REPUBLIC OF COLOMBIA

REPORT ON GEOLOGICAL SURVEY
OF
PIEDRANCHA AREA

PHASE I

FEBRUARY 1981

METAL MINING AGENCY OF JAPAN

JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

The Government of Japan, in response to the request of the Government of the Republic of Colombia, decided to conduct collaborative mineral exploration in Piedrancha area in south-western Colombia and entrusted its execution to Japan International Cooperation Agency (JICA) and Metal Mining Agency of Japan (MMAJ).

Between 12 August and 4 November, 1980, Metal Mining Agency of Japan despatched a survey team headed by Mr. Junnosuke Oikawa to conduct the Phase I of the project.

The survey had been accomplished under close cooperation with the Government of the Republic of Colombia and its various authorities.

This report is a compilation of the survey of the Phase I, and after the completion of the project the consolidated report will be submitted to the Government of the Republic of Colombia.

We wish to express our appreciation to all of the organizations and members who bore the responsibility for the project; the Government of the Republic of Colombia, Instituto Nacional de Investigaciones Geologico-Mineras (INGEOMINAS), and other authorities and the Embassy of Japan in Colombia.

February 1981

Keisuke Arita
President
Japan International Cooperation Agency

Masayuki Nishiie
President
Metal Mining Agency of Japan

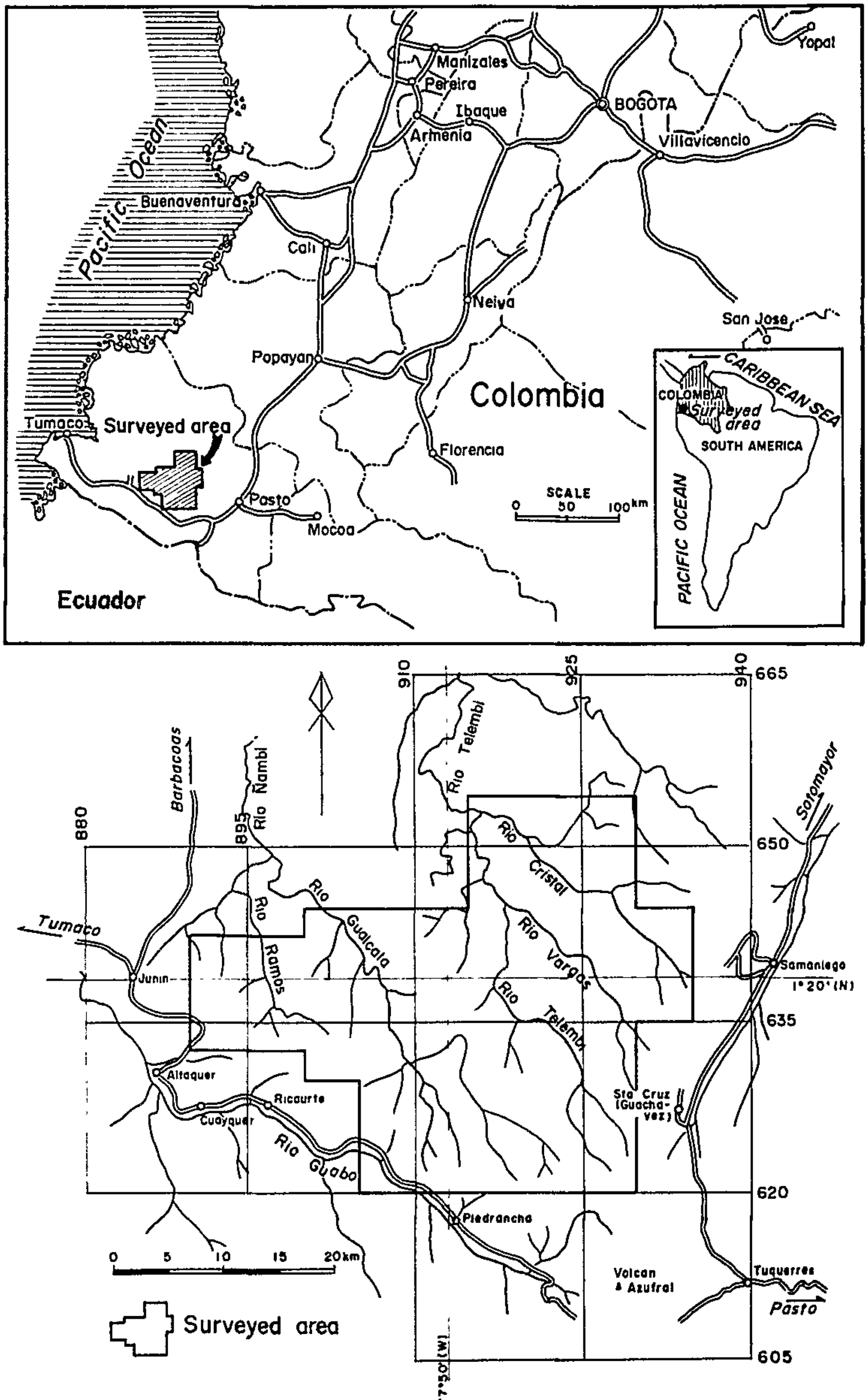

Fig. 1 Location map of the surveyed area

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ABSTRACT

The present survey has been carried out in accordance with the Scope of Work agreed upon in June, 1980 between two bodies; Prelimary investigation and negotiation body despatched by the Japanese government, and Geology and Mine Survey Bureau of Colombian government (INGEOMINAS). The actual survey team of Japan was despatched on August 12, 1980 and performed geological survey and geochemical survey till November 4, 1980. The surveyed area extends to 1,000 km^2, total explorative length to 540 km, and collected samples of stream sediment amount to 1425 in numbers.

Since no satisfactory topographic map was available for the area to be surveyed, a new drainage and quasi-topographic map (1/50,000 in scale) was prepared using various obtainable data such as Landsat image, etc., and photogeological interpretation was made for the support of field survey information and synthetic analysis.

Six Japanese geologists including a chief of the survey team conducted survey works at the site, accompanied by a Colombian geologist of counterpart in the field too.

Being densely covered with trees without any driveway under tropical climate and in range of 300 m to 3,000 m above sea level, the surveyed area presents a steep and sharp topography, making the exploration works in the site extremely difficult, together with each river rich in water and swift in stream.

Regarding geological features, weak metamorphosed sedimentary rocks are distributed in the east region, green volcanic rocks in the west, and granodiorite penetrates in the central portion of the east region in the form of batholith. These sedimentary rocks, consisting of black shales, slates, sandstones, conglomerate, etc., have been subjected to regional

weak matamorphism and contact metamorphism by granodiorite. Those green volcanic rocks comprize green tuff breccias, basalts, andesites, etc. each of which is regarded as Cretaceous sediment. The strike of the sedimentary rocks is generally N-S to N 30°E, presenting an isoclinal folding inclined to the east, whereas the green volcanic rocks are distributed, showing low dip undulation. The fault structures appear remarkably in three directions; NE-SW, NW-SE, and NNW-SSE, among which those two in NE-SW, and NW-SE directions have conjugate relation each other, having a grid-like pattern of 7 km distance approximately.

As a results of geochemical exploration, geological survey, and experimental research indoors, five (5) regions of porphyry copper type mineralization showing and two (2) regions of new auriferous minerlization showing were extracted. The former regions are situated in the western part of the surveyed area and distributed in the fault belt of the NE-SW system. However, the scale and quality of the ore deposit are unknown, requiring future investigation. There is a possibility of discovery of new vein and ore deposits in the latter regions, especially in the anomaly area of Nevada, and also a expectation of placer gold deposits in middle basin of Gualcala anomaly area. In addition, the known gold ore deposits located in the area include two types, namely milky white quartz vein type, and polymetallic vein type which contain useful metallic resources such as sphalerite, galena, etc. The above resources are not yet utilized but a considerable amount of reserves might be expected. Therefore, the exploration and research into ore quality are of much importance. Under such circumstance, the following items are recommendable as the survey works in the fiscal second year:

(1) Precise geological survey into the mineralized zone in the porphyry copper type mineralization showing, and exploration for strongly

mineralized zone by means of geochemical soil sampling along the ridges.

(2) More detailed geochemical exploration and geological survey in Nevada area among the new auriferous mineralization showings. Pitting survey and investigation into river gravels distribution and topography for placer gold deposits on the middle basin of Gualcala.

(3) Precise geological survey, geochemical exploration, drilling investigation, and metallurgical research for the purpose of grasping vein distribution and evaluation in the gold bearing polymetallic vein type deposits.

CHAPTER 1. INTRODUCTION

1-1 Circumstance and Purpose of the Survey Works

The Republic of Colombia is situated in the north-western corner of the South American Continent, having a total area of 1,139,000 km^2 and prevailing industries of agriculture and stock-farming including coffee production which is famous all over the world. In addition, the national economy was greatly dependent upon the crude oil production that was sufficient for domestic demand until 1975.

Under such circumstance, Colombia has made little progress in prospecting activity and mining industry except crude oil development on the basis of international capital and processing of precious metals and stones such as gold, silver, platinum, emerald, etc., that was the traditional industry from pre-Spanish colonial age.

However, the discovery and development of large-scale copper ore deposits one after another in the Pacific coast of South America since 1960 has made an important role in accelerating the positive prospecting and development of non-ferrous metal deposits in Colombia.

Such being the case, Colombia requested Japan in September 1964 to cooperate in investigating undeveloped non-ferrous metal resources. Consequently, Overseas Technical Cooperation Agency of Japan despatched a survey team twice, in 1965 and 1966.

Thereafter, exploration activity was made since 1965 for the western chain of mountains with the aid of American International Development Agency, resulting in the discovery of the copper ore deposit zone in 1972 in the north-western part of Colombia (Cerro Pantanos). Furthermore, in 1973, mineral resources exploration plan was established with the aid of United Nations Development Program Agency (UNDP), and led to the discovery of mineralization showings including prospective copper, molybdenum, lead, and zinc in five regions; Acande area in Choco Department, Rovira area in Tolima Department, Mocoa and Patascoy areas in Putomayo Department, and Piedrancha Area in Nariño Department. Further investigation was made into the above five areas, among which the prospecting of copper and molybdenum ore deposits in Mocoa area has made achievements most and been still developed with the aid of UNDP.

In December 1976, basic agreement for technological cooperation was made between Colombia and Japan and enabled various technological assistance. In 1978, Colombia requested Japan to cooperate in research and development of mineral resources under government cooperation basis. In response to the above, Japan International Cooperation Agency and Metal Mining Agency of Japan, both despatched the survey team twice, in July 1978 and June 1979 to discuss with the Colombian Authority concerning the possibility of application of the "collaborative mineral exploration" system.

As a final result, the following four areas were nominated as most suitable places for collaborative investigation: Acande area, southern part of Rovira - Chaparral Area, Piedrancha area, and Cerro Pantanos Area. Moreover, in order to evaluate the order of technological priority, for each object a planning and survey team comprizing four geological experts was despatched to the site. On the basis of the results of site survey from September to October in 1979, the above team recommended two areas - Cerro Pantanos and Piedrancha - as objects of collaborative investigation.

Colombian government, however, decided to proceed with survey by themselves into Cerro Pantanos area, and formally requested Japan to cooperate in surveying Piedrancha area. In order to determine the matter in detail, Japanese government despatched Preliminary investigation and Negotiation Team in May, 1980, who, after the observation of Piedrancha area, discussed about the Scope of Work with the counterpart; INGEOMINAS (Instituto Nacional de Investigaciones Geologico-mineras = Geology and Mine Survey Bureau of Colombia) in regard to the Scope of Work, which was determined and agreed upon between two bodies.

The present survey work, carried out in accordance with the Scope of Work agreed upon under the above-mentioned circumstance from fiscal this year, includes the following definite purpose: The acquirement of useful guideline for the next-stage exploration activity by means of conducting geological survey and geochemical exploration, and grasping geological environment and ore deposit showings that are expected for the elucidation of geological structure and existance of ore deposit, together with the investigation on the existing reports.

1-2 Outline of the Survey Works in the First Phase

1-2-1 Surveyed Area

The surveyed area is situated at the southwestern end of the Republic of Colombia and in the middle of Department Nariño which is facing the Pacific Ocean, and extends to 1000 km^2 with overall length of 45 km, 35 km in east-to-west and south-to-north direction, respectively.

There are a lot of drainage systems including Gualcala river and Telembi river, flowing to NNW in the surveyed area, where the height above sea level ranges from 300 m at the minimum to 3000 m or something at the maximum. The lower part of the area presents a tropical jungle, high in temperature and rich in rain, however, the climate becomes mild and warm in the elevated place, where stock-farms can be seen.

1-2-2 Method and Contents of Survey Works

As the survey work in this fiscal year, preparation of quasi-topographic map, photogeological interpretation, geological survey, and geochemical exploration were accomplished.

Radar image was mainly used for the preparation of quasi-topographic map and photogeological interpretation with the aid of Landsat image. An aerialphotograph of 1/30,000 scale was available for the middle part of the eastern area, and the analysis results were used for the survey work. Regarding the geological survey and geochemical exploration, the surveyed area extends to 1,000 km^2, total explorative length mainly along rivers to 540 km, and collected samples of stream sediments amount to 1425 in numbers.

As to the surveying procedure, the area to be surveyed was divided at around the centre line into east and west part, taking into consideration the existing drainage system. The east part was surveyed during the first half period of survey, and the west part during the second half. The exploration of main rivers was performed by six (6) survey groups, each of which consists of one Japanese geologist, one assistant and five labors of the region.

The geological survey was carried out using measure tapes, clinometers, and hand-levels, and by spacing and visual measuring for steep and sharp topography.

In the survey site, geological data and rock samples were collected along with the drawing-up of route map (1/5000), which was finally compacted as a route map of 1/25,000 and geological map of 1/50,000.

The geochemical exploration, in company with the geological survey, was accomplished by means of collecting stream sediments samples of 80 mesh under at intervals in range of 300 m to 500 m but 100 m to 300 m for some areas showing the possibility of mineralization zone.

In the above practice, simplified qualitative analysis (copper with biquinolin method) was made for collected samples according to the demand and used for the extraction of mineralized area and judgement for the importance of the area to be surveyed.

Also, at the places where samples were taken for geochemical exploration, panning was made for the purpose of placer gold exploration.

Samples for geochemical exploration were analyzed in Japan for five elements of gold, copper, lead, zinc, and molybdenum, and the analysis results were subjected to statistical processing with a electronic computer.

A part of examination on the result of survey was made at the office of INGEOMINAS in Popayan, but the synthetic analysis, after comparative examination with the existing reports and technical discussion with the survey staffs of Colombian side, was conducted in Japan to prepare the present report.

In addition, the synthetic analysis includes not only 7125 analysis values of geochemical samples, but also 176 items of chemical analysis for ores, 3 items of age-determination of igneous rocks, 5 items of complete rock analysis, 36 pieces of rock thin sections, 10 pieces of mineral polished sections, 2 items of X-ray microanalysis, and 2 items X-ray diffraction test.

1-3 Organization and Members of Survey Team and its Itinerary

1-3-1 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 -

Satoshi Yoshikawa	Ministry of International Trade and Industry (MITI)
Hideaki Mukai	International Cooperation Agency

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

Michel Hermelin	INGEOMINAS
Herman Dugue - Caro	- do -
Luis Jairo Vesga O.	- do -
Ricardo Escovar	- do -
Hector Castro Paez	- do -

Members of Survey Team in Japan side;

Junnosuke Oikawa	Chief	MESCO, Inc.
Yoshihiro Nagumo	Staff	- do -
Yasuhiro Kayano	- do -	- do -
Tetsuo Hatasaki	- do -	- do -
Nobuyuki Goto	- do -	- do -
Hiroshi Takahashi	- do -	- do -
Shigemi Kimura	in charge of Photogeology	- do -

Member of Survey Team in Colombia side;

Pedro Antonio Marin	INGEOMINAS

1-3-2 Itinerary

Serial Number	Date	Day of Week	Itinerary	Contents of Survey
1	Aug. 12	Tues.	Dep: Tokyo - (via Mexico)	Transfer
2	13	Wed.	- Arr: Bogota	- do -
3	14	Thur.	in Bogota	Japan Embassy, JICA, INGEOMINAS
4	15	Fri.	Dep: Bogota - Arr: Pasto	Transfer
5	16	Sat.	in Pasto	Procurement of survey tools, food
6	17	Sun.	Dep: Pasto - Arr: Samaniego	Transfer
7	18	Mon.	Dep: Samaniego - Arr: Socorro	Geological Survey
8	19	Tues.	Dep: Socorro - Arr: Sande	- do -
9	20	Wed.	in Sande	Laborer arrangement, Food Distribution, Radio Base Installation
10	21	Thur.	Organization of 6 Survey Groups, for Eastern Area	Geological survey, Geochemical Survey
:	:	:		- do -
35	Sep. 15	Mon.		- do -
36	16	Tues.	Piedrancha	Arrangement of Surveyed Data & Next Survey
:	:	:	- do -	Preparation
43	23	Tues	- do -	- do -
44	24	Wed.	Organization of 6 Survey Groups, for Western Area	Geological Survey, Geochemical Survey
:	:	:		- do -
65	Oct. 15	Wed.		- do -
66	16	Thur.	Piedrancha	Arrangement of Surveyed Data

Serial Number	Date	Day of Week	Itinerary	Contents of Survey
67	Oct. 17	Fri.	Dep: Piedrancha - Arr: Popayan	Transfer
68	18	Sat.	in Popayan	Arrangement of Surveyed Data, Interpretation
:	:	:	- do -	- do -
78	28	Tues.	- do -	- do -
79	29	Wed.	Dep: Popayan - Arr: Cali	Transfer
80	30	Thur.	Dep: Cali - Arr: Bogota	- do -
81	31	Fri.	in Bogota	Outline Report to INGEOMINAS, Japan Embassy
82	Nov. 1	Sat.	- do -	Preparation of transfer
83	2	Sun.	Dep: Bogota - (via Los Angeles)	Transfer
84	3	Mon.		- do -
85	4	Tues.	- Arr: Tokyo	- do - (Returned to Japan)

1-4 Outline of the Surveyed Area

1-4-1 Location and Traffic

Situated in lat. 1°10' to 1°30' and long. 77°30' - 78°00' geographically and around the middle of Department Nariño in the Republic of Colombia, the surveyed area is divided administratively into five municipios;

Samaniego, Sta Cruz, Piedrancha, Ricaurte, and Barbacoas.

In regard to traffic facilities for the surveyed area, domestic airliners are available, taking about one hour to go from Bogota, the capital of the Republic of Colombia, to Pasto, the Metropolis of Department

Nariño. After that, it takes a car by land about three hours to go through a distance of 122 km from Pasto to Samaniego, the eastern base of the area to be surveyed, and about three hours through a distance of 126 km to Piedrancha, the southern base. National roads and state roads are available, surrounding the surveyed area from east, south, and west, but no driveway exists inside the area, where the traffic is dependent upon horseback and walkways only. A set of wireless radio was used for communication between camp site and Samaniego or Piedrancha office.

1-4-2 Topography, Climate, and Vegetation

Located at the end of the great chain of mountains in the Republic of Colombia extending along the Pacific Coast in NNE-to-SSW direction, the surveyed area presents a steep topography, which is divided by a lot of rivers flowing to the north or north-west, and high in the south and low in the north.

Therefore, the land now in use is restricted to the farm-stocks and the neighborhood of small-scale gold mines that have been scattered and developed along the main rivers.

The surveyed area is situated in lat. 1° approximately, that is, close to the equator, and the rainy tropical zone, where rainfall, temperature, and vegetation varies remarkably from place to place because of much difference in altitude; there are a lot of rainy days throughout the year except the dry seasons of June thru September having comparatively fair weather, recording annual rainfall of 2000 mm to 5000 mm with annual average temperature of 15°C to 27°C.

The surveyed area, from north-west to the middle, (300 m to 2000 m approx. above sea level) is the area of high temperature and humidity which is densely covered with tropical trees. However, south-eastern belt of over 2000 m in altitude is thickly wooded by shrubs with rather mild temperature.

1-5 Existing Reports and Bibliography

Few bibliography is available for the geology inside the surveyed area owing to insufficient previous survey. First and systematic investigation was begun by the first wide-range survey by UNDP - INGEOMINAS that was organized in May, 1973. The above survey was made for the general geology mainly on the basis of the regional geochemical survey, resulting in the discovery of anomaly areas of copper, molybdenum, lead, zinc in the upper basin of Telembi river and Gualcala river, and the extraction of nine places recommendable as the object of the second-stage survey.

The second-stage survey, however, was not realized because of the serious restriction and inconvenience in traffic and climatic conditions, expensiveness in equipment and personnel expenses, and the priority given to another hopeful project. Hence the detailed aspect of anomaly still remains unknown.

Furthermore, the correct location of anomaly area is not yet decided since the topographic map is incomplete owing to the insufficient aerial-photograph due to long rainy season accompanied with abundant cloud at almost all times.

The mineral resources development planning and survey that was carried out in September, 1979 prior to the present Survey, along with the Survey Report (1977) by UNDP - INGEOMINAS "Mineral Resources in Colombia" (1978) and the result of the site survey, led to the following conclusion in regard to Piedrancha area:

"This area is judged to be of much interest as the area containing prospective ore deposits of gold, silver, copper, lead, zinc, and molybdenum because of the reasons described hereunder;

i) According to the survey by UNDP - INGEOMINAS, there exist a lot of anomaly of copper, molybdenum, lead, and zinc.

ii) In the north-eastern and comparatively accessible area, there exist a lot of gold mines accompanied with copper, lead, and zinc, and mineralized together with quartz porphyry which penetrated after granodiorite.

iii) The above mineralization showing area is arranged in relation to the several and almost parallel fault belts of NW-SE direction under the geological environment capable of forming large-scale ore deposits.

Furthermore, the method of survey during three years has been described as follows as a guideline of investigating into the area: The first year survey works include preparation of topographic map for survey, geochemical and geological survey by stream sediment sampling along major rivers, geological survey for ore deposits of existing mines, and thereafter, the stepwise application has been recommended including geophysical and boring exploration."

No other geological literature is directly available for this area. However, in regard to the Cretaceous and basic volcanic rocks that are widely distributed in the surveyed area, several literatures have been available and cited hereunder as bibliography including those especially served as reference:

Anglo, R.C., 1978. Recursos Minerales de Colombia. INGEOMINAS Report.

JICA, 1980. Report on the Survey for Mineral Resources Development in the Republic of Colombia

Lipeltier, C., 1964. A Simplified Statistical Treatment of Geochemical Data by Graphical Representation. Economic Geology, Vol. 64, pp. 538 - 550.

Lozano, D. B., 1979. Geology of the Central Western Cordillera, West of Buga and Roldanillo, Colombia. INGEOMINAS, Colombia.

Londale, P., Klitgord, K. D., 1978. Structure and Tectonic History of the Eastern Panama Basin. Geol. Soc. of Am. Bull. Vol. 89, pp. 981 - 999. July.

Miyashiro, Akiho, 1967. Metamorphic Rock and Metamorphic Belt (in Japanese) IWANAMI

NACIONES UNIDAS, 1977. Proyecto 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 Report.

Stibane, F.R., 1975. The Encyclopedia of World Regional Geology, Part I. Colombia, pp. 245 - 250.

The Society of Mining Geologists of Japan, 1980. Granitic Magmatism and Related Mineralization. Mining Geology Special Issue, No. 8.

CHAPTER 2. PREPARATION OF DRAINAGE AND QUASI-TOPOGRAPHIC MAP, AND PHOTOGEOLOGICAL INTERPRETATION

2-1 Preparation of Drainage and Quasi-topographic Map

Extremely abundant clouds over the surveyed area throughout the year made the topographic map unavailable except aerialphotographs of only one series (eleven sheets) for a part of eastern area. However, the most precise map is indispensable to carry out survey into such area as this being steep and inaccessible in topography for the most part and involving possibility of various danger. In view of the above, "Drainage and Quasi-topographic Map" (1/50,000 scale) was prepared as "Map for Survey", making full use of existing and all available informations and articles as listed hereunder:

(1) Landsat Image 1/250,000, two sheets, for confirmation of main rivers position.

(2) Radar Image to read smaller topography than Landsat Image, such as branch of river and ridge lines.

(3) Aerialphotograph --- Preparation of topographic map (7 km east-west, 24 km north-south, approx. with 11 sheets aerial photographs for the middle of eastern area)

(4) Drainage Map -------- Prepared by "Instituto Geografico Nacional de Colombia" using the Rader Image. The east part is connected to the adjacent topographic map "PASTO" (1: 100,000).

(5) Mine Distribution Map --- Prepared by Mining Bureau, Pasto (1: 500,000). Used as reference for name of valley and the location of Mine.

(As to details, see 2-3. Used Data)

After the preparation of the above Quasi-topographic map (1: 50,000), the enlarged one (1: 25,000) was carried to the field for use in survey and arrangement. The errors in the map that were found during the actual survey have been corrected after the survey.

The middle part of eastern area in the topographic map was contoured at intervals of 50 m. Regarding base points used for aerial trigonometry, only three points of determined altitude with an altimeter were used, causing considerable errors. Such being the case, it is necessary in future to prepare correct and precise topographic maps by increasing the area to be aerialphotographed.

2-2 Outline of Photogeological Interpretation

This Photogeological Interpretation work was accomplished for the purpose of interpreting the geology and geological structure in the object area to be surveyed (1000 km^2, approx.), and at the same time, of contributing to the compilation of survey into the field geology to be carried out during the first fiscal year.

Different from fine weather, abundant rain and thick clouds throughout the year in this area made aerialphotograph and complete topographic map unavailable except for extremely limited places. Moreover, Landsat Images are almost impossible to interprete on account of thick clouds as an obstacle. For above reasons, the photogeological interpretation work was carried out, using Radar Images (1: 250,000 and 1: 100,000) for the most part and, as supplementary data, Landsat Images (1: 250,000, Positive color and black-and-white print) and aerialphotographs of 11 sheets for the limited region in the east of the surveyed area.

Different from optical aerialphotography, the Radar images are obtained using intensive microwave capable of penetrating even into thick clouds, and are advantageous in clarifying the characteristics on the earth such as fault, etc. by the enhanced relief in topography due to shadow effect. On the other hand, the disadvantage is that the places where microwave fails to reach such as mountain cove cause shadow without giving any information.

The blank part in the Radar Image Interpretation Map is the shadow due to the above reason.

As a result of photogeological interpretation, in comparison with existing geological data, the geology in this area can be divided into 14 geological units (Ref. PL.2) comprizing Sedimentary rocks, pyroclastic rocks, lavas, granites, and the like in the Cretaceous period to Cenozoic area. The result of this interpretation is summarized hereunder:

(1) The surveyed area can be divided into two principal groups —— western area rich in sedimentation of pyroclastic rocks and lavas, and eastern area where Cretaceous sedimentary rocks and granites are widely distributed.

(2) Much of the linear structures that were extracted as lineaments in the radar image can be interpreted as terrestrial sign of faults from the scale and size of the structures. In the western area, fault system of NE-SW direction has developed remarkably with that of oblique NW-SE direction existing at intervals of about 7 km.

Existing ore deposits and mineralized zones are concentrated around the intersection of the above two fault systems, and presumed to be mainly distributed along the NE-SW fault system.

This NE-SW fault system is regarded as a wide-range fault system which is observed universally inside and outside the surveyed area, however the development is not remarkable in the geological units that are interpreted to consist of pyroclastic rocks.

(3) In the eastern area, granites and related rocks are widely distributed, penetrating into the Cretaceous sedimentary rocks. Further, there are a lot of faults of NW-SE and NNW-SSE directions, especially those of NE-SE direction along Rio Vargas.

2-3 Used Data

Data that were used for this interpretation include Radar Image and Landsat Image (positive color print,, the details of which are as follows:

(1) Radar Image

Colombia Radar Mapping Sheet No. 3

(Uncontrolled Mosaic, Scale 1: 250,000)

Enlarged print (1: 100,000)

(2) Landsat Image

Identification No. E-21204-14202 (Imaged on May 10, 1978)

Identification No. E-21330-14262 (Imaged on September 13, 1978)

Scale ; both 1: 250,000

(3) Aerial photograph

Photo No. C1931-323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333 (Total 11 sheets)

Scale ; about 1: 30,000

2-4 Method of Photogeological Interpretation

(1) Radar Image

The Radar Image used for interpretation is a mosaic image prepared by putting nine sheets of striped radar images together. (1: 250,000 and 1: 100,000)

The radar image of scale 1: 100,000 was prepared by enlarging the one (1: 200,000) in order to observe in more detail. As is the case with general aerial photographs, the interpretation consists of principal two works; one is to classify into units, each having the same photocharacteristics and topographical features, paying attention to interpretation elements such as tone, texture, pattern, drainage, topographic undulation, etc., and the other is to extract linear or circular patterns that are closely related to the geological structures having faults and sheared zones.

As stereoscopic observation of the radar image used for interpretation was impossible, the interpretation of topographic undulation was mainly dependent upon the shade and drainage on the photograph.

In general, the topographic undulation and the extent of unevenness on the surface of the earth are closely related to the resistance of the constituent rocks and stones against erosion and corrosion or the geological structures and the like, and are expressed on the radar image as variation in the light and shade, difference in texture, or shadow itself. It has also been understood that drainage patterns formed by the rivers that flows dividing surface of the earth present a variety of topographic features in correspondence with the type of rocks, and geological structures.

In case topographical variations are recognized as terrestrial sign of faults or sheared zones, these are expressed as continuous shadow patterns on a radar image, enabling to extract the patterns easily.

The practical interpretation was performed by placing overlays on the radar image (1: 100,000), observing the image on a tracing board, and then tracing the result of observation on the overlay. In order to facilitate the grasp of the general characteristics, the radar image (1: 250,000) and Ladsat images were compared with each other during the course of the work.

(2) Landsat Image

The thick clouds which covered over the most of the surveyed area made the overall observation by use of the Landsat image impossible. Hence, some lineaments were extracted in the observable area for the aid of radar image interpretation.

The images that were used for the observation are two scenes of MSS images obtained in May and September, 1978. Lineament extraction work was carried out by preparing falsecolour image comprizing Band 4, 5, and 7 (1: 250,000) per each scene and black-and-white image of Band 5, and then, by observing both images pseudoscopically.

(3) Aerialphotograph

Interpretation was possible only for the restricted area in the east. The results of lithological classification and fault reading have been arranged in PL.2 in company with the results of radar image interpretation.

In regard to interpretation procedure, each two adjacent sheets among eleven sheets of successive aerialphotographs were subjected to stereoscopic observation. Positional verification between the radar image, and aerialphotographs was made on the basis of the drainage system.

2-5 Geological Units

V: Volcanic rocks and pyroclastic rocks

G: Intrusive rocks

M: Volcanic rocks for the most part

S: Sedimentary rocks

(1) Unit V_5

This unit is distributed not in the surveyed area, but widely within the length of about 20 km from the north-western end of the surveyed area to the plain and between Rio Guabo and Rio Telembo.

From the topographic point of view, this unit forms the piedmont of mountains and hills including the surveyed area. A lot of rivers of parallel flow have developed with scattered tablelands that are presumed to be the traces of piedmont alluvial plains. Judging from such topographical features, the unit can be interpreted to consist of alluvial deposits including volcaniclastic materials.

(2) Unit V_4

This unit is locally distributed along the ridges to the west of Piedrancha and the south of Rio Guabo. Being unconformably underlain with Unit S_4 as mentioned hereunder, most of this Unit V_4 has been eroded away, remaining only the existing one presumed to be the residue.

This unit present a very light tone, smooth and fine texture, and mild topographic undulation on the photograph, and is interpreted to consist of pyroclastic materials.

(3) Unit V_3

This unit is widely distributed from the western and of the surveyed area to the west and south-west direction of Altaquer. The characteristics on the photograph is the light tone and comparatively smooth texture. In general, parallel to subparallel drainage patterns can be observed without remarkable development. Topographic undulations are rather mild.

As is the case with V_5, this unit unconformably overlies Unit S_4 which is widely distributed in the south side of Rio Guabo, but the stratigraphical relation to V_5 is not clear. With respect to rock properties, this unit is regarded as similar to V_2, and interpreted to consist of pyroclastic materials similar to agglomerate or tuff breccia.

(4) Unit V_2

This unit is distributed in the upper basin of Rio Ñambi, the north-west of the surveyed area, and partially exposed as a strip being about 3 km wide and 12 km long, along the basin of Rio Ñambi Branch which flows to north-eastern direction at around Junin. The surroundings are covered with Unit V_3. As a photographic characteristics, smooth and fine texture and mild topographic undulation are noted. Parallel to subparallel drainage patterns are prevailing. As to rock properties, fine grained pyroclastic rocks and fine grained, massive argillaceous rocks can be considered.

(5) Unit V_1

This unit is widely distributed to the west of Piedrancha and South-east of Santa Cruz. The characteristics on the photographs are rough testure, shadows along the deep valley, and big topographical change, etc. Although quite irregular, the drainage patterns are parallel to radial provided attention is paid only to large rivers. Comparatively poor vegetation in this unit with the trace of radial movement leads to the interpretation that the unit may consist of lava and pyroclastic materials.

(6) Unit G_3

The unit is a group of small rock bodies that are locally exposed 8 km south of Altaquer and 6 km south-west of Cuayauer, and forms high hills of round shape. The smooth texture is contrastive against the rough texture of the adjacent Unit S_3. The projecting configuration from inside the Unit V_3 leads to the interpretation that the unit may consist of intrusive igneous rocks.

(7) Unit G_2

This unit is distributed around La Esperanza in the east of the surveyed area. Photographic characteristics include the topography assuming round, light tone, smooth to rather rough texture. As a whole, the unit is massive and shows poor development of drainage system. Scattered and fine lineaments suggest the features and distribution of granites and the like as already indicated in the existing reports.

(8) Unit G_1

This unit lies at the north end of the surveyed area and northern side of Rio Cristal, and forms a core sized 4 km and 3 km approximately in NS and EW direction, respectively against annulus structure of 8 km in NS and 6 km in EW. The whole aspect of drainage present rectangular pattern which flows down making curves almost at right-angles except the drainage inside the annulus structure being centripetal pattern. From the above feature, the development of possible crack or fault in the Unit G_1 can be suggested. Drainage systems that show centripetal pattern but do not belong to the above system, flow down along the outline of this Unit G_1. Judged from such structural conditions, the Unit G_1 may be interpreted as intrusive granite or something.

(9) Unit M_2

This unit is widely distributed from the north end of the surveyed areas to the north with extremely irregular configuration and small specific altitude. At the place which is 4 km north of the annulus structure including Unit G_1, it is interpreted that the Unit S_3 overlies the Unit M_2. An annulus structure of about 3 km in diameter lies at the place about 12 km WWN of the annulus structure, showing caldera-shaped topography. Since this unit is not of single type of rocks but presents irregular and massive topography resembling the photographic characteristics of the Unit M_1, it is estimated that this unit consists of volcanic rocks or something.

(10) Unit M_1

This unit is distributed at around Rio Gualcala and the north side of Rio Guabo in the west part of the surveyed area. Topographical features are irregular configuration with much variety, and rather rough texture. Drainage systems show dendritic to parallel patterns of much variety, and sometimes remarkably zigzag patterns just like those of Rio Gualcala. As a whole, massive structure is observed instead of stratified one. In view of the development of NE-SW-system faults in the distribution area of this unit, the complication of rock property and topographical structure can be suggested. Regarding the positional relation on the plane, this unit is divided into south and north part by the Unit V_3 having the possibility of covering this unit.

The characteristics of this unit which resemble those of the Unit M_2 lead to the interpretation that volcanic rocks (lava) are major components of this unit.

(11) Unit S_4

This unit is distributed from the middle of the surveyed area to the place between Rio Gualcala and Rio Vargas. Topographically, the unit forms a shallow basin as a whole with successive small undulation and variation which seem to reflect the stratified structure. Drainage system presents rather centripetal and quasi-dendritic pattern.

Surrounded by the faults of NE-SW, NW-SE, NNW-SSE system, this unit is isolatedly distributed in the Unit M_1. As the result of field exploration, the existence of tuffaceous sandstones have been confirmed in the half west part of this unit.

(12) Unit S_3

This unit is widely distributed in the west of the surveyed area and in the basin of Rio Guabo, to the west of Piedrancha. The photographical characteristics is the regular variation in tone due to small undulation and topographic change that seem to reflect the stratified structure. Dendritic drainage pattern is most prevailing with partial sub-parallel pattern. In view of the above, sedimentary rocks of advanced stratification can be taken into consideration, however, the field exploration proved the existence of slate and clastic rocks.

(13) Unit S_2

This unit is distributed in south-north direction as a strip in the western side of the Pacual Fault which runs toward NE-SW and NNE-SSW directions around Samaniego to the east of the surveyed area. Parallel to sub-parallel drainage pattern is remarkable instead of regular tonal pattern which is observed in the Unit S_3. It is interpreted that the massive and fine grained sedimentary rocks and volcanic rocks are probably predominant.

(14) Unit S_1

This unit is distributed in the east of the Pacual Fault. The photographic characteristics are fine and irregular change in topography and dendritic drainage pattern. This unit is covered with the Unit V_1 in the southern part. It is interpreted that the major components are argillaceous rocks.

2-6 Geological Structure

In this surveyed area, a lot of lineaments that seem to be the terrestrial sign of various scale of faults are recognized including the predominant lineaments of NE-SW, NW-SE to NNW-SSE system. The above lineaments are remarkable in the distribution area of sedimentary rocks and lavas, but are limited in the area of granites and pyroclastic rocks.

At the place being about 7 to 14 km west of the Decio Village in the

Table 1 Photogeological Interpretation Chart

UNIT	PHOTO CHARACTER-ISTICS (TEXTURE)	TOPOGRAPHIC CHARACTERISTICS					INFERRED LITHOLOGY
		DRAINAGE		RESISTANCE	LINIAMENT	BEDDING	
		PATTERN	DENSITY	ROCK			
V_5	rough partly smooth	fan-like, meander	coarse	very weak	rare	none	alluvial deposits
V_4	smooth	-	rare	very weak	none	"	pyroclastic materials
V_3	very smooth	parallel ∿ sub-parallel	very coarse	medium ∿ high	rare	"	pyroclastic materials (agglomerate ∿ tuff breccia)
V_2	smooth	parallel ∿ sub-parallel	medium	weak	few	"	volcaniclastic materials, argillaceous rocks
V_1	rough	radial ∿ parallel	coarse	high	rare	"	lavas, pyroclastic materials
G_3	smooth	centrifugal	medium	very high	none	"	granitic rocks
G_2	slightly rough	centrifugal	coarse	very high	many	"	intrusive rocks
G_1	rough	rectangular	coarse	medium∿high	few	"	intrusive rocks
M_2	rough	dendritic	dense	medium	many	"	mainly volcanic rocks
M_1	rough	dendritic ∿ parallel	dense	medium	many	"	mainly volcanic rocks
S_4	very rough	centripetal ∿ dendritic	dense	medium ∿ weak	rare	clear	sedimentary rocks, mainly tuffaceous sandstones
S_3	very rough	dendritic ∿ sub-parallel	dense	weak	many	clear	sedimentary rocks (slates ∿ mudstones)
S_2	rough	parallel ∿ sub-parallel	dense	weak	few	vague	sedimentary rocks, and/or volcanic rocks
S_1	very rough	dendritic	dense	weak	rare	vague	sedimentary rocks, mainly argillaceous rocks

north end of the surveyed area, there exists a shallow basinal topography sized about 6 km and 8 km in length of EW and NS direction, respectively. In the central portion of the basin, intrusive granites are distributed within the length of 3 km and 4 km in EW and NS direction, respectively, forming the core of the basin. It is most probable, from the topographical characteristics, that the geological structure is that of depression.

The similar annulus structure can be seen at the place of about 35 km from Junin and on the fault system which runs in NE-SW direction at the north-western part of the surveyed area, and goes through the neighborhood of the village.

Furthermore, a strip of basinal topography being about 11 km long toward NS and about 5 km wide toward EW is observed at the place about 8 to 13 km north-west of La Esperanza Village in the central part of the surveyed area. It is estimated that the above basinal topography is not of depression type, but has been formed by the isolation of rock bodies having different lithological properties from those of surroundings.

The outline of general trend in stratum will be described hereunder although difficult to interprete in general: A large scale of fault (the Pacual Fault) runs from Samaniego Village to the neighborhood of Santa Cruz, turns its direction at Samaniego from original NE-SW direction to NNE-SSW, and again extends to NE-SW direction at around the middle between the above village and Santa Cruz. According to the existing reports, in the western side from the fault, that is, the border, are distributed Cretaceous diabase and sedimentary rocks, whereas in the eastern side are distributed Cretaceous andestic volcanic rocks and sedimentary rocks, forming belts along the fault. These trend resembles that of the Pacual Fault. The general trend of the Cretaceous sedimentary rocks distributed in the east of the surveyed area has proved to be mostly toward NNE-SSW with steep gradient as the result of field exploration. On the other hand, in regard to the isolated Unit S_4 around the middle of the surveyed area, stratum of rather mild gradient is presumed from the topographic features on the radar image.

In the west of the surveyed area, massive structure is prevailing without showing stratification.

Regarding the granites that are distributed in the east part of the surveyed area, not only a large-scale granites exist around La Esperanza Village, but also small-scale ones of Boss type stock are scattered. The above fact leads to the understanding that the igneous activity had been violent.

CHAPTER 3 GEOLOGY

3-1 General Geological Aspect of the South-Western Area of Colombia

The general geology of Colombia is divided largely to compose of Guayana Shield in Eastern district and Andes orogenic belt distributed in Central and Western districts. Guayana shield is making the heartland of South American Continent with Brasilian Shield. Andes orogenic belt is formed by repeating the fold and the upheaval of the geosynclinal belt developed in the north-western margin of Guayana shield. The investigation area is enclosed in Nariño Department which is located in the south-western part of Colombia. The mountains lined in three rows in the northern area adjacent to Nariño Department, closing together as falling downward to the south to form the highlands having the width of about 150 km in east-west direction in Nariño Department,

The center thereof is mainly composed of the palaeozoic to Cretaceous system and the Tertiary system in both sides of east-west thereof. However, the western area is composed of basic volcanic rock of eugeosyncline type and slate and quartzite which are formed by metamorphism of shale and sandstone. The eastern area is composed of miogeosyncline sediments such as sandstone, conglomerate, shale and limestone. The south western area is largely covered with the effusives formed after basic or intermediate volcanic activity in the Tertiary and the Quarternary System, and the geological survey in this area is delayed, which allows the detail of the geological structure thereof to be unclear yet. However, regarding to Cauca Department northerly adjacent to Nariño Department, there is the report prepared by G. Paris, P. Marin (1979), and generally the geological structure is lined in north & southern direction, which can be greatly referred since this year's investigation objectives are the extension thereof.

Green volcanic rocks, sedimentary rocks and intruded granites of this investigation area are correlated with Diabasas group and Dagua group of Cretaceous system and the Tertiary intrusive quartz diorites.

Diabasas group is composed of basic volcanic rocks and the alternation of volcanic rock and sedimentary rock, and Dagua group is named for low bed metamorphic rocks such as slate, phyllite and quartzite. Dagua strata group is considered as lower formation or contemporoneous hetero-facies. Granites are composed of intrusive rocks of the mid-Tertiary system developing the variation of the rock facies of grano-diorite, quartz diorite and diorite with the large amount of rock bodies thereof.

Furthermore, the geological structure is continuing to north-south direction at western mountains "Cordillera occidental"; Pacific side piedmont with about 70 Km of width in east-west direction, locating Cerro Pantanos porphyry copper deposits zone in about 600 Km north direction, and Chaucha porphyry copper deposits located at southern Ecuador being generally known.

3-2 General Geology of the Surveyed Area

3-2-1 Green Volcanic Rocks

The rocks crop out in the large area extending from the central to the whole western part, and a narrow exposure in the south-eastern part of the investigation area.

The rocks include dark green or dark gray colored medium - fine grained andesite and basalt lava, dike, and sheet and essential tuff breccia. As the intercalation of green volcanic rocks, green tuffaceous sandstone and shale (strata thickness of 80 m) are observed in the mid-down basin of Telembi river, and black shale and slate (strata thickness

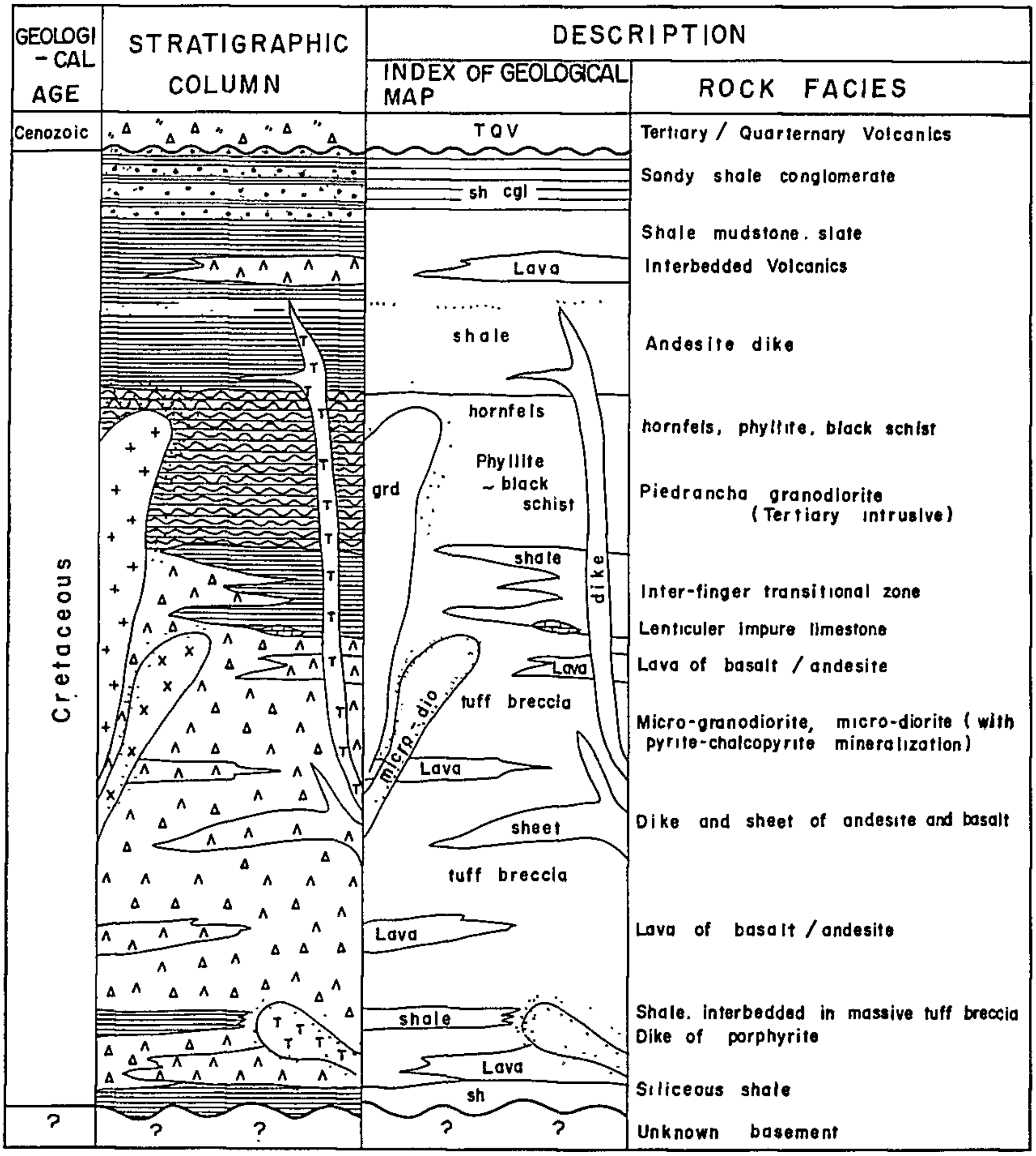


Fig. 2 Schematic geological Column of the surveyed area

of 5 m approximately, four strata) in the branch of Gualcala river mid-basin.

Furthermore, blue siliceous shale is exposed in Ramos river upper basin located in the western investigation area. However, it is unknown whether it is the intercalation of green volcanic rocks or the underlying strata due to narrow distribution thereof observed. The green volcanic rocks is generally characterized by the massive non-stratification, permitting to make difficult in correlating for the individual stream zone. Among the rocks, tuff breccia distributed most widely is constituted from the essential subangular breccia with the breccia size of 50 cm - 80 cm. Under the microscope, light-brownish common pyroxene and plagioclase are generally observed as phenocrysts, and a part or whole of pyroxene altered to chlorite and epidote. The amount of amphibole is quite few.

Plagioclase is indicating the albitization with crystal size of 0.3 mm - 0.7 mm, and observing the zonal structure slightly. Matrix is composed mainly of plagioclase and magnetite, subordinent amount of quartz, albitizating plagioclase and volcanic glass.

The rock sample No. 1557 is composed of a large amount of common pyroxene, no quartz observed, indicating basic rock facies considerably. The rocks are developing contact metamorphic mineral in the intrusion circumference of granitic rock.

It will be common that andesite or basalt will not develop the sensitive action for recrystallization against the heat in comparing with psammtic rock, thereby in this zone chrorite, calcite, epidote, biotite and amphibole (partially possibility of actinolite) are developing as a metamorphic mineral.

In the zone generating the minerallized alteration by granitic

Table 2 Age-determination of Igneous Rocks

Sample No.	Locality	Rock Name	Mineral	Ar^{40} ppm	K^{40} ppm	40ArR/40K	Age M.Y.	Remarks
0-15	Rio Canellera	Quartz diorite	hornblende	0.001558	1.010	0.001541	26.2 ± 1.5	
0-17	ditto	Hornblende-bio -tite grano -diorite	hornblende	0.001520	0.902	0.001684	28.6 ± 1.7	dyke rock
637	Rio Vargas	Basic hornfels	whole rock	0.001890	1.069	0.001766	29.9 ± 1.7	metamophosed green volcanic rock

$\lambda_e = 0.585 \times 10^{-10}$/year $^{40}K/K = 1.22 \times 10^{-4}$ g/g

$\lambda_\beta = 4.72 \times 10^{-10}$ /year 40ArR : Radiogenic argon 40 intrusive rock, the rocks are accompanied with pyrite, chalcopyrite and plagioclase affected by sericitization and epidotization.

The alteration of plagioclase causes initially the scale of micro-sericite along the crack of crystal, as advancing the alteration, developing sericite on the whole crystal, and becoming partially to develop the micro-crystal and the fine vein of calcite.

The rocks constitute the lowest strata in the investigation area, according to 1: 1,000,000 geological map of Colombia published by INGEOMINAS, and the rocks are corresponding to the part of Cretaceous volcanic rocks occupying both wings of Western Cordillera.

Besides, according to the geological report of Cauca Department adjacent to the northern investigation area, massive metavolcanic rock equivalent to the rocks, and shale and sandstone strata containing thin layers of metavolcanic rock overlayed on the massive metavolcanic rock are named Diabasas group.

Because of containing the fossil of radiolaria indicating Conician period within said Diabasas group, it is considered to be equivalent to said Cretaceous period. Furthermore, the rocks are correlated with Cañasgordas group distributed in the north-western Colombia, correlating with Basic Igneous Rocks of Ecuador, according to respective chronological measurement, reporting the result indicating large difference thereof ranging from 110 ± 10 my to 54 ± 5 my. (Goossens, P.J. et al. 1973).

The age of green volcanic rock No. 637 sampled in Vargas basin available in this time was indicating 29.9 ±1.7 my. However, since the result thereof shows possibly the age that the rock had been affected by thermal alteration, it would be necessary to reanalyze by using fresh sample in the future.

3-2-2 Sedimentary Rocks

The rocks are distributed in the eastern part of the investigation area, and developing considerably in mid-upper stream area of Cristal river and Vargas river. The rocks are composed of black shale, slate, fine grained sandstone, dark gray limestone and weak metamorphosed rocks thereof, changing the rock facies according to the location thereof.

In other words, while black shale is dominating in the central zone, other rudite of fine medium grained sandstone intercalated within the shale strata develops in the upper streams of Vargas river, Cristal river upper stream and at the western flank of Alto Pacual.

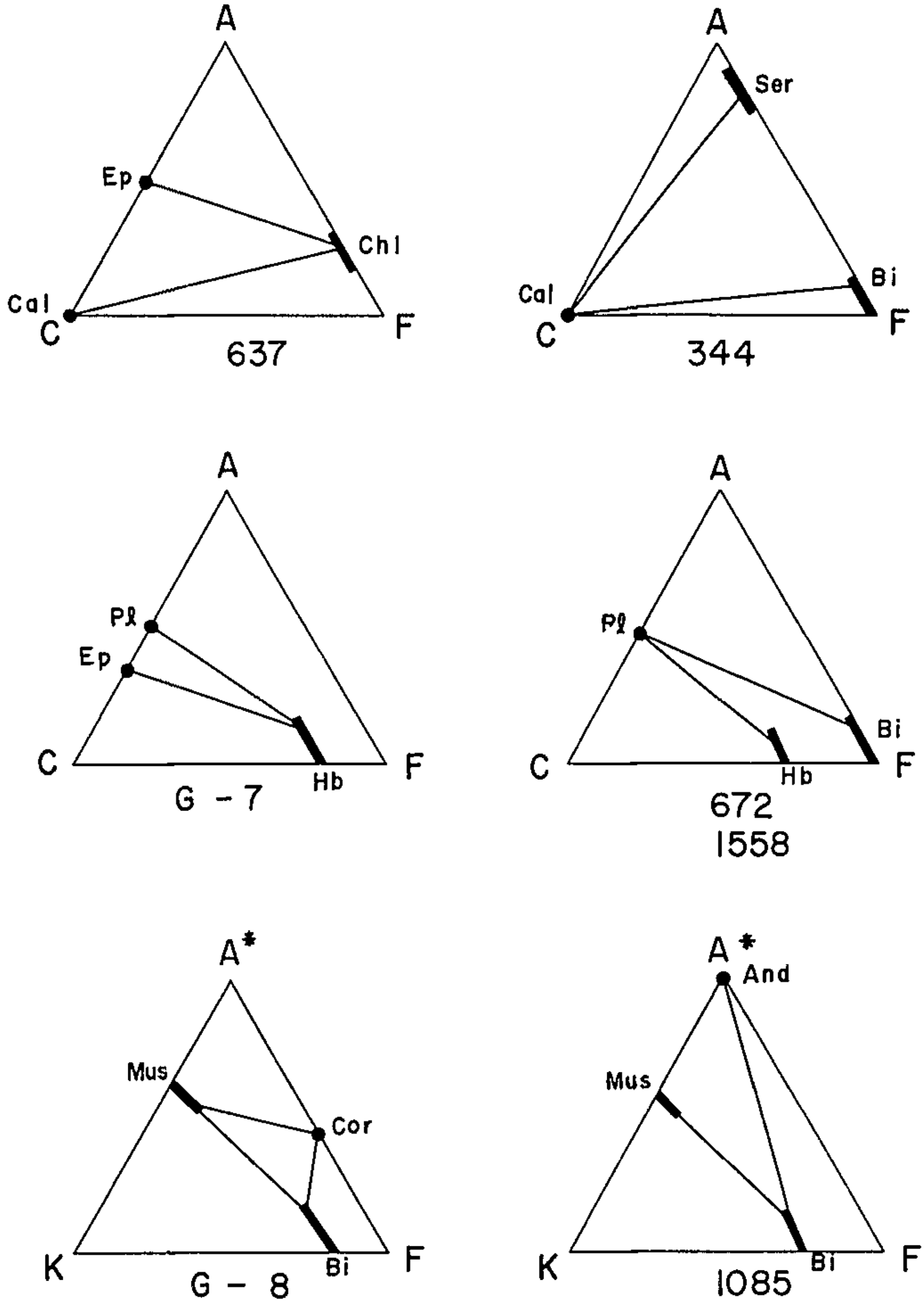
Besides, dark gray limestone with the thickness of about 10 m is observed at the vicinity of the boundary with green volcanic rocks located at the mid-basin of Telembi river. The general strike of the rocks is dominating NS - N 30°E, the dip of 50° - 80° towards east.

Piedrancha granodiorite is intruded within the rocks, forming the contact metamorphic zone containing the large quantity of blastoporphyritic crystals of andalusite having the width of 500 m - 1500 m within the surrounding shale.

While under the microscopic observation, aside from andalusite, anhedral biotite is recrystallized to form paragenesis, shale positioned in this zone is rich in Al_2O_3, and is estimated to recrystallize in the sequence of andalusite and biotite.

In the surrounding of intrusive body, crystallinity of biotite is well developed due to the increase of temperature, and coordierite is formed as the grain size of recrystallized biotite increased. For example, coordierite - muscovite - biotite hornfels such as rock sample G - 8 is formed.

This is belonging to amphibolite facies in metamorphic rock facies.



A : $Al_2O_3 + Fe_2O_3 - (Na_2O + K_2O)$

A* : $Al_2O_3 + Fe_2O_3 - (Na_2O + K_2O + CaO)$

C : CaO K : K_2O F : $FeO + MgO + MnO$

Fig. 3 ACF and AKF diagrams of contact metamorphic mineral assemblages in the aureole of granitic intrusives

The original rock, for rock sample No. 344 having somewhat more calcareous than common shale, is showing biotite-calcite - sericite mineral assemblage of hornfels having the lowest metamorphic grade.

The stratigraphy of the rock, from the bottom to the top thereof, is showing 10 m thickness of lens shape dark gray limestone, followed by at exceeding 2500 m thickness of black shale. Black shale is forming partially slaty and at the upper strata, fine medium grained sandstone is intercalated.

The rocks are slipping as indicating interfinger relation with said green volcanic rocks. While there is a large amount of green tuff at the bottomset bed as the parting of shale, they are completely disappearing at the medium-upper bed.

Black shale is dominating in the rocks, and is difficult to find out a sample to decide the age. However, the rock is considered to be corresponding to Diabasas group of upper Cretaceous period in according to the same data of the Green Volcanic Rocks.

3-2-3 Acidic and Intermediate Igneous Rocks

Although acidic-intermediate hypabyssal-plutonic rocks are distributed to form large or small scale of intrusive body in the whole investigation area, among them the rock body extending from Piedrancha which is located in the southern zone to north-eastern direction forms the largest one which is called Piedrancha granodiorite in the field.

The scale of the rock body forms the maximum 10 Km in brachy direction and more than 35 Km in an extension direction, intruding mainly into the sedimentary rocks (black shale). The largest amount of hexagonal tabular biotite idiomorphic crystals and columnar amphibolite are contained within medium coarse grained holocrystalline amphibole -

biotite granodiorite.

The rock body is homogenous in grain size and rock facies, free from alteration thereof. However, the regular arrangement of amphibolite is observed in the part of the rock body's west edge in Telembi river or Vargas river basins.

The microscopic characteristics of granodiorite is explained in the description of microscopic observation of thin section of the rock sample 0 - 60. In other words, biotite of light brown color, light brownish green 2 mm ± of amphibole as mafic minerals, plagioclase, quartz, and small quantity of orthoclase are contained.

Furthermore, the result of norm calculation by whole chemical analysis value of the rock is shown in Table 3-B. Quartz-plagioclase (albite + anorthite) - orthoclase molecular ratio of norm is calculated to plot in "granitic diorite" in the USGS granitic rocks classification.

Besides, it is characterized by lack of FeO in comparing with the chemical composition of other granitic rocks. The rock samples 0 - 24, 0 - 25 are selected from stock type granitic rock available in the vicinity of El Tabano Gold Mine located in the western area of Piedrancha granodiorite body. The petrographic property of 0 - 24 observed by the microscope is essentially same as Piedrancha granodiorite. However, the rock sample 0 - 25 represents structure of the final consolidates of magmatic differenciation which shows a graphic texture with orthoclase and microcline. Canellera rock body is distributed by forming the circular shape with 7 Km diameter on the north extension of Piedrancha rock body to form the coarse grained holocrystalline diorite which is rich in amphibole.

The rock is represented by the rock sample 0 - 15 which is generally short of or free from biotite. This allows K_2O contained in the chemical

Table 3-A Results of Complete Analysis of Rock Samples

Sample No.	0-15	0-17	0-60	1385	637
SiO_2 weight %	56.98	53.97	63.22	59.54	48.32
TiO_2	0.51	0.61	0.52	0.38	0.63
Al_2O_3	19.10	18.35	16.49	17.47	12.64
Fe_2O_3	1.72	1.30	3.95	2.59	8.59
FeO	4.79	7.19	1.71	2.48	2.18
MnO	0.20	0.21	0.14	0.18	0.19
MgO	2.12	3.67	2.30	2.15	7.86
CaO	7.63	9.67	5.65	5.88	10.50
Na_2O	2.86	2.19	2.59	3.04	2.04
K_2O	1.40	1.02	2.38	1.47	0.78
P_2O_5	0.33	0.20	0.16	0.23	0.15
CO_2	0.0	0.0	0.0	0.0	3.03
H_2O^+	1.18	0.60	0.55	3.33	2.04
H_2O^-	0.24	0.03	0.12	0.53	0.21
total	99.06	99.01	99.78	99.27	99.16
$FeO^*(FeO+Fe_2O_3)$	6.49	8.50	5.32	5.04	10.22
FeO^*/MgO	2.99	2.28	2.29	2.24	1.26
Na_2O/CaO	0.38	0.23	0.46	0.52	0.19
(molecular ratio) Al_2O_3/K_2O+Na_2O+CaO	0.95	0.82	0.96	1.02	0.54
$100xMgO/MgO+FeO^*+Na_2O+K_2O$	16.80	24.16	18.40	19.07	38.35
mole percentage: $Al_2O_3+Fe_2O_3-Na_2O-K_2O$	34.94	28.08	39.67	38.94	24.87
mole percentage: CaO	34.67	34.11	33.47	33.22	34.10
mole percentage: FeO+MgO	30.39	37.81	26.86	27.84	41.03

0-15, 0-17 : granitoids from Canellera
0-16 : Piedrancha granodiorite from north of Piedrancha
1385 : granitoid from Maisal area
637 : basic Volcanic rock from Q. Colon of Rio Vargas

Table 3-B Calculation of Normative Minerals of Rock Samples

Sample No.	0-15	0-17	0-60	1385	637
Q (mole %)	41.53	25.68	61.28	55.97	25.42
C				1.21	0.0
OR	2.77	1.97	3.86	2.61	1.28
AB	8.60	6.41	6.38	8.20	5.09
AN	23.54	24.29	14.46	16.63	12.79
Sal. total	76.44	58.36	85.99	84.62	44.57
DI WO	0.37	6.16	0.35	0.0	4.96
DI EN	0.19	3.14	0.35	0.0	4.96
DI FS	0.18	3.01	0.0	0.0	0.0
HY EN	9.62	13.38	8.36	8.92	25.17
HY FS	9.57	12.83	0.0	2.69	0.0
MT	2.01	1.48	2.94	2.71	3.88
HM		1.39	0.84	0.0	4.43
IL	1.19	0.26		0.80	1.22
AP	0.43			0.27	0.16
CC				0.0	10.64
Fem. total	23.56	41.64	14.01	15.38	55.43
Color index	23.56	41.64	14.01	15.38	55.43
mole percentage Q	54.33	44.00	71.26	67.10	57.03
mole percentage OR	3.62	3.38	4.49	3.13	2.88
mole percentage AB+AN	42.05	52.60	24.24	29.77	40.12
AB/AB+AN	26.76	20.88	30.61	49.31	28.47

0-15, 0-17 : granitoids from Canellera
0-16 : Piedrancha granodiorite from north of Piedrancha
1385 : granitoid from Maisal area
637 : basic Volcanic rock from Q. Colon of Rio Vargas

composition of said rock to harmonize the low content thereof in comparing with other Piedrancha granodiorite.

The rock sample 0 - 17 represents the dike having the porphyritic texture and contains brownish biotite estimated as the secondary formations. The rock is accompanied with mineralization of pyrite and a small quantity of chalcopyrite with a tendency of strong mineralization at the marginal zone, and the center thereof being remained comparatively fresh.

Fine grained diorite type small rock body is distributed in the vicinity of Maisal, Canellena. This contains needle-like amphibole, free of biotite, and is similar to Canellena rock body in the vew point of mineral assemblage.

The rock body is intruded into green rock dominant zone. One of them, has the scale about 4 Km x 1 Km distributed in the vicinity of Santa Rosa River. Besides, there is a rock body distributed with the range of 3 Km x 2 Km in the vicinity of Ramos river.

Both of them are important because they accompany with mineralization of pyrite and chalcopyrite or chalcopyrite - molybdenite.

According to the microscopic observation, the original mafic mineral of the intrusive rock of Santa Rosa is almost altered to form chlorite and sericite. Biotite is not also presented in the relic mineral. In case of Ramos, the porphyritic texture is distinguished in the intrusive rock, which contains light green biotite.

For one of the classification of granite of orogenic belt of the world advocated recently, the use of ACF diagram and table is practiced (WHITE CHAPELL 1974, 1977). In plotting in this diagram, the granitic rock of this zone is classified in I type clearly. Besides, the molecular ratio of $Al_2O_3/Na_2O + K_2O + CaO$ is indicating less than 1.1 and classified as I type thereof.

The classification of CHAPELL is mainly stressed the difference of the origins. I type is derrived from igneous origin material, and reversely, S type is originating the sial originated material such as sedimentary rock. In relating to the mineral deposit, the difference thereof is that I type becomes the host rock of molybdenum and copper mineral deposit, and S type becomes tin mineral deposit conventionally.

The intrusion period indicates, according to the absolute age determination, 26.2 ± 1.5 m.y. for Canellera diorite, indicating 28.6 ± 1.7 m.y. for granodiorite dike appeared in the vicinity of Canellera diorite. Both of them are estimated to indicate the Tertiary Miocene age.

3-2-4 Andesite Dike

The dike and sheet-like intrusives of andesitic and basaltic rock are abundantly observed in the sedimentary rock of the Cristal river basin, in the river outcrop of Ramos river basin in the western part.

Those rocks indicate cryptocrystalline and uniform fine groundmass, containing pyroxene and olivine as phenocryst and rarely amphibole therein, which shows dark gray color generally and black color occasionally.

While the thickness of the thin rock is about 50 cm at the outcrop of those dikes, some of them indicates 10-odd meters. It is observed the rock having no characteristics at the upper/lower boundary such as lavaflows show commonly, and is homogeneous, showing in some place a cutting relation with the shaly country rock.

However, regarding to the intrusive period of individual dike thereof, it is difficult to decide because there is no outcrop to indicate a distinct intrusion relation. However, at the present, two general groups are observed in such a manner that the intrusive rocks group of the sedimentation period or the last period thereof of volcanic rocks and sedimentary rocks, and the group completing the intrusion of granodiorite and diorites.

3-2-5 New Volcanic Rocks

The exposure of new volcanic rocks is not observed in the investigation area. However, it is widely distributed to cover the mountains along the automobile road from Piedrancha village to Tuquerres town so as to surround the southern edge of the investigation area.

In the southern direction of Piedrancha village adjacent to the investigation area and the hills of the south of Guabo river, tuff beccia is exposing, as new volcanic rocks, to cover slate bed , andesite and granodiorite thereunder.

Whereas many tuff breccias are affected by weathering, indicating gray color appearance generally, with 1 cm - 20 cm diameter sub-brecciated fragments, and containing the gravels such as andesite and granodiorite, the consolidation thereof is comparatively weak, and provides coarse soft rock generally.

No regularity of arrangement of the rock or the gravel is observed, lacking of the development of crack, and massive rock covering above mentioned slate, granodiorite and andesite in unconformity.

3-3 Geology on the Main Surveyed Routes

3-3-1 Geology on the Basin of Rio Cristal

Cristal river is located at north-eastern zone of the investigation area, flowing west-northern direction from the divide of the elevation about 3000 m running south and north located at about 5 Km west from Samaniego village, and joining Telembi river at about 25 Km.

The vicinity of the confluence thereof gives the elevation of 250 m locating at the lowlands, subsequently providing steep slope in the midway to give a rapid stream. Cristal river is joining with the important tributary streams, with other many small tributaries, such as Canellera river in the midstream thereof and Carrisal river and Nevada river in the upper stream.

The explanation is supplemented from the downstream to the upper stream as follows:

(1) Geology from the confluence joined with downstream Telembi river to the vicinity of the confluence with Canellera river is distributing widely andesitic tuff breccia and andesite lava.

The thin strata of slate is observed, with strike N 50°E 70°SE dipping in Sabaleta valley going up from the confluence of Cristal river and Canellera river to the south of 1.5 Km upperstream.

In the upperstream, the small rock body of granodiorite is intruded into andesite lava. It is granodiorite containing the medium grained hornblende (1 x 2 mm), biotite, quartz and plagioclase. Whereas the rock body and the surrounding andesite lava are observed argillation and pyritization without observing copper mineralization.

Further, in about 2 Km upperstream from the confluence of Telembi river and Cristal river, there are two tributaries Verde and Sergia flowing from north-east. In the central section of the area interposed by both trubutaries thereof, andesitic porphyrite, extending about 1 Km south-north and about 0.3 Km east-west, is distributed. And, in the small creek located downward of Verde primary school, there is the outcrop having the homogenous medium grained dioritic rock. Those rock body is affected by the mineralization of pyrite (main) and chalcopyrite (minor) with the southern extension corresponding section providing 20 m wide of the strong clay belt in Sergia

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(2) Canellera river is approximately located at the central zone of north-eastern of the investigation area. The soil is exposing tuff breccia in the downstream of Canellera river, and black shale and slate in the midstream thereof, distributing large scale of diorite in the upperstream thereof.

Tuff breccia, no-bedding mass, is green color altered tuff containing large quantity of breccias such as andesite, basalt and diabase sizing several cm to several tens of large/small rocks. Black shale strata in the midstream thereof gives strike south-north to N16°E and nearly in vertical, inclining occasionally about 75° in east or west direction.

Whereas they contain the alternation of strata of sandy shale of 10 cm strata thickness and mudstone, and thin strata of conglomerate, generally forming phyllitic shale strata having a black oily luster. Partially, they are affected by strong silicification, forming hornfels, to give a hard fine massive black petrified rock free from fissility.

The bedding surface is completly adhered by recrystallization, which may remain only unregular striped pattern. For such rock, the fine-grained pyrite dissemination is observed in the internal fresh part.

For confirmation, the specimens are sampled every 3 m widness from four locations. However, any content of copper is hardly observed. But gold is contained with 2.4 g/t in 0 - 12, which indicates extremely high as content in slate strata, thereby it is necessary to investigate further, (Ref. Table 6 0-12, 13, 14, 16).

Diorite body is distributing in the wide valley area where the tributaries of Canellera river are branched in a fan shape. The rock is forming the coarse grained plutonic rock containing the large quantity of amphibole reaching to 1 cm - 2 cm, wherein any biotite hardly observed, containing 53 % of silica by analysis, showing basic property, and the appearance and the composition thereof being different from the south Piedrancha granodiorite body.

Partially, the crystal is arranged parallelly in a gneissose form. In the western boundary vicinity of the rock, there is diorite dike intruded into black shale strata (sample No. 0 - 17), observing two outcrops of said rocks at the most upperstream of one tributary in the middle of Canellera main stream and two tributaries of said western upper stream.

Lithology is somewhat basic and contains large amount of amphibole, with dark gray color medium equigranular holocrystalline, and gives the important characteristics for the dissemination of pyrite and chalcopyrite.

The dike provides the width of several to 10-odd meters, controled by fissures in both walls to wide and narrow extremely, and the dip thereof is 50° - 70° west.

As an intrusive rock, small scale of coarse grained diorite is distributed in the other central place, somewhat southern district of Canellera main stream, in ranging approximately 500 m x 500 m, and in the downstream located 1.5 Km west thereof, the same nature of dike with the width of about 10 m is observed in the tributary of the southern bank joining at the point thereof.

They are free from pyrite dissemination and not altered. Concerning the indication of mineral, chalcopyrite dissemination accompanied with said diorite dike and also boulders of gold contained·chalcopyrite and quartz dike are observed considerably in the eastern branch river (Cinta Roja and Andalucia etc.). The accurate location of the outcrop is not confirmed.

(3) Between Canellera river and Sande village, there are Patoquilia river in the north bank of Cristal river, and Tigre river in the south bank. Patoquilia river is extending about 8 Km, flowing approximately in an east-western direction, with jagged banks, observing many big boulders, and the valley whereat is very difficult to walk.

Geology thereof is dark green color tuff breccia upto about 1.5 Km from the river-mouth, observing only black shale as passing through the transition zone intercalated sandstone and shale as going up the stream thereof.

These strikes are generally N-S to N 30°E, with the dip of 70° - 80° East. There is a water-mill for mining gold ore at the location 1 Km from the river-mouth of Patoquilia river. The crude ore produced from Patoquilia gold mine located at the elevation about 980 m is processing actually.

In the mine, 5 cm - 20 cm of narrow vein is distributed irregularly, showing the remarkable dislocation caused by faults. Furthermore, in this investigation, non-mined quartz vein has been discovered at the north bank of the point about 1 Km upstream further from the water-mill.

There are, in the distance of 15 m, comparatively firmed 50 cm - 90 cm of quartz vein, 20 cm of sulfide containing (about 50% oxidated) quartz vein and 2 cm - 50 cm of several quartz veins having an irregularity of strike-dip and discontinuity thereof.

Whereas the result of analysis on 20 cm of sulfide containing quartz reveals Au : tr, Cu : 0.04 % i.e. non productive vein. However, the Patoquilia gold mine is located on the north extension line of this quartz vein group thereof, then this will be a chain of mineralization zone. It would be necessary to investigate the intermediate zone thereof in higher elevation. (Ref. Fig. 6 - F).

Tigre river is going up from Sande village to the south direction, where is locating the largest El Tabano gold mine in this district. In Tigre river, is exposed the faulty fracturing structure for south-northern strike direction, having the narrow vein of quartz in the fissure group thereof.

However, gold mineralization will not present in quartz narrow vein group thereof. The operation objective of El Tabano mine is a quartz vein having the horizontal or gentle dip located at the boundary vicinity between the small scale intrusive diorite and black sandstone - shale strata of the country rock with the varing width of 50 cm - 200 cm accompanying pyrite.

The samples are taken from five locations in the mine. The analysis results reveals free of gold or contains upto 30 g/t of gold, which show irregular results. Copper content is 190 - 500 ppm in a very small amount and arsenic content is 0.01 % - 0.03 %. (Ref. Table 6).

Black shale strata is distributed in the horse trail from Sande village located at the confluence of Tigre river until Madroño river to East, and between them Dorada river and Escalera river tribute to south. However, the upper-stream of Dorada river is located at El Tabano mine zone, many boulders of silicificated rocks burnt in light brown color, available from near vicinity, are observed in the river thereof.

Granodiorite is exposed in the vicinity of Madroño river, not exposing in the north bank of Cristal river. However, pyrite nodule (containing a very small amount of chalcopyrite) is observed spotedly, having 2 cm - 5 cm of diameter in silicificated rock exposed in the north bank tributary Tierra Sana valley.

The granodiorite is distributed, with about 8 km width, from Piedrancha town. Slate located at the circumference of the rock body presented at north end of Piedrancha granodiorite is affected by thermal metamorphism to develop hornfels.

The geological exposure condition of this area is not favorable, unabling to observe indetail. However, biotite - andalusite - coordierite hornfels and biotite - andalusite hornfels are observed, each of them having about 500 m width, the former distributing close to granodiorite, and the later distributing far away therefrom. (Ref. Table 7, T 1805). Sedimentary rocks, composing of black slate, shale, slate and conglomerate thin strata, is distributed in the vicinity of Socorro mine and the upper stream zone thereof, Transveal valley, Cartuja valley and Nevada valley.

It is prevailed by strike NNE - SSW, dip 60° - 90° east, and prevailed by sandy and conglomeratic thin strata toward the eastern zone. Faulty fissures are presented in places, confirming the disturbance of strike dip of formation at both sides thereof, and observing frequently gold bearing quartz vein.

There are Concordia and Cartuja mine, as the old Floresta mine as newly developed mine, any one of which is auriferous quartz vein with small amount of sulfidizing mineral. Among those mines Concordia is the most produced mines and so damaged, old tunnels that is difficult to investigate. Socorro ore dressing factory, under operation at present, is processing the ore available from Floresta mine, which produces small amount of tonnages per day. (Ref. 6-2-7 El Tabano - Concordia mines).

3-3-2 Geology on the Basin of Rio Vargas

This area occupies nearly the central district of the investigation area, covering the district from the confluence of Telembi River and Cristal River to about 30 Km of the ravine district approaching the ridge of Guachavez town.

Vargas river of this district is originated from the ridge of Guachavez town, about 20 Km toward NW direction to join with Telembi river. The topography of the basin thereof is extremely steep, forming the typical V-shape valley at the upstream thereof, and giving gradually the gentle landform in reaching the vicinity of the confluence with Telembi river.

Furthermore, Telembi river of this district is meandering about 10 Km toward N direction approximately to join with Cristal river. The big area and the plenty rainfall of this district are giving extremely the large amount of the water therein.

The geology of this district, composes generally of tuff breccia and black slate, and exposures of granodiorite and the small rocks of andesite by intruding therethrough. Tuff breccia is distributed in said district, Telembi river whole downstream and Vargas river downstream district, constituting 5 cm - 30 cm diameters of the breccias of basalt and andesite, having basaltic rock spotly and mostly andesitic rock, and affected by chloritization and epidotization. Besides, a part of this rock presents the rock facies of basalt and andesite, observing the appearance of green rock fragments in the Colona valley which is the branch valley of Vargas river downstream.

In Telembi river downstream the thin strata of sandstone and slate is intercalated giving a strike about NNW, the dip 20° - 25°NE. In the upperstream thereof, the massive appearance is noticed, and observing no regularity of the breccias arrangement. Besides, in this district the strata thickness thereof is unclear because of no lower strata of this area confirmed.

Black slate is exposed widely from Vargas downstream to the upper-stream thereof, and a part of it changes to black schist due to regional metamorphism. Adjacent to the granodiorite intrusive, it is accompanied by andalusite schist caused by thermal metamorphism.

The rock designates a clear stratification with the strike about NNE, the dip 65° - 80°SE, which shows the interfinger relation with tuff breccia, and transforms from tuff breccia dominant strata to the black slate dominant strata in this district.

The majority of tuff breccia, shows the massive rock, showing few stratification which makes difficult to describe the general structure thereof. However, regarding black slate, isoclinal fold, with the axis parallel to the strike of strata, may be presumed from the exposures and the distribution condition thereof. In estimating from the analysis of the geological profile, the thickness of the strata would be estimated more than 2500 m.

Furthermore, it could not be confirmed the exposures indicating the large fault structure. Nevertheless, it may be presumed the fault of NS direction in the vicinity of the confluence of Vargas river and Telembi river by observing a big structural difference revealed in the intercalation of slate (the strike NNW, the dip 20° - 25° NE) in the part of tuff breccia of Telembi river downstream and the stratification of black slate (the strike NNE, the dip 65° - 80° SE) observed widely in Vargas river.

Granodiorite is exposing dominantly in the midstream of Vargas river and its tributaries. The rock outcrops about 1.5 Km width at Vargas river main stream, showing about 6.5 Km at the divide between Vargas river system and Telembi river system, tapering off in the north direction, forming a large intrusive body extending to NE - SW direction, is coarse grained homogeneous granodiorite having 0.5 cm - 1.0 cm of grains of biotite, amphibole and quartz.

Andesite is exposed in the upstream of Vargas river within black slate having the width 100 m approximately 500 m - 800 m in lengthwise trending NNE - SSW direction. The rock shows the minute fine grained appearance having a dark gray - dark brown color. Both of the rock (andesite and its adjacent black slate) suffer from remarkable hornfels by said granodiorite.

While it is difficult to identify the occurrence of the andesite it may be a sheet-like parallel dike within the black slate strata from the observation of the exposure and the distribution thereof.

Regarding the mineral indications, the dissemination of pyrite are observed in several places in tuff breccia, black slate, granodiorite and andesite, further, partially the dissemination of charlcopyrite being confirmed. Noteworthy is the indication, silicified pyrite dissemination zone in the vicinity of the confluence of Telembi river and Blanco river.

Where it is observed gossan zone having quartz vein in this vicinity, it is corresponding to the north edge of Blanco river mineral indication area and the detailed explanation would be given in 3-3-3 geology of Blanco river and 6-2-2 Rio Blanco mineralizing zone.

3-3-3 Geology on the Middle and Upper Basin of Rio Telembi

The geology of Telembi river midstream and upperstream basin is composed of green volcanic rocks and shaly sedimentary rocks distributed in downstream and Piedrancha granodiorite distributed widely in the upper-stream zone. The former two rocks have general trend of NNE direction, showing zonal distribution, in the order of green volcanic rocks, shaly sedimentary rocks, porphyritic andesite and again shaly sedimentary rocks from lower to upper strata.

The green volcanic rocks are mainly composed of andesitic essential volcanic breccia containing 3 cm - 20 cm subangular breccias and massive lava flow. They suffer from regional chloritization of mafic minerals, containing partially epidote and glauconite, giving a green color mainly, and presumed to be a product of submarine volcanic activity.

In the north area of Eden village, the sedimentary rock, composed of dark gray limestone, black slaty shale, phyllite and fine-grained sandstone, is appeared from the bottom to up in this succession at the eastern bank of Telembi river. Dark gray limestone at the basement, contains limy rock fragments, and under the microscope it is rich in undetermined fossil fragments.

The general strike-dip of the sedimentary rocks indicates N 30° - 40° E, 70° - 80°SE. While the relationship of green volcanic rocks and the upper strata of the sedimentary rocks is generally presumed as the conformity therebetween, the thin strata of sedimentary rock and volcanic rocks is appeared on the alternation of the strata in the vicinity of the boundary thereof to make the gradual transformation or the interfinger relation.

The above mentioned volcanic and sedimentary rocks form the contact zone having the width 500 m - 1000 m in the rock periphery affected by the thermal action of granodiorite which is distributed widely from Eden east side to Telembi river upperstream. The sedimentary rock is metamorphosed up to amphibolite facies represented by coordierite-biotite - sericite hornfels. (Ref. Fig. 3). On the other hand, hornblende and epidote are developed in the green volcanic rocks.

Additionally, hornblende andesite dike (porphyrite), which is intruding in the green volcanic rock, is exposed at the mark numbers 301, 309 in the vicinity of the confluence with Vargas river, with the dike width of 50 m and 200 m respectively. The fissure system observed in this area is most significant in three systems of N 45° - 50°E, N-S and N45°W.

The intrusion directions of the dike are also indicating N 40°E and N 30°E which are following to the fissure system above stated.

Granodiorite is normally called as Piedrancha granodiorite, having the comparatively homogeneous rock facies medium-coarse grained biotite - amphibole granodiorite, where biotite is characterized by presenting idiomorphic crystal of hexagonal form.

The marginal facies of the rock located in Eden village east is composed of amphibole granodiorite, lacking of the homogeneous lithology and lacking of biotite, and contained melanocratic xenolith. Besides, in such marginal area, granodiorite develops schistose structure with strike N 50° E 60°E dip, suggesting a stress during the intrusion.

In the south district, Santa Cruz river upperstream, the schistose structure is not developed and granodiorite becomes the fine grained, and aplitic dikes intrude into the surrounding sedimentary rock in the direction (N 65°E) harmonized with the general strike of the country rock. In the vicinity of La Esperanza village, the fine-grained granitic dike rock and quartz vein are intruded.

The granitic dike rock is in general free from alteration and is slightly observed the weathering of onion structure on the surface. Only exceptions are in Desquite and El Paraiso gold mines, where partial silicification, sericitization are observable in the granite dike rocks.

Regarding to the mineral indications, the pyrite dissemination along the fissue of NE direction observed at the point located at 0.7 Km southward from Vargas confluence and the weak green copper seepage along the foot wall fissure of porphyrite appeared in the same vicinity are discovered. Besides, the boulder of quartz vein which disseminates pyrite in the valley located in 5 Km south of Vargas confluence is confirmed.

For the mineralization in Telembi river basin located in the south of Eden, metalliferous vein type in granodiorite, fissue filling vein type and skarn type in andesite are confirmed. Two of the formers are exampled by gold mines Desquite and El Paraiso operating presently. The vein of Desquite mine is composed of mainly pyrite and sphalerite, having the alteration to form sericite and quartz. Skarn type is located within andesite distributed in the east of granodiorite.

In the Cartagena valley, there observed the boulders indicating the fine vein type mineralization of chalcopyrite and pyrite associated with skarn mineral. Aside from the above-mentioned, the mineralization of mainly pyrite is observed in the hornfels zone locating close to the granodiorite contact, and giving a marked gossan in the vicinity of the ground surface.

3-3-4 Geology on the Basin of Rio Blanco

The geological stratigraph of this vicinity occupies tuffaceous sandstone and shale strata in the medium strata, and develops basalt or andesite lava strata in the upper and lower strata. The thickness of strata distributed in this vicinity is estimated 300 m - 400 m. At least a part of volcanic rock strata of the lower strata shows the texture of hypabyssal rock, quartz diorite, whick crops out from the vicinity of confluence of Rio Blanco and Rio Telembi up to 4 Km southward, and has a medium grained equigranular texture, containing pyrite in dissemination and small amount of chalcopyrite.

Generally the rock facies change remarkably, producing partially dark gray color gabbroic rock which contains mica. (TH 4). Such rock may be corresponding to hypabyssal rock facies of the peripheral green volcanic rocks. Or it may be quartz dioritic intrusive rock which intrudes therein.

Andesite lava indicates a brecciated occurrence presenting the dark green - dark violet color. Breccia is compositely the same as andesite having subangular breccias with 20 cm - several cm diameter, which will be mostly lava flow. In the andesite lava located at the upper strata, the bright green and dark green banded andesitic lava with intercalation of thin strata of mudstone alternates with sandstone and tuffaceous sandstone.

Coarse grained sandstone, conglomerate and tuffaceous sandstone are distributed on the upper strata thereof. The sandstone is well sorted with intercalation of calcareous sandstone and containing imbricated texture of mudstone. The green volcanic rocks may be also distributed on the still more upper strata from observing the floats in the valleies.

The mineralization is observed somewhat in andesite, which is unimportantly the fine vein of pyrite along the fissure of N 60° W. The general strike of the sedimentary rock observed in the medium strata indicates unsteadily N 20° E - N 10° W, which undulates partially with the unfavorable dip having about 19°. The fissure and the joint developed in the andesite rocks are dominated in NW system.

3-3-5 Geology on the Basin of Rio Gualcala

Gualcala river originates from the south eastern district of the investigation area, flowing about 40 Km toward north-west direction, which is classed as the big river joined with Telembi river and has many tributaries. The river basin area of the investigation district occupies about 250 Km^2.

The main basin located within the investigation district is divided into three sections such as upper basin, mid-basin and down basin. The geology of each basin is explained as follows:

(1) Gualcala river upperbasin

The basin is located in the utmost upper stream of Gualcala river, the elevation of the riverbed whereof is in exceeding 1500 meters, and the whole basin is covered with the thick forest. Gualacala river is developing V-valley, the riverbed elevation of the downstream whereof is ranged 1500 m - 1860 m, without shining the direct sunlight, causing the wading in the mossy river beach with large boulders to make difficult extremely. Bombona river is branched from the main stream at the point in the vicinity of the riverbed elevation of 1860 m.

The geology of this district is divided into three large zones, where green andesite and andesitic tuff breccia, alternation of shale and sandstone, and granodiorite are distributed as going up the upperstream. Green andesite and andesitic tuff breccia indicate massive and compact appearance, where the fist-size of cognate volcanic breccias are contained in tuff breccia. The breccias indicate the arrangement of strike, dib with N 40° - 60° E, 50° - 60°SE. The alternation of shale and dandstone represents the fine alternation of the strata of black shale and fine grained sandstone (thickness of a strata 5 cm - 10 cm), which is intercalated partially with the thin strata of banded chert, green tuff and green andesite. The rock strata indicates generally strike, dip of N 30° E, 80° SE, the strata thickness whereof is estimated to exceed 3000 m.

Granodiorite indicates massive outcrop having frequently the sea gull holes. The main mineral composition is amphibole, biotite, plagioclase and quartz, having a coarse grained homogeneous rock with the mineral grain diameter of 3 mm - 4 mm approximately, and indicating the fresh rock body in this district.

The geological structure of this district is comparatively simple, that provides the conformity relation between green andesite, andesitic tuff strata which is lower horizon and the alternation of black shale and fine grained sandstone which is upper horizon, where the rock facies change is indicated to allow the sand muddy sediment to dominate from the dominant facies of volcanic rock and its pyroclastic rock from the bottom to the upper strata. While the notable fault and fold are not observed, the strata indicates the strike NE - SW, the dip with steep angle toward the east side, developing the schistosity structure as approaching granodiorite to present slate and phyllite, where the sandstone is forming hornfels.

Granodiorite, although the direct intruding boundary section not observed, indicates obviously the intrusion rock body on account of the distribution thereof by truncating the strike of the alternation of the strata of shale and sandstone, and the observation of the metamorphism above mentioned.

On the investigation route, the indication of mineralization is not observed. Nevertheless, in Bombona river of the upperstream district, the boulders of granodiorite with pyrite dissemination is slightly discovered, besides, there is Bombona mine (Au), operating greatly before several tens years, in the vicinity of said Gualcala mountain base.

Since the discovery of the mineral indications of dissemination type copper deposit is concentrated in this survey, the survey of the utmost upperstream district is discontinued. Even so, the future survey of gold mine development would be necessary.

(2) Gualcala River Mid-basin

o South-Western Tablon Valley. Carbonera Valley Basin.

This basin is locating at the tributary of Gualcala river midbasin, locating at the east-south edge of the western part of the investigation area, extending in a fan shape at the upperstream, to form generally the valley sized 6 km x 7 km. For both of them, the origin thereof is started from the ridgeline forming the boundary with the basin along Guabo river where the automobile road is running through, wherein the main stream is flowing to the north-east direction to join with Gualcala river.

Generally the geology of this district is widely distributing andesitic tuff breccia and andesitic lava, exposing partially black slate. Andesitic tuff breccia is containing sub-angular breccias of andesite sized 5 cm - 30 cm diameter, no regularity of breccia arrangement observed, and forming the massive rock with lack of developing the fissures. Andesitic lava of the fine-medium grained pyroxene andesite is forming massive compact rock. Moreover, both of tuff breccia and andesitic lava are affected generally by chloritization and epidotization to give a dark green - light green color.

Black slate is exposing at several locations as the parting within tuff breccia from the vicinity of the confluence of Gualcala river and Tablon valley, which forms the distinct stratification in a slaty rock with the fine-grained siliceous sandstone giving a strike approximately NE 20° - 30°, the dib with 30° - 60°E.

In view of the fact that the massive tuff breccia is widely distributed and the exposure of black slate is limited partially, the general structure may not be described. Furthermore, the exposure, indicating the large fault structure could not be observed. Regarding the mineralization, the dissemination of pyrite is observed within tuff breccia discovered at the downstream of Tablon valley (near the vicinity of the confluence with Gualcala river) and the upperstream of Tablon valley with a slight amount thereof, whereat a noteworthy discovery could not be achieved as the minerals indication of this district.

o Mid-Gualcala River, Ramos Valley Basin

The vicinity of Gualcala river, with the wide river bank terrace at both banks thereof, distributes the river deposits containing the large boulders (diameter 1 m - 2 m) of granodiorite.

The geology of this basin distributes widely andesitic tuff breccia and andesitic lava. The andesitic tuff breccia is containing the essential sub-round - sub-angular pebbles. The color thereof presents the dark green - light green gray color by chroritization and epidotization. The breccias are sized 80 cm max. 10 cm ave., unfavorable for sorting and grading, which presents non-stratified massive appearance.

In the vicinity of the midstream of Ramos valley, the intercalation of black slate with 50 m width is observed in tuff breccia. The strike and the dip of the rock thereof is N 30°E, 70°E. Andesitic lava presents the dark green color affected by chloritization and epidotization, lack of continuity, and presents within tuff breccia as an intercalation.

In 500 meters upstream of the confluence of Carbonera river and Gualcala river, the fine grained granodiorite is intruded without observing the mineralization entirely. In the vicinity of the downstream of Ramos river, hornblende porphyrite is intruded. In this rock, the tabular crystal of hornblende, 6 mm x 2 mm, is observed, giving the hornfels to the peripheral tuff breccia, and observing the dissemination of pyrite.

(3) Gualcala River Downstream

- East Bank

The lava, mainly with green - dark green andesite, is distributed as the dominant thereof, observing also other volcanic sedimentary rock (green tuff breccia, siltstone, mudstone) and andesitic tuff, lithic tuff. The green-dark green andesite is normally the fine - medium granined pyroxene andesite, and the colored minerals are affected by chloritization and epidotization. However, non-alterated pyroxene is observed in the coarse facies to from dioritic rock.

Regarding the mineral indications, all area covering from Agua Tigre to Rio Blanco provides the weak-mineralization zone, where the rock is composing of said lava and the cognate tuff breccia. The alteration is affected generally by argillization (partially silicification), observing the green oxidized copper ore in some places, and presenting largely the dissemination of pyrite and the fine network mineralization. The mineralizing zone itself is the congregation of mineralizing alteration zone having a width of 3 m - 4 m with directions of N 75°W - N 60°W, 60° - 70° S, wherein the andesite lava is occupied free of pyrite completly.
(Ref. 6-2-3).

- West Bank

In this district, there are three tributaries, Santa Rosa, Cristal and San Fransisco, each of which is flowing to north-eastern direction and joins with Gualcala river. The geology is composed of volcanic rocks containing basalt, andesite and andesitic tuff breccia, and fine grained diorite. Basalt is distributed in Santa Rosa, Cristal rivers located at the downstream basin, which is characterized largely by containing the light yellow green olivine phenocryst, and containing chalcedonic quartz phenocryst in some places.

In the district of San Fransisco river, the rock facies indicates andesitic, containing mainly pyroxene as mafic mineral, and appearing phenocryst (1 mm - 2 mm dia) of plagioclase. In the float of this district, many olivine basalt and andesitic tuff breccia are observed. Those volcanic rocks are generally affected by the chloritization, providing epidote in some places, which is called meta volcanics. The fine-grained diorite is composed of amphibole, plagioclase, quartz by presenting the fine grained dark green color with the grain size of 2 mm - 3 mm as the main constituent minerals, the distribution whereof is covering more than 3 Km from the midstream of Santa Rosa river to the upperstream thereof with the intermittent exposures thereof.

The fine-grained diorite may be presumed to intrude into said volcanic rock by seeing from the geological condition of the vicinity thereof, whereas the contact boundary is not observed. The fault of this district is conspicuous in a north-south direction in parallel with Gualcala river, where the extension direction of the fine-grained diorite is also indicating NNE - SSW direction in parallel therewith.

The mineralization is primarily pyrite dissemination observed in the part of the fine-grained diorite exposed in Santa Rosa river, observing the indication of porphyry copper deposit type mineralization wherein the filmy mineralization of chalcopyrite is the secondary. (Ref. 6-2-4).

3-3-6 Geology on the Basin of Rio Ñambi

Ñambi river is the big river covering the river basin of the western half of the investigation area to flow nothwardly, having the big tributaries such as Gualcala river and Ramos river, and the upperstream thereof is reaching to the western Junin village vicinity.

(1) While the main stream upperstream district is originally excluded

from the investigation plan, owing to discovering porphyry copper deposit type minerals indication in Ramos main and mid-stream districts, the geology and the geochemical prospecting from Ramon river to the upperstream thereof are carried out for seizing the geological condition of the margin thereof.

Whereas the survey is troublesome in Ñambi river upperstream district as both banks thereof are comparatively steep with the waterfalls in some places, the massive green tuff breccia is distributed in all over the south bank located close to Ramos district. The stratification is scarcely observed in the rock, the round andesitic or basaltic breccias sized scores centimeters is contained, while the whole structures will not be confirmed due to the irregularity of the arrangement thereof.

In the ridge line about 2 Km westward from the confluence with Ramos river, andesitic agglomerate or tuff breccia is overlaying on said green tuff breccia, besides, exposing on Junin-Balbacoas automobile road.

The matrix of the rock indicates somewhat the coarse soft appearance, and at fresh exposure shows the gray green color, while at dry location presents white color, and red color in some places due to hematile gossan. Further, a part of them shows mud-flow appearance, which is estimated as new period. The minerals indication of copper or gold is not discovered in this district, where the outcrop and the boulders are of all fresh rocks.

(2) Ramos river basin occupies almost the central district of the western part of investigation area, the upperstream whereof forms the wide fan-shaped valley sized about 10 Km x 10 Km. The main stream runs nearly toward the north direction to join with Ñambi river, which is rich in water considerably, owing to the large catchment area and the large amount of rainfalls in this district.

The geology of this district is occupied generally and widely by tuff breccia, distributing partially siliceous shale and basalt, andesite, besides, granodiorite is exposing in the central district thereof to intrude therethrough. Tuff breccia is composed of andesitic and balsaltic breccias sized several cm to scores cm, which is affected by chloritization and epidotization. No regularity of the breccia arrangement is observed, besides, lacking of the development of fissure thereof, presenting the massive compact appearance, which is at least sized 150 m strata thickness.

Siliceous shale is exposing to the upperstream of Ramos river, that is, exposing at the midstream of Verde river, the westerly tributary, located in the south thereof, which is the gray or light green color siliceous shale.

The stratification is of distinct with the strike east-west approximately, the dip of north direction 15° or 26° to form comparatively a gentle inclination.

In the upperstream located further from the exposure position thereof, there is a big waterfall enabling to observe the boundary with said tuff breccia where tuff breccia overlies on the shale strata in conformity.

As the exposure of siliceous rock is appearing in a narrow range sized about 400 m along the river, it could not be explained exactly the general structure, which is elevating toward the south highland in parallel with the inclination of topography to the north district.

The exposure of large fault structure could not be observed. Granodiorite is exposed at two places located at the vicinity of the confluence of Mirador river branched from Ramos midstream eastwardly and chuspi river midstream.

Among them, granodiorite exposing at Mirador river is distributing in 1.5 Km x 0.8 Km oval shape extending to north-south direction from Ramos river as a center thereof, in Ramos river bank and in the vicinity of Mirador river confluence, observing the coarse grained homogeneous granodiorite having a crystal grain sized 0.5 cm - 1.0 cm, and presenting the appearance of quartz porphyry having a non-homogeneous porphyritic texture of quartz and feldspar in the location of about 500 m upperstream thereof.

The granodiorite mentioned contains generally the dissemination of pyrite, further, observing the mineralization of chalcopyrite in Sardinera river located in the south-east district and in the tributaries of Ramos River located in the western bank. Granodiorite distributed in Chuspi river midstream north side appears lighter gray medium grained rock than those observed in Mirador, wherein the dissemination of sulfide minerals is not observed.

Regarding the minerals indication, the copper dissemination zone of Ramos river midstream is important and explained separately in later chapter. No mineralization is observed elsewhere.

3-3-7 Geology on the Basin of Rio Guabo

Guabo river is a big river and originates from Volcan Azufral, which flows to north-west direction to join with Mira river, along the river thereof running the automobile road to reach to the west seaside Tumaco harbor, and including the main stream and the tributaries for this investigation area. The river slope of the main stream is comparatively gentle, both banks whereof are distributing widely the talus deposits.

The geology of this district is distributing granodiorite which intrudes andesitic tuff breccia and slate. While excluding from this investigation area, in the opposite bank hill areas interposing Guabo river of Piedrancha village, slate, granodiorite and andesite intruding slate, and tuff breccia covering thereon are exposed, wherein said tuff breccia has comparatively weak consolidation, and generally coarse soft nature to allow to presume as new volcanic rocks.

Andesitic tuff breccia is distributing in the vicinity of Curucuel valley located 8 Km north west of Piedrancha village, generally affected by the considerable weathering to present yellow brownish color, and showing non-stratified massive appearance. The rock distribution in this vicinity is quite scarce to allow the decision of geological condition, from observing the rock facies thereof, which will be the same as the tuff breccia of Carbonera valley and Ramos valley located at the north and north-eastern districts located in crossing over the ridge, that will be underlain by slate described hereinafter.

Black slate is distributing covering 4 Km range in the central district of Piedrancha village and Curucuel village, besides, exposing at the opposite bank of Piedrancha village.

The stratification is extremely clear having the strike about NNE, the dip of 70° - 80°E in the eastern district, indicating a straight line thereof without variation, while the strike N 70° E, the dip 60° - 70°SE in Canpanario valley located at north side in the western district, and in the automobile road along Guabo river located at south side the strike N 15° W, the dip 45°E, and estimating to draw the strike line in the circular arc line expanding to the west side at the central district.

Besides, the eastern district of the rock mentioned is observed biotite-andalusite hornfels, which will be affected by the thermal metamorphism by intruding granodiorite understated.

Granodiorite is exposing in the range about 3 Km wide in the vicinity of Piedrancha village, that is composing of the coarse grained homogeneous crystal grains such as amphibole, biotite, plagioclase and quartz with slight variation of rock facies.

The exposure of andesite is extremely small, with slightly exposing in the ridge of Guabo river south bank located at the Piedrancha village south district which is excluded from the investigation area. The rock facies presents dark gray color with massive compact nature, which indicates a small dike intruding slate and affected by hornfels with the intrusion of granodiorite.

Tuff breccia of new age, similar to andesite above stated, is exposing in the ridge of the opposite bank of Piedrancha village.

The majority of rock mentioned is affected by weathering, presenting generally gray white appearance, which is containing subangular breccias in size with 1 cm - 20 cm diameter, composed of andesite, slate and granodiorite, having a weak consolidation to give the soft and porous rock. The rock has no regularity of the arrangement of the broccias and overlies slate, granodiorite, and andesite with unconformity.

Regarding the minerals indication, there is the old mine, the open-pit of manganese deposit, located about 2 Km of north-east of Curucuel village. The mineral deposit is a stratified mineral deposit within slate and assumed to be syngenetic deposit, though the genesis and occurrence are lacking clearness. Noteworthy copper and other minerals indication could not be observed.

3-4 Geological Structure

In taking a wide view of the geology of the investigation district, the eastern district distributes black shale and slate dominant strata and the large rock of granodiorite to intrude therethrough, and in the district extending from the central to the western district, andesitic tuff breccia, andesite and basalt, and a small intrusive rock such as diorite and granodiorite are exposed.

The geological structure dominating in this district indicates NNE - SSW or NE - SW direction viewing from the strike of the sedimentary rocks, schistosity direction and the extension direction of the rock of the intrusive rocks, and the arrangement condition.

Black shale and slate strata will be the isoclinal fold with the axial direction of NNE - SSW in the north and the axial direction of NE - SW in the south estimating from the distribution area and the partial small exposures, which will be formed by the east-western lateral pressure applied from the Pacific Ocean side.

Andesitic tuff breccia forms the massive non-stratification, where the intrusive shape of dike, sheet is complex which allows the structural presumption to make difficult. Whereas a gentle anticlinal structure is presumed having the axis of NE - SW direction extending from Ricaurte town to Blanco valley located at Gualcala river downstream basin by the parting of the black shale and the slate which are observed partially and the strike and the dip exposed in Ramos river upper basin. In the extension of the axis of anticline whereof the intrusive diorite of Blanco river (Telembi tributary) is presented, and the extension direction of the rock indicating the same as the axial direction thereof.

Further, in the western district, granodiorite and diorite are presenting in Ramos river mid-stream and Santa Rosa river of the tributary of Gualcala river downstream, the distribution arrangement and respective extension whereof are locating also in NE - SW direction to deduce the presence of the axis of syncline/anticline or the fracturing structure.

The fault system of the investigation district is not confirmed clearly on the outcrop due to the luxuriant plants and the rock weathering, while in referring to the photogeological analysis the presence of three fault groups such as NE - SW, NW - SE and NNW - SSE may be estimated.

There is the tendency of indicating that the north-west side thereof is transposed to NE direction by NE - SW system fault, and the north-east side to transpose to NW direction by NW - SE system fault.

Those both of fault lines are indicating the relation to cut each other, which may be nearly formed in the same period, and both of which will be forming the conjugate shear failure against the EW compression force. NNW - SSE system fault may be formed in the comparatively new period after forming said faults owing to having comparatively a good continuity.

In the vicinity of the confluence of Telembi river and Vargas river and the confluence of Cristal river and Tigre valley locating in close to Sande village, there is indicating the steep inclined fault in NS direction, along respective extended direction whereof the intrusive rock such as granodiorite, diorite and porphyrite is extending to arrange in the same direction.

The large rock of granodiorite intruding black shale - slate strata is exposing by the affection of two directional (N-S, NE-SW) structural control. Besides, the NW - SE system fault is controlling the metalliferous vein deposits of Diamante, Patoquilla gold mines, and also controlling the direction of quartz vein-lets of both of minerals indication of Blanco, Gualcala, which will be considered to be the noticeable structural direction on the exploration of the metalliferous vein type deposit.

In summarizing the aforementioned, the investigation district is corresponding to a part of eugeosyncline of Cretaceous period extending to approximately NS direction, where the basic - intermediate volcanic rocks and pyroclastic rock initiated deposition followed by the thick strata of the sedimentary rock mainly composed of black shale.

The vicinity of the boundary of the volcanic rocks and the sedimentary rocks indicate the interfinger type transitional relation, dominantly distributing the volcanic rocks in the west investigation district, and dominating the sedimentary rocks in the east district.

Both of rocks are affected by the lateral force applied from the east-west direction to fold, indicating specially the considerable fold of the sedimentary rocks for presenting the isoclinal fold to incline eastwardly.

The fault system, in corresponding to said lateral applied force, is remarkable in the conjugate two shear surfaces of NE - SW and NW - SE and NNW - SSE direction. Granodiorite of the Tertiary Miocene is intruded into the central axial section of the fold zone, affecting the thermal metamorphism to the peripheral rock.

The small rock of the fine grained granodiorite and diorite, which is deduced to be formed in the preceding period of said intrusive rock, is exposing spotly in the west district.

CHAPTER 4. GEOCHEMICAL SURVEY

4-1 Outline of Geochemical Survey

The majority of the investigation district is covered with the forests characteristics of the tropics having dense trees, and presents the steep topography causing the difficulty to carry out the survey, whereby for the discovery of difficulty to carry out the survey, chemical survey by use of the stream sediment was considered to be the most effective method.

The number of samples collected is 1425 from the entire investigation area covering 1000 km^2. The sampled stream sediment was shipped to Japan for the analysis. Furthermore, in the course of the investigation at the job site, by using a part of the specimens copper analysis by Biquinoline method was employed to make use of grasping the mineralized zones.

4-2 Sampling of Stream Sediments, Chemical Analysis, and Interpretation

4-2-1 Sampling Method

The specimens of the geochemical survey were principally sampled from the silty stream sediment having less than 80 mesh deposited in the flowing river bed.

The specimens are screened in the water by using 80 mesh steel screen to sample 40 gr - 60 gr. It paid attention to sample free of organic substances and coarse riverbank sediments which may cause the errors. The specimens are reserved in the paper pouch or vinyl pouch after rinsing to collect in the outdoor camp for natural drying.

Each dried specimen is divided into two one for analysis in Japan and the other for INGEOMINAS by keeping it in a paper envelope to prevent from mixing, further, packed in a vinyl bag.

The selection of the sampling location is planned so as to allow the survey route to cover the whole district to equalize the sampling spacing as possible.

The sampling locations are spaced in every 300 m - 500 m on the survey route to sample one specimen, in case of the anomaly district presumed from outcrops and rolling stones and Biquinoline method, sampling one specimen in every 100 m - 300 m spacing to increase the density of sampling.

In the sampling point, the numbered aluminum plates were nailed on the trees which are keepable as the target.

4-2-2 Preparation of Sample and Chemical Analysis

For the analysis purpose, the specimens weighted 20 gr - 30 gr for each were divided into about 5 gr analysis specimen by the quartering method.

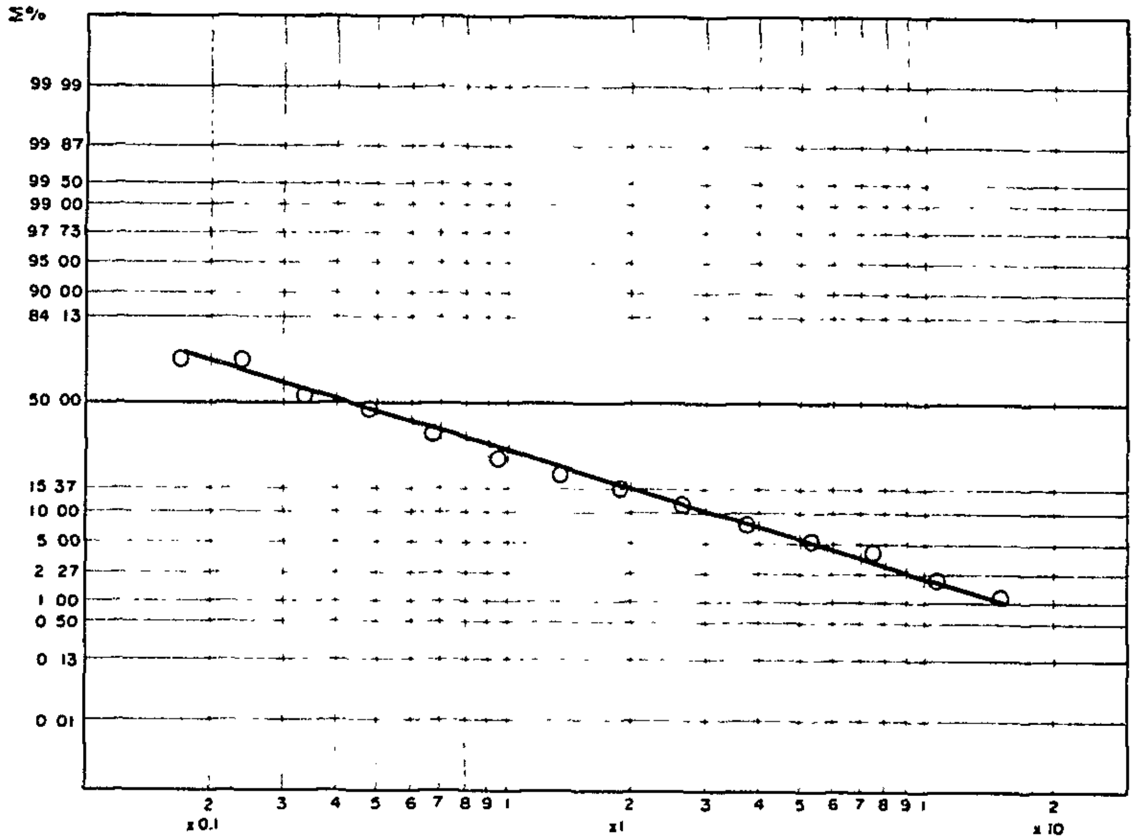
The analysis is implemented for Au, Cu, Pb, Zn, and Mo. The atomic absorption analysis method is employed for Au, Cu, Pb, Zn. The absorbance method, having a high accuracy, is used for Mo due to the small quantity therein. The analysis flow sheet is shown in Fig. 5.

4-2-3 Statistical Process and Analysis of Data

The statistical process with the computer is carried out by using the analysis results of the stream sediment. The cumulative frequency distribution and the histogram of all specimens are shown in Fig. 4-A, B, C, D, E for each element.

The histogram for each element indicates the normal logarithmic

CUMULATIVE FREQUENCY DISTRIBUTION FOR Au.



HISTOGRAM FOR Au

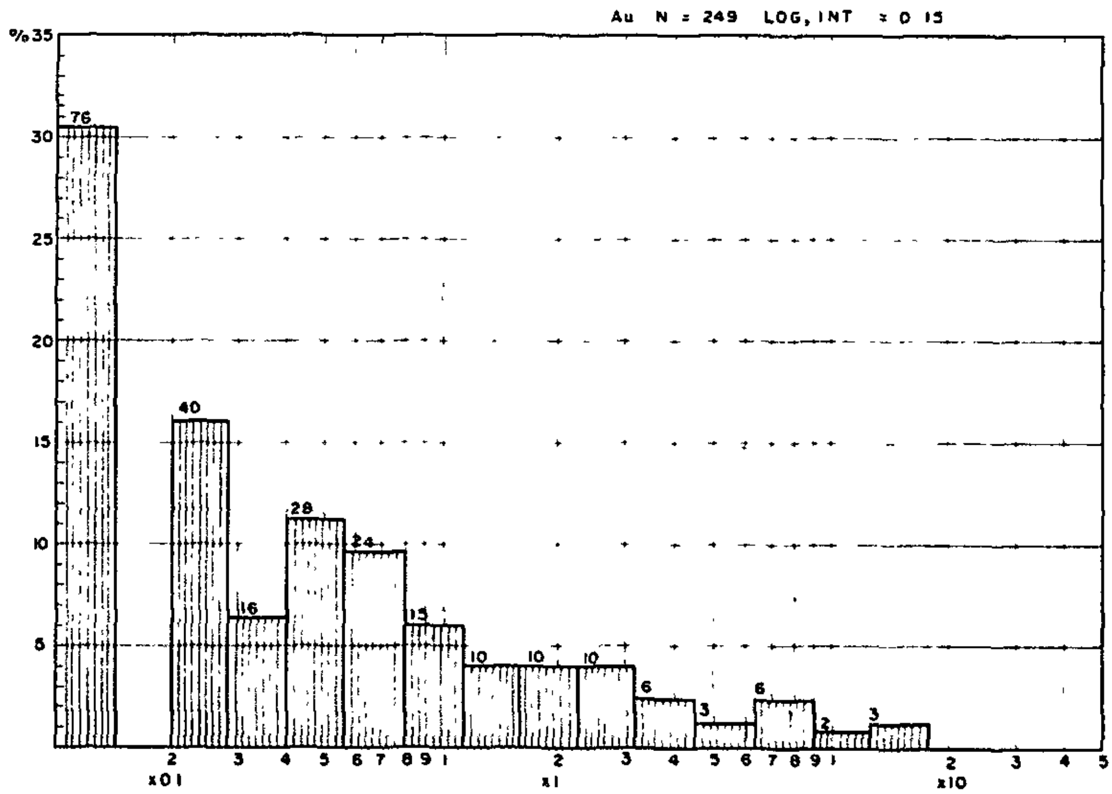
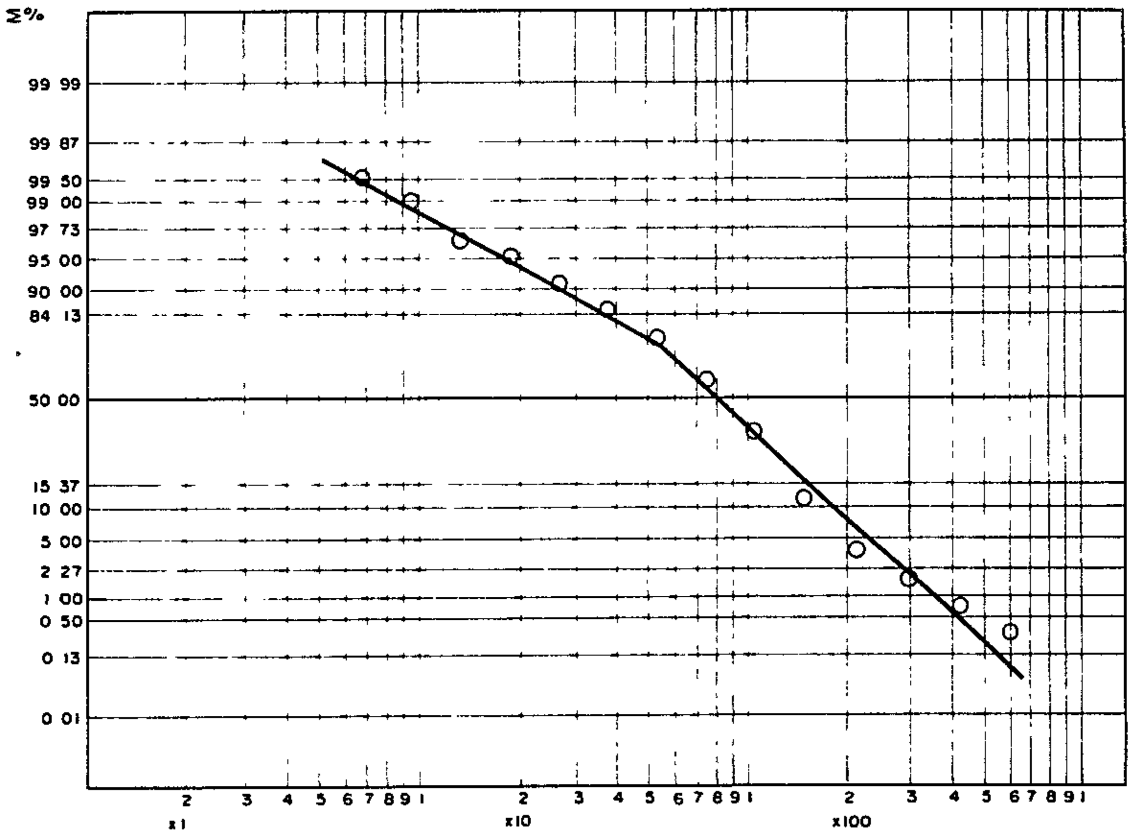


Fig. 4-A Statistic analysis of geochemical data. (Au)

CUMULATIVE FREQUENCY DISTRIBUTION FOR Cu



HISTOGRAM FOR Cu

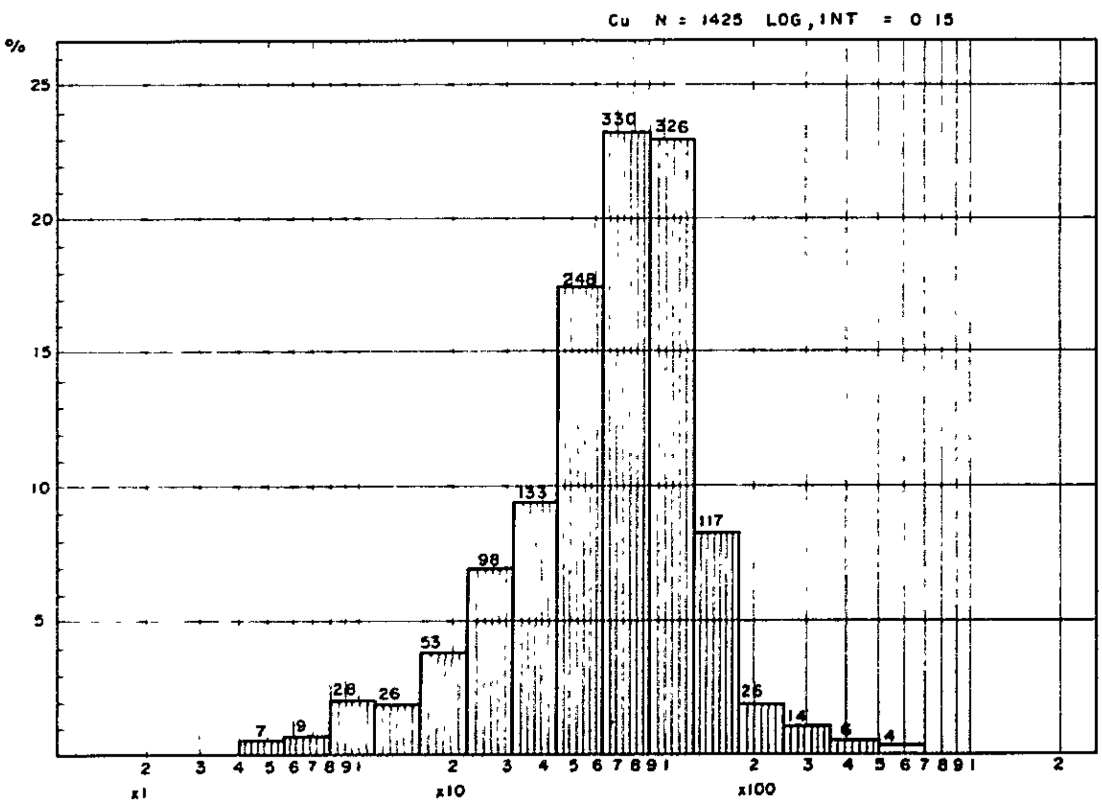
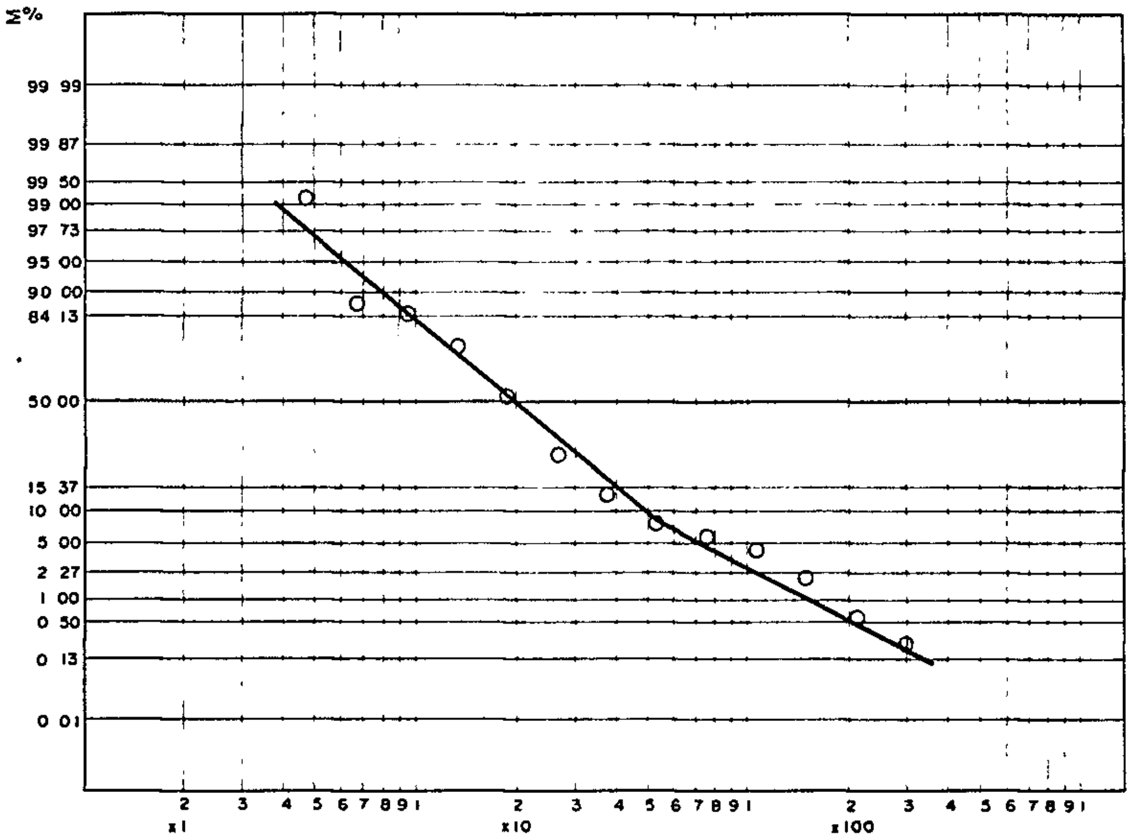


Fig. 4-B Statistic analysis of geochemical data (Cu)

CUMULATIVE FREQUENCY DISTRIBUTION FOR Pb.



HISTOGRAM FOR Pb

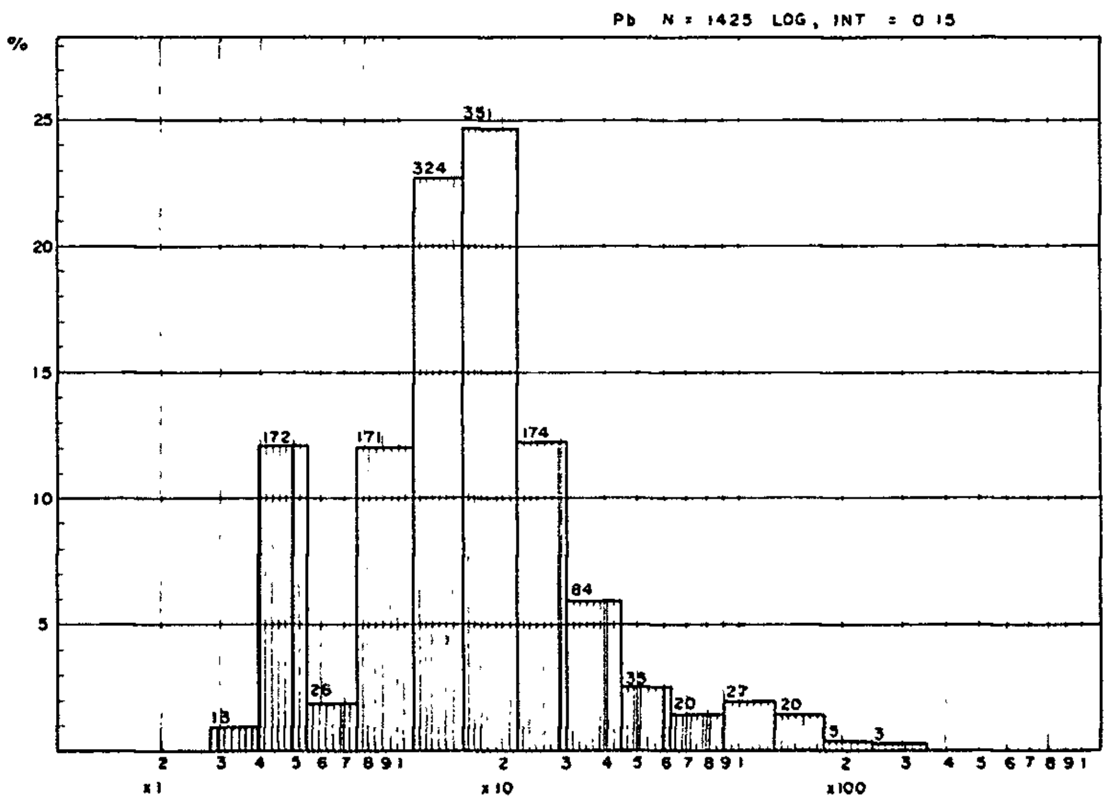
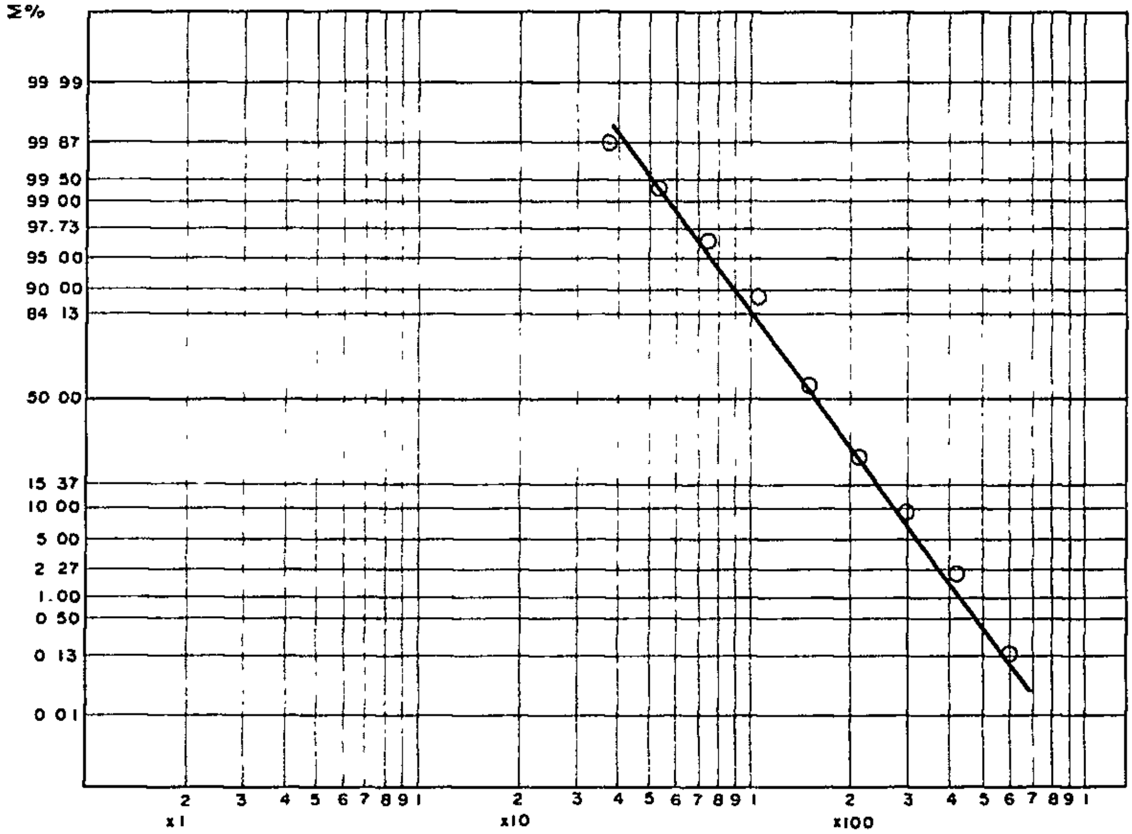


Fig. 4-C Statistic analysis of geochemical data. (Pb)

CUMULAITIVE FREQUENCY DISTRIBUTION FOR Zn



HISTOGRAM FOR Zn

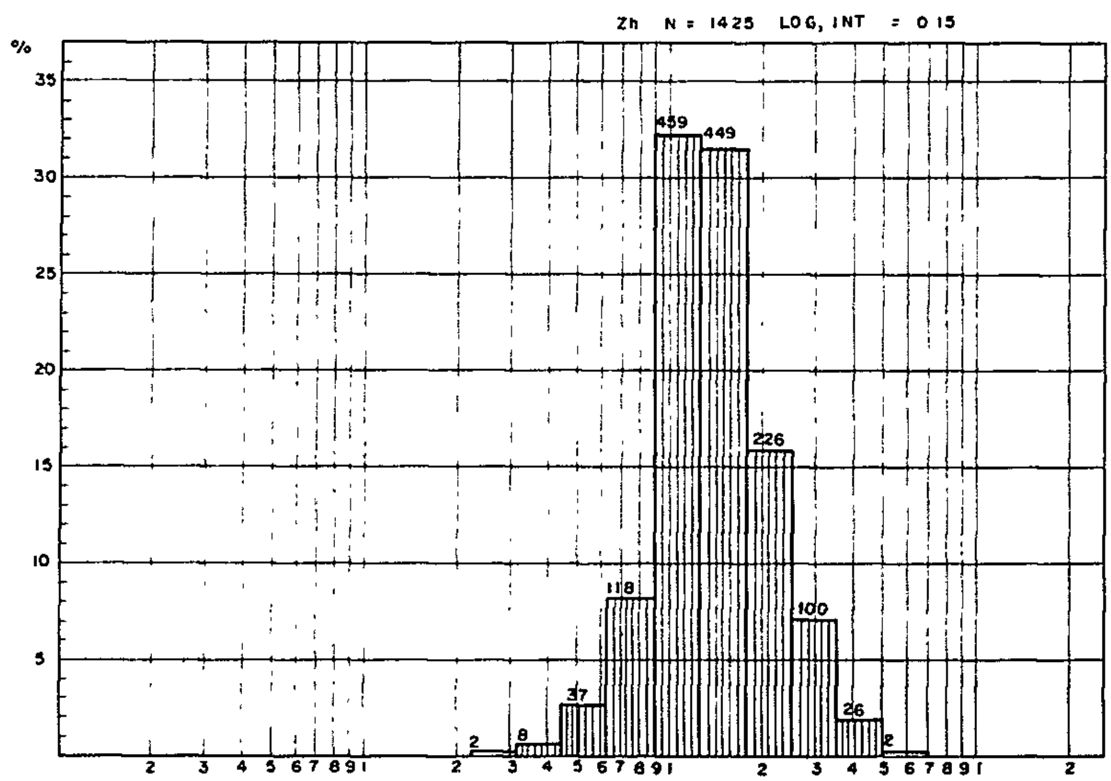
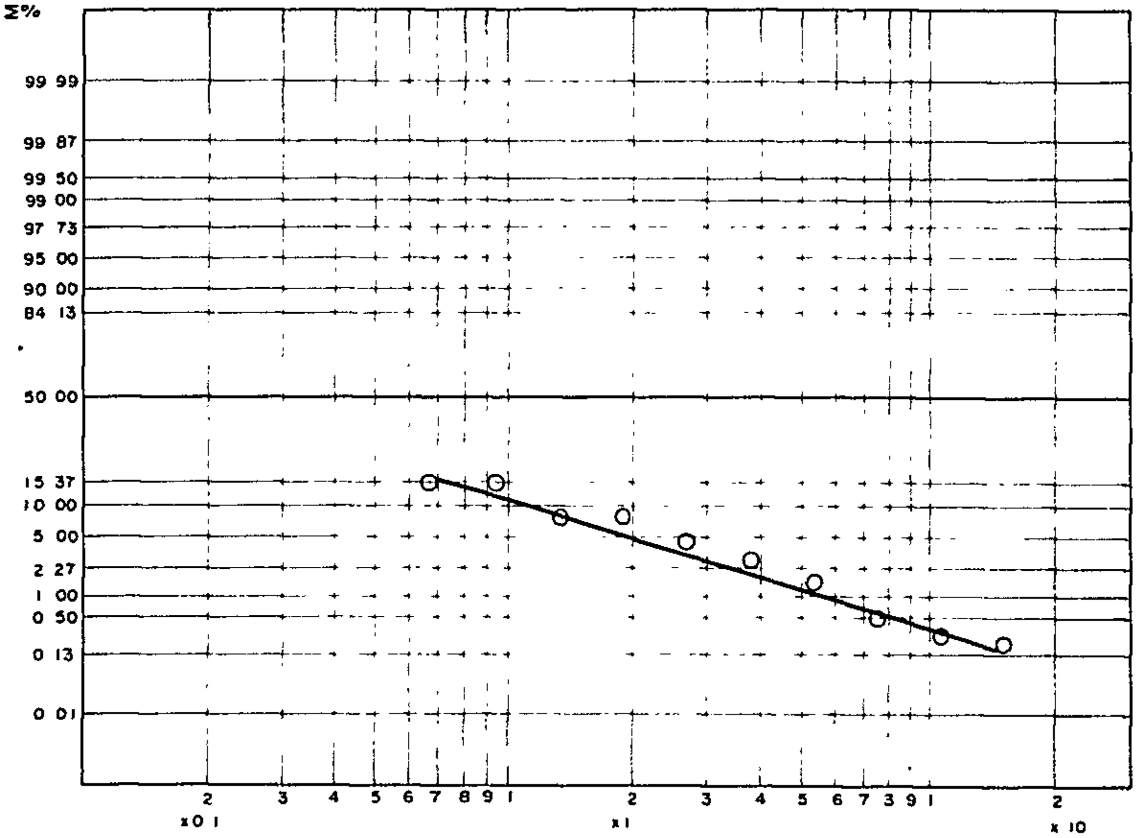


Fig. 4-D Statistic analysis of geochemical data. (Zn)

CUMULATIVE FREQUENCY DISTRIBUTION FOR Mo.



HISTOGRAM FOR Mo

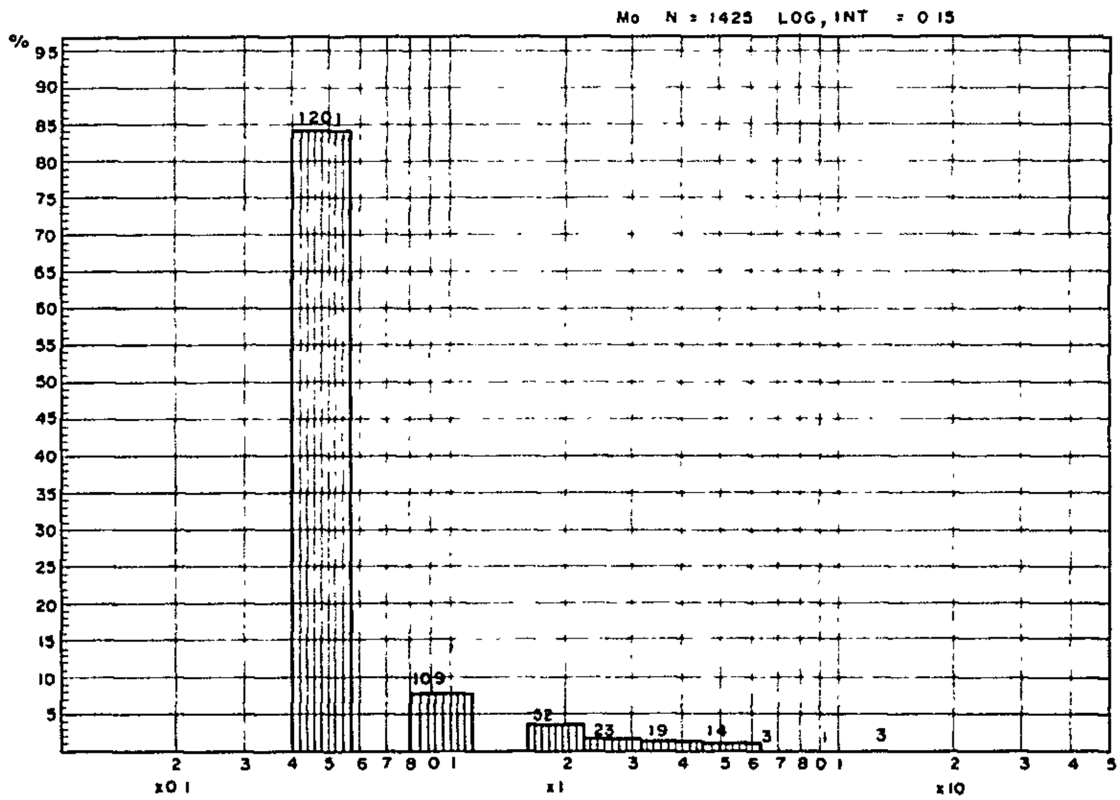


Fig. 4-E Statistic analysis of geochemical data (Mo)

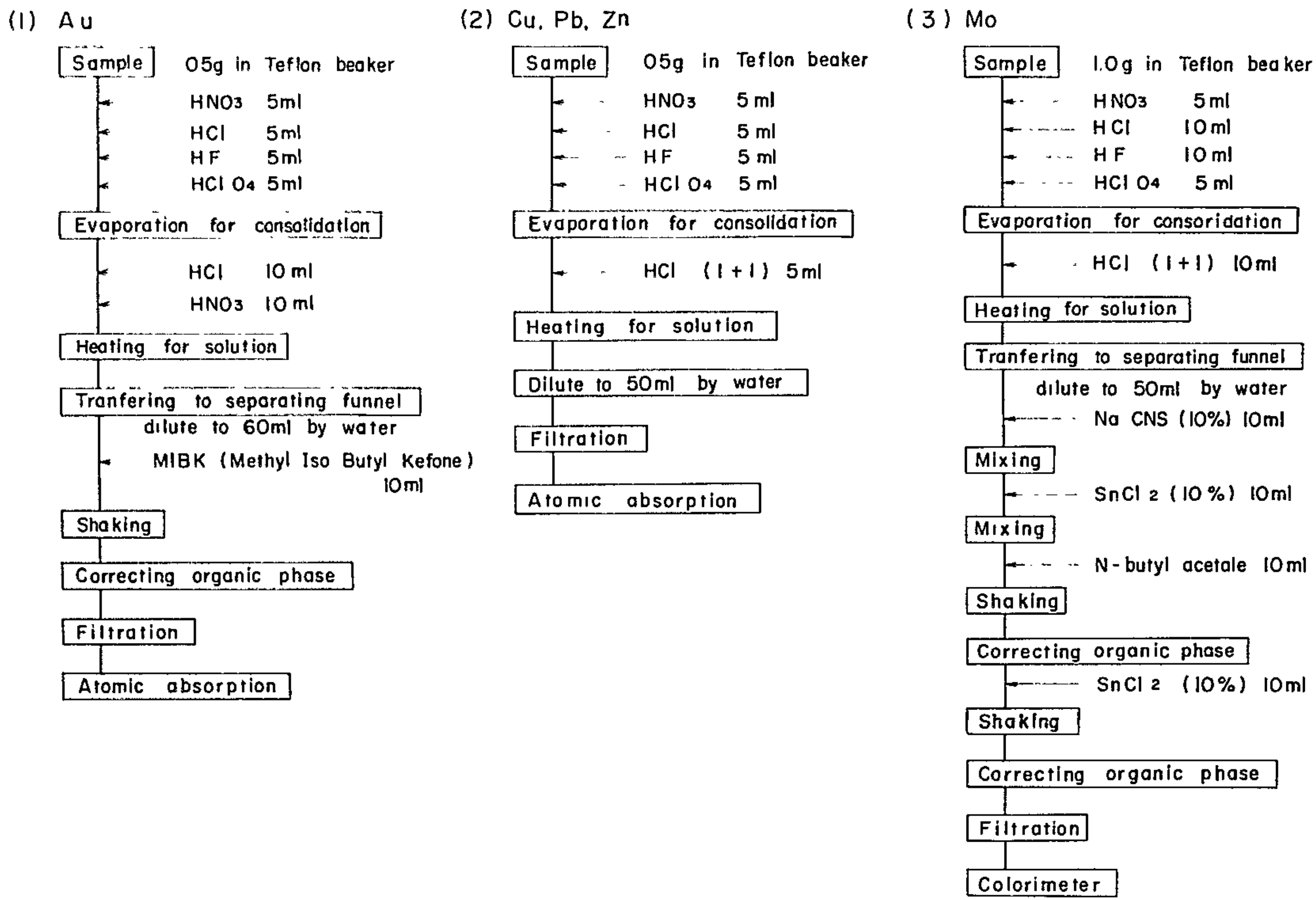


Fig 5 Flow sheets of chemical analysis

distribution, and the cumulative frequency distribution shows approximately in a straight line. The average value ($\overline{X}$) and the standard deviation (S) of each element obtained therefrom is shown in Table 4-A. Further, in order to compute the correlation with the geology in the sampling vicinity, the rock facies of the survey district was classified in three groups.
The first group is represented by the mark (G) for Piedrancha granodiorite, wherein Canellera diorite will be also included. The second group is represented by the mark (V) composing of green volcanic rocks and acid - intermediate small - medium sized intrusive rock having a copper minerals indication which is intruded therethrough.
The third group is represented by the mark (S) to show the sedimentary rocks represented in black shale. $\overline{X}$ and S of each element of respective group are shown in Table 4-B. In comparing $\overline{X}$ values, Pb, Mo indicate the maximum in G group and Cu indicates the minimum therein. Cu designates the maximum value in V group, and Au, Zn, Mo designates the minimum therein. Au, Zn shows the maximum value in S group and Pb shows the minimum therein.

The results above stated are corresponding to the various understated facts ascertained by the geological survey, that is, the district having a high value of Mo agrees exactly with the distribution of Piedrancha granodiorite of G group. Furthermore, many Cu minerals indications are observed in V group, while many Au mineral deposits are observed in S group.

Regarding to all specimens and individual rock facies group, the coefficient of correlation between the respective two elements is designated in Table 4-C.

The coefficient of correlation between respective two elements within all specimens is generally low.

The coefficient of correlation between elements within respective rock facies group indicates high values for Zn and Pb, Zn and Cu, Zn and Au

Table 4-A Mean and Standard Deviation of Stream Sediment Samples

Element	Mean $10^{\bar{x}}$	Standard Deviation 10^{s}	$10^{\bar{x}+s}$	$10^{\bar{x}+2s}$	Skew	Kurtosis
Au	0.39	3.66	1.409	5.15	0.796	-0.202
Cu	63.53	2.06	130.62	268.58	-0.790	1.334
Pb	16.07	2.13	34.28	73.11	0.609	1.217
Zn	137.40	1.52	209.41	319.15	0.098	0.701
Mo	0.61	1.69	1.03	1.75	2.970	8.797

N = 1,425 * Au N = 249 ($\bar{x}$: logarithmic mean)

(s : logarithmic standard deviation)

Table 4-B Mean and Standard Deviation of Stream Sediment Samples Classified by Lithology

Element	Lithology	Mean $10^{\bar{x}}$	Standard Deviation 10^{s}	$10^{\bar{x}+s}$	$10^{\bar{x}+2s}$	Skew	Kurtosis
Au	G	0.32	3.03	0.81	2.95	0.719	-0.216
	V	0.31	3.22	0.99	3.19	1.018	0.434
	S	0.83	4.51	3.74	16.87	0.111	-1.068
Cu	G	37.50	2.28	85.31	194.09	0.124	-0.757
	V	73.62	1.88	138.36	260.02	-1.157	4.151
	S	50.70	2.02	102.57	207.49	0.155	0.020
Pb	G	22.13	2.49	55.21	137.72	0.391	0.059
	V	15.35	2.02	31.05	62.81	0.422	1.289
	S	13.55	2.06	27.86	57.28	1.342	2.947
Zu	G	151.00	1.48	222.84	328.85	0.787	0.172
	V	131.22	1.51	198.61	300.61	-0.080	0.803
	S	162.55	1.57	255.86	402.72	0.257	-0.458
Mo	G	0.72	2.08	1.58	3.30	1.603	1.289
	V	0.57	1.52	0.86	1.32	3.853	16.293
	S	0.71	1.99	1.403	2.89	2.157	4.293

G : granodiorite N(G) = 229 * Au N = 63
V : volcanic rocks N(V) = 1,044 * Au N = 132
S : sedimentary rocks N(S) = 152 * Au N = 54

Table 4-C Coefficient of Correlation between Analyzed Elements

(1) Total

	log(Au)	log(Cu)	log(Pb)	log(Zn)	log(Mo)
log(Au)	100.0	-5.7	7.2	14.1	8.5
log(Cu)	-5.7	100.0	16.5	20.1	14.8
log(Pb)	7.2	16.5	100.0	29.7	9.9
log(Zn)	14.1	20.1	29.7	100.0	2.3
log(Mo)	8.5	14.8	9.9	2.3	100.0

(2) Granodiorite

	log(Au)	log(Cu)	log(Pb)	log(Zn)	log(Mo)
log(Au)	100.0	39.1	18.7	44.3	15.6
log(Cu)	39.1	100.0	41.6	49.6	34.5
log(Pb)	18.7	41.6	100.0	58.3	0.5
log(Zn)	44.3	49.6	58.3	100.0	3.8
log(Mo)	15.6	34.5	0.5	3.8	100.0

(3) Green volcanic rocks

	log(Au)	log(Cu)	log(Pb)	log(Zn)	log(Mo)
log(Au)	100.0	-16.0	18.5	-23.4	23.0
log(Cu)	-16.0	100.0	18.2	26.7	18.5
log(Pb)	18.5	18.2	100.0	24.0	7.8
log(Zn)	-23.4	26.7	24.0	100.0	-5.9
log(Mo)	23.0	18.5	7.8	-5.9	100.0

(4) Sedimentary rocks

	log(Au)	log(Cu)	log(Pb)	log(Zn)	log(Mo)
log(Au)	100.0	-9.9	6.8	38.3	-14.5
log(Cu)	-9.9	100.0	15.9	5.0	33.6
log(Pb)	6.8	15.9	100.0	20.2	20.7
log(Zn)	38.3	5.0	20.2	100.0	7.2
log(Mo)	-14.5	33.6	20.7	7.2	100.0

in G group. The coefficient of correlation is generally low in V group, whereas Zn and Au, Mo and Cu indicate comparatively high coefficient of correlation in S group.

4-3 Anomaly

4-3-1 Extraction of Anomaly

In general geochemical prospecting, the anomaly value represents more than $\overline{X} + 2S$. In case of deducing as the minerals indication attentive zone according to Biquinoline method or geologically at the job-site as explained previously in this survey, the specimen sampling density was increased about three times or more, so that the sample numbers which indicate the threshold value of the anomaly will be higher than the method sampled uniformly.

Then, the anomaly of this survey is valued more than $\overline{X} + S$ to extract the anomaly.

The grade of the anomaly is called weak anomaly for the range $\overline{X} + S \sim \overline{X} + 2S$, and called the strong anomaly for more than $\overline{X} + 2S$.

The threshold value of the anomaly of each element is as follows:

Unit: ppm

	$\overline{X} + S$	$\overline{X} + 2S$
Au	1.41	5.15
Cu	130.62	268.53
Pb	34.28	73.11
Zn	209.41	319.15
Mo	1.03	1.75

The analytical limitation of respective element is as follows:

Au	:	0.1 ppm
Cu, Pb, Zn, Mo	:	1 ppm

The threshold values of the practical anomaly are as follows:

Unit: ppm

	$\overline{X}$ + S	$\overline{X}$ + 2S
Au	1.4	5.2
Cu	131	259
Pb	34	73
Zn	209	319
Mo	1	2

The anomaly is graded from the area where the anomalous values are distributing concentratively.

4-3-2 Interpretation of Anomaly

By adopting the anomalyous value of the previous paragraph, the geochemical prospecting anomalous value distribution map illustrates Cu, Mo, Au in PL. 4-2 and Pb, Zn in PL. 4-3, whereby the anomaly of respective element is extracted and analyzed.

(1) Cu, Mo, Au

Numbers of the anomalous value of respective element are as follows:

	Sample size	Weak anomaly sample numbers	Strong anomaly sample numbers
Cu	1425	122	19
Mo	1425	108	115
Au	249	33	13

The analytical limitation of Au is 0.1 ppm, and the samples having less than this value is counted as 0 ppm for the statistical processing by the logarithmic calculation, which causes to decrease considerably the samples used.

Since, the analytical limit to Mo is 1 ppm, and 84 % of the analysis values whereof showing less than 1 ppm with 1 ppm interval, it allows to reverse the sample size between the strong anomaly and the weak anomaly.

The list of the anomaly districts from the east to the west of the investigation area is as follows:

( ) indicates the anomalous element.

(1) Nevada valley of Cristal river upperstream basin (Au).

(2) La Verde valley of Cristal downstream basin (Cu, Mo).

(3) Blanco river of Telembi river downstream basin (Cu, Mo).

(4) Tributary of the right bank of Telembi river midstream basin (Cu).

(5) Tributary of the left bank of Telembi river midstream basin (Mo).

(6) Telembi river upperstream basin (Mo).

(7) Gualcala river midstream basin (Mo, Au).

(8) Gualcala E of the right bank of Gualcala river downstream (Cu).

(9) The left bank of Gualcala river midstream basin (Cu, Mo).

(10) Santa Rosa river of Gualcala river downstream basin (Cu).

(11) Ramos river mid-upper stream basin (Cu, Mo).

Within seven districts extracted as the anomaly of Cu, in any of five districts (2) (3) (8) (10) (11), the small body of acidic-intermediate igneous rock is distributed in the green volcanic rocks, where the noticeable pyrite mineralization is observed in a part and the periphery of the intrusive rock.

The mineralization of the porphyry copper ore deposit may be presented, which will be the important district for the close investigation.

The anomaly (4), signifying the weak anomaly limited in one tributary zone and having a narrow width, will be formed by the small scale mineralization.

The anomaly (9) designates the anomaly, having of primary Cu and of secondary Mo, scattering in all over the left bank of the Gualcala ranging more than 10 Km in the north-south extension direction, involving the difficulty to extract the distinct collected district.

This will probably be attributable to the mineralization along the weak partial fissures.

The anomaly of Mo is extracted from seven areas, wherein three zones (2) (3) (11) are designating the porphyry copper ore deposit type mineralization zones.

The anomaly (5) (6) (7) designates the area distributing on the Piedrancha granodiorite and the others presenting many riversand sediments originated therefrom.

The anomaly (9) was explained in Cu paragraph.

The anomaly of Au is presenting in two areas located in the eastern district.

The anomaly (1) is locating at the mineral deposit zone having the gold mines such as Concordia, Floresta and Socorro in the downstream whereof, anticipating greatly the existence of the mineral deposit in the basin similar to the above-mentioned.

The anomaly (7) is corresponding to the zone wherein Gualcala river is bending from the west stream to the north stream with a sharp angle, with a gentle slope thereof, at the both banks whereof the riverbed sediments of 0.5 Km - 1 Km wide having the large stones of Piedrancha granodiorite.

In the utmost upperstream of this basin, the Bombona gold mine exploited actively in the past is locating, which may inform of the existence of the alluvial gold deposit originated wherefrom.

(2) Pb, Zn

Anomalous samples of respective element are as follows;

	Sample size	Weak anomalous samples	Strong anomalous samples
Pb	1425	98	68
Zn	1425	165	165

The following nine districts are extracted as the anomaly, wherein the level of the anomaly designates the maximum value of Pb with 325 ppm, the maximum value of Zn with 585 ppm, which indicates comparatively low value, and will not designate directly the existence of Pb, Zn mineral deposit.

(1) Nevada valley of Cristal river upperstream basin (Zn, Pb)

(2) La Verde valley of Cristal river downstream (Zn)

(3) Telembi river midstream basin (Pb, Zn)

(4) Blanco river of Telembi river downstream basin (Zn)

(5) Gualcala river midstream basin (Pb)

(6) Ramos valley of Gualcala river midstream basin (Pb)

(7) Blanco river of Gualcala river downstream basin (Pb, Zn)

(8) Carbonera valley of Gualcala river midstream basin (Pb)

(9) Tributary of Ñambi river basein (Zn)

The anomaly (1) designates the composite anomaly of Pb, Zn, concentrating the anomaly of Zn in the upperstream, and the anomaly of Pb in the downstream, which are overlapped with the anomaly of Au.

Pb, Zn will probably denote the designated element of the gold deposit anticipated in this basin.

The anomaly (2), (4) is overlapped with the above-mentioned Cu anomaly.

Both of the anomaly (3), (5) are locating at the upperstream side of the zone where Telembi and Gualcala rivers are changing their flow directions and the river slopes thereof are locating at a gentle slope area. The anomaly will be formed by the transportation from the upperstream.

The comparatively substantial Pb anomaly is presented in the anomalies (6), (8), the district whereof is presenting the zone of the volcanic clastic rock affected by weathering, which will be the concentration of the trace elements in the country rock.

The anomaly (7) indicates Pb, Zn composite anomaly, where the concentration of Zn in the upperstream, and Pb in the downstream are observed in a manner same as (1).

In this district, the strong pyrite mineralization is observed, which will be the result of the weak Pb, Zn mineralization attended therewith.

The anomaly (9) presents the weak Zn anomaly extending widely, where is distributing the volcanic clastic rock affected by weathering in a same manner as explained in (6), (8), This will be the concentrate of the trace elements in the country rock.

4-4 Geochemical Survey by Biquinoline Method

There will be the limitation for grasping the anomaly district from the outcrop and the rolling stones which will evince the minerals indication. Furthermore, the quick analysis of the cold acid extracted copper by Biquinoline method is employed during the job-site survey and sampling the stream sediment to know the mineralization indication zone at the job-site and to enrich the survey and sampling density due to the wide survey district.

Biquinoline method employed in this survey is as follows:

The stream sediment of 2 gr. is filled in the 20 ml capped test tube with a measuring spoon, adding 10 ml of the extract solution (adding 50 ml of acetic acid to 25 gr. of sodium acetate and dilute with the pure water to make 500 ml. pH = 4), and shake two minutes violently.

The extracted solution is filtered, and the filtered solution is filled in 20 ml capped test tube.

After adding 1 ml of hydroxylamine hydrochloride solution and 10 ml of buffer solution (400 gr. of sodium acetate and 100 gr of calcium sodium tartrate are diluted in 1 lit of pure water) in 2 ml of the filtered liquid (reagent), 1 ml of Biquinoline liquid (liquid obtained by adding 0.1 gr of 2.2' Biquinoline solution in 500 ml of isoamyl alcohol to dissolve by heating 50°C.) is added and shakes for two minutes violently.

The filtered liquid (reagent) is separated into two phases, the organic phase whereof is colored. The color tone is compared with the naked eye.

3 ppm, 6 ppm and 9 ppm of Cu 2.2' Biquinoline solution were sealed in the capsule in Japan as the colorimetric standard solution.

As the results of this survey, the noticeable collective zones of anomaly were confirmed in La Verde of Cristal river Basin, Blanco river downstream basin of Telembi river basin, Tigre-Blanco valley of Gualcala river downstream basin, Ramos midstream basin of Ñambi river basin.

Those areas can be designated as the prospective zones from the geological survey and the stream sediment analysis results.

The survey was the effective method to extract the copper minerals indication area.

CHAPTER 5. PANNING SURVEY

5-1 Purpose and Method of Investigation

It has been known that there are a few active gold mines in the survey area and also incidents of gold being accompanied by porphyry copper type mineral deposit are reported often.

Carried out the panning survey of stream sediments to find out mineralized zones taking gold as the indication element.

Panning survey point were made identical with the geochemical survey sample collection spots, collected heavy mineral particles by panning method of 3 times using a wooden dish of the diameter 30 cm ∿ 40 cm called "Batea", and counted number of gold particles with the naked eye.

5-2 Interpretation of Investigation Results

By results of the survey, the districts where gold particles were observed are as follows:

(1) The Basin of the Cristal River

For the Cristal River main stream, gold particles were observed over the whole area from the upper stream to the down streem confluence with the Telembi River. But along this river, many gold mines are located and natives in several spots are engaged in gold collection from river sand even now. (But the quantity of collected gold is so little that the yield of a whole family can only support their living narrowly).

Besides the above, gold particles were found through the panning survey also at the Nevada Valley and Transveal Valley of the upper most stream basin, the Tigre Valley and it's east side valley of the middle reach basin and the Patoquilia Valley and Canellera River of the middle-lower stream basin.

(2) The Basin of the Vargas River

Observed gold particles at 2 spots of a valley leads to El Tabano gold mine and an upper stream portion near it.

(3) The Basin of the Telembi River

In this basin, gold particles were observed in the vicinity of Diamante gold mine at the upper stream basin and in valleys near both gold mines of Desquite and El Paraiso at the middle-upper stream basin.

As to the main stream, some natives are collecting gold by panning process at a spot about 4 km up-stream from the confluence with the Vargas River which locates in the lower stream basin, and here also gold particles were observed.

(4) The Basin of the Gualcala River

Gold particles were observed at the middle basin of the main stream.

No gold particles were observed besides the above districts and especially in the whole western part of the surveyed area, utterly no gold particles were observed.

Any of the gold particles observed in the above-mentioned districts is separated simple substance native gold of 1 or 2 pieces, presenting the form of a flat particle with diameter of 1 mm ∿ 0.0X mm and as it gathers on the bottom of panning plate together with black magnetite, judgment is comparatively easy.

For the most part, the districts where gold particles were observed in this survey are located in lower stream basins of spots where existence of gold ore deposit is known already.

However, though the quantity is a little, gold particles are observed at the Nevada Valley in the Crystal River upper stream and the basin of the Gualcala River middle reaches where mines are not known. And from the results of analysis on stream sediment in these districts, a few gold anomalous spots are discovered also, therefore existence of unknown gold deposits in both districts are expected. The entire amount of panning samples collected was delivered to INGNEOMINAS Popayan branch office based on the agreement with the counterpart.

CHAPTER 6. MINERALIZATION SHOWING AND ORE DEPOSITS

6-1 Outline of Mineralization

Mineral deposits and mineralization showings embedded in this survey area are as shown in Table 5. They can be gathered into two groups roughly classifying by the type of mineral deposits.

Porphyry copper deposit type mineralization showings:

La Verde, Rio Blanco, Gualcala-E, Santa Rosa and Ramos mineralization zones.

Gold bearing polymetallic vein type deposits:

Diamante, Desquite, Bombona, El Salado, El Tabano, Concordia, Patoquilia and Floresta mines.

6-1-1 Porphyry Copper Type Mineralization Showing

From the results of exploration of copper mineralization area applying the methods of bi-quinoline, geological survey on the boulders and outcrops and geochemical exploration of stream sediment, five copper mineralization zones including La Verde and others were succeeded to discover and identify.

These areas locate in the middle to western part of the surveyed area and are distributed forming roughly a line in the NE-SW direction. The country rock of the mineralization is consisted of Cretaceous volcanic rocks and of Tertiary diorite, granite porphyry, etc. intruded into it. The mineralization is chiefly of pyrite accompanying a small amount of chalcopyrite, and a few molybdenite is observed in places.

As to the alteration of the country rock, chloritization, sericitization, silicification and kaolinization are observed and biotite assumable as the secondary crystallization is found locally. The outcrop

Table 5 Mineralization Showings in the Surveyed Area

Name (Evaluation) Main mineral	Location (Map)	Grid position (Figure)	Area of mineral.& alteration (Area to be surveyed) km²	Number of geochemical samples in anomaly				Geological comments
				El.	wk	st	Tt	
1.La Verde (Prospective) Cu,Mo	North-central (PL.4-2-E,No.2) (PL.4-3-E,No.2)	E920N654 (Fig.6-A)	1.2x1.2 (1)	Cu Mo Zn	8 6 10	2 4 5	19 19 19	Abundant py with rare cp and Mo are visible in network of small veinlets,in porphyrite and porphyritic diorite.
2.Rio Blanco (Prospective) Cu,Mo	North-central (PL.4-2-E,No.3) (PL.4-3-E,No.4)	E915N645 (Fig.6-B)	2x5 (11)	Cu Mo Zn	5 2 11	9 8 1	18 18 20	Anomaly is in the diorite intrusive with quartz veinlets. Limits of mineralization toward NW and SE are not determinated.
3.Gualcala-E (Prospective) Cu	North-central (PL.4-2-W,No.8)	E806N640 E909N638	1.5x1.5 1 x 1 (3.3)	Cu Mo Pb Zn	30 0 9 5	0 0 0 0	83 83 49 49	Twd anomalies are extracted from Agua-Tigre and Rio Blanco. Mainly altered andesite is their country rock. It is relatively low grade anonaly but wide area.
4.Santa Rosa (Prospective) Cu	North-western (PL.4-2-W,No.10)	E902N642 (Fig.6-C)	1 x 3.5 (3)	Cu Mo	9 1	0 1	22 22	Microdiorite is suffered chloritization and pyritization with relatively poor Cu mineralization and very poor molibden.
5.Ramos (Prospective) Cu,Mo	Western (PL.4-2-W,No.11)	E897N637 (Fig.6-D)	1 x 1 (2)	Cu Mo	5 1	3 7	8 8	Southern part of porphyritic granodiorite(1.5x2km²) is mineralized with py-cp-Mo. Contact zone is more oxidated but central part of intrusive is very fresh.
6.Nevada (Prospective) Au	Eastern (PL.4-2-E,No.1)	E933N637	1 x 3 (15)	Au Zn Pb	3 2 4	3 6 1	12 12 12	The area is on the south of the Concordia-Floresta gold mines, and in black slate and shale. There is not known old mine.
7.Gualcala-Middle Au	South-central (PL.4-2-E,No.7) (PL.4-3-E,No.5)	E912N632	0.5x 4 (2.5)	Au Mo Pb	5 11 4	1 9 18	36 36 24	Boulders and gravels of granodiorite are abundant in wide valley, and the old gold mine"Bombona"is to the south-East upper stream. Placer gold deposit will be prospective.
8.Diamante mining area (Prospective) Au,Zn,Cu	South-eastern (PL.1-E)	E930N625 (Fig.6-E)	0.8x2.5 (2)	—		-	-	The principal vein has 600m and more length with direction of N 60W dipping to NE60,with 1.2m to several meters wideness. Au(3.3-32.0g/t),Zn(1-2%),Cu(0.3-1.5%), and As(0.5-32.0%) are main constituent elements of ore minerals. Only superficial soft oxidized ore has been mined in small scale.
9.Bombona mine (Area very required detailed survey) Au,Zn,Cu	South-eastern (PL.1-E)	E922N623	1 x 2 ? (2)	—		-	-	No geological survey has been carryed out,but as the most famous old mine,this had a record of gold production up to twenty and more kilogram a month in past. Being similar to Diamante mine,it may expect considerable remained sulfide ore reserves.
10.Desquite mine Au,Zn	Eastern (PL.1-E)	E925N630	0.2x0.3	—		-	-	Gold bearing sphalerite-pyrite vein with 0.2-1.0m wideness and 250m length is in small scale mining. Vein occures in granodiorite and E-W is general direction, and dipping steeply.
11.Concordia mine Au	Eastern (PL.1-E)	E932N642 (Fig.6F)	0.5x0.5	—		-	-	One milky white quartz vein with breccia had been mined in several decade years ago. It contents 10 +g/tAu in 20-200cm.
12.El Tabano mine Au	North-eastern (PL.1-E)	E924N644 (Fig.6-F)	0.3x0.3	—		-	-	Slow dip--horizontal milky white quartz vein,0.5-2m wideness, has been mined out almostly. North corner of tunnel has a quartz pyrite vein with 16 g/t Au and 50cm wideness,which is now producing small tonnage by 10—15 miners.
13.Floresta mine Au	Eastern (PL.1-E)	E932N642 (Fig.6-F)	0.1x0.1 (Old mining area:0.5 x 0.5)	—		-	-	A milky white quartz vein(20-30cm) with a few sulfide is principal source(Au 10g/t) for Socorro Plant,located at 500m NW from Floresta tunnel.Many other old adits distribute nearby.
14.Patoquilia mine Au	North-eastern (PL.1-E)	E925N650 (Fig.6-F)	0.2x0.2					Narrow white quartz vein is in black shale,dislocated by several fault. Sulfide part with its oxide contains more Au.
15.Telembi-hiddle-north Cu	East-center (PL.4-2-E,No.4)	E920N638	1 x 2	Cu Mo	5 0	0 1	5 5	Weak copper anomaly is checked in a valley only. It may be an indication of vein like mineralization. No appears Au anomaly.

which includes observable copper minerals by naked eye is very rare in any mineralized area, so the scale and grade of mineralization are still unknown.

6-1-2 Gold Bearing Polymetallic Vein Type Deposits

Auriferous vein type ore deposits in the surveyed area are possible to divide into two types of veins like a siliceous quartz vein type which is chiefly consisted of quartz vein and rather small quantity of sulfide minerals mostly of pyrite like El Tabano, Concordia, Patoquilia and Floresta mines in the basin of the Cristal River; and a polimetallic vein type mineral deposits as represented by Diamante mine which includes sphalerite of comparatively much amount and quartz of rather small. Every of them includes gold of 5 ∿ 15 g/ton and have been developed as an auriferous mine and most of them are at work still present though the scale is small. They are, very important to say, also accompanied by arsenide minerals.

These auriferous veins are operated by hand digging only, therefore it is possible to find out further more quantity of ore reserves and better quality for certain mines by adding explorating survey.

6-2 Particular Description on the Mineralization Zones

6-2-1 La Verde Mineralization Zone

The location of this mineralization zone is at the northernmost part in the eastern map of this survey area.

The area has about 1 km width from east to west and locates between two branch rivers of Cristal River: La Verde and Sergia River. Mineralized and altered outcrops are conspicuously located in a small branch valley of La Verde River, and the mineralization is consisted of mainly pyrite and some chalcopyrite in the form of dissemination.

The geology is consisted of, in lower layer, olivine basalt which is black and looks like as sand by weathering in places, and in upper layer, alternative strata of black shale and fine sandstone with strike of N 10° E and dip of 60°E in general. (Refer to Fig. 6-A)

The host rock of the mineralization zone is andesitic porphyrite and medium grained diorite intruded into the boundary of above-mentioned two layers. These intrusive rocks extend in the north-south direction controled by fissures, and in the eastern border traverse the black shale strike, but in the western border, pyritization is weakened gradually and there is no clear boundary of mineralization and alteration in outcrops due to effect of weathering, so the border of lithofacies also is hard to discriminate.

However, considering the area of geochemical anomaly, extension of the mineralization zone itself is assumed as 300 m in width from east to west and 1000 m in length from north to south. And the results of analysis on rock tip samples (collected the sample at 30 cm interval for length of 3 m) revealed the following values:

Sample number	Sampling length	Analyzed values	
		Cu (%)	Mo (ppm)
1013 - 2	3 m	0.27	9
1357	3 m	0.29	60
1362	3 m	0.16	5

Mineralization in this area is accompanied with intrusive rocks and is porphyry copper type showing with fissure filling and dissemination mineralization, but its scale is rather small.

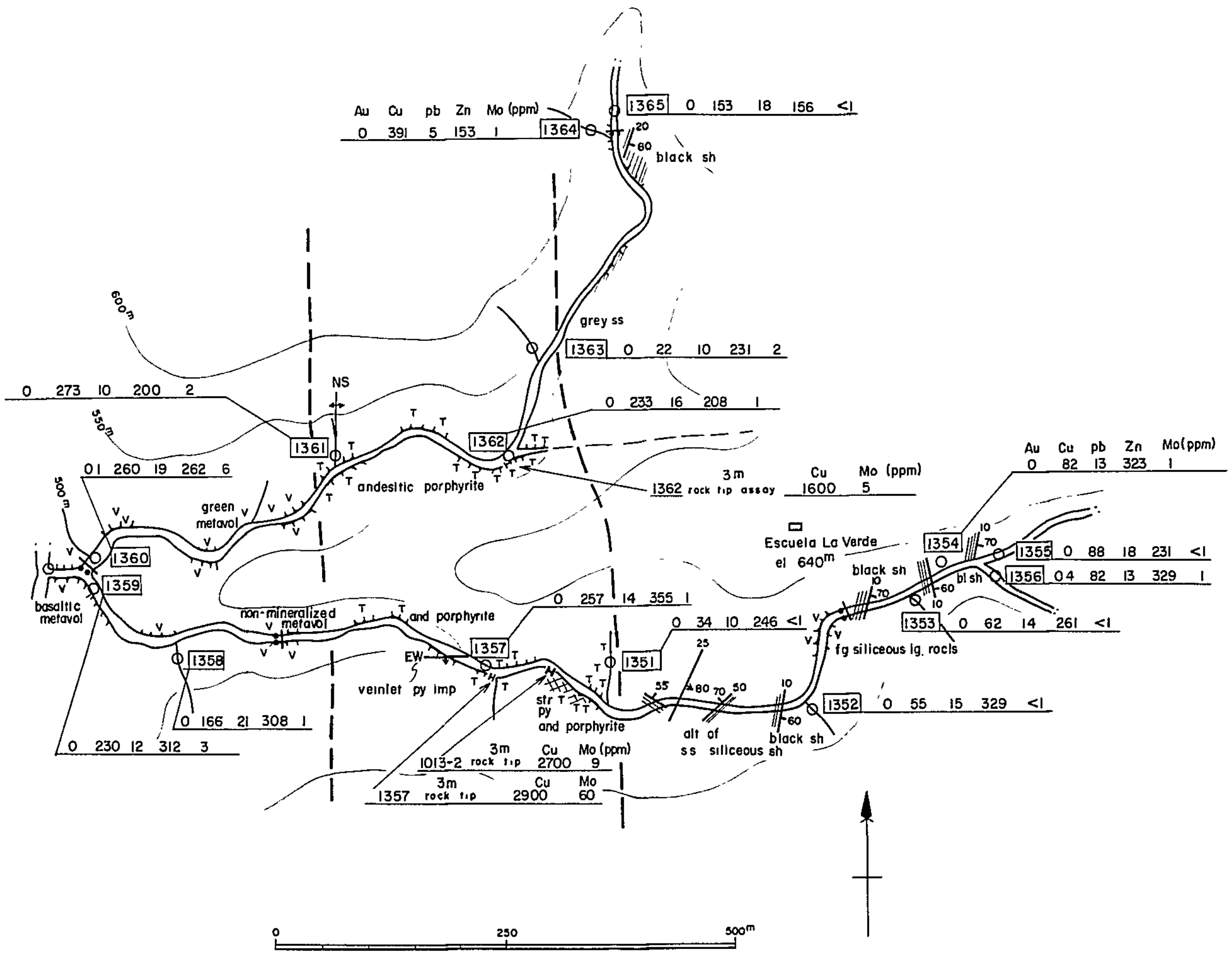


Fig. 6 - A Geological seteh of mineralization showing : La Verde prospective area

6-2-2 Rio Blanco Mineralization Zone

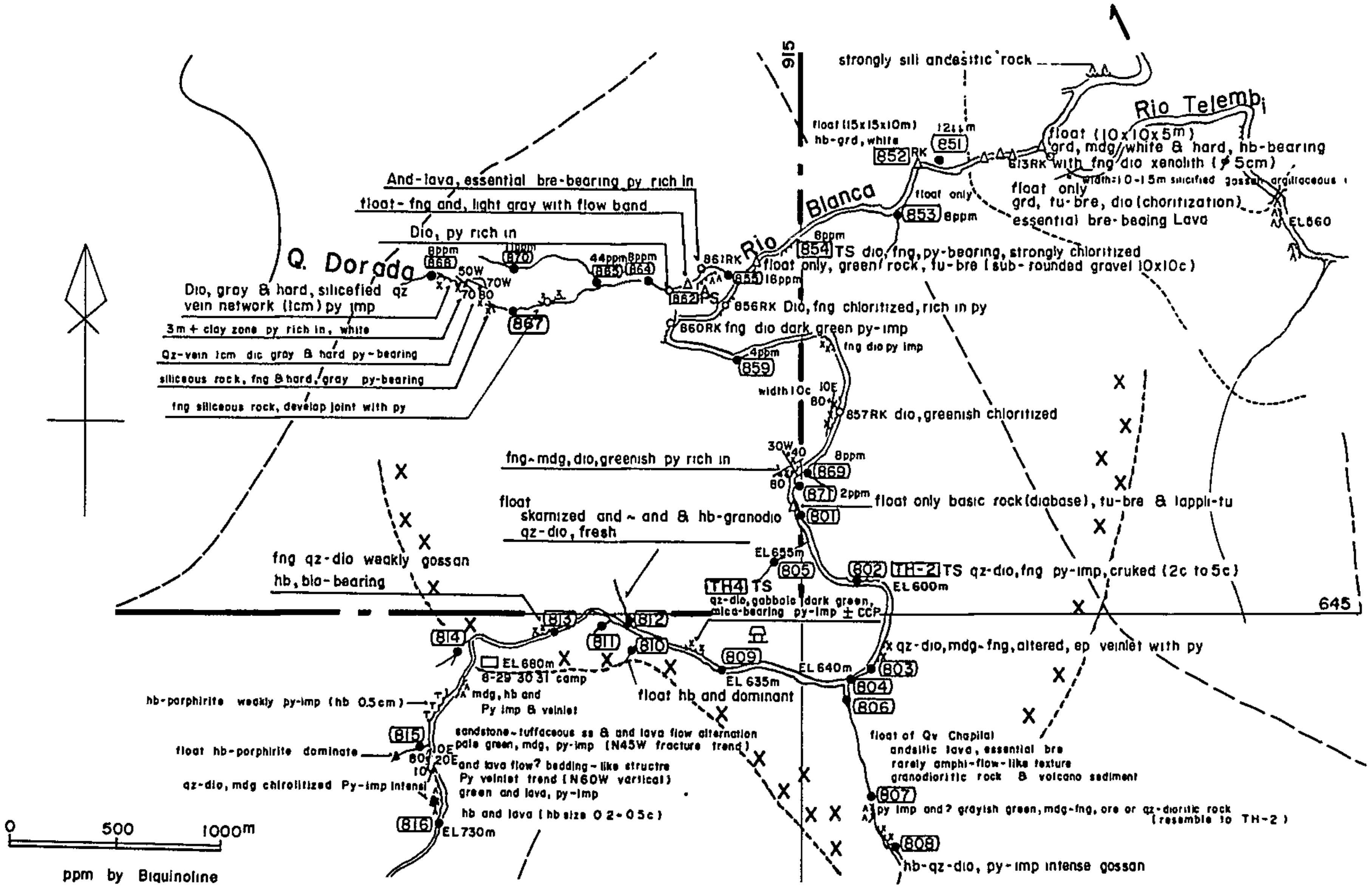
For the zone of about 4.5 km from the Telembi River to the Rio Blanco upper stream, bi-quinoline anomaly and stream sediment geochemical anomaly were noticed. Geology of the area is consisted of fine grained quarz diorite, in which are developed thin quarz veinlets and observed secondary mica. The scope of mineralization zone seems as around 2 km x 5 km, but it is not clear because borders of the north-western end and south eastern limit have not been known yet. In the outcrop, pyrite together with a very small amount of chalcopyrite are observed. Moreover it is recognized a molybdenum strong anomalous area by geochemical exploration also, it is considered as a indication zone of poryphery copper type mineralization.

Since gold particles have been observed by panning test, future survey shall be made cautiously on it.

6-2-3 Gualcala-E Mineralized Zone

Extending over the Agua Tigre and Rio Blanco which are branches in the east bank of the Gualcala River, a mineralized zone of pyrite in andesite is observed. The area of mineralization is recognized as a wide area of geochemical Cu anomaly by bi-quinoline method, and from the results of stream sediment sample analysis, 1.5 km x 1.5 km in the basin of the Agua Tigre and 1 km x 1 km in the basin of the Rio Blanco were spotted. Andesite nearby is affected by weak alternation of regional metamorphism and amphibole is altered partially to chlorite, but in the mineralized zone, silicification, argillization (chlorite, montmorillonite, sericite) and epidotization are observed furthermore. (Ref. Fig. 9)

Strictly speaking, the mineralized zone is not a homogeneous disseminated body but controlled its grade by numbers of fissures strongly



Analysis of stream sediments

NO	Au	Cu	Pb	Zn	Mo
	ppm	ppm	ppm	ppm	ppm
801	0.0	258	23	228	1
802	0.0	231	35	172	0.5
803	00	206	23	188	0.5
804	0.0	89	21	172	05
805	0.0	32	15	123	05
806	0.2	382	24	295	20
807	0.0	379	22	214	2.0
808	0.0	285	17	210	2.0
809	00	102	24	183	0.5
810	0.0	77	27	207	05
811	0.0	82	26	244	05
812	00	114	18	164	05
813	0.0	83	26	244	0.5
814	0.0	80	17	182	0.5
815	0.0	90	22	453	10
816	0.1	101	31	264	0.5
851	0.4	79	5	328	0.5
853	0.0	194	5	240	0.5
855	0.3	320	13	145	2
859	0.0	79	5	93	0.5
864	00	305	5	145	2
865	00	506	5	88	4
867	0.1	289	5	52	05
868	00	321	17	312	1
869	0.0	220	14	252	3
870	0.0	489	5	80	5
871	0.0	58	5	104	05

Fig. 6-B Geological sketch of mineralization showing : Rio Blanco prospective area

and where minerallization is well developed, density of fissures is also got high. As to the direction of fissures, two series (N 60° - 70° W and N 40° - 50°E) are prevailed and the place where strongly mineralized part is in the order of a few meters width.

6-2-4 Santa Rosa Mineralized Zone

This mineralized zone locates in the northwestern part of the survey area and was discovered at the Santa Rosa River which is a branch of the Gualcala River running through the survey area from the southeast direction. Since survey items at the present stage are reconnaissance geological survey along major valleys and sampling of stream sediments, then the whole aspect about extension of the mineralized zone has not been investigated yet. The mineralization is that of pyrite (principal) and chalcopyrite (subordinate) which indicates precipitation along joints and dissemination into the country rock. Diorite is fine grained rock which includes amphibole and biotite of grain size 1 mm - 2 mm in 20 % - 30 % amount.

The mineralized diorite continues, exposing intermittently, from sampling spot No. 204 of stream sediment up to the survey terminus (sampling No. 214) for about 1.2 km (Ref. Fig. 6-E). Mineralized diorite has joints at the interval of 5 cm - 10 cm and pyrite are disseminating into joint walls and country rock in the form of film and spot. Chalcopyrite associated with pyrite is found locally.

Chloritization, some kaolinization and silicification are observed in the altered country rock, but it is so weak in general that identification of original colored minerals is possible by the naked eye. Judging from the type of mineralization, it is a porphyry copper type mineralization, but the alteration and mineralization which has been now investigated may be peripheral aspects that better mineralized zone could be found

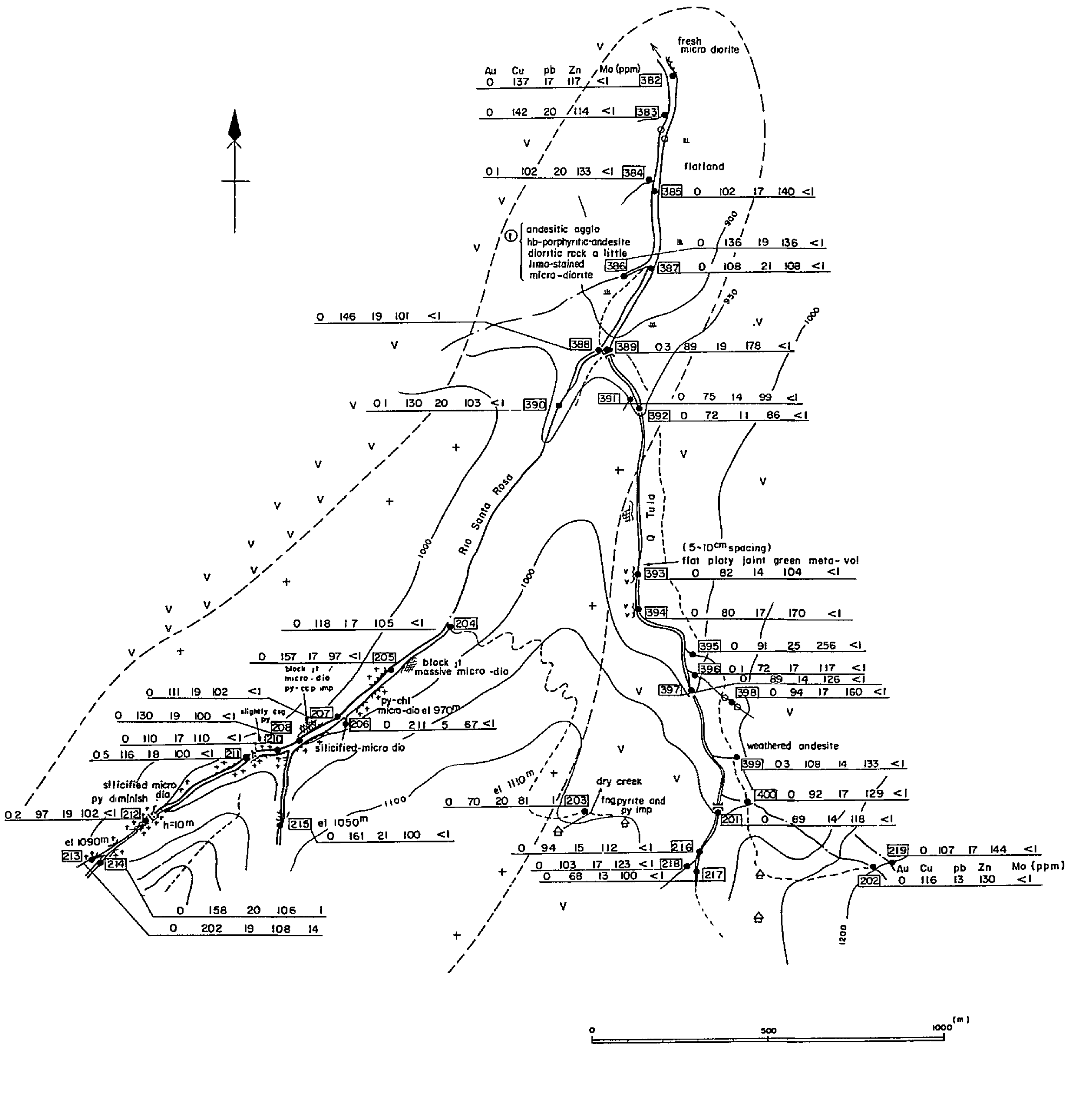


Fig. 6 – C Geological sketch of mineralization showing
: Santa Rosa prospective area

in deeper zone, so, precise survey in future is necessary.

6-2-5 Ramos Mineralization Zone

There is an intrusive rock body of diorite or granodiorite at about half way up the Ramos River and mineralized zone of pyrite, chalcopyrite and molybdenite is observable in the southwestern and southeastern parts of the intrusive rock with a elliptical shape. Cupriferous indication was noted by bi-quinoline test, and in the results of analysis of stream sediment samples, among eight samples from the neighboring area, five weak Cu anomalous values and three strong ones were detected. In the anomalous zone on the west bank of Ramos River, outcrop of oxidized silicified rock, so called "gossan", and argillized fracture zone are visible.

The size of the mineralized area including such outcrop of altered rock is about 1 km x 1 km.

However, for the central part of intrusive rock near the Ramos main stream and its branch Mirador River extending eastward, mineralization of pyrite is observed in joint fractures but almost no copper minerals are found. The rock has been scarcely fractured and is fresh comparatively.

At the spot of sample No. 102 on the east bank of the Sardinera River, dark green altered andesite is observed being subjected to chloritization, pyrite and chalcopyrite mineralization. Chalcopyrites are precipitated rather in large quantity in the form of film attached to joints. Analyzed values of stream sediment were Cu 305/Mo 6 for No. 102A and Cu 406/Mo 5 for No. 102B (each in ppm). But inside the country rock, almost no dissemination was observed and from the result of microscopic observation also, only actinolite-like amphibole, sericite and magnetite are observable which are considered as formed by contact metamorphic reaction on the occasion of diorite intrusion. (Ref. Table 7, No. 0-37)

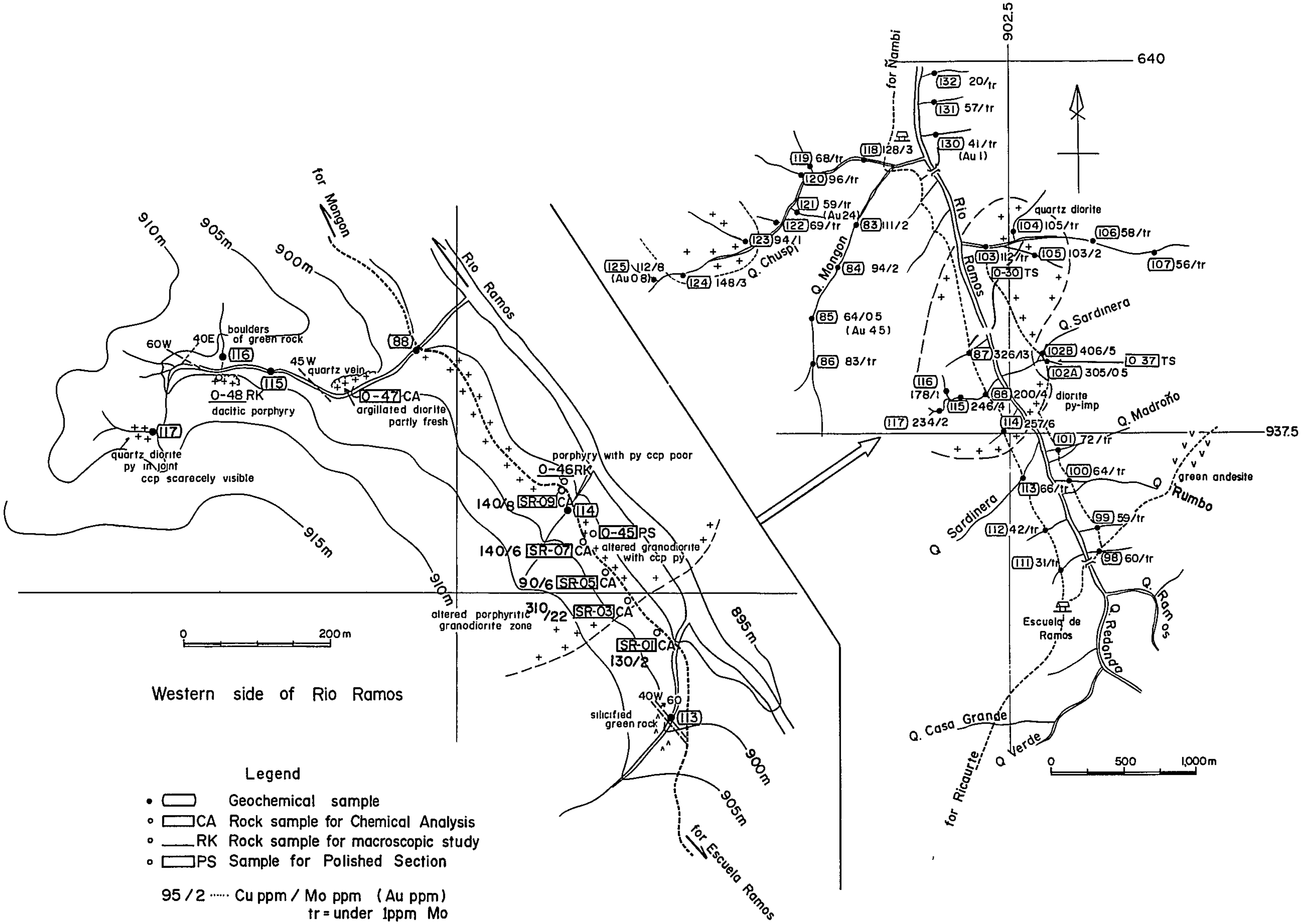


Fig. 6-D Geological sketch of mineralization showing ; Ramos prospective area

Analysis of sampled altered rock subjected to argillization (0-47, horizontal length 2 m, width 5 cm, channel sampling) showed values of Cu: 370 ppm and Mo: 7 ppm. Among five soil samples collected at 50 m interval between No. 88 and No. 114 of the stream sediment sampling spot for analyzed values of samples were low as Cu 90 - 140 ppm, Mo 2 - 8 ppm and only one value was Cu: 310 ppm and Mo: 22 ppm.

Upto the present, these values of analysis give an impression on the whole that the mineralization shall be weak. But the outline of mineralization zone is unknown yet, so to find out the central portion of the mineralization, further detailed survey is necessary to carry out.

6-2-6 Diamante Mining Area

Surrounding Mt. Gualcala which occupies the southeast corner of the survey area, gold and silver mines which accompany small amount of lead, zinc and copper minerals such as Diamante, Desquite, Bombona, El Salado, etc. are distributed. To learn the geological outline of mineral deposit in this area, carried out a survey on the Diamante mine among them this time. (Ref. Fig. 6-E)

Diamante mine locates in southwest of Guachavez (Santa Cruz) town, with a distance of about 4 km in a straight line and lies in Diamante Valley, the uppermost stream of the Telembi River. Between heights from 2500 m to 2700 m above sea level, numerous old mines are distributed and following the recent raise of gold and silver prices, 4 of these old mines are reopened and re-digging of filled wastes in old tunnels and a few prospecting are progressing.

Within the length of about 1 km, there are located mining adit entrance, crushing unit, and panning gold collection shop by water-mill power in 4 places.

Reconnaissance Survey has been carried out in the mining adits called respectively as Hormiga, San Rafael, Auxiliadora, Diamante, Gualquilia and San Sebastean where were possible to enter and perform rough sketching of geology of mineralization, and collect samples for analysis and microscopic observation. Wall rocks of the vein are grayish green massive and compact andesite, and mineral deposits are a fault origin fissure filling vein type. Some differences are found for mineral assemblage of each mine, and their features are as mentioned in the followings:

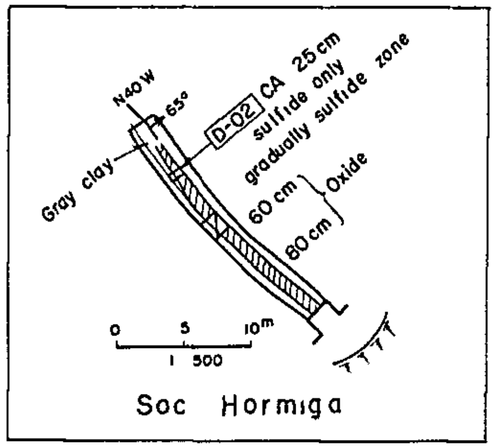
San Rafael mine Width about 50 cm, dipping 40° - 70°N, siliceous and abound with arsenopyrite and sphalerite.

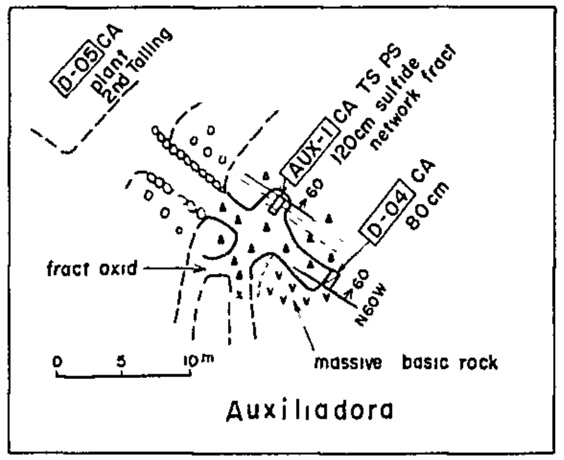
Hormiga mine Width around 20 cm - 100 cm, abound with pyrite, arsenopyrite, accompanied with clay vein. The vein shows conspicuously pinching and swelling.

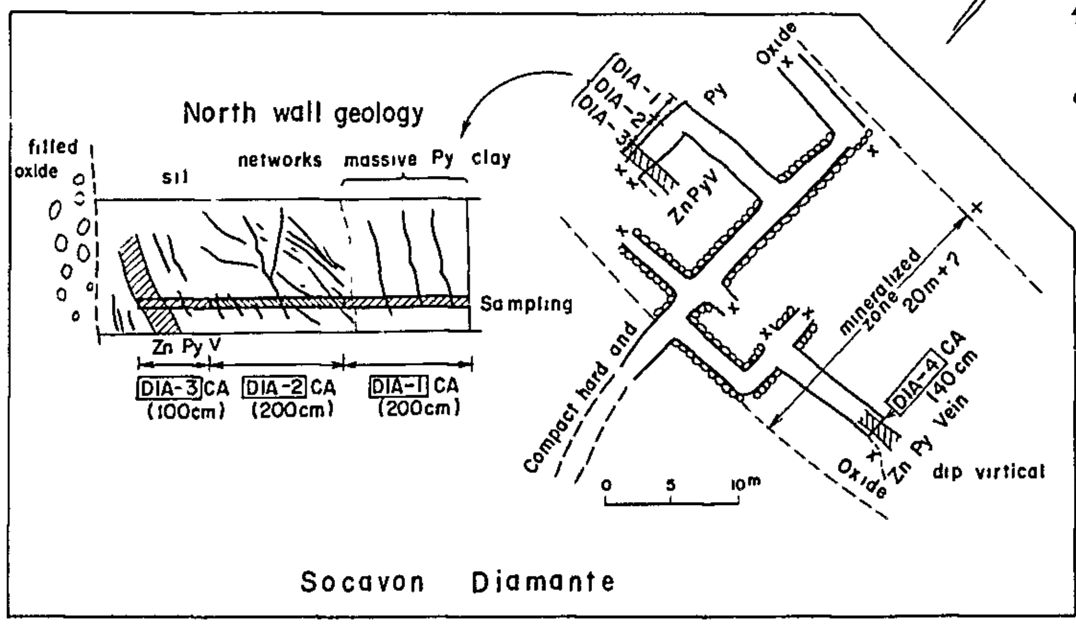
Auxiliadora mine Fractured and silicified basic andesite is country rock of sulfide (principally pyrite) mineralization. Strike of major fissure (Ref. Fig. 6-E Sample No. AUX-1) is N 60°W, dip 60°NE in a brecciated networked veinlets. There is an altered rock which looks like dacite in the matrix of brecciated rocks, and there is a possibility of existing of acidic rock which intruded in brecciated zone with mineralization.

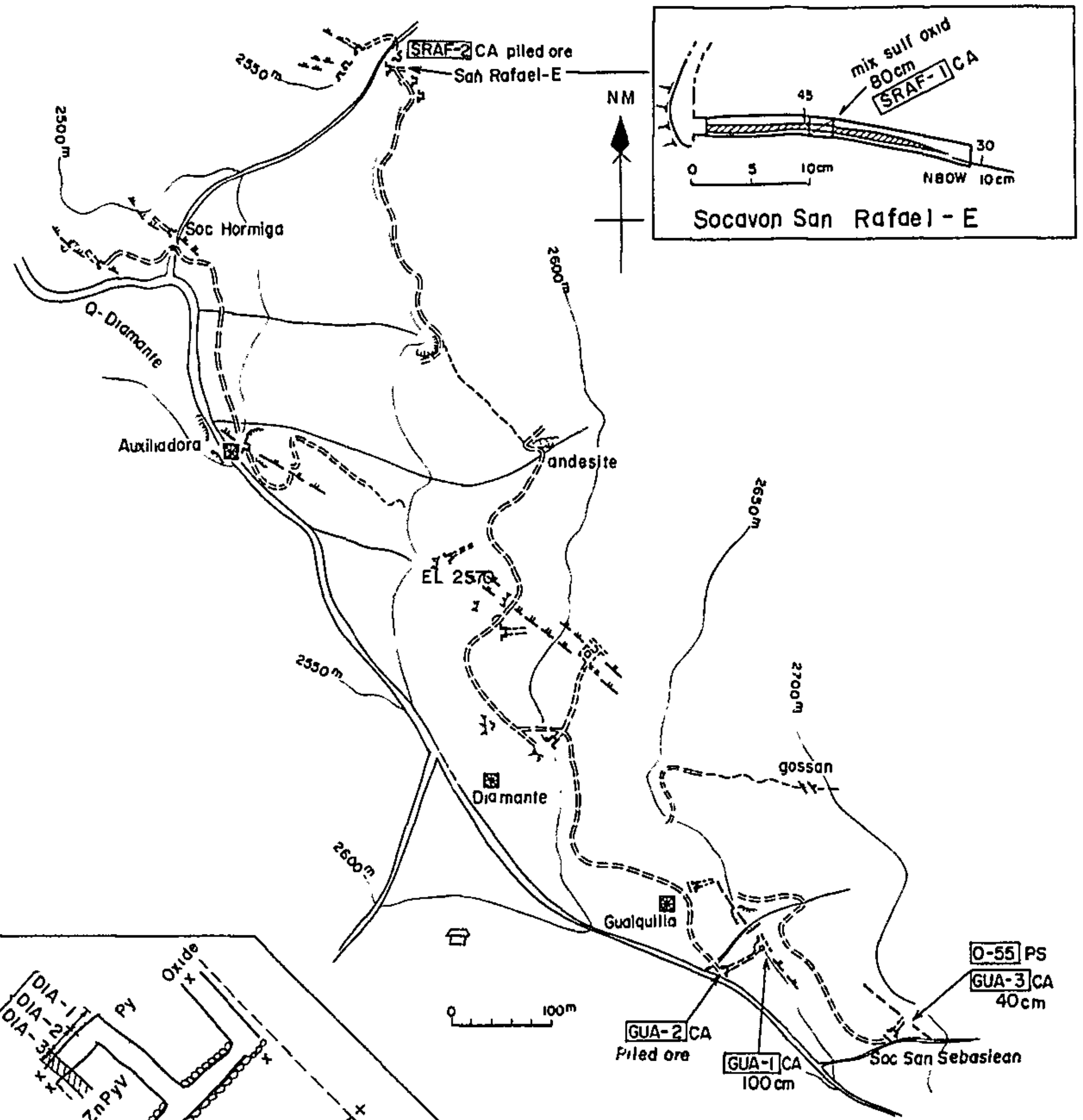
Diamante mine

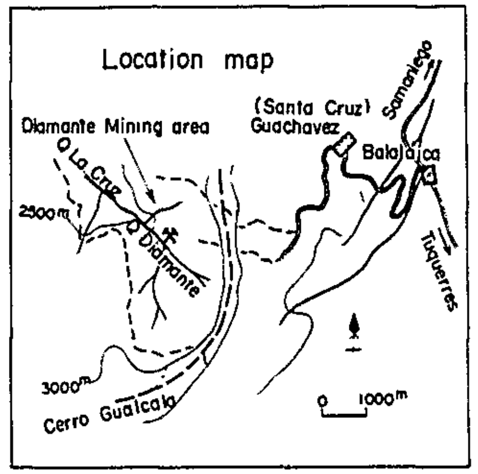
Encountered with a wide mineralized vein at 100 m X-cut front, the ore is digged out easily from the old tunnel, and is transported and treated in the water mill ore dressing plant, where 1 set of 2 m table, specific gravity ore separator, are provided. And gold extraction from tailing sulfide rich sand by cyanide process is under test partially. On the inner north wall, massive pyrite is appeared in the east side and a few stripes of sphalerite galena veinlets are











	Au ppm	Ag ppm	Cu ppm	pb %	Zn %	As %
D-02	17.0	143	3100	0.19	1.30	23.00
D-04	3.3	90	2300	0.10	2.20	32.00
D-05	112.0	75	2700	<0.01	0.02	0.84
AUX-1	15.7	13	930	0.01	0.01	0.16
DIA-1	2.0	3	500	0.03	0.14	0.64
DIA-2	7.6	122	4200	0.13	1.10	1.60
DIA-3	25.5	76	1300	0.24	1.50	6.00
DIA-4	8.8	46	1100	0.20	2.00	4.40
GUA-1	0.8	74	2000	0.37	0.32	0.52
GUA-2	32.0	236	15000	0.89	2.10	1.70
GUA-3	1.7	263	9600	1.50	1.40	0.56
SRAF-1	17.6	56	370	0.40	0.04	9.40
SRAF-2	3.5	76	1000	0.45	0.72	17.00

Fig. 6-E Geological Sketch of mineralization showing : Diamante mining area

distributed irregularly in the central part where is subjected to argillization a little. In the west side, a compact vein consisted of sphalerite - pyrite - arsenic sulphide - quarz, inclining 60° eastward and width 70 cm - 80 cm is observable. At its further westside, a filled old tunnel is existing and it is assumed that oxidized or perhaps clayey mineral vein abound with pyrite had been existed there. Adding these, the total width becomes 20 m and more. On the face of mining toward south, a vein of compact sphalerite and pyrite is observed.

Gualquilia mine Met with the old tunnel at X cut of 40 m and on the face fronting on south, sphalerite - pyrite- quarz vein is existed roughly in vertical and accompanies white siliceous dike rock on the west side.

San Sebastean mine This is an old adit located at the southernmost end and highest level. Mineralized vein is 40 cm in width and nealy vertical in posture. It is quartz rich and accompanies tetrahedrite besides sphalerite and galena. Boulaugerite is observed under the microscope also, and content of arsenic is high too. And silver apparently increases in the southern part.

As to their mutual relation, the Auxiliadora and Diamante mine are on the same principal vein, but other mines are working its branch veins. The principal vein may continue to an outcrop of "gossan" located in road side about 200 m in northeast from Gualquilia in that case vein length will be 1000 m approximately, so that, further survey is necessary to follow. There still remains space for prospecting in both northwestern and southeastern extension. Amount of minerals brought out from each mining front is very small due to hand digging and water mill treatment capacity which is limited also. And the recovery ratio of gold is no good. For example, in tailing minerals after twice pannings at Auxiliadora mineral dressing unit, gold of 112 g/ton was remaining yet. (Ref. Table 6 No. D-05)

Desquite mine locates in the Telembi River east bank about 7 km lower stream from the Diamante mining area and is under operation by 10 and odd miners. Ore minerals are constituted similarly to Diamente mineral deposit, that is, sphalerite galena, pyrite, a small amount of arsenides associating gold. Detailed survey was not performed this time, however it is known that the mineralized vein is single, strike is E-W, length about 250 m and vein width 20 cm - 50 cm. The country rock is Piedrancha granodiorite, different from Diamante. Wall rock is subjected to argillization and gold particle is an electrum consisting of Au and Ag with a ratio of Au : Ag = about 60% : 40% which is estimated by X-ray micro analysis. (Ref. Fig. 8-B, Fig. 9).

Furthermore, as the mine which contains sphalerite, arsenopyrite and other minerals in auriferous vein, there are the Bombona mine about 8 km to west of Diamante, and also El Salado mine locates about 4 km to the southeast.

6-2-7 El Tabano - Concordia Mining Area

In the basin of the Cristal River flowing the northeastern part of the survey area, many old gold mines are located, and some of them are under the second time development stimulated by recent gold boom.

Especially El Tabano mine near the mountain pass to the Vargas River in south of Sande village had a hydraulic power plant several ten years ago, where mechanical mining and dressing equipments had been used and prosperous activity of bygone days is inherited by inhabitants. Even now mining is continued by ten and odd miners though it is digged manually. Mining tunnels under operation at present situate at height about 1250 m

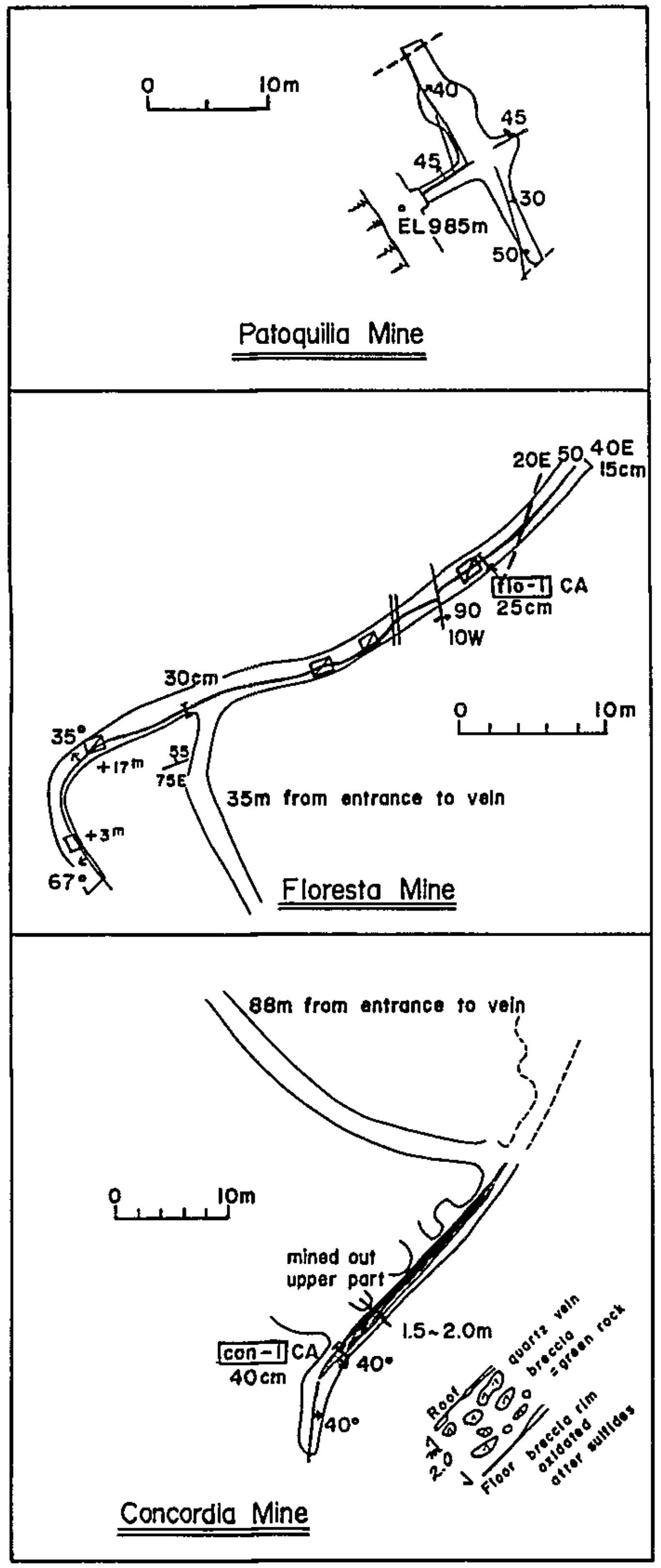
from sea level and a sketch map of tunnel is as shown in Fig. 6-E. The vein is consisted of milky white quarz of thickness 50 cm - 200 cm which is dipping very moderately and almost horizontal in places. Breccia and sub-breccia of size about 10 cm x 20 cm are included in it and some pyrite are precipitated on the surface of them like a ring shape surrounding them or forming pyrite layers of thickness 5 cm - 30 cm beside upper wall or foot wall of quarz vein, and gold is associated with pyrite. The country rock was not possible to observe except a limited portion, but diorite is intruding into green rocks consisted of basaltic andesite and green tuff in forms of stock or dike, and mineralization of quartz and pyrite was progressed in the manner to fill moderate dipping fissures which were formed later than intrusives.

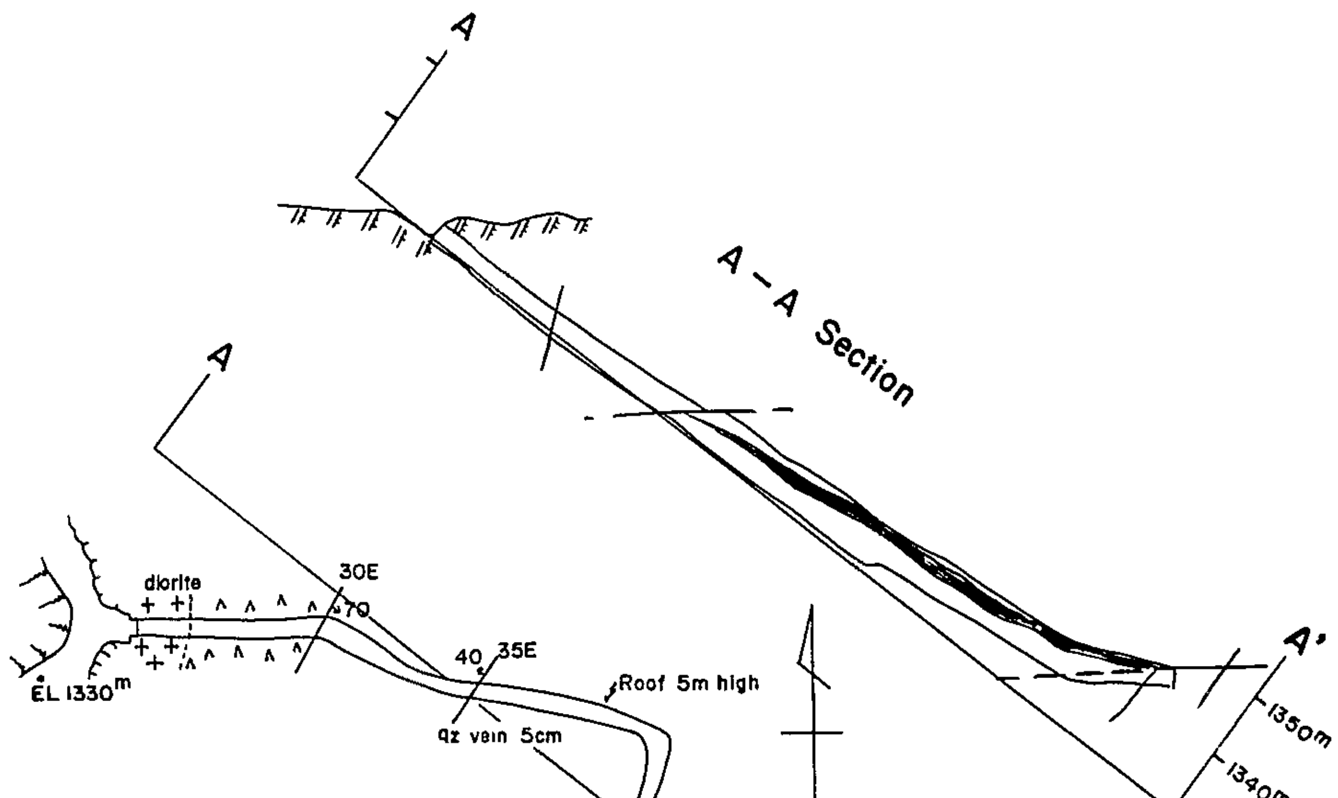
For the surface of mine, flume cuttings and mines, many white aplitic dikes were observed. (Ref. Table 7. 0-25).

Grade of gold differs greatly by sampling spot and the grade of a sample from front which is under mining was Au 6.0 gr/t with the vein width 50 cm. It contains arsenopyrite of a small quantity, but spalerite etc. are very little.

Concordia mine is also located at the junction with the Nevada River about 2 km upward from Soccoro's dressing facility in the upper stream of the Cristal River. This mineralized vein is also of milky white quatz principally and sulfide minerals are rare. Dip of vein is gentle and the country rock is black slate layer.

Besides the above, Floresta mine which produces ores for Socorro dressing facility is located in the midway south bank between Concordia mine and Socorro plant, and there are many old mines on the north bank also. The mineralized vein of Patoquilia mine existing on the northern bank of lower stream of Patoquilia valley is also a narrow vein of 10 cm - 20 cm, and





Sample No.	Au g/t	Ag g/t	Cu ppm	As %
TAB-1	30.0	23	450	<0.01
TAB-2	0.7	3	190	<0.01
TAB-3	32	3	220	0.01
TAB-4	tr	tr	190	0 01
TAB-5	16.0	8	500	0 02
flo-1	10 0	3	—	0.05
con-1	10.7	4	—	1 10

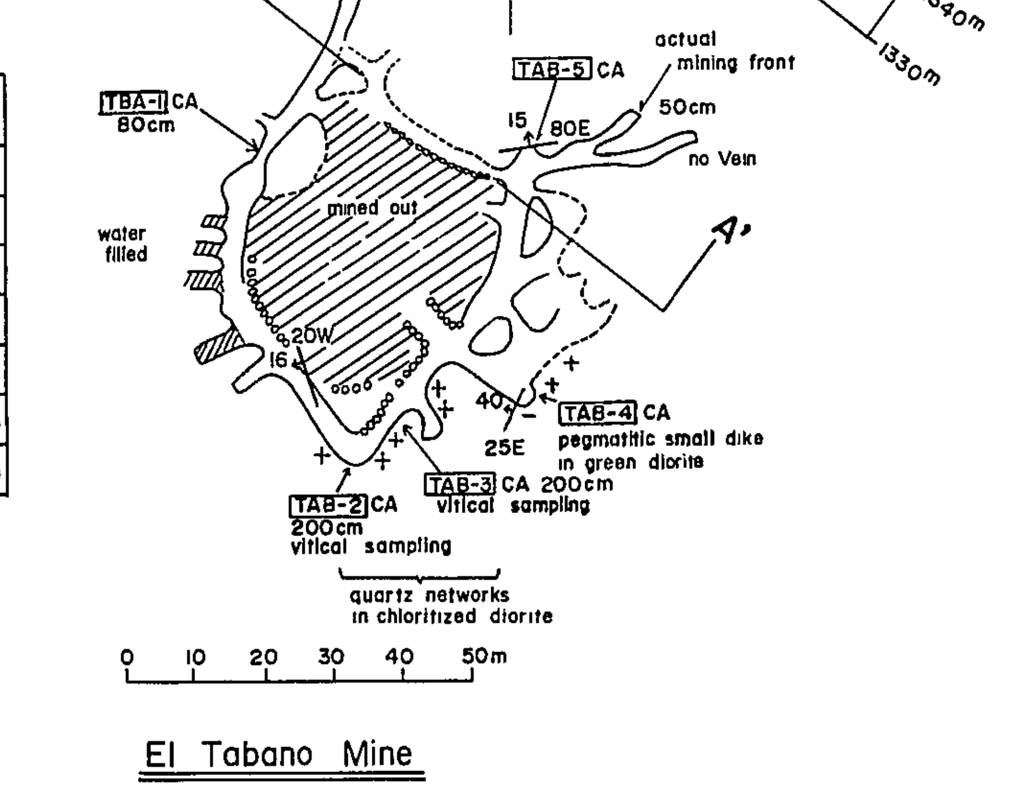


Fig. 6-F Geological sketch of El Tabano, Patoquilia and Concordia mines

a milky white quartz vein acompanying pyrites. The vein is positioned in black shale and has been dislocated by numerous faults. (Ref. Fig. 6-F)

CHAPTER 7. GENERAL DISCUSSION AND CONCLUSION

7-1 Discussion on the Geology and Mineralization

Generally speaking about geology of the surveyed area, weakly metamorphosed shaly sedimentary rocks are distributed in the eastern part, and green volcanic rocks consisted of tuff breccia, basalt, andesite, etc., are distributed all over the western part, and Piedrancha granodiorite and Canellera diorite are intruded into the eastern centeral part.

As to mineralization, heterogeneous ones are distributed respectively harmonizing with the different rock facies of the eastern and western parts. Namely in the eastern part, gold bearing polymetallic vein type ore deposit is distributed and in the western part, porphyry copper deposit type mineralization zone is distributed. And the gold bearing polymetallic vein type ore deposits are able to classify into two groups by their mineral quality and location of the northeastern part or the southeastern part. The northeastern vein group has principally milky white quartz veins while the southeastern one contains much more sulfides comparatively. The country rock of the southeastern group is consisted of grayish green andesite (the major part), fine grained sandstone, shale, etc. and exhibit a massive outlook since had subjected to silicification. As features of sedimentary rocks such as slate were not observed, classified it as green volcanic rocks on the geologic map for the present, but it differs a little with agglomeratic tuff breccia, therefore corrective investigation is necessary in future. As comparatively fresh hornblende andesite is observed around the Diamante mine, there is possibility that chronologically new rocks may be distributed.

On the other hand, putting together the geological survey basic data and results of photogeological analysis, geological lineament of this area are summarized into 3 directions of NE-SW, NW-SE and NNW-SSE.

Grouping by districts, NNW-SSE system is predominant in the eastern part and NE-SW system is prevailing in the western part.

Among the lineament of 3 directions, continuity of NNW-SSE system is comparatively superior that it may have been formed most newly. It is observed from the dislocating direction of stratum that NW-SE system and NE-SW system are in conjugated relation as the maximum shearing stress line against the east-western compressive force. These fault lines are developed at interval of about 7 km, but 5 copper mineralization showings extracted this time are distributed along NE-SW system fault zone from Ramos copper mineralization zone to La Verde, and located near cross points with NW-SE system fault zone. Many tectonic lines are observed in this NE-SW direction with a space of about 7 km is exhibiting a wide sheared zone.

As the relation between the gold bearing vein of the northeastern part and tectonic line, in case of milky white quartz vein of the north eastern part, it's dip is moderate in general, direction is irregular and continuity is poor due to dislocating by faults. There are many unknown points for the southeastern polymetallic veins yet, but dislocation by faults is few and vein of the Desquite mine of the same kind of ore deposits is occurred in Piedrancha granodiorite body. There exist no great faults in Piedrancha granodiorite body, and so, it is considered as that the granodiorite intruded after developing of major tectonic faults, so from the above facts these veins abound with sulfide minerals are formed after the intrusion of granodiorite clearly. And there is a possibility that the milky white auriferrous quartz vein was formed before intrusion of granodiorite. Accordingly, the gold ore deposit is possible to have two periods of mineralization. In porphyry copper type mineralization zone, there is intrusion of diorite or fine grained granodiorite except Gualcala - E area, and relating to such intrusive rock, mineralization of pyrite, chalcopyrite and molybdenite are occurred.

About the shapes of these intrusive rocks and its relation with fault structures, it is not known yet and since the materials enable to discuss about it are very few the time of the intrusion is unknown.

Rock facies of these small scaled intrusive rocks are not the same, diversing widely, but from two points that their distribution is made on the same tectonic zone and they are related to the same mineralization, then it may be reasonable to consider as to be intruded in the same geological period. The isotopic age of slightly poryphryric diorite (sample No. 0 - 17) with pyrite and chalcopyrite which is exposing at halfway up the Canellera River, showed 29 million years by age-determination analysis. This is somewhat older than Piedrancha granodiorite.

Existence of gold ore deposit often affords the clue for poryphyry copper ore deposit exploration, so from this view point are investigated El Tabano, Concordia, Damante mines, etc, but phenomena to indicate such possibility is not noticed. Samples collected by way of trial (example: No. TAB - 2, 3, 4) also contained only very small amount of copper and no alteration of original rock such as silicification, sericitization, etc. accompanying generally with porphyry copper deposits was observed.
Also at the above mentioned five copper mineralization zones, no anomalous value of gold was coexisted in stream sediment samples.

But as to the chronological difference between these copper mineralization and quartzose gold ore mineralization, there are no materials to discuss about yet.

7-2 Comparison with the Results of Previous Survey

For the survey area, only drainage maps of 1 : 100,000 scale prepared from radar images were available, but to carry out the field survey this time, prepared plain drainage maps of 1 : 50,000 scale using Landsat color images, aerial photographs for certain areas, and rereading of radar images, after that, corrected it by informations got from field survey and made clear the names of rivers, villages, etc. In old drainage maps, location of the west part was deviated southward about 10 km and village name's such as Rio Vargas, Rio Telembi, etc were erroneous, to be corrected this time.

Through geological survey, it was made clear that the upper sedimentary formation was folded remarkably and sunk down in the eastern part and subjected to weak metamorphism, and granodiorite intruded into the sunk down bottom. In the former geological map, it was understood reversely that to the place of anticline structure was formed, igneous rock body has intruded. That is, metamorphic rocks called as Dagua group in the northern province has been considered to be under Diabasas group which is corresponded to the green volcanic rocks in the surveyed area.

And by geochemical exploration, five zones of copper, molybdenum mineralization showings were caught this time, but two places of these Cu - Mo anomalies are duplicated with the results of UNDP-INGEONIMAS survey; No. 49 (Rio Blanco) and No. 50 (Ramos). And other three places were discovered newly. As to lead and zinc anomalies, 3 kinds of anomalies were extracted; the first related to contamination from old mines located in the upper stream; the second is concentration of a very small quantity in the country rock by meteoric alteration; and the third related to copper and gold mineralization showing. In the Nevada Valley it succeeded to extract an area to be surveyed hereafter which has been undeveloped utterly concerning gold, and also extracted another area at the middle stream of the Gualcala River where an alluvial placer gold deposit may be possible.

Among gold mines under operation in small scale at present, the veins of Diamante mining area located in the southeastern area contains pretty quantity of useful metallic minerals such as sphalerite, galena and others. The sulfide ore is left as not mined because of difficulty in mining and separation. The area is recommended to make detailed survey for exploration as a prospective project to future development.

7-3 Conclusion and Future Prospect

7-3-1 Conclusion

Survey results of the 1st phase may be 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 are 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 quarz vein group distributed in the northeastern part; another is polymetallic vein group abound with sulphide minerals in the southeastern 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.

7-3-2 Future Prospect

The following surveys are recommended to include in the 2nd phase survey program:

A) Concerning the porphyry copper type mineralization zones (La Verde, Rio Blanco, Gualcala-E, Santa Rosa, Ramos), only anomalous values of stream sediment samples taken along major rivers were found out and it is necessary further to know the scope of mineralization, details of geology, features of mineralization, etc., and for this purpose:

   i) Geological medium precision survey.
   Proceed geological survey while making route maps at scale : 2,000 or 1 : 5,000 and prepare the geologic map of scale 1 : 10,000.

   ii) Geochemical exploration
   Carry out geochemical exploration by collecting soil samples at roughly regular interval along ridges.

   By the above processes extract the object areas for explorations such as geophysical exploration, boring exploration, geological detailed survey, etc. of the next phase.

B) Gold mineralization showing areas (Nevada, Gualcala middle), 2 areas are anticipated to have different type of ore deposit, so the following surveys shall be made respectively.

   i) For Nevada area including anomaly area and it's upper stream, perform more detailed stream sediment geochemical exploration, panning survey and geological survey including observation of boulders and carry out trenching and others as necessary.

   ii) In the Gualcala River Middle area, anomaly of 3 elements (gold, molybdenum, and lead) coincide, but it is a wide river terrace bed and there are piled boulders of granodiorite abundantly. Gold and lead from Bombona mine located in the upper stream and molybdenum from granodiorite are considered to get precipitated there, but prudent survey is required whether it has economical value or not. Firstly, conduct pit sampling at important points in the anomaly area and if possibility of economical value is found, make topographical maps of the valley and should be performed systimatic sampling survey.

C) The gold bearing polymetallic vein type ore deposit area (Diamante, Bombona, El Salado) is unknown in detail about extension of outcrop, direction, scale, quality etc., and as there are complex minerals with arsenides, examination of ore dressing and metallurgical problems are also necessary. Therefore;

i) Geological detailed survey

Thorough tracking of vein outcrop, topographical and geological detailed survey on the surface and underground and sampling, etc.

ii) Geochemical exploration

Exploration of prolongation of the vein by soil sampling, and stream sediment sampling in the direction of ore vein extension especially in the upper stream area.

iii) Boring exploration

Investigation of mineral quality and potentiality under the surface. This exploration work is mostly recommended as a effective way.

iv) Geophysical exploration

Exploration of dormant vein, its prolongation, and swelling part.

v) Study of mineral quality

Since content of arsenic is high, metallurgical examination of ore is important to know its occurence and to study problems about ore dressing.

Owing severe climatic and topographical condition, development of this survey area is retarded. However, by the survey of this phase, it became clear that potentiality of mineral resource latent in this area is high.

Especially the Copper-molybdenum mineralization prospective zones are distributed over districts of difficulty of transportation in the western part, and then many problems will accompany to proceed exploration work and development hereafter. However, if large scaled copper ore deposit of superior quality were able to discover and develop, it will be not only a merit for the mining industry but it may serve as the prime mover of the regional development. And the gold bearing polymetallic vein type deposit is not active at present except small scaled operation, but there is a possibility that it may have far larger scale ore reserves and accomplishment of technical cooperation through its prospecting ore reserves and study on treatment method of complex ore will contribute to the regional development as a quick effective aid, and also will be useful for development of similar ore deposits in other districts of Colombia.

APPENDICES