REPORT ON GEOLOGICAL SURVEY

OF

LAS CANITAS AREA

DOMINICAN REPUBLIC

PHASE II

MARCH 1985

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

PREFACE

The Government of Japan, in response to the request of the Government of the Dominican Republic, decided to conduct the investigation in relation to the survey of the ore deposit including geological survey in order to confirm the potential of occurrence of mineral resources in the Las Canitas area, and entrusted its execution to the Japan International Cooperation Agency (JICA). Because of its essential qualities that it belongs to a special field involved in the survey of geology and mineral resources, JICA consigned it to the Metal Mining Agency of Japan (MMAJ).

The survey is scheduled to be performed for three years from fiscal 1983, and this year is the second phase. MMAJ organized a team for field survey consisting of three members and dispatched it to the Dominican Republic from August 24, 1984 to October 27, 1984.

The survey was accomplished as scheduled under close cooperation with the Government of the Dominican Republic and its various agencies, especially with Dirccion General de Mineria (DGM) of the Ministry of Commerce and Industry.

This report is the compilation of the survey of the second phase and will form a portion of the final report.

We wish to express our heartful gratitude to the Government of the Dominican Republic and its appropriate agencies including D.G.M. of the Ministry of Commerce and Industry as well as the Ministry of Foreign Affairs, the Ministry of International Trade and Industry, the Embassy of Japan in the Dominican Republic and the companies concerned for the cooperation and support extended to the Japanese survey team.

February 1985

Keisuke Arita

Keisuke Arita
President
Japan International Cooperation Agency

Masayuki Nishiie

Masayuki Nishiie
President
Metal Mining Agency of Japan

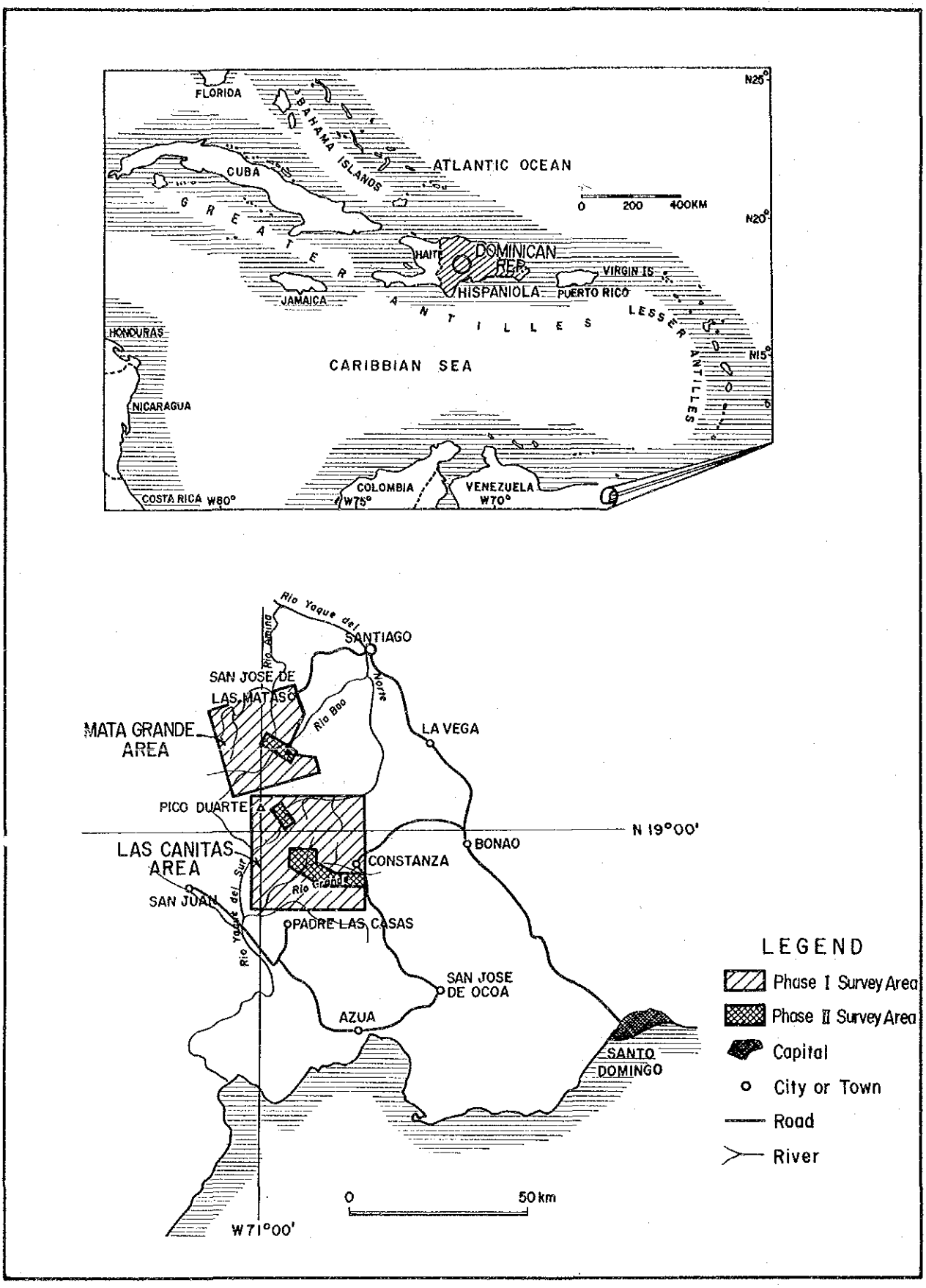

Fig. 1 Location Map of the Survey Area

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ABSTRACT

In the survey of the second phase of the collaborative mineral exploration conducted in the Las Canitas area in the Dominican Republic, geological survey and geochemical survey were carried out in the three sub-areas such as Constanza, Pico Duarte and Mata Grande with an extent of 181 square kilometers in total which were extracted by geological survey and geochemical survey performed in the first phase, for the purpose of extracting the promising areas of occurrence of ore deposits by grasping the characters of geologic structure, igneous activity and mineralization and also by making clear the relationship between them.

The geological survey led to a discovery of outcrops of mineralized zone at about 250 points. The analyses of geology and geochemical anomalies resulted in to obtain the facts mentioned below. Measurement of magnetic susceptibility was also made in the Pico Duarte sub-area.

1. The mineralized zones in the areas would be formed during the period between Paleocene and before Oligocene in association with the tectonic movement and the igneous activity in the latest stage of the Laramide Orogeny, and include the vein-type and porphyry copper-type mineralized zones.
2. Vein-type mineralized zones are found in the Constanza sub-area, which include the two groups such as (1) copper vein-type mineralized zones which are related to tectonic lines of NW–SE system, such as El Gramoso, Hato de Los Rodriguez and Sabana, and (2) copper and copper-lead-zinc veins in the southern part which are related to the tonalite intrusive bodies.

The former is superior to the latter in ore grade and scale.

The groups of ore veins at El Gramoso and Hato de Los Rodriguez where many copper veins were discovered by the survey mostly show the structure striking northwesterly and dipping northward, and overall distributions of the veins extends in the direction of northwest which is the main structure of geology of the region.

Because of the presence of geochemical anomalies in the eastern part of El Gramoso and on the northeastern slope of Mt. Loma Sito Grande situated in the southeastern part of El Gramoso, it is expected that the veins of same system as that of El Gramoso would exist in the surrounding area of Mt. Loma Sito Grande.

3. In the Pico Duarte sub-area, porphyry copper-type outcrops having an extent of 450 m x 250 m was discovered in granodiorite.

In this part, copper-geochemical anomalies, low magnetic susceptibility zone and alteration zone extend to the southern part covered by soil. It is expected, therefore, that the extent of mineralized zone would be expanded to 500 m x 500 m in total, if the part covered by soil can

be included.

4. It was made clear that the outcrops of Mata Grande copper vein deposit in the Mata Grande sub-area extended for about 1.2 kilometers in the direction of NW–SE along the extension, geochemical anomalies continued for about 3 kilometers as a result of geological survey and geochemical survey. The deposit is composed of three veins occurred as a form of echelon in the vicinity of mine, and the largest vein is the one in the southern part having the strike length of 500 meters.

Ⅰ. INTRODUCTION

CHAPTER 1 OUTLINE OF THE SURVEY OF SECOND PHASE

1–1 Outline of the Survey Area

The survey areas of this phase include the following three areas (Fig. 2) 181 square kilometers in total, which were extracted by the geological survey and the geochemical survey conducted in the first year in the Las Canitas area and the Mata Grande area about 2.00 square kilometers in total.

1. Constanza sub-area (140 km^2)
2. Pico Duarte sub-area (15 km^2)
3. Mata Grande sub-area (26 km^2)

The Constanza sub-area is an area extending from the west to the south of Constanza. The geology is composed of acidic and intermediate volcanic rocks and pyroclastic rocks of the same source of the Cretaceous Tireo formation, in which vein-type mineralized zones are occurred.

The Pico Duarte sub-area is situated in the southeastern part of Mt. Pico Duarte. The geology consists of andesite lava of the Tireo formation and granodiorite intruded into it. The mineralized zone found in the area is porphyry copper-type mineralized zone occurred in granodiorite.

The Mata Grande sub-area is an area centered on the Mata Grande mine, in which vein-type copper deposits are found.

1–2 Purpose of the Survey

The purpose of the survey of this phase is to make clear geology and occurrence of mineralized zone and to extract promising areas for exploration of ore deposit.

The different works were set up as in the following method for each place because the characters of the mineralization are different in places.

1. Constanza Sub-Area and Mata Grande Sub-Area

The geologic structure and mineralization, and geochemical characters are to be comprehensively investigated in this area to extract promising areas.

The condition of occurrence of ore veins are to be investigated for the veins discovered, on the basis of the analyses of mineralization and the detailed observation.

In the Constanza sub-area, the lateral extension of the veins distributed in the Sabana and the south of Constanza is to be traced to grasp the scale of the veins. Further, efforts are to be made to find new veins in the geochemically anomalous areas.

In the Mata Grande sub-area, the lateral extension of the copper veins of the Mata Grande

mine is to be traced to grasp the scale. Furthermore, the origin of geochemically anomalous zones of gold detected in the first phase is to be pursued and also the origin of placer gold scattered in the survey area is to be investigated.

2. Pico Duarte Sub-Area

The origin of porphyry-copper mineralized boulders discovered in the first phase is to be investigated to grasp its extension and scale.

1–3 Content and Method of the Survey

In order to efficiently accomplish the purpose of the survey mentioned above, geological survey and geochemical survey by soil sampling (B-layer) (semi-detailed survey) are to be carried out in the three areas aforementioned in the survey of this phase.

The geological survey and the sampling for geochemical survey were started on July 30, 1984 and were completed on October 22, 1984. The length of the survey route was 310 kilometers, and the number of samples obtained for geochemical survey was 926.

The result of geological survey was compiled to the geological maps of the areas such as Constanza 1/10,000, Pico Duarts 1/5,000, and Mata Grande 1/5,000 on the basis of the route maps such as Constanza 1/10,000, Pico Duarte 1/5,000, and Mata Grande 1/5,000.

For geochemical survey, the soil samples (B-layer) were chemically analyzed for six components such as Au, Ag, Cu, Pb, Zn and Mo, and single component analysis and multivariate analysis were made, which were compiled to the geochemical anomaly maps.

The location of the mineralized outcrops was compiled to the location maps 1/200 to 1/500 in scale, and the main mineralized zones were described on the sketches 1/20 to 1/100 in scale. Eighty six ore samples obtained in the geological survey were chemically analyzed for Au, Ag, Cu, Pb Zn and Mo according to the kinds of ores, to provide for the data for analysis.

The details of the content of survey of this phase and various kinds of samples are shown in Tables 1 and 2.

The content of survey of each area is as in the following.

1. Constanza Sub-Area

The geological survey was conducted over the whole area of the extent of survey of 140 square kilometers, and the detailed data of geology and ore deposit were obtianed. Geochemical survey was preponderantly carried out for the mineralized area and the geochemically anomalous areas detected in the survey of the first phase about 90 kilometers in total. The density of

Table 1 Outline of Phase II Work Schedule

Works	Period	Length of Routs Traversed	Numbers of Soil Samples
Preparation and Orientation	Jul. 25~Jul. 31, 1984		
Semi-detailed Geological and Geochemical Survey	Aug. 1~Oct. 16, 1984	310 km	962 samples
Constanza Sub-Area	Aug. 1~Oct. 16, 1984	(220)	(566)
Pico Duarte Sub-Area	Sep. 11~Oct. 7, 1984	(39)	(105)
Mata Grande Sub-Area	Oct. 2~Oct. 12, 1984	(51)	(291)
Compilation and Removal	Oct. 13~Oct. 22, 1984		
Data Processing and Report	Oct. 28, 1984 ~Feb. 8, 1985		

Table 2 Numbers of Tested Samples

Samples	Constanza Sub-Area	Pico Duarte Sub-Area	Mata Grande Sub-Area	Total
Rock and Ore Samples				
Thin Section	13	6	6	25
Polished Section	15	5	3	23
X-ray Diffractive Analysis	29	63	8	101
Dating (K-Ar method)	2	2	2	6
Chemical Analysis of Ore	52	15	19	86
Soil Samples	566	105	291	962

sampling was 6 to 7 samples per square kilometers, and the total number of samples obtained was 566. It is a matter worthy mentioned that many veins were discovered in the areas such as El Gramoso and Hato de Los Rodrigues.

2. Pico Duarte Sub-Area

Geological survey and geochemical survey, magnetic susceptibility was carried out over the whole area of survey of 15 square kilometers, resulting in to discover a porphyry copper, of which the extent and the scale were made clear. In regard to the granodiorite terrain which is important as the host rock of the mineralized zone, efforts were made to grasp occurrence of mineralized zones and alteration zones by the concentrating survey. The total number of samples for geochemical survey was 105.

3. Mata Grande Sub-Area

The geological survey was conducted over the whole area of 26 square kilometers. The samples for geochemical survey were taken in a form of grid at right angles to the trend of the Mata Grande vein for the purpose of tracing the extension of the Mata Grande vein, making clear the occurrence of parallel veins, and pursuing the origin of gold geochemically anomalous zones detected in the survey of the first year. The number of samples obtained was 291.

1–4 Members of Survey Team

The personnel who participated in the survey are as follows:

Japanese members for planning and negotiation

Yasuhisa Yamamoto	Metal Mining Agency of Japan (MMAJ)
Yozo Baba	do.
Yoshiyuki Kita	do.
Tsuyoshi Ogitsu	do. (Mexico Office)

Dominican members for planning and negotiation

Miguel Antonio Peña	Direction General de Mineria (DGM)
Alejandro Alejandro	do.
Ramon Elias Ramirez	do.
Hector Ramon Santos	do.

Japanese members of the survey team

Hideo Kuroda	MMAJ
Yoshinori Tsuguma	do.

Hiroshi Takahashi	MMAJ

Dominican members of the survey team

Héctor Ramon Santos	DGM
Victor Manuel Garcia	do.
Giovanni Bloise	do.

Ⅱ. PARTICULAR

CHAPTER 1 OUTLINE OF GEOLOGY AND MINERALIZATION IN THE SURVEY AREA

The survey of the first phase was conducted for the targets such as the Las Canitas area and the Mata Grande area having an extent of about two thousand square kilometers in total.

The geology of the survey area is composed of pre-Cretaceous, Cretaceous, Tertiary and Quaternary from the base upward. The pre-Cretaceous consists of the Amina formation in the lower and the Duarte formation in the upper, and the Cretaceous consists of the Tireo formation (Fig. 2 & 3).

The Amina formation is distributed at the northern end of the Mata Grande area in the northern part. The formation is composed of schistose rocks derived mainly from acidic to intermediate volcanic tuff, showing a gentle fold structure.

The Duarte formation occupies most part of the Mata Grande area, and consists of metal basalt and green schist derived from basalt lava and tuff of the same source. These metamorphic rocks show schistosity and were subjected to an intense folding. Both of Amina formation and the Duarte formation were affected by regional metamorphism, which is low in metamorphic grade, and most of them belong to green schist facies.

The Tireo formation is widely distributed in the Las Canitas area, and consists of intermediate to acidic lava and pyroclastic rock. It was hardly subjected to metamorphism different from the lower Amina formation and the Duarte formation.

The Oligocene series is composed of shale and limestone, and widely distributed in the southern part of the Las Canitas area which is situated in the northern periphery of the San Juan-Azua Graben, having been intensely folded. Also the Oligocene series consisting of conglomerate in the narrow graben which is bordered on both sides by the Amina formation and the Duarte formation for each, in the Mata Grande area.

The Quaternary system is found along the lower reaches of Rio Grande in the southern part of the Las Canitas area. Acidic volcanism took place in Quaternary time, and dacite is widely distributed in the southern part of the Constanza area.

Tonalite intruded as two big batholiths called El Rio and El Bao. Many stocks and dykes of tonalitic rocks intruded surrounding these batholiths.

In the project area and in its surroundings, the formations such as Amina, Duarte and Tireo, and the Tertiary system are distributed in zones, becoming younger from the north toward the south, with the trends of NW–SE to WNW–ESE, being in contact with the faults each other. Tonalite was also intruded along the faults in a form of batholith. Such an arrangement of the formations might be assumed to be a result of subduction from the north toward the south.

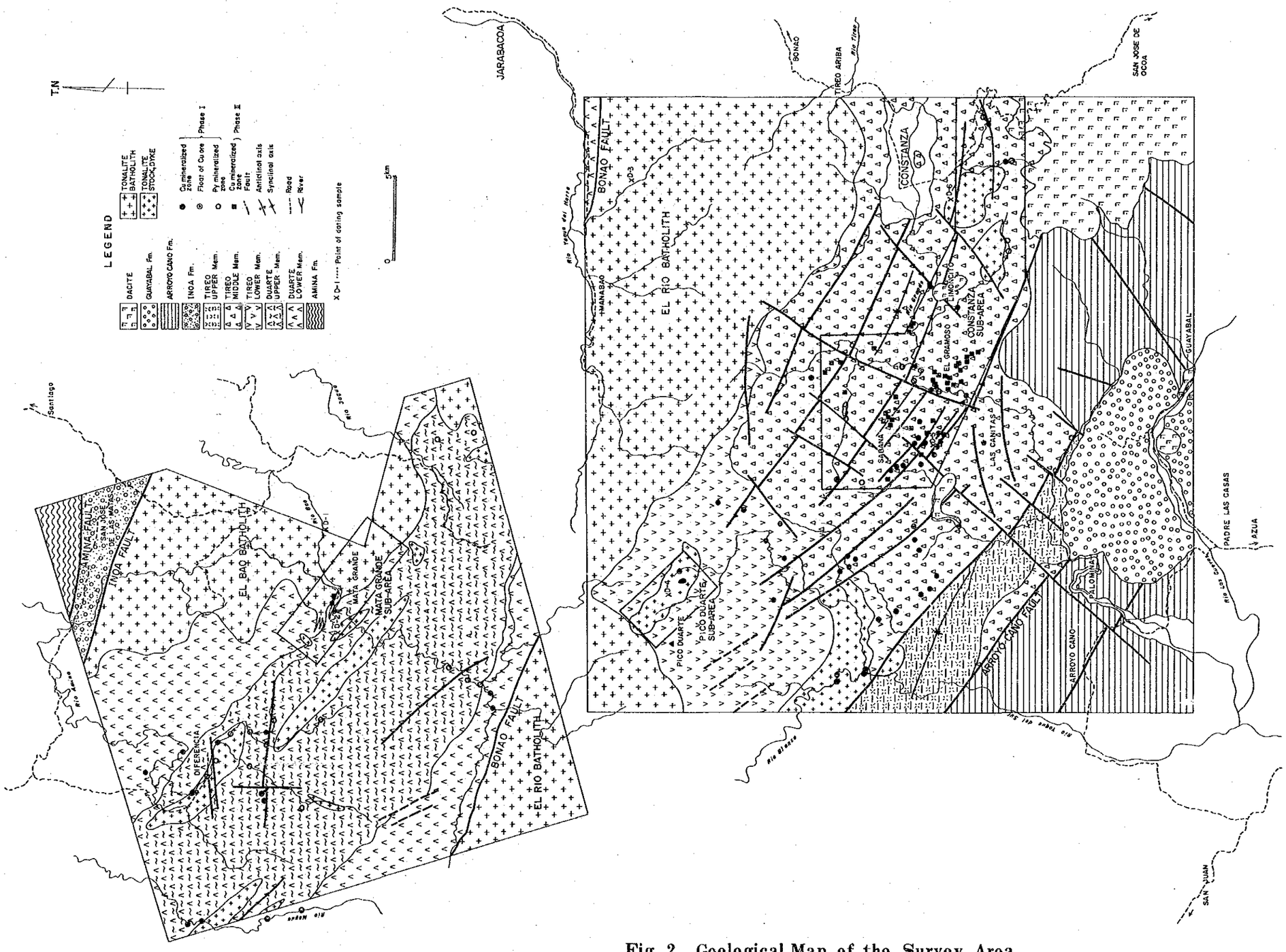
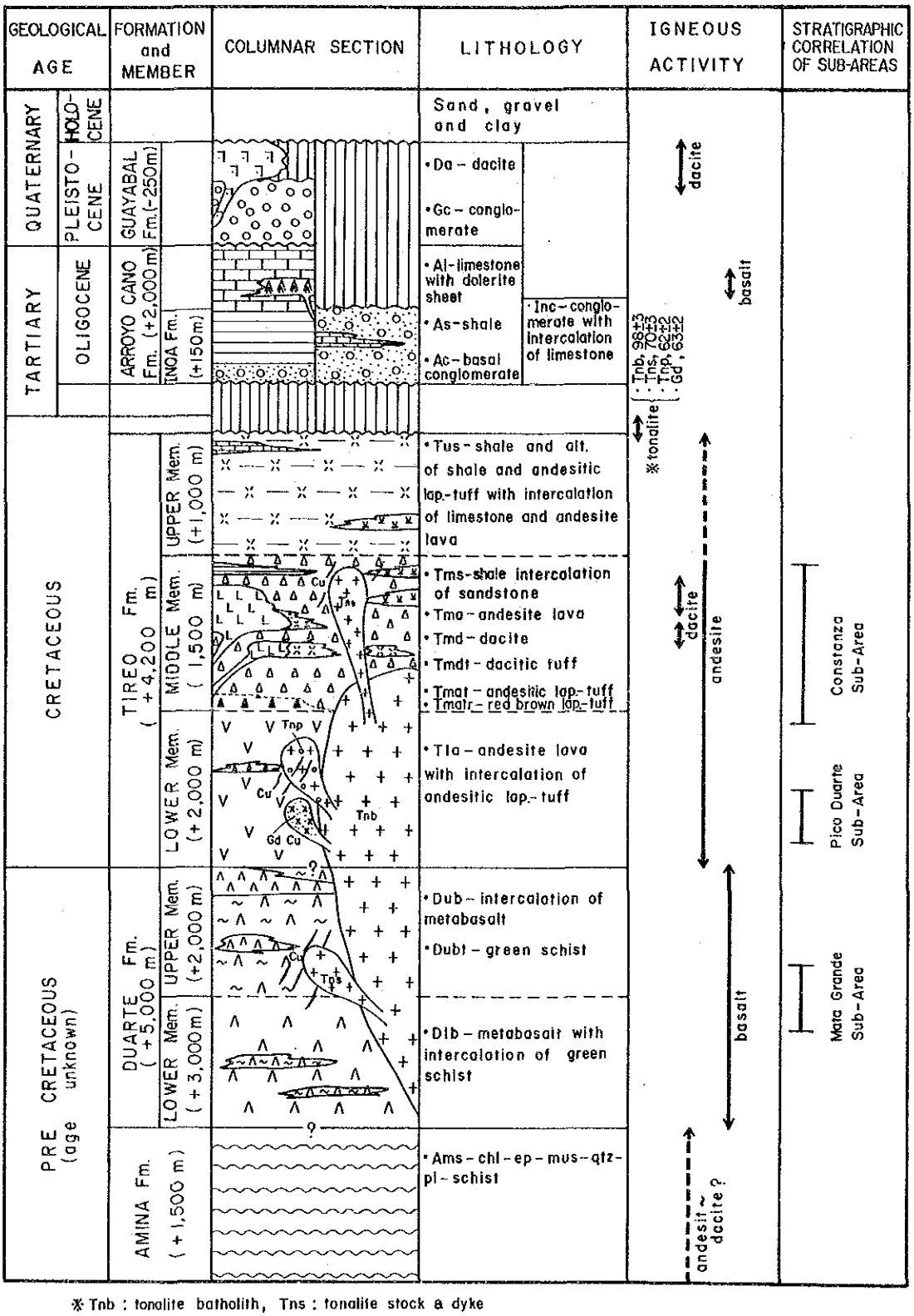


Fig. 2 Geological Map of the Survey Area



※ Tnb : tonalite batholith, Tns : tonalite stock & dyke
Tnp : porphyritic tonalite stok & dyke
Gd : granodirite stock

Fig. 3 Generalized Stratigraphic Columnar Section of the Survey Area

The survey of this phase was conducted for the target of three sub-areas such as Constanza, Pico Duarte and Mata Grande which were extracted as promising areas of high potential for occurrence of ore deposit by the survey of the first phase.

Geology of the Constanza sub-area is composed of the Tireo formation and the tonalitic rocks. The Tireo formation is dominant with andesitic lapilli tuff, interbedded with andesite lava. Many vein-type copper mineralized zones are found in the area. These copper veins are classified into those associated with the tectonic lines of NW–SE system and those related to the tonalite intrusive bodies.

Geology of the Pico Duarte sub-area consists of the Tireo formation and granodiorite. Granodiorite intruded into the andesite lava of the Tireo formation with the northwesterly trend. Porphyry copper-type mineralized zone disseminated with chalcopyrite and molybdenite is found in granodiorite.

Geology of the Mata Grande sub-area is composed of the Duarte formation and the tonalitic rocks. The tonalitic rocks are classified into the El Bao batholith and the dyke rocks, and the batholith occupies an extensive part of the area. Mineralization of the area is copper veins of NW system as represented by the Mata Grande mine. The area is also known as the place of production of placer gold.

CHAPTER 2 CONSTANZA SUB-AREA

2–1 Geology and Geologic Structure

The area near the Constanza basin contains Sabana, El Gramoso, Limoncito and Pinar Bonito in a form, being 140 square kilometers in the area.

By the survey, many vein-type copper mineralized zones were discovered, and notable geochemical anomalies were detected in the area.

The access to the surrounding area of Pinar Bonito in the southern part is relatively good. The driveways are present along the Rio Grande from Constanza. On the contrary, the access to the western side of Constanza is poor, since no driveway extends beyond Limoncito. The team was obliged to camp for a long time for the survey of the Sabana and El Gramoso areas.

1. Geology

The geology of the area is composed of late Cretaceous the lower and middle members of the Tireo formation which were intruded by tonalitic rocks.

The lower member of the Tireo formation consists of andesite lava (Tla). The rock is so-called "propylitized" green augite andesite and observed on a small area along the Rio Yaquesito in the northern part of the area.

The middle member of the Tireo formation is distributed widely in the area, being the important host rock of the copper mineralized zone. The member is mainly composed of andesitic lapilli tuff (Tmat), intercalated with andesite lava (Tmdt) and shale (Tms).

Andesitic lapilli tuff (Tmat) is pale to dark green, and sometimes varigated. The rock is hard and compact, being highly consolidated. Although it does not generally show, bedding stratification by sorting in water is sometimes observed.

The rock intercalated sometimes with coarse-grained tuff and tuff breccia. The matrix is andesitic and the pebbles essentially consist of angular to subangular essential andesite breccia a few accidental dacitic breccias. Hematitized reddish brown matrix is locally observed, but is poor in continuity.

Andesite lava (Tma) is greenish blue massive rock which have been altered to dark green rock in some parts. The rock facies of the rock has a strong resemblance megascopically to the lower member.

Dacite (Tmd) is white to gray, and it is characterized by presence of columnar joint.

The rock is distributed on a small area at the western corner of the area and at Pinar Bonito.

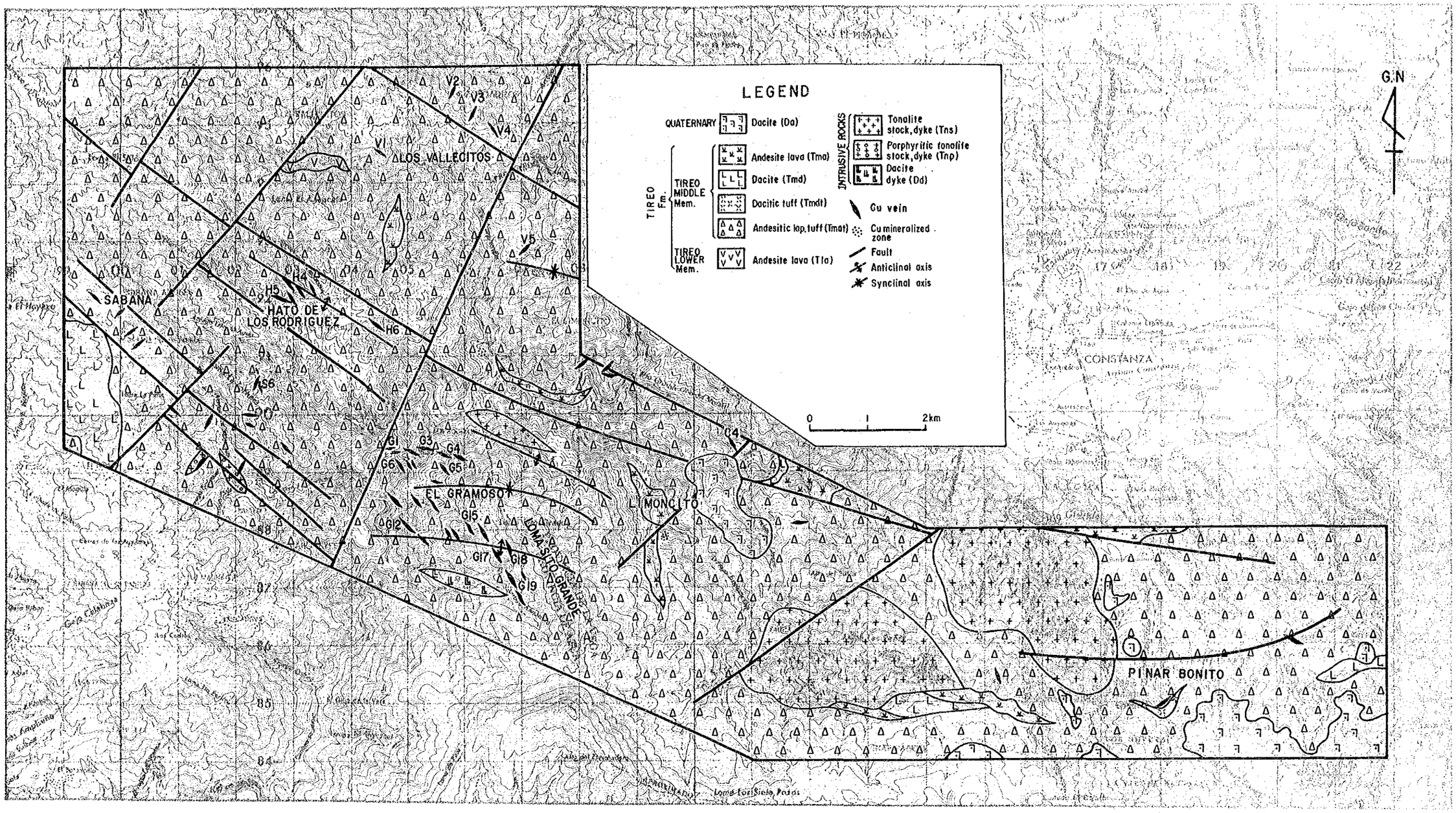


Fig. 4 Geological Map of the Constanza Sub-Area

Dacitic tuff (Tmdt) is white to gray and massive, often being disseminated by pyrite.

Shale (Tms) is dark gray and generally tuffaceous, though partly calcareous. Bedding is distinct, being intercalated with siltstone and fine-grained sandstone.

The intrusive rocks are classified into tonalite stock and dyke (Tns), porphyritic tonalite dyke (Tnp), dacite dyke (Dd) and basalt dyke.

The tonalite stock and dyke (Tns) are subdivided into a stock form and a dyke form. Two stocks are found at the south of Constanza in ellipsoid form with two to three kilometers in diameter.

Although the northern body was discovered and was described in the survey of the first phase the southern one was first discovered this phase.

Since the copper veins are distributed around these bodies, they are considered to be related with the copper mineralization. The rock facies of these masses have a strong resemblance to each other. Both of them are massive hornblende tonalite, gray in color. The rock is medium to fine-grained, and the fine-grained part shows an appearance of dacitic facies.

The result of microscopic observation of typical rock is as follows:

SG021 hornblende tonalite (Ar. Limoncito, northern body)

Texture: Holocrystalline

Main constituent minerals: Plagioclase. quartz ≫ common hornblende

Accessory mineral: Iron mineral

Plagioclase is euhedral, about one milimeter across, showing myrmekitic structure. Quartz is present in plagioclase in a eroded form and independently in euhedral form. Common hornblende has been all replaced by epidote and chlorite, showing a relic crystal form. Chlorite and epidote form network veinlets.

Many dyke-form bodies were confirmed in a surrounding area of Limoncito and El Gramoso, trending northwesterly and northeasterly.

The rock facies of the dyke bears a close resemblance to that of the tonalite stock being gray, partly showing an appearance of dacitic facies. Many copper veins have been discovered in the vicinity of these tonalite dykes, leading to an assumption that the dykes were in close relation to copper mineralization.

The porphyritic tonalite dykes (Tnp) trend northwesterly and partly northeasterly, and they were confirmed such as several Sabana dykes. The largest one among these dykes reaches to 200 meters wide, and other are less than 70 meters wide. The rock facies is plagioclasequarts porphyry. The rock is pale green, containing phenocrysts of quartz and plagioclase five millimeters across. Quartz is white and nearly transparent, and plagioclase is pale pinkish white.

Under the microscope, the rock display holocrystalline porphyritic texture, and the constituent minerals are plagioclase, quartz, hornblende and iron minerals. Copper mineralization is also observed in the vicinity of the dykes.

The dacite dykes (Dd) are distributed with the trend of WNW–ESE in the southern part of El Gramoso and Hato de Los Rodriguez. The rock facies is white to gray dacite containing a small amount of hornblende.

The basalt dykes intruded into the Tireo formation. The dykes are 1 to 2 meters wide, which can not be expressed on the geological map (1 : 10,000 in scale). The trend of intrusion is dominant in the two directions of N-S and E-W. The rock facies is black augite basalt.

The Quaternary dacite (Da) is distributed at the heights along a ridge in the vicinity of Limonsito and the southern part of the area. The rock facies is common hornblende dacite, displaying gray in color. According to the report on geothermal survey by direccion General de Mineria (D.G.M., 1983), radiometric age dating of the rock in the southern part of the area indicated the ages in the vicinity of 0.5 m.y., which leads to an assumption that the time of activity of the rock was late Pleistocene.

2. Geologic Structure

Fault and fold structure which are related to the Laramide Orogeny and tectonic movement after that have been developed in the Tireo formation and in the intrusive rocks except for the Quaternary system.

In the survey of the Phase I, faults were classified into those of three orders according to their scale.

The faults belonging to the WNW-ESE system which is the major tectonic line of the Hispaniola Island was classified as the first order, those of WNW-ESE to NW-SE system and NW-SE system as the second order, and the fractures including the epidote-quartz veins as the third order.

Many faults of the second order which is likely to have stemmed from the faulting of the first order are found in the area. The faults of this order belonging to WNW-ESE to NW-SE system dip 70 to 80 northward. A number of faults of NE-SW system were formed in association with the former two. The faults of these two systems form complicated structural blocks.

The faults of NE-SW system which shifted the faults of WNW-ESE to NW-SE system in a form of left hand-side displacement are found in the west of Sabana and in the south of El Gramoso.

In this way, there are two kinds of faults in those of NE-SW system such as those which are

conjugate with the WNW-ESE tto NE-SW system and those formed after the movement of the WNW-ESE to NE-SW system.

The fractures of the third order are often filled with quartz and epidote, in which calcite is hardly found.

Two systems of NW-SE and NE-SW are dominant in the trends of veins in the area, and copper mineralization is observed in some of these veins. The veins of NW-SE system are dominant in the surrounding area of El Gramoso, while those of NE-SW system are found in abundance in the vicinity of Sabana, which are distributed in a direction of NW-SE, and they are consistent with the faults of the second order.

It can be interpreted that the group of ore veins of NW-SE system filled the shearing fractures stemmed from the faults of the first and the second orders, while those of NE-SW system filled open fractures formed at the incipient stage of formation of those of the second order.

Although the block movement associated with the faulting mentioned above is the main tectonic movement, fold structures are found in the Tireo formation. Anticlinal and synclinal structures running in the direction of NW-SE to WNW-ESE are found in the Tireo formation successively from the north toward the south. These fold axes plunge northeastward by the affect of the upheaval in the surrounding area of Pico Duarte in the northwestern part of the area.

2–2 Mineralization and Alteration

The relationship between the mineralized zone of vein-type and pyrite dissemination-type occurred in the Constanza sub-area and geologic structure as well as igneous rocks was made clear by the survey of the first phase. It was also made clear that vein-type mineralized zone of the Sabana area had a relation to the tectonic line of NW-SE system which constitutes main structure of geology of the area and that vein-type and pyrite dissemination-type mineralization are related to the intrusive mass of tonalite, which resulted in to provide a guidance for exploration.

Based on the data obtained from the geological and geochemical survey in the Phase I, the survey of the Phase II was conducted effectively and many mineralized zones were discovered at the El Gramoso, Hato de Los Rodriguez and Los Vallesitos.

These mineralized zones newly discovered are copper vein occurred in andesite lavas and pyroclastic rocks.

PL. 1 shows the location of the mineralized zones and Table A–5 shows the assay result of the ores. The details of the mineralized zones are described in the following.

1. El Gramoso

The area is situated about 12 kilometers west-south-west of Constanza. It takes about an hour and a half from Constanza to get to northern place of Limoncito by jeep. From there, the site can be reached within about an hour and a half on mule back.

Geology of the El Gramoso area mainly consists of andesite lava, lapilli tuff and tuff breccia of the same source which belong to the middle member of the Tireo formation, and partly accompanied by small intrusive bodies of tonalite and dacite.

The ore veins discovered this year at 20 places (45 outcrops) consist of gold bearing copper veins. The ore minerals are composed of malachite, chalcopyrite, bornite, chalcocite, pyrite, specularite, and limonite, accompanied by gangue minerals such as quartz, chlorite, and epidote.

The veins mostly occur as a single vein, although network and dissemination are partly contained. The veins are uniform in their width, and extend laterally for a considerable distance as compared with those in the Sabana area.

The scale of the veins observed at the outcrops is 0.3 to 1.5 meters wide and several meters to 70 meters long along the strike. The grade of copper is one to 10 per cent, and gold is 0.2 to 0.5 gram per ton ubiquitously.

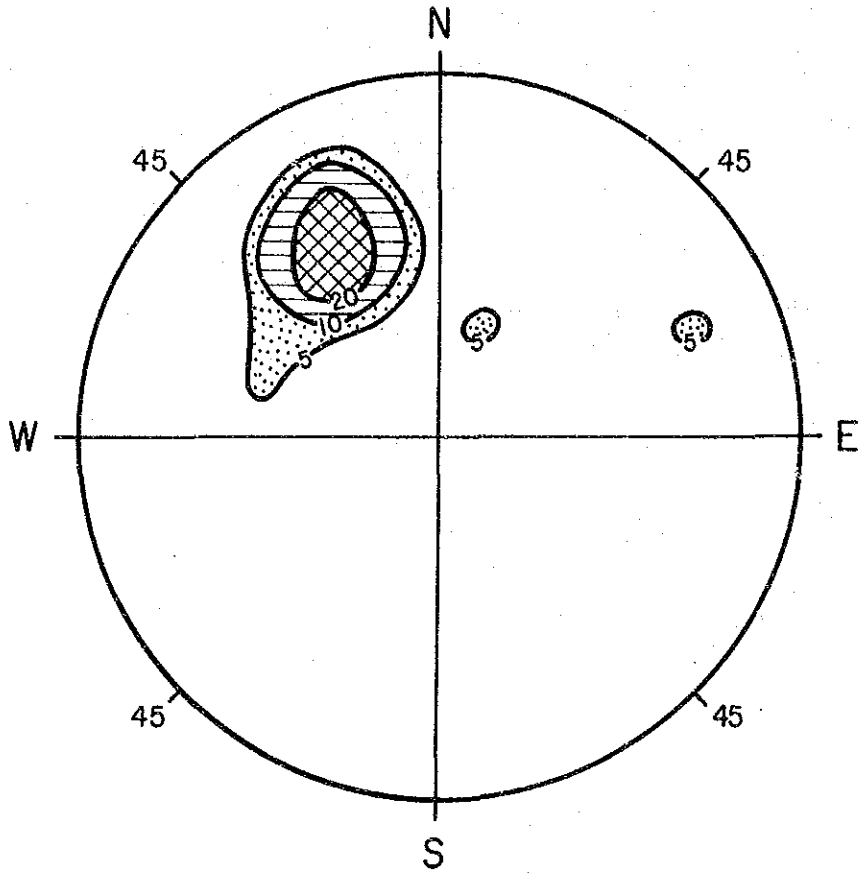
Most of the veins strike northwesterly and dip northward. They are distributed in parallel with good continuity in the northwest direction (Fig. 2.4, PL 1).

The extent of distribution of these veins is about 1 kilometer wide and about 3 kilometers long, which extends continuously from the north of the El Gramoso settlement to southern part along the hillside of the Loma Sito Grande Mountains. Although the outcrops are likely to be distributed further to the south and to the east of the area, the whole aspect of these has not yet been made clear because the time for survey was restricted in this phase.

The strike of each vein as well as the general tendency of distribution of the vein group at El Gramoso are consistent with the direction of the tectonic lines of the NW-SE system which is the main structure of geology of this area. It is thought that the mineralization has a genetic relation with the NW-SE structure. There is a contrast to strike of the veins in the Sabana area, where they trend northeasterly, which was described in the report of the Phase I.

Silicification is a most strong alteration observed in the area, which is accompanied by chloritization and partly by epidotization. This point is also different from those of the Sabana area, where chloritization, epidotization and white-argillization are the main ones.

In addition, although malachite is a main ore mineral in the vein-outcrops in the Sabana area, chalcopyrite is found in abundance in the outcrops in the El Gramoso area. This face suggests that the primary sulfide zone is positioned near the surface in the El Gramoso area.



(upper hemisphere projection)

Note; Density indecated in percent, n = 20

Fig. 5 π-Diagram of Veins in the El Gramoso

The descriptions are made in the following on the vein outcrops discovered in the survey of this phase. Their positions are shown in Fig. 4 and PL 1.

(1) G–1

This portion is situated at Hondo Valle to the north of the El Gramoso settlement, and the small outcrops of copper veins are scattered at four places within the distance of about 40 meters in a direction of northwest (Fig. 6).

Geology of the adjacent area mainly consists of andesitic lapilli tuff and partly of andesite lava. The copper veins show a form of network and single vein. They are present as small outcrops 0.1 to 0.3 meter wide and 1 to 3 meters long extending northwestward. The country rocks have suffered chloritization and silicification and were partly accompanied by epidotization.

Fig. 6 shows the position of the outcrops, and the description is made in the following.

Outcrop No.	Size width x length (m) (m)	Note
1	0.7 x 3	Outcrop of network vein consisting of malachite, specularite and epidote, extending N70°W. The country rock is andesitic tuff. The main alteration of wall rock is chloritization, accompanied by weak epidotization.
2	0.1 x 1	A single vein consisting of malachite, quartz and epidote, extending N30°W. The country rock is andesite, and the wall rock alteration is marked in silicification, accompanied by chloritization.
3	0.5 in diameter	A single vein consisting of malachite, specularite, bornite, quartz and epidote. The country rock is andesitic lapilli tuff, and the alteration incluces chloritization and silicification.

The assay result of the outcrop is as folows:

Sampling width(m)	Au g/T	Au g/T	Cu %	Pb %	Zn %
0.50	0.50	0.90	4.18	0.15	0.02

4	0.3 x 1	Network vein consisting of malachite, specularite, bornite, quartz and epidote. The country rock is andesitic lapilli tuff, and the alteration includes silicification and chloritization.

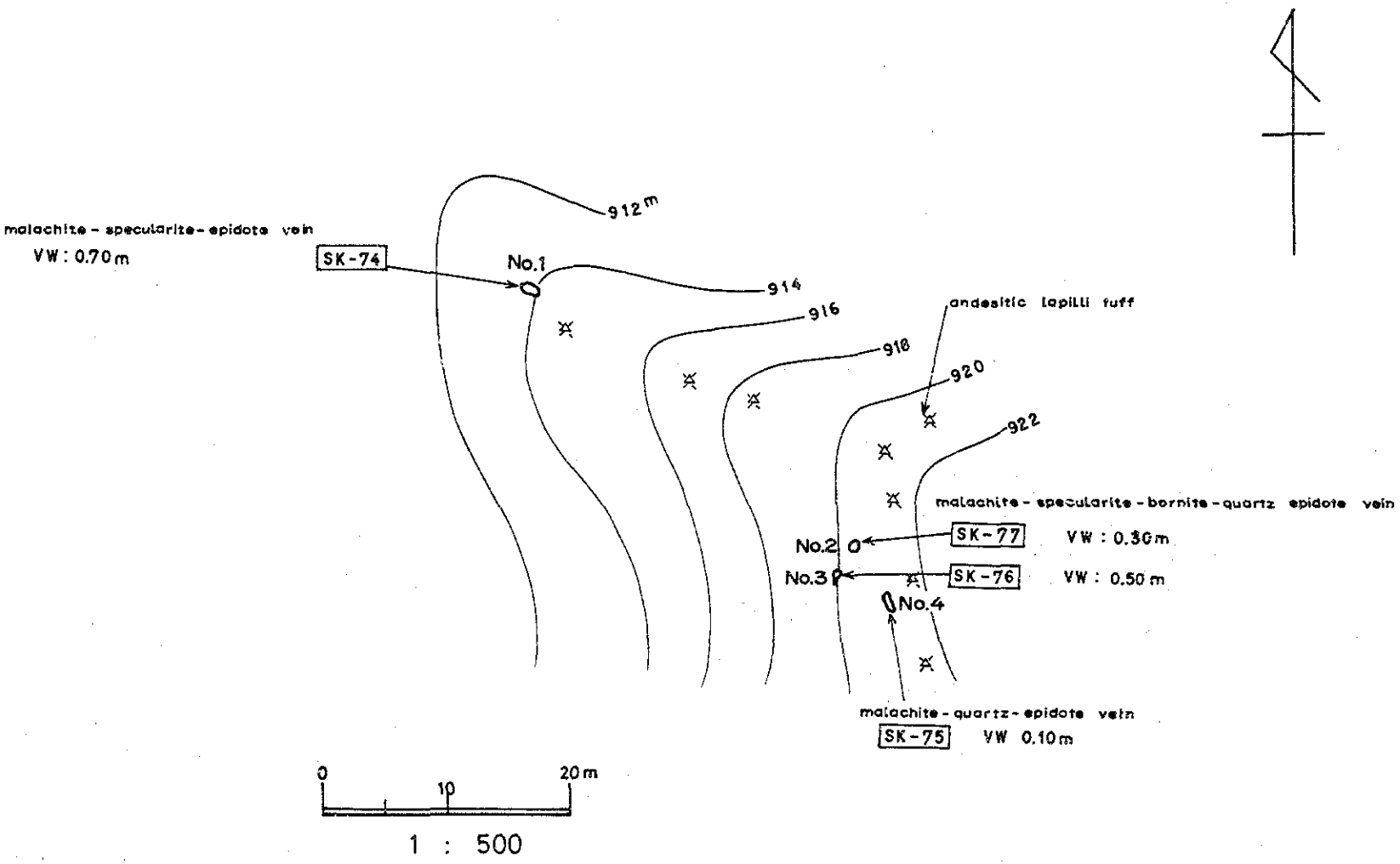


Fig. 6 Location Map of Outcrops at the G-1

(2) G–2

The spot is situated at Hondo Valle. The outcrops of copper veins were discovered at three places. There are two veins. The one is network vein about 2 meters wide and 7 meters long. The other is a single vein 0.1 meter wide and 1 meter long.

The country rock is hematitized andesitic lapilli tuff. Fig. 7 shows the location, and the descriptions is as follows.

Vein No.	Size w (m) x l (m)	Note
1	2 x 8	Network vein consisting of malachite, chalcopyrite, covelline, pyrite, limonite, quartz and epidote, striking N70°W and dipping 55°N. The mineralized zone is 2 – 2.3 meters wide, in which several veins 0.1 – 0.3 meter wide are present. The alteration consists mainly of chloritization, and a weak silicification is observed in the wall of vein. The country rock is hemtatitized andesitic lapillif tuff.

The assay result of the outcrop is as follows:

	Sampling width	Au g/T	Ag g/T	Cu %	Pb %	Zn %
SK079 ----	0.20	0.20	5.9	1.89	0.91	0.02

2	0.1 x 1	The outcrop is composed of chalcopyrite-bornite-malachite-quartz vein, striking N70°W and dipping 55°N. The vein is emplaced in hematitized andesitic lapilli tuff. The alteration of wall rock is zoned outwardly in succession to silicification, chloritization and epidotization.

The assay result of the outcrop is as follows:

	Sampling width	Au g/T	Ag g/T	Cu %	Pb %	Zn %
SK080 ----	0.10	0.20	6.5	2.65	0.12	0.04

From the microscopic observation of SK079, chalcopyrite occurs in a form surrounded by limonite which is the secondarily altered mineral by oxidation. Limonite forms a banded texture of concentric circle containing the small grain of chalcopyrite at the center. Covelline is formed at the boundary between these two minerals.

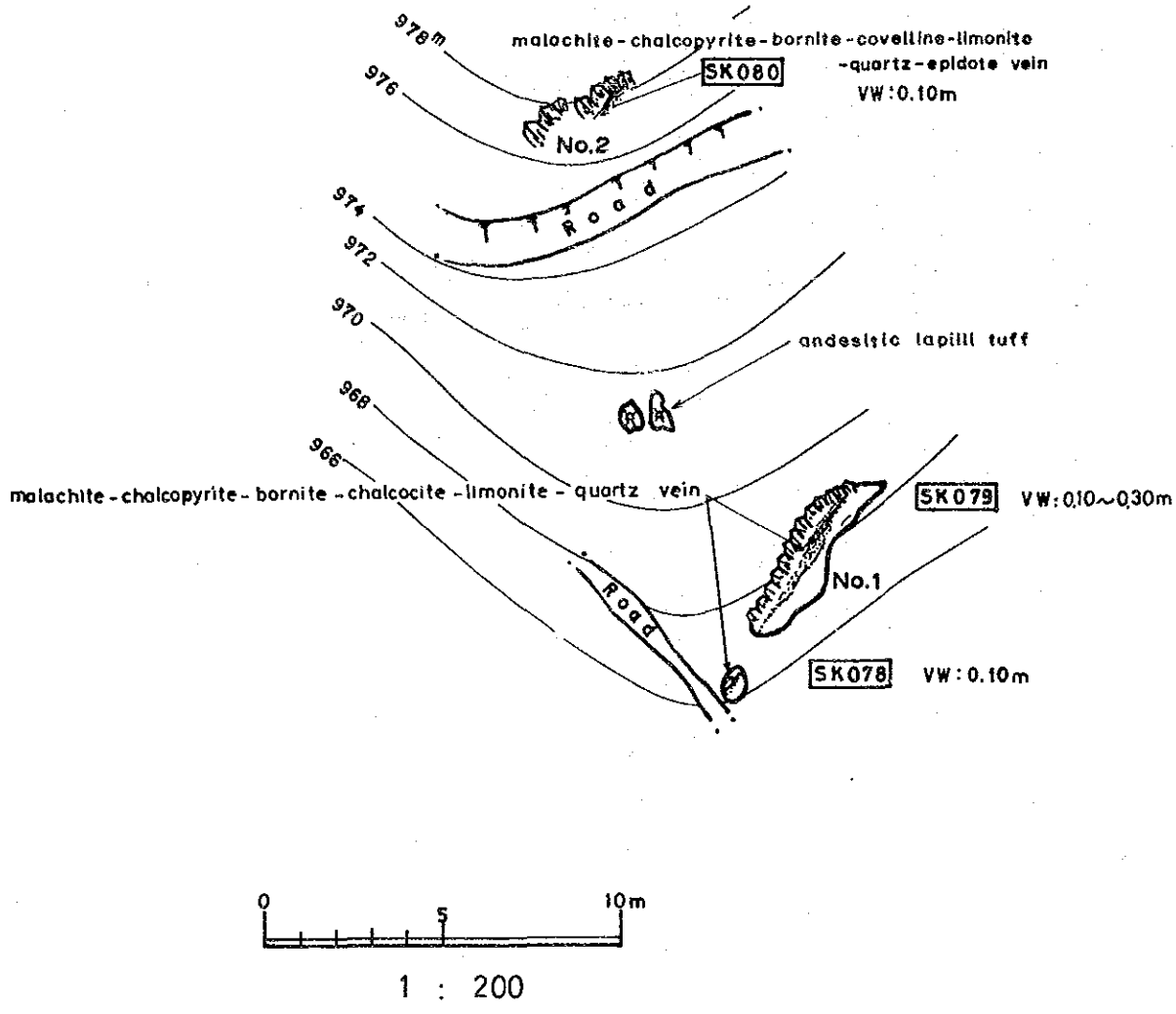


Fig. 7 Location Map of Outcrops at the G-2

(3) G–3

The spot is situated at Hondo Valle. The outcrops of copper veins were discovered at 6 places in the section of about 40 meters. The outcrops are composed of three groups of veins trending northeasterly, among which the largest one is 0.4 meter wide and 17 meters long along the strike of outcrop. Fig. 8 shows the position of outcrops, and the descriptions is as follows.

Vein No.	Size w (m) x l (m)	Note
1	0.4 x 17	Network vein consisting of malachite, chalcopyrite, chalcocite, covelline, limonite and quartz, extending N80°E. The country rock is an altered rock highly silicified and chloritized, accompanied by epidotization in the adjacent part. The original rock is andesite.

	Sampling width	Au g/T	Ag g/T	Cu %	Pb %	Zn %
SK082 -----	0.40 m	0.33	16.5	6.15	0.14	0.10

2	0.3 x 1.5	The outcrop is composed of malachite-chalcopyrite-limonite-quartz vein, striking N70°E and dipping 65°N. The country rock is andesite, which is chloritized.

	Sampling width	Au g/T	Ag g/T	Cu %	Pb %	Zn %
SK081 -----	0.30 m	0.10	2.8	0.99	0.05	0.10

3	0.5 x 2	Two sheets of veins are present in the whole width of 0.5 meter, such as chalcopyrite-chalcocite-covelline-malachite-quartz vein 0.1 meter wide and malachite-limonite-quartz vein about one centimeter wide. The vein strikes N20°E and dip 30°N. The mineralized zone is highly chloritized and silicified.

The process of limonitization of chalcopyrite which originally occurred as 1 to 15 millimeters in a vein can be read by the observation of SK082 and SK083 under the microscope. Limonite was formed in the cracks of chalcopyrite and in the surroundings, and chalcocite and covelline have been formed at the boundary between the two minerals.

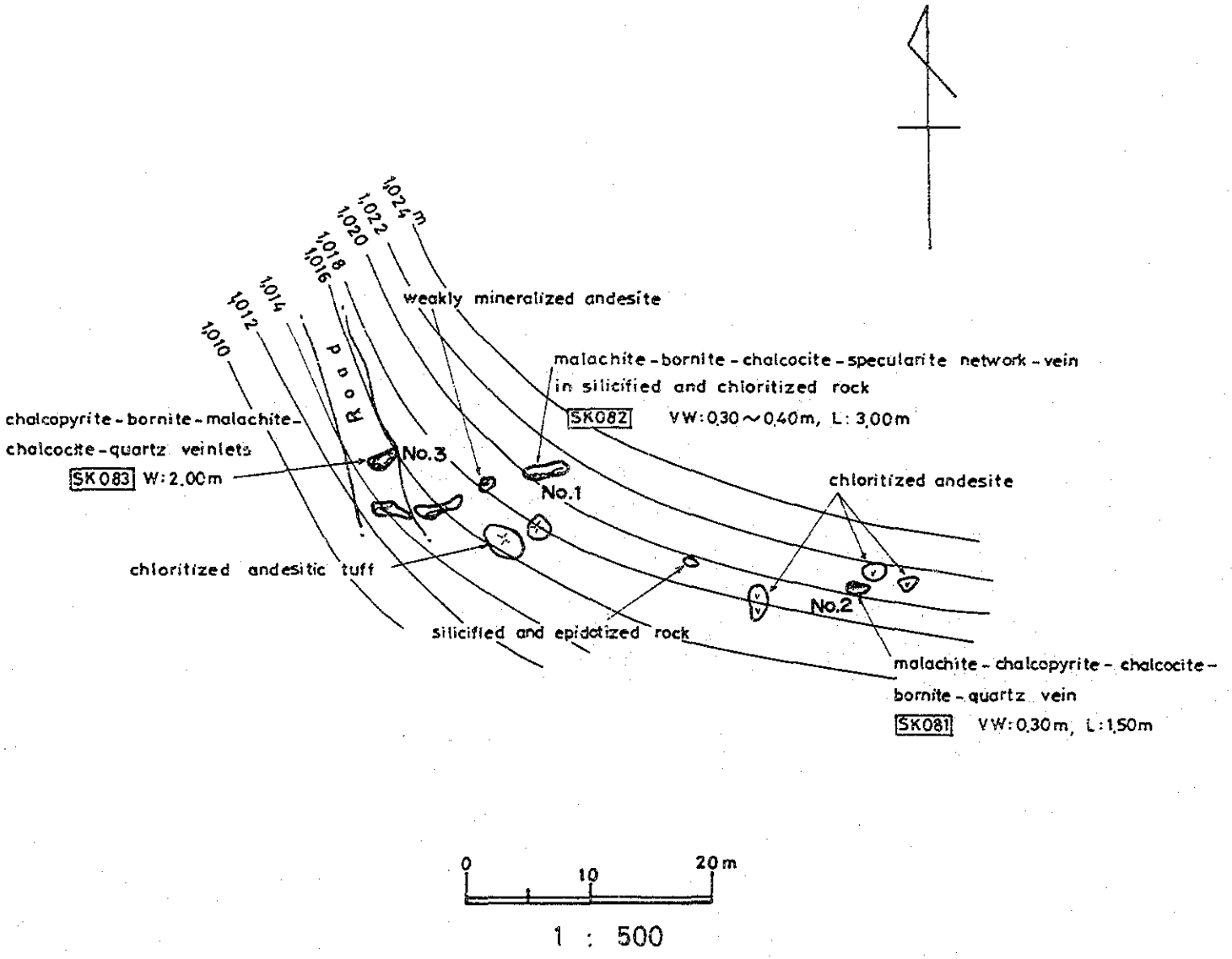


Fig. 8 Location Map of Outcrops at the G-3

(4) G–4

The spot is situated at Hondo Valle. The outcrops of copper veins were discovered at 2 places in the area. They are a network vein composed of chalcopyrite, bornite, malachite and specularite, extending N70° to 80°W. The outcrop is small in size, being 0.2 to 0.3 meter wide and 0.5 meter long.

The country rock is andesitic tuff, and the alteration is remarkable in silicification and chloritization.

The assay result of the ore from the outcrop is as follows:

	Sampling width	Au g/T	Ag g/t	Cu %	Pb %	Zn %
SY005	0.50	0.02	0.02	1.90	0.07	0.02

(5) G–5

The spot is situated in the northeast of the El Gramoso settlement, and many floats of copper vein and outcrops were discovered there. The geology is composed of andesitic tuff, lapilli tuff and tonalite, and the mineralization can be seen in the both rocks. The mineralized floats and outcorps are found at 3 places at the intervals of 50 meters (Fig. 9).

The mineralized zone is aggregate of veinlets composed of malachite, chalcopyrite, chalcocite, limonite and quarts. The mineralized zone is 1 to 2 meters wide and 4 to 20 meters long or spread 5 to 20 meters wide in the case of the floats.

Fig. 9 shows the position of the floats and the outcrops. The description is made in the following.

Vein No.	Size w (m) x l (m)	Note
1	1 x 5 (extent)	A group of floats which is aggregate of veinlets composed of malachite, chalcocite, limonite and quartz in a highly silicified rock. There are three large floats more than 1 meter long and several small ones.

The assay result of the mineeralized float 0.5 meter wide and 1.3 meters long is as follows:

	Sampling width (m)	Au g/T	Ag t/T	Cu %	Pb %	Zn %
SK084 -----	0.50	1.00	43.1	29.83	0.12	0.06

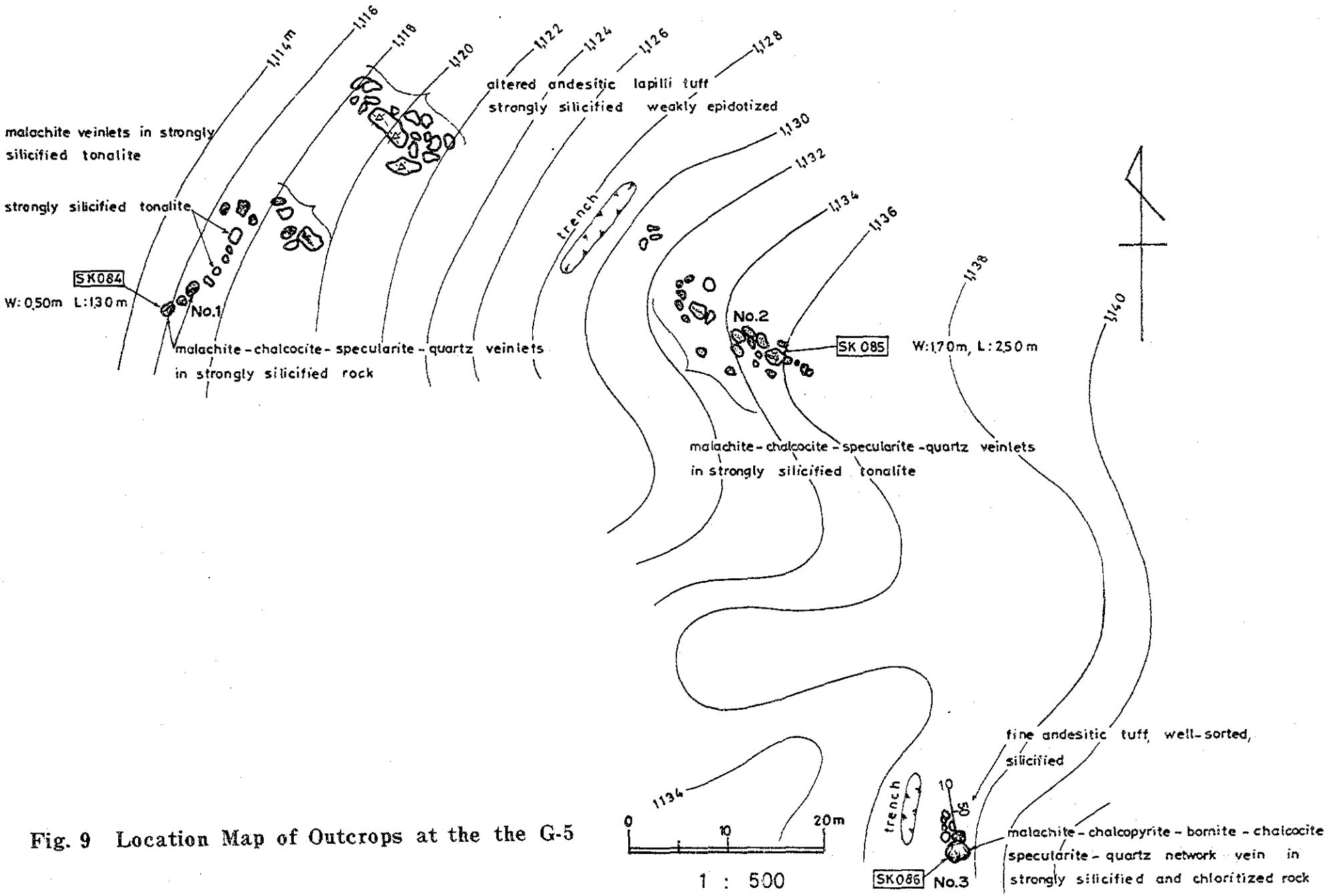


Fig. 9 Location Map of Outcrops at the the G-5

Vein No.	Size w (m) x l (m)	Note
2	5 x 20	A group of floats which is aggregate of veinlets consisting of malachite, chalcocite, limonite and quartz. More than ten pieces of floats more than 1 meter long are distrubuted. The country rock is tonalite, which is markedly silicified.

The assay result of the mineralized float 1.7 meters wide and 2.5 meters long is as follows:

	Sampling width (m)	Au g/T	Ag g/T	Cu %	Pb %	Zn %
SK085 ——	1.70	0.20	5.0	1.97	0.08	0.02

3	0.1 x 5	The mineralized zone is formed by a malachite-chalcopytized.

The assay result is as follows:

	Sampling width (m)	Au g/T	Ag g/T	Cu %	Pb	Zn %
SK086 ——	0.10	0.10	3.9	1.97	0.07	0.01

Another malachite-Chalcopyrite-limonite-quartz vein is exposed on the road about 150 meters to the northwest of the outcrops above mentioned. It is 10 centimeters wide and 7 meters in extension, showing the structure of N25°W and 40°N. The country rock is andesitic lapilli tuff, which is highly chloritized. Alteration zone is about 70 centimeters wide.

The assay result of the vein is as follows:

	Sampling width (m)	Au g/T	Ag g/T	Cu %	Pb %	Zn %
SK073	0.10	0.30	11.2	2.58	0.17	0.06

Under the microscope, chalcopyrite has been replaced by limonite in a form of network, showing a texture of progress of oxidation by weathering. Malachite is present in interstices of gangue mineral and cracks of the country rock in a form of irregular veins.

(6) G–6

The spot is situated along the road of the Rio en Medio which is situated in the north of the El Gramoso settlement. The outcrops were discovered at 5 places in this portion. The outcrops consist of copper veins occurred in andesitic lapilli tuff. There are two ore veins extending northwesterly. The ore minerals are malachite, chalcopyrite, bornite, hematite and

limonite, accompanied by gangue minerals such as quartz and epidote. The beins which contain the ore minerals grade into barren quartz veins and silicified rock at the terminal part. The country rock has been silicified and chloritized. An outcrop (SK054) found on the road is 0.50 meter wide and 8 meters in extension, showing the structure of N45°W and 50°N. The other outcrop (SK072) found on the northern downside of the road is 3 meters wide and 20 meters in extension, extending in the direction of N20°W.

The assay result of these veins is as follows:

	Sampling width (m)	Au g/T	Ag g/T	Cu %	Pb %	Zn %
SK054	0.50	0.30	7.0	1.27	0.16	0.04
SK072	3.00	tr.	1.0	0.68	0.08	0.02

(7) G–12

This is a big outcrop of copper bearing quartz vein discovered about 600 meters south of the El Gramoso settlement. It extends for about 70 meters in the direction of N20°W. The ore minerals consist of malachite, chalcopyrite, chalcocite and limonite, which occur in quartz veins in the form of network veinlets and dissemination. The average width is about 1.5 meters. The country rock is andesitic tuff, and it has suffered chloritization and weak silicification.

The assay result of the outcrop is as follows. Fig. 10 shows the position.

	Sampling width (m)	Au g/T	Ag g/T	Cu %	Pb %	Zn %
SK060	0.90	tr	2.5	0.97	0.07	0.04
SK061	0.40	0.50	16.3	2.01	0.08	0.04
SK063	0.30	0.50	9.8	1.38	0.04	0.02
SK064	1.00	0.33	24.5	5.43	0.12	0.10
SK065	0.80	0.30	24.3	3.97	0.09	0.02
SK066	1.20	0.40	28.6	4.33	0.16	0.06
SK067	0.70	0.40	15.3	4.43	0.09	0.05

(8) G–17

The outcrop is situated 1.5 kilometers southeast of the El Gramoso settlement, at the central part between G–15 on the northern side and G–19 on the southern side. These three are considered to be the same series of vein on the basis of the strike, dip and characteristics of the veins. The whole extension of these is 1.2 kilometers.

The outcrop strikes N25°W and dips 60° northward. Although it is discontinuous, it can be traced for about 200 meters from a small creek to a top of ridge on the northern side.

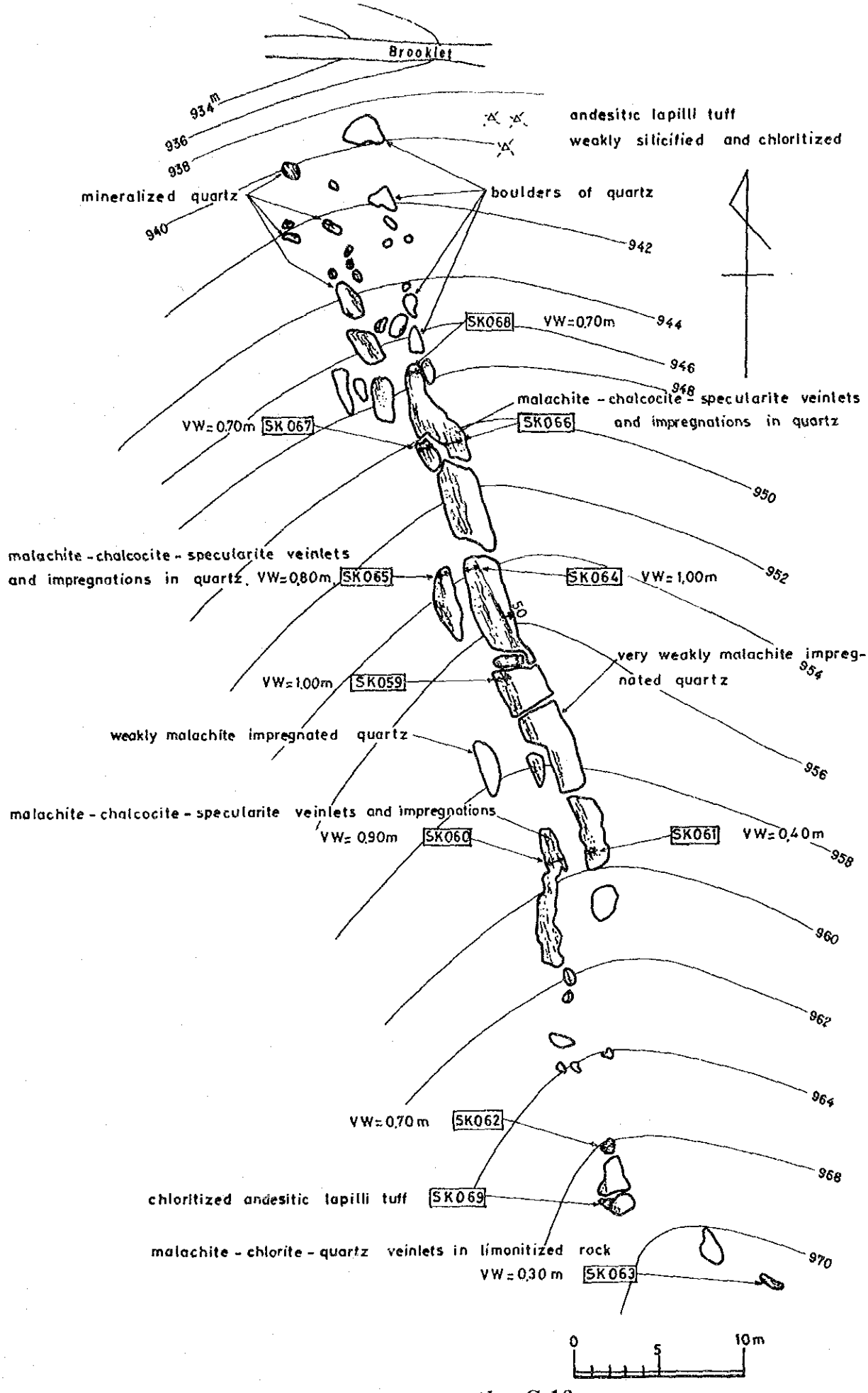


Fig. 10 Location Map of Outcrops at the G-12 1 : 300

The outcrop in the creek shows an occurrence that several copper bearing epidote-quartz veins about 10 centimeters wide for each are present in a whole width of about 3 meters. The outcrop found on the ridge displays a form of a single vein 2 meters wide, seemingly converged from those branched off into one.

The outcrop on the ridge has been strongly weathered to become soil, and surfide minerals have been also limonitized, resulting in to show an occurrence that the copper component has been leached out.

The ore minerals in the vein are malachite, chalcopyrite, bornite, chalcocite, specularite and limonite, and the gangue minerals are quartz and epidote. The country rock is massive, coarse-grained andesitic tuff poorly sorted and graded. The country rock is relatively strongly chrolitized

The assay result of the samples obtained from the outcrop is as follows:

	Sampling width (m)	Au g/T	Ag g/T	Cu %	Pb %	Zn %
ST001 (creek)	0.30	0.10	2.8	1.73	0.08	0.04
ST008 (northern ridge)	1.00	0.20	25.4	2.63	0.08	0.02
ST007 (top of ridge)	1.50	0.20	4.8	0.44	0.17	0.40

(9) G–18

The outcrop is found on a steep ridge 1.5 kilometers southeast of El Gramoso. The outcrop consists of three veins in an extent of about 10 meters. These are parallel veins striking N30°W and dipping 30° northward. The ore minerals are malachite, chalcopyrite and limonite, and the gangue minerals are quartz and epidote. These three veins are 1.5 to 2.0 meters wide. The ore minerals occur as small banded veins 1 to 2 centimeters wide which are present within an extent of 0.5 to 0.7 meter wide in the upper part of the veins. The lower part of the veins is occupied by barren quartz vein. The country rock is andesitic lapilli tuff and chloritization is a notable alteration of that.

The assay result of the typical ores of the veins is as follows:

	Sampling width (m)	Au g/T	Ag g/T	Cu %	Pb %	Zn %
ST010	0.50	tr.	2.1	0.17	0.07	0.02
ST011	0.50	tr.	2.5	2.39	0.07	0.02
ST012	0.70	0.20	4.9	2.83	0.02	0.04

It is likely that the southern extension of these continues to a quartz vein which contains limonite and discovered at a place apart about 500 meters from the above. It is also probable that these are in relation to the quartz veins in a brecciated rock found further to the south.

The microscopy of ST012 shows an aspect of very advanced oxidation, in that chalcopyrite has been mostly altered to limonite, being survived only a small amount in limonite. Malachite occurs along interstices of gangue minerals.

(10) G–19

The spot is situated about 2 kilometers southeast of the El Gramoso settlement. The outcrops of high-grade copper veins were discovered at four places. These outcrops are composed of two series of veins of NW system. They correspond to the southern extension of G–17 megascopically and extends further to the southeast.

The ore minerals consist of malachite, chalcopyrite and small amount of chalcocite, accompanied by the gangue minerals such as quartz and chlorite. The vein are aggregate of network veinlets. The country rock is andesitic lapillip tuff, which is highly chloritized. The veins observed on the outcrops are 0.7 to 1.5 meters wide and 3 to 15 meters in extension. They strike N25°w and dip 40° to 70° northward.

The status of the main outcrops is described in the following.

Outcrop No.	w (m) x 1 (m)	Note
1	1 x 3	The zone of aggregate of network veins one to 20 cm wide consisting of malachite, chalcopyrite, chalcocite, covelline, sphalerite, limonite and quartz. The country rock is andesitic lapilli tuff, which is chloritized.

The assay result is as follows:

	Sampling width (m)	Au g/T	Ag g/T	Cu %	Pb %	Zn %
SK104	— 1.00	1.50	123.4	11.72	0.12	0.02

2	0.7 x 8	The zone of aggregate of network veins one to 20 cm wide consisting of malachite, chalcopyrite, chalcocite, limonite and quartz. The vein strikes N25°W and dips 40°N.

	Sampling width (m)	Au g/T	Ag g/T	Cu %	Pb %	Zn %
SK106	— 0.70	0.30	82.6	7.04	0.12	0.02
SG033	(massive ore)	0.20	7.4	0.97	0.19	0.04
SG034	(massive ore)	0.33	25.5	4.82	0.05	0.02

Under the microscope, chalcopyrite has been limonitized in a form of network, and very small amount of chalcocite and covelline are formed at a boundary between chalcopyrite and limonite.

Very small amount of tiny grains of sphalerite are observed in SK104. Malachite is found in the interstices of gangue minerals outside of chalcopyrite and in limonite as a form of vein.

2. **Hato de Los Rodriguez**

The area is situated about 13 kilometers west of Constanza. The access from Constanza to the site is at first to drive jeep for an hour and a half to the north of Limocito, then it takes about two hours to reach the site on mule back.

The geology in the vicinity of Hato de Los Rodriguez consists mainly of andesitic tuff, lapilli tuff, tuff breccia and partly interbedded with andesite lava of the middle member of the Tireo formations.

The veins at 6 spots (the total number of outcrops includes the 14 places discovered in this phase) are composed of network and single copper veins emplaced in these rocks. The ore minerals include quartz, epidote and chlorite. The veins are 0.1 to 1.5 meters wide and 1 meter to 30 meters in lateral extension at the outcrops. The copper content is 1 to 10 per cent, showing that these are relatively high-grade ore veins.

Most of these veins show the structure striking northwest and dipping northward the same as those in the El Gramoso area, and it is thought that the mineralization of this area has a genetic relation with the geologic structure of NW-SE system.

The alteration of mineralization zone of this area is notable in chloritization and silicification, and accompanied by epidotization. The surrounding area of these is generally subject to hematitization.

It is shown that chloritization spreads 30 centimeters to 2 meters in wall rocks of vein, silicification 10 centimeters to 2 meters, epidotization 30 centimeters to 5 meters, and hematitization 100 to 400 meters an extent up to several hundred meters. In the marginal part of hematitization, it tends to take a form of banding or vein with a survived unaltered part several tens centimeters to several meters wide. The similar form is also shown in a zone of epidotization.

Among the alteration of the wall rocks, chloritization and silicification can be said to be the narrow hydrothermal alteration, while hematitization would have to be called the regional

hydrothermal alternation. Regarding the constituent minerals, the difference is also recognized between those in the central part and the peripheral part.

The veins which contain the metallic minerals vary to quartz vein or quartz-epidote vein at the tail end. The tendency is recognized in the whole veins distributed in tis area. In the outside of the zone of ore veins, quartz veins and quartz epidote veins are distributed.

(1) H–4

The spot is situated on the southern slope north of Hato de Los Rodriguez. Three series of outcrops of copper veins consisting of seven small outcrops were discovered (Fig. 11).

The geology in the vicinity is composed of andesitic lapilli tuff which have generally been subject to hematitization and chloritization.

Exploration by trenching has been done at two places in the northern and southern parts of the vein. The present status of the outcrops and the trenches are as follows. Fib. 11 shows their position.

Outcrop & Trench No.	Size w (m) x 1 (m)	Note
1	0.25 x 2.5	The veins consist of malachite, chalcopyrite, bornite, chalcopyrite, bornite, chalcocite, limonite, quartz and epidote. The coutry rock is black, silicified andesitic lapilli tuff. Silicification is notable. The assay result of the veins is as follows.

	Sampling width (m)	Au g/T	Ag g/T	Cu %	Pb %	Zn %
SK039	– 0.25	0.20	13.0	2.61	0.02	0.04
SK040	– 0.10	0.20	5.7	1.14	0.14	0.04

Trench No.1	1.5x13x0.7 (depth)	Hematitized and epidotized andesitic tuff is observed in the both treahces, and no mineeralization was observed The bottom is filled with soil.
Trench No.2	1.8x18x0.7 (depth)	

Under the microscope, bornite is more abundant in amount than chalcopyrite. Bornite contains chalcopyrite which shows irregular form, and the peripheral part has been altered to chalcocite. The boundary between bornite and chalcopyirite is irregular in shape, showing myrmeckitic texture. Chalcopyrite contains bornite of irregular form, and the peripheral part has been altered to chalcocite. Chalcocite occurs at the peripheral part and along the cracks of chalcopyrite and bornite.

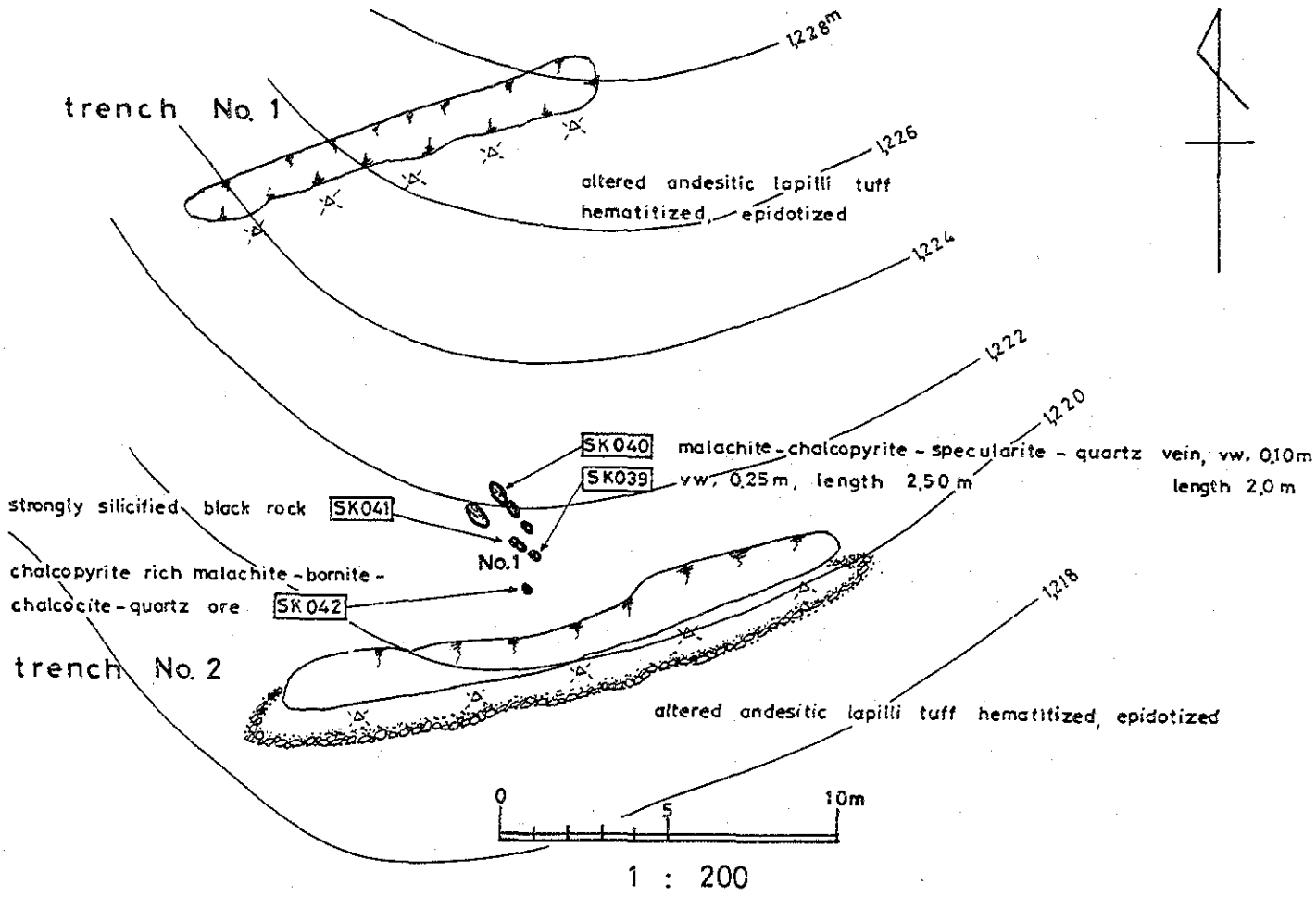


Fig. 11 Location Map of Outcrops and Trenches at the H-4

The peripheral part of chalcocite has been altered to limonite. Malachite is present in a form of vein in the gangue minerals outside of chalcocite.

(2) H–5

The spot is situated in the southern slope north of Hato de Los Rodriguez, where three series of outcrops of copper veins were discovered. The largest one is 1.6 meters wide and 12 meters in extension. The geology in the vicinity is composed of fine-grained and coarse-grained andesitic tuff. Fig. 12 shows the position of the outcrops and the trenches, and the discription on the outcrops and trenches is made in the following.

Outcrops & Trench No.	Size w (m) x l (m)	Note
1	1.6 x 12 (average)	A vain in the form of network and dissemination, composed of malachite, chalcopyrite, bornite, chalcocite and limonite, extending N25°W. The northern extension grades into the shear zone 10 centimeters wide. The country rock is coarse-grained andesitic tuff, which is strongly chloritized. Silicification is weak. The assay result of the outcrops is as follows:

	Sampling width (m)	Au g/T	Ag g/T	Cu %	Pb %	Zn %
SK046 –	1.10	tr.	1.3	1.53	0.03	0.10
SK047 –	2.70	0.10	1.4	1.23	0.15	0.15

2	0.3 x 2	The both are composed of vein in the form of network and
3	0.7 x 1.5	dissemination, consisting of malachite, chalcopyrite, bortized. The outcrop SK–45 extends N30°W, and SK–49 shows the structure of N70°W and 85°N.

The assay result of the outcrops is as follows:

	Sampling width (m)	Au g/t	Au g/T	Cu %	Pb %	Zn %
SK045 –	0.7	tr.	tr.	4.93	0.22	0.10

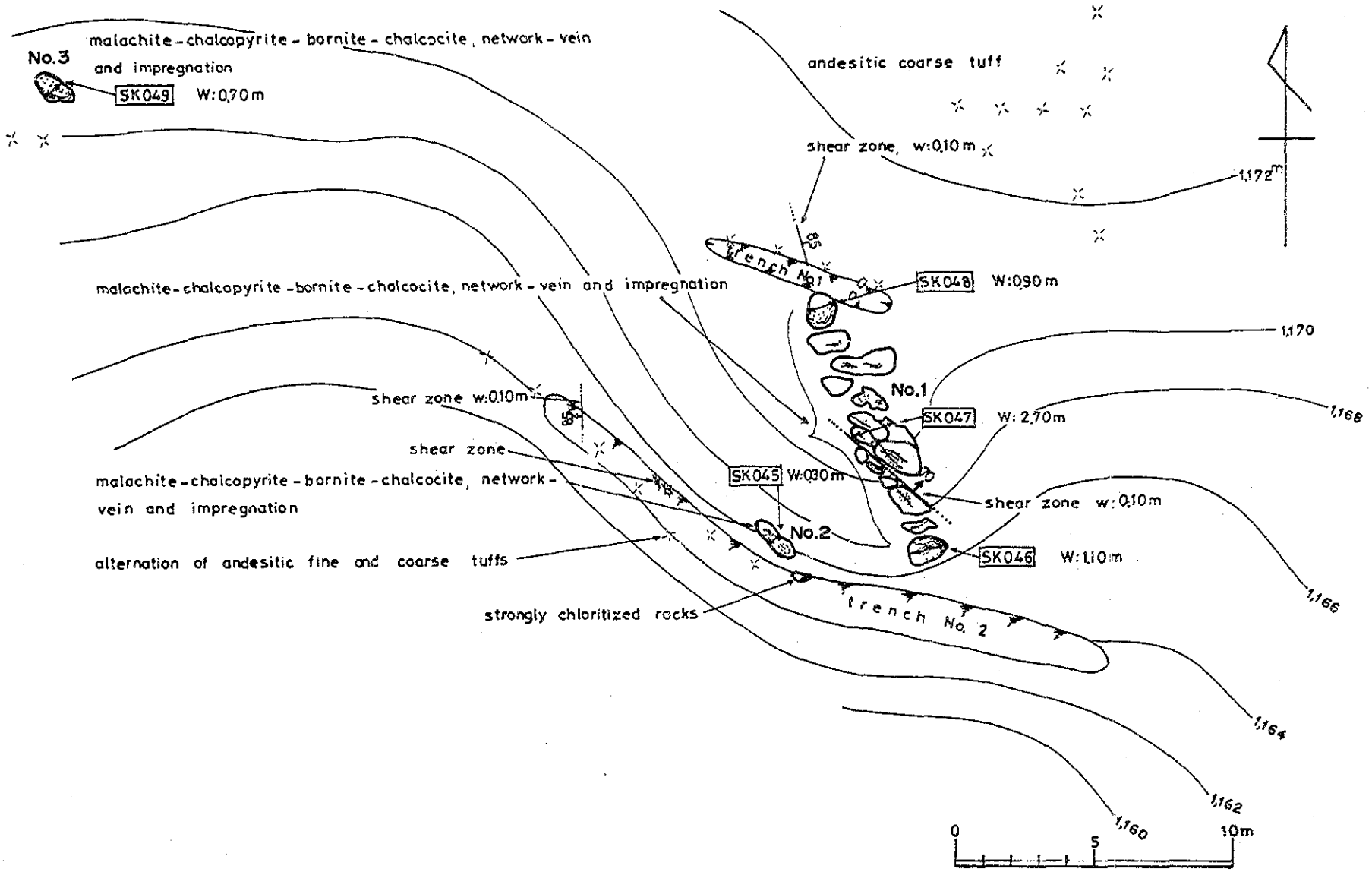


Fig. 12 Location Map of Outcrops and Trenches at the H-5

1 : 200

Outcrop & Trench No.	Size w (m) x l (m)	Note
Trench No.1	1 x 7 x 0.5 (depth)	A trench in coarse-grained andesitic tuff. No mineralization is observed. Weak chloritization is seen. A shear zone 10 centimeters wide is present on the extension of the outcrop (No. 1) of the ore vein showing the structure of N10°W and 85°N.
Trench No.2	1.5 x 23 x 0.5 ~ 1.0	The rocks are composed of weakly chloritized andesitic lapilli tuff and fine-grained tuff. A network vein consisting of malachite, chalcopyrite and limonite is present in an extent of about 1 meter on the extension of the outcrop SK045, and strong chloritization is seen in this part. This trench was excavated in weathered zone. No extension of the outcrop SK046 was found in it.

(3) H–6

The spot is situated on a hilltop east of Hato de Los Rodriguez, where three outcrops of ore vein were discovered. These outcrops continue northwesterly trending, having a whole extension of about 12 meters. A trench was excavated on the southeastern extension of the above. Fig. 13 shows the position and Fig.14 shows the sketch of the bein on the side wall of the trench. The description on the outcrops of the vein and the trench is made in the following.

Outcrop & Trench No.	Size w (m) x l (m)	Note
1	0.1 x 2	An ore vein consisting of malachite, chalcopyrite, bornite, chalcocite, covelline, limoniteand quartz is found on the side wall of the trench (Fig. 14). Lenticular veins mainly consisting of bornite and chalcocite are also found. The country rock is fine-grained and coarse-grained andesitic tuff, in which silicification and chloritization are conspicuous. The assay result of the vein is as follows:

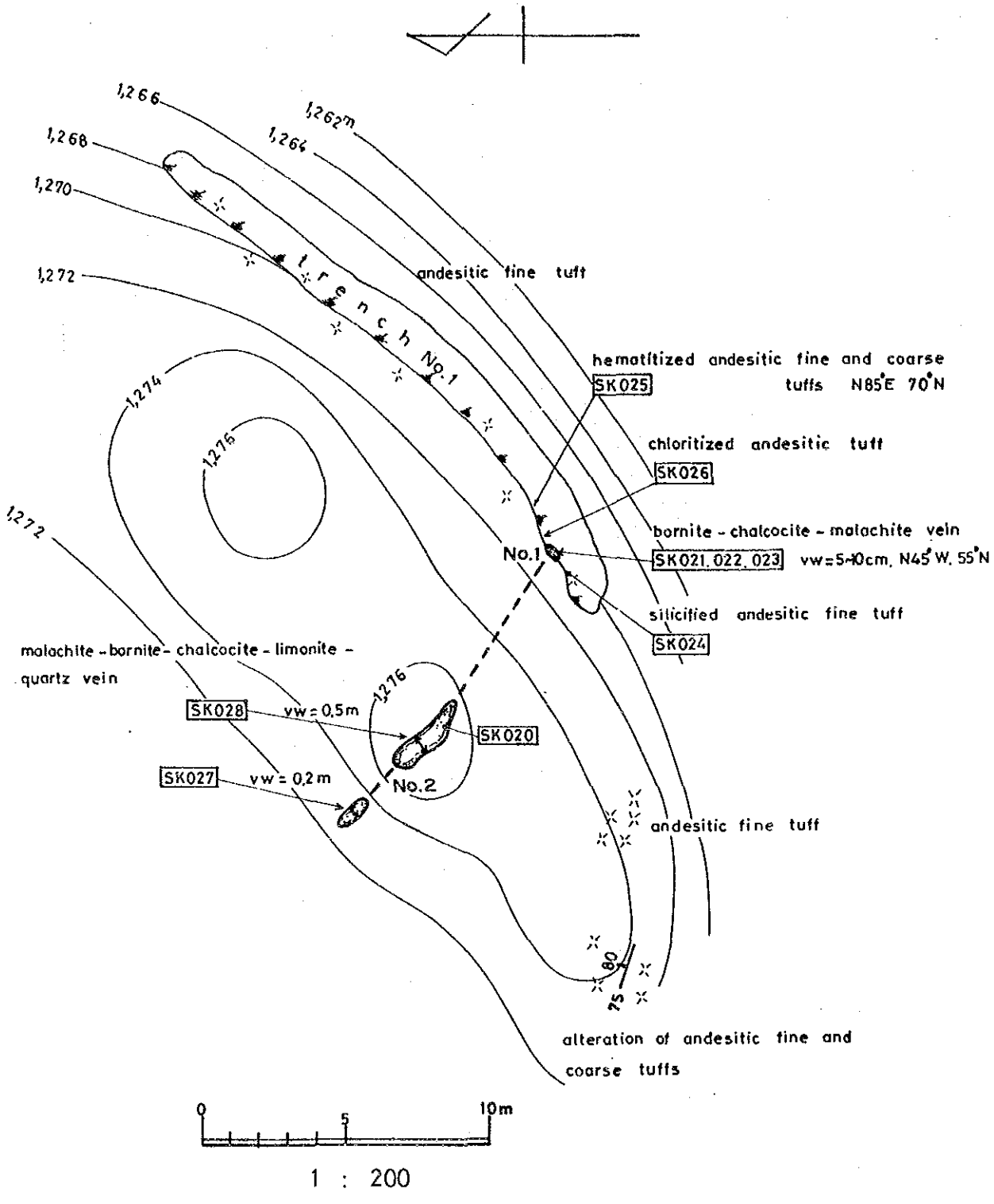


Fig. 13 Location Map of Outcrops and Trench at the H-6

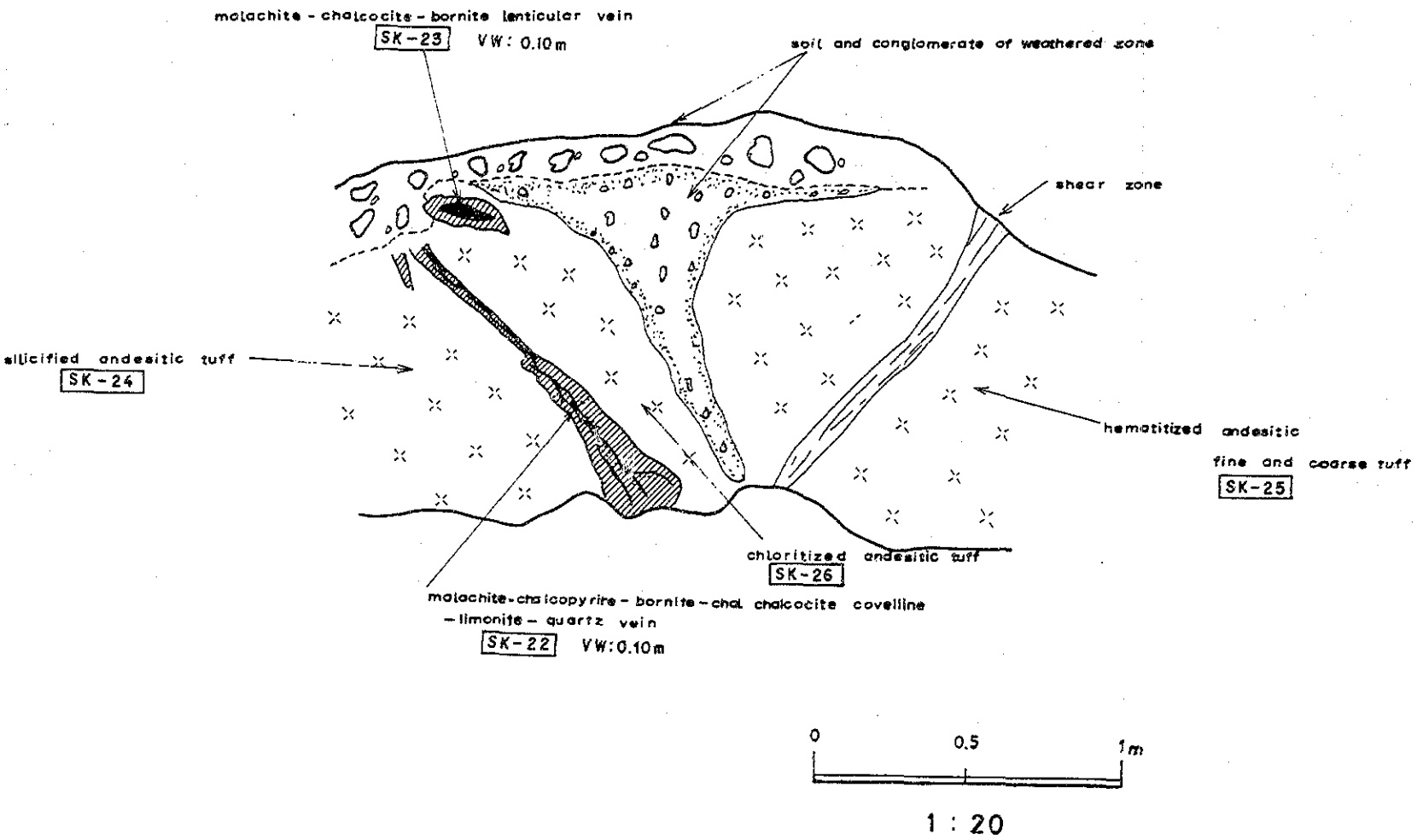


Fig. 14 Sketch of Veins in Trench at the H-6

Outcrop & Trench No.	Size w (m) x l (m)	Note

		Sampling width (m)	Au g/T	Ag g/T	Cu %	Pb %	Zn %
	SK022 --	0.10	0.67	21.3	8.02	0.08	0.10
	SK023 --	0.10	1.50	247.3	30.26	0.44	0.04

2	0.5 x 3	An ore vein consisting of malachite, bornite, chalcocite, limonite and quartz is found on the hilltop, extending N50°W. The outcrop extends to a small outcrop on the northwest and to a vein in a trench on the southeastern side. Although the country rock is thought to be andesitic tuff, the detail is obscure because soil covers the surrounding area. The assay result of the outcrop is as follows:

	Sampling width (m)	Au g/T	Ag g/T	Cu %	Pb %	Zn %
SK027 --	0.50	1.10	11.7	2.64	0.09	0.05

Trench No.1	1.5 x 20 x 1 ~ 1.5 (depth)	A trench is excavated in the zone of alternating beds of hematitized fine-grained andesitic tuff and coarse-grained tuff. Only a vein shown on the sketch is found in the south western part of the trench.

Under the microscope, chalcopyrite grains which was originally several millimeters in diameter have been weathered to alter to limonite. Chalcopyrite survived in limonite. Irregularly shaped bornite and partly the sphalerite star are present in chalcopyrite in a very small amount.

Covelline and a small amount of chalcocite occur at the boundary between chalcopyrite and limonite. Malachite is present as a form of vein in the gangue minerals at the outside of limonite. Bornite is found in abundance in SK023, which has been altered to chalcocite at the outer periphery. Two kinds of chalcocite are observed: the one is the part (A) which is bluish gray and shown to be isotropic, and the other is the part (B) which is brightly white and weakly anisotropic. The latter occurs always on the outside of the former, being in contact with limonite. According to the qualitative analysis by EPMA, the "A" contains some Fe, and it seems to belong to a mineral of $(Cu, Fe)_{1.8}S$ (digenite) series. Since the "B" hardly contains

Fe, and it is likely to be Cu_2S (chalcosite) ~ $Cu_{1.96}S$ (djurleite) series of the mineral of Cu-S system.

3. Los Vellecitos

The area is situated about 11 kilometers west-northwest of Constanza.

The access to the site from Constanza is at first to drive jeep for about an hour to the north of Los Corrales, then it takes about two hours to reach the site on mule back.

The geology of Los Vallecitos mainly consists of andesite lava, and lapilli tuff and tuff breccia of the same source of the middle member of the Tireo formation. The outcrops of ore vein discovered in five spots are composed of gold bearing copper veins emplaced in these rocks. The ore minerals include malachite, chalcopyrite, bornite, chalcocite, pyrite, specularite and limonite, accompanied by gangue minerals such as quartz, epidote and chlorite. The copper veins show the form of network and dissemination. The veins are small in scale in many cases, being several tens centimeters wide and several meters in extension.

The discovery of these outcrops in the survey of this phase resulted in to make clear the source of geochemical anomalies detected by geochemical survey conducted in the first phase.

PL. 1 shows the position of the outcrops. The detail on the outcrops is described in the following.

(1) V–2

The spot is situated about 2 kilometers north of the confluence of the Rio Yaquesillo and the Arroyo La Sabina. The geology in the vicinity is composed of hematitized andesitic tuff breccia.

The ore veins are emplaced along the fractured fissures in the rock. The ore minerals include malachite, chalcopyrite, bornite, chalcocite and limonite, accompanied by quartz as the gangue mineral. The mineralized zone is 1.5 meters wide, in which several small veins 1 to four centimeters wide are present. The extension of the vein is considered to be about 5 meters from the length of the pit excavated. The vein strikes N-S to N10°E and dips 60° to 65°W. Chloritization is notable in the country rock. Pitting was conducted in the past, and a small amount of ore is piled in the vicinity of the pit.

The assay result of the vein is as follows:

	Sampling width (m)	Au g/T	Ag g/T	Cu %	Pb %	Zn %
SY023–1	0.04	0.33	21.0	4.77	0.16	0.10

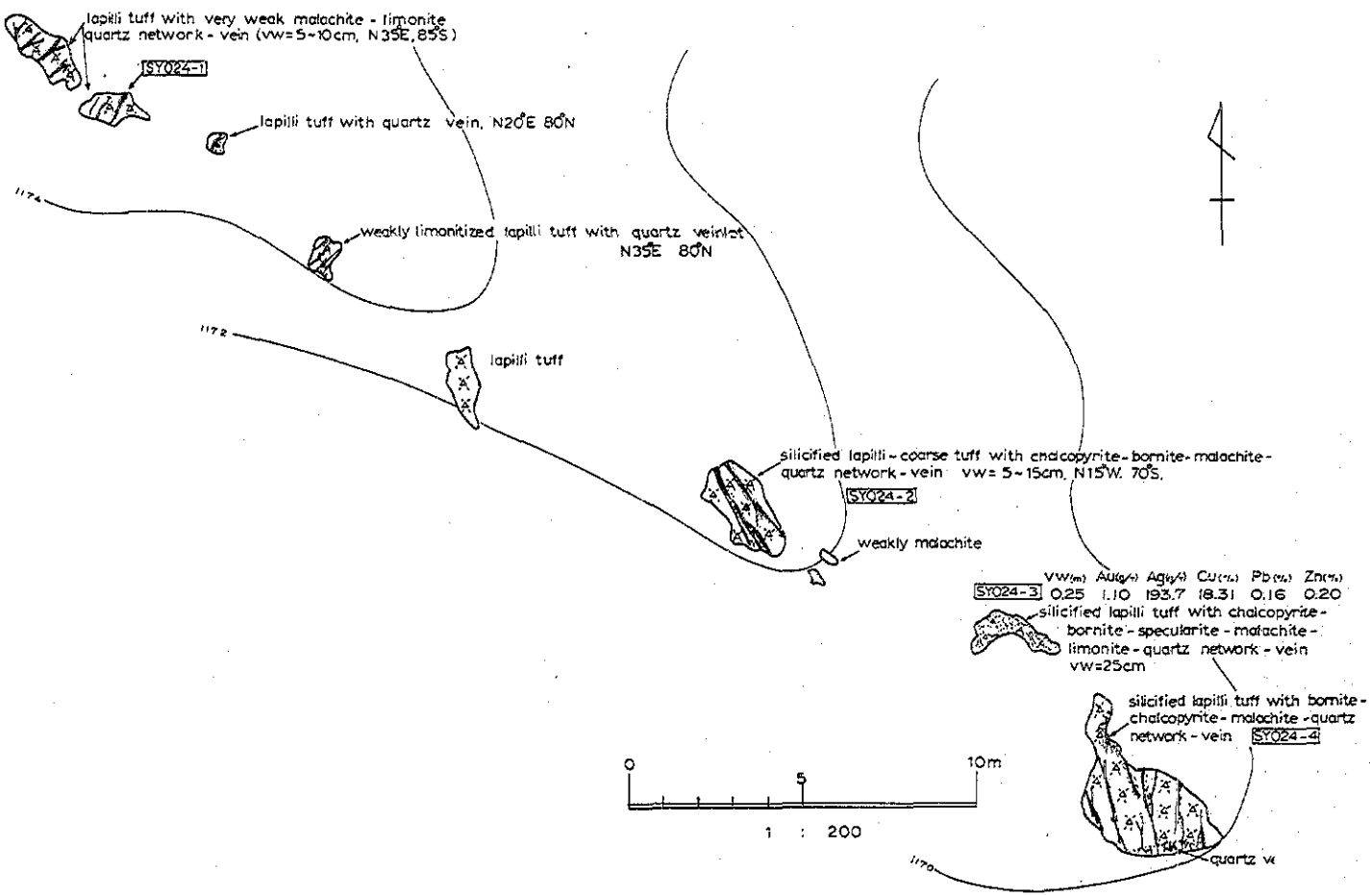


Fig. 15 Location Map of Outcrops at the V-4

(2) V–4

The spot is situated about 1 kilometer north of the confluence of the Rio Yaquesillo and the Arroyo La Sabina. The outcrops of the ore veins were discovered at five places. (Fig. 15). The outcrops are composed of the network veins consisting of malachite, chalcopyrite, bornite, chalcocite, pyrite, specularite, limonite and quartz. Two trends of veins sch as NW system and NE system are seen, and the veins are emplaced in the fractured fissures.

The geology in the vicinity consists of andesitic tuff and tuff breccia, and chloritization and silicification are common alteration of the country rock. The veins of NW system found in the southern part are 0.2 to 0.9 meter wide, striking N20° to 25°W and dipping 60° to 80°S, which can be traced for about 20 meters laterally.

The assay result of the high-grade part is as follows:

	Sampling width (m)	Au g/T	Ag g/T	Cu %	Pb %	Zn %
SY024–3	0.25	1.10	193.7	18.31	0.16	0.20

(4) Others

(1) Caño del Gallo (S–6)

The spot is situated about fifteen kilometers west of Constanza, in the northeastern part of the vein groups in the Sabana area. The geology in the vicinity consists of andesitic lapilli tuff of the middle member of the Tireo formation. The mineralized zone is composed of copper veins in the form of network and dissemination. The main mineralized zone observed in this spot is only the outcrops distributed between the pits No.1 and No.2, and others have been mined out by pitting and trenching (Fig. 16).

Six outcrops of the ore veins are found in an extent of 4 m x 1.5 m. These are the veins of network and dissemination consisting of malachite, specularite, limonite and quartz. The largest outcrop is 0.4 m x 1.2 m in size, and the assay result of it is as follows:

	Sampling width (m)	Au g/T	Ag g/T	Cu %	Pb %	Zn %
SK004	0.40	tr.	tr.	9.36	0.22	0.04

Fig. 16 shows the location of the pits and trenches. The present status of the mineralized zone is described in the following.

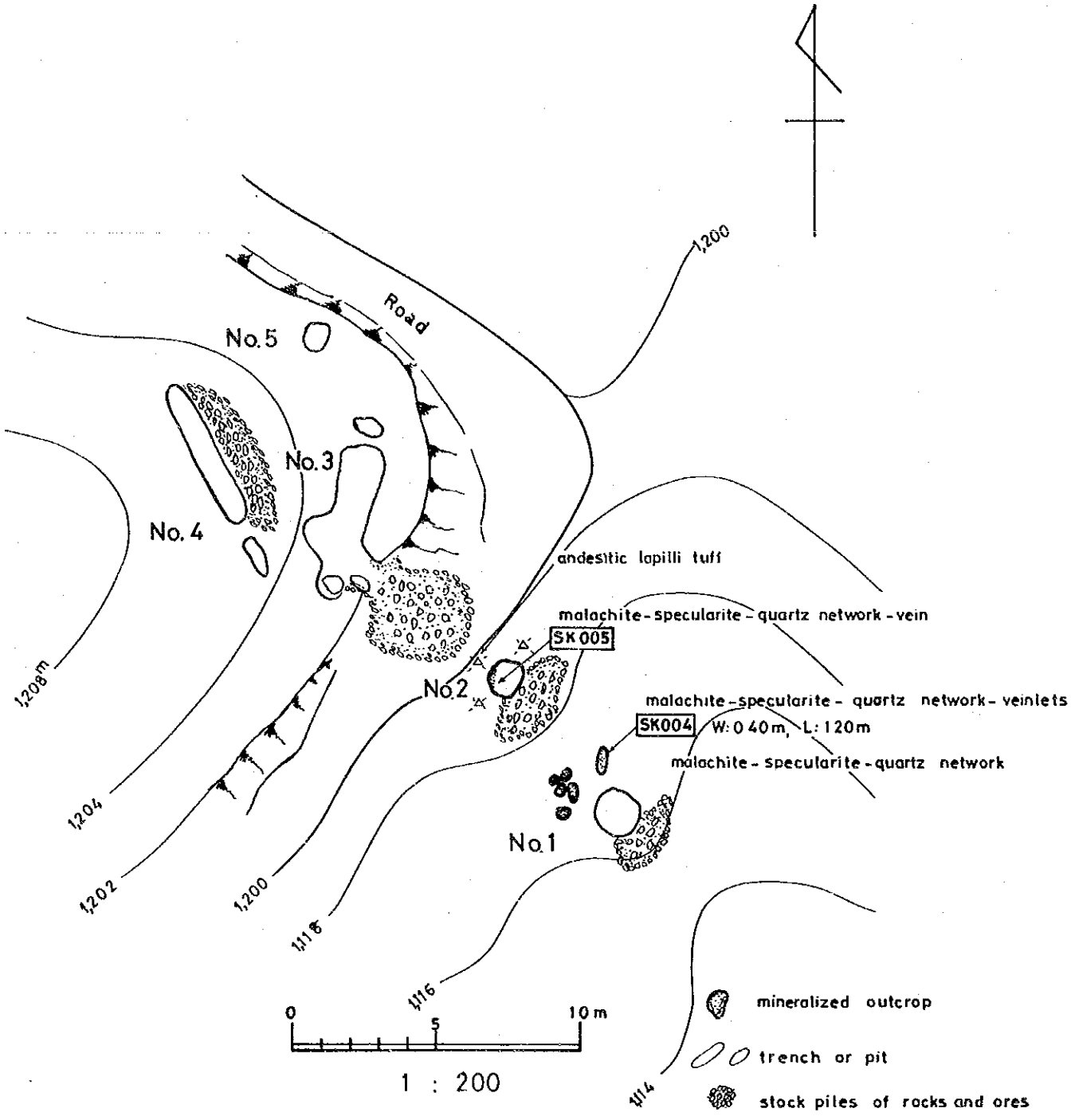


Fig. 16 Location Map of Pits and Outcrops at the Cano del Gallo (S-6)

No.	Size w x l x d	Note
1	4m x 4m x 2m	The pit was excavated in the soil and gravel, and no bed rock has been exposed. The ore containing malachite which mixed with the waste pile is piled.
2	1.8 x 2.5 x 0.8	Andesitic lapilli tuff is exposed within an extent of 1m x 1m, in which network vein of malachite 0.5 meter wide is present. The country rock has been chloritized. The grade of this part is assumed to be about three per cent.
3	3 x 9 x 1.6 ~ 2.0	Most part of the wall are soil and gravel. Fractured black siliceous rock seemingly derived from andesitic lapilli tuff is exposed at the bottom of the wall of the mountain side, in which a small vein of white clay striking N30°W and dipping 60° northward and a quartz-epidote vein striking
4	3 x 13 x 1.2 ~ 1.8	The wall is composed of black siliceous rock of unknown source, in which network veins of white clay striking N70°E and dipping 10° southward and a quartz-epidote vein striking E-W and dipping southward are present.

(2) C–4

The spot is situated about 6 kilometers west-southwest of Constanza, and the outcrop is located on the left bank of the Rio Grande. The geology of the surrounding area consists of coarse-grained andesitic tuff of the middle member of the Tireo formation, and the outcrop is composed of copper bearing quartz vein emplaced in the rock. The maximum width of the quartz vein is 6 meters, among which copper mineralization is observed in a width of 2 meters in the lower part. The ore minerals consist of chalcopyrite, pyrite, malachite and limonite, being relatively rich in sulfide minerals. The vein is 1.5 to 2.0 meters wide in the southern extension on the hill side, which is traceable for about 100 meters. While the northern extension is difficult to trace because it runs along with the Rio Grande in the the stream.

The assay result of the outcrop is as follows:

	Sampling width (m)	Au g/T	Ag g/T	Cu %	Pb %	Zn %
CT002	2.0	tr.	1.1	0.93	0.18	1.10

2–3 Geochemical Survey

In the survey of this phase, geochemical survey by soil was conducted.

The samples obtained were chemically analyzed for six components such as Au, Ag, Cu, Pb, Zn and Mo. The assay results of these were statistically processed by computer, and single component analysis and multivariate analysis by factor analysis were made.

2–3–1 Method of Sampling and Analysis

The sampling of soil was preponderantly carried out for the extent of about 90 square kilometers on the basis of the result of geochemical survey by stream sediment and survey of geology and ore deposit conducted in the first phase. The density of sampling was 6 to 7 samples per square kilometer, and the total number of samples obtained was 566. The location of sampling is shown in PL. 4–1 to 4–3.

At every sampling point, the humus soil (A-layer) was removed and the weathered clastics (B-layer) were obtained. The sample number, color and the name of rock (parent material of soil) were recorded on the sampling list at the site.

The samples thus taken were dried by natural seasoning at the office at Constanza where the base camp was set, and those of about twenty grams each divided by qaurtering were brought back to Japan, which were chemically analyzed. As the method of analysis, atomic absorption method was applied for Au, and plasma luminescence spectrochemical analysis (ICP method) for Ag, Cu, Pb, Zn and Mo.

The limit of detection of each element was 0.01 ppm in Au, 0.1 ppm in Ag, 1 ppm in Cu, Pb and Zn, and 0.01 ppm in Mo.

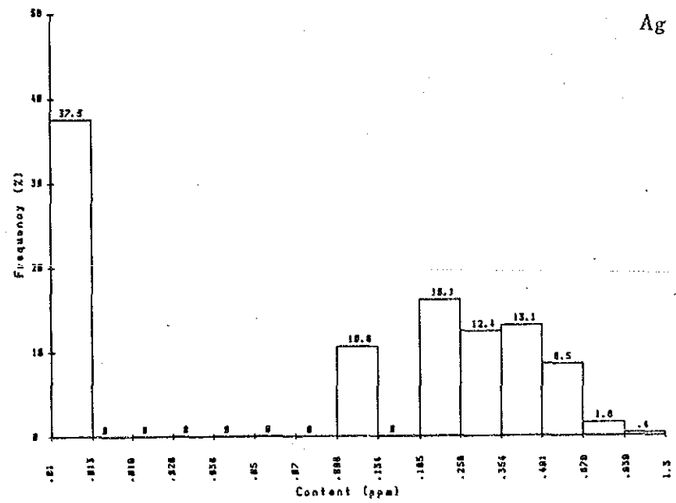
2–3–2 Data Processing

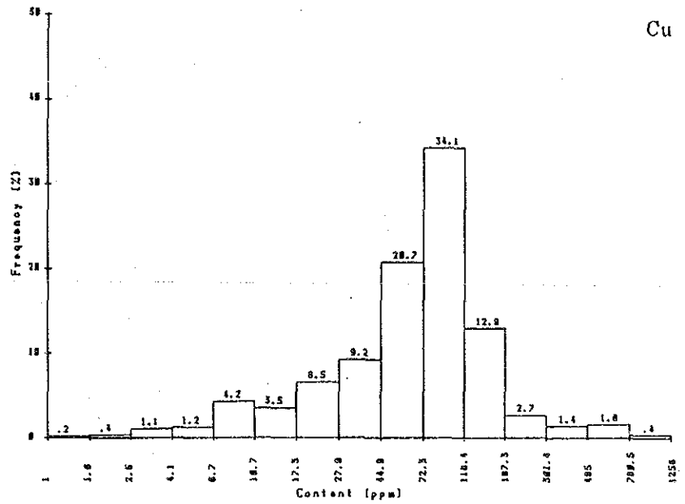
The result of analysis of the 566 samples for six components is as shown in Table A–6. The result of these analyses was input into the computer together with the rock type.

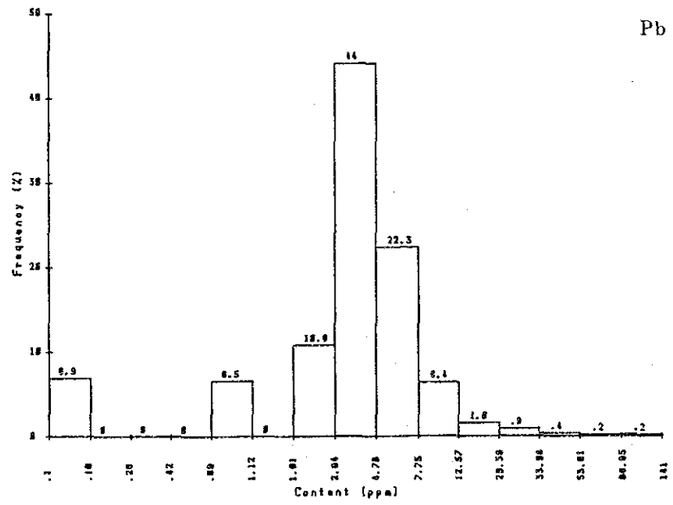
2–3–3 Single Component Analysis

The histogram and cumulative frequency distribution graph were produced for each component to extract the anomalous values (Fig. 17 and 18).

In terms of gold and molybdenum, the values below the detection limit occupied about 99 per cent and 92 per cent respectively, so that the histogram and cumulative frequency distribution graph could not be produced.







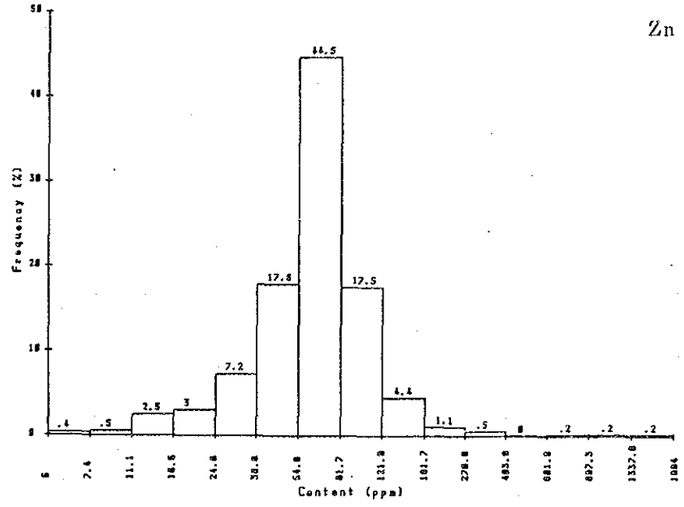


Fig. 17 Histograms of Geochemical Data from the Constanza Sub-Area

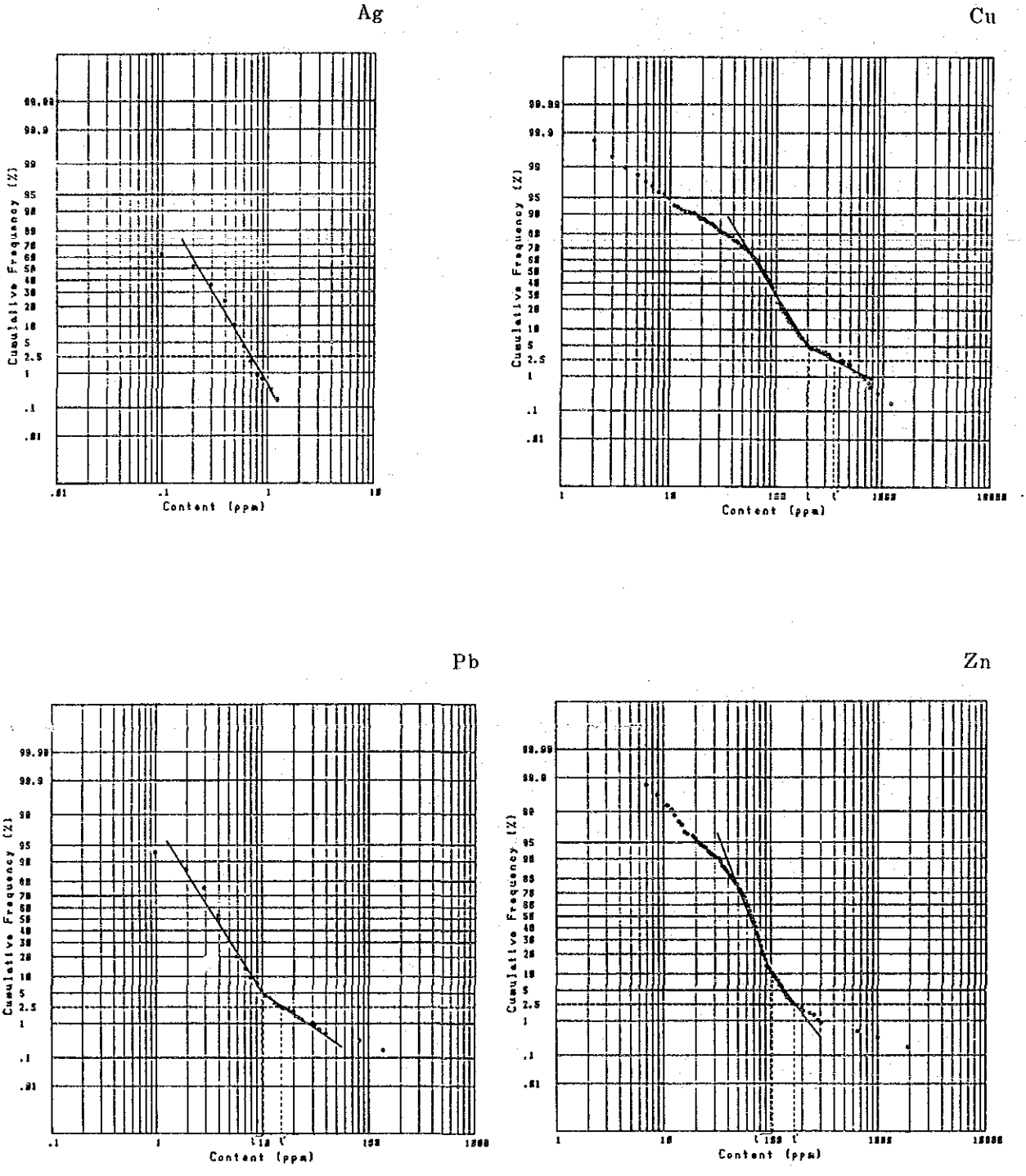


Fig. 18 Cumulative Frequency Distributions of Geochemical Data from the Constanza Sub-Area

Table 3 Result of Simplified Stratistical Treatment of Geochemical Data from the Constanza Sub-Area

Element	Max. (ppm)	Min. (ppm)	Mean (ppm)	t (ppm)	t' (ppm)
Au	0.06	<0.01	–	–	–
Ag	1.3	<0.01	0.08	–	–
Cu	1252	1	62.0	200 (5%)	350 (2.5%)
Pb	141	<1	3.0	10 (5%)	15 (2.5%)
Zn	1994	5	61.4	100 (10%)	160 (5%)
Mo	0.8	<0.1	–	–	–

Table 4 Result of Factor Analysis of Geochemical Data from the Constanza Sub-Area

Factor loading (varimax rotation)				Communality
Factor No. / Element	Factor 1	Factor 2	Factor 3	
Ag	0.168	0.121	0.443	0.239
Cu	0.759	-0.052	0.221	0.628
Pb	0.043	0.442	0.092	0.205
Zn	0.720	0.268	0.202	0.631
Factor contributions	1.126	0.284	0.294	

The method of C. Lepeltier (1964) was used to determine the anomalous values and the threshold values of background. It is a method to produce a cumulative frequency curve by dividing the cumulative frequency distribution graph by segments and to determine the threshold values on the basis of the skew points if there are any distinct ones.

In order to more accurately produce the cumulative frequency curve, attention was paid for comparison between the cumulative frequency curve and the histogram, and for investigation of them. These method resulted in to obtain a simple statistic result as shown in Table 3.

These results were expressed as the geochemical analysis graph for each component.

1. Gold (Au) (PL. 5–1 ~ 5–3)

Gold was detected only in four samples among those of 566, and the maximum value was 0.06 ppm. Four points showing the values more than 0.01 ppm are scattered in the vicinity of Sabana.

2. Silver (Ag) (PL. 5–1 ~ 5–3)

The assay values of silver showed the minimum of less than 0.1 ppm and the maximum of 1.3 ppm. The cumulative frequency curve is nearly straight, and no distinct threshold value could not be obtained since these analytical values are composed of a single population.

The equidensity lines in the analysis graph are at 0.2 ppm, 0.3 ppm, 0.5 ppm and 0.9 ppm and each cumulative frequency is about 50%, 35%, 10% and 2.5%.

The low values less than 0.2 ppm are found in abundance in the eastern part as compared with the western part. While the high values more than 0.5 ppm are consistent with the distribution of the copper mineralized zones at Pinar Bonito in the eastern part and at Limoncito and El Gramoso in the central part, they does not coincide with the mineralized zone at Sabana in the western part.

3. Copper (Cu) (PL. 6–1 ~ 6–3)

The assay values of copper show the minimum of less than 1 ppm up to 1256 ppm, showing a marked variation. Two populations are recognized in the histogram. These are observed in the cumulative frequency curve, shown as distinct skew point. The value of skew point 200 ppm was determined to be the threshold value (t), and mean value of anomalous population 400 ppm to be the supplementary threshold value (t').

The equidensity lines in the analysis graph are at 60 ppm, 100 ppm, 200 ppm (t) and 350 ppm (t') and the cumulative frequency for each are about 60 %, 30 %, 5 % and 2.5 %.

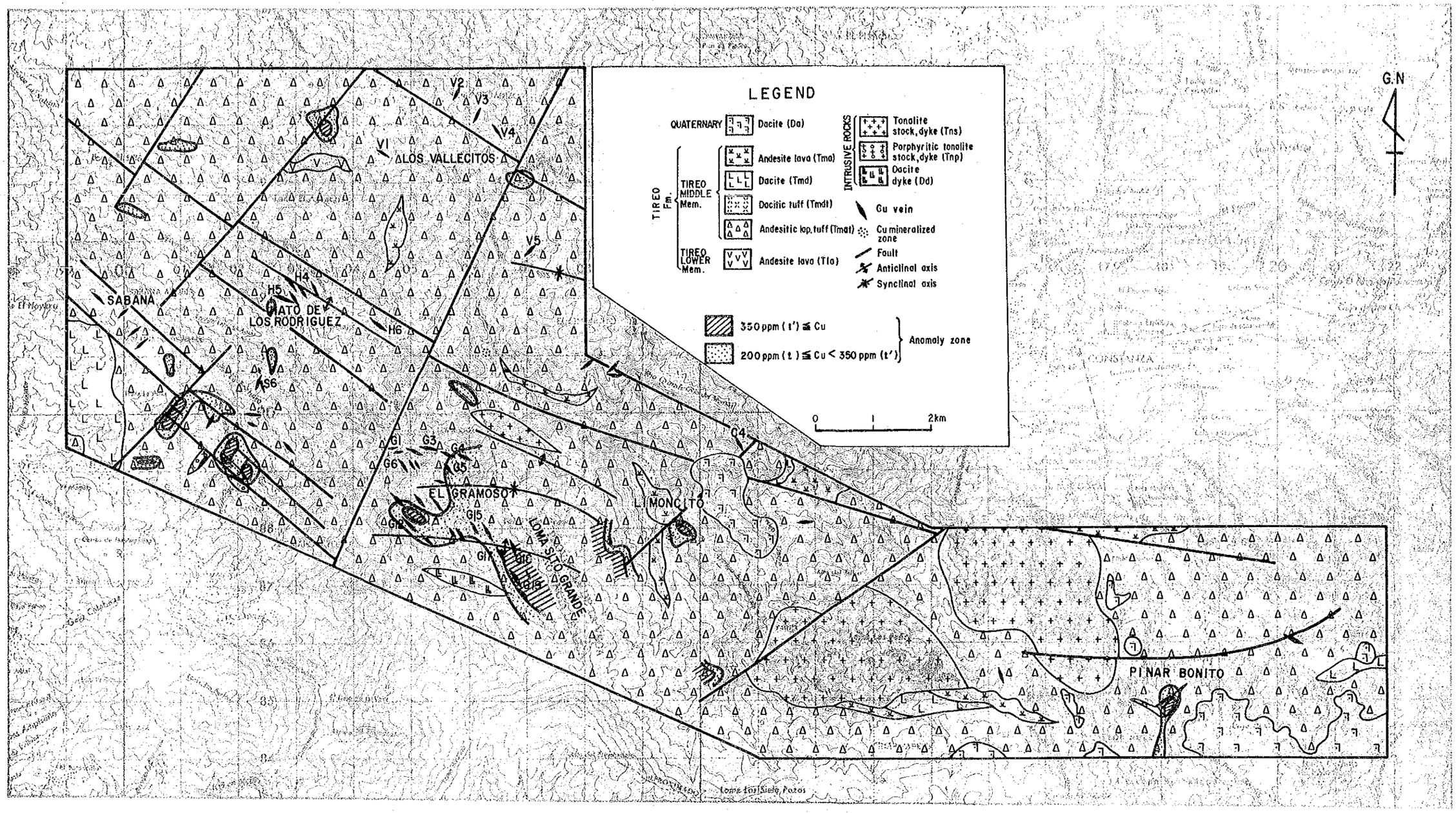


Fig. 19 Geochemical Analysis Map (Cu) of the Constanza Sub-Area

The anomalous zones higher than t coincide with the copper mineralized zones at Pinar Bonito, Limoncito, El Gramoso and Sabana. A highly anomalous zone higher than t' distributed to the west of Limoncito seems to continue through Roma Sito Grande to the highly anomalous zone at El Gramoso to the west.

In the Sabana area, the highly anomalous zones reflect the Roblito deposit and the Fortuna deposit surveyed in the first year.

The geochemically anomalous zones of copper at Ar. La Sabina detected by sediment sampling in the first phase did not show any distinct geochemical anomaly in this phase.

4. Lead (Pb) (PL. 7–1 ~ 7–3)

The assay values of lead showed the minimum of less than 1 ppm and the maximum of 141 ppm. These values are composed of two populations similar to those of copper, and the value of skew point on the cumulative frequency curve 10 ppm was determined to be the threshold value. The values more than 10 ppm occupy five per cent of the whole, and the value of 15 ppm shown at the point of geometric mean of the anomalous population was determined to be the supplementary threshold value.

The equidensity lines in the analysis graph are at 4 ppm, 5 ppm, 10 ppm (t), and 15 ppm (t'), and the cumulative frequency for each are about 50 %, 30 %, 5 % and 2.5 %.

The anomalous zones higher than t coincide with the copper mineralized zones at Pinar Bonito, Limoncito and El Gramoso. In the vicinity of Sabana, the anomalies do not coincide with the copper mineralized zone, but are found in a barren zone.

5. Zinc (Zn) (PL. 8–1 ~ 8–3)

The assay values of zinc showed a marked variation from the minimum of 5 ppm to the maximum of 1994 ppm. These values are composed of two populations similar to those of copper and lead, and the value of skew point of 100 ppm was obtained as the threshold value (t). The mean value of the anomalous population 160 ppm was determined to be the supplementary threshold value (t'). The equidensity lines in the analysis graph are at 60 ppm, 80 ppm, 100 ppm (t) and 160 ppm (t'), and the cumulative frequency for each are 70 %, 30 %, 10 % and 5 %.

The anomalous zones higher than t coincide with the copper mineralized zones at Pinar Bonito, Limoncito and El Gramoso similar to the case of copper, but they do not coincide with the copper mineralized zones at Sabana and along Ar. Sabina in the western part, which are distributed in the surroundings of them.

6. Molybdenum (Mo) (PL. 8–1 ~ 8–3)

About 92 per cent of the assay values of molybdenum showed the values less than 0.01 ppm which is the detection limit. The point detected only coincide with the zinc mineralized zone at Pinar Bonito, and the anomalies are scattered without any relation to other elements.

2–3–3 Multivariate Analysis

Although there are many methods of analysis for multivariate geochemical data, factor analysis method was used this time as was in the first year. The elements used for factor analysis are the four elements such as Ag, Cu, Pb and Zn. Au and Mo were excluded because most of the assay values of these elements showed those below detection limit.

The factor analysis is a technique in which what extent of factors are possessed by each sample is expressed by factor score obtained by establishing a small number of temporary variates (factors) from many variates. In the case of geochemical data, some of these factors are expected to indicate some kind of mineralization, and therefore, it is assumed that the extent of mineralization of each sample can be explained by the factor score obtained.

The calculation was made by computer and processed by varimax method. As the result, three factors were obtained including the first factor of Cu–Zn and the second factor of Pb. The factor loaidngs, community and contributions of each factor are shown in Table 4.

When the high factor score of each factor, the copper mineralized zone and the single component analysis graph of copper are investigated, it seems that the first factor (Cu–Zn) would be the copper mineralization factor.

The high score zone more than 1.0 in the first factor is well consistent with the distribution of the mineralized zone found at Pinar Bonito, Limoncito, El Gramoso and Sabana. Especially, the high score zone shows considerably wide distribution between El Gramoso and Limoncito (PL. 9–1 ~ 9–4). The factor is the one which characterizes the copper mineralization as shown in the above, which shows a good consistency with the result of analysis of geochemical data obtained by sediment sampling in the first year.

While the second factor is characterized by lead and the third factor by silver, the high score zones of the second factor and the third factor become more conspicuous in agreement with the copper mineralized zone toward the east. Taking into account this fact putting together with the result of single component analysis, the zonal arrangement of elements can be assumed from the west toward the east, such as Cu–Zn at Sabana, Cu–Zn–Pb at El Gramoso and limoncito and Cu–Zn–Pb–Ag at Pinar Bonito.

2–4 Discussion and the Promising Area

2–4–1 Discussion

There are many mineralized zones in the Constanza sub-area, such as the vein-type mineralized zones distributed at El Gramoso, Hato de Los Rodriguez and Los Vellesitos, Sabana and the south of Constanza and the pyrite dissemination zone distributed at the south of Constanza. These occur in the lower and the middle members of the Tireo formation and the acidic intrusive rocks.

The mineralized zone in the area include those associated with the tectonic line of NW–SE system and those with the intrusive masses of tonalite at the south of Constanza.

The vein-type copper mineralized zones at El Gramoso, Hato de Los Rodriguez and Sabana correspond to the former, and vein-type copper mineralized zones and copper, lead and zinc mineralized zones at Pinar Bonito and at (C–4) along the Rio Grande to the latter.

The copper veins at El Gramoso and Hato de Los Rodriguez strike northwesterly and dip northward, and the whole trend of distribution of the veins extends a northwesterly.

Each copper vein at Sabana strikes northeasterly and dips northward, and both the whole trend of distribution of the veins and that of the quartz-plagioclase porphyry extend northwestward. These facts suggest that the mineralization in both cases is related to the tectonic movement of the second order of the northwestern direction, and that the formers were occurred in the shearing fissures of NW system and the latters in the fracturing fissures of NE system formed in association with the tectonic lines of NW system.

Because the veins and the pyrite dissemination zone at the south of Constanza previously mentioned are megascopically positioned on the southeastern extension mentioned above, and because the mineralized zones of the area surround the intrusive mass of tonalite (PL.27), it is thought that the mineralization is closely related to the intrusive mass, though the relation with the tectonic lines of the northwesterly trend can not be neglected.

The time of mineralization of the area is considered to be in the period between Paleocene and before Oligocene, because (1) the mineralization is observed in the acidic intrusive bodies intruded into the Cretaceous Tireo formation, because (2) the time of intrusion of tonalite intrusives is considered to be from late Cretaceous to early Paleocene because the age of the intrusives which obtained from rediometric age determination was from 60 to 70 m.y. and because (3) the pebbles of ore which was formed in the country rocks belonging to the Tireo formation is found in the basal conglomerate of the Oligocene formation. In other words, it is thought that the mineralized zones of the area were formed by mineralization accompanied by tectonic movement and igneous activity in the later stage of the Laramide.

The variation of assemblage of constituent minerals of the veins is observed in the copper veins as well as the copper, lead and zinc veins in the area. That is, when a vein is traced laterally, the ore minerals decrease toward the tail end of the vein to become the quartz vein or quartz epidote vein.

This variation is recognized in the area where the plural veins are distributed: quartz vein or quartz-epidote vein is generally distributed surrounding the outside of the veins containing the ore minerals. Similar tendency is recognized in alteration of the country rocks, though there is some difference according to the characters of the veins. For example, in the case of strong copper mineralization, (1) silicification and chloritization are notable: El Gramoso area, northern Sabana area and southern Constanza area, (2) chloritization is notable: Fortuno and Roblito deposits in the Sabana area and a part of the veins at Hato de Los Rodriguez, and (3) silicification and epidotization is notable a part of the veins at Hato de Los Rodriguez and El Gramoso.

Thus the alteration becomes weak toward the outside of the group of veins.

The characteristics of the copper veins and the copper, lead and zinc veins of the area above mentioned are (1) scanty in calcite, (2) scanty in pyrite and abundance in specularite, (3) bornite occurs as the primary mineral, and (4) epidote is present relatively in abundance as gangue mineral or alteration mineral of the country rock, as compared with the common vein-type deposit.

These facts suggest that the hydrothermal solution which formed the copper vein and the copper, lead and zinc vein of the area was relatively low in partial pressure (fugacity) of sulfur and carbon dioxide.

The area is likely to be a zone subjected to a great amount of erosion after the formation of mineralized zone. That is, the presence of ore pebbles in basal conglomerate of the Oligocene formation distributed in the south of the area indicates that the area had become the land and the erosion had advanced from the surface to the deeper part where the ore minerals had been deposited.

The amount of erosion before the Pleistocene has not been made clear. But, although the amount of erosion after the extrusion of the Pleistocene dacite (0.5 m.y. in absolute age) is different from place to place, the rocks in the south of Constanza have been eroded 150 to 300 meters vertically (the amount of erosion is 0.3 to 0.6 milimeter annually).

The tectonic movement of the area is basically the block movement in which the blocks might moved downward or upward, and it is thought from the situation of distribution of the Tireo formation that the northwestern edge was elevated and the southeastern edge was depressed in a direction from the northwest to the southeast. Therefore, it is assumed that the

amount of erosion was greater in the northwestern part than the southeastern part taking the present topographical condition into consideration.

This is supported by the fact that the ore deposits of Sabana, El Gramoso and Hato de Los Rodriguez which are distributed in the northwestern edge of the area are composed of the veins mainly consisting of copper ores, and that the ore veins at the south of Constanza include a number of copper, lead and zinc veins. This is consistent with the fact that the copper ratio is greater in the northwestern part in terms of the abundance of elements in geochemical survey, and that the lead and zinc ratio is greater in the southern part. Therefore, it is important, when the exploration is to be considered, to evaluate the amount of erosion together with that of scale of the mineralized zone.

Regarding the copper minerals, a compornent in the veins of the area, the variation from the center to the outside is observed in such a way, chalcopyrite-bornite through chalcocite-covelline-limonite to malachite, in which the process of oxidation in association with weathering can be read.

2–4–2 Promising Area

As a result of the survey of this year of geology and ore deposit in the Constanza sub-area, following areas were extracted as the promising areas.

1. Loma Sito Grande Area

The area has an extent of about 8 square kilometers putting Mt. Loma Sito Grande at the center, and includes the zones distributed by the veins in the vicinity of El Gramoso. At El Gramoso on the southwestern slope of Mt. Loma Sito Grande, 45 outcrops of gold bearing copper veins which are stable in size and grade have been discovered in an extent about 3 square kilometers. The largest one among them is 1.5 meters wide in average extending for 70 meters, showing the grade such as 0.3 g/T Au, 17 g/T Ag and 3.2% Cu.

Most of these veins show the structure striking northwesterly and dipping northward, and the shape of distribution extends northwesterly with a similar structure of the first and the second orders which is the direction of the main structure of the geology of the region. This fact indicates the possibility of continuation of each vein. Since the topography of the area is very steep, being poor in access from both Constanza and Padre de Las Casas, this is the first time that a systematic survey has been conducted. Therefore, the whole aspect of the group of veins newly discovered has not been made clear, although it is likely that they extend toward the south as well as the east. However, because the geochemical anomalies of copper and the

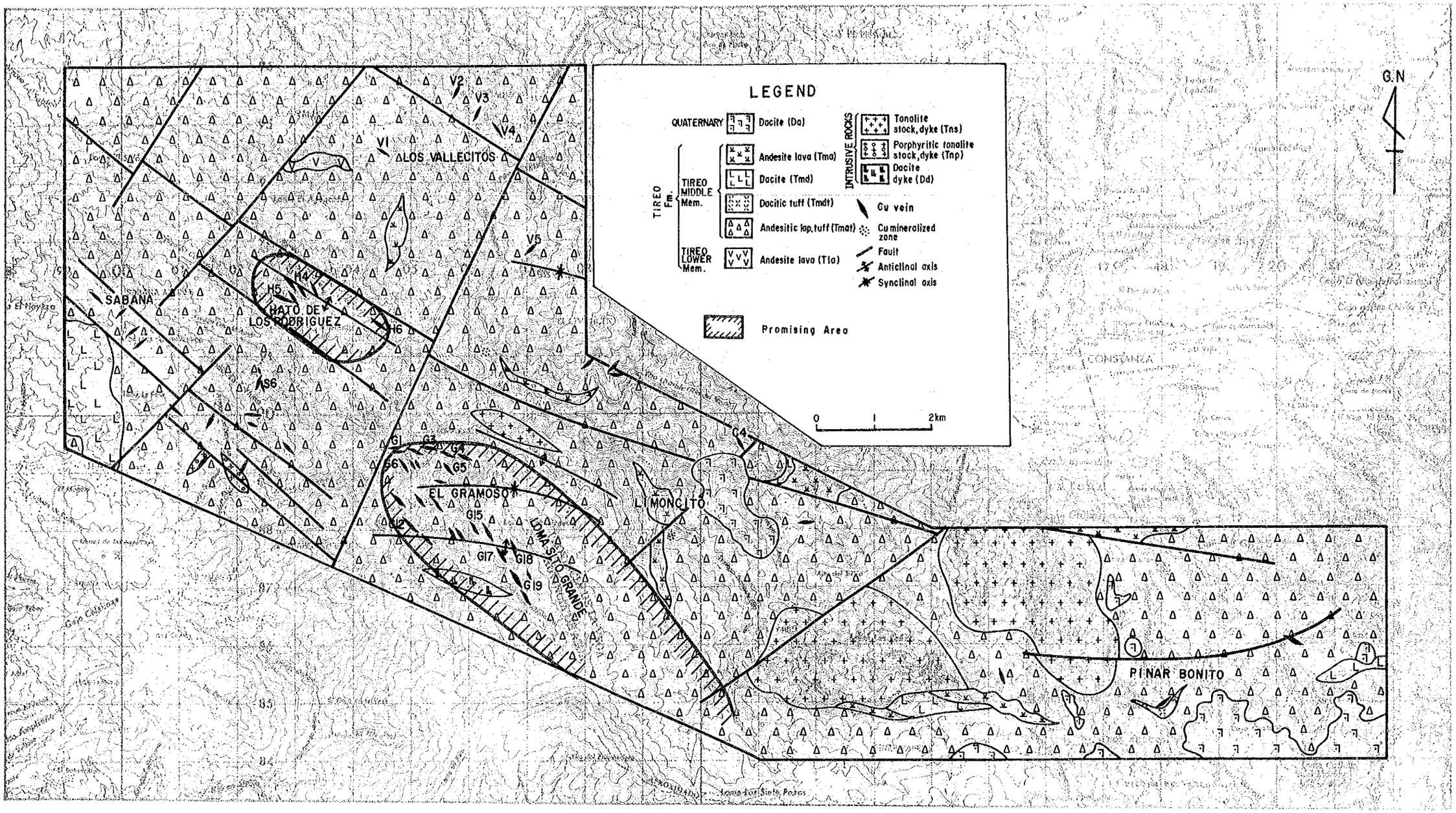


Fig. 20 Promising Areas in the Constanza Sub-Area

high score of factor-1 (Cu-Zn) are present on the northeastern slope of Mt. Loma Sito Grande, it can be expected that the group of veins as the same system as that of the El Gramoso area might occur from the top of the mountain to the northeastern slope. Since the rate of denudation of the area is small as compared with other areas from the view of stand-point of topography, it is highly possible that the latent ore veins would occur (shoot of the veins might remain) in this part.

When the vein-type deposits in Japan are compared with those in this area with respect to the density of distribution and the extension, these in the 32 mines in Japan which produced more than 5,000 tons of copper or 20,000 tons of lead plus zinc among the 81 copper or lead and zinc mines are about 5 veins per square kilometers and approximately 11 square kilometers respectively (Kuroda, 1973). While the density of distribution at El Gramoso is about 7 veins per square kilometers and the extent of geochemical anomalies in the areas including El Gramoso is shown to be about 12 square kilometers. These facts suggest that the ore deposits to be worth the amount of metals mentioned above would exist in the area with a high probability. Moreover, since chalcopyrite is found in abundance at the outcrops of the veins of the area, it is possible that the primary sulfide zone would occur near the surface, which leads to provide a condition to be easy to proceed with exploration and mining.

2. Hato de Los Rodriguez

The area has an extent of 1.5 square kilometers centering on the spot where 14 gold bearing copper veins similar to those at El Gramoso were discovered. The largest outcrop among those newly discovered is 1.6 meters wide and 12 meters long showing the values such as 1.3 % Cu.

The veins of the area is relatively high in grade, striking northwest and dipping northward. The group of veins shows the northwesterly trend as a whole, which is consistent with the structure of the first and the second orders, the main geologic structure of the region. Therefore, the continuation of the veins and the presence of the latent deposits can be expected in this area.

CHAPTER 3 PICO DUARTE SUB-AREA

3–1 Geology and Geologic Structure

The area is situated on the eastern slope of Pico Duarte (3,078 m. a.s.l.), the highest peak in Dominican Republic.

In the survey of the first phase, many floats of porphyry copper-type ore were discovered along the Rio Yaque del Sur in the southeastern part of the area. These ores are composed of dissemination of chalcopyrite and molybdenite in hydrothermally altered granodiorite, which showed the assay value of 0.2 to 0.76 % Cu.

The granodiorite body, the country rock of the ore, intruded in the direction of NW-SE, and the survey area is 15 square kilometers, having an extent of 3 kilometers wide and 5 kilometers long which contains the intrusive body.

The topography is very steep, being more than 1,000 meters in the difference of elevation between the bottom of valleys and ridges, and the valleys show a V-shape. The vegetation is mostly the natural forest of conifers since the area is included in the National Park, where the undergrowth is dense.

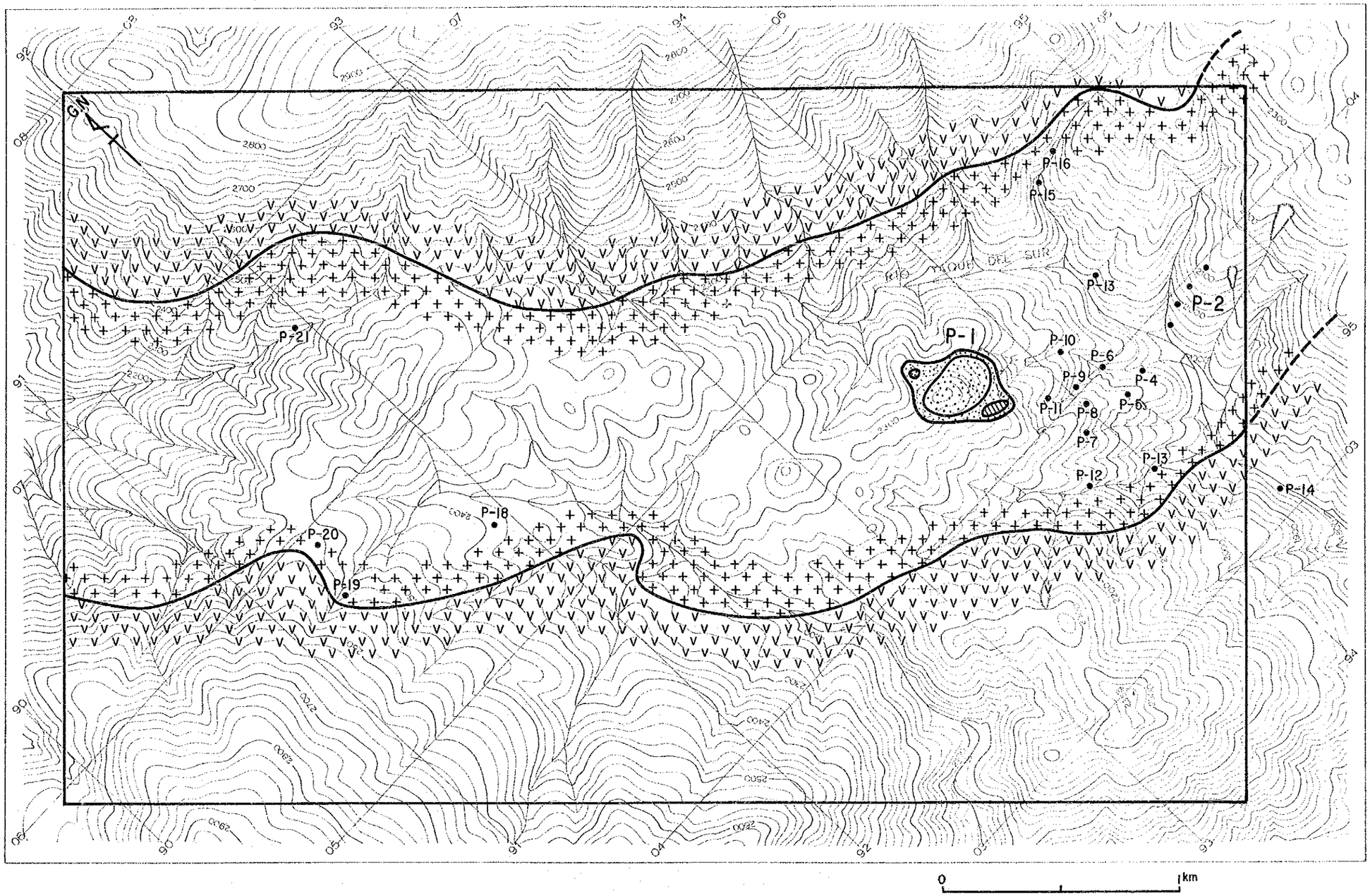
The access is quite bad. A path up a mountain (horse road) from Manabao, the terminal of driveway (it takes three hours by car from Constanza) to the peak of Pico Duarte is the only passage passing through the northwestern part of the area, and no other footpath nor horse road is found in these parts.

For the survey in the southeastern part of the area, the survey team went up southward on horse back along the path, then went down southward apart from the horse road to reach El Valle along the Rio Yaque del Sur after one-day trip. The day after, the camp was set up at the southeastern corner of the area after a walk for five hours along the Rio Yaque del Sur.

1. Geology

Geology of the area is composed of the lower member of the late Cretaceous Tireo formation, granodiorite intruded into it, and dyke rocks intruded into all of the aboves.

The lower member of the Tireo formation consists of andesite lava (Tla). The rock has undergone so-called "propylitization", displaying green color. Under the microscope, the rock is augite andesite. Augite of phenocryst and plagioclase in the matrix are both replaced partly by chlorite, sericite and epidote. Although the rock is generally massive, the flow units (0.5 ~ 5 m) of lave are distinctly observed in the vicinity of the mountaintop of the Pico Duarte and along the Rio Yaque del Sur outside of the area, and quartz-epidote veins occur in every place. The



LEGEND

- Tireo lower mem. Andesite lava (Tla)
- Granodiorite (Gd)
- High grade zone
- Medium grade zone
- Low grade zone
- Small mineralized zone

Fig. 21 Geological Map of the Pico Duarte Sub-Area

cracks developed at the contact with the intrusive rock in which an effect of thermal metamorphism is noted, and it is observed in the rocks at the southwestern and at the northeastern parts: silicification is observed in the former part, while porphyroblasts have formed in biotite amphibolite in the latter part, showing a weak alignment.

The result of microscopic observation of the thermally metamorphosed rocks in the northeastern part is as follows.

PM09 Amphibolite (along the path up the mountain)

Texture : Granoblastic

Constituent minerals : Common hornblende ≫ plagioclase > quartz ≫ iron minerals

Common hornblende is about 0.5 millimeter in size, showing parallel orientation. Plagioclase is 0.5 millimeter in size. It is present in a form to embay common hornblende, but porphyryoblats 1 millimeter across are partly observed. Plagioclase is intermediate or An rich one, partly replaced by calcite. Quartz is contained in a small amount in a form of spot.

The intrusive rocks are classified into the granodiorite stock and the dyke rocks intruded into the stock and the andesite lava.

The granodiorite stock is distributed in the central part of the area in the direction of NW-SE system having an extent of 1.5 kilometers wide and 6 kilometers long along the strike. The stock is the country rock of the porphyry copper-type mineralized zone, and many mineralized outcrops were discovered in the stock by the survey of this phase. Since radiometric age dating of granodiorite provided ages in the vicinity of 63 m.y., the time of intrusion of the stock is assumed to be Paleocene.

The rock facies of the stock is medium-grained (1 to 3 millimeters in grain size) common hornblende-biotite granodiorite. The color index preferred the mafic minerals is 10 to 20 per cent, and the rock is relatively homogenous, although some parts are shown to be an appearance of tonalite where the index reaches up to 30 per cent. Under the microscope, the rock consists of the main constituent minerals such as plagioclase, quartz, biotite, common hornblende and potash feldspar (approximately 1 millimeter in size), accompanied by accessory minerals including iron minerals.

The dyke rocks include andesite and aplite. Especially, these were confirmed in a large number in the southeastern part of the area. The width of these dykes is 5 meters in maximum, but most of them are less than 1 meter wide.

Andesite is green, hornblende andesite and quartz veins accompanied by copper minerals are rarely observed in the vicinity of the contact with granodiorite intruded by it.

Hydrothermal alteration is observed at the uppermost reaches of the Rio Bao in the northwestern part.

Aplite is white, being very scanty in content of mafic minerals. Copper mineralization in a form of dissemination is often observed in the dyke and the surrounding area.

The result of microscopic observation of the typical rocks is as follows.

PM002 Augite andesite (southeastern part of the area)

Texture : Holocrystalline, porphritic texture

Phenocryst : Augite

Phenocryst is small in amount. Augite is present in a form of aglomeroporphyritic aggregate two millimeters in size, and partly replaced by chlorite, calcite and secondary quartz.

Groundmass : Augite > plagioclase ≫ iron mineral

Augite elongates irregularly, and is partly replaced by chlorite and calcite. Plagioclase is present in a form to embay augite, which is relatively fresh though it is contaminated in appearance.

PM024 Biotite aplite (southereastern part of the area)

Texture : Holocrystalline equigranular texture

Main constituent minerals : Potash feldspar > plagioclase. quartz > biotite

Accessory mineral : Iron mineral

Potash feldspar is euhedral to subhedral, one to two millimeters across, showing perthitic structure.

Plagioclase is subhedral to anhedral, one to two millimeters across, partly replaced by sericite.

Quartz is euhedral to subhedral, about one millimeter across. Biotite is small in amount and has almost been replaced by epidote and chlorite.

2. Geologic Structure

The lower member of the Tireo formation in the area and the surroundings strikes north and dips toward the east.

The trend of intrusion of the granodiorite stock is of the NW-SE system, and it dips northward.

Since the direction of intrusion of the stock is in parallel with that of the Bonao fault belonging to the first order, which is the main tectonic line of the hispaniola Island, and the dip is also consistent with it, it is thought that the intrusion was related to the shearing of the second order stemmed from the faulting of the first order.