REPUBLIC OF COLOMBIA

REPORT ON GEOLOGICAL SURVEY OF PIEDRANCHA AREA

PHASE II

MAY 1982

METAL MINING AGENCY OF JAPAN
JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

In response to the requirements of the Government of the Republic of Colombia, the Japanese Government has decided to perform collaborative mineral exploration in Piedrancha area located in the southwestern part of the country and has entrusted its performance to the Japan International Cooperation Agency, who has decided to entrust that performance to the Metal Mining Agency of Japan because the subjects of this investigation belongs to a special field of the geological and mineral resources survey.

This investigation was started in 1980 as the first phase. For the second phase plan, the Metal Mining Agency of Japan organized an investigating mission of seven persons to dispatch it to the site from August 10, 1981 to January 14, 1982.

The investigation on the site was completed on schedule by the cooperation of agencies relative to the government of the Republic of Colombia, especially Instituto Nacional de Investigaciones Geologico-Mineras.

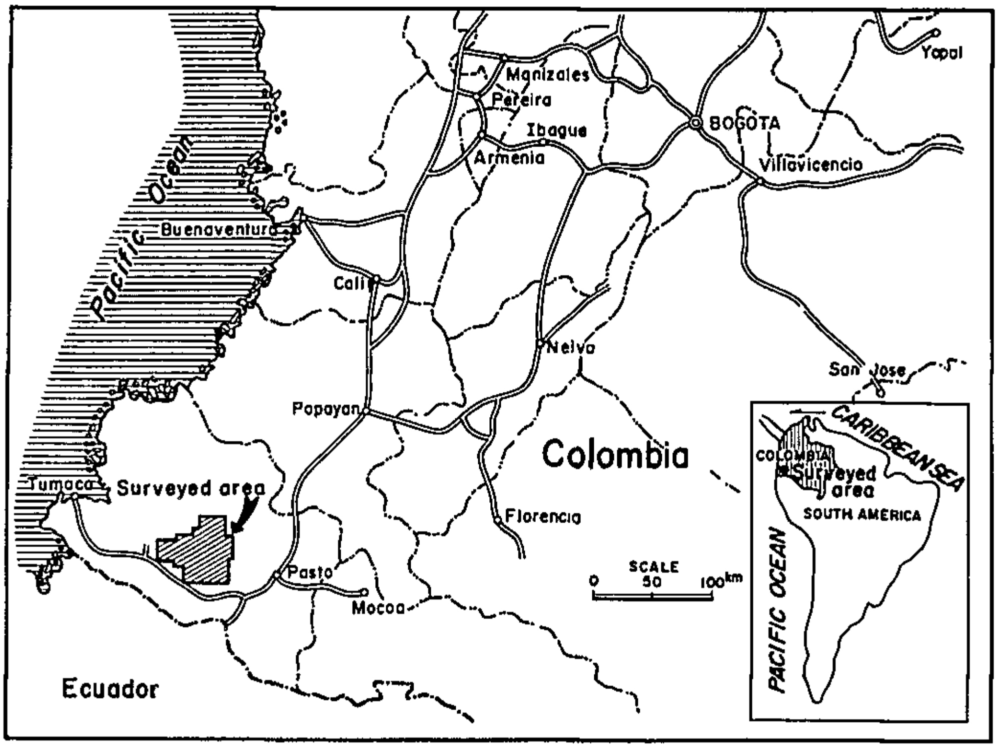
This report has collected and arranged the results of the investigation in the second phase to make a part of the final report.

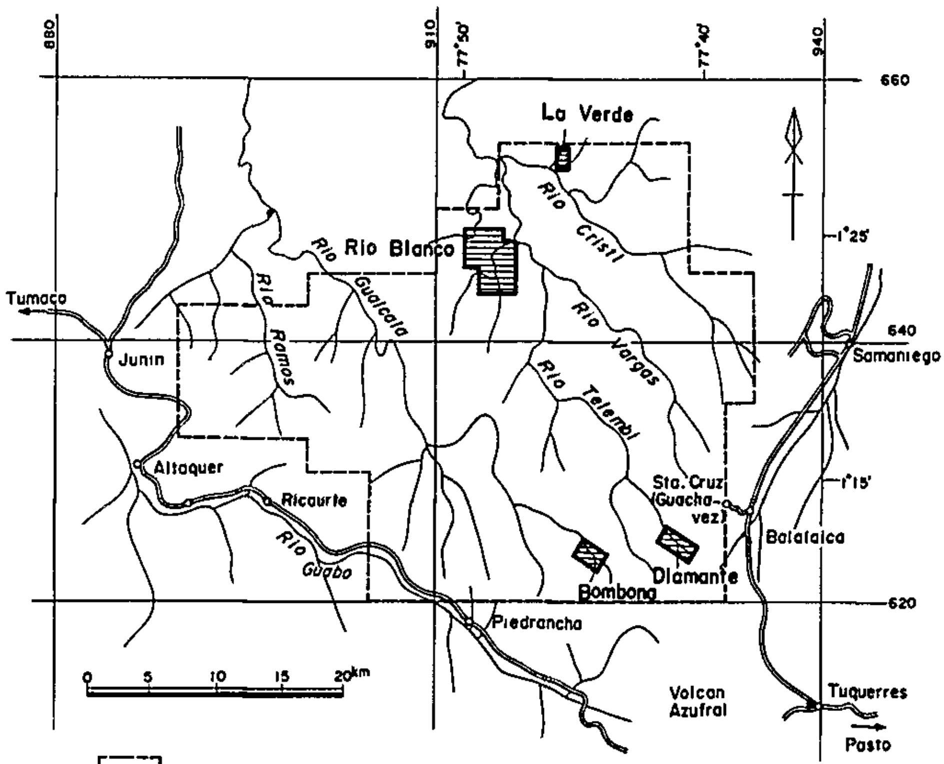
Finally we express our heartiful thanks for the cooperation of the agencies relative to the Government of the Republic of Colombia, and also to the Ministry of Foreign Affairs, Ministry of International Trade and Industry, the Japanese Embassy in Colombia, and all personnel of the companies concerned in the performance of this investigation.

March, 1982

Keisuke Arita
President
Japan International Cooperation Agency

Masayuki Nishiie
President
Metal Mining Agency of Japan





Surveyed Area (1980)

Surveyed Area (1981)

Fig. I-1 Location map of the surveyed area

CONTENTS

ABSTRACT

In the survey of this second phase, four areas (Rio Blanco, La Verde, Diamante and Bombona) were selected from the mineral indication areas extracted from the regional geologic survey of the first phase, and then geologic survey, geochemical survey and drilling work were performed. The purpose of this survey was to clarify the geologic structure, to grasp the geological environment, where the existence of ore deposits was expected, and the conditions of embedment of ore deposits, and to obtain the survey guide for the next phase.

The outline of survey is as follows:

Period of on-site survey:	From August 10, 1981 to January 14, 1982.
Members of survey team:	4 Japanese geologists and 3 boring engineers
	3 Colombian geologists
Area of surveyed area:	Total of 4 areas: 26.5 km^2
Total extension of survey:	163.1 km
Total length of drilling:	7 drill holes: 757.2 m

The results of survey for each area are outlined below.

<u>Rio Blanco area</u>:

The geology in this area consists of Cretaceous green volcanic rocks, sedimentary rocks and Tertiary diorite intruded into these rocks. Diorite has a stock-like shape with a diameter of about 5 km, and its central portion is of coarse grained holocrystalline and its marginal portion is of fine grained porphyritic. At the Dorada valley on the marginal portion north of this diorite, the fissures in two directions of ENE-WSW and WNW-ESE are developed and the mineralized zone and accompanied alteration zone are distributed there.

The mineralized zone was caused by the filling of veinlets in country

rocks and impregnation-like pyritization, and a small amount of chalcopyrite is observed in some places.

Alteration zone has the zonal distribution featured by silicification at its center and by epidotization at its surrounding portion.

Mineralized and altered zone has an elliptic shape 1000 m long in the E-W direction and 500 m long in the N-S direction.

In view of style of mineralization and features of alteration of country rocks, these mineral indication areas are considered to result from the porphyry copper deposit type mineralization.

From the results of geochemical survey based on the soil samples, it was found that the anomalous zones of copper and molybdenum are distributed within the same range of the mineralized zone and alteration zone stated above. Though the mineralized zone has prospective parts in depth, it locates at the bottom of valley and far from existing road, therefore an advanced exploration for this area should be commenced after comparing thoroughly with the other prospective projects.

La Verde area:

The geology of this area consists of Cretaceous green volcanic rocks and alternating layers of sandstone and shale, and stratum strikes the N-S direction and steeply dips east. Tertiary diorite is intruded to the boundary portion between these rocks. This intruded rock extends in the N-S direction with a scale of 2000 m from north to south and of 400 m in average from east to west, and its southern end is closed with a tongue-like shape. The mineralization along joints and impregnation in this diorite mainly consist of pyrite accompanied by chalcopyrite.

From the results of geochemical survey using soil samples, the presence of anomalous zone of copper and molybdenum was found in the diorite stated above and in the area where green volcanic rocks were distributed in adjacent to and at the west side of the diorite, and this anomalous zone is 300 m long in the E-W direction and 800 to 1200 m long in the N-S direction.

The mineralization and alteration of this area are similar to those of the mineral indication area in Rio Blanco, country rocks subjected to the sericitization and potassic feldspathization are recognized, and there is a possibility of already exposed mineralized zone. There still remains an unexplored part due to scarce exposures of the area, but mineralization is not strong enough to commence immediate exploration work.

Diamante area:

Green volcanic rocks are widely distributed in this area and a small stock of granodiorite is intruded at the southeastern corner of this area. The mineralization in this area is all observed in the form of fissure filling vein type deposits.

The mineralized zone is divided into three zones; Diamante principal vein mineralized zone, Marina mineralized zone, and Gitana mineralized zone. And grouped mineral veins in each zone are arranged in an echelon form.

Ore veins generally strike N60°W and dip 70°N, and their width considerably varies from 30 to 900 cm.

The mineral compositions are pyrite, arsenopyrite, sphalerite, galena and chalcopyrite as ore-minerals, and mainly quartz as a gangue mineral. Also, as gold and silver minerals, electrum, argentite, pyrargyrite, polybasite and freibergite are recognized through microscope and an X-ray microanalyzer. The results of geochemical survey using the soil samples show that the anomalous zones of arsenic and zinc well correspond to the known ore veins and area where the ore veins are considered to be present from the geologic survey.

Six gold mines are currently under exploitation in a small scale in this area.

Drilling work in Diamante area:

This work was carried out at the Diamante principal vein mineralized zone, and auriferous veins were recognized at four holes out of seven drill holes. These grouped veins that were recognized have common strike and dip, and thus they are considered to be within the same mineralized zone. However, each ore vein greatly varies in width, ratio of Ag/Au, and in its mineral composition. Whether the same vein simply continues or not is still unknown.

The mineralized zone detected by the drilling work has a horizontal length of about 300 m or more, a vein width of 50 to 900 cm, and a vein width weighted-mean grade, for the mineral portions of 4 drill holes, of 8.9 g/t for Au, 60 g/t for Ag, 0.14% for Cu, 0.09% for Pb, 4.58% for Zn and 5.12% for As in the case of mean vein width of 278 cm. These grade values are almost the same as those in the Diamante mine.

Bombona area:

Geology in this area consists of granodiorite which is the Tertiary intruded rock. Mineralization in this area is observed in the form of fissure filling vein type deposits as same as the Diamante area.

The mineralized zones are observed in both upstream portion (Bombona alto) and downstream portion (Bombona bajo) in this area. Ore veins have the general strike of N60°W and dip of 60°-90°NE with an echelon arrangement. Width of veins is several centimeters to several decimeters, and their horizontal length is 100 to 300 m.

The mineral compositions of the ore veins are mainly pyrite, and arsenopyrite accompanied with small amounts of sphalerite, galena and chalcopyrite as ore-minerals and also quartz as a gangue mineral.

Based upon the results of soil geochemcal survey using zinc and arsenic as indicator elements, anomalous zones were extracted at known ore veins and their horizontally extended portions, and also two anomalous zones were extracted in places where the parallel veins of known ore veins are considered to be present. Gold-bearing quartz veins are currently under exploitation in a small scale at two places, in Bombona alto and Bombona banjo. There is still a room for exploration below the old-mined veins and at places northwest of the downstream ore vein group.

By examining the results of survey of this fiscal year, it is desired to carry out the following items of investigation for the next phase of survey:

1. Drilling exploration in the mineralized zone of Diamante principal vein:
   The purpose of this survey is to clarify the factors which control the mineralization of Diamante principal vein, to grasp the continuity and scale of mineralization, to facilitate the examination of possibility of development in this mineralized zone, and to obtain the guide for the survey of similar mineralized zones in the vicinity.

2. Detailed geologic survey in the vicinity of Diamante, Paraiso, and Bombona areas:
   Detailed geologic survey associated with soil geochemical survey is to be carried out for Diamante area, an area extended northwestward from the Diamante area, and a northern part of Bombona. The purpose of this detailed survey is to obtain the information concerning the potentiality of nearby ore deposits by exploring the ore veins by using both the detailed geologic survey and soil geochemical survey using zinc and arsenic as indicator elements whose effectiveness was proved by the survey in this phase.

3. Detailed geologic survey in Ramos area:

Five areas of Rio Blanco, La Verde, Ramos, Sta Rosa and Gualcala-E were extracted as the mineral indication areas of porphyry copper deposit type from the survey of the first phase. However, in the second phase of survey, two areas of Rio Blanco and La Verde were selected out of five areas stated above in consideration of the intensity of mineralization and the accessibility to the areas, and the survey was conducted there. As a result, it has been found that the copper-mineralized zones accompanied with diorite are widely distributed in both areas, alteration in country rocks and veinlet fissures are well developed, but the grade of outcrops is still low with a value of less than 0.3% for copper so that the further increment of mineralization at deeper underground parts will be the key which governs the future of these areas. Though the geophysical survey using the induced polarization method and so on and drilling survey can be considered as a means of forecasting the deeper portions, considerable costs and preparatory work will be required for transporting the equipment and materials to the survey areas. Therefore, for the mineral indication areas of porphyry copper deposit type, it is preferable to perform a detailed geologic survey and a soil geochemical survey which are relatively easy to perform, to determine the priority order for each mineral indication area, and then to proceed to the exploration of deeper parts in the next stage. In view of the above, it is recommended to perform a soil geochemical survey and a detailed geologic survey in Ramos area in the next phase of survey, which is a promising mineral indication area comparable to Rio Blanco and La Verde.

INTRODUCTION

INTRODUCTION

CONTENTS

CHAPTER 1. SURVEY WORKS IN THE FIRST PHASE

1-1 Outline of Survey Works

The area to be surveyed situates at about a center of Nariño Department in southernmost part of the Republic of Colombia and the areal coverage is 1000 Km^2. Interpretation of photo-geology, geological survey, and geochemical survey with stream sediments were performed.

The object of these surveys is to clear the regional geology, geological environment of potential mineral deposit, and mineral indication areas, through which to obtain guidance for further exploration works.

1-2 Conclusion of the First Phase

Survey results of the 1st phase was summarized as follows:

(1) Geologically in this area, green volcanic rocks of the lower layer occupy the western part and sedimentary rocks of the upper layer which occupy the eastern part and area subjected to folding strongly, sustained regional metamorphism and furthermore suffered hornfels type metamorphism by intrusion of granodiorite later.

(2) By geochemical exploration, succeeded extraction of five porphyry copper type mineralization zones and two auriferous mineralization showings areas.

(3) By photogeology, distribution of geological tectonic lines has been made clear. Especially found that five copper mineralization zones are arranged on the faulting zone of NE-SW system.

(4) Gold ore deposits are divided into two groups; one is milky white quartz vein group distributed in the northeastern part; another is polymetallic vein group abound with sulphide minerals in the south-

eastern part. The former is irregular veins and amount of remaining ore reserves are few, but the latter holds possibly enough quantity for development in future.

CHAPTER 2. OUTLINE OF THE ACTUAL SURVEY WORKS

2-1 Objective of Survey Works

Objective of survey works is to investigate the mineralized areas extracted by the 1st phase, elucidating geological structure which contains mineral deposit and clarifying shapes and natures of the mineral deposit and obtaining guidance for further exploration work.

2-2 Method and Contents of Survey Works

The survey of this year is at the precision survey stage for all areas and geological survey and geochemical survey on soil samples were performed. Furthermore, drilling work was carried out in the Diamante area.

Main contents of survey works were:

Geological survey	...	4 areas, total area 26.5 Km^2
		total traverse line 163 Km
Geochemical survey	.....	soil samples collected 920
Dilling survey	....	7 holes total drilled length 757.2 m

2-3 Outline of the Surveyed Area

Four surveyed areas of this year are as follows:

(1) Rio Blanco area:

A porphyry copper deposit type mineralization zone. Area 17 km^2. It is located in the northern end of the central part of the region surveyed last year, and it can be arrived at from the nearest town of Samaniego within 3 days on foot. It occupies the Rio Blanco basin, a branch of the Telembi river.

(2) La Vrede area:

A porphyry copper deposit type mineralization zone. Area 2 km^2. It is located in the northern end of the eastern part of the region surveyed last year. To get there, it takes 2 days from Samaniego on foot. It occupies the area intersected by La Verde and Sergia rivers, branches of the Cristal river.

(3) Diamante area:

An auriferous polymetallic vein type deposit. Area 4.5 km^2. It is about 4 km to the west of the nearest town Guachavez. It takes about 3 hrs on foot to get there. It is located in the southernmost end of the eastern part of the region surveyed last year and it occupies the mountainous district rising from 2400 m to 3100 m above the sea. It is the upper-most stream area of the Telembi river.

(4) Bombona area:

An auriferous polymetallic vein type deposit. Area 3 km^2. It is about 12 km to the west-southwest from the nearest town Guachavez. It takes 7 hours' walk to arrive there. It is located in the steep mountainous district rising from 2400 m to 3000 m above the sea and it is the source of the Gualcala river.

2-4 Organization and Members of Survey Team

Persons in charge of survey planning and negotiation in Japan side;

Kyuzo Tadokoro	Metal Mining Agency
Shozo Sawaya	- do -
Toshio Koizumi	- do -

Persons in charge of survey planning and negotiation in Colombia side;

Alfonso Lopez Reyna	INGEOMINAS
Hernan Duque-Caro	- do -
Francisco Zambrano	- do -
Pedro Antonio Marin	- do -

Members of Survey Team in Japan side;

Junnosuke Oikawa	...	Chief	MESCO, Inc.
Yoshihiro Nagumo		Member (Geology)	- do -
Norio Ikeda		- do -	- do -
Shigehisa Fujiwara		- do -	- do -
Kiyotaka Obase		Member (Boring)	- do -
Masao Kimura		- do -	- do -
Kiyoshi Sakashita		- do -	- do -

Members of Survey Team in Colombia side;

Pedro Antonio Marin	INGEOMINAS
Abigail Orrego Lopez	- do -
Raul Muñoz	- do -

2-5 Itinerary

No.	Date	Day	Itinerary	Survey contents
1	8/10	M	(Leader and 3 Geo. Surv. members) start from Tokyo	Travel
2	11	T	→ Bogoda	"
3	12	W	→ Bogoda	Courtesy visit·work arrangement. Japanese embassy, JICA, INGEOMINS.
4	13	T	Start from Bogota via Cali → Popayan	Travel
5	14	F	→ Popayan	Prepare survey articles.

No.	Date	Day	Itinerary	Survey contents
6	8/15	S	Start from Popayan → Pasto	Travel. Procure food stuffs
7	16	S	Start from Pasto → Guachavez	Travel
8	17	M	→ Guachavez	Arrange laborers and horses. Prepare mountain tour
9	18	T	Rio Blanco and Diamante, Bomboa	Geological survey, geochemical exploration
				"
.	.	.		
.	.	.		
.	.	.	Inside survey area.	"
.	.	.	Organize 4 survey teams.	
.	.	.		
.	.	.		"
36	9/14	M	(Boring team 3 members) start from Tokyo	Travel
37	15	T	→ Bogota	"
38	16	W	→ Bogota	Courtesy visit·Work arrangement. Japanese embassy·JICA, INGEOMINAS
39	17	T	Start from Bogota → Popayan	Travel
40	18	F	Start Popayan → Guachavez	"
41	19	S	→ Guachavez	Prepare mountain tour
42	20	S	Guachavez → Diamante	Prepare heliport. Set up temporary hut, boring base, etc.
.	.	.		
.	.	.		
.	.	.		
45	23	W		Transportation by a helicopter.
.	.	.		
.	.	.		
.	.	.		
48	26	S		
.	.	.		
.	.	.		

No.	Date	Day	Itinerary	Survey contents
52	9/30	W	Return of geological survey team to base camp.	
53	10/ 1	T	Guachavez	(Geolog) Survey adjustment. Next survey preparation.
54	2	F	"	(Boring) Start boring operation
55	3	S	"	
56	4	S	"	
57	5	M	Geolo. team La Verde, Diamante	Geological survey, Geochemical exploration
58	6	T		
59	7	W	Leader start from Bogota, return home tentatively.	
60	8	T		
.	.	.		
.	.	.		
.	.	.		
96	11/13	F	Geo. team, Return to base camp	Travel
97	14	S	Guachavez	Survey adjustment
98	15	S	"	"
99	16	M	Start Guachavez Popayan	Travel
100	17	T	Leader start from Tokyo → Bogota	Survey adjustment. Analyzing work
				"
.	.	.		"
.	.	.		"
108	25	W	Geo. team 3 members start from Popayan → Cali	Travel
109	26	T	Start from Cali → Bogota	
110	27	F		Courtesy visit·Work report. Embassy·JICA, INGEOMINAS

No.	Date	Day	Itinerary		Survey contents
111	11/28	S	Geo. team 3 members start from Bogota		Travel
112	29	S			"
113	30	M		→ Tokyo	"
.	.	.			
.	.	.	Leader		
.	.	.	Boring team (3 members)		
139	12/26	S	Diamante	→ Guachavez	Boring work Field operation finish.
140	27	S	Guachavez	→ Pasto	Travel
141	28	M	Pasto	→ Popayan	"
142	29	T		Popayan	Report work INGEOMINAS
143	30	W	Popayan	→ Cali	Travel
144	31	T	Cali	→ Bogota	"
145	1/ 1	F	Boring team 3 members start from Bogota		"
146	2	S			Travel
147	3	S		→ Tokyo	
.	.	.			
.	.	.			
.	.	.			
155	1/11	M			Work completion notice. Interim reporting meeting (INGEOMINUS)
156	12	T	Leader start from Bogota		Travel
157	13	W			"
158	14	T		→ Tokyo	

PARTICULARS

PART I

GEOLOGICAL AND GEOCHEMICAL SURUEY

PART I GEOLOGICAL AND GEOCHEMICAL SURVEY

CONTENTS

Page

Page

LIST OF FIGURES

LIST OF TABLES

LIST OF PLATES

CHAPTER 1. OUTLINE OF SURVEY

1-1 Surveyed Area

The areas which are the subject of survey in this year are the following 4 areas:

(1) Rio Blanco area

(2) La Verde area

(3) Diamante area

(4) Bombona area

All of them contains ore deposits and/or mineral indications and the existence of porphyry copper deposit type mineralization zone in (1), (2) and auriferous polymetallic vein type mineral deposit in (3), (4) have been found.

The sites lies about the central part of Nariño Department which is located on the Pacific coast's southernmost end of the Republic of Colombia and they belong to Municipalities of Sta Cruz, Samaniego and Piedrancha.

Each survey district is situated in precipitous mountains and rapid current encroaches them deeply in Cordillera Occidental, a part of the Andes and the altitude of the districts vary greatly from 500 m to 3100 m above sea level.

The flora varies from tropical forest zones growing thick in the low land up to the high mountain zones of prevailing shrubs and bomboo, and rain fall and the average temperature also vary greatly from the tropical rain belt of the low land to the cool scarce rain-fall high-lands, according to the height of each area.

As for communication with this region, road-ways are opened to the nearest town Guachavez (a town of about 200 houses) located east of the survey area from the Pasto of Nariño Department and to Samaniego (population 51 thousands), and a regular bus service is also operating.

The distance between Pasto and Guachavez is 109 km, the time it takes a car to travel that distance is 3 hours; the distance between Guachavez and Samaniego is 27 km this takes a car about 1 hour. However, the "roads" to the survey districts are all only small lanes which allow only walking or horse riding.

Explanations for each survey area are summarized and tabulated as follows:

Table Explanation of areas surveyed

	Name of area	Subject area km^2	Survey items	Location, communication, etc.
(1)	Rio Blanco	17	Geological survey. Soil geochemical exploration	Located in the Blanco basin, a branch or the Telembi river. 500 m ∿ 1200 m above sea level. One arrives at the spot after 3 days of travel on foot from Guachavez.
(2)	La Verde	2	Ditto	Located in the area cut through by 2 valleys Sergia and La verde, branch streams of the Crystal river. 450 m ∿ 700 m above sea level. One arrives at the spot after 2 days travel on foot from Guachavez via Samaniego.
(3)	Diamante	4.5	Geological survey. Soil geochemical exploration. Boring.	Constitutes the source of the Telembi river. Located in a mountainous zone rising 2400 m ∿ 3100 m above sea level. A lane for men·horses exists to Guachavez and it takes 3 hours on foot.
(4)	Bombona	3	Geological survey. Soil geochemical exploration.	Constitutes the source of the Gualcala river. Occupies the mountainous zone of 2400 m ∿ 3000 m above sea level. One arrives at the spot after 7 hours of walking.

1-2 Method and Contents of Survey Works

In the survey this year, geological survey and geochemical survey for soil samples were performed. The Survey staffs consist of 4 geologists and 3 Columbian geologists. The field surveying period was from the 10th of August 1981 to the 11th of January 1982 and the analyzing operation of survey results was done partially during the field surveying period but most of it was carried out in Japan, including analysis of collected specimens and indoor investigation.

1-2-1 Geological Survey

The survey base points in each survey district were decided on, based upon the topographic maps of scale 1 : 50,000 prepared in the previous year's survey and topographic surveying of the scale 1 : 2,000 were performed and the results of geological findings were described on the map. The transit compass made by Ushikata and nylon tape were used for measurement in the survey. Rivers, valleys and roads to make a path for the travers survey were selected spacing 500 m as the maximum and 300 m as the average, and the cut off course of the traverse was arranged, when necessary. One survey team was organized with the necessary personnel consisting of one engineer, one assistant, 2 or 3 laborers, (a total 4 or 5 men) and despatched the necessary number of survey teams to the area.

During the survey works, a temporary office was installed at Guachavez, which was furnished with one jeep and a radio set. These facilitate communication and transportation to the working site; communication with offices of Ingeominas in Bogota and Popayan.

1-2-2 Geochemical Survey

Ridge and spur geochemical soil sampling was conducted, taking into consideration that the area is unexplored, that no topographic map is available and is thickly vegetated with tropical flora.

Distance between sampling lines is 300 to 500 m and the sampling points on the line are spaced every 50 m.

Soil samples were taken from the "B zone" and carefully collected to avoid any contamination. Depth of the soil sampling is 50 to 100 cm, an average of 80 cm in Rio Blanco and La Verde areas and 100 to 200 cm, an average of 150 cm in Diamante and Bombona areas.

Collected soil samples were dried at the site and divided into two parts, one for Ingeominas, the other for the survey team which is to conduct analysis in Japan.

The analysis was carried out through the Atomic absorption method. Analysis of copper and molybdenum was done for Rio Blanco and La Verde specimens, and zinc and arsenic analysis for Diamante and Bombona specimens.

The assay results were analyzed statistically, through a computer transaction programed by Mesco.

CHAPTER 2. GENERAL GEOLOGY OF THE SURVEYED AREA

Geology of a wide area including 4 survey districts of this year's survey is summarized as follows. (Result of previous year's survey). The rocks constituting this area are Diabasa group consisted of green volcanic rock, black shale, Sandstone and conglomerate thought to be upper Cretaceous age. Piercing these rocks, batholith of the Tertiary Miocene intruded. Many intrusive rocks of nearly the same lithology in shapes of dykes and stocks exist around this intrusive rock body. The Quarternary andesitic volcanic activity products are distributed in the south-eastern part of the area which still remains volcanic topography.

The Diabasa group is changing rock facies from volcanic rocks prevailing facies to sedimentary rocks prevailing facies, from the lower level to the upper level, and the distribution is volcanic rocks in the west part and sedimentary rocks and partly volcanic rocks in the east part, and the general strike of the stratum reveals NNE-SSW. Structurally it represents a synclinorium structure with axis of N-S direction and intruding rock of granodiorite has appeared along the axis extending in a N-S direction.

As to the tectonic lines, 3 systems of NW-SE, NE-SW and N-S are developed and the former 2 are considered to form a conjugate shearing fault and the N-S system is considered to form a fracture surface by compression. Each district surveyed this year occupies the following situation in the above-mentioned geological structure.

Rio Blanco district: Zone where small intrusive rock body is distributed in green volcanic rock.

La Verde district: Zone where small intrusive rock body is distributed near the boundary of green volcanic rock facies and sedimentary rock facies.

Diamante district: In green volcanic rocks which are distributed in the east part of Piedrancha granodiorite intrusive rock body.

Bombona district: The eastern edge of Piedrancha granodiorite.

On the other hand, stratigraphy of each district surveyed which became clear by detail geological surveys this year is shown, in Fig. I-2. Details of each district will be described in the later part, but Rio Blanco and La Verde are considered to be nearly the same horizon of the Diabasa group.

And the facts clarified through age determination by radiometric and complete rock analysis results for granitic rocks at various places of districts surveyed in forms of batholith, stocks, dykes, etc. are as follows:

Radio metric age determination indicates $20.7 - 57.1 \times 10^6$ years which correspond to the geological age of Miocene to Eocene.

The triangle diagram from the results of complete rock analysis and the differentiation index (Thornton & Tuttle 1960) graphically indicate; La Verde district (D-2) falls under the area of quartz monzo-syenite, Rio Blanco district (R-253) falls under the area of quartzo-monzonite, La Verde district (V-22), Diamante district (ND-52) and Bombona district (B-22) fall under the area of granite.

And all specimens except V-22 belong to I-type (according to the classification of Chappel & White 1974, 1977).

If granitic rocks of the surveyed area are assumed to have originated and dispersed from the same magma, then the order of formation becomes; Canellera rock body → Rock bodies of La Verde, Rio Blanco, Diamante → Piedrancha batholith.

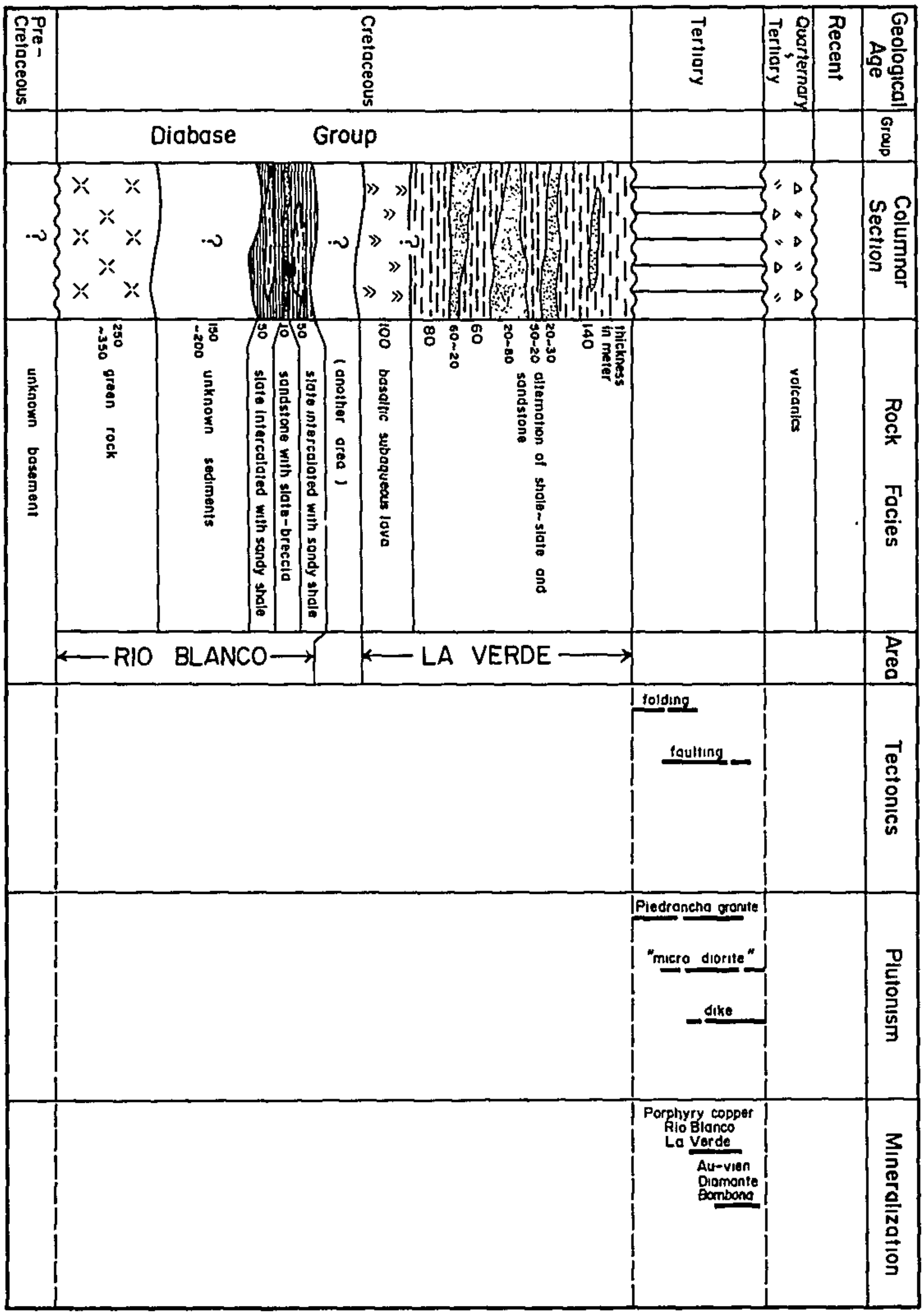


Fig. I-2 Generalized stratigraphic section in the surveyed area

Table I - I Age Determination of Granitic Rocks

Sample No.	Locality	Rock Name	Mineral	Ar^{40} ppm	K^{40} ppm	40ArR/40K	Age M.Y.	Remarks
R-253	Rio Blanco	Micro diorite	Biotite	0.001841	0.542	0.003391	57.1 ±4.3	Biotite very chloritized
ND-52	Diamante	Granodiorite	Biotite	0.000939	0.391	0.002398	40.5 ±3.0	Biotite very chloritized
B-22	Bombona	Granodiorite	Biotite	0.01015	8.340	0.001217	20.7 ±0.8	

$\lambda e = 0.585 \times 10^{-10}$/year 40k/k = 1.22×10^{-4} g/g

$\lambda \beta = 4.72 \times 10^{-10}$/year 40ArR : Radiogenic argon 40

Table I-2 Chemical Analysis of Rock Samples

Sample No.	B-002 DIORITE	D-002 DIORITE	ND-052 DIORITE	R-253 DIORITE	V-022 DIORITE
Weight %					
SiO_2	64.53	57.59	60.12	56.37	61.09
TiO_2	0.40	0.55	0.50	0.73	0.52
Al_2O_3	17.32	18.50	16.63	18.40	18.08
Fe_2O_3	1.71	3.48	1.03	3.07	1.82
FeO	2.74	2.94	4.37	2.70	3.49
MnO	0.10	0.15	0.14	0.10	0.02
MgO	1.77	3.49	2.30	3.62	3.35
CaO	5.37	4.71	6.43	6.62	4.77
Na_2O	2.91	3.48	1.91	4.30	2.36
K_2O	1.59	3.21	1.63	1.17	1.33
P_2O_5	0.14	0.24	0.17	0.83	0.24
CO_2	0.0	0.0	0.93	0.0	0.0
H_2O^+	0.50	1.45	2.24	1.15	3.15
H_2O^-	0.14	0.83	0.61	0.48	0.61
total	99.22	100.62	99.01	99.54	100.83
FeO + MnO	42.22	29.10	54.09	27.37	38.19
Fe_2O_3 + TiO_2	31.38	38.00	18.34	37.22	25.42
MgO	26.39	32.90	27.57	35.41	36.39
Al_2O_3-Na_2O-K_2O	37.37	30.14	33.08	28.67	36.60
CaO	33.72	27.75	32.99	34.31	24.89
FeO + MgO	28.90	42.11	33.93	37.02	38.51

Table I-3 Calculation of Normative Minerals of Rock Samples

Sample No.	B-022	D-002	ND-052	R-253	V-022
Weight %					
Q	26.72	9.75	27.20	9.20	26.66
C	1.40	1.33	2.76	0.01	4.80
OR	9.53	19.29	10.24	7.06	8.10
AB	24.98	29.94	17.18	37.16	20.57
AN	26.09	22.16	26.49	28.00	22.76
Sal. total	88.72	82.47	83.87	81.43	82.89
EN-HY	4.47	8.84	6.09	9.21	8.59
FS-HY	3.19	1.93	7.03	1.43	4.21
MT	2.52	5.13	1.59	4.55	2.72
IL	0.77	1.06	1.01	1.42	1.02
AP	0.33	0.57	0.42	1.96	0.57
Fem. total	11.28	17.53	16.13	18.57	17.11
Color index	11.28	17.53	16.13	18.57	17.11
Weight percentage Q	30.60	12.02	33.53	11.30	34.14
Weight percentage OR+AB	39.52	60.67	33.81	54.31	36.71
Weight percentage AN	29.88	27.31	32.66	34.39	29.15

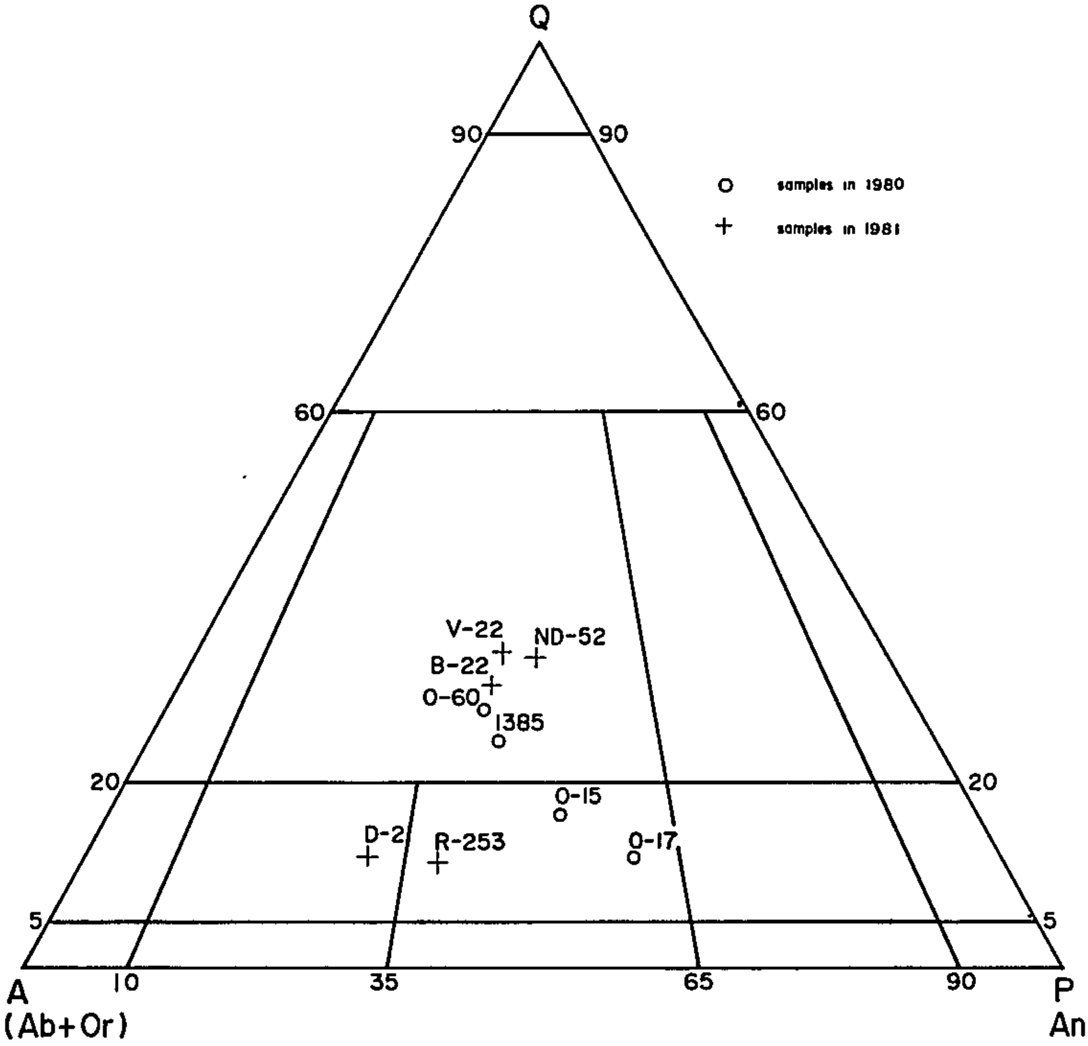


Fig. I-3 Normative plagioclase (anorthite) — alkali feldspars (orthoclase + albite) — quartz of granitic rocks (Geotimes, 1973)

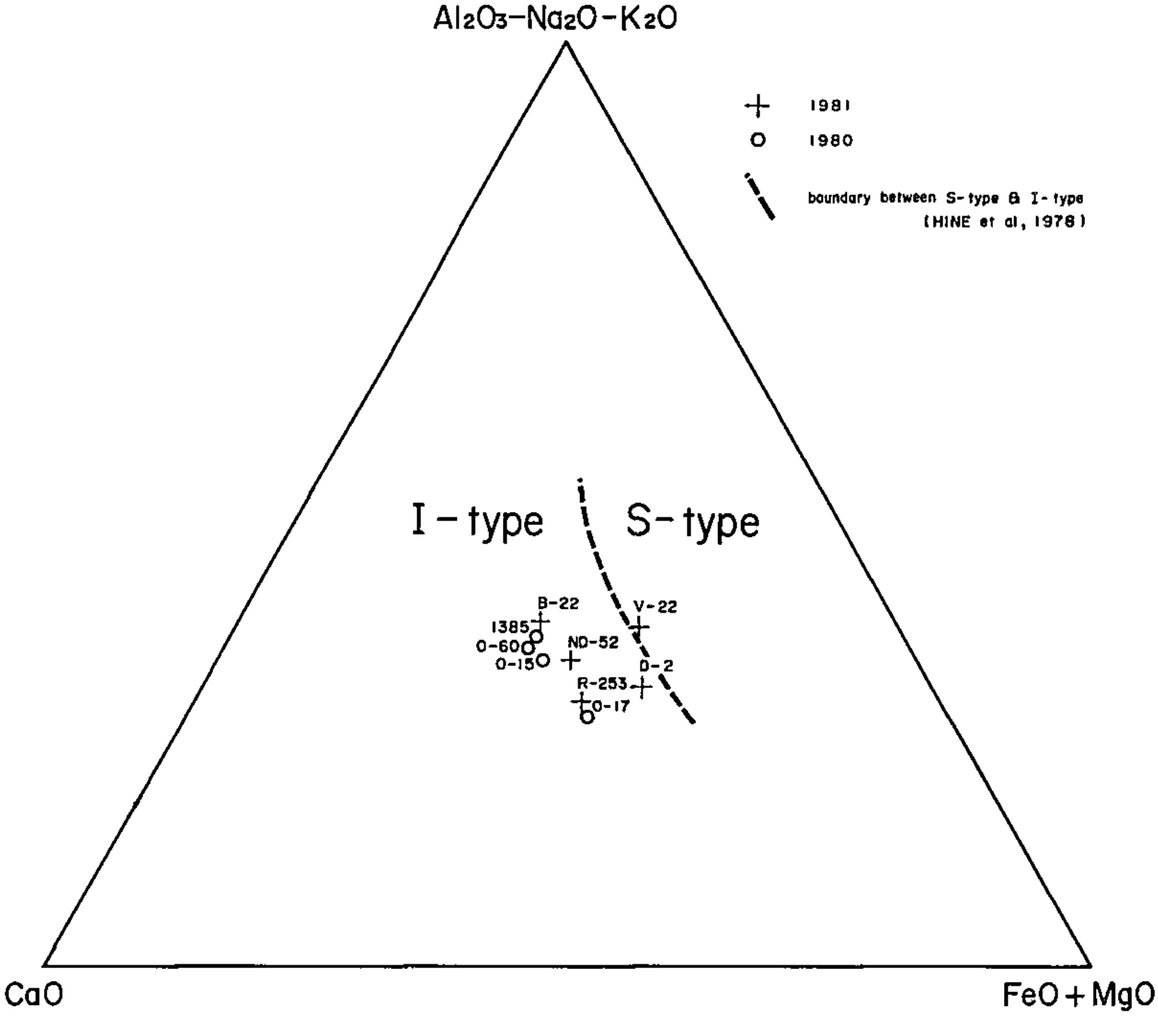


Fig I-4 ACF diagram (molar ratios, $A=Al_2O_3-Na_2O-K_2O$, $C=CaO$, $F=FeO+MgO$) for granitic rocks

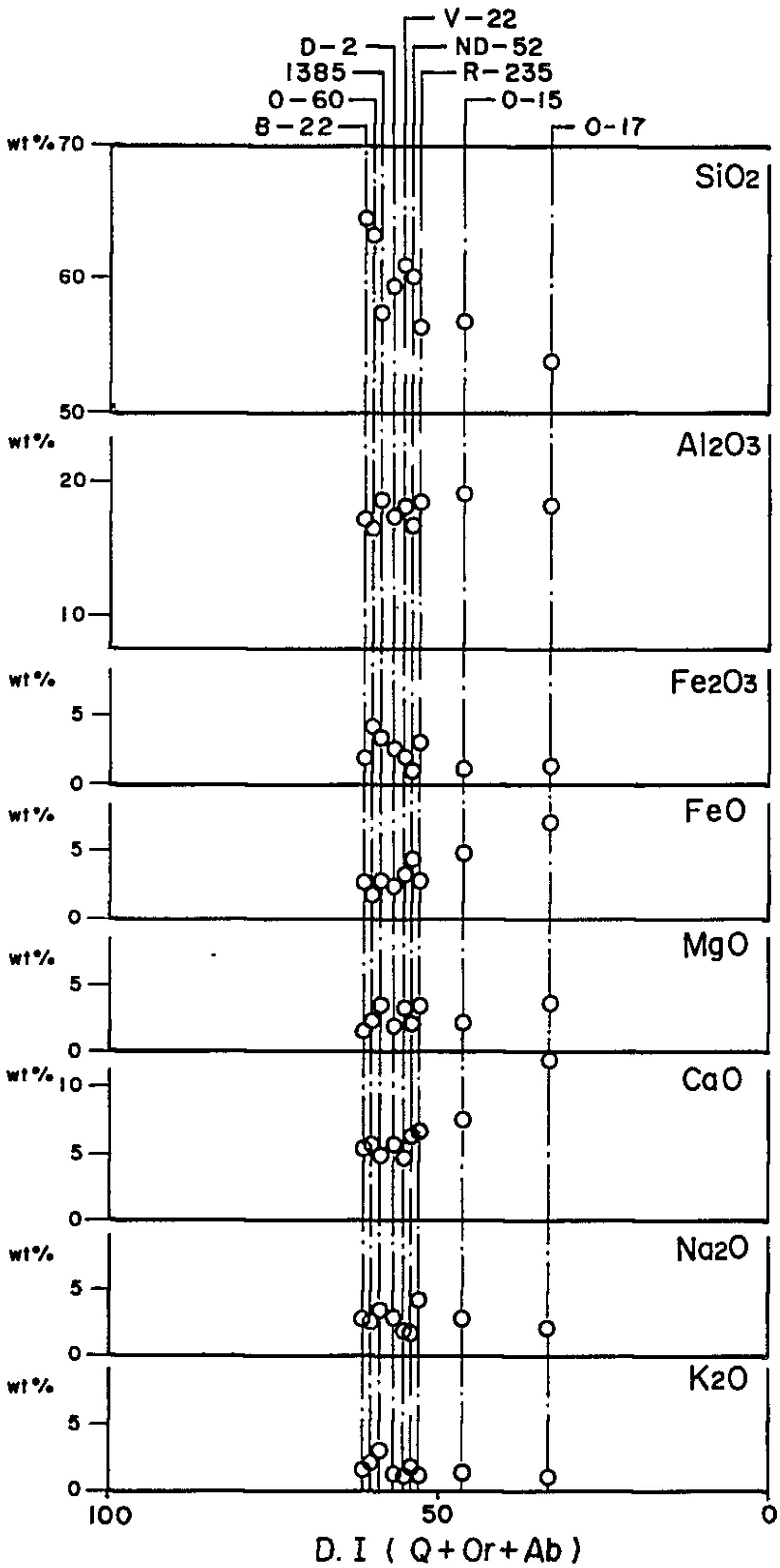


Fig. I − 5 Variation diagram of granitic rocks (Piedrancha area 1980, 1981)

CHAPTER 3. DETAILS OF THE SURVEYED AREA

3-1 Rio Blanco Area

This area is located in north end of the central part of the surveyed area in the first phase, occupying the lower reaches of the Rio Blanco, a blanch of the Rio Telembi.

The area stretches 1 km north, 4 km south, and 4 km west, from the junction of the Rio Telembi and Rio Blanco, forming a nearly rectangular shape with an area of 17 km^2. It includes the Q. Naya, branch river of the Rio Tlembi at north end, and the Q. Chapilal, branch river of the Rio Blanco at south end.

Elevation above sea level reaches from 500 to 1200 m, as our base camp on the right bank of the Rio Blanco was decided to be 600 m.

It is directly 25 km northwest from Guachavez where is the survey base camp. It takes three days on horse back.

It is a jungle over grown with plants, but there scatter a several cultivating farm houses.

3-1-1 Geological Features and Structure

(1) Geology

The geology of this area consists of the Cretaceous sedimentary rocks, considered as Diabasa layer group, and tertiary igneous rocks intruding into the former rocks.

Sedimentary rocks

These rocks are distributed in the basin of the Q. Naya of the northwestern part, the upper reaches of the Q. Dorada of the central north part, and the Rio Blanco of the southwestern part.

The rock facies are silicious tuff, alternative layer of black shale and sandstone, from bottom toward their top.

Siliceous tuff:

This rock is a green compact hard rock with a bedding of 20 - 50 cm in layer thickness. This is alternate layer of fine grain compact layer and crystal tuff (chlorite keeping outward form of amphibole is visible frequently). Generally the rock is altered to chlorite, or replaced by epidote, and pyrite is crystallized in chlorite. It has none or very feeble magnetism, if any.

Under microscope, it presents cataclastic texture (R-242). It can be observed that there are some part where aggregates of fine felsic mineral packs mineral chists such as quartz, plagioclase, amphibole, and calcite of fine grain size of 0.2 mm, and other part where chiefly coarse grain size, 1.5 mm, plagioclase and amphibole, and a small amount of quartz and fragments of andesite are involved.

Black shale: This rock is shaly and black to grey. Locally it forms alternate layer with sandstone, a several to tens of cm in thickness.

In the Q. Dorada, it is produced in the form of roof pendant, with conspicuous lamina of black - brownish white, overall subjected to silicification.

In a branch of Q. Naya, fine calcite vein is developed in irregular directions.

Near the intrusive rock, in the upper stream of the same river, it is subjected to silicification as Q. Dorada area, it is also subjected to chloritization.

Sandstone: This rook is a greyish white tuffaceous sandstone with grain size from medium to fine. In thin alternate layer with slate, weak graded bedding can be observed. In the Q. Naya, in this rock, there exists a porous hard rock including angular pebble of slate of 2 cm in diameter, constituting a key-bed to structural analysis.

Intrusive rocks

Intrusive rocks are micro diorite which extends in major part of the area, and eucocratic granite, diorite and porphyrite in the form of small dike.

Micro diorite: This rock is massive, green to light greyish green, consisting of granodiorite to diorite.

Larger part of this rock is composed by fine grain size rock, 2 mm of smaller in radius, but in the upper stream of the Rio Blanco, a little toward the west from the central part of distribution, a concentric circular structure due to grain in which medium (grain) size part of about 3 mm is surrounding coarse grain holocrystalline part as the center, can be observed. The main constituent minerals of this rock are amphibole, plagioclase, and quartz, and frequently it contains a large amount of magnetite.

Under microscope (R-253), the main elements are amphibole, and plagioclase of equigranular, 0.2 to 0.3 mm, accompanied with a small amount of potash feldspar and quartz, and as sub-constituent mineral, titanite, and cloudy minerals, scattered.

Amphibole is anhedral, feebly subjected to chloritization and epidotization. In plagioclase, zonal structure and twin is developed, and is entirely contaminated.

According to the radiometric age determination, this rock is estimated at 57.1 x 10^6 years, the Eocene epoch.

Leucocratic granite dyke: This appears as a dyke of 5 m in breadth in the Q. Liza, east part of the area.

Diorite dykes: These dykes appear in NW-SE, NE-SW, and E-W directions in the Q. Naya, upper stream of the Rio Blanco and Q. Chapilal etc. This is characterised in having phenocrysts, 5 to 7 mm in size, of amphibale.

Correlation between rocks

Fine grain diorites are distributed across strike and dip of the sedimentary rocks. It is observed that the dip of black shale and sandstone layer, distributed in the basin of the Q. Naya, is disturbed to be sharp high angle dip near the micro diorite. Dykes cross the sedimentary rocks and micro diorite.

(2) Geological structure

General strike and dip of the sedimentary rocks are approximately E-W, 10°N in the Q. Naya. The alternate layer of sandstone and shale, slightly exposed in the micro diorite area in the Q. Dorada valley, runs N40° - 70°E with high angle dip, but on the north boundary strikes N85°E, and dips 85°S. On the left bank of the upper stream of the Rio Blanco strike and dip of silicious tuff are N25 - 30°E, and 40° to 50°NW. The grain size of the micro diorite varies from coarse in the center to fine in the outer side. Overall this diorite forms a boss shaped structure, about 5 km in diameter.

Strikes of dykes are mainly two directions, that is to say, NE to SW, and NW to SE; it is to be noted that one of them is parallel to, and the other is perpendicular to, the direction of the micro diorite outward form. As the lineation system of this area, three directions; (1) NE-SW to ENE-WSW, (2) NNW-SSE to NW-SE, and (3) N-S, are conspicuous. (1) is a structural line passing through from the Rio

Blanco to Q. Dorada, the mineralized zone direction in the upper stream of the Q. Chapilal, (2) is a fault directing from the Q. Naya to Q. Dorada, a fault separating the sedimentary rocks and micro diorite, in the upper stream of the Rio Blanco. (3) is recognized as the stream direction in the middle stream of the Rio Blanco. The micro diorite, forming a boss shape shows two protruded part in the (2) direction in the north part and the (3) direction in the west part. The above lineation is considered to limit partly intruding direction of the intrusive rock, too.

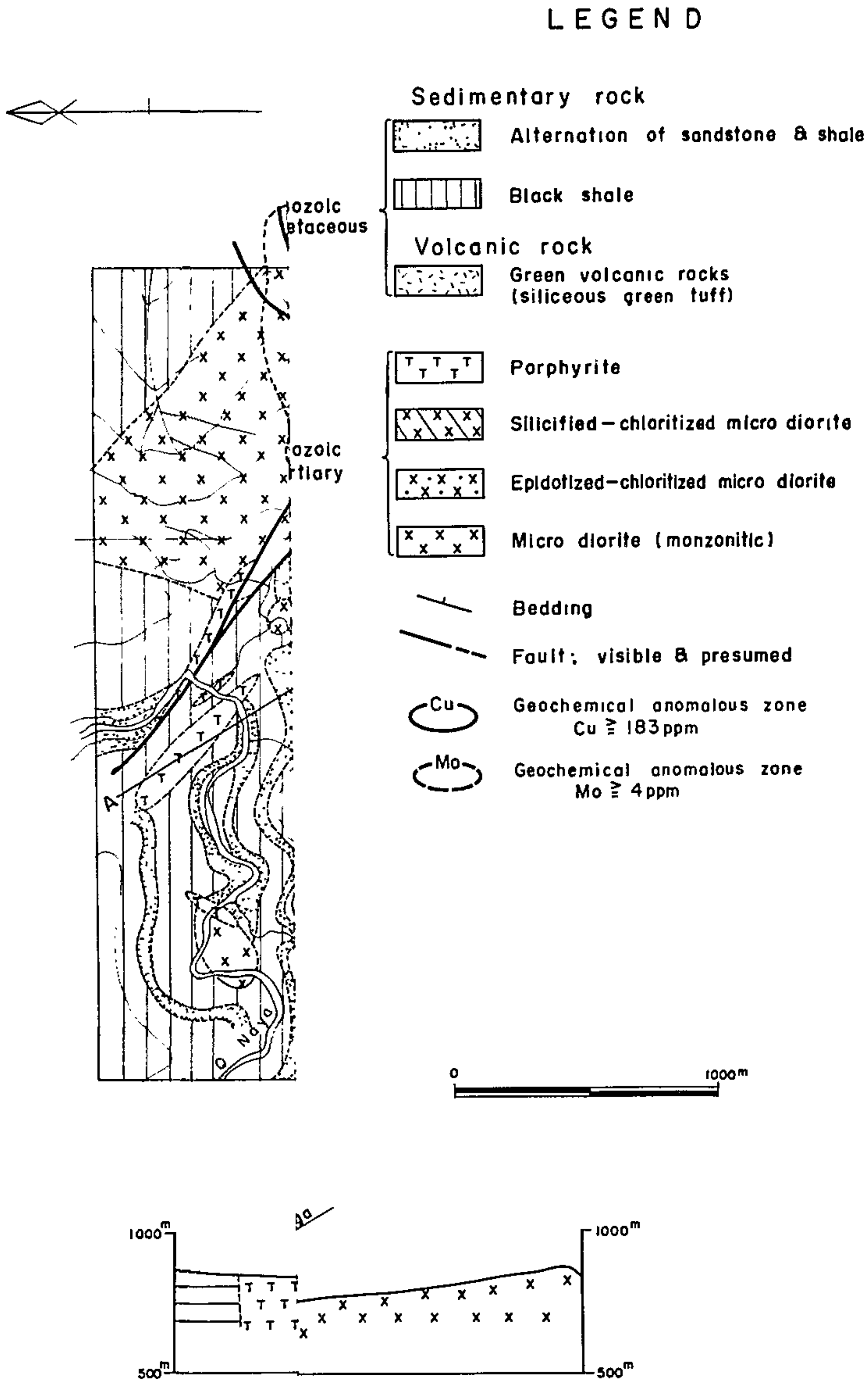
3-1-2 The Results of Geochemical Survey

The geochemical survey in this area was intended for the survey of porphyry copper deposit. Copper and molybdenum (hereinafter referred to as Cu and Mo) were selected as indicative elements, and soil samples were taken along the ridge.

The number of chemical analysis is 675 pieces. Results of chemical analysis are shown in the table of A.I-1 in the end of this volume. For statistical treatment, common logarithms of analysed value is used and the entire area was calculated as one group. Results of interpretation analysis are as follows, referring to Fig. I-6 and Table I-4.

Regarding to accumulative curve, Cu's line is approximately linear, but Mo's curve has two bending points, showing the existence of two populations. The distribution forms of both Cu and Mo is a negative skewness, slightly distorted on the right hand. As to kurtosis, Cu is nearly a normal form, but Mo is rather large.

The correlation between Cu and Mo is weakly positive. The analysis results of Cu and Mo are as follows:


LEGEND
Sedimentary rock
Alternation of sandstone & shale
Black shale
Volcanic rock
Green volcanic rocks
(siliceous green tuff)
Porphyrite
Silicified – chloritized micro diorite
Epidotized – chloritized micro diorite
Micro diorite (monzonitic)
Bedding
Fault; visible & presumed
Cu
Geochemical anomalous zone
Cu ≧ 183 ppm
Mo
Geochemical anomalous zone
Mo ≧ 4 ppm
ozoic
etaceous
ozoic
rtiary
A
0
1000m
1000m
1000m
500m
500m

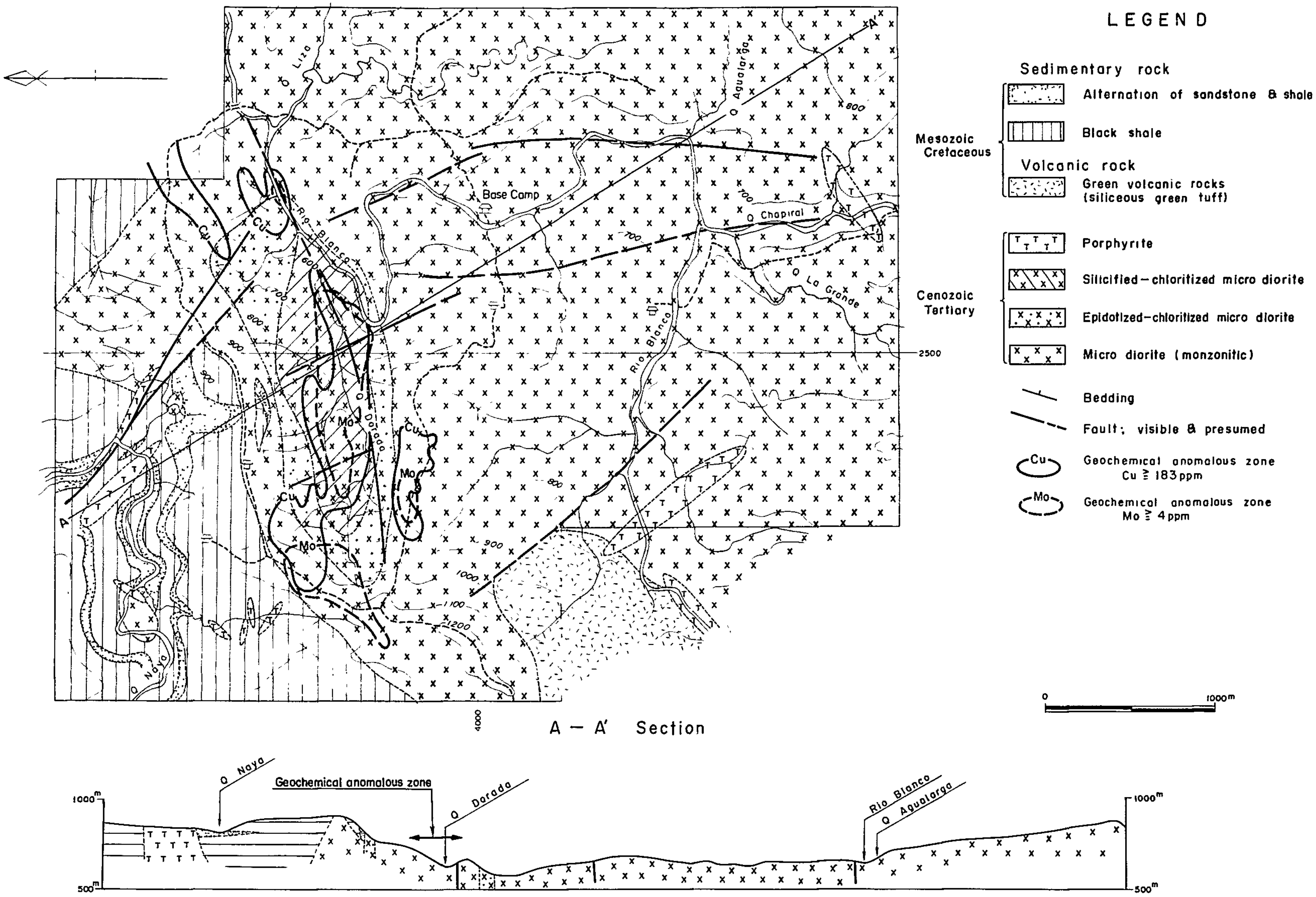


Fig. I-12 Compiled map of Rio Blanco area

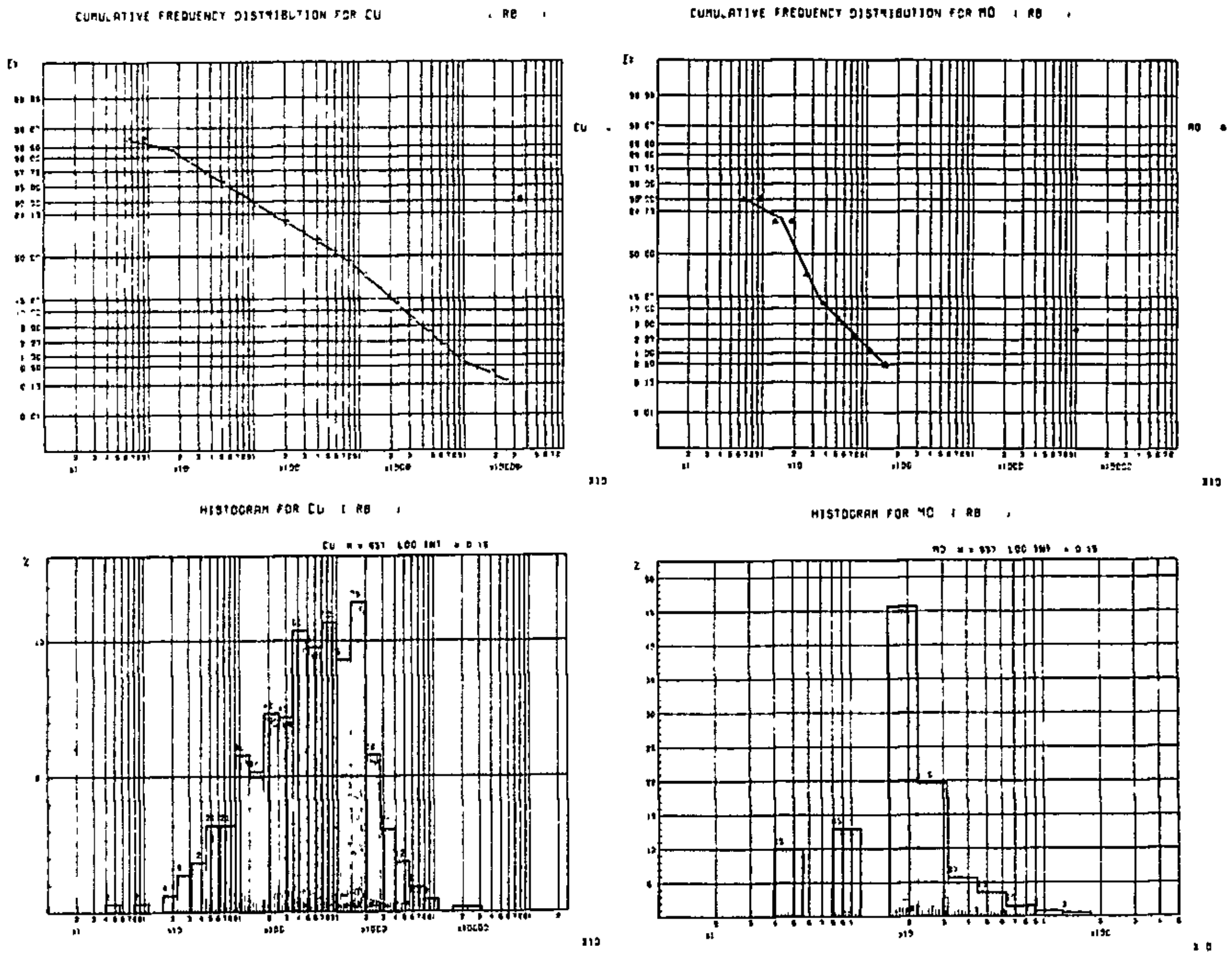


Fig. I-6 Statistic Analysis of Geochemical Data (Cu, Mo), Rio Blanco

Table I-4 Statistic Analysis of Soil Samples (Cu, Mo), Rio Blanco

Area	Element	b	b+S	b+2S	Skew	Kurtosis	Number of Samples	Correlation Coefficient
Rio Blanco	Cu	49.5	182.8	674.5	-0.400	0.013	657	-0.128 (Cu, Mo)
	Mo	1.9	3.7	6.9	-0.403	0.554	657	

b: mean background value, ppm

s: standard deviation, ppm

b+2S: threshold value, ppm

Cu : range - max. 2501 ppm, min. <1 ppm;

mean value - 49.5 ppm

Mo : range - max. 14 ppm, min. <1 ppm;

mean value - 1.9 ppm

For each element, mean value plus standard deviation, and mean value plus two times standard deviation were regarded respectively as weak anomalous value and strong anomalous value. The locations where anomalous values are concentrated were extracted as anomalous zone.

Cu has fine anomalous zones, from (I) through (V). Mo has three anomalous zones, from (VI) through (VIII). (see PL I-7)

Each anomalous zone is described as below:

Cu anomalous zones

(I) Area around the Dorada valley: It is the largest one in this area, including Mo's anomalous zone (VI) in the interior.
The zone extends ENE to WSW, the same as the valley, with a strong anomalous zone, 400 m x 400 m, including a weak zone, 1900 m x 300 m. In the strong anomalous zone, there exist three high grade parts, 1698, 2501, and 990 ppm, at three continuous sampling points. This zone coincides with the area where diorite is subjected to strong silicification, a joint is developed in an unit, and subjected to strong chalcopyrite mineralization, according to geological survey.

(II) A branch stream of the Dorada valley left bank: This is located at 500 to 800 m northeast of (I). There are two anomalous zones which size is about 700 m by 100 m, and 400 m by 150 m respectively, and are considered to be an externally extended part.

(III) A watershed limited south part of the Dorada valley: This zone forms a southern external extending zone of (I) as in the case of

(II). This is a weak anomalous zone divided into three or four zones. The size of the largest anomalous zone is about 600 m by 150 m.

(IV) A ridge of the right bank in the middle stream of the Rio Blanco: This is a area in which distribute scattering various weak anomalous zones, and their sizes and anomalous values are small.

(V) The right bank of the Rio Blanco upper stream: A weak anomalous zone, smaller than (IV).

Mo anomalous zones

(VI) Area around the Dorada valley: As in the case of Cu, this is the largest anomalous zone in this area. A weak anomalous zone spreads 1000 m by 250 m including a strong anomalous zone, 500 m by 200 m.

(VII) West ridge of the Dorada valley: This is a weak anomalous zone, about 700 m by 200 m, distributed over a ridge, 500 m west of (VI). This is considered to be an anomalous zone forming externally extended part of (I) and (VI).

(VIII) A ridge of the left bank of the middle stream of the Rio Blanco: This is a scattered weak anomalous zone with a size of about 200 m by 100 m.

Examining the above anomalous zones, the anomalous zones to be picked up in this area are an area around the Dorada valley, mainly consisting of (I) and (VI), including (II), (III) and (VII). The rest zones are not so important.

3-1-3 Mineralization

Mineralization observed in this area is that of pyrite disseminated along the joint or into the micro diorite, locally accompanied with a small amount of chalcopyrite and chalcocite. Magnetite can be considerably observed in the form of vein or dissemination into diorite. A main mineralized zone of this area is around the basin of the Dorada stream, but generally mineralization of pyrite filling the joints of diorite, can be observed throughout the area except the basin of the Naya valley, in the northern part. In the upper basin of the Chapilal river, two or three traces of small scale level prospecting, pursuing oxides along fissure, were found.

(1) Around the basin of the Dorada valley: This area, considered to have been developed along fault in ENE to WSW direction, forms a valley, deeply carved in the same directions as the above.

The basin is limited by a main ridge directing from north to south in the western part, and two paralel ridges extending to ENE ramified from it. Relative heights to the main stream of a branch ridge on the north side and a branch ridge on the south side are respectively more than 250 m and more than 200 m, a little lower than the former. The distance between the north and south branch ridges is about 1000 m, and the straight distance between the main ridge and the junction of the stream to the main river is 2000 m.

Pyrite mineralized diorite continues as long as 1500 m up the stream from the junction of the main river. Fissures in a several cm unit are developed in this rock, and a film of iron pyrite along the fissures and disseminated pyrite in the rock can be observed. The amount of pyrite reaches 3 to 5%. A small amount of chalcopyrite also coexists with pyrite.

This rock is also subjected to silification and chloritization, so that colored mineral can be only assumed to have been amphibole or pyroxene from its outward form. As secondary minerals, sometimes small crystals of chalcocite and/or magnetite can be seen.

Assay values of samples taken from out-crops from this valley is as follows:

Sample No.	Sample length m	Analysis value Cu %	Au g/t
R-206	10	0.04	tr
R-210	3	0.07	tr
R-213	10	0.25	tr
R-214	20	0.07	tr

The above-mentioned silicified and chloritized zones also apread in many branch stream ramified from the Dorada stream, as a whole, forming an oval form, 1700 m in major axis and 500 mm in minor axis, extending in the direction of ENE and WSW. This altered zone extends further 400 m northeastward from the junction of the river. In the outside of this silicified and chloritized zone, diorite becomes in which colored minerals can be clearly discriminated, forming a altered zone characterized in epidotization in the form of veinlet or spott. Fissures in the mother rocks grow up to tens of cm in space unit, reducing mineralization of pyrite a little.
This mineralized zone shows a metamorphism of "Porphyry Copper" type deposit which presents a zoning alteration of silicification and chloritization in the central part, epidote and chloritization in the externally extending part, around fissures directing ENE-WSW.

(2) The upper reaches of the chapilal river: There is a trace of prospecting gold in old times. It seems that people pursued oxides in diorite. It is a mineral indication of fissure filling type, extending NE and SW, showing only a country rock subjected to altered

into clay

After digging 1 to 2 m deep from an outcrop of the river bank, people left the place as it was.

3-1-4 Discussion

(1) Geology and mineralization

In the mineralized zone in the area of the Dorada valley, the largest mineral showing is located at:

(i) the north periphery of micro diorite, and

(ii) a meeting point of lineation of ENE-SWS and NNW-SSE systems.

Two conditions as above are favorable to produce many fissures in micro diorite. The mineralization extends ovally through ENE-SWS fissure, a main passage, forming ovally Dorada pyritized zone accompanied with a small amount of chalcopyrite.

Copper contents of four samples of the river bank outcrop are 0.25 to 0.04%, that is relatively low grade.

Alteration of the country rock shows an zoning structure of silicified-chloritized zone, and epidotized-chloritized zone, around the main passage.

The most intensely mineralized part of pyrite approximately concurs with the silicified-chloritized zone.

(2) Geochemical survey results and mineralization

According to geochemical survey for the anomalous zone, the most intense and largest anomalous zone is formed in the basin of the Dorada valley, presenting well coincident with the pyritization zone.

(3) From the above description, it is clear that the basin of Dorada valley has the mineral indication of "Porphyry Copper" type deposit; moreover, alteration and pyritized zone widely spreads, so that this

area can be considered to be one of the areas to be prospected.

3-2 La Verde Area

The surveyed area is located at about 27 km northwest of Samaniego, and it occupies the lower basin of the La Verde river, a branch of the Rio Cristal.

The dimensions of the area are 2 km north and south, 1 km east and west, with La Verde at west end, and the Sergia river at south end, with an area of 2 km^2.

The height above the sea level in the area, varies from 450 to 770 m, by taking the junction of the La Verde and the branch stream as the reference point, to be 500 m high above the sea level.

A means of traffic to the surveyed areas is 2 day horse back from Terminal, one end a half hour car drive from Samaniego, through Decio, Buena Vista, and Bretaña.

3-2-1 Geological Features and Structure

(1) Geological features

The geology of this area, just like Rio Blanco, consists of sedimentary rocks and basalt lava of the Diabasa group and intrusive diorite.

Basalt lava

This rock is distributed in the southwestern part of the surveyed area. This is a dolertic basalt lava, 150 m + in layer thickness, dark-green to black; pillow structure and autobrecciated structure, and flow structures are often observed. This is subjected to chloritization, and some of it appears like a sandstone by weathering.

Under microscope (V-1), it presents doleritic texture, main constituent minerals are ordinary pyroxene, 0.3 to 4.0 mm, and plagioclase, 0.1

to 1.0 mm. Pyroxene presents pseudomorph replaced by chlorite and clay mineral.

Sedimentary rocks

These rocks are widely distributed in the east half part of the surveyed area. The layer thickness is 450 m +. Rock facies consist of black shale, and light grey to violet grey, fine to medium grained sandstone. Black shale is predominantly distributed, and in the geological map, "sandstone layer" is presented to represent an thin alternate layer of sandstone and black shale, and included sandstone predominant layer also. Fine exfaliation are developed approximately parallel to bedding plane in black shale. Sandstone is calcareous, boudinage structure is often observed in it. Thickness of the alternate layer of black shale and sandstone is small, a several to tens of cm in unit.

Diorite

The distribution of this rock shows that it extends north and south, 100 m at the sourthern part and 700 m or more at the northern part in breadth.

This rock is grey to green, 10 to 20 color index, with many fissures. This consists of mainly amphibole and plagioclase, but amphibole is almost entirely altered into chlorite, only remaining its crystal outward shape grain size of colored mineral is fine, 1 to 2 mm.

Near a contact parts of this rock and basalt, a porphyritic texture accompanied with phenocryst of plagioclase, 4 mm in length, can be observed.

Under microscope (V-22), this present feeble porphyritic texture, and phenocryst plagioclase was observed to be subjected to potash feldspathization, chloritization, and sericitization.

Geological structure

Spherulitic part of pillow structure, observed in basalt lava, shows apparent strike and dip, like as N10-23°W · 35°NE. The general structure of sedimentary rocks is homoclinal structure with strike and dip, N30-50°E · 50-70°E.

According to the previous survey, basalt takes lower layer and sedimentary rocks take upper layer. Diorite extends approximately in N-S direction across the strike and dip of sedimentary rocks. Around contact part of both rocks, they are subjected to mylonitization.

Four fault systems, NE-SW, NW-SE, N-S, and E-W, are developed. Especially the combination of both NE-SW and NW-SE fault systems limit rock body of diorite extending N-S. E-W fault system is developed in the area of sedimentary rocks.

A model of geological structure development history of this area is shown in Fig. I-7.

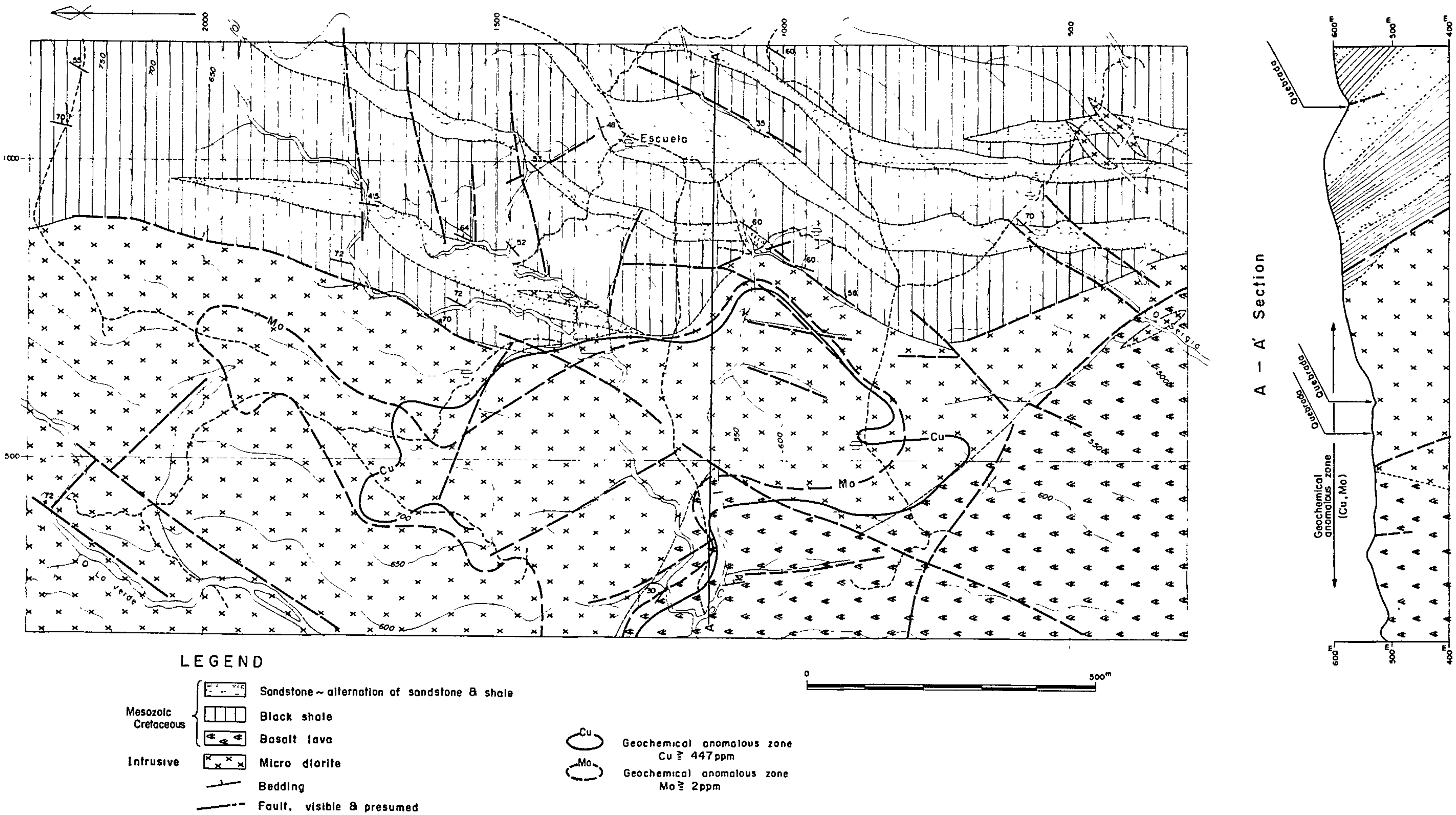


Fig. I-13 Compiled map of La Verde area

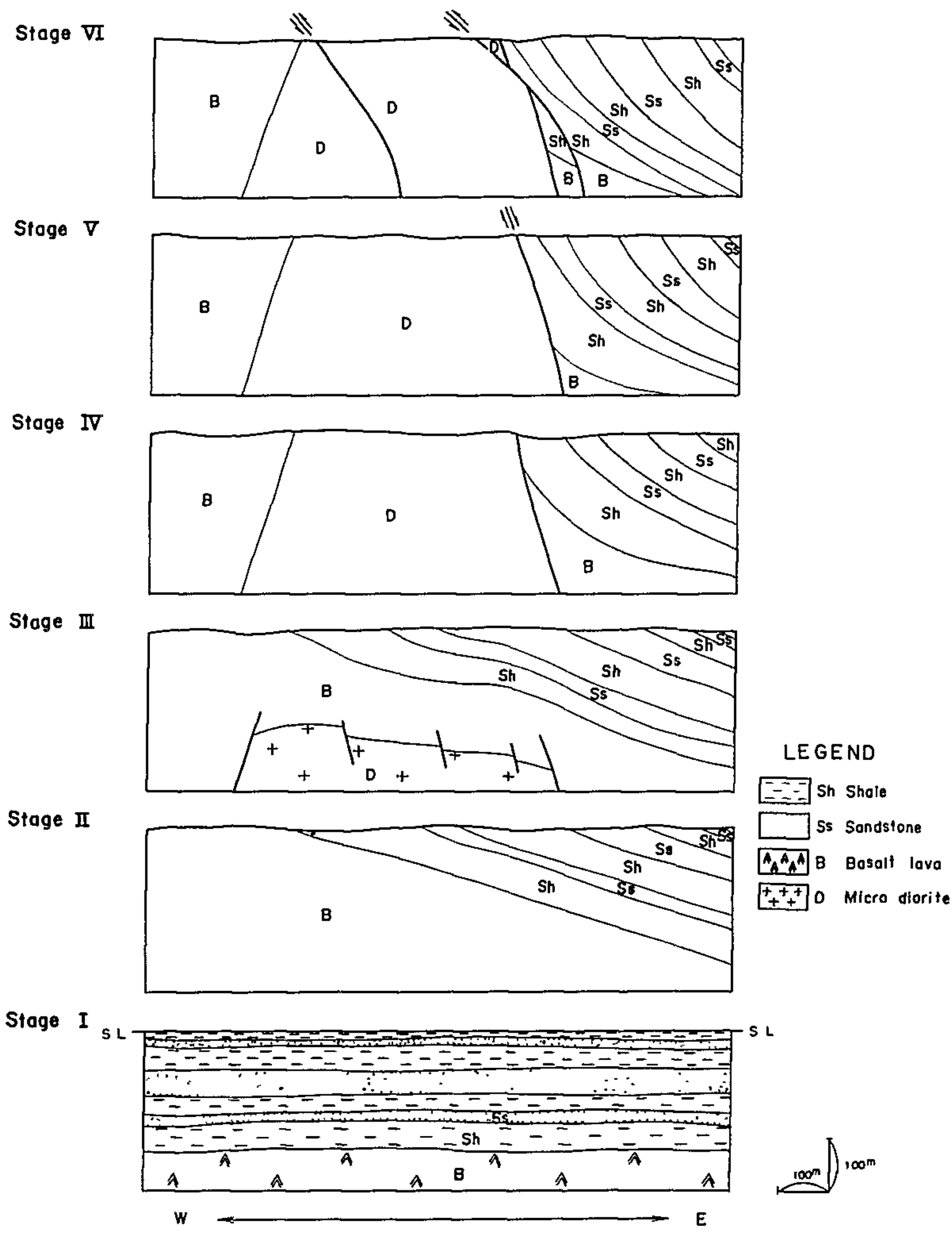


Fig. I-7 Profile showing tectonic history in La Verde area

3-2-2 The Results of Geochemical Survey

The results of soil analysis of this area is shown in A. I-1. Analyzed elements are Cu and Mo, as Rio Blanco area. Number of samples is 122 pieces. Statistical treatment of these samples by computer is carried out as one group. (see Table I-5, and Fig. I-8).

In Cu's accumulation curve, three bending points are observed, which suggests existence of three populations. This seems to reflect three constituent rock facies of this area, dicrite, basalt and sedimentary rocks. Mo's accumulation curve bends toward negative side, which shows that analyzed values are biased on the low value side of the population.

Distribution form of Cu is slightly distorted toward right with normal kurtosis, on the other hand, Mo is distorted toward left with kurtosis of round at the top.

The analyzed values of Cu and Mo are as follows:

Cu : range - max. 997 ppm and min. 17 ppm,
mean value - 204.2 ppm

Mo : range - max. 7 ppm, and min. 0.5 ppm,
mean value - 0.9 ppm.

For each element, an anomalous zone was extracted by taking mean value plus standard diviation, and mean value plus two times standard deviation, as weak anomalous value and strong anomalous value, respectively.

Correlation coefficient of Cu to Mo is 0.538, possitive correlation can be recognized.

Extraction of anomalous zones

The anomalous zone of this area can be collected in one region. This is a weak anomalous zone of Cu and Mo including a several points of strong

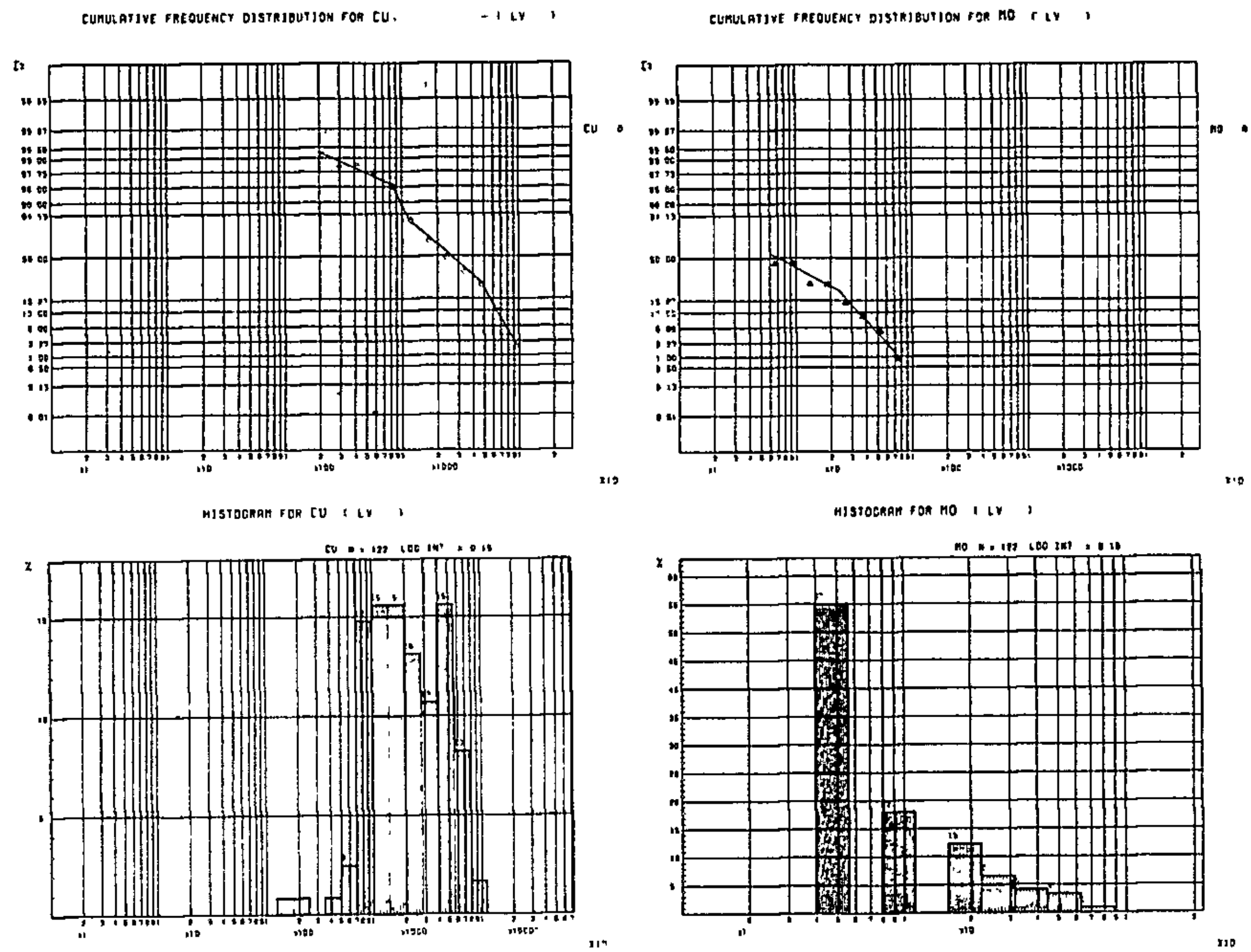


Fig. I-8 Statistic Analysis of Geochemical Data (Cu, Mo), La Verde

Table I-5 Statistic Analysis of Soil Samples (Cu, Mo), La Verde

Area	Element	b	b+S	b+2S	Skew	Kurtosis	Number of Samples	Correlation Coefficient
La Verde	Cu	204.2	446.7	977.2	-0.293	-0.006	122	0.538 (Cu, Mo)
	Mo	0.9	2.0	4.3	0.969	-0.381	122	

b: mean background value, ppm

s: standard deviation, ppm

b+2S: threshold value, ppm

anomalous value, clearly harmonizing with diorite distribution. The spread of the anomalous zone is approximately NS by EW, 800 m by 300 m for Cu, 1200 m by 300 m for Mo.

This zone is not closed in the west part, but has the possibility of farther spreading together with extension of diorite. (see PL I-8)

3-2-3 Mineralization

Mineralization observed in this area are as follows:
(1) pyrite, a small amount of chalcopyrite and malachite, filling checkered fine veinlet fissures in diorite, (2) pyrite - chalcopyrite - clay, in fissure vein type, and (3) placer gold. Mineralization of (2) and (3) are on a small scale. (1) is exposed in two branch streams of the central part of this area. Its country rock is diorite subjected to chloritization, and altered to clay. In this mineralized diorite and its intruded basalt lava, white quartz-zeolite can be observed in veinlets and reticular.

Mineralized zone spreads about 300 m east and west, and 300 m + north and south. Joints and small fissures of NE, NW and E-W systems are developed, with pyrite filling fissures and disseminating into the country rock. Five to six veins, 2 to 10 mm in breadth, of chalcopyrite - malachite - pyrite - quartz vein of NE-SW to ENE-WSW systems are observed between 3 m in an outcrop in a stream, to the south of a school, in which rock including copper mineral is seen.

The analysis results of chip samples of the outcrop are as follows:

Sample No.	Sample length m	Analysis value Cu %	Au g/t
V-13	20	0.07	tr
V-18	30	0.05	tr
V-21	20	0.13	tr
V-55	3	0.00	tr
V-58	3	0.03	tr
V-60	3	0.05	tr

On the other hand, the following analysis values were obtained in the first year in the same area:

			Cu %	Mo ppm
1013-2	(50 m down the stream from V021)	3 m	0.27	9
1357	(middle point between V-13 and V-21)	3	0.29	60
1362	(40 m up the stream from V-60)	3	0.16	5

From the above analysis values, it can be assumed that the part with copper content of 0.1% or more is biased to the eastern half of diorite.

(2) On the right bank of the La Verde river, north end of the survey area, a clay vein, 0.7 to 0.8 m in vein breadth, including of pyrite and chalcopyrite, strike and dip of N36°E · 72°E is observed. The country rock is diorite subject to intense chloritization and epidotization.

(3) There is a place where villagers gather placer gold, near a ridge directing east and west, between both branches of the Sergia and La Verde rivers. This place is in a dry stream in the south slope, 40 to 50 m down

from the ridge. No outcrop rocks can be seen. Two or three grains of gold has been found by panning.

3-2-4 Discussion

Geology and mineralization

Main mineralization of this area is that of pyrite - a small amount of chalcopyrite filling fine fissure vein. This mineralization is limited only in a region where diorite is distributed. High content copper part has a tendency to be biased the in eastern half of the rock body. Alteration of the country rock consists of mainly chloritization of colored minerals, and feeble silification and white fine vein group of quartz — zeolite, ranging from the western to nothwestern part of the high copper content part, can be observed.

Under microscope, local potash feldspathization and sericitization of plagioclase are found out.

As to fissure system, joint - fissure is developed in three directions. Though mineralization is rather small in scale and low in intensity, mineral indication is considered to be porphyry copper deposit type.

Mineralization and geochemical anomalous zone

Anomalous zone of geochemical survey has a spread of 300 m east and west, and 800 to 1200 m north and south, including mineralized outcrop, as composite zone of Cu and Mo.

Considering from the aforementioned, the following prospecting is recommended to this area:

(1) Target area: anomalous zone of geochemical survey

(2) Method : Detail systematic geochemical exploration, and geophysical survey by induced polarization method which could detect down to the depth of about 300 m, and magnetmetry. Consecuently, three to four identification borings after obtaining good results of the above investigation works.

3-3 Diamante Area

Diamante Mine is about 4 km to the southwest of Guachavez Town in Santa Cruz Municipality and is located on the right bank of Diamante Valley the most upstream of the Telembi River. A number of old pits are distributed in the range from 2,500 m to 2,700 m in altitude, and six of these old pits were reopened and several workers in each mine are presently working by hand mining as a result of rise of prices of gold and silver in recent years.

This area has very steep terrain with slope occasionally exceeding 30 degrees since it is located near the ridge line of mountain range of the Cordillera Occidental. Though this area is near to the equator, temperature is 10° to 20°C because of its altitude and thus is mild for the living. However, frequent rainfalls occur in April and May and October through December, resulting in considerably damp air. Upstream area has lower temperature with dwarf bamboos and low shrubs, but many trees about 15 m high grow densely in the downstream area, thus forming a tropical forest in this area.

There is no motorway in this area and thus people has to walk or ride on a horse (about 3 hours) from the Guachavez Town, however, a motorway half-built about 30 years ago still remains and the road construction work may be relatively easily performed now if this is properly utilized.

During the first phase of the survey in this area, reconnaissance survey was conducted for the inside and outside of mines in the place mainly around Diamante lode where the old pits are the most densely located. During this survey, 13 specimens for ore analysis were sampled, analyzed, and reviewed. As a result, it was found out that auriferous and argentiferous grades were relatively high, small amounts of zinc, copper and lead were also accompanied, and the scale of mineral vein was large and reached to even several hundred meters in extension and several meters in width, from which it was evaluated that additional survey would be very worthwhile.

As a result, the following survey was planned and carried out as the survey work for this second phase:

(1) Drilling of seven drill holes with a total extension of 757.2 m for Diamante principal vein.

(2) Detailed geologic survey and geochemical soil survey for an area of 4.5 km^2 around the principal vein.

As a result of drilling work, four out of seven drill holes intersected gold and zinc mineral veins and, from the geologic survey and geochemical survey on the ground surface, not only the structure of principal vein but also the presence of Marina mineralized zone almost in parallel to the principal vein have been clarified. In addition, through the microscopic study and X-ray analysis and test, mineral compositions and paragenesis have become clear.

The survey routes along valleys, rivers, mountain roads and ridges were established to cover the whole survey area with grid lines spaced at about 250 m approximately, and the terrain was mapped to describe the geology by using transit compass and measuring tape. In the geochemical survey, sampling lines with NE-SW strike intersecting with general strike of vein of NW-SE were established on the ridge lines spaced almost at 500 m, soil sampling was performed every 50 m on these lines and 80 samples in total were collected. Also, the survey area was increased by 30% because an exposure of granodiorite was found outside of and in the south of the survey area and because of surveying of the half-completed motorway.

The detail of drilling work and geology and mineralization of each drill hole are described in Part II, the results of geologic survey and geochemical survey will be reported hereinafter, and an overall assessment not only on these results but also on the results of drilling will be described in Paragraph 3-3-4.

3-3-1 Geological Features and Structure

Though the exposure of river bed and both banks is relatively good because of steep terrain, the geology in this area is generally monotonous, and is represented by the distribution of agglomeratic tuff breccia and lack of variation with location. The appearance of this rock is of greenish and massive type, its internal breccia is of quasi-circular or circular, with diameters ranging from 5 to 20 cm are irregularly distributed, and stratification is not seen on this rock. Also, small pebbles with size of about 3 to 10 mm are also seen in the matrix. Short prismatic, dark-greenish minerals about 2 to 4 mm long subjected to the alteration to the chlorite or epidote, and the plagioclase 2 to 3 mm long whose color was turned to the white after subjected to the alteration to the calcite or sercite were observed in the form of phenocrysts in both the matrix and pebble portion. Also, it was observed under microscope that euhedral or subhedral crystals of plagioclase was subjected to sericitization, silicification, chloritization, and calcitization and that colored minerals originally assumed to be monoclinic pyroxene were replaced with tremolite, sericite, calcite, and chlorite. Also, spherulitic texture was seen relatively often, and the filled spherulite with chlorite, calcite and sericite was observed. The presence of tremolite was confirmed by the X-ray diffraction of specimens sampled from the boring cores. This rock body corresponds to "green volcanic rocks" found in the regional survey conducted in the first phase survey, and green volcanic rocks regionally consists of basic pyroclastic rocks, and sheets and dykes of the same kind, but no dyke was recognized in this area.

There is a half-completed motorway abandoned about 30 years ago at the southern edge of this survey area and, at its southeastern part, there is an exposure of granodiorite extending in the north-south direction with a width of about 300 m. This is a small stock-like dyke about 500 m long extending in the north-south direction, which was found to be formed about 40.5 million years ago from the results of age determination analysis and to be the intrusive rock of Eocene epoch which was earlier than that of granitic rocks of Canellera and Ramos surveyed in previous year. Its lithology is equigranular medium grained (3 to 4 mm) rock containing mainly of biotite, amphibole, quartz, and plagioclase, and it was found out under microscope that the colored minerals existing at a ratio of 10% to the whole were subjected to chloritization and calcitization and that the plagioclase was subjected to potassic feldspathization and sericitization. This intrusive granodiorite gave weak alteration to the surrounding green volcanic rock, silicification and pyritization, and the alteration faded away about 100 m from the intrusive boundary.

Though the structure of the green volcanic rocks is not clear since the stratification has not been observed, fissures are well developed. Generally, fissures have three trends of N-S, E-W, and NW-SE, and the vein

has the trend of NW-SE. Since the transition of vein due to the N-S trending fault is observed in the Gualquilia Norte tunnel, it is apparent that fissures of NW-SE trending were formed before those of N-S trending. The ore vein is covered by the surface soil and thus the confirmation is not possible, but it is considered that the east side of ore veins in the Diamante-Gualquilia-San Sebastean mines was slightly shifted to the south by the group of N-W trending faults, so that these veins may be considered to be one continuous vein. Also, by assuming a fault passing in the N-S direction along the river to the northwestern extension of the vein, it can be interpreted that the principal vein continues to Hormiga mine and the vein of Auxiliadora mine continues to Hormiga W tunnel.

3-3-2 Results of Geochemical Survey

Mineralized zones such as Diamante principal vein, Marina and Gitana No.1 and Gitana No.2 are present in this area, and sampling lines spaced at an interval of 500 m were established to survey the extensions of these and new veins and, basing upon the information disclosing that old pits were present not only at the left bank but also at the right bank of Diamante valley where these mineralized zones were distributed, sampling lines were programmed near the opposite bank of Auxiliadora mine and on the right bank of Q. Agua Clara in downstream area, and samples were taken same way.

Elements analyzed were two components of zinc and arsenic (Zn, As) widely contained in quantities in the ore veins in this area. The results of analysis are shown in A. I-1 and the results of statistical treatment are shown in Table I-6 and Fig. I-9. Since the number of samples is small and there is no extremely high anomalous value, the distribution does not indicate ordinary normal distribution. Analysed value for Zn was 431 ppm maximum, 29 ppm minimum and 74.5 ppm in average, and analysed value for

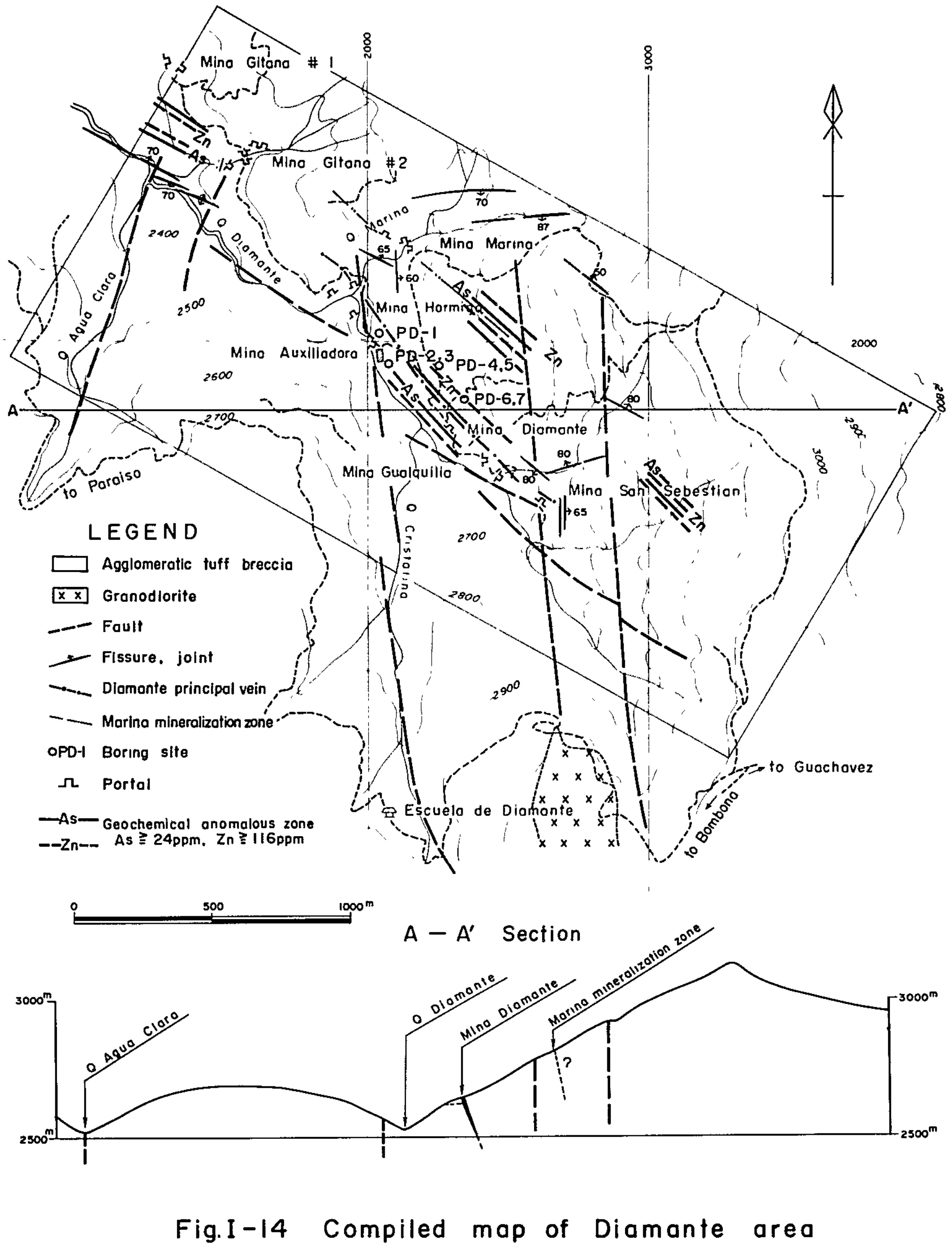


Fig.I-14 Compiled map of Diamante area

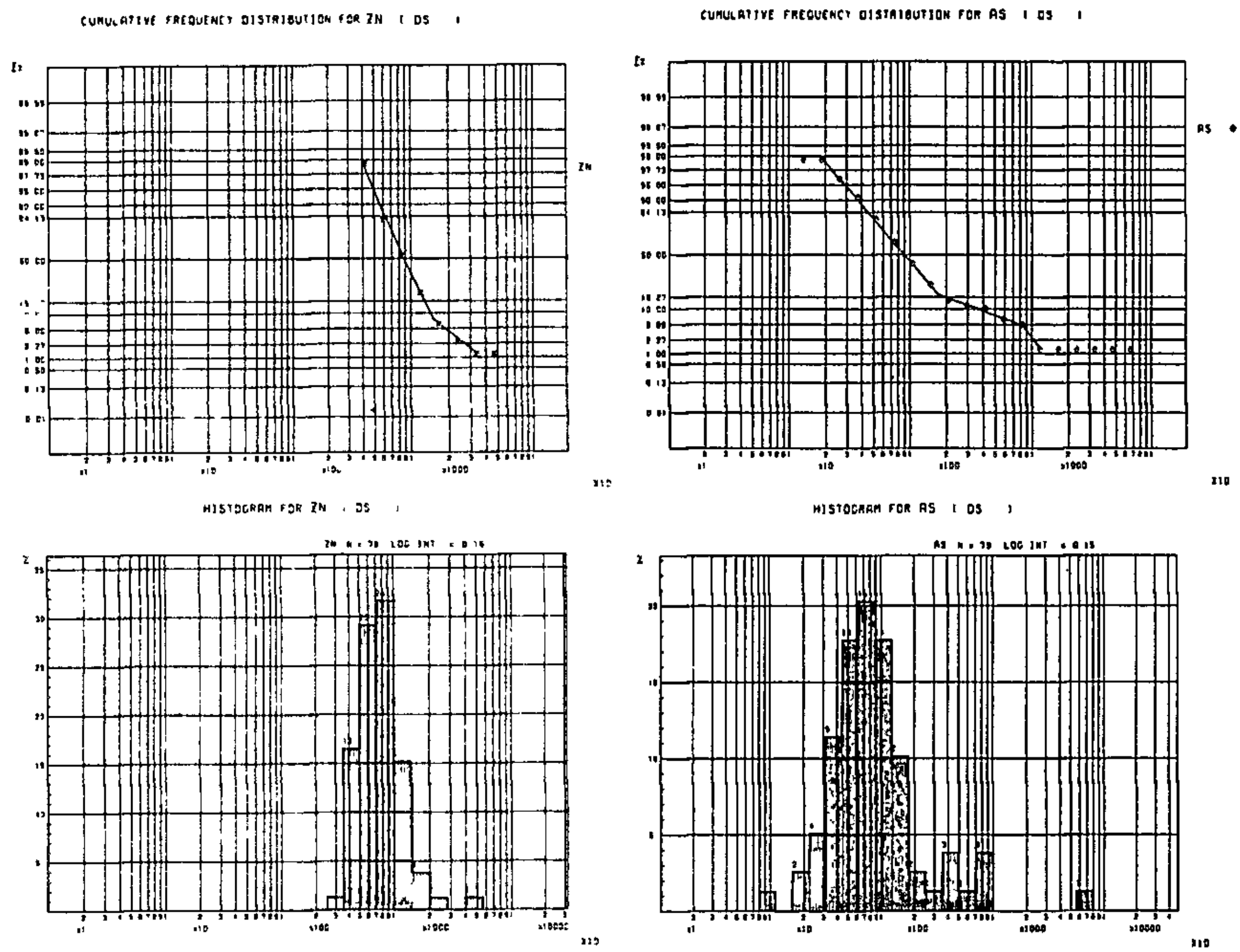


Fig. I-9 Statistic Analysis of Geochemical Data (Zn, As), Diamante

Table I-6 Statistic Analysis of Soil Samples (Zn, As), Diamante

Area	Element	b	b+S	b+2S	Skew	Kurtosis	Number of Samples	Correlation Coefficient
Diamante	Zn	74.5	116.4	182.0	0.941	2.156	80	0.535 (Zn, As)
	As	9.0	24.0	64.4	1.313	3.787	80	

b: mean background value, ppm

s: standard deviation, ppm

b+2S: threshold value, ppm

As was 635 ppm maximum, 1 ppm minimum and 9.0 ppm in average. The correlation coefficient for Zn and As was 0.535 and thus the positive correlation was recognized. In addition, anomalous zones were extracted for each element by using average value plus standard deviation as threshold for weak anomalous zone and also by using average value plus 2 times standard deviation as threshold for the strong anomalous zone.

As a result, the following points were extracted:

Strong anomalous zones:

	Notification on the map
(1) Near the portal of Diamonte mine	Ⓘ
(2) Near a place 500 m in the west of Gitana No.1 mine .	Ⓘⓘ

Weak anomalous zones:

(1) Point 400 m northwest of Diamanter mine	ⒾⒾⒾ
(2) Near a place 400 m north of Gitana No.1 mine	ⒾⓋ
(3) Near a place 800 m northeast of San Sebastean mine .	Ⓥ
(4) Near a place 500 m east of San Sebastean mine	ⓋⒾ
(5) Near a place 300 m east of San Sebasteam mine	ⓋⒾⒾ

Interpretation for the above will be described in Para. 3-3-5.

3-3-3 Mineralization

In the Diamante mine zone, there are several galleries under exploitation in small scale or currently being explored, and geologic survey and collection of analysis samples were performed in these galleries. Location of gallery, gallery plan and location of sampling are shown in PL I-15, and results of analysis are shown in PL I-15 and A. I-2. Also, using the rock and mineral samples, microscopic observation of thin sections and polished sections, determination of minerals by X-ray diffraction, and study on the compositions of minerals and ores by X-ray microanalysis were conducted. Results are respectively shown in Appendices A. I-6, -7, -8 and A. II-19.

Ore deposits in this area are of vein-type, and three mineralized zones of Diamante principal vein zone, Marina mineralized zone, and Gitana mineralized zone are known, former two of which are the NW trending fissure-filling vein-type deposits running almost in parallel to each other with an interval of about 500 m between them.

In Diamante principal vein, there are Hormiga, Hormiga W, Auxiliadora, Diamante, Gualquilia Norte, Gualsuilia Sur and San Sebastean mines ranging from north to south, and people may enter into these mines. In addition, many adits of old mines which may not enter because of collapses are distributed on the upper side of the Diamante mine.

A part of the above-mentioned mines were surveyed during first phase survey, and the geologic conditions in the mine are described hereinafter though the description may be overlapped in some parts.

Hormiga pit:

The vein was followed 20 m long. The vein has strike of N40°W and dip of 65°NE with oxidized portion up to a point of 10 m from the portal. Analysed grade of sulfide ore at deeper portion was found to be 17.0 g/t for Au and 143 g/t per 25 cm of sampling width. However, a rich amount of arsenopyrite was present there and 23% of As was contained.

Hormiga W pit:

The vein consists of clayey oxide ore, 20 to 30 cm of vein width, with strike of N50°W, dip of 50°NE, and 12-m long is followed. The vein is not so significant.

Auxiliadora pit:

Ore body of networks-like impregnation complicatedly mixed with many veinlets mainly with N60°W trending and accompanied with impregnation of pyrite and arsenopyrite. Results of analysis for 120 cm of significantly mineralized portion show 15.7 g/t of Au and 13 g/t of Ag. Also, 3.3 g/t of Au and 90 g/t of Ag were found at the southeastern portion. A small amount of sphalerite is contained. Some portion is bleached and shows a quartz porphyry-like appearance, and the results of microscopic examination show that the country rocks are all agglomeratic tuff breccia subjected to the alteration to silicification and sericitization. Rocks other than tuff breccia were not found even in the vertical drill hole PD-1, 20 m in the north of this pit.

Diamante pit:

This gallery yields the largest output (2 to 3 t/day) in this area and mining is continuously made for a long period of time. The deepest portion of about 20 m long in the gallery which is extending 100 m toward the north from portal, is a wide mineralized zone, where many old pits for mining this high grade portion still remain longitudinally and transversely. The whole area is supported by timbering because of soft rocks and the whole mineralized zone cannot be observed, but the conditions of mineralization can be examined through gallery being used for new mining. (Refer to PL I-15.) There is an exposure about 5 m long on the wall of central portion facing to the north on which sampling was possible as shown in PL I-15. In addition, sampling was possible in gallery facing to the west below this exposure and in winze shaft. Grades of samples are shown below (though Sb was also analysed, its result was omitted since values were almost found to be 0.00%).

(1) North wall:

Sample No.	Width of sampling	Au g/t	Ag g/t	Cu %	Pb %	Zn %	As %
DIA-1	200 cm	2.0	3	0.1	0.0	0.1	0.6
DIA-2	200	7.6	122	0.4	0.1	1.1	1.6
DIA-3	100	25.5	76	0.1	0.2	1.5	6.0
Average	(500)	8.9	65	0.2	0.1	0.9	2.7

(2) Side wall of lower gallery

2-D-10	300	2.4	59	0.1	0.1	0.9	2.9
2-D-11	300	16.3	64	0.1	0.1	1.4	1.1
2-D-12	300	4.6	80	0.1	0.2	1.6	2.6
Average	(900)	7.8	68	0.1	0.1	1.3	2.2

(3) Winze shaft

2-D-2	120	5.3	134	0.6	0.2	3.0	7.4
2-D-3	100	9.3	46	0.3	0.1	2.9	2.2
Average	(220)	7.1	94	0.4	0.2	3.0	5.0

(4) Simple mean of the above grades: {(1) + (2) + (3)} x 1/3

7.9	76	0.2	0.1	1.7	3.3

That is, ore body near the places where the sampling was made seems to have the grade of about 8 g/t for Au, and 75 g/t for Ag. Width of the mineralized zone beings at a place in the west of points of these samplings where the mining was completed and the mineral conditions could not be observed. However, it is said that only the high grade portion was mined there, so the presence of about 10 m of ore zone can be considered there. Its width and grade are very close to the scale and grade (9 m, 9.0 g/t for Au and 59 g/t for Ag) of ore portion found in drill hole PD-6 drilled in this fiscal year. Quality of ore can be generally divided into the following three kinds:

(1) Siliceous sulfide ores:

A large amount of pyrite, arsenopyrite, and sphalerite are contained in the compact quartz veins about 30 to 60 cm wide as seen at the sampled places in DIA-3, and also a small amount of chalcopyrite and gelena were recognized by naked eyes. A large amount of gold is generally contained.

(2) Veinlet-like sulfide impregnated ores:

These are seen in the sampling location in DIA-2. Sulfide ores such as pyrite, arsenopyrite and sphalerite are contained in the form of 0.5 to 2 cm veinlet within the clayey country rocks in the form of irregular network or in parallel to each other. Though the content of gold in each veinlet is high, overall grade is slightly low. In the case of DIA-2, slight regularity of direction is seen, and strike of N60°W and dip of 45-60°NE are recognized. Near the wall at the eastern end of this ore body, slickenside of fault with N40°W and dip of about 80°NE is seen and the structure of end wall at the west side is standing almost vertically; these veinlets with gentle slopes will correspond to the secondary shearing fracture sandwiched by two strong fault fissures.

(3) Massive sulfide ores:

These correspond to DIA-1 and were considerably altered to sulfide ores such as pyrite and marcasite to the degree where the internal structure cannot be recognized. They contain a small amount of gold. Though the silicification is accompanied, sphalerite and chalcopyrite are rarely seen.

Though the causes of difference of mineral quality and scale are still unknown in many respects, it has gradually become much clear from microscopic observation of ores that the mineralization was taken place more than once. This will be explained in later.

Gualquilia Norte pit:

Though the massive ores of pyrite of ore quality class described above are seen near the front of tunnel, continuation of ores are lost by the N-S trending fault. Though the width of vein seems to be large, it cannot be well observed since the vein is visually obstructed by timbering. Its upper portion was being mined during survey by the team.

Gualquilia Sur pit:

The width of vein seems to be about 50 to 80 cm but complete sampling and observation were not possible because old timbering still remained there.

San Sebastean pit:

Siliceous sulfide ores of 30 to 40 cm wide vein are seen at the front facing to the south. They have the strike of N70°W and dip of about 80°NE. Veins are also seen on the roof and are stuck with oozed out green copper ores. Grades found by the analysis are shown below.

Sample No.	Width of sampling	Au g/t	Ag g/t	Cu %	Pb %	Zn %	As %
ND-47	40 cm	4.6	350	0.67	0.40	0.10	2.18
2-D-5	30	7.7	263	Same vein as ND-47, but 2 m westward			

It is significant that this pit has higher contents of silver, copper and lead than those of others.

Though all of the above-mentioned veins are present in the mineralized zone of Diamante principal vein, northern extension of rich mineralized portion in Diamante pit continues to the Hormiga pit, and the vein of relatively small scale in the Auxiliadora pit continues to the Hormiga W pit.

In addition to the galleries stated above, there are also Marina mine about 500 m upstream eastward of Hormiga pit and also Gitana No.1 pit and Gitana No.2 pit northwest of Marina mine newly being explored since 1981 in this area.

Marina mine:

This is located about 1 km NNE of Auxiliadora pit and its altitude is 2570 m. One vein is distributed on the left bank and three veins on the right bank of Q. Marina. Water wheel stamping shed is located there for small-scale exploitation. Vein at the left bank was developed to the scale of 20 m at an level of 2570 m, and oxidized vein about 60 to 80 cm wide is present up to a length of 10 m and then sulfide ore with a narrower width is present beyond the oxidized vein. The results of analysis of the first phase survey are shown below.

Sample No.	Width of sampling	Au g/t	Ag g/t	Cu %	Pb %	Zn %	As %
D-02	25 cm	17.0	143	0.31	0.19	1.30	23.0

There are two or three portals of old mines and open pit about 10 m above the gallery stated from top, but conditions are unknown because of collapses and devastation.

The strike and dip of each of veins at the right bank are respectively N30°W and 80-90°NE, N55°W and 75°NE, and N70°W and 75°N, and these veins tend to converge upon and continue to the vein at the left bank described above. The vein at the center of these veins reaches to ores through the cross cut developed about 40 m to the northwest and is being explored, but the mineralization of vein is weak and the results of analysis for 40 cm of sampling at the front show a trace of Au and 30 g/t of Ag.

However, the country rocks in the nearby area are somewhat silicified tuff-breccia and impregnation of pyrite is also seen. Veins at the left bank contain much sulfide ores but siliceous ores are present at the right bank.

Gitana No.1 mine:

This mine is located at a place about 500 m northwest of Marina pit and its elevation is 2,500 m. This mine reaches to vein after 10 m of cross cut and exploration is being carried out for a distance of 16 m in the direction of S70°E. It dips 70°NE and a large amount of arsenopyrite is contained in a narrow quartz vein about 20 cm wide. The grades obtained from the analysis are shown below.

Sample No.	Width of sampling	Au g/t	Ag g/t	Cu %	Pb %	Zn %	As %
ND-8	20 cm	1.2	40	0.0	0.0	0.1	11.7

Gitana No.2 mine:

This mine is located about 500 m northwest of No.1 mine and its altitude is 2,500 m, and exploration is being carried out in a small scale. Three veins, each 20 to 80 cm wide, are located at the north side and also three veins about 50 m away from them are distributed at the south side. A gallery of 10 to 20 m is provided for each vein, and the width of siliceous vein is about 50 to 120 cm. The results of sampling and analysis are shown in A-I-5 which shows 4.8 g/t for Au and 32 g/t for Ag for a sampling width of 30 cm of vein at the extreme north side but grades for others are extremely low. Strike of vein is either NNW or NW trending. The country rocks are tuff breccia as same as other cases.

Paragenesis of minerals:

The results of microscopic observation of the ore samples obtained from mines stated above and the core samples obtained from boring are described in the table at the end of this report. However, the mode of occurrence of each of principal mineral components is outlined hereinafter.

Pyrite: This occurs the most often, and subhedral or anhedral crystal form is predominant but automorphic rarely occurs. It is observed that some of pyrite contains galena, chalcopyrite or occasionally electrum inside (ND-42(c), D6073).

Arsenopyrite: This occurs the most often as pyrite does, and subhedral or anhedral is dominant, but euhedral crystal occurs more frequently than it does in pyrite. Inside of crystal is relatively uniform and compact, and galena and electrum are seen in very rare cases (ND-49, D7144(D)).

Sphalerite: This shows anhedral crystal form with filling between pyrite and arsenopyrite, and also shows the shape of corrosion and replacement of both the pyrite and arsenopyrite (D6083, D6065, D6073). In most of cases, chalcopyrite is contained in quantities in the form of dotted fine particles of 5 to 10 μm (ND-17, ND-426, D6083).

Chalcopyrite: This has the anhedral crystals, each being 0.2 to 2.0 mm in size, and takes a form of filling between quartz, pyrite, arsenopyrite and sphalerite or a form of corrosion and replacement of pyrite and arsenopyrite (ND-46(A), ND-46(B), D6073(B), D6086(D)). Also, the chalcopyrite scatters in the form of dotts in the sphalerite and is filled in cracks (50 μm±), in crystals of pyrite and tetrahedrite in the form of veinlet (D7145).

Galena: Only a small amount of galena is present. Galena is the anhedral crystal with a size of 50 to 300 μm which crystallizes between arsenopyrite, pyrite and sphalerite, and indicates a close association with sphalerite and chalcopyrite, all of which seem to have the same age (D6073(b), D-SP-2). Though there are fine crystals (30 μm) of gelena in some parts which seem to be contained in the pyrite and arsenopyrite, it is considered that the galena entered later and formed there since small cracks are seen in the nearby area (D6065, D6073(I)).

Tetrahedrite $(Cu,Fe)_{12}(SbS_3)_4S_{0-10}$: This is recognized in the samples taken from San Sebastean mine. Tetrahedrite shows mineral paragenesis with arsenopyrite and the subhedral crystal, and it is considered that the tetrahedrite was corroded by sphalerite and chalcopyrite as same as the case of arsenopyrite (D-SP-1, OD-A, OD-B). Also, it was observed that some of tetrahedrite was contained in the chalcopyrite (D-SP-1).

Boulangelite $(Pb_5Sb_4S_{11})$: This was found during the first phase survey, and was also found in the galena in the form of inclusion 150 μm in length and 1 to 2 μm in width within the sample D6073 taken during the present survey (D6073 (G), -(H), -XMA). In addition, in the same sample, the presence of argentite (Ag_2S)(20 μm) which has a paragenesis relation with chalcopyrite, polybasite $((Ag, Cu)_{16}Sb_2S_{11})$ (50 μm), pyrargyrite (Ag_3SbS_3) (30 μm) and freibergite (Ag rich tetrahedrite) (50 μm) was confirmed by the X-ray microanalysis.

3-3-4 Possibility in the Neighbourhood

There is a group of gold deposits currently under exploitation in small scales such as Paraiso, Desquite and Delicia in an area about 7 km to the northwest of the Diamante mining area. It was considered to be vitally important to review the potential of future mine development in the vicinity since the drilling work for Diamante principal vein was almost successfully carried out during the survey, so that a reconnaissance survey was conducted in the Paraiso mine area though the duration of it was very short.

In this reconnaissance survey, major outcrops already known were visited, some samples were taken, surveying was conducted using pocket compass and measuring tape, and it was tried to mainly grasp the relation between the outcrops. The results of this rough survey compiled together with the topographic map prepared during the first phase survey are shown in Fig. I-10.

Deposit was the fissure filling vein type deposit in the Pierdrancha granodiorite body, and four mineral vein outcrops were surveyed. They are all outcrops only and have no gallery. After sampling at four places shown in Fig. I-10, the samples taken at San Antonio outcrop located about 800 m in the west of Paraiso elementary school with an altitude of 2,100 m and also taken at San Luis outcrop exposed at a point about 1 km further in the west were analyzed, and the results of 4.6 g/t (300 cm) and 4.8 g/t (170 cm) were respectively obtained. In the San Luis outcrop, gold particles were recognized even by a simple panning test, and this outcrop seems to be very interesting for the exploration since the structure of this vein is considered to be related to the outcrop in Oso valley found about 1,200m in the southeast of San Luis outcrop. At the San Antonio outcrop, a depression with a diameter of about 15 m is formed at the site of open-pit mining, fine branch veins are accompanied at both sides of the main, and a brecciated zone about 8 m thick is formed by these depression and branch veins. Gold was not detected at both the outcrops in Ruidosa valley and Lulo valley and, thus, it will be necessary to take samples from slightly deeper

sections.

Water wheel ore-crushing shed was built near the San Antonio mine, but the exploitation is being performed only during spare time made available from the stock farm business. At a place about 3 km in the east of this mine, the Desquite mine is located and is under exploitation in small scale. Also, at a place about 4 km in the south of this mine, several old pits called Delicia mine are located for which reopening and mining are currently being prepared. Certain information disclosed indicates that there are still more mineral vein outcrops which have not been explored between this area and Bombona mine surveyed in this phase and, thus, it is required to survey the geological potential of this area to determine whether this area can be expected as a group of satellite mines for the development of Diamante mining zone.

3-3-5 Discussion

Through the geologic and geochemical survey in the Diamante mining area in this phase, it has been clarified that both Diamante principal vein and Marina mineralized zone run almost in parallel to each other with a distance of about 700 m between them in the direction of NW-SE. Also, from the drilling survey, it has been found out that the northern extension of Diamante principal vein is likely to continue to Hormiga vein.

However, whether these zones are reflecting the true mineralized zones is not apparent since the spacing between soil geochemical lines was too large and since anomalous values of geochemical survey occurred at independent points not as values for plural anomalous zones including the adjacent points.

In addition, it is currently uncertain whether Gitana No.1 and Gitana No.2 mineral indications are the mineralized zone of principal vein continued

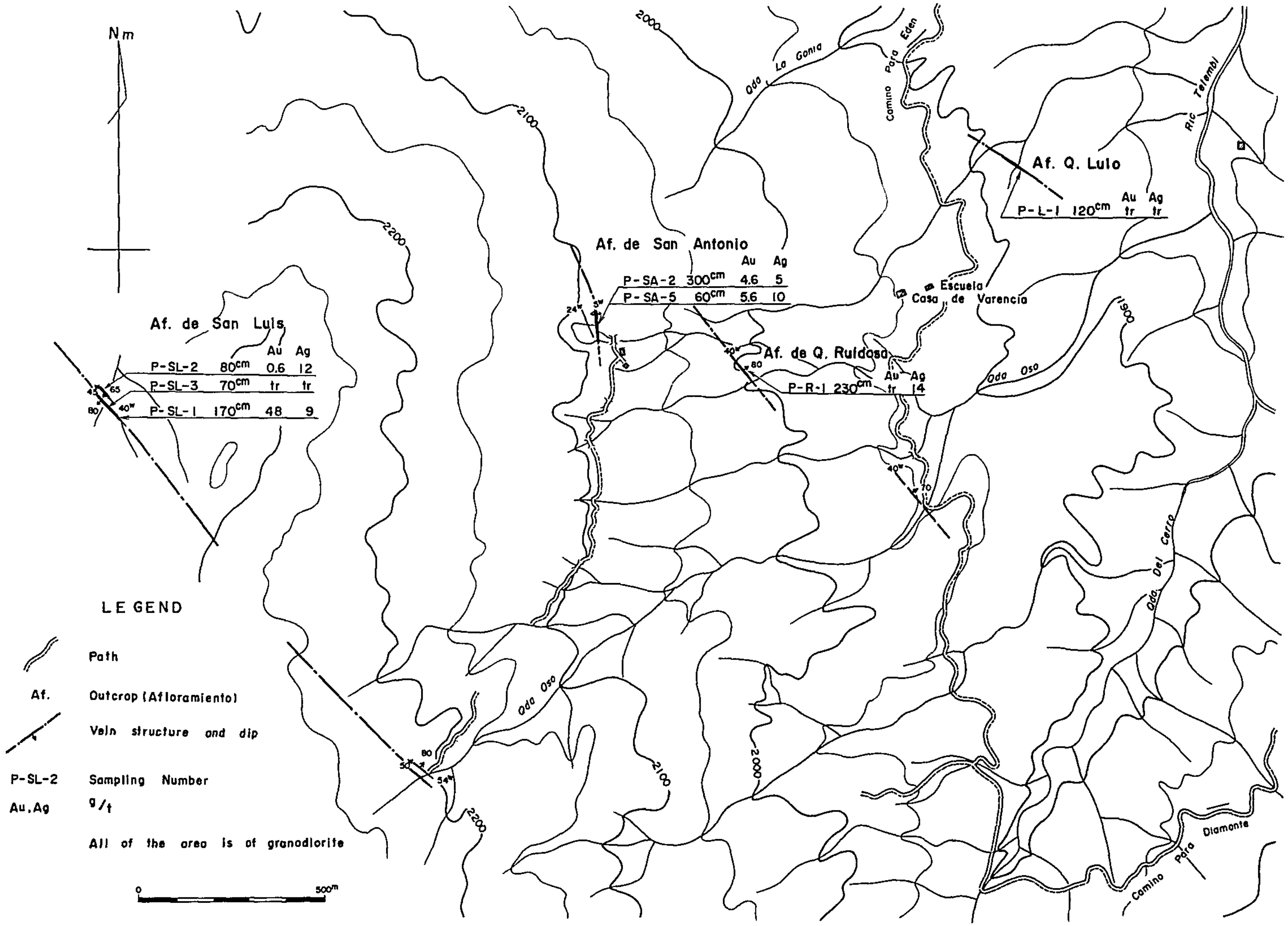


Fig. I-10 Map of the Paraiso area, showing location and results of samplings for chemical analysis and deviated by faulting, are the extension of Marina mineralized zone, or are the continuation of echelon arrangement.

In order to clarify the questions described above, it is required to establish the geochemical survey lines with a smaller spacing between them (such as 200 m) and to take samples at a shorter interval (such as at 25 m on centers) between two adjacent lines. In addition, it is required to directly confirm the presence of ore vein or its altered zone by stripping soil in rivers near the anomalous zone.

Though Diamante principal vein was found to be the high grade vein from the results of drilling survey, there was an indication of extreme pinching and swelling in the vein and, thus, it is vitally important to continue the drilling survey at the middle of drilled sites in this second phase and at the southern part of Diamante pit. Also, by studying the core samples from this drilling survey, the trends of mineral vein configuration and mineral distribution must be grasped, and approximate scale of the mineral deposits must be determined.

Though the positive results were obtained from the survey of this fiscal year with respect to the potential of this mining zone, the survey density is still low and thus many uncertain elements are remaining. Even with respect to the mineral component of the deposits, various kinds of sulfide ores are contained and they are very complicated. According to the results of microscopic observation, there are such advantages that most of electrum is contained in vein quartz or between crystals of sulfide minerals and enclosed only in a small amount in pyrite or arsenopyrite. But, at the same time, minerals such as sphalerite and arsenopyrite which are disadvantageous for the gold extraction by cyanide process are also contained together. Whether gold and silver contained can be economically recovered and whether the separation and recovery of accompanied valuable metal minerals (especially sphalerite and cupriferrous and argentiferous minerals) can be made are the vitally important problems for carrying out the exploration of these mineral deposits.

In addition, the existence of at least several hundred thousand tons of ore reserves is basically required for the modern development of the mine, the Diamante principal vein must be fully surveyed and the survey for mineral deposits in the nearby areas must be also strengthened to obtain a certain outlook of the potential of other ore veins.

3-4 Bombona Area

This area is about 12 km to the west-southwest of Guachavez and includes the upstream watershed of the Bombona river, a branch of the Gualcala river. Survey was conducted within an area of 2 km x 1.5 km = 3 km^2 extending in the direction of WNW-ESE.

As reference altitude, the location of water-wheel-grinding shed in Bombona Alto mine currently under exploitation was determined to be 2400m. This area has steep mountainous terrain ranging from 2200 m to 2800 m in altitude, and vegetation in this area is represented by densely grown tropical broadleaf trees and bamboos.

About 7 hours of riding a horse will be necessary to enter into this area passing over ridges an altitude of about 3100 m from Guachavez.

3-4-1 Geological Features and Structure

Geology:

Rocks forming this area comprise mainly the granitic rocks and partly the sedimentary rocks.

Granitic rocks

These rocks are classified based on the lithology into fine grained granodiorite, medium grained granodiorite and aplite, the former two are present in the form of grey or grayish white massive rocks and the third as dykes.

The difference of mineral composition between the fine grained and medium grained granodiorites is insignificant. About 35 to 40% of amphibole and biotite are contained in these rocks but it is significant that the medium grained granodiorite contains the phenocrysts of amphibole and biotite exceeding 10 mm of grain size. Also, zenolith of fine grained granodiorite is contained in the medium grained granodiorite.

The mode of occurrence of aplite will appear in the form of small milk white dyke with a width of about 10 cm. Microscopic observation of the fine-medium grained granodiorite (B-4, B-10, B-11, B-20, B-22) shows equigranular or porphyritic texture. The principal minerals forming the rock are amphibole, biotite, plagioclase, potassic feldspar, quartz, and auxiliary components are sphene, epidote, apatite, opaque minerals.

According to the results of age determination based on radioactivity (B-22), 20.7×10^6 years of age is found.

Sedimentary rocks

Chert: This rock is distributed along the horse road to Guachavez at northeastern end of the survey area. Chert was weathered and was altered by weak impregnation of pyrite due to emplaced granodiorite and has grey-brown color. Strike and dip of the rock is N-S and 70°-80°E.

Geologic structure:

The survey area is located at the southeastern edge of the central part of Piedrancha granodiorite body (33 km x 2-13 km), and this location is close to the point of inflection where the granodiorite body extending in the N-S direction at the northern part changes its direction to SW at the southern part.

The fissure system of four trends indicated below are well developed in the survey area:

(1) N60°-70°W, steep dip: Mineral vein

(2) N50°-70°W, gentle dip: Mineral vein

(3) N10°-30°E, 55°-80°W: Joint

(4) N-S, 55°E: Joint

(1) is the fissures where the largest and the most typical ore vein is present within the surveyed area.

With respect to the relation between (1) and (2), the vein of (1) cuts the vein of (2) in most of cases, and northern portion of (2) is dislocated several milimeters to several centimeters higher than (1). In certain parts, on the contrary, the vein of (2) causes the vein of (1) to be deviated in the form of reversed fault with small angle. That is, (1) cuts (2) or (2) cuts (1) in their mutual relation. However, the relation between (3) and (4) is not clear.

3-4-2 The Results of Geochemical Survey

Two groups of ore veins called Bombona Alto and Bombona Bajo are located at the left bank of Bombona valley in the survey area.

Geochemical survey was conducted on the selected ridge almost perpendicular to the strike of veins for the purpose of exploring the extension of groups of veins stated above and unknown parallel veins. The elements analyzed were, as same as the case of Diamante area, two elements of zinc and arsenic (Zn and As) and the number of samples taken was 61. The results

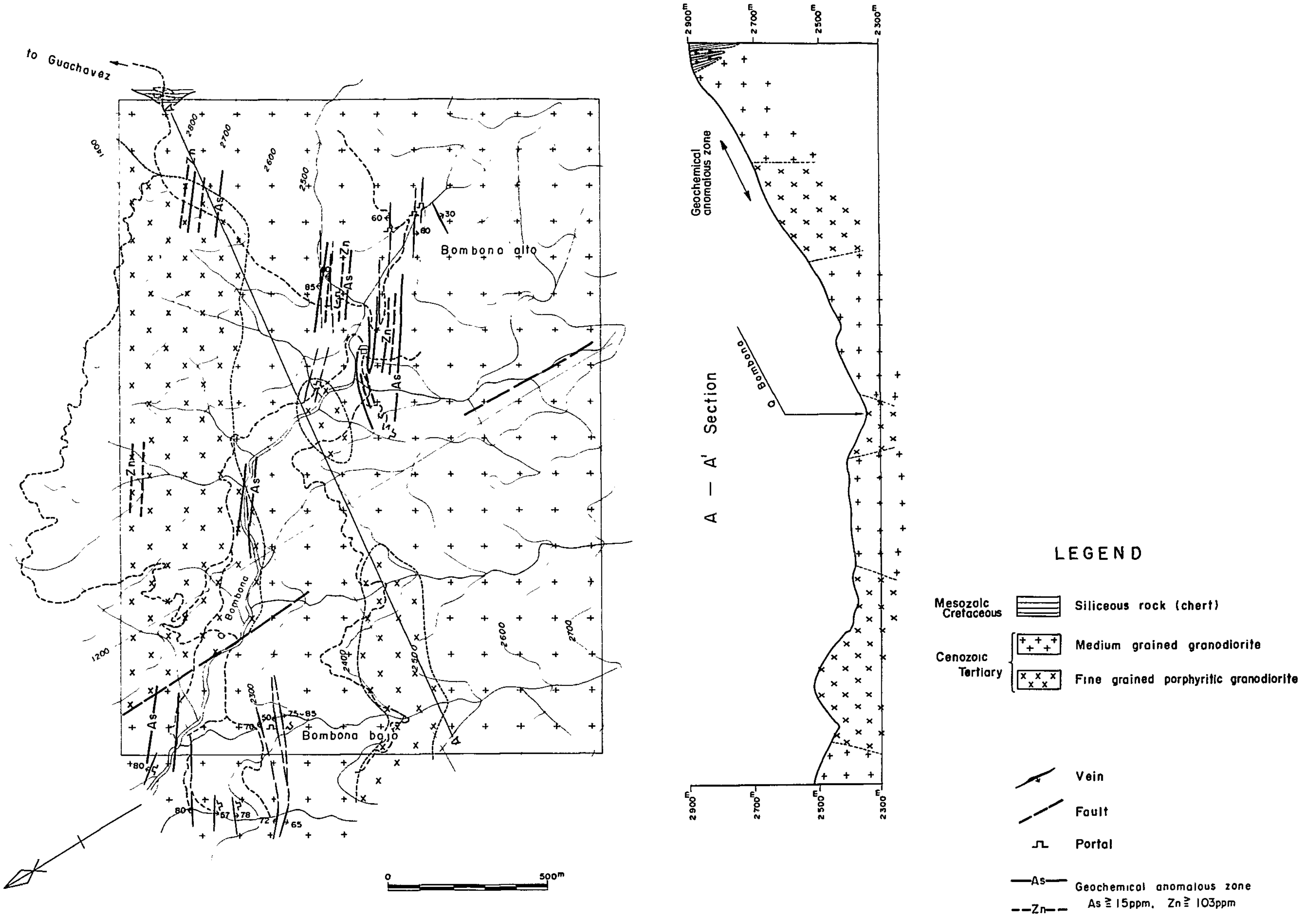


Fig. I-15 Compiled map of Bombona area

of soil analysis are shown in A. I-1 at the end of this report and the results of statistic treatment in Table I-7 and Fig. I-11.

Correlation coefficient between Zn and As was found to be 0.506 from which weak positive correlation can be recognized.

Analysis values are: Range = 431.2 ppm max. and 9 ppm min.; average = 65.6 ppm for Zn. Range = 1,137 ppm max. and 0.6 ppm min.; average = 3.4 ppm for As.

For each element, the anomalous zone was extracted using the average + standard deviation as threshold for weak anomalous value, and average + 2 x standard deviation as threshold for strong anomalous value. (PL I-10) As a result, 103.3 ppm for Zn and 14.6 ppm for As in weak anomalous zone; 162.5 ppm for Zn and 63.5 ppm for As in strong anomalous zone. Finally selected anomalous zones based on the above results are:

Strong anomalous zones:

As : (1) Ridge behind the water-wheel-grinding shed in the Bombona Alto mineral deposit area, which is about 70 m from the shed. .... Ⓘ noted on the PL. I-10

(2) Eastern ridge of old pit Raul-3. .... Ⓘⓘ

(3) Western ridge of old pit No.1 to No.3 in Bombona Alto vein group. .... Ⓘⓘⓘ

Zn : (1) Same range as (1) of As. .... Ⓘ

(2) Ridge about 0.5 km northeast of (3) of As. .... Ⓘⓥ

The above anomalous zone is distributed with good correspondence with known vein groups but Zn (2) only has no corresponding known veins.

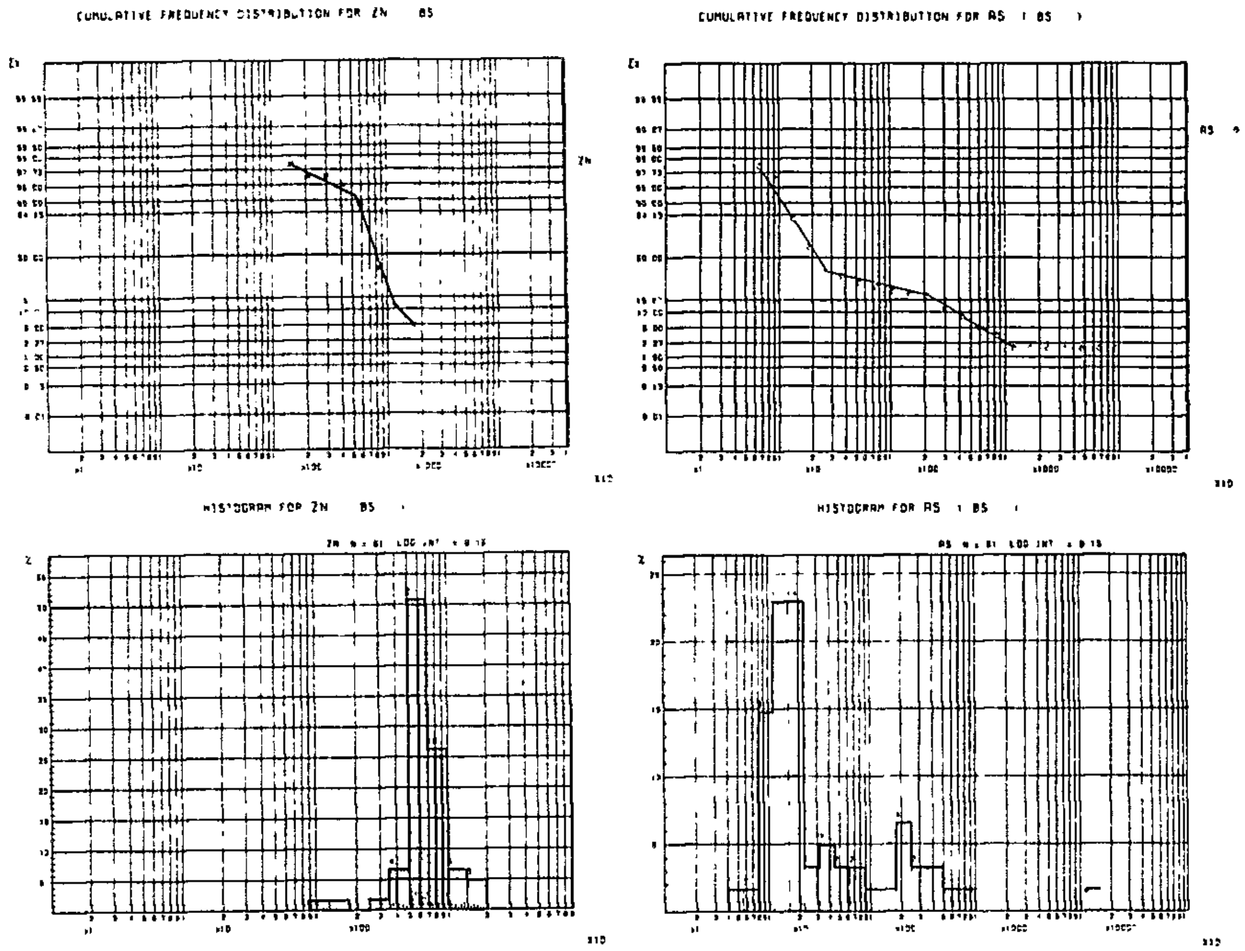


Fig. I-11 Statistic Analysis of Geochemical Data (Zn, As), Bombona

Table I-7 Statistic Analysis of Soil Samples (Zn, As), Bombona

Area	Element	b	b+S	b+2S	Skew	Kurtosis	Number of Samples	Correlation Coefficient
Bombona	Zn	65.6	103.3	162.6	-1.406	6.478	61	0.506 (Zn, As)
	As	3.4	14.6	63.5	1.614	2.699	61	

b: mean background value, ppm

s: standard deviation, ppm

b+2S: threshold value, ppm

Weak anomalous zones:

These zones are distributed around the strong anomalous zones stated above, and additionally two weak anomalous zones shown below were selected for each of As and Zn.

As : (1) Right bank of Bombona Valley (opposite bank of Bombona Bajo minerals indication area). .... (V)

(2) Central portion of Bombona Alto / Bajo at the left bank of Bombona valley. .... (VI)

Zn : (1) Central portion of Bombona Alto / Bajo at the right bank of Bombona valley 400-m to the north. .... (VII)

(2) Eastern extended portion of Bombona Bajo vein No.1. .... (VIII)

By reviewing the results shown above, three zones out of four strong anomalous zones correspond to the known veins, there may be a potential presence of unknown ore vein in the rest of zones.

3-4-3 Mineralization

Mineralization in this area is a fissure filling vein type deposit. Groups of ore veins appear at two places in this area and each is currently under exploitation in a small scale.

General strike and dip of the ore veins are N60°W and 70°N-80°S respectively and show an echelon arrangement.

Width of ore vein is 40 cm maximum, and vein is rich in pinching and swelling but lacks the continuity. There was a known vein for which the longest tracing up to 60 m was possible, but most of veins with quartz changed to oxidized clayey veins after the tracing of about 10 m. These veins are mainly the auriferous quartz veins and small amounts of pyrite, arsenopyrite, sphalerite, galena and chalcopyrite are accompanied also.

List of ore veins observed in this area is shown in the following table I-8.

Table I-8 Description of the Ore Veins in Bombona Area

Location	tunnel	Vein: strike·dip	Vein: width (m)	Vein: horizontal extension (m)	Sample No. (length. m)	Assay grade: Au g/t	Ag g/t	Cu %	Pb %	Zn %	Sb %	As %	Remarks
Bombona alto	No.1	N70W~N48W·75N	0.4	7^{+}	·								SE extension is followed by tunnel 15 m length, the vein diminished and changed into clayey material.
"	No.2	N62W·80N	0.05 0.05										2 veins exist with 2 m apart.
"	No.3	N64W·85N											Filled with water at the entrance.
"	NO.5	N60W											
"	No.9		2.5		B-SO-9 (2.5)	0.7	6	<0.1	0.2	<0.1	<0.1	0.7	
"	No.10	N60W·60N	0.8										Clayed vein composed of 3 quartz veinlets.
"	No.11	N60W·85S	2.0		B-SO-11 (2.0)	8.1	219						
"	No.14	N60W·85S	0.4	21.3^{+}	B-SO-14 (0.4)	80.0	230	<0.1	0.5	0.7	<0.1	5.4	The vein was followed by tunnel 21.3 m toward SE direction.
"	No.15	N60W·85S	0.4		B-SO-15 (0.4)	1.7	51	<0.1	<0.1	<0.1	<0.1	1.0	Upper continuation of No.14.
"	Raul 4	N86W·30S	0.4										Brown quartz vein appeared at the entrance of winze 4 m length.
"	Raul 3												Old mined area, remained only floats of arsenopyrite-pyrite-chalcopyrite quartz vein
Bombona alto/bajo		N64W·85N -82S	0.3	60^{+}									The old tunnel continues more than 60 m. vein width 0.3 m arsenopyrite-galena-pyrite-chalcopyrite-sphalerite quartz Vein.
Bombona bajo	No.4	N65W·50N	0.3		BA-SO-4 (0.3)	3.7	48	<0.1	<0.1	<0.1	<0.1	3.7	
"	No.5	N50W·85S	0.4 0.2	10^{+}	BA-SO-5 (0.4)	0.7	13	<0.1	<0.1	<0.1	<0.1	0.7	The tunnel followed two parallel veins spacing 0.7 m apart.
"	No.6	N60W·90	0.3	10^{+}									Following upper continuation of No.5 about 10 m above.
"	No.7	N40W·72NE	0.4		BA-SO-7 (0.4)	6.3	812	<0.1	0.2	<0.1	<0.1	2.5	Arsenopyrite-pyrite-sphalerite quartz vein within limonitized-kaolinized granodiorite
"	Raul 5	N60-75W· 57-90S	0.1 -0.3	20^{+}	B-15 (0.1)	4.9	54	0.02	0.14	0.03	0.00	3.15	
"	Raul 5/Raul 6	N74W·70-80S	0.4		B-16 (0.4)	10.3	108	0.03	0.30	0.03	0.03	5.30	

3-4-4 Discussion

It is said that ore deposits in this area were exploited in a large scale around 1950, and actually many old pits can be still seen in this area and the foundation for old mills still remain, but most of old pits are collapsed at the portal and entering to the pits is not possible. Exploitation of a small scale is still going on at two places, in which ore veins near the old pits are being mined by few workers and gold particles are separated and recovered for grinding using hydraulic power, panning and amalgamation. Systematic exploration for ore deposit is not being performed.

In the survey of this fiscal year, the geology of known ore veins was surveyed, soil samples were collected along the ridge intersecting with the direction of ore veins to explore the extension, and then geochemical exploration was conducted using zinc and arsenic contained in quantities in the ore veins as indicator elements.

As a result, the distribution of ore veins in this area has been well clarified. That is, these mineral veins generally strike N60°W with steep dip and show an echelon arrangement from northwest to southeast direction in the area.

The geochemical survey based on the arsenic and zinc is very effective for determining the location of ore veins, and the location of old mines almost perfectly corresponds to the distribution of the anomalous zones.

Also, the anomalous zones were extracted even in the areas where there were no known old pits, which suggests that there will be a potential presence of unknown ore veins.

By considering both known ore vein groups and anomalous zones determined by the geochemical survey all together, the presence of seven mineralized zones may be forecasted in this area, and those mineralized zones have the horizontal length of about 500 m and width of 50 to 150 m. The mineralized zone in the northwestern part extend to the area downstream of Bombona valley and show a sign of gradually increased predominance, so that it is required to further strengthen the survey toward the northwest.

With respect to the method of exploration, it is considered to be very effective to perform the geochemical survey using soil samples taken along the ridge in addition to the geologic survey.

CHAPTER 4 DISCUSSION AND CONCLUSION

4-1 Study on Geology and Mineralization

Two mineral indication areas of porphyry copper deposit type (Rio Blanco and La Verde) and two mineral indication areas of gold-bearing polymetallic vein type (Diamante and Bombona) were selected out of the mineral indication areas extracted from the survey of first phase, and then detailed geologic survey and geochemical survey were conducted in these areas to clarify the relation between mineralization and geology. The following results of survey on the geology and mineralization were obtained for each area:

Rio Blanco Area:

There is a slightly round stock-like diorite body with a diameter of about 5 km in this area, and the central portion of this body has coarse grained holocrystalline lithofacies while its perimeter portion has fine grained porphyritic lithofacies. The northwestern perimeter portion of this rock body was subjected to the mineralization, and the fissure structures mainly trending toward ENE-WSW and NNW-SSE was developed in the surrounding area. These fissure structures correspond to the direction of structural lines in this area which were recognized from the results of regional photogeological analysis in the survey of first phase. In the places near mineral indication area, specially the structural lines trending toward ENE-WSW are prevailing, and both mineralized alteration zone and geochemical anomalous zone have the elliptic shape which extends in the E-W direction.

Mineralization is mainly seen in the joints or fissures developed at interval of 5 to 15 cm and seen in the form of impregnated pyritization in country rocks associated with weak chalcopyrite mineralization, and the chalcopyrite is a little recognized at the outcrops in Dorada valley. The strongest pyritization occurs at a middle stream portion about 500 m long in Dorada valley, and the country rocks in this portion was subjected to the medium degree of silicification and chloritization. In the area upstream of Dorada valley, which is in the west of the mineralized zone, both the chloritization and epidotization are seen significantly. Also, in the northeastern part of the mineralized zone, micro diorite subjected to the strong enrichment of magnetite is seen and the veinlets consisting of pyrite and magnetite are also recognized. The geochemical anomalous zone is overlapped with the central portion where the silicification stated above is seen to a great extent, and the combination of both mineralization and alteration suggests that part of mineralized zone of the porphyry copper deposit type is likely to be exposed.

However, greatly silicified zone, potassic feldspathization zone, or sericitized zone (or clayed zone) which should be frequently seen in high grade deposits of the type described above is not seen and, with respect to the pyritization, no outcrop oxidized in net shape is recognized. Analysis values of ore samples taken from the outcrop were only 0.04% to 0.25% for Cu. From these facts, a conclusion may be reached that there might be a weak mineralization as a whole. There is, however, an idea that expects that a high grade mineralized body would be latent yet in deeper level. But, there is scarce data to support it.

La Verde area:

The mineralized zone in this area is distributed in the southern end portion of diorite body extending in the N-S direction, and the prevailing trends of its fissures are NE-SW and NW-SE.

In the country rocks of mineralized zone exposed in La Verde valley and Sergia valley, there are recognized weak silicification, chloritization, potassic feldspathization of plagioclase, and sericitization. In addition, the presence of molybdenite was recognized in some part, and it is considered that the alteration zone and mineralization in this area are also of porphyry copper deposit type. However, the results of samples taken at the outcrop in valley indicated a very low value of 0.1 to 0.3% for Cu.

Density of sheared fissures, intensity of pyritization and alteration of rocks, are weak in general. Copper mineralization does not seem to increase remarkably according to depth. However, in this area, because the space between the geochemical sampling lines was too large or 300 m to 400 m, and there were not sufficient outcrops for geological observation, determination of a high mineralized place resulted difficult. Also there is very poor information to decide, in a three dimensional sense, which part of the mineralized body is seen actually.

From the present data on this area, there is no other way than to make a pessimistic conclusion. However, if more information is wanted, it is recommended to effect detailed geochemical exploration in grid and a geophysical survey.

Respect to the country rocks in Rio Blanco and La Verde area:

By summarizing the correlation between the mineralization and the results of age determination and chemical analysis of holocrystalline instruded rocks performed in the survey of first phase and this fiscal year, rocks can be divided into two groups; the group of medium-scale dioritic bodies with 30 to 50 million years of geological age, and the group of Piedrancha Granodiorite whose geological age is assumed to be 20 to 30 million years. The group of the former almost always has the copper mineralized portions (such as Canellera, Ramos, Rio Blanco, etc.). However, Piedrancha Granodiorite does not have copper mineralized portions though it gives regional alteration to its surrounding area, but instead it is accompanied with many gold veins within itself or in its surrounding area.

With respect to the country rocks in mineralized zones in both Rio Blanco and La Verde areas, one of significant geologic conditions common to both of these areas is that part of a large stock has become a mineralized zone. That is, the mineralized diorite in Rio Blanco area continues to the diorite body distributed at its southeastern part, and the mineralized diorite in La Verde area continues, in the same manner, to fresh diorite at its northern part.

That is, the igneous rock related directly to copper mineralization is not found there. It is not clear whether the igneous rock is not recognized because of strong alteration or is latent in the subterranean, or is absolutely absent. Clarifying the point mentioned above is an important key factor to forecast the shape of the ore body. Therefore, future survey must be carried out taking full precautions.

Diamante area:

As a result of surveying conducted during the geologic survey of second phase, the location of galleries distributed in this area was accurately grasped and then the distribution of mineral veins was also clarified. In addition, by the drilling work conducted between the Auxiliadora pit and Diamante pit, the continuity at the northern part of Diamante principal vein was investigated. In consequence, many facts were found with respect to the properties of mineralized veins in this area as already described in foregoing paragraphs. However, there are still some questions as stated below, for which further examination will be necessary in future.

a. Vein structure:

Diamante principal vein is considered not to continue to the Auxiliadora ore body but to continue to Hormiga vein through the dislocation by faults, but there are quartz vein hardly containing the sulfide minerals at the vein in the drill hole PD-3. This fact will raise a question whether the veins indicate a partial change in mineral composition in the same vein or are the separate veins which do not continue. Currently, these veins have been considered to be the same vein since the directions of veins are the same. Nevertheless, it can be said that they are occasionally arranged in a zigzag form.

Also, whether the northwestern prolongation of Hormiga vein continues to Gitana No. 2 pit is unknown, and also continuity between them is not clear since the geological structure of faults between them is not clear. In addition, the southeastern extension of bonanza in Diamante pit has the mineral properties similar to those of mineral vein in north pit of Gualquilia, so that this extension seem to be continuing while making dislocation by faults. But this is uncertain since only a part of faults is exposed.

b. Country rocks and scale of veins:

Diamante principal vein has the largest width near the Diamante pit, and this width suddenly decreases as the vein runs northward and to deeper part. The variation in directions of veins (horizontal and vertical) is one of the factors that govern the width of mineralized veins but, in this case, the variation is greatly affected by the stress distribution there and by the change in properties of country rocks. According to the results of survey in this phase, the relation to the change of country rocks was not so clear but this is the notable survey item for the future.

c. Compositions of minerals:

Through the microscopic observation and examination using X-ray microanalyzer for the ores, the paragenesis of minerals has been clarified considerably.

Currently, the sequence of crystallization of minerals can be considered as listed below.

First stage: Pyrite, arsenopyrite, quartz, electrum.

Second stage: Tetrahedrite, galena, silver ores, electrum, quartz.

Third stage: Sphalerite, chalcopyrite, quartz.

Fourth stage: Pyrite, marcasite, quartz.

However, quartzose gold vein with very little sulfide ores and other veins with much sulfide ores are present in the area, and also there is a fact that the gold to silver ratio considerably varies depending upon the location. Though the distribution map of elements cannot be prepared since the number of drill holes is small at present, this map may be very useful for predicting the shape of ore deposit if more data are obtained in future. Though the stages of mineral crystallization stated above are considered to be progressed in succession, a trace of crushing of existing minerals once before the pyritization in fourth stage was observed.

d. Field of regional formation of vein structure:

The strike of vein group in this area varies from N40°W to N80°W. And the dip also varies from the vertical to about 45°NE. Upper wall of Diamante principal vein observed in Diamante tunnel has a strike of N40°W and a dip of 80°NE. However, strike and dip of medium-sized veins to veinlets in the mineralized veins are found to be N60°-65°W and 40°-65°NE, suggesting that the upper wall of mineral vein was structurally formed by its movement northwestward and upward. This is the same as the direction of movement during formation of main structure near this area which was pointed out in the regional geological interpretation made during the survey of first phase. However, it is considered that this mineralized zone is not a long vein parallel to its structural line but a group of mineralized veins distributed in the structural zone having a certain width.

Bombona area:

Exploitation in very large scale was made about 30 years ago in this area but most of galleries were collapsed and buried thereafter, and the inside of these galleries cannot be seen. Thus, the ore deposits can be evaluated only by checking the outcrops on the ground surface and the conditions of few reopened pits currently under exploration. Mineralized veins are present in granodiorite generally in the form of veinlets, and the width of veins is about 10 to 40 cm. The veins are the gold veins mainly consisting of quartz with a relatively large amount of arsenopyrite. General strike of these veins is N50°W and their dip is about 70°NE, and they extend straight with almost no change in the direction of strike. However, the length of mineral veins is relatively small or 100 m to 300 m approximately. The vein groups in this area can be divided into two parts; a group distributed in high elevation zone in the southeastern part, and another group distributed in low elevation zone in the northwestern part. There is no mineralized vein developed in the intermediate portion between these groups. The direction of each vein group is not on the same line, thus suggesting that they are arranged in an echelon form. Though the presence of a further extended portion of the vein group in the northwestern part is expected, their extension has not been surveyed. The formation of regional fissure system and the distribution of the center of mineralization must be urgently clarified by the regional survey in future.

4-2 Conclusion and Future Prospect

4-2-1 Conclusion

Main findings which became clear from the results of survey of this fiscal year will be described hereinafter.

(1) Detailed geologic survey and soil geochemical survey were first conducted in Rio Blanco and La Verde areas within the copper and molybdenum mineral indication area extracted from the regional survey including the stream sediments geochemical survey of the first phase, and then the presence of mineral indications of porphyry copper deposit type was confirmed in each area.

(2) The copper ore indication area of Rio Blanco area is distributed in Dorada valley running almost in the E-W direction, and the range with strong silicification and pyritization extends about 1000 m in the E-W direction and about 500 m in the N-S direction and almost coincides with Cu and Mo anomous zones determined from the soil geochemical survey. Most general alterations found were chloritization, epidotization and magnetite impregnation, but silicification, sericitization and potassic feldspathization were very weak or hardly seen. By referring to an ordinary model of porphyry copper deposits, the top or outer portion of the mineralized zone is considered to be exposed, and there is a place for exploration in the lower portion. However, since the pyritization is generally weak, it might be difficult to expect high grade ore deposits.

(3) In La Verde area, the southern end portion of diorite extended long in the N-S direction and intruded in the wedge form was subjected to the mineralization at the boundary between the green volcanic rocks and the alternating layers of shale and sandstone, and the copper anomalous zone determined by the soil geochemical survey extends about 300 m in the E-W

direction and about 800 m in the N-S direction. In the Verde valley running almost in E-W direction through the central portion of this area, diorite with fine fissures trending NWN-SES and NE-SW is exposed, which was subjected to the pyritization and copper mineralization. Also, potassic feldspathization and sericitization were observed in some portions of country rocks. According to the results of sampling at the outcrops, the grade of Cu was 0.1% to 0.3%. However, the soil sampling line of the geochemical survey in the mineralized zone runs only along the ridge line and the sampling density is low and, thus, more detailed survey will be recommended for proper evaluation of this area.

(4) From the results of survey of the first phase, the survey of copper-molybdenum indication zones and auriferous polymetallic vein type deposit areas described before was recommended, then the detailed geologic survey was conducted in two extracted areas of Diamante and Bombona. In the Diamante area, the drilling of seven drill holes (a total depth of 757.2 m) was performed in the Diamante principal vein which had been expected to be the most promising, and then auriferous veins were recognized in four drill holes. In addition, the soil geochemical survey was conducted to survey the extensions of known ore veins and to find new veins, and effective results were obtained.

In the Bombona area, detailed geologic survey and geochemical survey were conducted, positional relation between the groups of ore veins was analyzed, and place for exploration was clarified.

(5) For the drilling exploration in Diamante area, the lower portion of bonanza existing at the deepest part of Diamante pit which had the strongest vein intensity, the lower portion of Auxiliadora ore body existing about 400 m north of the Diamante pit, and the intermediate zone between them were surveyed by drilling. The depth of this exploration was limited to

the altitude of 2,500 m which corresponded to the elevation of Auxiliadora portal. As a result, ore veins with gold content between 7 and 9 g/t were detected in four holes of PD-3, -5, -6 and -7. Then, the detected vein portions were converted to the horizontal vein widths and the results of analysis of four holes were averaged, and average grades of 8.9 g/t for Au, 60 g/t for Ag, 0.14% for Cu, 0.09% for Pb, 4.58% for Zn, and 5.12% for As were obtained for an average vein width of 278 cm. The maximum vein width (converted to the horizontal) was 9.0 m in hole PD-6 and the minimum vein width was 0.5 m in hole PD-5, thus indicating considerable pinching and swelling. Some of high grade values recognized were 90.9 to 93.0 m (210 cm; 168 cm for the horizontal) and 25.4 g/t in hole PD-6. Since this vicinity is located about 40 m directly below the old pit, the above results well correspond to the results of sampling made in the old pit (7 to 9 g/t for Au).

Not only from the results of analysis and examination of drilled cores but also from the results of study on the mineral compositions of ores taken from the galleries, two kinds of ore, siliceous ore containing little sulfide mineral and the one containing much sulfide mineral, were recognized. In addition, they can be also divided into two kinds; the ores with high gold to silver ratios, and the other ores with low gold to silver ratios. However, the amount of data is still insufficient for describing the overall tendency of distribution of these component ores or elements. With respect to the electrum, it was found that electrum was present freely in quartz in the indeterminate form, was present in sulfide ore particularly at the edge of or in cracks of the pyrite, or was present in a small quantity within arsenopyrite or pyrite, so that the electrum is in the state where it may be easily separated. Also, as an unusual phenomenon in ores, it was recognized that many fine drops of chalcopyrite were paragenetic in sphalerite.

In the Diamante area, there are aside from Diamante principal vein two groups of veins of Marina and Gitana-1 and -2, which have not been fully developed yet. In a place about 7 km in the northwest of this area, there are also vein deposit zones such as Desquite, Paraiso and Delicia in adjacent to the Bombona area. The area between the vein deposit zones stated above and the Diamante area has never been explored before and is also the portion extended from the Diamante vein, so that discovery of new veins may be expected from the survey.

(6) In the Bombona area, there are two groups of ore veins at upstream and downstream portions with a distance of about 1,200 m between them, both of which are the fissure-filled veins trending toward NW, formed within granodiorite. These veins have the width between 10 cm and 40 cm and are the quartz veins accompanying arsenopyrite and pyrite, but the amounts of sphalerite and chalcopyrite contained in these veins are less than those in the Diamante area. These veins are straight with little bends and many short veins, each 100 m to 300 m long, are distributed. The general strike and dip of the veins are N60°W and 60°-90°NE, and veins are arranged in an echelon form. The portion below the level of river near the outcrops of ore veins seems to have not been mined before though this was not confirmed because most of old pits were collapsed. Also, for the grouped downstream veins, survey area was enlarged and additional survey was performed, but the survey was discontinued at a place where the vein intensity gradually had increased and, thus, it is required to further enlarge the survey area near this place in the future.

4-2-2 Future Prospect

In view of the development of mineral resources in the whole project area, the area can be divided into two groups for the prospect to the future.

(1) Copper-molybdenum mineral indication areas of porphyry copper deposit type such as Rio Blanco, La Verde and other areas.

(2) Gold bearing polymetallic vein type mineral indication areas such as Diamante, Bombona and other areas.

These two groups have the characters very different from each other as described below, and it is required to make the most appropriate survey plan for each group.

(1) Porphyry copper deposit type mineral indication areas:

From the results of survey of first phase, five areas of Rio Blanco, La Verde, Ramos, Santa Rosa and Gualcala-E were extracted, and the detailed survey was conducted for two areas of Rio Blanco and La Verde which indicated relatively good indications. As already described in detail for each item, the ore deposits in each area indicated the porphyry copper deposit type mineralization and alteration. However, in the Rio Blanco area, presumed mineralized zone is distributed in the river bed of the Dorada River running in the E-W direction and is interlayered with terrain which steeply slopes at an angle of about 30 degrees in the N-S direction. This means, in consideration of future development, that a considerable amount of costs for stripping earth will be required and that exploitation is very difficult to perform unless the grade is higher than the standard grade (0.7 to 0.8% for Cu) for this kind of ore deposit. However, only few positive signs suggesting the presence of such standard grade have been found up to now.

In the La Verde mineralized zone, there is a relatively good exposure at the banks of La Verde valley and Sergia valley and also there are portions where develops good fracturing. The grade of analysis of exposed rock samples was low or less than 0.3% for copper.

However, both areas are 20 to 30 km away from the end of motorway, it takes two to three days on foot to get there, and weather is unstable and the rainy season lasts long in these areas, which means that a considerable amount of cost will be necessary for both exploration and exploitation. Thus, the survey plan for these areas must be carefully made, and final decision should be made after comparing the investment efficiency to those of other copper projects including other areas. Because of the reasons stated above, it is primarily important to perform the detailed geologic survey and the geochemical survey in order to raise the information level of Ramos and Santa Rosa mineral indication areas of the same kind abstracted from the survey of first phase to the information level of Rio Blanco and La Verde as the survey of next fiscal year on the porpyry copper deposit type mineral indication areas.

(2) Gold bearing polymetallic vein type mineral indication areas:

Though the mining of oxidized portions near the ground surface is currently being performed in both Diamante and Bombona areas, it became clear from the results of drilling exploration that there are still considerable ore reserves in deep underground parts. In addition, the outcrops of ore veins in Paraiso area about 7 km downstream of Diamante were roughly surveyed, and the results show that there is a possibility of considerable mining development of groups of veins and ore deposits in this vicinity in the future.

Among these groups of veins, Diamante principal vein seems to be the most promising vein in view of its scale and grade, and the results of drilling show an average vein width of 278 cm, and grade of 8.9 g/t for Au, 60 g/t for Ag, 0.14% for Cu, 0.09% for Pb, 4.58% for Zn, and 5.12% for As. The results of microscopic study on ores have clarified that most of electrum is scattered in quartz and crystal boundary of sulfide and only a relatively small amount of electrum is contained in crystals which cannot be easily recovered. Also, information concerning the paragenesis of sulfide has been accumulated. However, it is not possible to determine a clear picture of the shape of the ore deposits from survey of this fiscal year alone which used a large spacing between drill holes since the scale of ore veins varies considerably and the mineral compositions of veins also vary considerably from quartzose portions to portions richly containing the sulfide ores. Also, it is required to investigate the deeper underground portion since the grade of this kind of ore deposits frequently tends to suddenly decrease toward the deeper portion. Diamante mining zone is located closely to and is about 4 km away from Guachavez village, the location of which is advantageous in view of infrastructure. Also, the cost required for the construction of mining installation can be extremely small, which is very advantageous compared to the porphyry copper deposit type mine. These mineral indication areas will be able to become very advantageous mining development areas if the grade of ores determined by the previous and future investigation becomes 7 to 9 g/t for Au and 60 to 90 g/t for Ag.

Therefore, it is vitally important to primarily investigate the Diamante mining zone also in future and it is recommended to survey the portions left unsurveyed between drill holes of the second phase survey and their extension to the south, by performing the drilling of holes spaced at about 100 m on centers. In addition, it will be needed to survey the potentiality of nearby ore deposits as satellite mines for the development of Diamante ore deposits by performing the detailed geochemical survey for the Marina mineralized zone running in parallel to and through the northeastern part of these areas, by investigating the continuity based on the detailed geochemical survey in the area between the mineral indication zones of Gitana No. 1 and No. 2 pits, and by surveying the ore deposits located between Diamante area and Paraiso area in the northwest of Diamante and the northern area of Bombona. In addition, it is very desired to investigate the dressing and metallurgical properties of ores as early as possible since relatively large amounts of sphalerite and arsenopyrite are contained in the ores of these deposits and since it is occasionally probable that these minerals and the recovery method of zinc ores adversely affect the recovery of electrum using the cyanide process.

REFERENCES

Alvarez, E.G & Chakrabarti, A.K. (1980)
Prospectos de porfido cuprifero en la cordillera occidental de Colombia
INGEOMINAS INFORME No.1832

Anglo, R.C. (1978)
Recursos Minerales de Colombia
INGEOMINAS

Irving, E.M. (1971)
La evolucion estructural de los andes mas septentrionales de Colombia
Boletin Geologico Vol. XIX No.2

Ishihara, S. (1970)
Introduction of Porphyry Copper Deposits Vol. II
(in Japanese)

Lipeltier, C. (1964)
A Simplified Statistical Treatment of Geochemical Data by Graphical Representation
Econ. Geol. Vol. 64 pp538-550

Lowell, J.D & Guilbert, J.M. (1970)
Lateral and vertical alteration-mineralization zoning in porphyry ore deposits
Econ. Geol. Vol. 65 pp373-408

Lozano, D.B. (1979)
Geology of the central western Cordillera, west of Buga and Roldanillo, Colombia
Publ. Geol. Esp. INGEOMINAS

Miyashiro, A. & Kushiro, I (1975)
Petrology Vol. II
Kyoritsu Zensho (in Japanese)

Naciones Unidas (1977)
Projecto de Metales Basicos en las Cordilleras Central y Occidental

Paris, G.Q. & Marin, P.A. (1979)
Generalidades acerca de la geologia del Departamento del Cauca
INGEOMINAS

Stibane, F.R. (1975)
The Encyclopedia of World Regional Geology Part I
Colombia pp245-250

Takahashi, M., Aramaki, S. and Ishihara, S. (1980)
Magnetite-series/Ilmenite-series VS
I-type/S-type granitoids
Mining Geology of Japan
Spe. issue No.8 pp13-28

The Mining and Metallurgical Institute of Japan (1975, 1978)
Gold-silver ore in Japan Vol. 1 & 2 (in Japanese)

The Mining and Metallurgical Institute of Japan (1979)
Handbook for the exploration in earth science Vol. 1
(in Japanese)

PARTICULARS

PART Ⅱ

DRILLING EXPLORATION

PART II DRILLING EXPLORATION

CONTENTS

LIST OF FIGURES

LIST OF TABLE

LIST OF PLATES

CHAPTER 1. OUTLINE OF DRILLING WORKS

1-1 Objective

As the result of the first phase geological survey and geochemical prospecting conducted in the Piedrancha area, the Diamante area was selected for drilling survey in the second phase. Drilling works were operated in this area to clarify the relation between geological structure and mineralization.

1-2 Outline of the Works

Three survey members left Japan on September 14, 1981. Material and equipment for the survey had been shipped from Yokohama in early August and were received at the port of Buenaventura. Transportation to Guachavez started on September 17 using trucks. Since no motor roads were available between Guachavez and the survey site, transportation to the site was carried out using a helicopter. New heliports were prepared for this purpose in the mine. After the transportation to the site was completed, drilling was commenced starting from PD-7.

The machine used for drilling was a TOM-3 (drilling capacity NQ 590 m, BQ 750 m). Seven holes totaling 757.20 m were drilled.

The work was, in general, performed in three 8-hour shifts. Each team consisted of one Japanese engineer and 3 Colombian workers. Several other Colombian workers were regularly employed to maintain the camp: to operate radio, to cook, and to drive vehicles. Additional workers were employed temporarily for transportation.

Drilling was conducted using the wire-line method in order to achieve good core recovery and to attain better efficiency.

Quantity of drilling works and core recovery are:

Hole	Drilled Length	Core Length	Core Recovery
PD-1	83.50 m	79.20 m	100.0 %
PD-2	81.00	48.00	77.4
PD-3	90.60	51.50	82.2
PD-4	100.10	67.80	70.6
PD-5	120.70	100.60	92.3
PD-6	120.60	96.80	84.9
PD-7	160.70	152.30	97.1
Total	757.20	596.20	87.7

(Note: Surface soil was excluded from the calculation of core recovery)

The drilling works continued for 97 days from September 21 to December 26, 1981.

1-3 Examination and Analysis of Cores

Cores from PD-7, 6, 5, and 4 were examined on site collectively after completing the PD-4 hole. Those from PD-3, 2, and 1 were studied at the end of each work. Lithology, alteration, fracture, and mineralization were observed and described. Results of the examination were compiled in 1:200 geological drill logs.

Each mineralized part of drilled core was cut in two along the axis using a diamond cutter. One of the halves was cut further in half. This quarter piece was ground and prepared for the analysis for gold, silver, copper, lead, zinc, antimony, and arsenic.

Microscopic observation was made on thin sections and polished sections to investigate the texture, alteration, and mineral paragenesis in rocks and mineralized parts. Part of the samples were subjected to

X-ray diffraction and X-ray microanalysis to determine the minerals and study mineral paragenesis.

Main items of analysis and the number of samples used were:

(1)	Microscopic observation on thin sections	10
(2)	Microscopic observation on polished sections	15
(3)	Analysis of mineralized parts (Au, Ag, Cu, Pb, Zn, Sb, and As)	65
(4)	X-ray diffraction analysis	15
(5)	X-ray microanalysis	5

CHAPTER 2. DRILLING WORKS

2-1 Works for Transportation

Three survey members left Tokyo on September 14, 1981 and arrived at Guachavez on September 18. After investigation of the sites where drilling works were to be done, plans for heliport preparation and transportation of material and equipment were made, and native workers were employed. Consent of the chief of the Guachavez village and the owners of the Diamante area was obtained concerning the use of lands for drilling sites, camp, heliport, etc.; trespassing in pastures; and the construction of access roads. For the heliport at Guachavez, a playground owned by the village was borrowed.

Two heliports were constructed in the Diamante area near the PD-7 site and near the camp. Access roads each of which were 2 m wide, totaling 900 m were constructed by human labor. Since both the access roads and heliports were located at elevations above 2600 m, interruption of construction was sometimes unavoidable due to drastic changes of weather, especially around the pass at 3200 m elevation.

Access roads were maintained by 8 - 10 temporary workers to facilitate transportation.

2-2 Drilling Sites

Diamante is located 10 km from Guachavez over a 3200-m pass. It takes 3 hours on horse back from Guachavez to Diamante. Location (longitudinal and latitudinal distances) and elevation of each hole were:

Hole	Longitudinal Distance (E)	Latitudinal Distance (N)	Elevation (m)
PD-1	2010	2022	2502.5
PD-2	2058	1919	2513.5
PD-3	2058	1919	2513.5
PD-4	2248	1912	2602.0
PD-5	2248	1912	2602.0
PD-6	2332	1788	2644.0
PD-7	2332	1788	2644.0

(* Station 21 at the portal of Mina Auxiliadora was defined as E 2000, N 2000, elevation 2500 m)

2-3 Construction of Sites

2-3-1 Transportation

Material and equipment passed customs and were carried by two trucks to Guachavez via Cali, Popayan, and Pasto. They reached Guachavez on September 19. Transportation from Guachavez to Diamante employed a 204 type helicopter. Moving from one hole to another was done by human labor, and sometimes with the winch of the drilling machine.

2-3-2 Setting Up

Setting up of the sites were started from PD-7. Construction of the 2-m access roads connecting PD-7, 5, 3, and 1 totaling 900 m and the preparation of drilling sites were done by human labor.

2-3-3 Water for Drilling

All 7 holes were supplied with water from neighboring streams by gravity flow using 1-1/2- or 1-inch plastic piping. The total piping was 1500 m long.

2-4 Drilling

Surface soil was dry-drilled using a 101-mm metal crown. Wire-line was employed after the hole reached bedrock. Casing pipes were successively installed. Last strokes were operated using BQ wire-line.

The results of each hole were as follows:

2-4-1 PD-1

Drilled length	83.50 m
Core length	79.20 m
Core recovery	100% (excluding surface soil)

Operated from Dec. 10 to Dec. 15, 1981

0.00 m - 7.40 m

Dry-drilled using 101-mm metal crown. Talus was drilled to a depth of 7.40 m. Rock quality stabilized but the wall collapsed. Cementation was performed. After the cement was expelled, NW casing pipe was installed to a depth of 7.40 m.

7.40 m - 55.70 m

Drilled using NQ-WL diamond bit and bentonite mud water. Rocks were agglomeratic tuff breccia with relatively stabilized rock quality. BW casing pipe was installed to a depth of 55.70 m. Three layers of mineralized zones were detected and confirmed between 15.80 - 17.60 m, 33.30 - 34.10 m, and 45.30 - 46.30 m.

55.70 m - 83.50 m

Drilled using BQ-WL diamond bit and bentonite mud water. Rocks were agglomeratic tuff breccia. The drilling completed at 83.50 m., achieving planned depth.

2-4-2 PD-2

Drilled length	81.00 m
Core length	48.00 m
Core recovery	77.4 % (excluding surface soil)

Operated from Dec. 2 to Dec. 7, 1981

0.00 m - 25.20 m

Dry-drilled using 101-mm metal crown. Drilling between 0.00 m and 19.00 m was difficult due to clay layer narrowing the hole. Below 19.00 m was fractured agglomeratic tuff breccia with clay. Conditions in the hole became worse in this layer and NW casing pipe was installed to a depth of 25.20 m.

25.20 m - 53.80 m

Drilled using NQ-WL diamond bit and libonite mud water. Rock consisted of fragile fracture zone of weathered agglomeratic tuff breccia. Conditions in the hole became worse and BW casing pipe was installed to the depth of 53.80 m.

A mineralized portion was detected and confirmed between 51.00 - 51.60 m.

53.80 m - 81.00 m

Drilled using BQ-WL diamond bit and libonite mud water. Rock consisted of fragile fracture zone of weathered agglomeratic tuff breccia. Purpose was achieved and drilling completed at 81.00 m.

2-4-3 PD-3

Drilled length	90.60 m
Core length	51.50 m

Core recovery 82.2 % (excluding surface soil)

Drilled from Nov. 23 to Nov. 30, 1981

0.00 m - 24.50 m

Dry drilled to a depth of 24.50 m using 101-mm metal crown. Unlikely thick clay layer was drilled. Water eruption (50 ℓ/min.) made the condition worse and NW casing pipe was installed to a depth of 24.50 m.

24.50 m - 64.60 m

Drilled using NQ-WL diamond bit and libonite mud water. Rocks consisted of fractured diabase and agglomeratic tuff breccia. Water eruption (60 ℓ/min.) was noted. Rock quality stabilized and BW casing pipe was installed to a depth of 64.60 m. Three layers of mineralized portions were detected and confirmed between 48.30 - 49.50 m, 51.50 - 54.00 m, and 57.30 - 58.50 m.

64.60 m - 90.60 m

Drilled using BQ-WL diamond bit and libonite mud water. Rocks consisted of fractured agglomeratic tuff breccia.

A mineralized portion was detected at 80.00 m and the drilling was extended by 10.00 m. Purpose was achieved and the drilling completed at 90.60 m. Three layers of mineralized portions were detected and confirmed between 72.70 - 74.10 m, 80.20 - 81.00 m, and 86.70 - 87.40 m.

2-4-4 PD-4

Drilled length 100.10 m

Core length 67.80 m

Core recovery 70.6 % (excluding surface soil)

Drilled from Nov. 10 to Nov. 17, 1981

0.00 m - 15.50 m

Dry-drilled using 101-mm metal crown. Rocks consisted of clay bands and diabase. Rock quality stabilized and NW casing pipe was installed to a depth of 15.50 m.

15.50 m - 62.00 m

Drilled using NQ-WL diamond bit and libonite mud water. Rocks consisted of weathered diabase having many cracks, agglomeratic tuff breccia, and fracture zone. The weathered fracture zone with numerous cracks caused rapid wear of the bit and lost circulation. Lost circulation was not eliminated in spite of efforts to prevent it. Cutting oil and Emal-20C were injected from the mouth and drilling was continued with a means to prevent vibration. Rock quality stabilized and BW casing pipe was installed to the depth of 62.00 m. A mineralized part was detected and confirmed between 60.50 - 62.00 m.

62.00 m - 100.10 m

Drilled using BQ-WL diamond bit and libonite mud water. Rocks were the fracture zone of agglomeratic tuff breccia having many cracks. This caused intensive bit wear and lost circulation. Lost circulation was not eliminated in spite of efforts to prevent it. Cutting oil and Emal-20C were injected and the drilling was continued with a means of preventing vibration. The purpose was achieved and the drilling completed at 100.1 m. A mineralized portion was detected and confirmed between 62.00 - 71.80 m.

2-4-5 PD-5

Drilled length	120.70 m
Core length	100.60 m
Core recovery	92.4 % (excluding surface soil)

Drilled from Nov. 2 to Nov. 9, 1981

0.00 m - 12.00 m

Dry drilled using 101-mm metal crown. Rock quality stabilized at 12.00 m deep and NW casing pipe was installed to the depth of 12.00 m.

12.00 m - 75.00 m

Drilled using NQ-WL diamond bit and libonite mud water. Rocks were diabase and agglomeratic tuff breccia. The fracture zone with many cracks caused intense lost circulation. Lost circulation was not eliminated in spite of efforts to prevent it. Emal-20C was injected from the mouth and drilling continued with a means to prevent vibration. After rock quality stabilized, BW casing pipe was installed to the depth of 63.00 m.

75.00 m - 120.70 m

Drilled using BQ-WL diamond bit and libonite mud water. Rocks were agglomeratic tuff breccia and clay bands. The purpose was achieved and the drilling completed at 120.70 m. Two layers of mineralized portions were detected and certified between 94.90 - 95.80 m and 104.90 - 110.00 m.

2-4-6 PD-6

Drilled length	120.60 m
Core length	96.80 m
Core recovery	84.9 % (excluding surface soil)

Drilled from Oct. 16 to Oct. 26, 1981

0.00 m - 16.00 m

Dry-drilled using 101-mm metal crown. Collapse of the wall was severe at 16.00-m deep and cementation was performed. After the cement was removed, NW casing pipe was installed to a depth of 16.00 m.

16.00 m - 72.10 m

Drilled using NQ-WL diamond bit and libonite mud water. Rocks were veinlets of quartz, diabase, and agglomerates. Collapse of the wall and lost circulation became severe between 16.00 m - and 20.10 m and on several occasions cementation was performed. After that, rock quality was relatively stabilized. BW casing pipe was installed to a depth of 72.10 m.

A mineralized portion was detected and confirmed between 63.00 - 72.10 m.

72.10 m - 120.60 m

Drilled using BQ-WL diamond bit and libonite mud water. Rocks were veinlets of quartz and agglomerates. The fractured quartz veins caused rapid wearing of the bit. The purpose was achieved and drilling completed at 120.60 m. Two layers of mineralized parts were detected and confirmed between 72.10 - 75.90 m and 81.80 - 99.20 m.

2-4-7 PD-7

Drilled length	160.70 m
Core length	152.30 m
Core recovery	97.1 % (excluding surface soil)

Drilled from Oct. 1 to Oct. 15, 1981

0.00 m - 12.10 m

Dry-drilled using 101-mm metal crown. Rock quality became good at 12.10 m and NW casing pipe was installed.

12.10 m - 113.10 m

Drilled using NQ-WL diamond bit and libonite mud water. Rocks were diabase, agglomerates, and agglomeratic tuff breccia. Collapse of the wall and lost circulation were severe from 12.10 to 20.00 m and on several occasions were cemented. NW casing pipe was installed in the expanded hole to a depth of 13.10 m.

Complete lost circulation occurred at 57.00 m. The crack was too large to prevent lost circulation. Emal-20C was injected from the mouth and drilling was continued without vibration. Rock quality stabilized and BW casing pipe was installed at a depth of 113.10 m. A mineralized was detected and confirmed between 98.70 - 99.70 m.

113.10 m - 160.70 m

Drilled using BQ-WL diamond bit and libonite mud water. Rocks were agglomeratic rocks and agglomeratic tuff breccia.

Rock quality showed relatively good stabilization. The purpose was achieved and drilling was completed at 160.70 m.

Two layers of mineralized parts were detected and confirmed between 132.10 - 132.50 m and 135.60 - 147.70 m.

2-5 Mobilization and Demobilization

2-5-1 Entering the area

Going to the side and setting up took 2 to 5 days before drilling was started at sites PD-7 - 6, PD-5 - 4, PD-3 - 2, and PD-1. Alteration of tilt and orientation of the drill hole at the same location took 1 to 2 days.

2-5-2 Leaving the Area

Upon departure, material and equipment were transferred to the playground owned by Guachavez using a 204 helicopter. After maintenance, the main equipment was carried to a stockhouse at Guachavez. Parts for tools were kept at the office of INGEOMINAS in Popayan.

Drilled cores of nonmineralized parts were kept at the stockhouse of Diamante with the consent of the engineers of Ingeominas counterpart. Those with mineralized portions were cut in halves using a core cutter.

One of the halves was divided in two, one of which was ground and subjected to analysis and the other examined with a microscope. The remaining half was encased in a core box and submitted to the office of Popayan Ingeominas.

2-6 Drilling Performance Results

2-6-1 Work Efficiency

As shown in A II-11, total length of the drilling holes was 757.20 m. Drilling efficiency was 4.65 m per each total shift and 5.05 m for an actual shift. Drilling rates and bit rotations are shown below:

	Drilling rate	Bit rotation
Hard rock	1.0-2.0 cm/min	400-500 rpm
Medium rock	2.0-3.0 cm/min	300-400 rpm
Soft rock	3.0-4.0 cm/min	50-150 rpm

In reality, efficiency substantially decreased due to fracture zones generally having clay and numerous cracks.

2-6-2 Core Recovery Rate

As shown in A II-11, 596.20 m of core was sampled during the drilling of 679.30 m excluding 77.90 m of surface soil.

Average core recovery rate was 87.7%.

Fig. II - 1 PROGRESS RECORD OF DIAMOND DRILLING PD-1

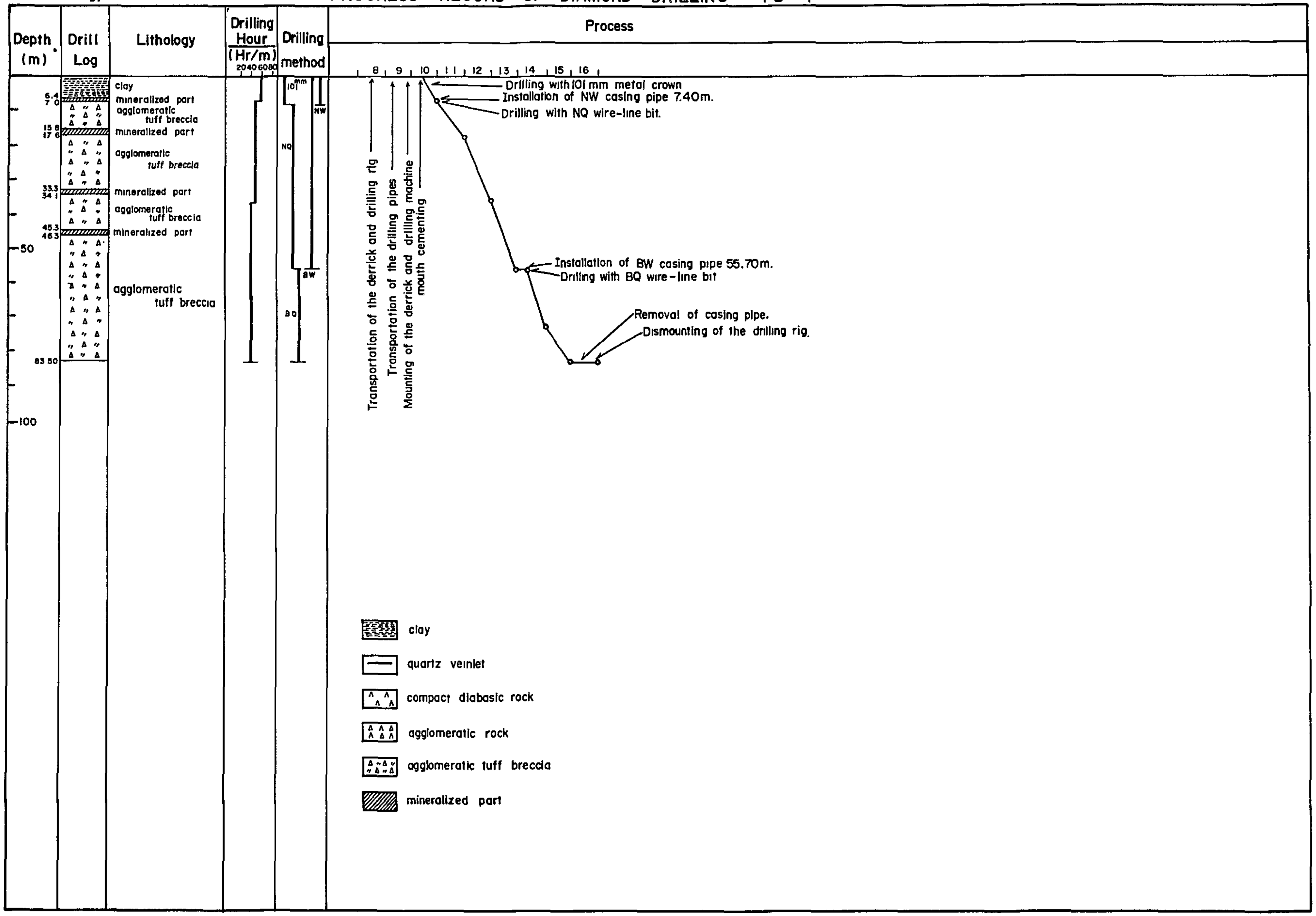


Fig. II - 2 PROGRESS RECORD OF DIAMOND DRILLING PD-2

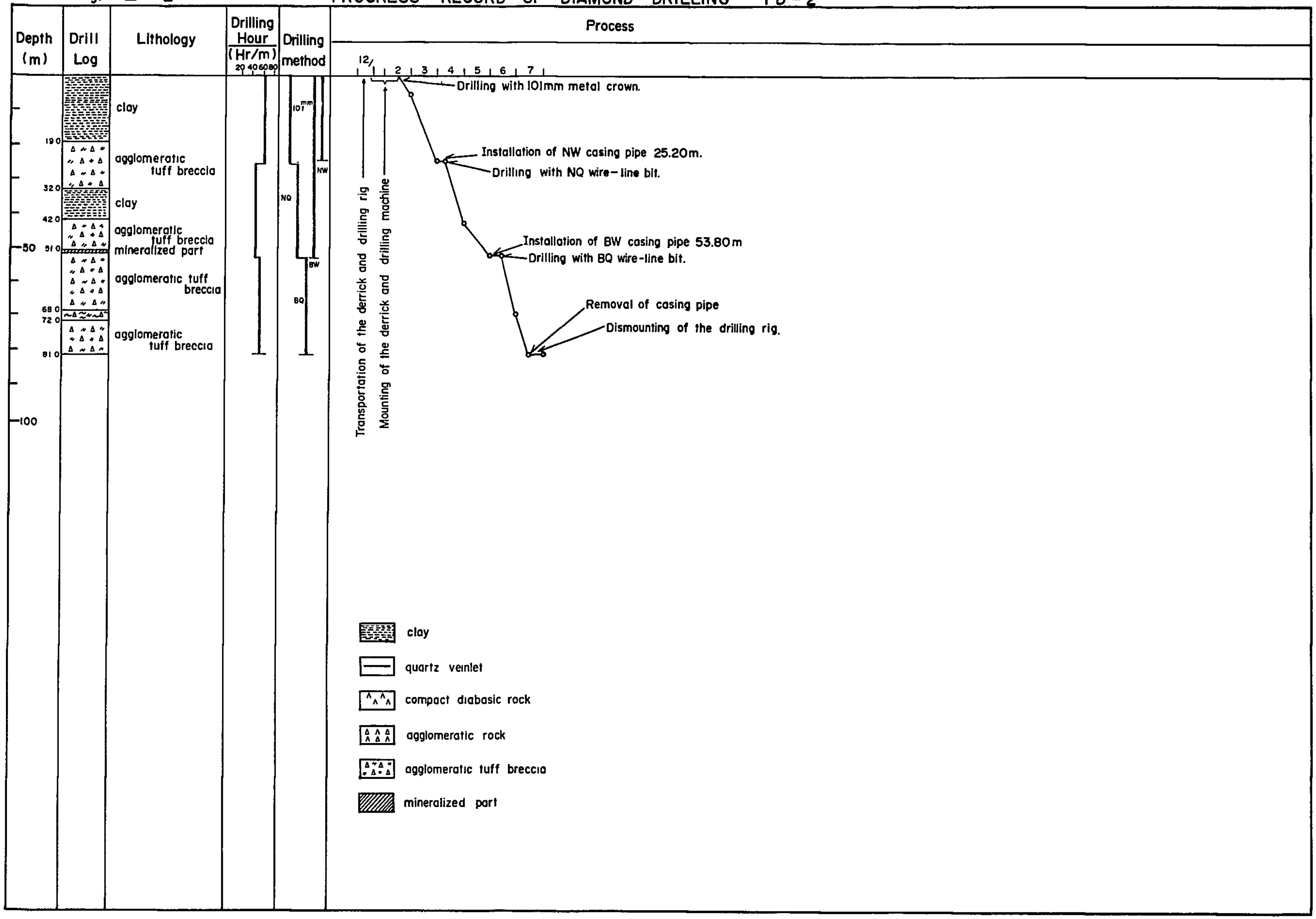


Fig. II − 3 PROGRESS RECORD OF DIAMOND DRILLING PD−3

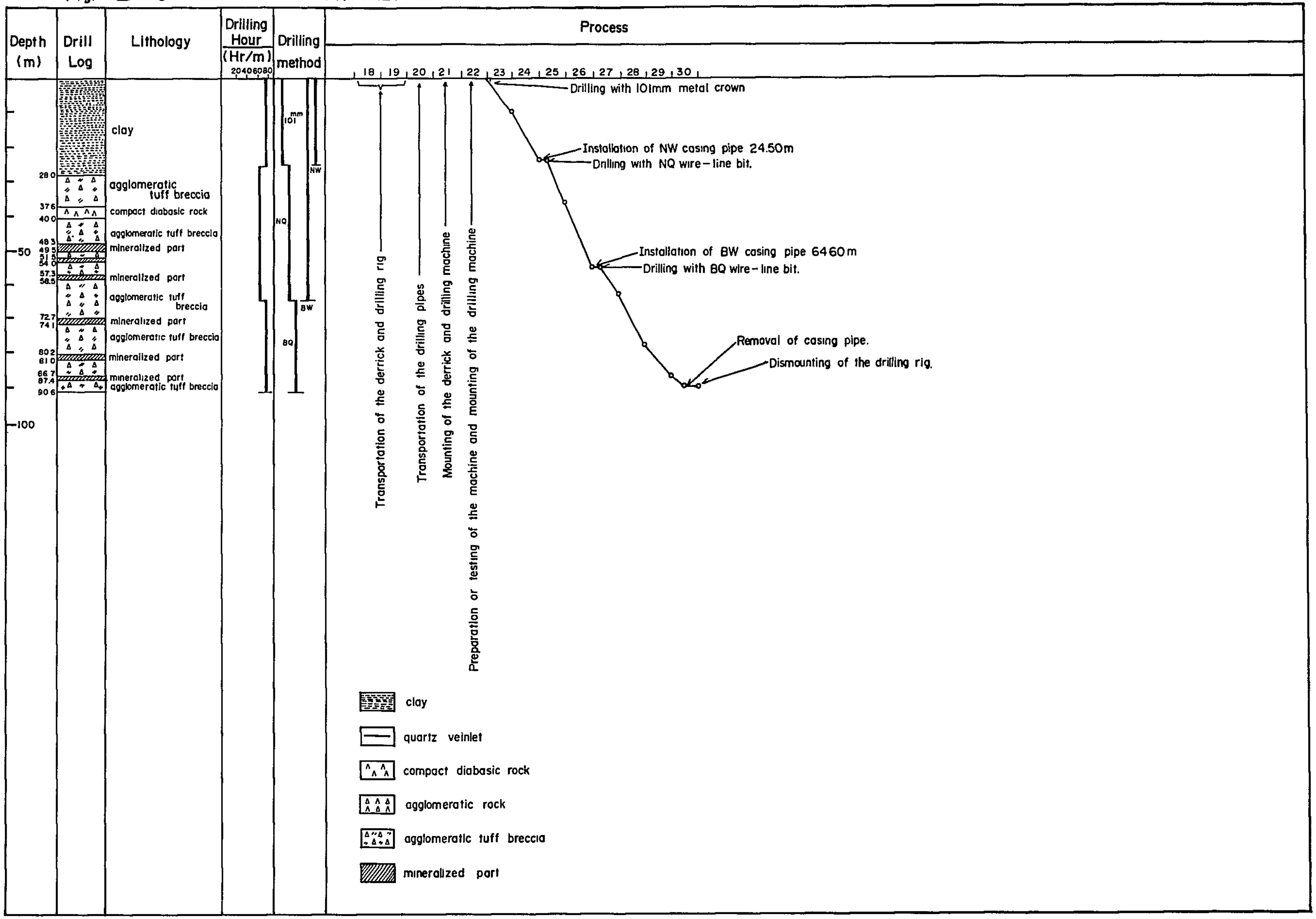


Fig Ⅱ - 4 PROGRESS RECORD OF DIAMOND DRILLING PD - 4

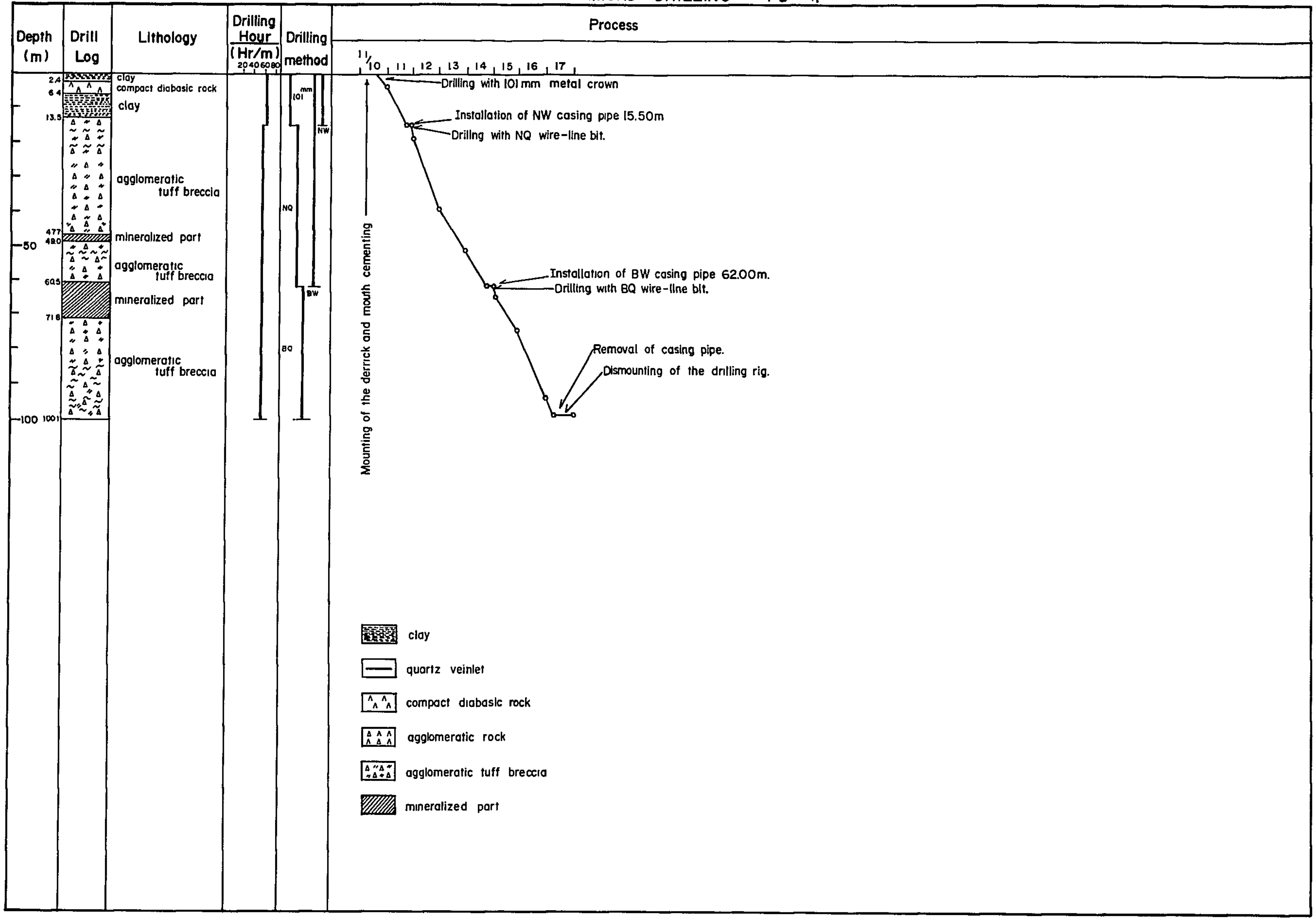


Fig. II − 5 PROGRESS RECORD OF DIAMOND DRILLING PD−5

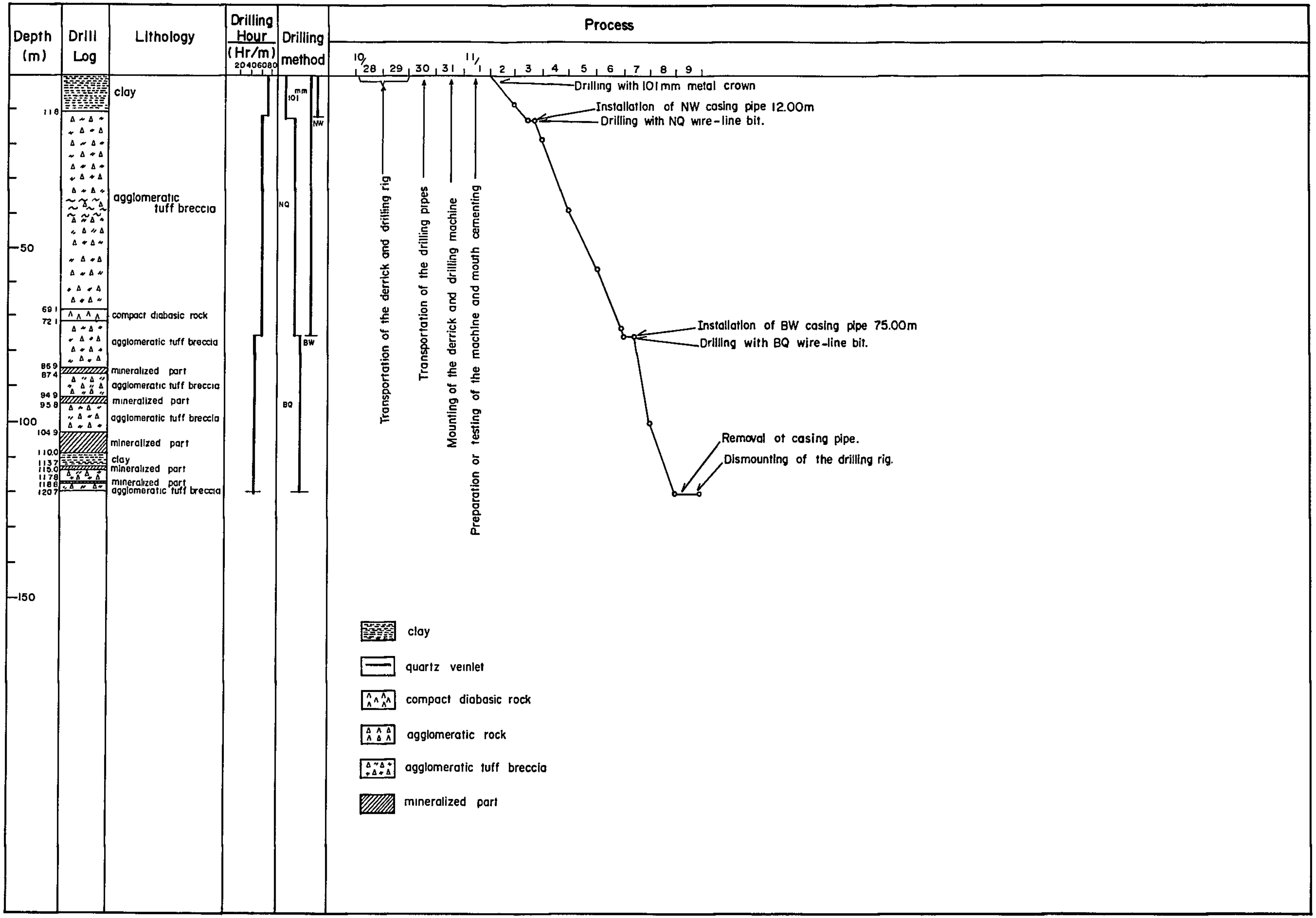


Fig II－6 PROGRESS RECORD OF DIAMOND DRILLING PD－6

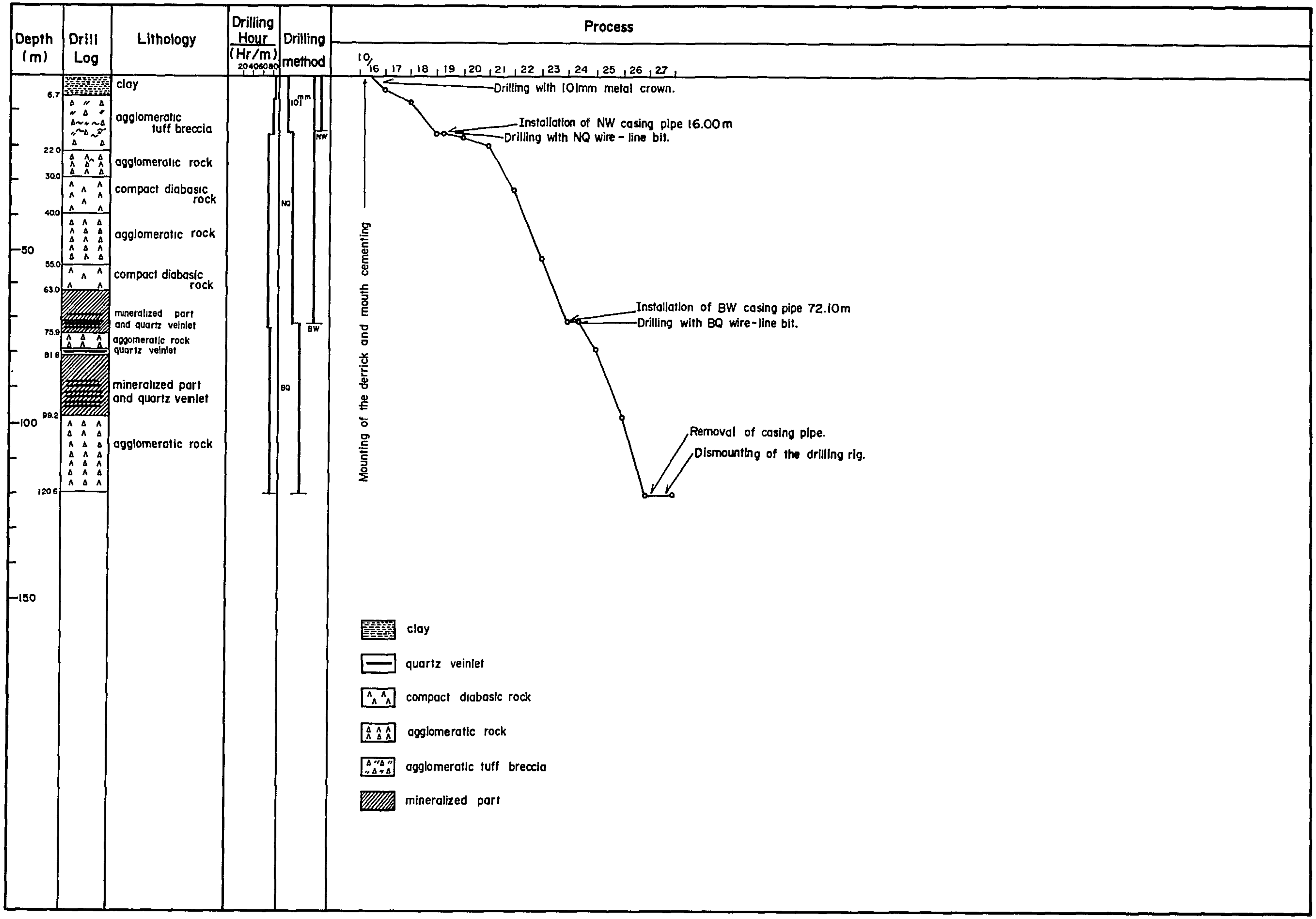
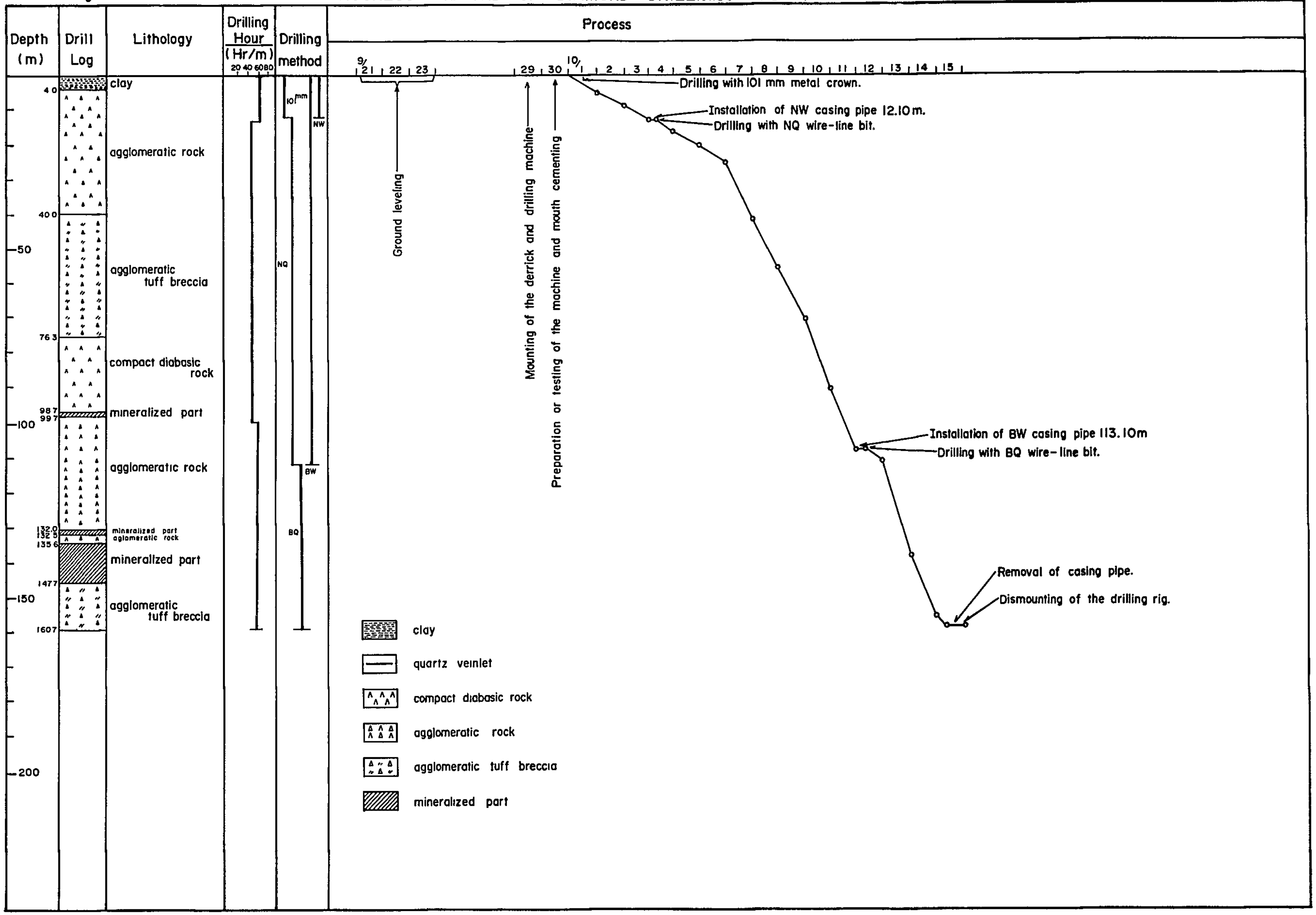


Fig. II - 7 PROGRESS RECORD OF DIAMOND DRILLING. PD-7



CHAPTER 3. GEOLOGY AND MINERALIZATION OF THE DRILL HOLES

3-1 PD-1

(1) Objective: The ore veins of the Auxiliadora mine located at 2500 m elevation contains an auriferous sulfide vein (width 120 cm, Au 15.7 g/ton), which is accompanying other irregular brecciated mineralizations nearby. This suggests the need for a survey of the deeper continuity of this vein. Since this vein generally dips northward at angles around 60°, the survey was planned to drill from a point about 20 m to the north of the portal and the hole to be drilled vertically.

(2) Location: Coordination N 2022, E 2010, elevation 2502.5 m, inclination -90°, drilled length 83.50 m. (Based on the coordinates on the map around the mine: same as the following)

(3) Lithology: From the surface to 4.3 m deep was a clayey yellow-brown surface soil. From this depth to the bottom of the 80.50-m hole was agglomeratic tuff breccia. Weak fracture was recognized from 9 m to 21 m, at 33 m, and at 59 m. But, in general, the rock is massive and compact and relatively fresh. Fractured parts contain a small amount of epidote and calcite. Under microscope (Sample No. D-1073), the rock is composed mainly of plagioclase and quartz of sizes of 0.2 to 0.3 mm.

Clinopyroxene of sizes around 0.2 mm was contained. Relatively abundant magnetite is scattered in the rock. Relatively strong calcitization was observed. On X-ray diffraction, tremolite was detected in samples of D 1006, 1016.7, and 1073, and phlogopite in sample D 1073.

(4) Mineralization and grade: Five mineralized parts with fine veinlets were recognized at points shallower than 50 m. They mainly consisted of quartz and contained small amounts of sulfide minerals (pyrite, arsenopyrite, sphalerite, etc.). Analysis was made on samples taken in each mineralized part at intervals of 30 to 130 cm. Only traces of gold and silver were detected.

(5) Discussion: This drilling revealed that the scale of the ore body at Auxiliadora mine is small.
Another drilling (PD-3) clarified that the Diamante principal vein lies somewhat to the east of this hole.
Thus, the Auxiliadora mine is not a continuation of the principal vein.

3-2 PD-2

(1) Objective: Like PD-1, this hole was operated to investigate the southern continuation of the Auxiliadora ore body. Since the ore distribution in the Auxiliadora mine is somewhat irregular, this hole was operated nearly horizontally (at -5°) to find its horizontal distribution.

(2) Location: About 110 m to the south of Auxiliadora mine, at the right-hand shore of Diamante river.
N 1919, E 2058, elevation: 2513.5 m, direction:
N15°W, inclination -5°, drilled length: 81.00 m.

(3) Lithology: Rock was generally oxidized due to the shallowness - 30 m from the surface at the deepest point - and changed to yellow-brown. Argillizations were apparent. These resulted in a lower recovery of the samples of the drilling cores. In parts deeper than

47 m where a fracture zone was located, cores were taken in forms of small particles like gravel or beans. The recovery rate was worst in this part. Although this placed some difficulty in rock identification, the rock in this part was determined as agglomatic tuff breccia like that in this vicinity, since brecciated andesite and tuff materials were recognized. Phenocrystalline minerals with a green alteration and plagioclase with sericitization and calcitization were recognized. Small amounts of magnetite and pyrite accompanyed them.

(4) Mineralization and Grade: Quartz vein was seen in some fractured cores from parts deeper than 47 m. Although most of them were contaminated with ferrous oxide, pyrites were seen in some of them. Paragenesis of magnetite, pyrrhotite, and a small amount of chalcopyrite were observed in a polished section (D 1006) of the ore vein. Gold and silver were not found when 8 samples in the mineral parts were analyzed.

(5) Discussion: It should be concluded that the ore body in Auxiliadora mine is a local mineralization lacking continuity, although this conclusion might be the result of the low core recovery in parts expected to be in the mineralized zone or it might be that gold particles had been washed away and were not detected on analysis. Results from PD-1 support this view.

3-3 PD-3

(1) Objective: This hole was planned to investigate the continuation of Auxiliadora ore body further to the south of PD-2. The hole was operated nearly horizontally since the level of survey objects was

assumed on the level of Auxiliadora mine (2500 m).

(2) Location: Dug from the same point as PD-2.

N 1919, E 2053, elevation 2523.5 m, direction:

N 70° E, inclination -5°: 90.60 m.

(3) Lithology: This hole was near the surface as in PD-2. Oxidized green rocks were found from the surface to 37.6 m. Parts deeper than this had tuff breccia. The hole intersected many fracture zones in deeper parts. The fracture zones contained fine veins of quartz and sometimes accompanied epidote and tremolite. Sericitic and potassium feldspathic alteration of plagioclase were seen in country rocks near the vein D-2051,2.

(4) Mineralization and Grade: Eight samples were analyzed. Gold was found in samples from depths of 80.2 to 81.0 m:

Width of vein	Au(g/t)	Ag(g/t)	Cu%	Pb%	Zn%	Sb%	As%
80 cm	9.6	5	0.04	0.00	0.00	0.01	0.01

On observation of polished section (D 2080.3), the constituent minerals are mostly pyrite accompanying a small amount of chalcopyrite.

Part of the pyrite had been replaced by marcasite.

Irregular electrum was scattered in quartz in sizes of about 10 μm (D 3080.3, EPMA). Small amounts of gold (0.2 g/t) were detected also in samples from 86.7 to 87.4 m.

(5) Discussion: The fracture zones in parts from 48.2 to 74.1 m corresponding to the continuation of Auxiliadora ore body has no mineralization of gold. Gold was first found at 80.2 m. This vein and the gold vein at PD-5 (see following) are considered to be the same vein,

in the direction of N 40°+W, that is the general tendency of the veins. Further elongation of this line to NW direction may be connected to the vein at the Hormiga mine.

3-4 PD-4

(1) Objective: This hole was planned to investigate the northern continuation of the mineral-rich part in the Diamante tunnel. It was expected to reach the mineralized zone at about the 2550-m level.

(2) Location: Directed to a point about 160 m NW of the mineral-rich part in the Diamante tunnel; drilling was started at the following location: N1912, E2248, elevation 2602.0 meters, direction: S 40°W, inclination -35°, drilled length: 100.10 m.

(3) Lithology: Since the drilling was almost parallel to a slope, most parts had been altered to clay due to the oxidation by surface water. Country rock was agglomeratic tuff breccia.

(4) Mineralization and Grade: Three samples taken from the most strongly fractured zone (60.5 - 71.8 m deep) were analyzed. Minute amounts of zinc and arsenic were found. Only a trace of gold was detected.

(5) Discussion: Results were unconclusive concerning the mineralized portions since most parts of the hole were drilled in weathered soft rocks. A fault (maybe younger than the mineralization) running across the hole with the direction of N 74° W and dip NE 75° is considered to be the reason that the gold vein was not detected. (See Fig. II-9 geological section of PD-4, 5).

3-5 PD-5

(1) Objective: Drilled from the same point as PD-4. This hole was planned to investigate the mineralization in levels lower than PD-4 at the 2500-m level.

(2) Location: Location and direction were the same as PD-4. Inclination was -60°.

N 1912, E 2248, elevation 2602.0 m, direction: S 40°W, Inclination: -60°, drilled length: 120.7 m.

(3) Lithology: From the surface to 11.8 m deep was a clayey brown surface soil. From this depth to the bottom was agglomeratic tuff breccia. Structure was fine and relatively fresh. Parts deeper than 85 m were generally silicified. Microscopic observation on sample D 5120 which was taken near the bottom of the hole revealed that fragmental plagioclase had undergone strong sericitization and some colored mineral that might be monoclinic pyroxene had undergone calcitization and chloritization. Quartz was crystallized in fish-eye-like or fine-veinlets form accompanying pyrites. Dolomite was found in samples D 5087 and 5108.8, detected by X ray diffraction.

(4) Mineralization and Grade: Six veins were recognized and analyzed from 86.9 m to the bottom. One vein at 86.9-87.4 m (0.50 m) contained high-grade gold and silver. Zinc and arsenic content were also high.

Horizontal width	Au g/t	Ag g/t	Cu %	Pb %	Zn %	Sb %	As %
50 cm	9.0	105	0.44	0.06	13.14	0.03	17.54

The other veins also contained 0.5 to 1.5 g/t of gold, about 0.5% of zinc and 1 to 2% of arsenic. The width of this mineralized zone suggested a correspondance to the mineral-rich portion of the Diamante tunnel. Structurally, it corresponded to the fracture zone found at 60.5 to 71.8 m in PD-4 hole (see cross section of PD-4 and 5) and extends northward to correspond to the fracture zone at 65.7 to 74.1 m in PD-3 hole.

Observation of the polished section from a depth of 87 m (D-5087) showed that the mineral assemblage was arsenopyrite, pyrite, and a small quantity of chalcopyrite. The chalcopyrite contained particles of magnetite with sizes 20 to 30 μm. Galena was seen in sample from a depth of 108.8 m (D 5108.8). Part of the pyrite in these samples had been replaced by marcasite.

Many particles of chalcopyrite were seen in sphalerite. A 30 μm electrum and seven minute (1-3 μm) ones were observed in the gangue of D5087.

(5) Discussion: The results were as expected partly owing to the location near the mineral-rich part of Diamante tunnel. However, PD-7 in the following section showed a rapid decrease in the width of the vein. Further examination of structural factors (such as faults) defining the vein is needed. Drilling should be performed on northern and southern extension.

3-6 PD-6

(1) Objective: This hole was planned to investigate the lower part of the mineral-rich part in the Diamante mine. Total structure of the mineralized zone was not clearly known because the mine is located near oxidized zone and a large portion of the mine is covered with puncheons. This drilling was expected to clarify the structure of the mineralized zone.

(2) Location: Directed to penetrate the lower part of the mineral-rich

part in Diamante tunnel at a depth between 50 to 100 m. Coordination: N 1778, E 2332, elevation: 2644.0 m, direction: S20W, inclination -60°, drilled length: 120.60 m.

(3) Lithology: From surface to 6.7 m was clayey surface soil. From this depth to the bottom was agglomerate and agglomeratic tuff breccia. Breccia was composed of green andesitic rocks. Size of the breccia varied from 3 to 10 cm. Phenocryst of pyroxene with and a small amount of biotite were seen. The matrix generally showed epidotization. It had a massive structure lacking stratification. Microscopic observation of samples D 6098 and 6102 showed fractured and flow structure in some parts. Monoclinic pyroxene and plagioclase in these sections showed amphibolic and sericitic alteration. Secondary minerals recognized were quartz, edipote, chlorite, feldspar, etc. filling interstices.

(4) Mineralization and Grade: The mineralized zone detected in this hole was the most valuable result of this year's survey. The parts with mineral indications (63.6-99.2 m) were divided into 21 samples and analyzed. The following 3 bands are contained 2.0 g/t or more of gold:

Drilling length (m)	Horizontal width (cm)	Au g/t	Ag g/t	Cu %	Pb %	Zn %	Sb %	As %
65.0-67.0	160	3.4	41	0.12	0.07	2.64	0.01	3.64
72.0-75.9	230	3.6	33	0.07	0.04	2.41	0.01	2.20
81.8-93.0	900	9.0	59	0.13	0.10	3.95	0.01	4.22

The highest assay of gold was 25.4 g/t at 90.9 to 93.0 m, that of silver was 116 gm/ton at 84.0 to 85.0 meters; that of zinc was 8.08%

part in Diamante tunnel at a depth between 50 to 100 m.

Coordination: N 1778, E 2332, elevation: 2644.0 m, direction: S20W, inclination -60°, drilled length: 120.60 m.

(3) Lithology: From surface to 6.7 m was clayey surface soil. From this depth to the bottom was agglomerate and agglomeratic tuff breccia. Breccia was composed of green andesitic rocks. Size of the breccia varied from 3 to 10 cm. Phenocryst of pyroxene with and a small amount of biotite were seen. The matrix generally showed epidotization. It had a massive structure lacking stratification. Microscopic observation of samples D 6098 and 6102 showed fractured and flow structure in some parts. Monoclinic pyroxene and plagioclase in these sections showed amphibolic and sericitic alteration. Secondary minerals recognized were quartz, edipote, chlorite, feldspar, etc. filling interstices.

(4) Mineralization and Grade: The mineralized zone detected in this hole was the most valuable result of this year's survey. The parts with mineral indications (63.6-99.2 m) were divided into 21 samples and analyzed. The following 3 bands are contained 2.0 g/t or more of gold:

Drilling length (m)	Horizontal width (cm)	Au g/t	Ag g/t	Cu %	Pb %	Zn %	Sb %	As %
65.0-67.0	160	3.4	41	0.12	0.07	2.64	0.01	3.64
72.0-75.9	230	3.6	33	0.07	0.04	2.41	0.01	2.20
81.8-93.0	900	9.0	59	0.13	0.10	3.95	0.01	4.22

The highest assay of gold was 25.4 g/t at 90.9 to 93.0 m, that of silver was 116 gm/ton at 84.0 to 85.0 meters; that of zinc was 8.08%

at 85.8 to 87.5 m; that of arsenic was 9.94% at 87.5 to 89.2 meters. Macroscopically following minerals are observable in the samples; ore minerals- pyrite, arsenopyrite, sphalerite and chalcopyrite, gangue mineral - quartz with transparent or white-colored semitransparent character. Under the microscope, in addition to the abovementioned minerals, the following minerals are recognized; pyrrhotite, galena, argentite, polybasite, pyragyrite, and boulangerite. Argentite (20 μm), polybasite (50 μm), and pyragyrite (30 μm) in paragenesis with chalcopyrite were seen embedded in pyrite. A Needle-like crystallization of boulangerite (width 1-2 um, length 150 um) in galena was recognized. These minute minerals were examined with X-ray microanalysis. Sphalerite contained a relatively large amount of chalcopyrite. It was noted that pyrite crystals in veinlets form filled the interstices of fractured crystals of sphalerite and chalcopyrite.

3-7 PD-7

(1) Objective: This hole was operated from the same location as PD-6 to investigate the status of ore in the mineral-rich part in Diamante mine at the 2500-m level.

(2) Location: Location and direction were the same as PD-6 but inclination: was -80°.
N 1788, E 2332, elevation 2644.0 m direction: S 20° W, inclination: -80°, drilled depth: 160.70 m.

(3) Lithology: Brown clay was found from the surface to 4.0 m deep. From this depth to 40 meters was agglomeratic tuff breccia. The lower part to 77 m was fine green andesitic rock. This rock included a

brecciated portion. From this depth to the bottom was agglomeratic tuff breccia containing 2 cm to 20 cm breccia. Epidotization and chloritization changes were generally noted. Monoclinic pyroxene with almost complete amphibolic alteration was observed with the microscope. Moderate sericitization and chloritization changes were also seen. Phenocrysts of plagioclase showed sericitic, chloritic, and edipotic alteration. Part of the phenocrysts had flow structure (D 7080, 7126, and 7160).

(4) Mineralization and Grade: There were weak mineralizations of gold near depths of 53.5 m and 99.5 m, accompanying a small amount of pyrite. The strongest mineralization was recognized between depths of 143.1 m and 145.1 m where the fracturing was also the strongest. Results of analysis were:

Horizontal width	Au gm/ton	Ag g/t	Cu %	Pb %	Zn %	Sb %	As %
(80 cm)	7.0	92	0.22	0.11	10.91	0.02	12.63

This mineral zone continued downward with a decreasing grade of gold. Samples from 145.1 to 147.7 m contained:

Horizontal width	Au gm/ton	Ag g/t	Cu %	Pb %	Zn %	Sb %	As %
(104 cm)	1.8	19	0.07	0.01	1.58	0.00	0.29

The vein seen between 143.1 and 145.1 m resembled the vein seen in PD-3 and PD-5 both in width and grade. The vein in PD-5 was almost identical to this vein in grades of zinc and arsenic.
Mineral composition of polished sections showed the same tendency. Arsenopyrite, sphalerite, and pyrite were the chief components. Sphelerite contained particles of chalcopyrite. Part of the pyrite

was replaced by marcasite. At the edges of arsenopyrite were 25 μm electrum in paragenesis with sphalerite (D 7144, 7155).

(5) Discussion: The drilling intersected a vein that may have economic value. Location of this vein was in concordance with that of the veins in PD-6 and PD-5.
More drilling will be performed around this vein to clarify whether the decrease in one width reflects a general tendency or is only local.

3-8 Conclusion of the Drilling Survey

Seven drilling works were operated in a 400 m distance from Auxiliadora mine to Diamante mine. Ore veins containing gold were detected in 4 holes of them (PD-3,5,6, and 7). PD-1 and 2, which did not cut a ore vein, showed that the gold ore body in Auxiliadora mine is distributed only locally.
The location where PD-3 hole cut the gold vein suggests the possibility that Diamante principal vein is not a continuation of the ore body in Auxiliadora mine but is lying about 50 m east of this ore body. The Diamante principal vein was considered to continue to the vein in Hormiga mine about 200 m north of it.

Evaluation of gold veins using drilling, sometimes, is too much affected by the change of the gold particles caught in the core samples. Then direct utilization of the analysis results for ore reserve involves some risk. But the results of this survey are appreciable as a general understanding of the nature of the Diamante principal vein. Important findings are:

(1) The veins in PD-3, 5, and 7 has a horizontal width of 80, 50, and 80 cm and gold grades of 9.6, 9.0, and 7.0 g/t. These values of grade showed the stability of the veins.

(2) In PD-6, a 1 to 2-m thick ore vein occurred in the upper (eastern) bed and another very thick mineralized zone occurred in the lower (western) bed across a low-grade or nonmineralized part. This structure is similar to that in Diamante tunnel. Grades in this hole were too similar to those found in the mine (7-9 g/t).

(3) Occurrence of the gold has the following characteristics:

a. The vein in PD-3 is a quartz vein lacking metal sulfides and having more Au/Ag than in other veins (1/0.5). The veins in PD-5 and 7 contained more sulfides and silver (PD-5 Au/Ag is 1/12, PD-7 Au/Ag is 1/13). The vein in PD-6 resembled those in PD-5 and 7, having Au/Ag of 1/10 to 1/7. Two forms of gold veins were discernible.

b. Irregular formed electrum is distributed in quartz in PD-3. Electrum in PD-5, 6, and 7 were distributed in interstices or on edges of the crystals of the sulfide minerals. Few were included in pyrite.

(4) Country rock is chiefly agglomeratic tuff brecia. Ore occurred in largely homogeneous rocks. However, geology of PD-7 has andesite in part and generally is compact.

(5) Main alterations are edipotization and chloritization. Silicification is rare. Sericitization and potassic alteration are typically weak. Horizontal variation was small, and vertical variation is a theme for the future survey.

The following questions were left to be solved in future surveys:

(1) Judging from the location, gold vein caught in PD-3 is considered to be the northern continuation of the vein in PD-5. The difference between the quality of these two may be the change of mineralization in a single vein or may show the two different veins.

(2) Horizontal extension of the mineral-rich body in PD-6.

(3) Microscopic observation, X-ray microanalysis, and X-ray diffraction clarified the relation between minerals of sulfide ore. Occurrence and paragenesis of argentite, pyrargyrite, sphalerite, etc. were found. Vertical and horizontal distribution pattern of them are left unknown because the num-er of checkpoints were not sufficient.

This drilling survey has been effected with a distance between their locations of 150 to 200 m, that was slightly too wide for prospecting for gold veins. More drilling should be done at points between the points surveyed here and in the area south of PD-6, and 7 using an interval of about 100 m.

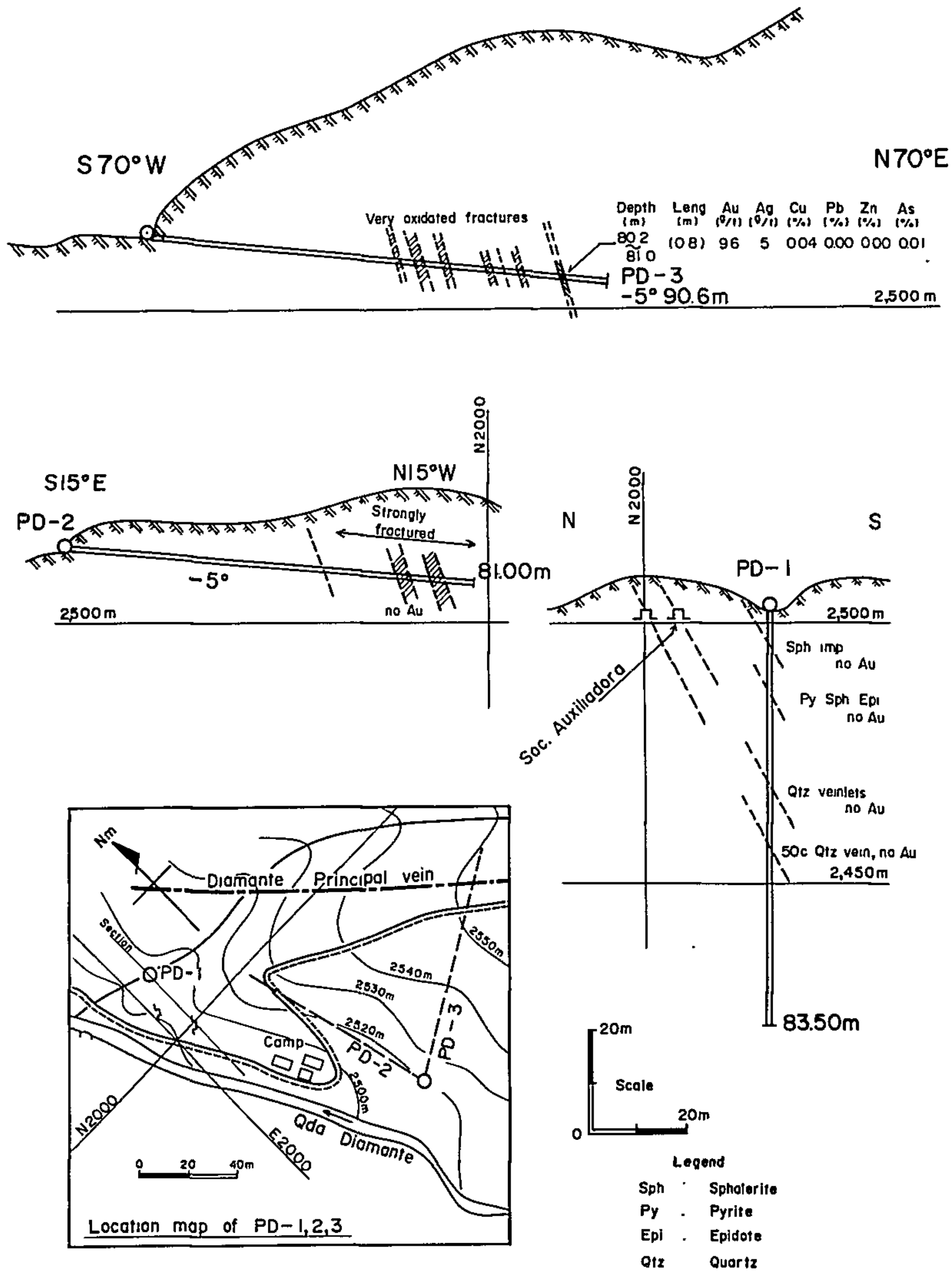


Fig. II-8 Geological section for PD-1, PD-2, PD-3

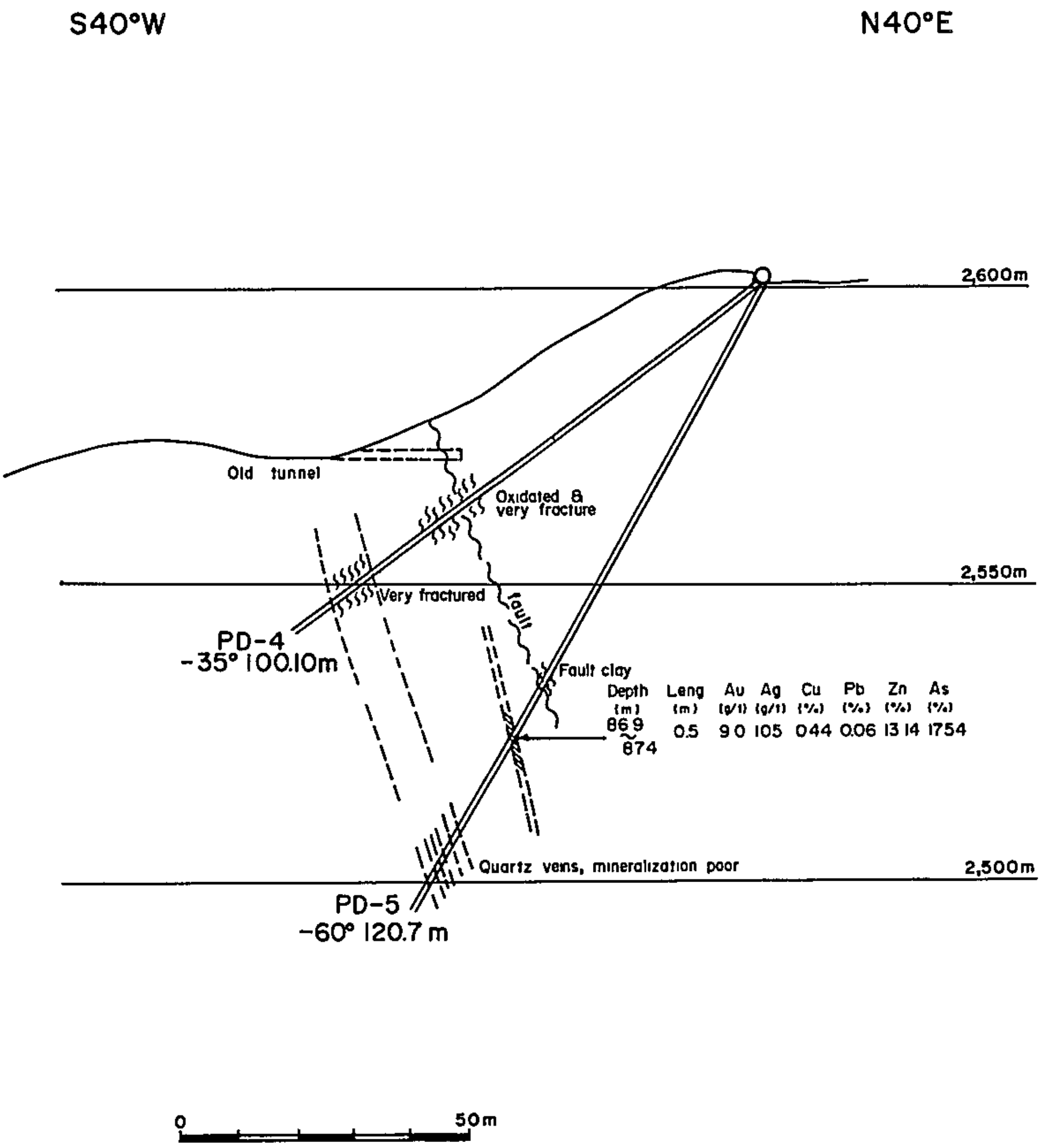


Fig. II-9 Geological section for PD-4, PD-5

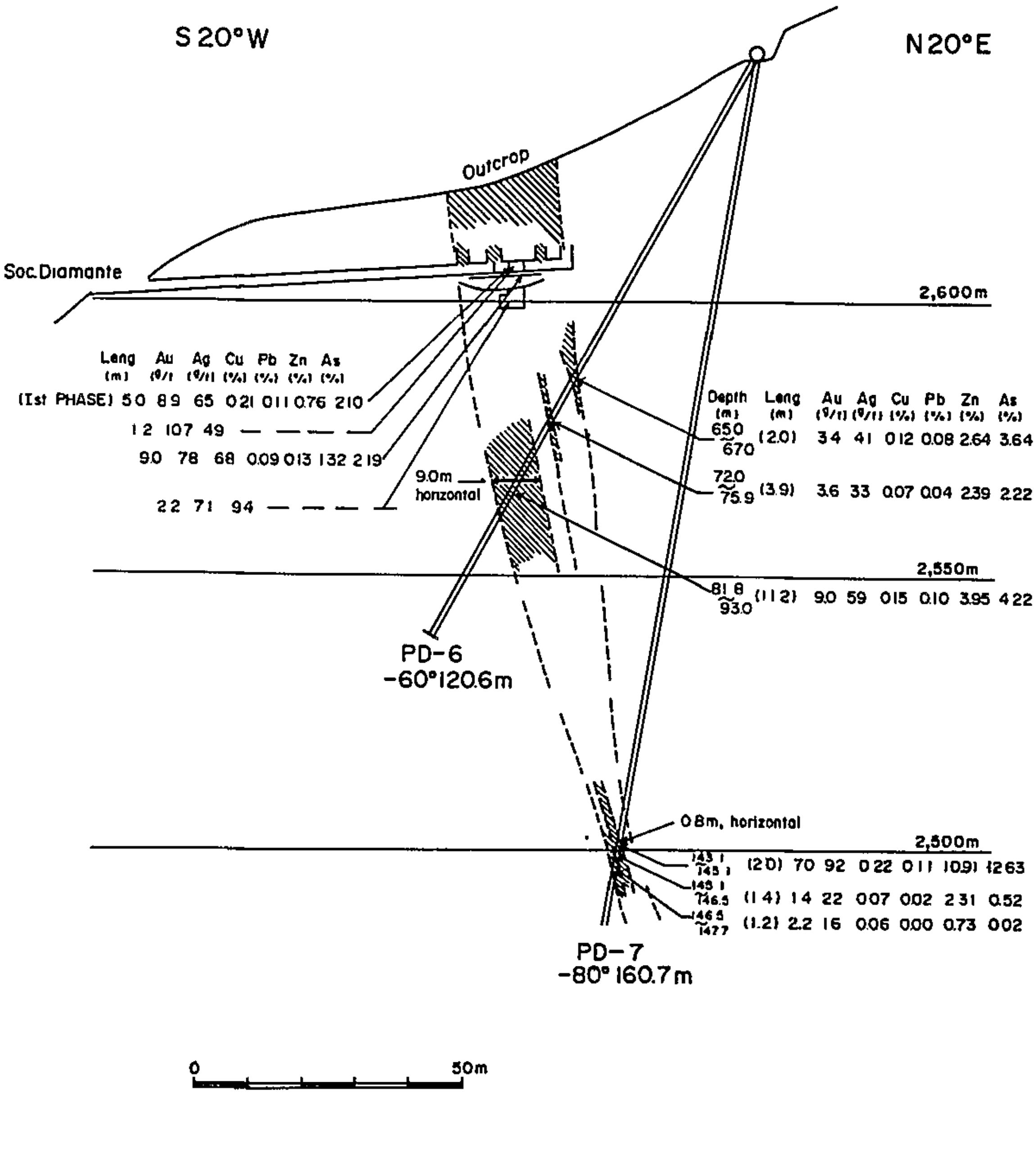


Fig. II-10 Geological section for PD-6, PD-7

Table II-1 Results of X-ray Diffractive Analysis

Sample No.	Locality	Geological Unit	Quartz	Plagioclase	Dolomite	Siderite	Epidote	Tremolite	Pyroxene	Chlorite	Sericite	Phlogopite	Kaolinite	Montmorillonite	Ore Mineral					
															Sphalerite	Chalcopyrite	Pyrite	Marcasite	Arsenopyrite	Hematite
D1006	PD-1	Pyrrhotite-magnetite ore		++				++	+++											
D1016.7	PD-1	Fe-oxide ore	++				++	++		++							++	++		
D1073	PD-1	Altered andesitic rock		++				+++	++			+++								
D2051.2	PD-2	Andesitic rock	++				+++	+++	++											
D3080.3	PD-3	Pyrite ore	++			++	++			++					+	+	+++	+		
D5087	PD-5	Pyrite ore	+		+++										+++	++	++	+	++	
D5108.8	PD-5	Pyrite-sphalerite ore	+++		++	+									++	+	+++			
D6083	PD-6	Sphalerite-pyrite-arsenopyrite ore	+++												+++	++	++			+
D6065	PD-6	Pyrite-arsenopyrite-sphalerite ore	+++												+++	++			++	
D6073	PD-6	Arsenopyrite-sphalerite-pyrite-chalcopyrite ore	+++												+++	++	++		++	
D6086	PD-6	Pyrite-arsenopyrite-sphalerite ore			+++										++		+++			++
D6098	PD-6	Altered rock	+++			++					++		++	++						
D7126	PD-7	Altered andesite	+++	+++				++	++	++										
D7144	PD-7	Sphalerite-arsenopyrite ore	++												+++	++	++		+++	
D7145	PD-7	Arsenopyrite-sphalerite-pyrite ore	++			++									+++	++	+++	++		++

Note : +++ ... Very much, ++ ... Much, + ... Present (recognizable peak)

APPENDICES

PART I

GEOLOGICAL AND GEOCHEMICAL DATA

LIST OF APPENDICES

A. I - I Chemical Analysis of Soil Samples

Note

Locality	Geology-Lithologic groups
RB - Rio Blanco	G - Granodiorite
LV - La Verde	V - Volcanic rocks
B - Bombona	S - Sedimentary rocks
D - Diamante	

Sample No.	Locality	Geology	Assay Cu(ppm)	Value Mo(ppm)
RS- 1	RB	G	148	3
RS- 2	RB	G	18	3
RS- 3	RB	G	37	3
RS- 4	RB	G	44	3
RS- 5	RB	G	21	3
RS- 6	RB	G	36	2
RS- 7	RB	G	65	3
RS- 8	RB	G	34	2
RS- 9	RB	G	74	4
RS- 10	RB	G	56	4
RS- 11	RB	G	97	12
RS- 12	RB	G	48	2
RS- 13	RB	G	185	6
RS- 14	RB	G	139	2
RS- 15	RB	G	38	3
RS- 16	RB	G	11	3
RS- 17	RB	G	8	6
RS- 18	RB	G	12	3
RS- 19	RB	G	10	3
RS- 20	RB	G	12	3
RS- 21	RB	G	12	3
RS- 22	RB	G	6	7
RS- 23	RB	G	8	3
RS- 24	RB	G	13	2
RS- 25	RB	G	5	5
RS- 26	RB	G	21	3
RS- 27	RB	G	6	4
RS- 28	RB	G	7	8
RS- 29	RB	G	5	4
RS- 30	RB	G	5	2
RS- 31	RB	G	9	2
RS- 32	RB	G	7	3
RS- 33	RB	G	5	3
RS- 34	RB	G	4	2
RS- 35	RB	G	4	2
RS- 36	RB	G	6	2
RS- 37	RB	G	7	2
RS- 38	RB	G	10	3
RS- 39	RB	G	7	3
RS- 40	RB	G	57	3
RS- 41	RB	G	18	3
RS- 42	RB	G	46	4
RS- 43	RB	G	9	3
RS- 44	RB	G	15	2
RS- 45	RB	G	19	3
RS- 46	RB	G	32	3
RS- 47	RB	G	133	2
RS- 48	RB	G	180	2
RS- 49	RB	G	240	2
RS- 50	RB	G	63	1
RS- 51	RB	G	11	4
RS- 52	RB	G	140	1
RS- 53	RB	G	202	1

Sample No.	Locality	Geology	Assay Cu(ppm)	Value Mo(ppm)
RS- 54	RB	G	295	1
RS- 55	RB	G	137	1
RS- 56	RB	G	28	2
RS- 57	RB	G	26	4
RS- 58	RB	G	32	2
RS- 59	RB	G	43	4
RS- 60	RB	G	289	1
RS- 62	RB	G	88	3
RS- 63	RB	G	83	2
RS- 64	RB	G	353	1
RS- 65	RB	G	66	2
RS- 66	RB	G	592	4
RS- 67	RB	G	30	5
RS- 68	RB	G	220	5
RS- 69	RB	G	328	6
RS- 70	RB	G	280	4
RS- 71	RB	G	261	3
RS- 72	RB	G	158	3
RS- 73	RB	G	156	3
RS- 74	RB	G	137	3
RS- 75	RB	G	155	2
RS- 76	RB	G	200	2
RS- 77	RB	G	94	2
RS- 78	RB	G	149	1
RS- 79	RB	G	220	2
RS- 80	RB	G	64	1
RS- 81	RB	G	63	1
RS- 82	RB	G	55	3
RS- 83	RB	G	90	3
RS- 84	RB	G	97	1
RS- 85	RB	G	41	2
RS- 86	RB	G	157	1
RS- 87	RB	G	144	2
RS- 88	RB	G	23	1
RS- 89	RB	G	59	1
RS- 90	RB	G	75	1
RS- 91	RB	G	34	1
RS- 92	RB	G	69	2
RS- 94	RB	G	154	1
RS- 95	RB	G	27	4
RS- 96	RB	G	36	2
RS- 97	RB	G	30	1
RS- 98	RB	G	36	2
RS- 99	RB	G	93	1
RS-100	RB	G	33	1
RS-101	RB	G	54	2
RS-102	RB	G	54	2
RS-103	RB	G	22	2
RS-104	RB	G	17	2
RS-105	RB	G	47	3
RS-106	RB	G	59	2
RS-107	RB	G	112	1
RS-108	RB	G	20	2