mineralized alteration zone in the Pena Blanca area has been formed contemporaneously with that in the former area, the age is very different from that of the formation of skarn zone. Namely, the irregularity of geochemical anomalies in this area may suggest the overlapping of two stage mineralization. Therefore, it is possible that the mineralization zones detected from the analysis of ore tend to concentrate along and around the NE-SW trending fault, though the distribution of anomalous values for each element is rather small-scaled and irregular.

PART III

CONCLUSION AND RECOMMENDATION

CHAPTER 1 CONCLUSION

1. General Geology

The basement of the survey area consists of the Maranon Complex, composed of metamorphic rocks mainly gneisses correlative with Precambrian rocks. Paleozoic rocks are the Olmos Complex (mainly schist) and the Salas Group (phyllite and micaceous sandstone intercalated with meta-pyroclastics). Mesozoic rocks consist of the following units in ascending order: Leche Formation (mainly calcareous rocks), Oyotun Volcanics (mainly pyroclastic rocks), Goyllarisquizga Formation(mainly siliceous sandstone), and Inca, Chulec, Pariatambo and Pulluicana Formations (mainly calcareous rocks). Intrusive rocks composed of diorites, granites, monzonites and porphyries intrude into the formers. Cenozoic rocks overlying the formers are composed of such Tertiary system as Llama and Porculla Volcanics and of such Quaternary stream sediments as Tamborapa Formation.

Through the phase II survey, the occurrence of the Leche Formation, hitherto unknown in this area, has been confirmed.

The clear evidence to verify the intrusion history constructed through the phase I survey can not be extracted, but the absolute age determined by K/Ar method (Apx. 4) gives 122± 6 to 16.4± 0.8 million years for diorite and 102± 5 million years for granites, which are inconsistent with the conclusion of the phase I that the granite is younger than dioritic rocks. This inconsistency is assumed to be resulted from the occurrence of younger granitic intrusion along the fault in a NE-SW direction.

2. Geological Structure

The extracted lineament frequency and its scale based on the LANDSAT image analysis during the phase I survey, N15° W trend is distinctive in the region, which is so called Andean trend. Through the phase II survey, it is clarified that the fissure system in a NE-SW trend, which is oblique to Andean trend, is predominant both in the Chontali South and Pena Blanca areas. If it is assumed that the intrusion form of intrusives reflects the fissure systems, those in a NE-SW trend are more predominant than those of NW-SE trending in the central part of the survey area, where the Chontali and Pena Blanca areas are located. Meanwhile, in the western part of the survey area, as represented by the San Felipe area surveyed in the phase I, fissures in a NW-SE trend are more predominant than those of NE-SW trending. In contrast to these areas, in the eastern part, as represented by the Palma area surveyed in the phase I, N-S trending fissure system is predominantly developed. The local variation in trend of fissure systems could indicates the local change of the forming process of the Huancabamba Deflection Zone, thus as shown in the report of the phase I survey, it will be difficult to explain the entire survey area based on a single force field. Therefore, the structural analysis for the survey area will be needed as forming a part of the structural analysis for the wide region, including the Huancabamba Deflection Zone for example.

Alteration in the area is confirmed to have occurred not through the remarkable major lineament extracted by LANDSAT images, but, as assumed in the phase I survey, through the subsidiary fissure systems or more small-scaled fissures. Namely, the mineralized-alteration zones in the Hualatan West area of Chontali, in which detailed geological survey is conducted in phase II, occur as silicified and silicified-argillized zones along the NW-SE fissure zone, developed between the NE-SW fissure systems. In Jehuamarca area, underground continuation of fissures distributed at the surface can not be recognized, and it can be assumed that the fissures had been too intensely agglutinated through silicified-alteration to be recognized. In Pena Blanca, silicified alteration zones were extracted between the NE-SW trending fault and its subsidiary ENE-WSW trending fault. Along the NE-SW trending fault, younger granitic rock is intruded and post magmatic metasomatism by the granites intrusion causes skarnization in Leche Formation along the fault.

3. Mineralization

Geochemical anomalies were identified throughout the survey area. However, those overlapped with alteration zones seemed to be significant in relation to mineralization were observed in Hualatan West and Tabacal South in the Chontali area, San Patricio and Angash-Triunfo in the Pena Blanca area. The mineralized alteration zones in Hualatan West were represented by gold, lead and zinc anomalous zones overlapping with combined silicified-argillized zones and those in Tabacal South by gold and lead anomalous zones overlapping with combined silicified-argillized zones. In Pena Blanca, the mineralized alteration zones in San Patricio were extracted as gold, lead and zinc anomalous zones overlapping with combined silicified-argillized zones and those in Angash-Triunfo as copper and zinc anomalous zones overlapping with skarn alteration zones.

Geophysical survey implemented in the Chontali area revealed that the alteration zones were characterized by low resistivity zones and that silicified and combined silicified-argillized zones in Hualatan West with closely developed quartz veins were extracted as high resistivity within the low resistivity zone. It is also clarified that at deep underground there exists a high resistivity basement of more than 1,000 Ω m and that high resistivity zone suggesting the existence of silicified alteration zones continues toward deeper underground to the rise of high resistivity basement. Judged from the laboratory tests of resistivity for inferred basement rocks (granites and/or schist, the values of them is 1,000 Ω m and 180 Ω m, respectively) and from analyzed results by homogeneous temperature of fluid inclusions in quartz veins, it is concluded that the rise of high resistivity basement can reflect the intrusion structure of granitic rocks. In Hualatan West, the part with large-scaled quartz veins(six veins, width 1.45-4.17 m, extension 40-140m) within the area with closely developed quartz veins overlaps with the said rise. Moreover, average grade (weighted means) in quartz veins is 2.54 g/ton Au, 13.99 g/ton Ag, 91 ppm Cu, 30 ppm Pb, 160 ppm Zn and 11 ppm Mo, suggesting the existence of gold and silver mineralization. Analyzed results by homogeneous temperature of fluid inclusions in quartz veins ranged from 96 to 271℃ , and the values for the large-scaled quartz veins was lower than 150℃ , which is obviously lower than the temperature most adequate for the mineralization of gold and silver (180-230℃). Therefore, in the deep extension beneath the large-scaled quartz veins, a gold and silver ore deposits can be expected to exist.

Drilling survey performed in the Jehuamarca area revealed that silicified zone extracted as high resistivity zone can be characterized by a mushroomed structure as interpreted through the phase I survey. The silicified zone has commonly undergone gold, silver, copper, lead and zinc mineralization, indicating the existence of a unique mineralization to form auri-argentiferous base metal dissemination deposits in the area. Moreover, in the mineralization zone extracted is a layered quartz zone of high-graded gold, silver, copper, lead and zinc, which is concordant with bedding plane. From the oxidized-leached zone of silicified breccia, high-graded gold and silver concentration zone is extracted. This indicates a very high potential of an existence of the mineralization in silicified breccia, which shows high anomalies of gold and silver and develops widely constituting the marginal zone of the Jehuamarca mineralized alteration zone.

Chemical analysis was performed for ores taken from the Pena Blanca area. The grade of sulphide deposit in the skarn zone developed in the Leche Formation is 0.19 g/ton Au, 11 g/ton Ag, 1164 ppm Cu, 100 ppm Pb, 258 ppm Zn and 19 ppm Mo. The grade is too low and the scale of ore body is too small (width; 1.25 m , extension; 70 m) as a sulphide deposit, therefore, there might be a slim chance obtaining a large-scaled deposit. The result for a silicified rock from silicified-argillized zone in the Oyotun Volcanics is 0.30 g/ton Au, 5 g/ton Ag, 4660 ppm Cu, 50 ppm Pb, 160 ppm Zn and 8 ppm Mo. and geochemical sample also gives the result 0.165 g/ton Au, < 5 g/ton Ag, 7 ppm Cu, 230 ppm Pb, 366 ppm Zn and 1 ppm Mo. Although no quartz veins were extracted in the area, these chemical results indicate a high potential of an existence of gold mineralization.