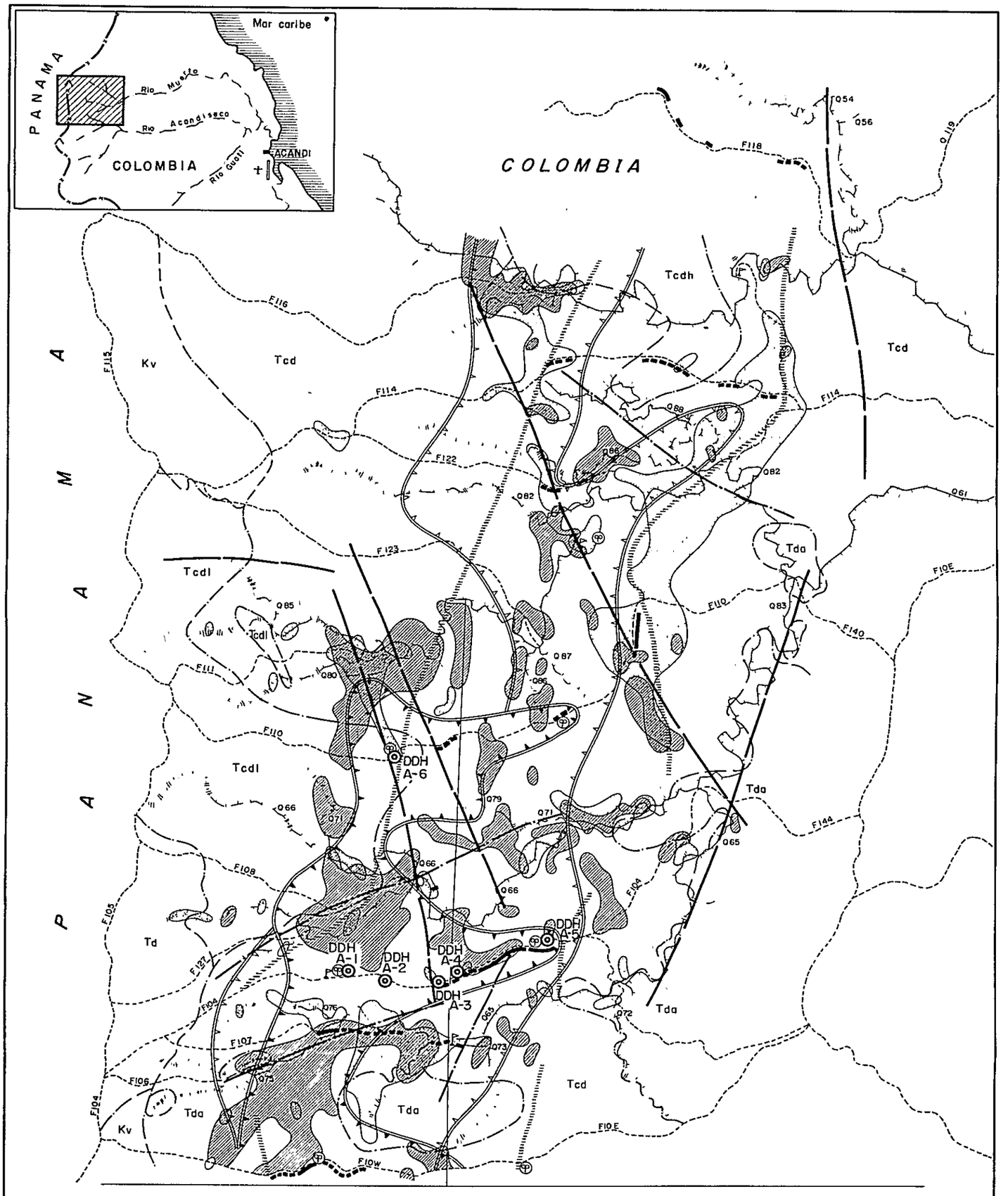
CHAPTER 7.

DESCRIPTIONS OF EACH SURVEYED AREA



Original map, 「Mapa compuesta」 Plancha II, Dec/78
Poyecto Col 76/030 NU-INGEOMINAS

Fig.-29 Compiled map of Acandi area

Chapter 7. Description of Each Surveyed Area

7-1 Acandi Area

7-1-1 Access and Topography

This is of a surface area of about 30 km^2 approximately 15 km northwest of Acandi town facing the Caribbean Sea in the north of Choco provinee.

In order to reach this area from Medellin, the second biggest city in Colombia, cars are used from Medellin to Turbo town, a fishing port on the Uraba bay, along a road 370 km long of which about two thirds is not paved, and from there to Acandi a ship or a small airplane is used crossing the Uraba bay.

The topography is that the stage of maturity, namely V-shaped valleys are developed well, being eroded to a great extent by much rain. The height above sea level is about 100 m to 500 m. Rivers are developed dendritically, all of them run eastward, flow into the Muerto river which reaches the Caribbean Sea.

7-1-2 History of Explorations

In 1974, the project of the survey of noble metals by UNDP and INGEOMINAS reported that the stream sediments taken near the mouth of the Muerto river contained copper. In 1975, the project of the base metals survey confirmed anomaly zones in upstream of the Muerto river.
This survey was carried out continuously from January 1975 to April 1976.

As the result of this survey a mineralization center about 2 km width from north to south, 0.5 km width from east to west was picked up in the

northwest of the Acandi area, where two potassic alteration zones existed. The distribution of the phyllic alteration zone and propylitic alteration zone was in good agreement with that of the ordinary Porphyry Copper type ore deposits, and with the pattern of geochemical anomaly. Geophysical prospecting also suggested the existence of promising deposit of sulfide ores. Basing on these, drilling exploration and the expansion of the geophysical prospecting area toward the north were recommended.

Following this recommendation the second stage survey was carried out from August 1977 to May 1979 in the northern half of about 15 km^2 where the first stage survey had been carried out it. The results of the summary is shown in Fig.-29 and Fig.-31. Contrary to the expectation based on the first stage survey, nothing but very low grade mineralization zones was found. The alteration zoning was also confirmed to be irregular that the phyllic alteration zone existed horizontally above the propylitic alteration zone, lacking potassic alteration zone.

7-1-3 Geology and Structure

i) Geology

Geology in this area consists of andesitic and basaltic volcanic rocks in late Cretaceous period, plutonic rocks of diorites in early to middle Tertiary period intruding the above volcanic rocks, and andesite or basic dyke rocks. The area is located at the joining point between the geological structure of Colombia and that Isthmus of Panama stretching to Panama and Costa Rica.

The volcanic rocks are located as roof pendant on plutonic rocks which intruded at various places between here and western Panama, and the contact boundary is nearly horizontal. They consist of lava, agglomerate, tuff and others. They are mainly of andesitic or basaltic rocks and contain some amount of diabase, rhyolite and disseminate magnetite and

pyrite.

The volcanic rocks are the oldest in this area and determined to be of the later Cretaceous period basing on the comparison with the western San Blas formation and the result of the determination of the absolute age of the intrusive rocks.

The plutonic rocks are classified from the earlier stage of intrusion as diorite, quartz diorite, leucocratic quartz diorite and hornblende quartz diorite. Among these quartz diorite is closely related to mineralization. Diorite is of fine to medium grain, grayish green and distributed as small stocks 1,200 m long and 400 m width in the western part of this area.

Quartz diorite occupies the central part of this area and is closely related to mineralization. It is of medium grain and gray or grayish green due to propylitization. Fracturing is developed and pyrite dissemination is observed with narrow veins. At some places the above mentioned diorite is contained in the quartz diorite as a xenolith, which suggests the intrusion of quartz diorite was after the diorite. The K/Ar method determined the age to be 36 ± 3 m.y., which is considered to show the time of the alteration. Therefore the intrusion of the rock is assumed to have taken place before that time. The leucocratic quartz diorite is distributed as stocks 1600 m long and 80 m wide as the maximum dimensions.

The hornblende quartz diorite is the rock body distributed in the northernmost part. Those color is dark green because hornblende contained in relatively high quantity altered to chlorite.

Besides the plutonic rocks mentioned above, andesitic and quartz porphyritic rocks exists in the above mentioned diorite in small quantity as peripheral facies or intrusive dyke.

As basic dyke rocks there are the dike of lamprophyre bearing the phenocryst of pyroxene and hornblende as size as 2 cm in diameter. This rock is the newest one that intruded into all rocks mentioned above, being considered to be Plio - Pleistocene epoch.

ii) Structure

As the main structural lines in this area, there are two systems of NW-SE and E-W, owing to San Blas fault extending from Panama runs continuously bending southward in Colombia. All rock bodies in this area are strongly sheared and fractured. Among their fault directions the two of N-S and E-W are predominant, and N45°E and N40°W are found, too, though less remarkable as the result of statistical study of fault. The dipping is vertical or steep (60°) on either side. Mineralization is found in all directions being not depended on any specifical direction. However, geophysical prospecting suggests mineralization is approximately in N20°E direction.

7-1-4 Mineralization and Alteration

i) Mineralization

Copper and molybdenum mineralization is accompanied by quartz diorite and leucocratic quartz diorite. Chalcopyrite and pyrite mineralization are in veinlet or adhering ferromagnesian minerals. Molybdenite is mostly in quartz veinlet or cavity.

Oxidation and bleaching occurred at the ridge up to 20 to 30 m depth. The oxidation zone changed directly into the primary mineralization zone without forming the secondary enriched zone owing to much rain.

On both banks of valleys, thin film of azurite, malachite and others are found locally. Some fresh rocks are observed widely at the bottom of rivers.

ii) Alteration

The relation between the distribution of alteration zones and mineralization zones was explained by the model of Lowell & Gilbert (1970) in the first stage survey. However, the results of drillings, detailed geological survey, microscopic observation of thin sections and other detailed study have shown no alteration zones except the phillic alteration zone and propylitization zone, and distribution of alteration is considered to be different from the former (Fig.-29).

Namely, phyllic alteration is accompanied by strong silicification and sericitization, general ferromagnesian minerals are altered to epidote, or completely replaced by quartz, and shows leucocratic color as a whole. This alteration zones are distributed upstream of Q-65, Q-65 valleys in the central southern part of this area and near No. 10, No. 104, No. 110 ridge (Filo 10, Filo 104, Filo 110), and the lower part of horizontal contact with chloritization zone. The thickness has been revealed to be 60 to 90 m by drilling, and thus being near the surface, plagioclase has been given strong kaolinization.

In the propylitization zone the chloritization of ferromagnesian minerals is remarkable, and epidote, calcite as well as albitized plagioclase are well observed. Propylitization zone is classified into two types; one is accompanied by silicification underlying phyllic alteration zone and other surrounds the above one, which contains pyrite and magnetite but no Cu-minerals and is distributed roughly corresponding to Pb-Zn geochemical anomaly. The former silicification and

propylitization zone are the alteration zone that has the highest grade of copper content in this area, but mineralization is weak as a whole, so Cu content is 0.15 to 0.25%, and Mo content is about 0.005% by drilling core assay. Pyrite : chalcopyrite ratio is 1 : 1 or 2 : 1. The mineralization of molybdenum is tend to be observed at quartz veins and silicified cavities in phyllic alteration zone.

Geochemical survey in the second stage survey revealed copper anomaly zone about 300 m east and west and about 1600 m north and south in the northeastern district, but no anomaly in the central southern district where the best copper mineralization had been observed by geological survey. This is probably because the PH and Eh of the soil are not appropriate to retain copper owing to the climate. On the other hand, molybdenum is distributed relatively in good agreement with geology, being not moved so much.

7-1-5 Summary of Technical Evaluation

The field survey was carried out in the No. 65 valley which lies south of the southern ridge (Filo 104) executed No. 1 to No. 5 drillings and is flowing eastward parallely to Filo 104, and in the No. 62 valley is flowing in the northeastern district where copper anomaly had been found and the continuation of survey had been recommended basing on geophysical survey. In No. 65 valley, the boundary between phyllic alteration zone and propylitic which were exposed at about 150 m south of the uppermost heliport, and their correlation was well observed. There, from the bottom to about 1 m above, chloritized quartz diorite is found which contains relatively large amount of magnetite and pyrite and a little amount of chalcopyrite. The upper part of nearly horizontal boundary is altered clearly into white or gray strongly silicified and sericitized

rocks (photo. 6), which contains very little amount of chalcopyrite, molybdenite and pyrite. However, they are assumed to be just the difference in the alteration facies in the same rock body because the textures of the original rocks are similar to each other and because no change in the grain size of original rocks is observed at the boundary. All exposed rocks at downstream are quartz diorite strongly chloritized and epidotized except andesitic dyke rock about 1 m width and calcite veins are also found sporadically, which shows to be a typical propylitization zone. Both alteration zones are weakly fractured and pyritization is observed in zones fractured more remarkably. But the pyritization is weak as a whole and only a little amount of chalcopyrite is found there. The fracturing gradually becomes weak to downstream and their rocks are mostly massive. Five drillings were done on the (Filo 104 line) ridge at north of this valley, of which the results are summarized in Fig.-31.
As shown here, the distribution of phyllic alteration zone and copper assay are good correlation in the surface geological observations.
Copper grade by these drillings is 0.03 to 0.15%. As the highest, only one location at the bottom of No.1 ranging 4.5 m width, gives 0.36% Cu.
Molybdenum grade is 0.001 to 0.008%.

Although the survey of No.62 valley had been expected well, as strong copper anomaly had been found and the continuation of survey had been recommended there basing on the result of geophysical survey, mineralization weaker than that in the drilled southwestern district had found.
Much attention was especially payed to quartz diorite having hornblende dominantly distributed in the northernmost part, which was found to be relatively fresh rock body of massive, black colored and medium grain. The map of anomaly distribution based on geophysical survey, which gave the

impression of the existence of anomaly around this rock body which extended itself like a tongue from the north, which directions (forming roughly V-shape) actually shows those of the development fissure in the rock body of quartz diorite. At the outcrops where many fissures are found strongly disseminated with pyrite and chalcopyrite. This rock body of quartz diorite with hornblende is assumed to have intruded after the mineralization, because fissure is less developed, relatively fresh, there is no Cu, Mo anomaly in its distribution area. In the survey described above, the assay result of a sample taken every 2 m long at the strongest mineralization in fracture zone shows 0.42% Cu, 6 ppm Mo and < 0.2 ppm Au, which is just locally.

Their grades are lower toward surrounding area. This area surveyed by the present mission had been said to be the most interesting one among Acandi mineralization zones.

No other places suggesting good meneralization were found. Therefore the present mission had to reach a pessimistic conclusion concerning this area.

This conclusion can be explained as follows; This area forms the joining point between Central America and South American continents. In the northwest, there lie porphyry copper type ore deposits such as Rio Pito, Petaquilla, Cerro Colorado and Chorcha.

Although Rio Pito has not been prospected yet, other three are deposits ore known to have commercial value. In the south, there are promising mineralization zones such as Murindó, Pantanos - Pegadorcito which are to be described below. Among these concerning porphyry copper type ore deposits in Panama, Kesler et al. (1977) concluded as —

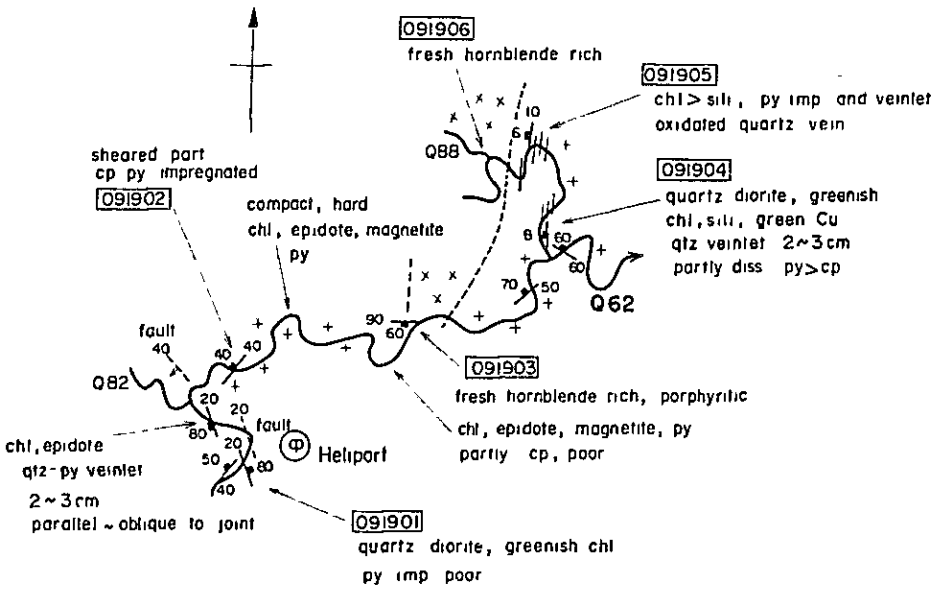
"Most, but not all, late-stage intrusions are the richer in potassium than

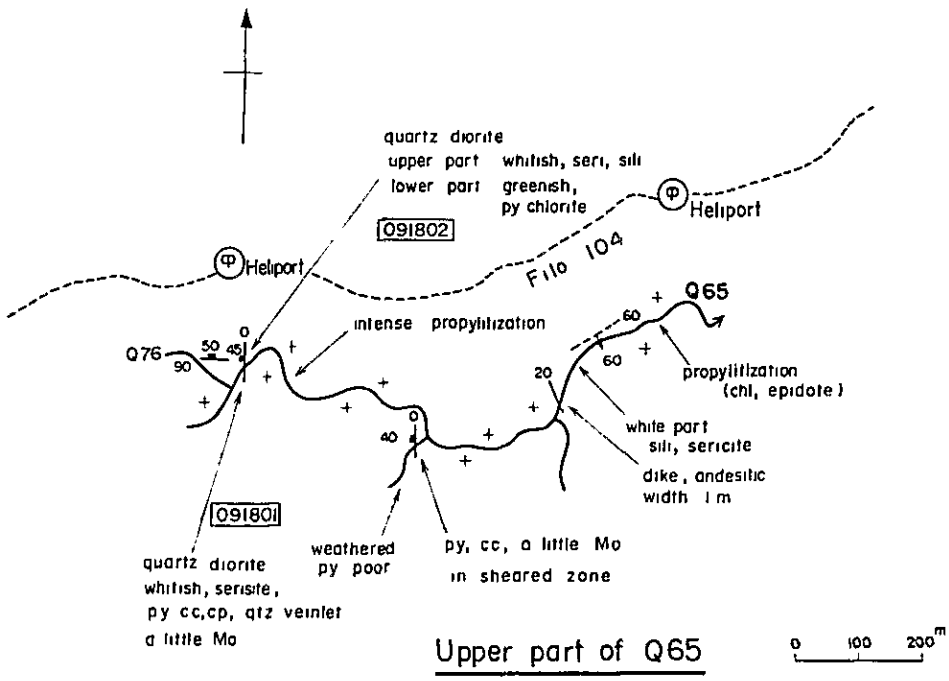
their earlier counterparts. Porphyry copper mineralization is widespread in these calc-alkaline rocks and is usually larger scale and higher grade in late-stage intrusions, regardless of their potassium content".

Concerning $Na_2O - K_2O$ content in host rock in this area, the results according to (Fig.-6) in the UNDP first survey report are compared with the results by above mentioned Kesler et al. in Fig.-32. Dividing at $Na_2O/K_2O = 2$, Acandi area falls into Na_2O rich group together with Azuero, Rio Pito and Guayabo, and Petaquilla, Cerro Colorado and Chorcha fall into K_2O rich group. The later is a group of good mineralization, and the former is a group of more or less weak mineralization. (Rio Pito, which has not been prospected sufficiently yet, is said to be of low grade at present depending to the survey up to present).
Pantanos - Pegadorcito belongs to the K_2O poor group in this diagram, but the ore deposit is formed by the intrusion of quartz porphyry into batholith rock body similar to quartz diorite in Acandi area (mandé quartz diorite). It is not clear that samples in the diagram belongs to that one.

One of the characteristics of mineralization in Acandi area is the sporadic distribution of low anomaly (in the case of Cu content in soil, b + s = 372 ppm, Mo b + s = 6 ppm) in wide range about 3 km east and west and about 10 km north and south. Further, though phyllic alteration zone exists at the area assumed to be the central part or alteration, only little potassic alteration zone is observed, silicification is weak as a whole.

From those described above, it is concluded that though it is located in the porphyry copper type ore deposit promising areas as Cerro Colorado — Petaquilla — Pantanos, because its no active "magmatic evolution" to





West part, overlaid white zone of phyllic alteration, and down stream exposes propylitized quartz diorite

Legend

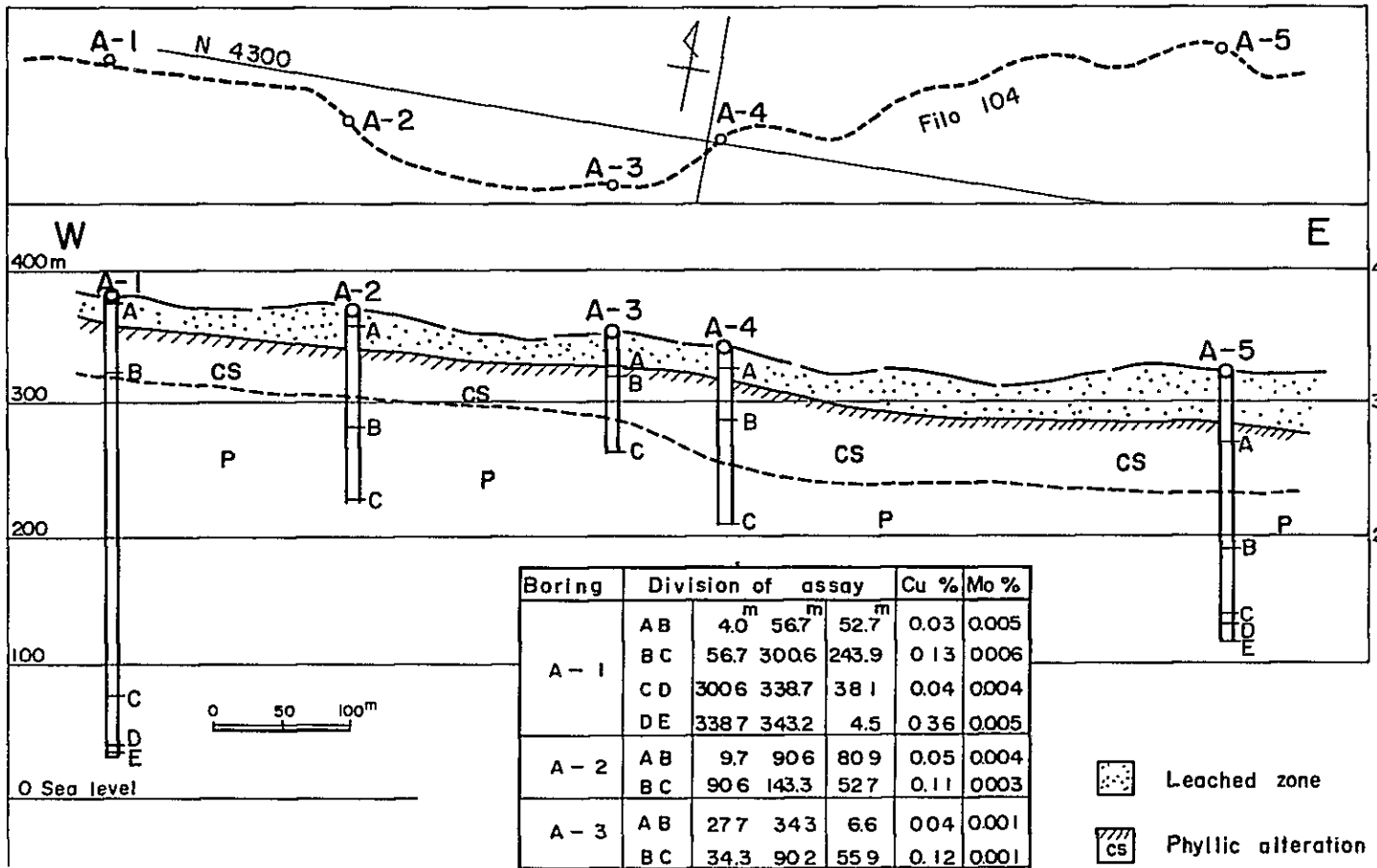
- × × hornblende quartz diorite
- + + quartz diorite
- chl chloritization
- sili silicification
- py pyrite
- cp chalcopyrite
- cc chalcocite

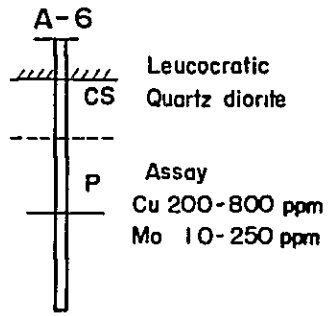
10/30 joint/fissure

60/50 fault

Sample No	Cu %	Mo ppm	Au ppm
091801	0 01	49	< 0 2
091902	0 42	6	< 0 2

Fig.-30 Geological sketch of investigated places in Acandi Area





Boring	Division of assay			Cu %	Mo %
		m	m	m	
A-1	AB	4.0	56.7	52.7	0.03	0.005
	BC	56.7	300.6	243.9	0.13	0.006
	CD	300.6	338.7	38.1	0.04	0.004
	DE	338.7	343.2	4.5	0.36	0.005
A-2	AB	9.7	90.6	80.9	0.05	0.004
	BC	90.6	143.3	52.7	0.11	0.003
A-3	AB	27.7	34.3	6.6	0.04	0.001
	BC	34.3	90.2	55.9	0.12	0.001
A-4	AB	26.04	53.33	27.29	0.04	0.001
	BC	53.35	77.89	24.54	0.13	0.008
	CD	77.89	133.01	55.12	0.06	0.005
A-5	AB	54.60	133.40	78.80	0.15	0.005
	BC	133.40	184.20	50.80	0.06	0.003
	CD	184.20	192.40	8.20	0.04	0.001
	DE	192.40	210.58	18.18	0.18	0.001

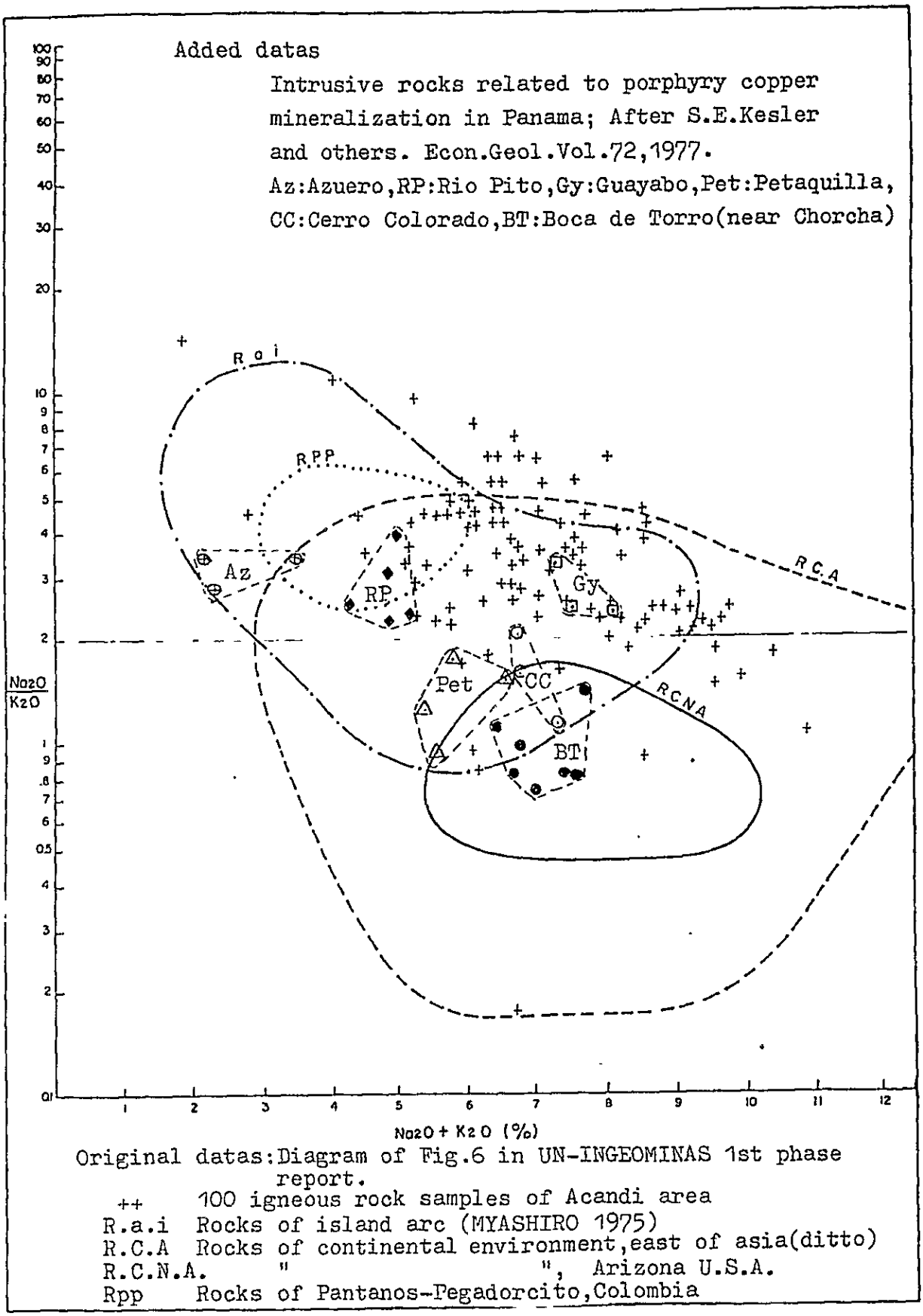
Leached zone

CS Phyllic alteration zone

P Propylitic alteration zone

Original: 「Seccion vertical」
Fig. 17, 12/78, Proyecto Col 76/030, NU-INGEOMINAS

Fig.-31 Summary Section of Diamond Drilling Exploration in Acandi Area



Original datas:Diagram of Fig.6 in UN-INGEOMINAS 1st phase report.

++ 100 igneous rock samples of Acandi area
R.a.i Rocks of island arc (MYASHIRO 1975)
R.C.A Rocks of continental environment,east of asia(ditto)
R.C.N.A. " ", Arizona U.S.A.
Rpp Rocks of Pantanos-Pegadorcito,Colombia

Fig.32 Diagram of Na_2O/K_2O v.s. Na_2O+K_2O of Acandi and neighboring Porphyry-Copper intrusive rocks.

Photo. 5 Heliport on the F-104 ridge, in Acandí area

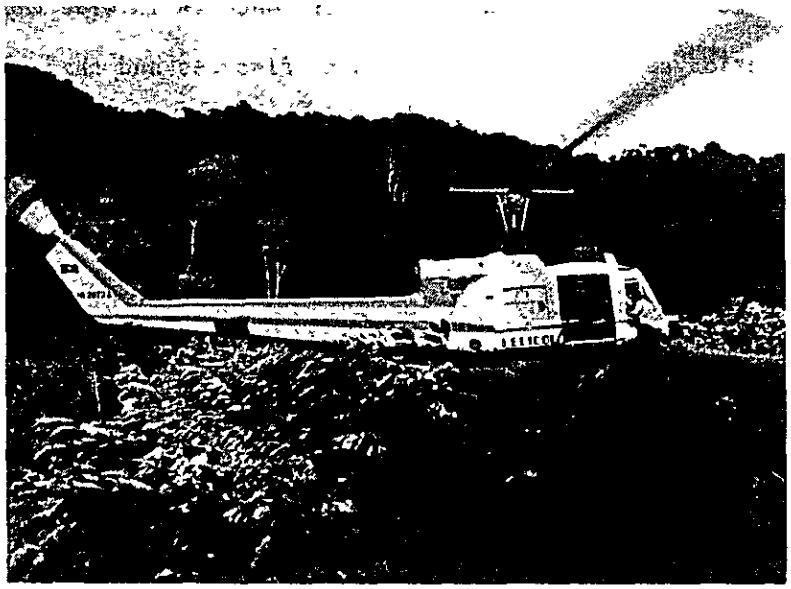
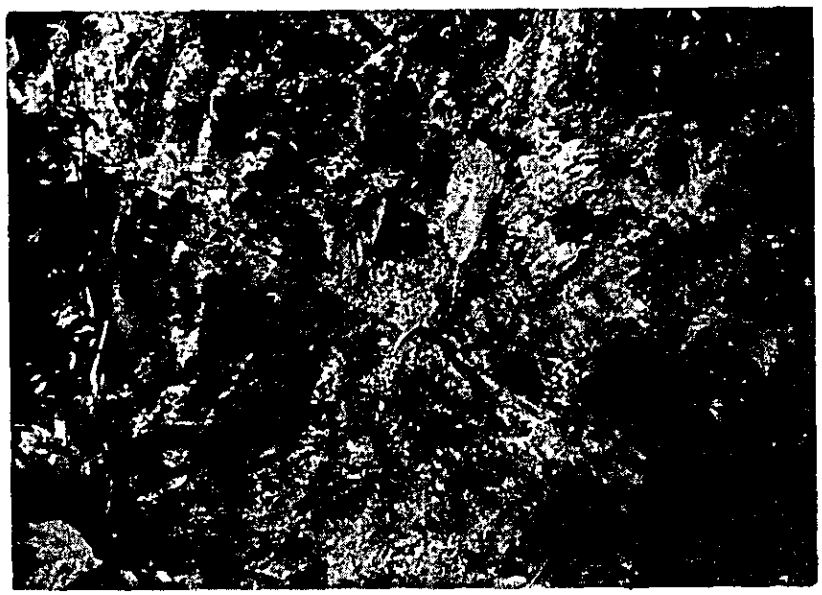


Photo. 6 Outcrop of altered quartzdiorite at Q-65 valley, in Acandí area



Upper part; Phyllic altered zone

Lower part; Propylitic altered zone

concentrate Cu-K_2O-SiO_2 took place, the rock body of quartz diorite is consolidated with small amount of copper contents in wide range, weak mineralization seems to be only fault fissures and their surroundings.

7-2 Cerro Pantanos Area

7-2-1 Pantanos-Pegadorcito Area

i) Access and topography

This is located in a tropical jungle near the northern end of the western flank of the western mountain ranges, about 120 km west-northwest of Medellin city, the capital of Antiquia province. It takes three to four days to go there from Medellin by land. Otherwise it takes an hour and a half from Medellin to Dabeiba town (base heliport), and thirty minutes from Dabeiba to here by helicopter.

Here the amount of rainfall is great. The topography is relatively flat 800 m to 1050 m above sea level.

ii) History of explorations

In 1970 INGEOMINAS found Pantanos-Pegadorcito Cu-Mo anomaly zone with geochemical survey in the regional reconnaissance survey of the western mountains area, which was surveyed again in detail by INGEOMINAS in 1973 and 1974.

As the result of geochemical survey (rock sampling), large scale anomaly zones have been found; one is elliptic shape about 4 km east and west x 1 km north and south with the Pantanos ridge as its center in Pantanos district, and the other is of round shape of diameter about 1 km in the northwestern Pegadorcito district, both of which contain 700 ppm to 15,000 ppm Cu.

The results of drillings are; No.1 and No.2 were non-core. No.3

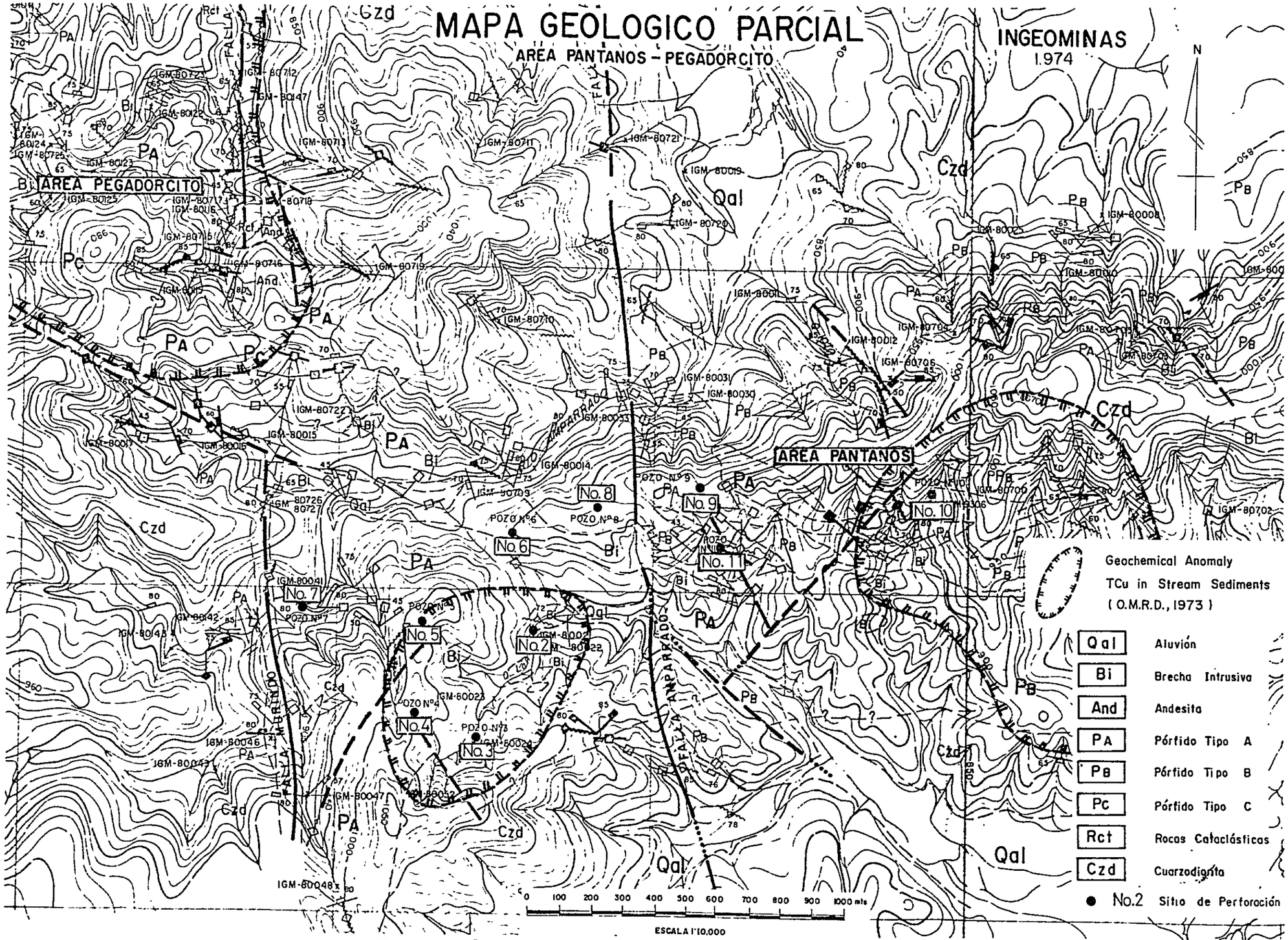


Fig.-33 Geological Map of Pantanos - Pegadorcito Area

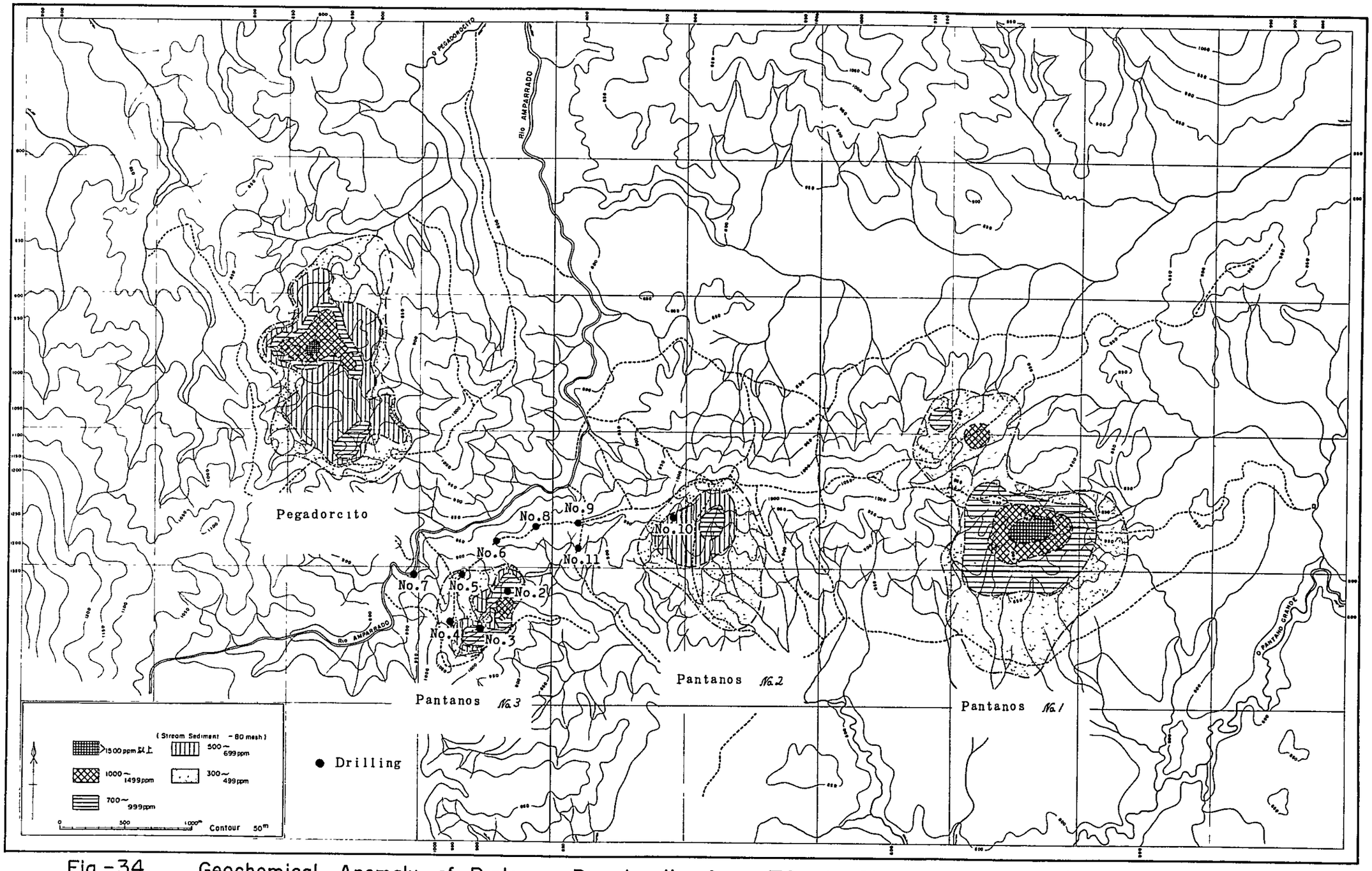


Fig.-34 Geochemical Anomaly of Pantanos-Pegadorcito Area, TCu in Stream Sediments (O.M.R.D., 1973)

showed 1.0% Cu at the maximum, 0.42% Cu in average, No.4 showed 1.0% Cu at the maximum, 0.32% Cu in average, and No.5 showed 1.6% Cu locally. Though No.11 showed average Cu in the entire core of 0.28% Cu, a typical porphyry copper type ore deposit of Cu 1.0% at the maximum, about 0.50% in average is observed from depth of 30 m below the leached zone to the drilling bottom of 100 m below the surface.

In the central part of this area, Overseas Mineral Resources Development Co., Ltd. (a Japanese enterprise = O.M.R.D.) carried out the brief geological and geochemical survey in April ∿ May, 1973. As the result the possibility was evaluated to be very high to find porphyry copper type ore deposit of 0.6 to 0.7% Cu with a scale of hundreds million tons.

iii) Geology and structure

1) Geology

This area is located in the Mandé batholith of the middle Tertiary period lying in long distance with a width of about 20 km in the western side of the northern part of the western mountains area. It consists of quartz dioritic batholith, porphyritic rocks intruding the batholith and breccia dyke. Andesite dyke are observed locally.

a) Quartz diorite

This is the main rock to compose Mandé batholith and widely distributed in this area, and is intruded by quartz porphyritic rocks, breccia dyke and others. It is apparently of medium grain with partly fine and schistosity is partly developed parallel to boundaries where intruded by quartz porphyry. The mafic minerals are mainly hornblende and a little amount of biotite. Most of the hornblende has been altered into secondary minerals such as chlorite etc.

In specimens obtained at deep position of No.9 and No.11 drillings,

as revealed by microscopic observation, granular and cataclastic texture is found, most of quartz phenocryst 1 ∿ 5 mm in diameter is elongated approximately to 5 : 1 and is arranged parallel, and wavy extinction is observed locally. These observations show that this rock was under the condition of compressive stress at low temperatures and low pressures.

b) Porphyritic rocks

These kind of rocks are most widely distributed in this area except quartz diorite, and are hypabyssal rocks with composition of dacite.

The facies of porphyritic rocks change depending on places remarkably. They are devided into three types, basing on textures and the contents of mafic minerals (INGEOMINAS 1974).

- A-type Porphyry

This type of porphyry is distributed in the western part of this area and mainly found along quebrada Lanito. The color is beautiful gray at fresh outcrop and white at strongly altered and leached ones, and green at containing malachite.

Main component minerals are quartz and feldspar which occupy more than 50 volume percent. Phenocryst consists of quartz 0.1 mm to 1 cm in diameter, plagioclase 0.5 mm to 3.5 mm in diameter and in a few cases pseudomorphic chlorite after biotite. The matrix is aphanitic, consisting mainly of feldspar.

- B-type porphyry

This type is exposed at the eastern part of this area and distributed narrowly in east and west direction. In general B-type is less altered than A-type and is dark gray owing to high content of ferromagnesian minerals.

The main component minerals are quartz, plagioclase and altered hornblende, which make phenocryst and occupy more than 50 volume percent of the rock. The amount of quartz in the phenocryst for B-type porphyry is reduced than for A-type, and plagioclase is increased.

- C-type porphyry

This type of porphyry is exposed in the north-western part in this area and mostly distributed near the branch streams of Quebrada pegadorcito.

The characteristics of this type, the matrix is more coarses than A and B-type and small crystals of fresh biotite (assumed to have been formed by hydrothermal alteration) are observed at a few outcrops.

This rock is usually gray and dark gray in which small phenocryst of plagioclase and quartz are observed remarkably. In this rock the ratio occupied by quartz phenocryst is lower than those in A and B-type.

c) Breccia dyke

This is distributed in east-west direction in the eastern part of this area, and accompany closely B-type porphyry.

This rock consists mainly of rounded and subangular fragments of quartz diorite and A-type porphyry, and is filled with greenish grey ∿ dark grey porphyritic matrix. The diameters of the rock fragments are several mm to 80 cm.

This rock is considered to be intrusive by the observations at Rio Amparradó.

2) Structure

In this area, the main structural lines are the following two faults run parallel to one another; Murindó fault of N-S and NNW-SSE system running from the west of Pantanos to the east of Pegadorcito, and Amparradó fault running about 1 km east of the Murindó one. It has been

observed in this area that crackings in rock tend to be in the direction of E - W, N70° to 80°W, or NS to N20°W and that shear pattern tends to be in the direction of N20°W to N20°E or N50° to 60°W. Thus, the fissure pattern shows the tendency to be nearly perpendicular to the main fault. On the other hand, the shear pattern shows the tendency to be parallel to it, which is assumed to have been caused by the structural movement when the main faults were formed.

These fissure system and shearing system controlled the intrusion of porphyritic rocks and breccia dyke.

iv) Mineralization and alteration

1) Mineralization

Sulfide minerals are disseminated along fissure systems and shear systems and concentrated at well cracked places. Most of veins are 1 - 2 mm wide, but some quartz-chalcopyrite-pyrite veins are as wide as 60 cm.

The difference in mineralization is observed depending on rocks. Concerning copper mineralization, breccia dyke is given pyrite-chalcopyrite dissemination only weakly in general. Among porphyritic rocks, mineralization on A-type rocks is superior, but lacks uniformity. Although good mineralization has been found so far on neither B-type nor C-type rocks, nothing conclusion should not be said here, because observation on the surface is very limited, no drilling has been done yet in B and C-type rocks. In the A-type rocks, four drillings of No.3, 4, 5 and 8 were carried out. No.3 core shows chalcocite-bornite and contains 1.0% Cu at the maximum, 0.42% Cu in average. No.4 core shows chalcopyrite-bornite-chalcocite and contains 1.6% Cu at the maximum, 0.32% Cu in average. No.5 core shows pyrite-chalcocite-bornite vein and partly contains 1.6% Cu. In quartz diorite, mineralization is generally

observed near the contact with porphyritic rocks. The mineralization becomes weaker, separating from the contact.

The mineralization at the bottom of valleys in Pantanos area is veins and dissemination of the primary pyrite-chalcopyrite. By the assay results of specimens taken there, the grade of the primary dissemination zone was 0.1 ∿ 0.45% Cu. On the other hand, what is observed in Pegadorcito area is largely secondary copper minerals of chalcocite-bornite, which are found in argillized C-type porphyry.

Molybdenite was found very slightly in the cores of drillings No.3, 4 and 11. Sphalerite was found only in small quantity under the microscopic observation.

Concerning gold and silver, 0.1 to 0.2 g/t Au, and 1 g/t Ag were found in samples from the outcrop as reported by O.M.R.D. (1973).

2) Alteration

In Pantanos-Pegadorcito area the following five kinds of alteration have been found accompanying porphyry copper; potassic alteration, phyllic (sericitic) alteration, argillic alteration, propylitic alteration and silicification.

Among these, potassic alteration is found rarely; a little secondary biotite is found in C-type porphyry in Pegadorcito district, potash feldspar (orthoclase) in quartz porphyry in No.11 drilling core (at about 290 ft), and potassic altered plagioclase in No.9 core (at about 140 ft) are found (Fig.-52).

Phyllic alteration and argillic alteration are found selectively in A-type porphyry, and are accompanied by some Cu minerals.

Silicification is found more remarkably in all porphyry rocks and several mm to several cm width quartz veins are found in a great number of its.

As far as the observation in drilled cores is concerend, strong sericitization is found where are many quartz veins.

Propylitic alteration are found often relatively in quartz diorite and B-type porphyry.

v) Summary of technical evaluation

Owing to the weather condition and the mechanical condition of the helicopter, the present mission's field survey was limited to ground checking and geochemical sampling at the western part of Pantanos area and at the mineralization zone along Quebrada Lanito (O.M.R.D. 1973, Pantanos No.3 anomaly zone). Starting at the Heliport near No.8 drilling site on the Pantanos ridge, the mission surveyed No.6, 5, 4 drilling sites, walking along the ridge, down to valley, and No.3, 2 drilling sites along the Quebrada Lanito. The rocks in the present survey area consist of A-type porphyry and breccia dyke. A-type porphyry contain the phenocryst of plagioclase and quartz are strongly silicified, sericitized and kaolinized and showed so called phyllic alteration zone. Veinlets and disseminations of pyrite-chalcopyrite-quartz are observed continuously, especially the mineralization was strong where there was much fracturing. Besides as secondary copper minerals - chalcocite, bornite and malachite - were observed at every place. The analysis of samples of altered porphyry disseminating chalcopyrite-chalcocite shows Cu 1.14%, Mo 17 ppm, and Au < 0.2 ppm. (Table - 5).

On the other hand, in breccia dyke, though silicification was found, other alterations were not remarkable and copper mineralization was weak. The analytical results in geochemical samples of stream sediments and soils taken in the present survey are shown in Table - 4. As shown there, the stream sediment shows as high Cu content as 441 ∿ 897 ppm.

The results of the field survey, observation of the drilled cores at INGEOMINAS Medellin branch office and the studies of rock samples are summarized as follows;

1) In Pantanos-Pegadorcito area, quartz diorite consisting of Mandé batholith of the middle Tertiary period is widely distributed, into which porphyritic rocks intruded, being controlled by fissures of NW-SE and E-W systems.

2) Mineralization in this area is porphyry copper type accompanying the later intrusive porphyritic rocks and shows the tendency to be concentrated at the contact zone between porphyritic rocks and quartz diorite.

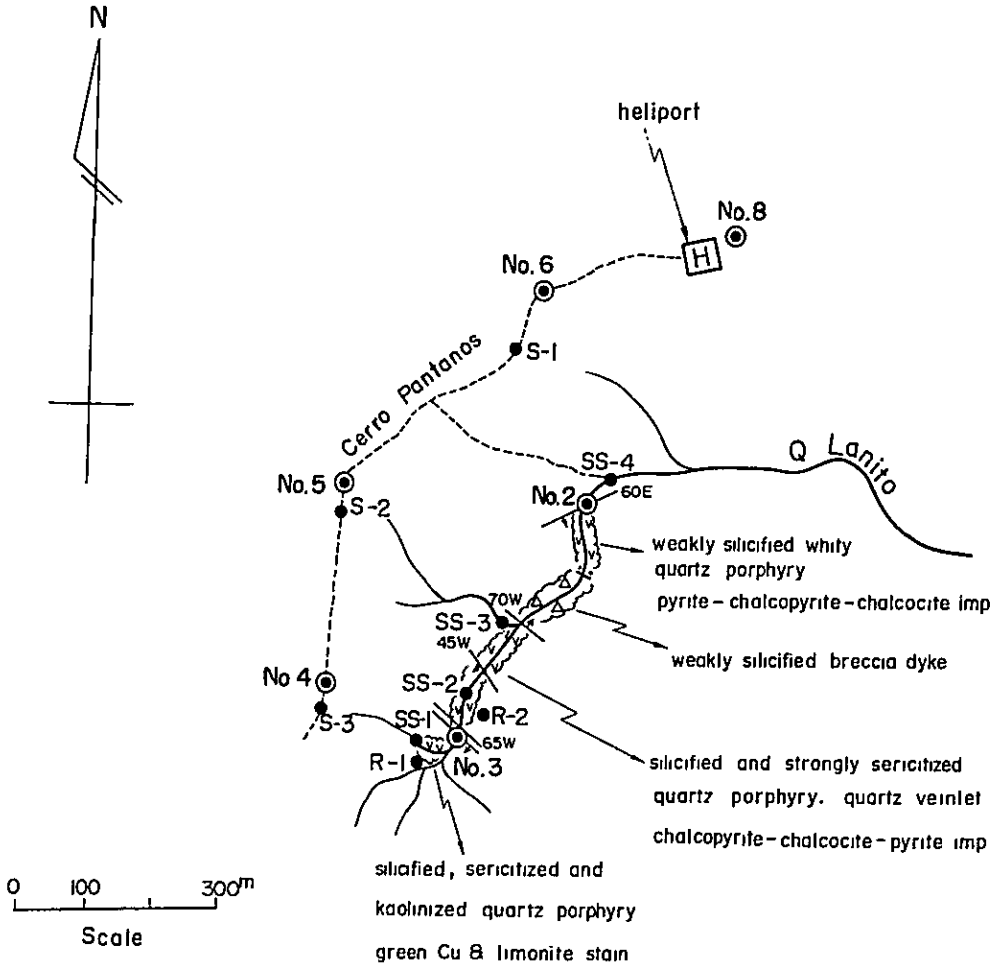
3) In this region, phyllic, argillic and propylitic alteration zones are confirmed widely. But potassic alteration zone is observed somewhat only in Pegadorcito district and at lower position below the surface (drilled core) in Pantanos area.

4) The center of mineralization zone is possibly located below the ground surface in the central to western part of Pantanos district (drilled region), and is possibly located a little shallower in Pegadorcito district.

5) As mineralization is dominant along intrusive boundaries of porphyritic rocks controlled by fissure systems, mineralization zone may be irregular and scattered with some blocks.

As described above, in Pantanos-Pegadorcito area typical porphyry copper type mineralization is observed, where considerable amount of ore deposit is expected to be found at the ground surface level by future prospecting and, further it can be expanded below the surface. Thus, this is to be very promising area.

Fig.-35 Geological Route Map of Quebrada Lanito, in Pantanos – Pegadorcito Area



LEGEND

middle tertiary

quartz porphyry

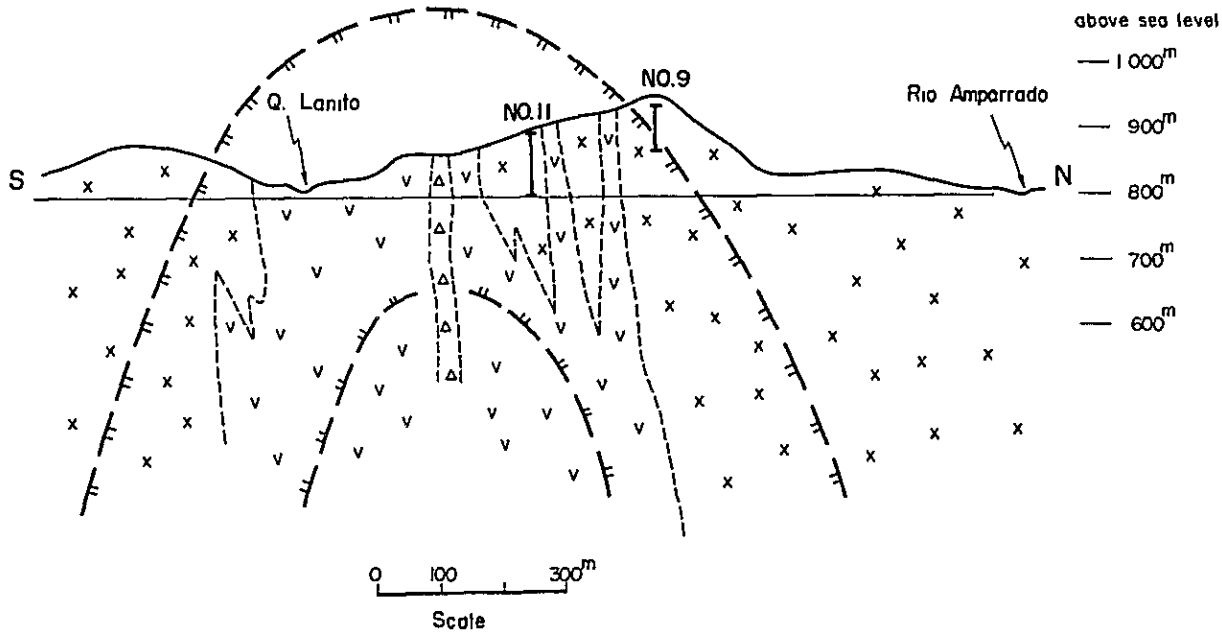
breccia dyke

drilling site

● location of samples

R – 1 . P (R) 092101
R – 2 : P (R) 092102
S – 1 : P (S) 092101
S – 2 : P (S) 092102
S – 3 : P (S) 092103
SS – 1 . P (SS) 092101
SS – 2 . P (SS) 092102
SS – 3 : P (SS) 092103
SS – 4 : P (SS) 092104

Fig.-36 Mineralization Model with Genetic Relationship to Porphyritic Intrusion in Central Pantanos



LEGEND

middle tertiary

quartzdiorite

quartz porphyry

breccia dyke

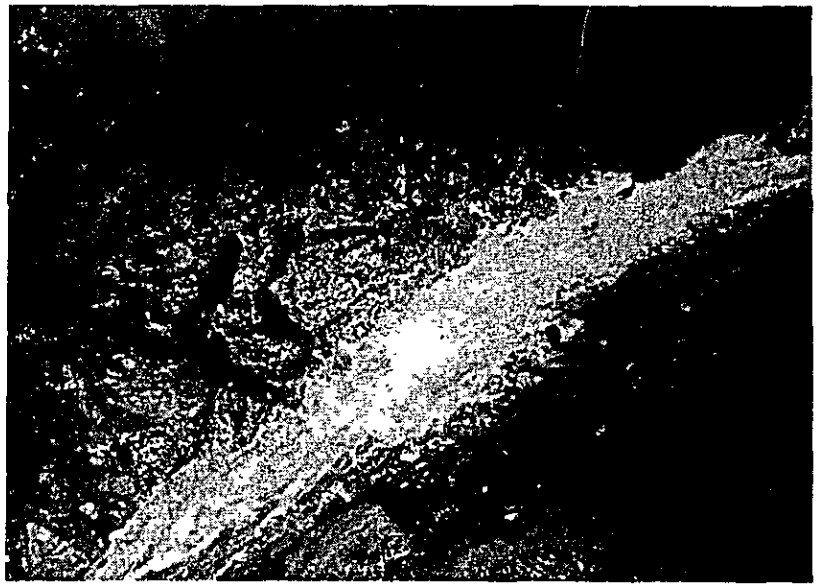
main mineralization zone

NO.11

drilling hole

Photo. 7 Geochemical soil sampling, in Pantanos-Pegadorcito area

Photo. 8 Outcrop of breccia dyke, at Lanito valley in Pantanos-Pegadorcito area



Weakly silicified but no mineralization

As described in the article of Acandi area, $K_2O - Na_2O$ diagram (Fig.-32) based on existing data shows that rocks in this area are plotted in K_2O poor zone where the formation of porphyry copper is said to be unfavaorable, which may make this area seem to be pessimistic like Acandi area. However, in this area strong activity of more acidic porphyritic rocks related to mineralization is observed, which offers a basis for future prospecting to be done further.

7-2-2 Murindó area

i) Access and topography

This is located at the northeast of Choco province about 40 km north-northwest of Pantanos-Pegadorcito area, at the boundary between Antiquia province and at the north end of the western mountain ranges.

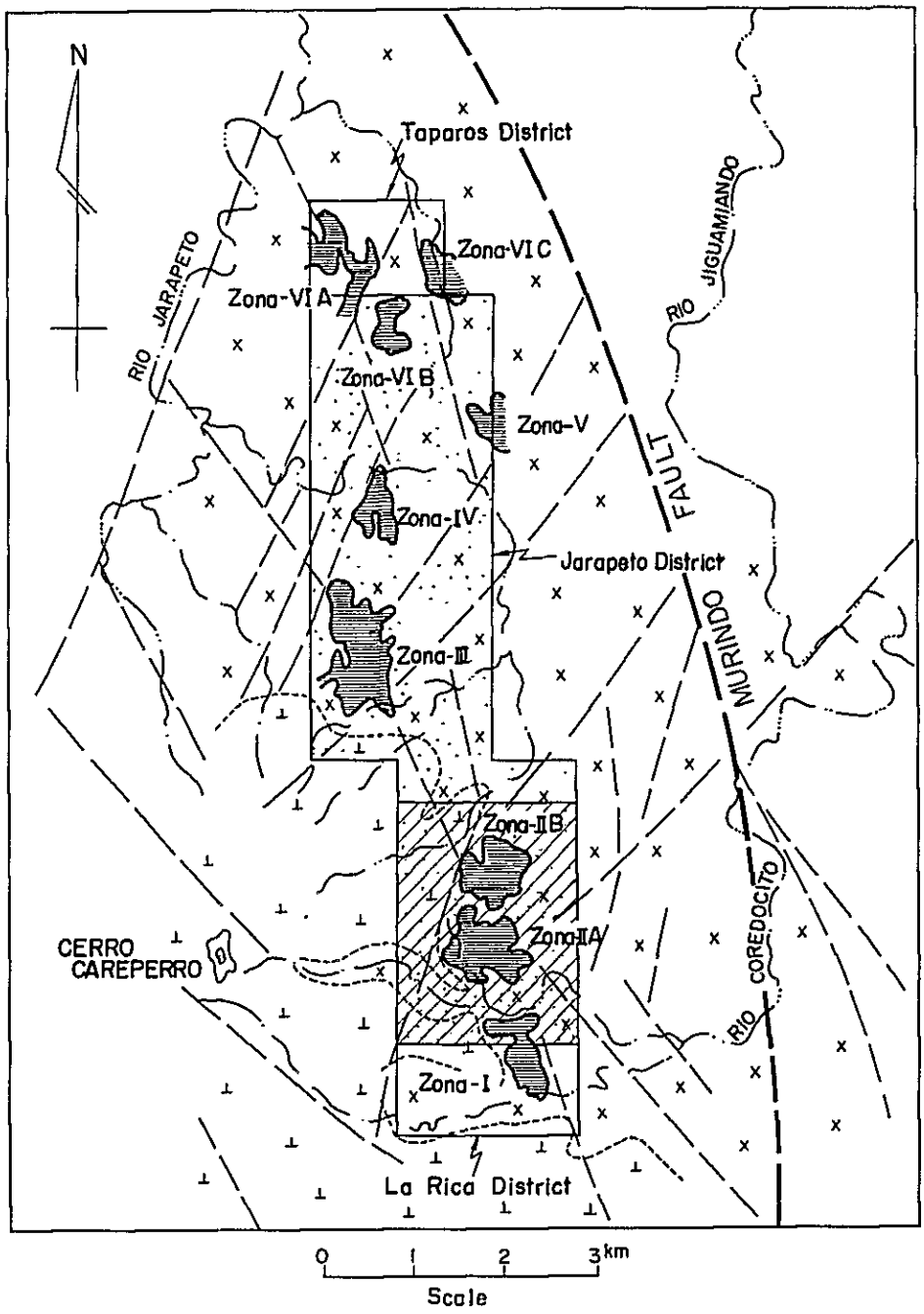
To get to this place, it takes three days from Medellin by land, it takes one to two days from Turbo facing the Caribbean Sea or Quibdo, capital of Choco province, by water. By air, using a helicopter, from Medellin via Dabeiba, it takes only about thirty minutes from Dabeiba to this area.

This area is located in a tropical jungle with a great amount of rainfall, 200 m to 500 m above sea level, and shows relatively falt topography.

ii) History of explorations

This area like Pantanos-Pegadorcito area, is one of Cu-Mo anomaly zones found by regional geochemical reconnaissance survey at the western mountains started by INGEOMINOS in 1970. Survey was again started for a area of 130 km^2 including anomaly zones in August, 1973. The survey was temporarily stopped from 1974 to December 1975. Detailed survey was carried out in a narrow area of about 20 km^2 including the most promising copper anomaly since January, 1976.

Fig.-37 Compiled Map of Murindó Area



Geochemical Survey Area (Soil)

Magnetic Survey Area

I P - RES. Survey Area

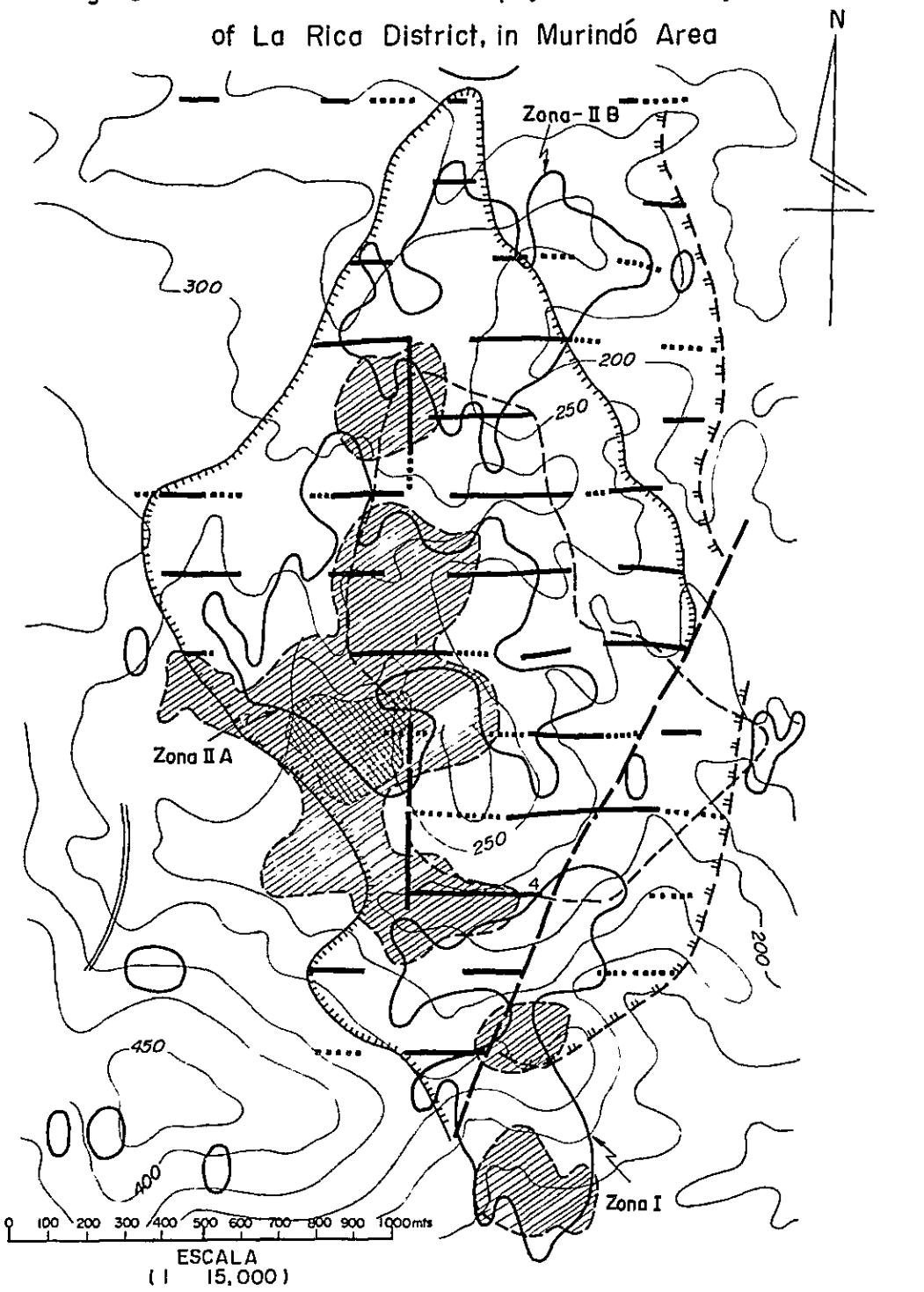
Geochemical Anomaly Zone (Soil, Cu > 800 ppm)

Cretaceous Basic Volcanic Rocks and Gabbro

Quartzdioritic Rocks (Mandé Batholith)

Faults

Fig.-38 Geochemical and Geophysical Anomaly of La Rica District, in Murindó Area



As the result of the detailed survey, two copper anomalies in the southern La Rica district and four copper anomalies in the northern Jarapeto and Taparos district, six anomalies in total, were found.

. La Rica district

Zone I	0.15 km^2 (Irregular)	Rock	Cu	700 to 10,000 ppm
		Soil	Cu	300 to 2,360 "
Zone II	1.0 km^2	Rock	Cu	700 to 20,000 ppm
(II-A, II-B)		Soil	Cu	300 to 4,200 "

. Jarapeto and Taparos district

Zone III	1.1 km^2	Rock	Cu	700 to 15,000 ppm
		Soil	Cu	350 to 1,390 "
Zone IV	0.12 km^2 (Irregular)	Rock	Cu	700 to 5,000 ppm
		Soil	Cu	350 to 2,800 "
Zone V	0.16 km^2	Rock	Cu	700 to 5,000 ppm
		Soil	———	
Zone VI	0.32 km^2	Rock	———	
(VI-A, VI-B, VI-C)		Soil	Cu	350 to 980 ppm

Among these, three anomalies of Zone-II, III, and VI, were estimated to be commercially important from the view point of scale and concentration in elements.

iii) Geology and Structure

1) Geology

In this area, sedimentary rocks (to be correlated with the Dagua group in the south of Colombia) of the Cañasgardas group in the Cretaceous system, ultrabasic and intermediate plutonic rocks of the end of the

Cretaceous period ∿ the lower Tertiary period that intrudes the sedimentary rocks, and Mandé batholith of the middle Tertiary period that intrudes the formers are distributed. Besides small scale narrow dacitic and andesitic porphyry and hornblende basalt intruding the batholith are also observed.

Ultrabasic and intermediate plutonic rocks consist of small rock bodies of serpentinite, gabbro and diorite. Serpentinite is observed along faults.

Mandé batholith consists of quartz diorite, microdiorite and quartzdioritic porphyry and shows quartzdioritic facies as a whole.

The existence of the last intrusive dacitic-andesitic porphyry and hornblende basalt suggests the development of calc-alkàline magnetism.

Igneous rocks distributed in this area are divided into four kinds of ultrabasic rocks, basic rocks, intermediate rocks and other rocks, and are described below;

a) Ultrabasic rocks;

. serpentinite; two outcrops have been found in this area.

. pyroxenite; are shown as boulder at the slope in upstream of Batatal river.

b) Basic rocks;

. hornblende gabbro; are found in quartzdiorite as small rock bodies being mixed with unidentified basic rocks. Quartzdiorite is seemed to intrude in this rocks. In general, taking xenolith such as a small rock body.

. hornblend diorite; the last intrusive rock in quartz diorite.

. hornblende basalt; plate like intrusion in quartz diorite at one place.

c) Intermediate rocks; are divided into quartzdioritic rocks and porphyritic rocks.

. quartzdioritic rocks; occupies most of the survey area and composes a part of Mandé batholith. The rock facies change to tonalite, porphyritic quartzdiorite, and quartzdioritic porphyry.

Quartzdiorite is phaneritic, messive and medium to coarse grain, and has black spots in white matrix. This beomes cataclastic near Murindó fault. As the whole rock body, cataclastic structure is observed, which suggests under the condition of compressive stress.

Rock facies change to a great extent in porphyritic quartzdiorite and quartzdioritic porphyry.

Main rock forming minerals are, in the order of the amount from much to less, quartz, plagioclase, and biotite (chloritized). Besides gangue minerals are observed. The change in rock facies of porphyritic quartzdiorite and quartzdioritic porphyry is closely related to mineralization. According to the observation at La Rica district, the anomaly center revealed by geochemical survey is occupied by porphyritic facies in quartzdiorite. However, these porphyritic facies may not be the change in rock facies from quartzdiorite, but may highly possibly be hypabyssal rock which intruded quartzdiorite in the later stage, which has not been confirmed yet. This must be made clear for future study of mineralization zones, so more detailed geological survey is needed.

. Porphyritic rocks; Besides quartzdioritic porphyry, dacitic porphyry and andesitic porphyry are observed in the entire area, which

intrudes quartzdiorite and expose themselves as small rock bodies of a form of plate like about 150 m wide at the maximum. Considering the similarity between rocks in this area and Pantanos-Pegadorcito area, these may possibly correspond to porphyritic rocks in Pantanos-Pegadarcite area. Thus, they are considered to be the magmatic differentiation from quartzdiorite-tonalite magma.

d) Other rocks;

. Breccia dyke; consists of quartz diorite fragment surrounded by the matrix of dacitic porphyry.

. Cataclastic rock; was formed by dynamic metamorphism caused by Murindó fault system.

2) Structure

The main structural lines in this area are Murindó fault systems continue more than 40 km long in the direction of N30°W.

Murindó main fault which runs east of mineralization zone continues from Pantanos-Pegadorcito area. Parallel to this another fault of Murindó system runs west of mineralization zone.

Generally speaking, each rock exposed in this area is fractured to different degree depending on the difference in its distance from the Murindó fault and a few additional faults.

In this area the main fissuring-shearing system exists approximately in the direction between N10E° and N10°W, and dips are 70° to 90°.

iv) Mineralization and Alteration

1) Mineralization

In this area mineralization is mainly found in intermediate rocks, in which primary sulfide minerals consisting mainly of pyrite-chalcopyrite

are observed microscopically. According to the microscopic observation of rocks in anomaly area, the ratio of pyrite : chalcopyrite (bornite is contained rarely) is approximately 4 : 1.

Most mineralization exists accompanying fissure system or shear zone, and the dissemination type of mineralization seems to be most important.

Most copper minerals are found especially accompanying quartzdiorite that composes Mandé batholith, or porphyritic microquartzdiorite and quartzdioritic porphyry. Sometimes they exist as very fine dissemination and can't be observed macroscopically.

Oxidation of sulfide minerals in this area is generally weak except La Rica district, and only some chrysocola, malachite and other green copper are observed.

Supergene enrichment (secondary enrichment) is very rarely observed entirely in this area, a little amount of chacocite and covelline which replaced pyrite and chalcopyrite are found only upstream of Batatal valley.

Other sulfide minerals such as molybdenite, sphaterite and galena are very limited in this area. Molybdenite was observed macroscopically only in boulders, sphalerite was observed microscopically only in the sample of Taparos valley, and galena was confirmed in a sample only.

Atomic absorption analysis in samples of soil and rocks of La Rica district gives high values of Au (as high as 1.98 ppm), which suggests that copper anomaly found by geochemical survey in this district should be auriferous.

2) Alteration

In Murindó area the investigation on hypogene alteration was very difficult, because weathering and supergene alteration were strong and

the outerops were limitted. INGEOMINAS reported (1977) potassic alteration, sericitic (phyllic) alteration and propylitic alteration, basing on Lowell and Guilbert (1970)'s classification method for the zoning of the alteration zones of porphyry copper deposit. Potassic alteration zone and propylitic alteration zone are developed well, but phyllic alteration zone is generally weak. Argillic alteration zone is almost lacking, being observed seldom partly.

Potassic alteration that is observed in quartzdiorite, tonalite, quartzdioritic porphyry, dacitic porphyry and especially in phorphyritic micro quartz diorite, is observed in close connection with main geochemical copper anomaly in La Rica district and Jarapetó-Taparos district.

In La Rica district, potassic alteration is accompanied by silicification and many quartz veins in irregular direction are observed.

In potassic alteration, potash feldspar and clear secondary foliated biotite are observed dominantly, often being accompanied by weak sericitization of plagioclase, chloritization of mafic minerals and silicification.

Though sericitic (phyllic) alteration is observed in cataclastic rock and quartzdiorite, its development is weak. It is often observed near falt zone and potassic zone. Sericitic alteration and potassic zone are often overlapped each other. Usually quartz and sericite are found in this alteration zone, and granular-mosaic xenomorphic secondary quartz is formed. Secondary quartz in cataclastic rock has not been deformed such as primary quartz, which suggests that the alteration occurred after the structural movement.

Some sericite fills microfracture, oftenly sericite is formed as fine aggregation with the alteration from plagioclase, some exists together with chlorite or sulphides, and some exists as fine foliated

aggregation.

Propylitic alteration is found in entire area. This alteration is observed in basic rocks such as gabbro and diorite as well as to porphyry and quartzdiorite.

Propylitization is often accompanied by chlorite, epidote and calcite, and seldom by zeolite and albitization.

v) Summary of Technical Evaluation

In this time the field survey was decided to be carried out at the place that was considered to be most promising basing on the study of available informations and should be suitable for the operation of a helicopter.

Field survey and brief geochemical sampling were thus carried out at the southern part of geochemical II anomaly zone (II-A anomaly) along the quebrada La Rica, a northern tributary in upstream of Rio Coredocito (the center of La Rica district).

II anomaly zone was remarked, because it had big anomaly zone, the highest value of copper and especially high value of gold. The assay values of samples of rocks, soil, stream sediments taken in the present survey show in Table - 4 and 5.

As revealed by the assay results, Cu values in stream sediments are high as a whole (3,342 ppm at the maximum), especially II-A anomaly in upstream of the tributary of Q. Rica shows the tendency to become more enriched toward the center suggesting II-A anomaly to be promising Cu mineralization zone. Further, the value of gold 0.1 $\sim$ 0.3 ppm shows to be gold-containing anomaly.

On the other hand, rocks distributed in the present survey route are somewhat porphyritic quartzdiorite and porphyritic rock which are

considered to form a part of Mandé batholith. They generally show sericitization, silicification (and what seems to be secondary biotite), and argillization, which apparently shows phyllic alteration zone. Pyrite and copper minerals such as chalcopyrite and partly bornite and chalcocite are contained. Thus, this has been confirmed to be porphyry copper type mineralization zone. As the exposures at the surveyed valley, pyrite-chalcopyrite-quartz veinlets and dissemination were observed continuously. But owing to leaching out, mineralized rocks on the ground surface did not give high assay values as shown in Table - 5.

At the bottom of the valley, several boulders with much malachite were found.

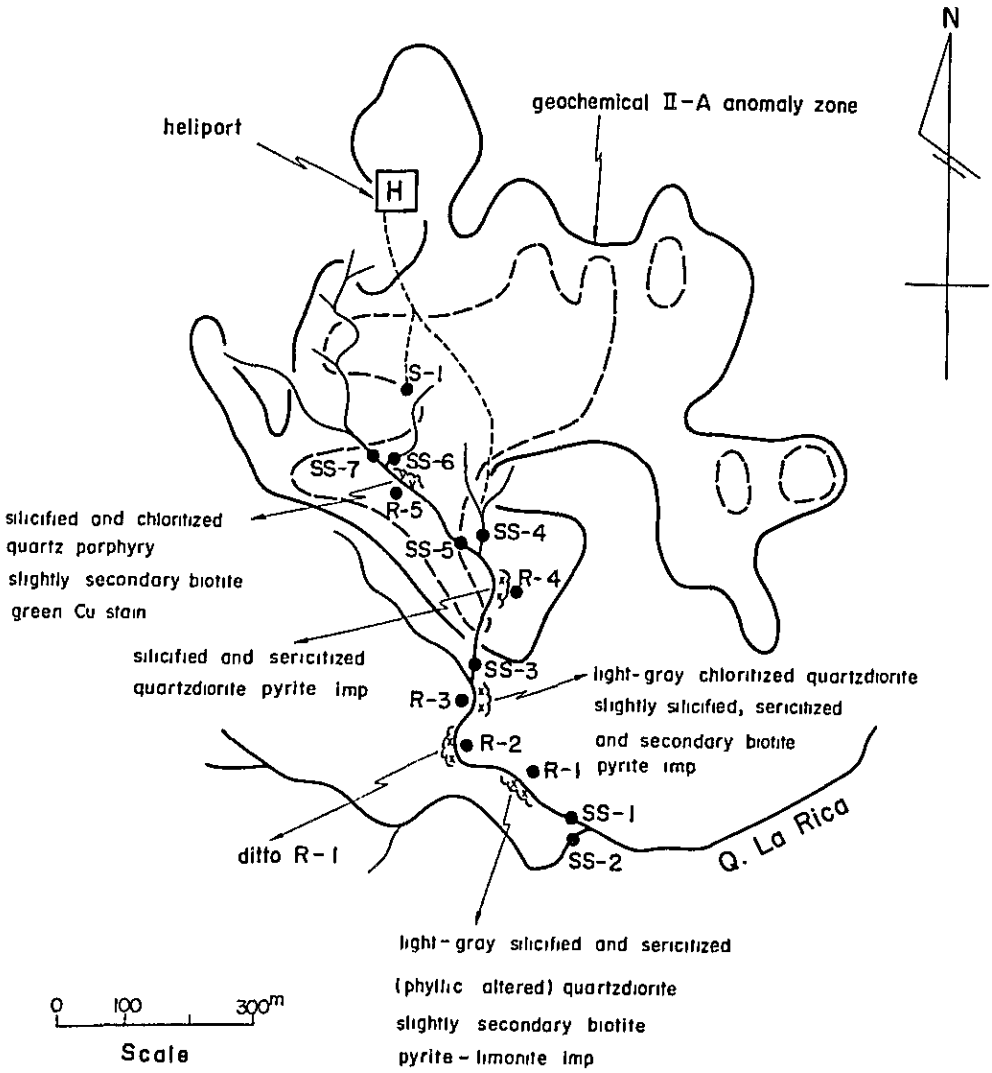
The results of the survey are summarized as follows taking other available informations also into consideration;

1) In Murindó area, sedimentary rocks of Cañasgordas group in the late Cretaceous system, ultrabasic plutonic rocks of the Cretaceous period to the early Tertiary period which intrudes the above sedimentary rocks, and Mandé batholith of the middle Tertiary period which intrudes the formers are distributed. Besides, long narrow dacitic and andesitic porphyry intruding batholith is observed.

2) Mineralization in this area is porphyry copper type mineralization accompanied by gold, which is observed in so called intermediate rocks, namely quartzdioritic rocks composing a part of Mandé batholith, and dacitic and andesitic porphyries intruding the above quartzdioritic rocks.

3) As the results of geochmeical and geophysical surveys, six copper anomalies were found in Murindó area, of which three have been considered to be commercially promising.

Fig.-39 Geological Route Map of Quebrada La Rica, in Murindó Area



LEGEND

middle tertiary

quartzdiorite

quartz porphyry

geochemical anomaly

Cu > 300ppm (soil)

Cu > 800ppm (soil)

● location of samples

R-1. M(R)092001	SS-1 M(SS)092001
R-2: M(R)092002	SS-2 M(SS)092002
R-3 M(R)092003	SS-3. M(SS)092003
R-4. M(R)092004	SS-4. M(SS)092004
R-5. M(R)092005	SS-5 M(SS)092005
	SS-6. M(SS)092006
S-1 M(S)092001	SS-7: M(SS)092007

Photo. 9 Field survey under escort of Colombian soldiers, at La Rica valley in Murindó area

Photo. 10 Outcrop of phyllic altered quartzdiorite, at La Rica valley in Murindó area

Containing pyrite-limonite-quartz veinlet and dissemination
(M(R)092001)

4) Quartzdioritic rocks show remarkable change in rock facies from porphyritic quartzdiorite to quartzdioritic porphyry. In general, copper minerals tend to be concentrated at porphyritic facies. In La Rica district, porphyritic facies in quartzdiorite occupies the central part of the geochemical anomaly zone.

5) On the other hand, the part of prophyritic facies mentioned above may be not a part of quartzdiorite where its facies changed, but highly possibly porphyritic rocks that separated from the identical magma and intruded later stage, which has not been confirmed yet though.

6) Small rock body of dacitic and andesitic porphyry which intruded quartzdioritic rocks at the later stage is compared with porphyritic rocks in Pantanos - Pegadorcito area, and is considered to be a product of the activity related to the mineralization in this area. However, as mentioned above, if the porphyritic facies is the intrusive rock of the later stage, these can be considered to be the activity of the same group at the last stage.

As mentioned above, mineralization in this area is geologically similar to Pantanos-Pegadorcito area. Further, comparing the scales of geochemical anomalies in both areas, this area can be considered to be a promising where it is highly possible to find big scale porphyry copper ore deposit as Pantanos-Pegadorcito area. Thus, this area wants to follow up the porspecting in future.

Concerning the diagram of $K_2O - Na_2O$ in host rock of ore deposit discussed in the article of Acandi area, this analysis has not been done for this area; since no such datum is available here. Because this kind of analysis using the diagram of $K_2O - Na_2O$ is considered to be helpful,

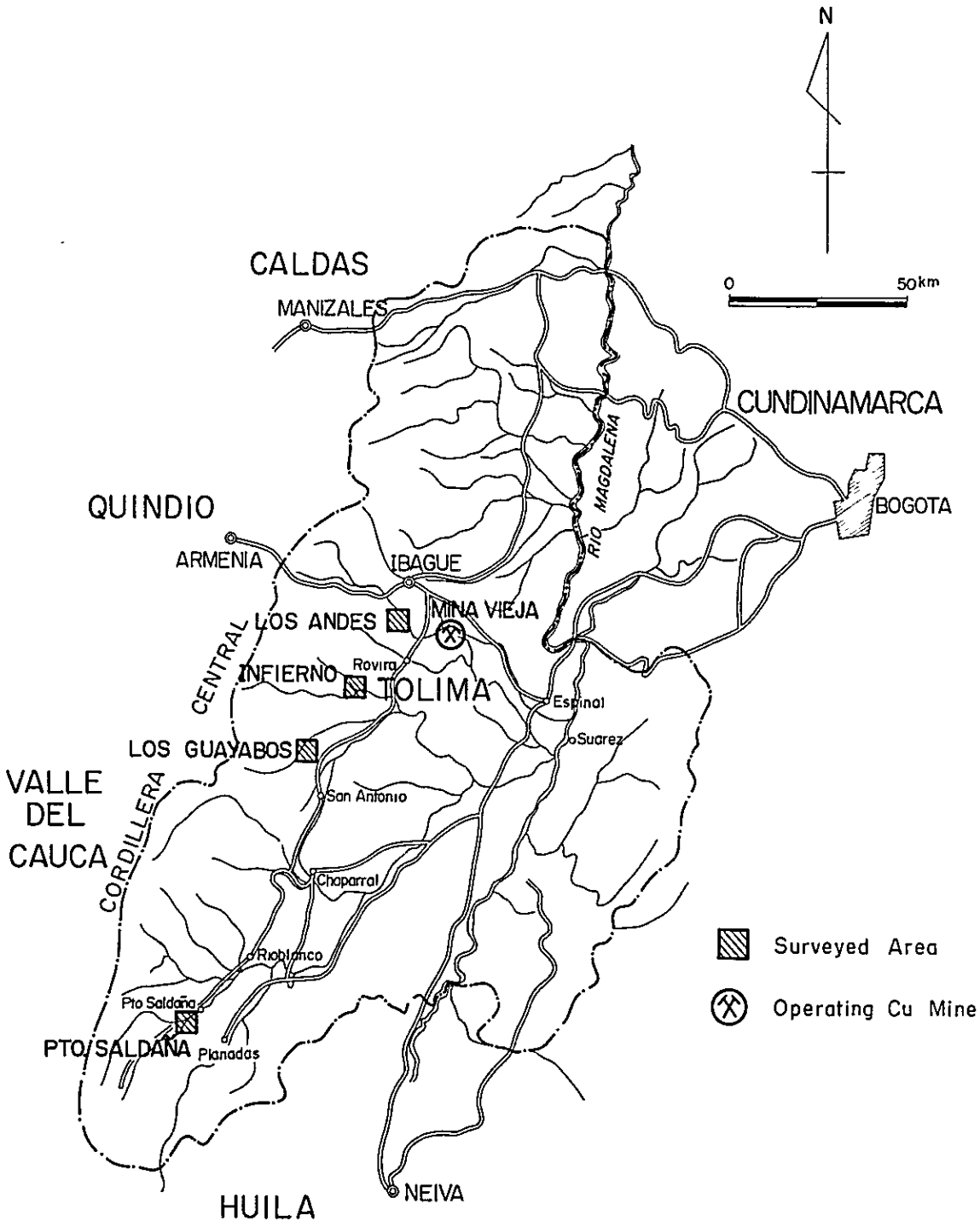


Fig. - 40 Location map of Rovira ~ South Chaparral area

Photo. 11 Discussion on geological informations of Rovira-South Chaparral area, at INGEOMINAS Ibagué Branch Office

Mr. N. Aizawa
Dr. O.H. Pulido (Geologo)
Mr. T. Suzuki
Dr. H.L. Quiroga (Jefe)
Mr. H. Kamono
Mr. J. Oikawa

Photo. 12 Observation of drilling cores, at INGEOMINAS Ibagué Branch Office

future study accompanying the advancement of prospecting is wanted in this area likewise the Pantanos-Pegadorcito area.

7-3 Rovira-South Chaparral Area

The area surveyed is situated at the eastern foot of the Central Cordillera to the south of Ibagué city, capital of Tolima Province and is subdivided into Los Andes, Infierno, Los Guayabos and Puerto Saldaña areas in discending order to the south. These four areas are situated at the eastern marginal part of Ibaqué batholith, where some porphyry copper type and skarn type mineralizations have been known.

The batholith is of great dimension, extending south-south-westward over 400 km with 45 km in maximum width from Tolima Province to southern Cauca Province along the eastern flank of Central Cordillera. Representative rock facies range from grey or pale grey colored medium to coarse grained quartz diorite to granodiorite containing quartz, feldspars and a small amount of biotite and amphibole. Dr. Barrero et al. (1976) suggested that the baloith is of upper Jurassic period.

7-3-1 Los Andes Area

i) Access and Topography

The mineralization zone situated along Chimbacito valley is accessible up to the southern most of it Chimbacito Valley by taking horse one hour and a half passing through a ridge. The ridge, Cuchilla de San Cristobal, is to the west of the small village which is situated 9 km north of Rovira. A truck road for transportation of coffee is available up to the junction of the Los Andes and Chimbacito river which is to the north of the principal mineralization zone. An altitude is 800 to 850 m above the sea level near Andes valley and is about 1400 m near Cuchilla

de San Cristobal.

ii) History of Explorations

Geological investigation has been carried out by INGEOMINAS from earlier time in order to prepare a geological map of Tolima province. In the area, INGEOMINAS also made a geological investigation in 1969 and geochemical sampling of the stream sediments in 1970. Subsequently, the first phase systematic exploration of ore deposits was started in 1975.

The exploration led to localize the showings of porphyry copper type mineralization-alteration zone. Subsequent second phase explorations, including 3 drillings of total depth of 582 m and I.P. method geophysical survey of total travers extension of 18 km, were carried out in 1976 on the basis of the above results.

Consequently, it was reported that the porphyry copper type mineralization is related to the intrusion of quartz porphyry and a grade of the drill cores is low, 900 to 950 ppm of average copper and 100 to 200 ppm of average molybdenium. The result led INGEOMINAS to abandon further exploratory activities.

The Mission carried out field survey to study a necessity of further exploration from a different viewpoint after an examination of the technical information and observation of the drill cores at Ibagué branch office.

iii) Geology and Structure

The geology consists of Ibagué batholith, quartz porphyry and intermediate to basic dikes.

Ibagué batholith is composed mainly of quartz diorite and locally granodiorite rich in potassic feldspar. The rocks show holocrystalline texture whose coarse grained plagioclase and fine to medium grained quartz

phenocrysts are isogranular with fine grained biotite, and are subjected to intensive hydrothermal alteration which is related to an intrusion of quartz porphyry. In the drill cores of No.1 ∿ No.3 drilling, additional biotitization and much sulphide minerals were observed microscopically, and plagioclase took often a tinge of pink owing to a contamination by iron oxide and looked like potassic feldspar megascopically.

Quartz porphyry intruded into Ibagué batholith as dike or stock of 10 m to several 10 m in width at valley of Chimbacito river and drilling sites. Microscopically, principal large phenocrysts of plagioclase, quartz, potassic feldspar and biotite lie in a groundmass of fine to minute quartz (mainly secondary quartz), biotite and feldspar in the rock. The rock is subjected to mineralization and alteration as well as the rocks penetrated, and it is difficult to observe fresh minerals in the rock.

A breccia dike crops out at the upper most stream of Chimbacito river whose breccias show similar rock facies and alteration to those of quartz porphyry microscopically, so it is considered that the quartz porphyry was followed by the breccia dike.

Intermediate to basic dikes occur as small dike and andesite to porphyrite of dark grey color and in part lamprophyre. It is considered that the rocks are of post mineralization owing to an evidence that the rocks of drill cores are fresh and cut the mineralization zone.

iv) Mineralization and Alteration

The mineralization in the area is of porphyry copper type related intimately to intrusion of quartz porphyry. The country rocks have been subjected to alterations of silicification, sericitization, biotitization, carbonatization and chloritization, and consequently a potassic ∿ phyllic

zone was formed in extensive propylitic zone. A scope of the potassic ∿ phyllic zone trends to coincide with that of the mineralization.

Ore minerals are pyrite, chalcopyrite, chalcocite, molybdenite, magnetite and oxidized minerals locally observed at the surface, and are of network veinlet or dissemination. Abundant pyrite occurs in the fractures with minor amount of chalcopyrite at Chimbacito valley. The breccia dike contains small amount of copper oxide minerals. A grade of copper of stream sediments collected by the Mission at the valley is poor in copper, 102 to 340 ppm Cu (Table-4).

Drill cores of INGEOMINAS show that the Cu-Mo mineralization is concentrated at intensely fractured parts around quartz porphyry and molybdenite is closely associated with quartz veinlets. A grade of the drill cores is average 900 ∿ 950 ppm of copper (maximum 3200 ppm Cu). Limonite and copper oxide minerals were recognized in oxidized zone which was about 10 to 20 m bellow the surface. Secondary copper enriched zones were observed between 20 m and 40 m below the surface except No. 2 drilling hole in which the zone is obscure.

v) Summary of Technical Evaluation

The Mission carried out geological investigation at valley of Chimbacito river where the most potentiality was expected by him. Consequently, it was confirmed that the mineralization and alteration are of porphyry copper type related intimately to intrusion of quartz porphyry, and a grade of stream sediments collected by the Mission is poor in copper and molybdenium. And a grade of the drill cores of INGEOMINAS drilling No.1 ∿ No.3 was low in copper and molybdenium, though the drillings were done at places where it was presumed to be the center of the mineralization-alteration zone.

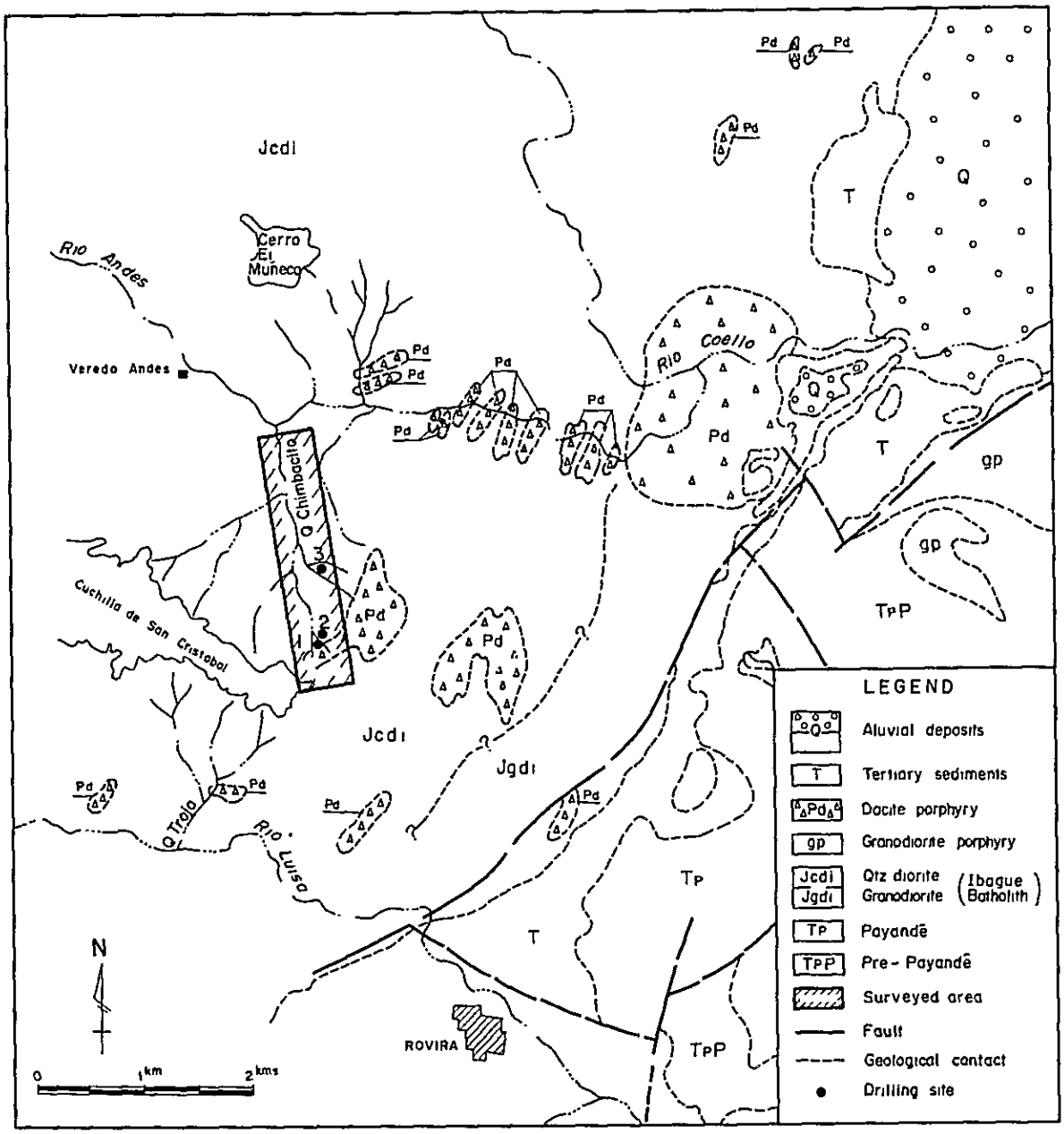
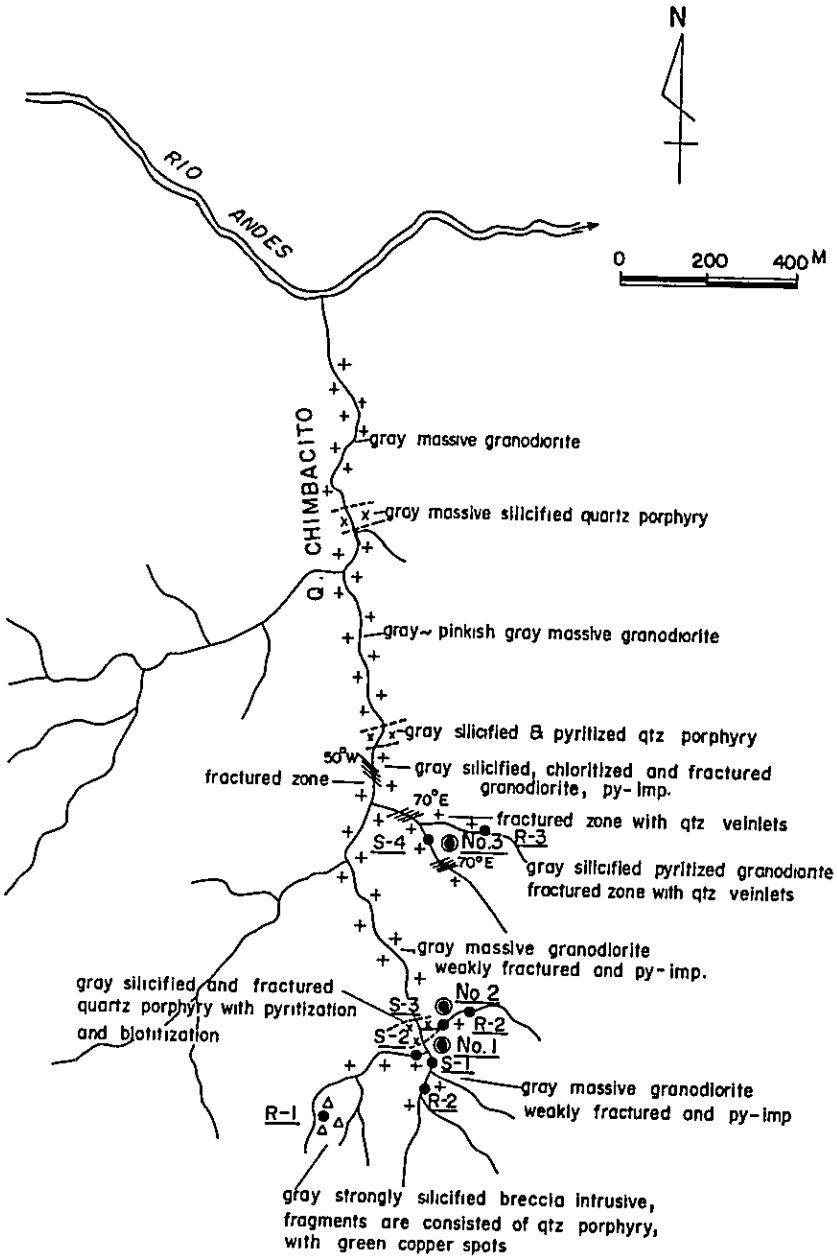


Fig.-41 Geological map of Los Andes area



LEGEND

UPPER CRETACEOUS TO TERTIARY

Δ Δ Breccia intrusive

x x Quartz porphyry

UPPER JURASIC

+ + Granodiorite, quartzdiorite (Ibague Batholith)

◉ Drilling site

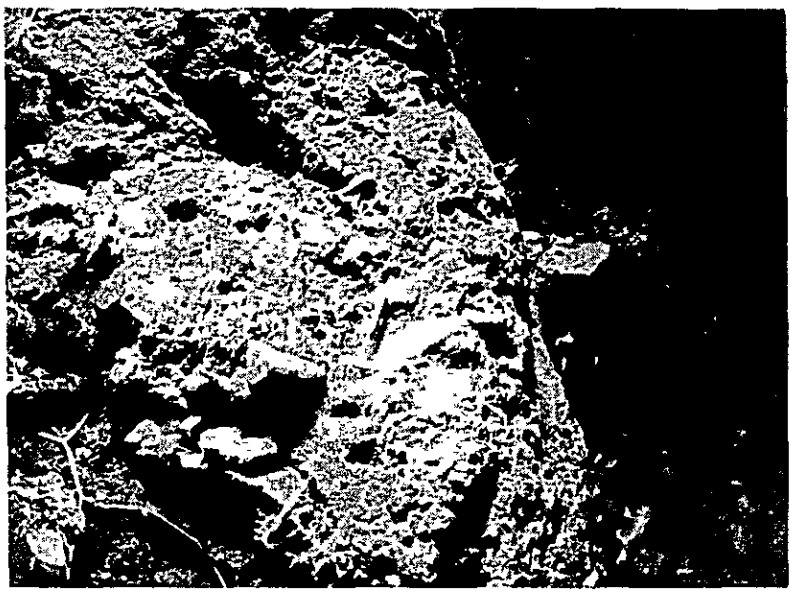
• Location of samples

R-1 : L A (R) 093001
R-2 : L.A (R) 093002
R-3 . L A (R) 093003
S-1 : L A (SS) 093001
S-2 : L A (SS) 093002
S-3 : L A (SS) 093003
S-4 . L A (SS) 093004

Fig.-42 Geological route map of Q. Chimbacito

Photo. 13 A view of drilling sites, in Los Andes area

Photo. 14 Outcrop of breccia dyke, in Los Andes area



Containing green copper slightly (L.A(R)093001)

Therefor, it is considered that it is not hopeful to expect porphyry copper deposit whose grade is more than 0.3% of copper in this area.

7-3-2 Infierno Area

i) Access and Topography

UNDP No.1 drilling site is accessible, except for the last course of 40 minutes on foot, by jeep up to the entrance of the Pajarito river which is about 4 km west of Hato Viejo village situated 14 km south of Rovira town. INGEOMINAS No.3 drilling site is about 6 km northwest of Hato Viejo villeage and is accessible by Jeep.

Topography is comparatively steep at the west of Pajarito river and the Bebedero river where igneous rocks crop out, on the other hand, is gently relieved at the east where Tertiary sequences are exposed. An altitude of the area investigated rangs from 900 m to 1500 m above the sea level.

ii) History of explorations

The area is one of the geochemical anomlous zones selected by the first-phase of UNDP survey including one drill hole of 191 m in depth which was carried out in 1973 - 1976. In 1977 - 1978, second-phase of UNDP-INGEOMINAS survey was followed as follows.

Geological investigation:	general 150 km^2, detailed 10 km^2
Geochemical exploration:	150 km^2
Geophysical survey:	I.P. method 5.7 km^2, geomagnetic 637 points
Drilling:	6 holes (total depth 1,217 m)

Consequently, porphyry copper type mineralization-alteration zones have been found out, but further exploration in the area was abandoned in June 1978, because it was considered that an intensity and continuity

of the mineralization was not enough to form an ore deposit of economic value.

iii) Geology and structure

Geology in the area is similar to that of Los Andes, but in the east part, Tertiary sedimentary rocks are exposed.

Ibagué batholith is composed mainly of quartz diorite rich in quartz and locally of granodiorite rich in potassic feldspar. The rocks have been often subjected to intense hydrothermal alteration which was related to the intrusion of quartz porphyry. In the rock sample (P.I.(R) 092902) collected by the Mission at Pajarito valley, most of feldspar are replaced by calcite, calcite, chlorite, sericite and secondary quartz, and ferromagnesian minerals are entirely altered to chlorite or calcite.

Quartz porphyry penetrated into Ibagué batholith as stock and dike at valley of Bebedero, Infierno and Tuamo river, of which the stock situated at Bebedero valley is the largest showing a diameter of 1000 m. The rock was well exposed along the road-cut near No.3 drilling site and Bebedero river, and was penetrated by the drilling where the rock was subjected to serious fracturing toward east-west and northwest-southeast. The rock is microscopically porphyritic presented by phenocrysts of plagioclase, quartz and minor amount of potassic feldspar, and shows locally rock facies of dacitic porphyry. Rock forming minerals of the rock are not fresh due to hydrothermal alteration. The rock near the road-cut has been oxidized and leached forming iron oxides and clay minerals such as kaolin and sericite etc. which showed various color of greyish white, yellowish brown, reddish purple and other.

Intermediate to basic rocks occur as small dike or stock like body, and show rock facies of andesite to porphyrite of dark color and of

lamprophyre sometimes at Pajarito and Bebedero river. Because rock forming minerals, plagioclase, amphibole and pyroxene, are fresh and the rocks cut the mineralization-alteration zone, it is considered to be of post mineralization.

Tertiary sedimentary rocks rest uncomformably upon Ibaqué batholith and quartz porphyry in the east of the area. The rocks are of continental origin and consist mainly of poorly sorted sandstone of yellowish red to reddish purple color and subordinately mudstone and conglomerate. The rocks, in general, trend north-south and dip 10° to 20° east without any faults and folding within the area, but lie in fault contact with Paleozoic formation at the east of the area.

iv) Mineralization and alteration

The mineralization in the area trends to concentrate in the potassic and phyllic alteration zone, where the rocks were well fractured. At valley of Pajarito river, a potassic zone was recognized around a small dyke of quartz porphyry and UNDP No.1 drilling site, and accompanied quartz veinlets and secondary biotite. In the zone, pyrite, small amount of chalcopyrite and locally copper oxides and molybdenite which was found associated with quartz veinlets were observed. UNDP No.1 drill cores contain abundant pyrite with minor amount of chalcopyrite and molybdenite and an average grade of Cu, Mo, Zn and Pb in ppm is 500 - 800, 10 - 20, 100 - 200, 50 - 120 respectively.

A grade of stream sediments collected by the Mission near ANDP No.1 drilling site is 1332 ppm of copper suggesting that the mineralization is the most intense around there, but a grade of the drill cores of ANDP No.1 drilling is poor in copper as descrived above (Table-4).

At valley of Bebedero river, the rocks have been intesely sericitized,

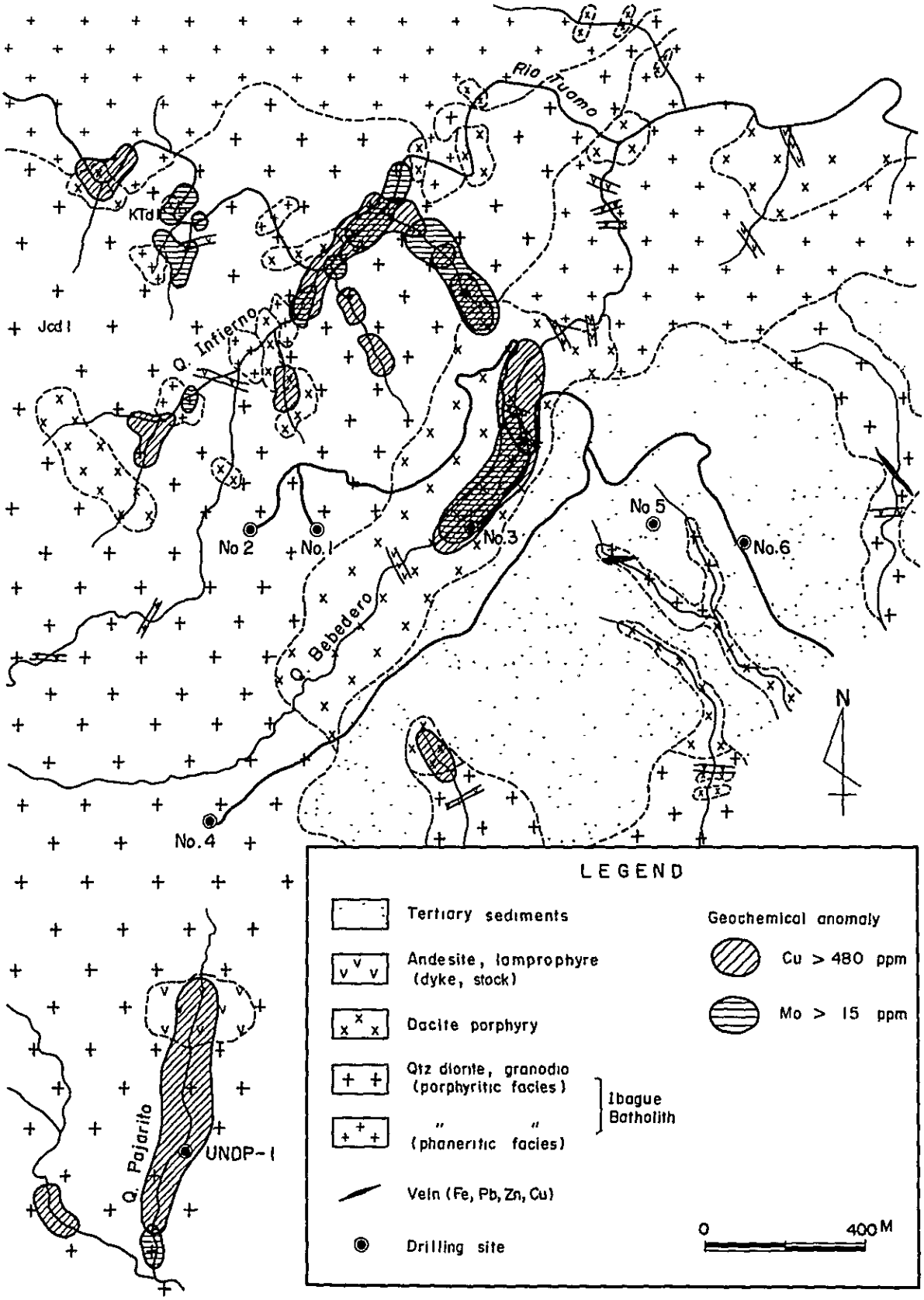


Fig.-43 Geological map of Infierno area

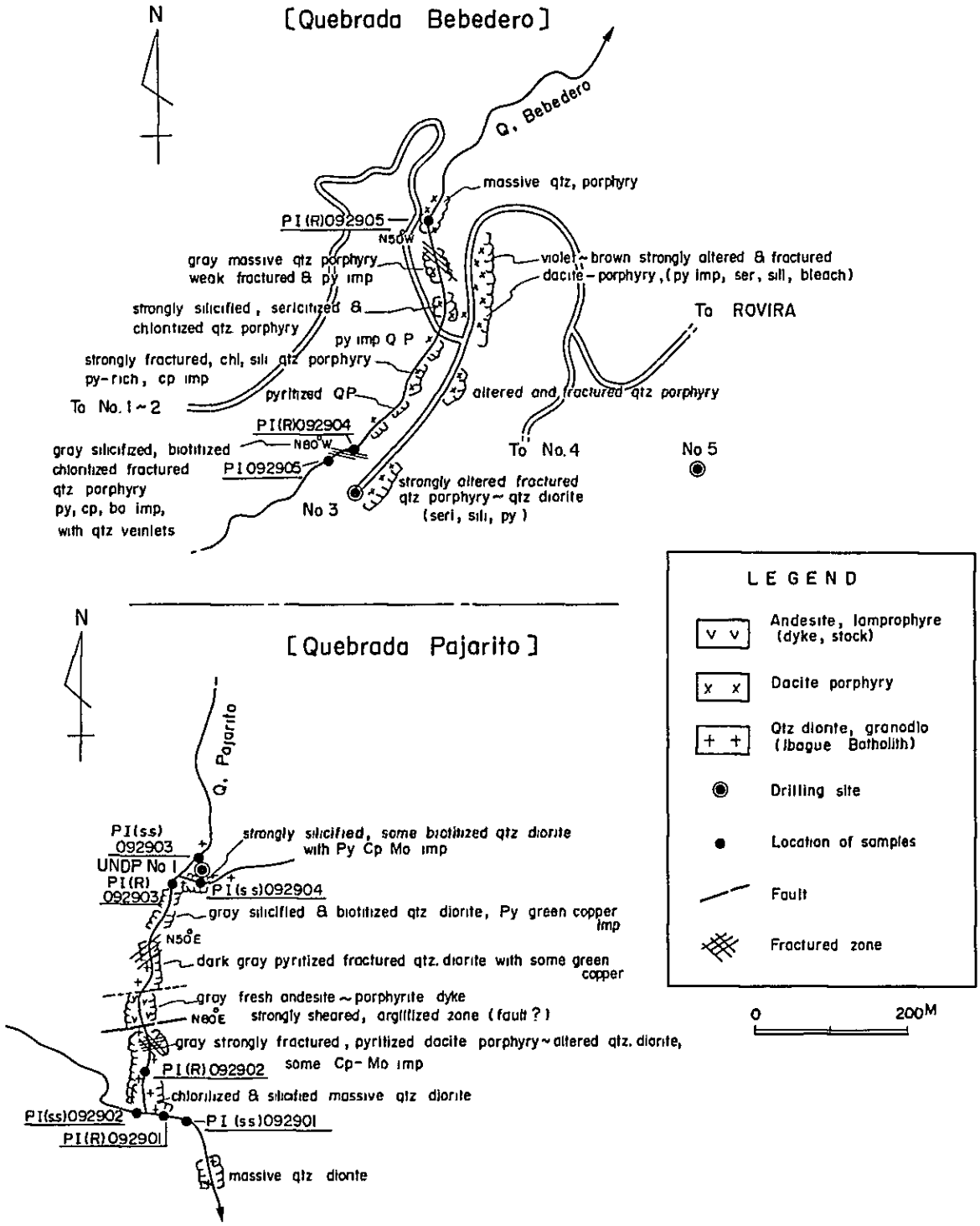
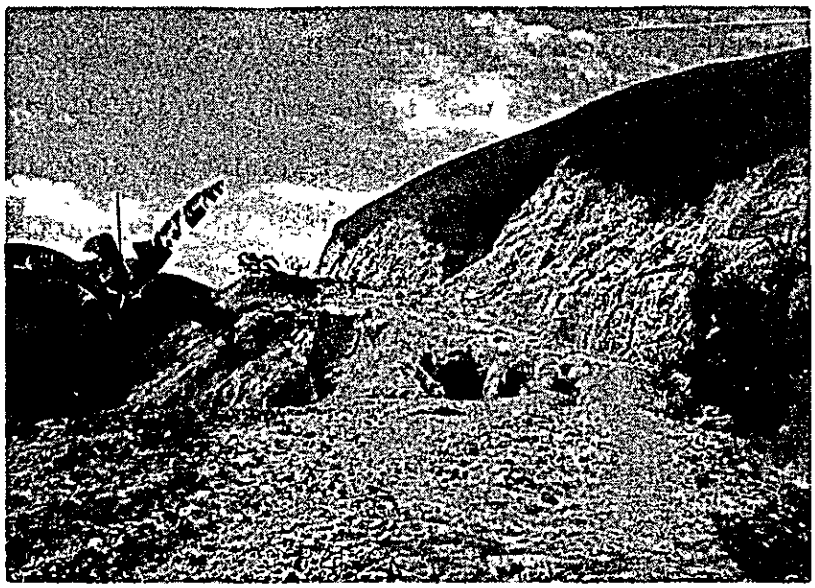


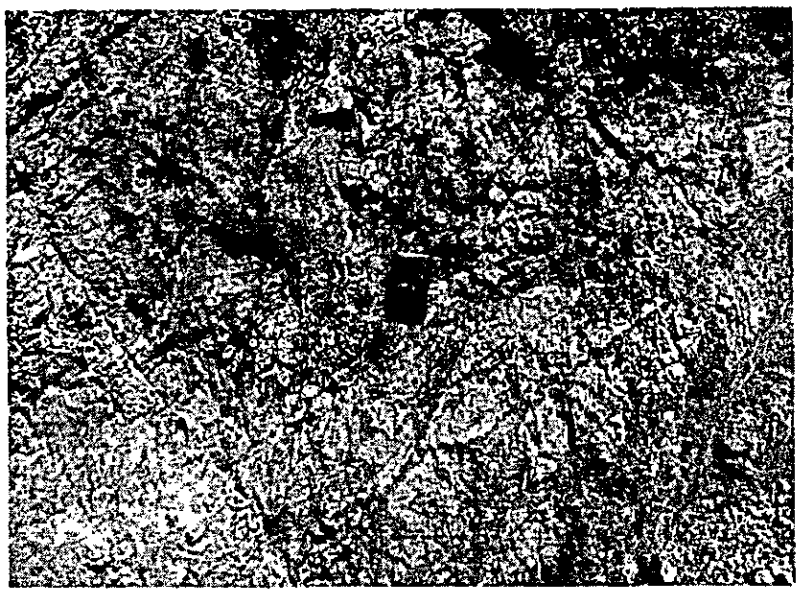
Fig.-44 Geological route map of Infierno area

Photo. 15 Outcrop of phyllic altered zone, in Infierno area



Looking from drilling site No. 3

Photo. 16 Strongly phyllic altered porphyritic Quartzdiorite, in Infierno area



Near drilling site No. 3, containing network of pyrite-limonite-quartz vein and dissemination

silicified and chloritized to form a phyllic zone in extensive propylitization-silicification zone around INGEOMINAS No.3 drilling site. But, the copper mineralization was weak in the zone. No.3 drill cores contain microscopically a much amount of pyrite of veinlet and dissemination with minor amount of chalcopyrite and molybdenite. An average grade of No.3 drill cores of Cu, Mo, Zn and Pb is 600, 30, 20 and 12 ppm respectively.

A grade of the stream sediments collected by the Mission at Bebedero river is poor in copper, 125 ppm Cu (Table-4).

v) Summary of technical evaluation

The Mission carried out field investigation since it was considered that the mineralization-alteration zones at valley of Pajarito and Bebedero river were the most important in the area in consequence of an examination of the technical informations and observation of the drill cores.

It was verified consequently that the mineralization and alteration are of porphyry copper type closely related to an intrusion of quartz porphyry. And it became clear that the Cu-Mo mineralization is limited to some fractured zones and is too weak to form economic ore deposit, as a result of the field and microscopical investigations and analysis of the drill-cores and stream sediments. The drillings were carried out at places where it was presumed to be at the most potential.

Therefor, it is considered that any other interesting district could not be found in this area.

7-3-3 Los Guayabos Area

i) Access and Topography

A outcrop occurs along the national road between Rovira and San Antonio town.

It takes about 40 minutes to get there by Jeep from San Antonio. The topography around there is steep and the outcrop is on the mountain side of 1500 m above the sea level.

ii) History of Explorations

It seems that the mineralization in the area has been known since the days of Spanish colony. The discovery of geochemical copper anomalies during the first phase survey of UNDP was followed by the geological and geochemical survey conducted by INGEOMINAS in 1977.

As a result, it was concluded that it is not hopeful to expect skarn copper ore deposit of large dimension, but geochemical soil sampling and geomagnetic survey were recommended in order to find one of medium to small dimension.

The Mission carried out field investigation along the road-cut and upstream of Los Guayabos river with reference to the technical informations and a knowledge of skarn type copper ore deposit of Mina Vieja mine.

iii) Geology and Structure

The geology in the area consists of Precambrian metamorphic rocks and sedimentary rock of Post Payandé Formation in Triassic system, and Ibagué batholith, quartz porphyry which intruded into the former.

The Precambrian metamorphic rocks are composed mainly of calcareous shale of dark grey to black color interbedded with thin layers of limestone and are exposed along the road-cut and at upstream of Mariano Bedoya river extending over north-south 1000 m and east-west 100 - 150 m. And gneiss crops out at the south of the road showing a xenolith like body of small dimension. It has been considered that the rocks are correlated with Precambrian group because the rock facies are similar to those of Precambrian group in Central Cordillera, but it is possible to

be of Payandé Formation owing to that limestone beds are interbedded within the Formation.

Quartz porphyry is of grey to dark color and contains remarkable phenocrysts of feldspar and quartz of medium to coarse grain. The rock penetrated into Ibagué batholith and Post Payandé Formation and caught Precambrian rocks as xenolith like bodies, and gave contact metamorphism to limestone and calcareous shale though the rock appears to be comparatively fresh near the intersection of the road with the river.

iv) Mineralization

The mineralization in the area is associated with skarn zone formed in limestone and calcarous shale near a contact with quartz porphyry.

A main skarn mineral is garnet, idiomorphic or hypidiomorphic andradite rich in iron, with subordinate amount of actinolite, epidote and calcite. Pyrite, chalcopyrite, hematite and magnetite are ore minerals. On the surface of the outcrop, copper and iron oxides were recognized. The mineralization and skarnization in the area was intensive near an intersection of the road with Los Guayabos river where NW-SE trend folding and faults formed fractured zone, and decreased the intension at the northeast of the outcrop.

At the upstream of the Los Guayabos river, neither skarnization nor mineralization were recognized and recrystallized limestone distributed. It is therefore assumed that the mineralization zone is of small dimension extending extending about 120 m long along the road with a thickness of 15 - 20 m.

Table-5 shows the assay of samples from the mineralized zone.

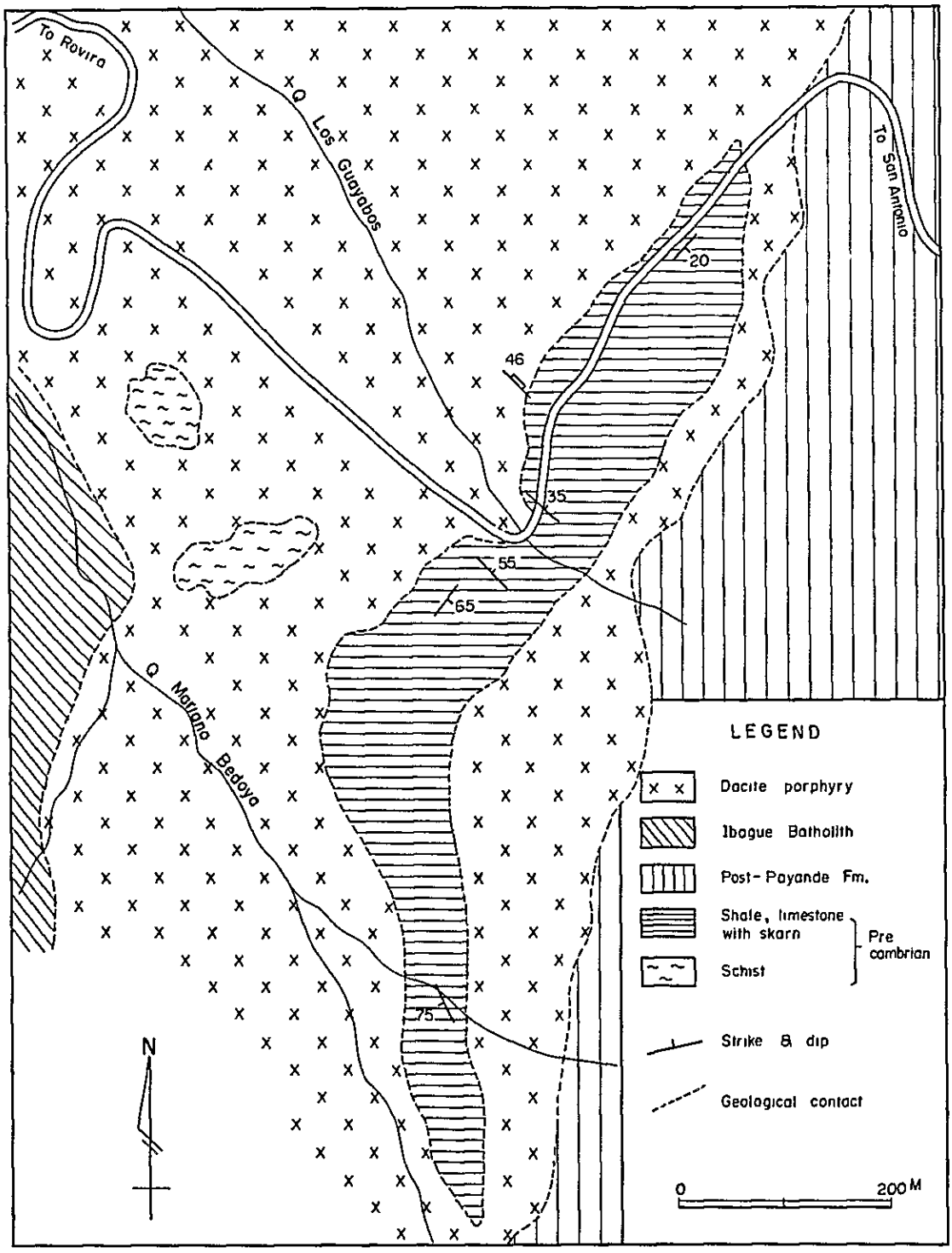


Fig.- 45 Geological map of Los Guayabos area

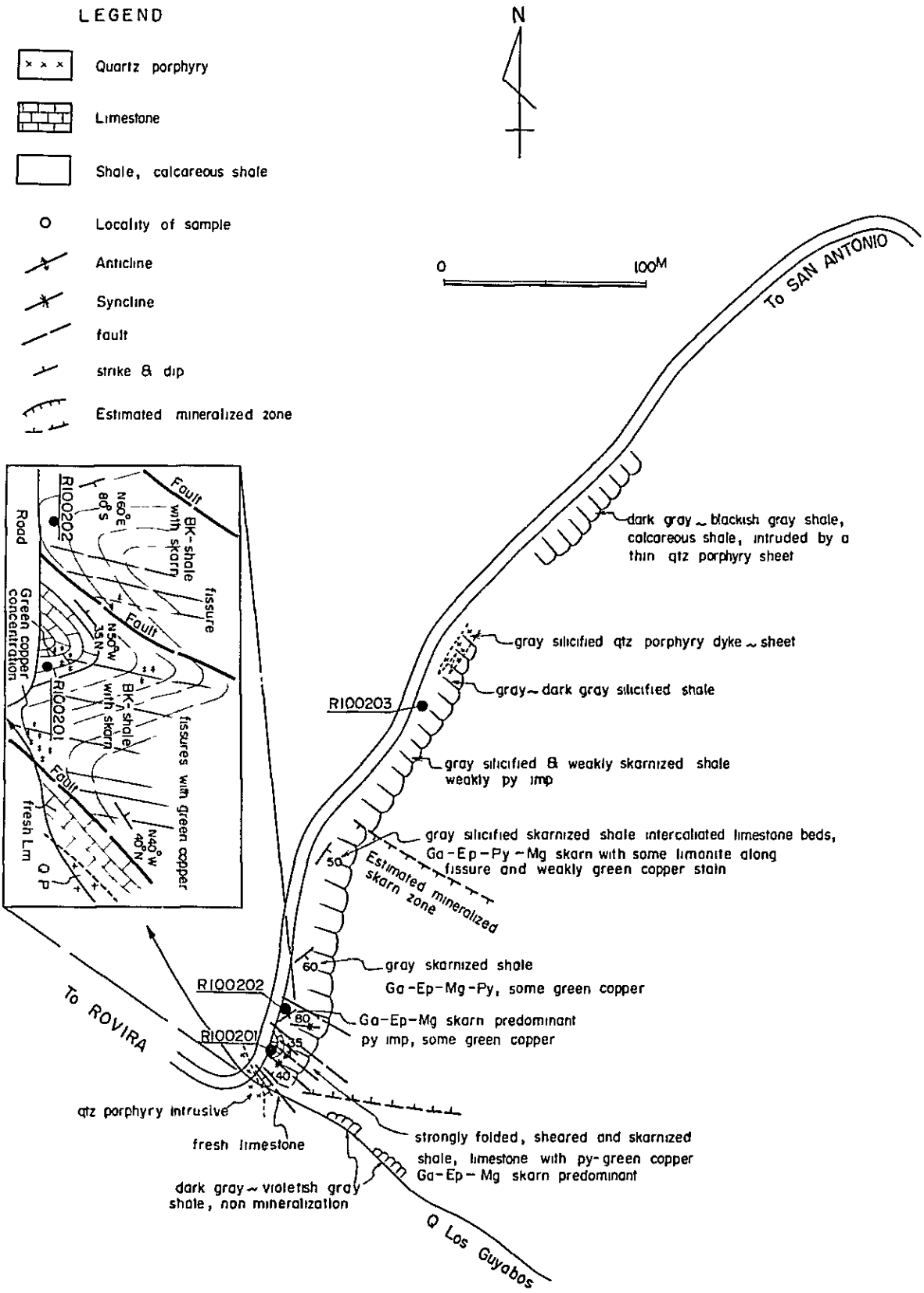


Fig.-46 Geological route map of Los Guayabos Area

v) Summary of Technical Evaluation

The mineralization in this area is skarn type associated with skarnized limestone and calcareous shale near the contact with quartz porphyry. It is assumed that the skarn copper mineralization zone is of small dimension, about 120 m long parallel to the road with a thickness of 15 - 20 m.

Therefore, it is considered that it is hopeful to expect a copper ore deposit of several hundreds of thousands of tons. Drilling is recommended for further exploration.

7-3-4 Puerto Saldaña Area

i) Access and Topography

The area is easily accessible by jeep as the road between Rio Blanco and La Herrera was constructed in 1976.

Topography around there is steeper than those of other three areas mentioned previously, because the area is near the Central Cordillera. There are steep cliffs on both sides of Saldaña river and many falls at branch streams.

ii) History of Explorations

The area is one of the geochmeical anomlous zones selected by UNDP first phase survey. Subsequently, geological and geochemical investigations were carried out by INGEOMINAS in 1977 since a mineralization-alteration zone was revealed along the road-cut. Consequently, it was reported that fourteen veinlets of quartz and pyrite and a small amount of chalcopyrite, molybdenite and bornite distributed in a zone which was extending over 3500 m along the road-cut and 60 - 70 m in width, but the mineralization was not so economic.

The Mission carried out field investigation along the road-cut and

branch streams of Saldaña river to study a necessity for further exploration in the area after an examination of the technical informations.

iii) Geology and Structure

The area is geologically composed of Ibaqué batholith, Precambrian metamorphic rocks and quartz porphyry which intruded into the first two.

The Precambrian metamorphic rocks essentially consist of biotite gneiss with subordinate amount of quartzite and amphibolite, and occur as xenolith like bodies of several to several 10 m and 1000 m in diameter at the southwest of the area and also along the road-cut. The biotite gneiss is of dark green to dark grey color showing finely banded gneissose texture. Microscopically, coarse grained quartz, plagioclase and biotite are arranged in parallel with the same direction. A regularity of the gneissosity is not clear despite large structures such as folding or faulting are absent.

Characteristics of Ibagué batholith and quartz porphyry are similar to those in Los Andes and Infiermo area. Ibagué batholith commonly distributed in the area investigated, on the other hand, quartz porphyry occurs as dike or stok of small dimension trending north-south at the west of Pto. Saldaña village and east-west at the south of the area.

iv) Mineralization and Alteration

A mineralization-alteration zone of porphyry copper type extends over about 3 km along the road-cut which is to the south of Pto. Saldaña village, but the width appears to be narrow. The mineralization-alteration zone are concentrated in and out of quartz porphyry where a fracturing is remarkable. The alterations are silicification, sericitization, biotitization, chloritization and carbonatization. The main ore mineral is pyrite associated with chalcopyrite, chalcocite and molybdenite of small

amount.

Microscopically, xenomorphic chalcopyrite and sphalerite of small amount were observed among idiomorphic to hypidiomorphic pyrite, and filmy chalcocite occurred along margin of pyrite.

The Mission collected stream sediments at branch streams which were to the west of the road. A grade of the stream sediments was poor in copper and molybdenium (Table-4), and the geochemical exploration carried out by INGEOMINAS revealed an absence of Cu-Mo anomalies at the west of the road. It is considered that it is hopeless to expect porphyry copper type ore deposit of economic value at the west as a result of the geomchemical exploration and geological investigation.

As a float of garnet skarn was found at a branch stream, Pradera river, situated the west of Pto. Saldaña villege, it is considered to may be skarn copper ore deposit at the west area.

One the other hand, geological and geochmeical investigations have not been carried out at eastern half area which was to the east of the road and Saldaña river. So, it is necessary to confirm a distribution of quartz porphyry and mineralization-alteration zone in the area, if possible.

v) Summary of Technical Evaluation

The geology in the area consists of Ibagué batholith, Precambrian metamorphic rocks and quartz porphyry which intruded into the first two. The Cu-Mo-Zn mineralization is of porphyry copper type related to the intrusion of quartz porphyry, and the mineralization zone extends over about 3 km along the road, but the width appears to be narrow and the grade is poor in copper and molybdenium according to the result of geological and geochemical investigations.

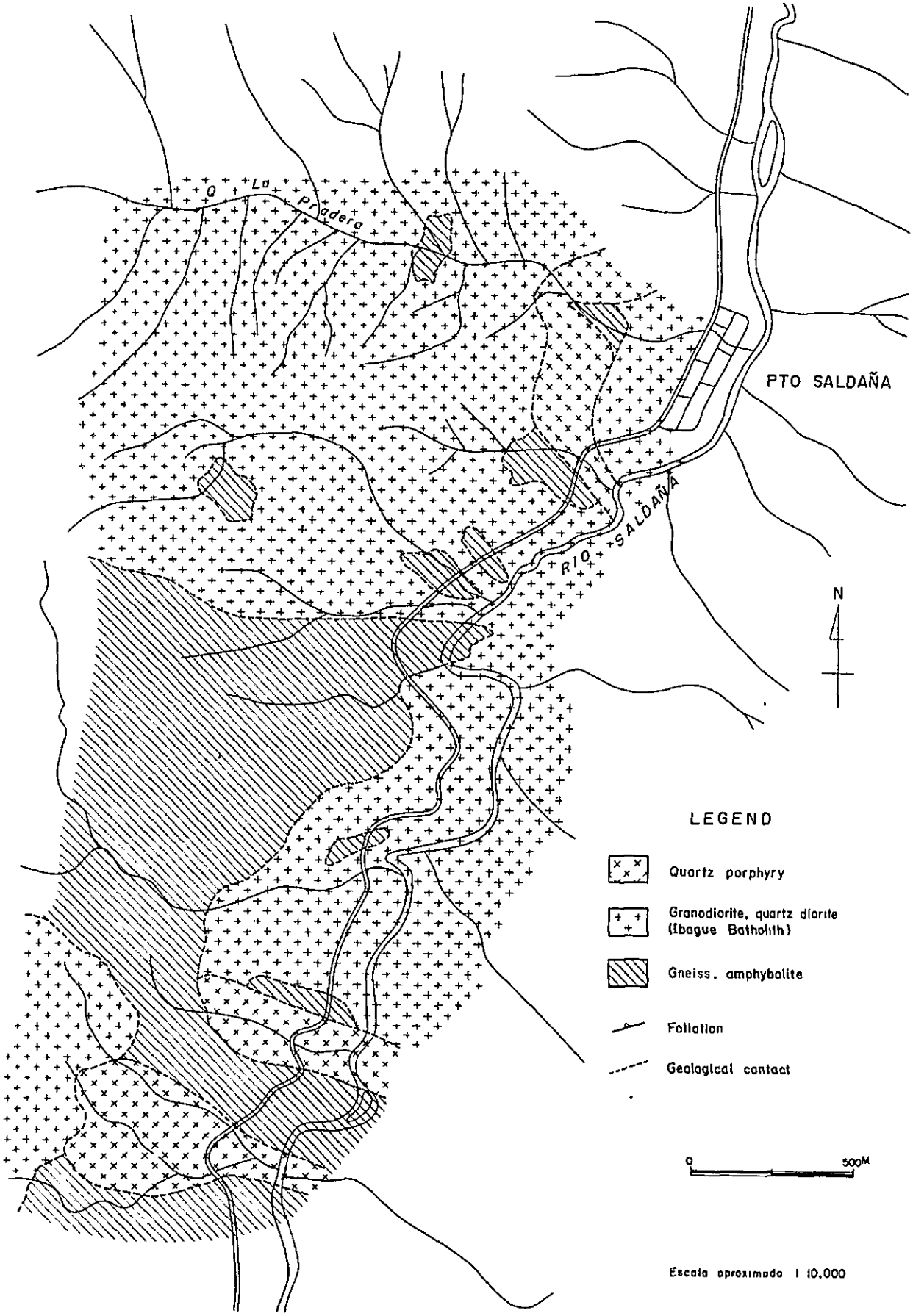


Fig.– 47 GEOLOGICAL MAP OF PUERTO SALDAÑA AREA

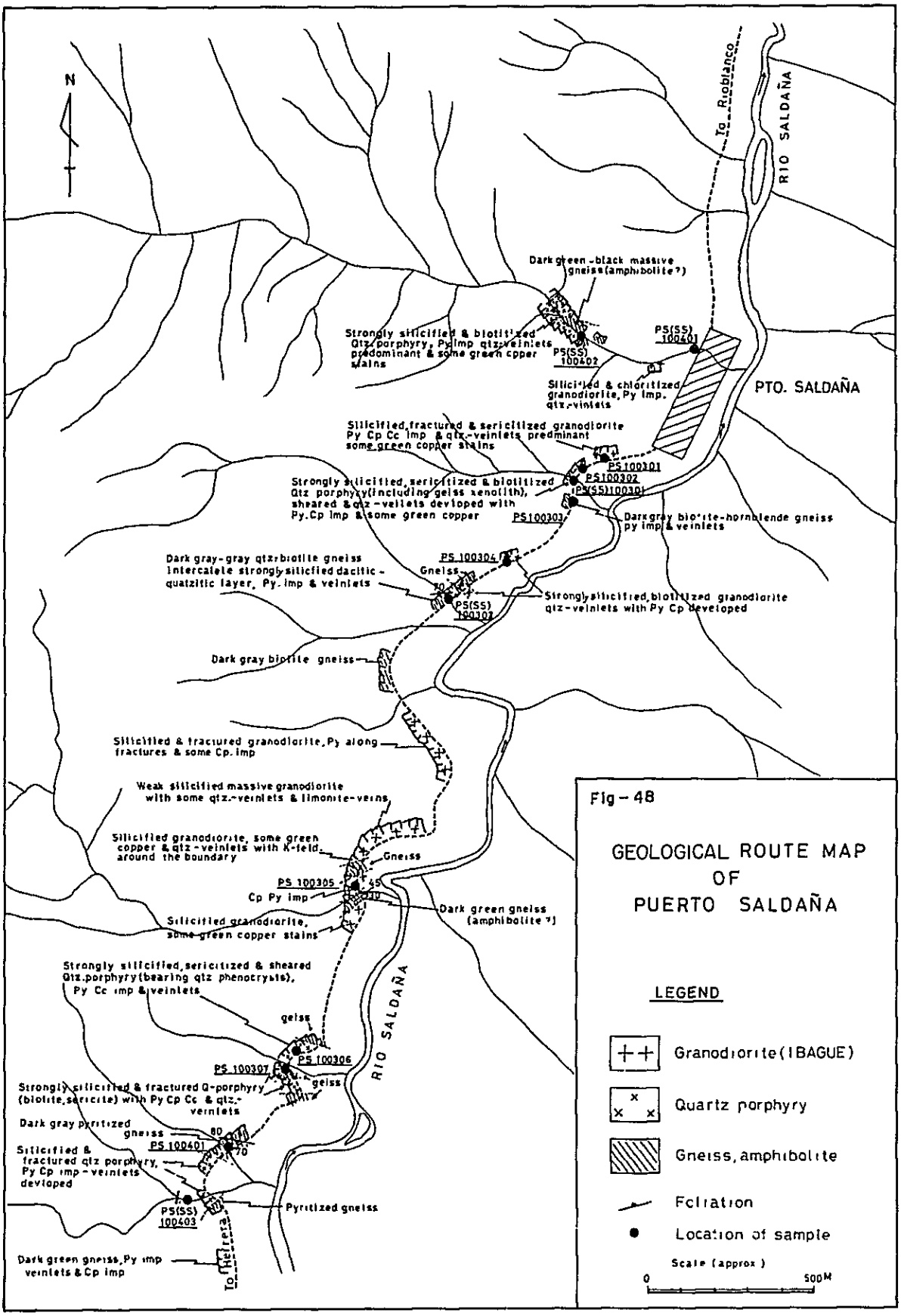
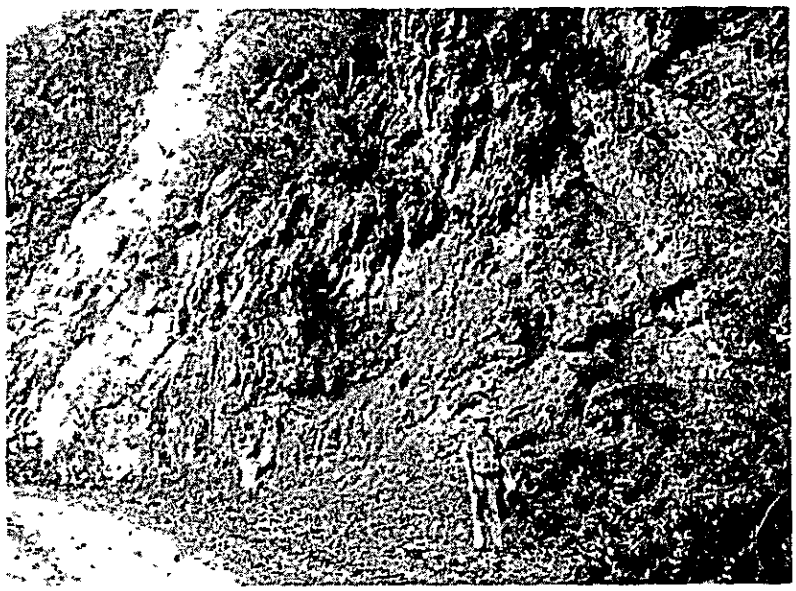
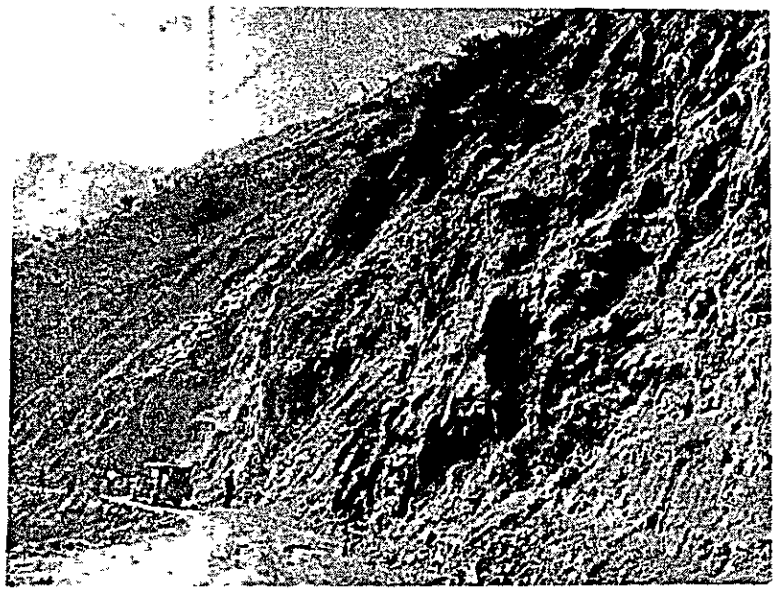

N
To Riobianco
RIO SALDAÑA
Dark green - black massive gneiss (amphibolite?)
Strongly silicified & biotitized Qtz. porphyry, Py imp qtz-veinlets predominant & some green copper stains
PS(SS) 100401
PS(SS) 100402
PTO. SALDAÑA
Silicified & chloritized granodiorite, Py imp. qtz-veinlets
Silicified, fractured & sericitized granodiorite Py Cp Cc imp & qtz-veinlets predminant some green copper stains
PS100301
PS100302
PS(SS)100303
Strongly silicified, sericitized & biotitized Qtz porphyry (including geiss xenolith), sheared & qtz-veilets developed with Py.Cp imp & some green copper
PS100303
Dark gray biotite-hornblende gneiss py imp & veinlets
Dark gray - gray qtz-biotite gneiss intercalate strongly silicified dacitic - quatzitic layer, Py. imp & veinlets
PS 100304
Gneiss
PS(SS) 100302
Strongly silicified, biotitized granodiorite qtz-veinlets with Py Cp developed
Dark gray biotite gneiss
Silicified & fractured granodiorite, Py along fractures & some Cp. imp
Weak silicified massive granodiorite with some qtz.-veinlets & limonite-veins
Silicified granodiorite, some green copper & qtz-veinlets with K-feld. around the boundary
Gneiss
PS 100305
Cp Py imp
Dark green gneiss (amphibolite ?)
Silicified granodiorite, some green copper stains
Strongly silicified, sericitized & sheared Qtz. porphyry (bearing qtz phenocrysts), Py Cc imp & veinlets
geiss
PS 100306
PS 100307
RIO SALDAÑA
Strongly silicified & fractured Q-porphyry (biotite, sericite) with Py Cp Cc & qtz.-veinlets
Dark gray pyritized gneiss
PS 100401
Silicified & fractured qtz porphyry, Py Cp imp - veinlets deviloped
PS(SS) 100403
Pyritized gneiss
Dark green gneiss, Py imp veinlets & Cp imp
To Helreta
Fig - 48
GEOLOGICAL ROUTE MAP OF PUERTO SALDAÑA
LEGEND
Granodiorite (IBAGUE)
Quartz porphyry
Gneiss, amphibolite
Foliation
Location of sample
Scale (approx)
0
500M

Photo. 17 Outcrop of mineralized skarn,
in Los Guayabos area



Containing chalcopyrite-magnetite-green copper
(L.G.(R)100201)

Photo. 18 Outcrop of strongly phyllic altered Granodiorite,
in Puerto Saldaña area



Containing pyrite-chalcopyrite-chalcocite-green copper
veinlet (P.S(R)100301 & 100302)

As geological and geochemical investigations have not been carried out at eastern half area which was to the eash of the road and Saldaña river, it is necessary to confirm a distribution of quartz porphyry and mineralization-alteration zone in the area.

But, it may be considered that the main zone of economic value in Pto. Saldaña area has been eroded out, already.

Therefor, it is considered that it is not so hopeful to expect economic ore deposit in the only area.

7-3-5 Outline of Mina Vieja

The Mission inspected Mina Vieja mine which was to the southeast of Ibagué city prior to the field survey. A summary of the present situation of the mine is as follows.

Mine name	:	Mina Vieja
Mine owner	:	Promociones Industriales Y Minero Ltdo.
Geology	:	The upper Jurassic Ibaqué batholith has emplaced in the Payandé Formation, consisting of limestone and chert intercalated with shale, where skarn minerals has been formed.
Ore deposit	:	Skarn type copper ore deposit. Skarn minerals are composed of garnet, epidote, diopside etc., and magnetite, pyrrhotite, pyrite, chalcopyrite and hematite are ore minerals.
Dimension of the deposit	:	Crescent-shaped extending to east and west with maximum 20 m in width. Swedish company; Boliden estimated the ore reserves

at 456,000 t of average copper grade of 1.7 % as a result of exploration during 1961 - 1962. The majority of them was already mined out.

Production : Crude ore 250 t/day, Cu 1.9 %
Concentrate 270 t/month, Cu 25 - 29 %

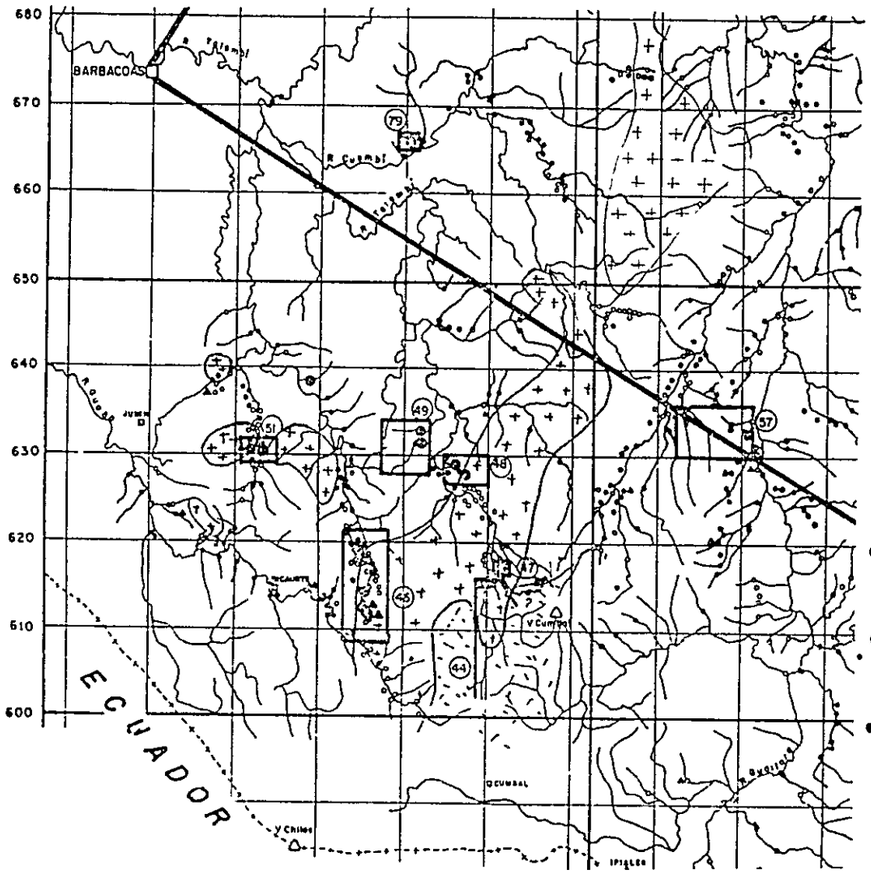
Personnel : underground 74 persons.
beneficiation 44 persons.

7-4 Piedrancha Area

7-4-1 Access and Topography

The Piedrancha Area is approximately 120 driving kilometers the west of Pasto and about 180 kilometers east from the Pacific coast. The potentially mineralized portion in the area lies within the lines of Long. 77°20' & 78°20' W. and Lat. 0°50' & 2°00' N. and has roughly 2,100 square kilometers of area (30 km x 70 km) with an axis in NNE direction.

The eastern part of the area has several villages such as Sotomayor, Samaniego and Guachaves (or Santa Cruz). In the south, many private houses exist along the driveway which connects Pasto with Tumaco harbor (Fig.-50). The most populated village in the south is Piedrancha which can be reached by three hours driving from Pasto and has some small restaurants and hotels. However, the central area where the potentially mineralized zone lies is very remote and covered with high-temperature and humid jungle where few village and no driveway is present. Existing here is only a small ranch (Ceiba) which is located at the junction of Sotomayor river and Cristal river. The ranch is about 25 kilometers east-north-east of Guachaves and connected with Sotomayor, Guachaves,



GEOQUIMICA

Resultados **Cu** y **Mo**

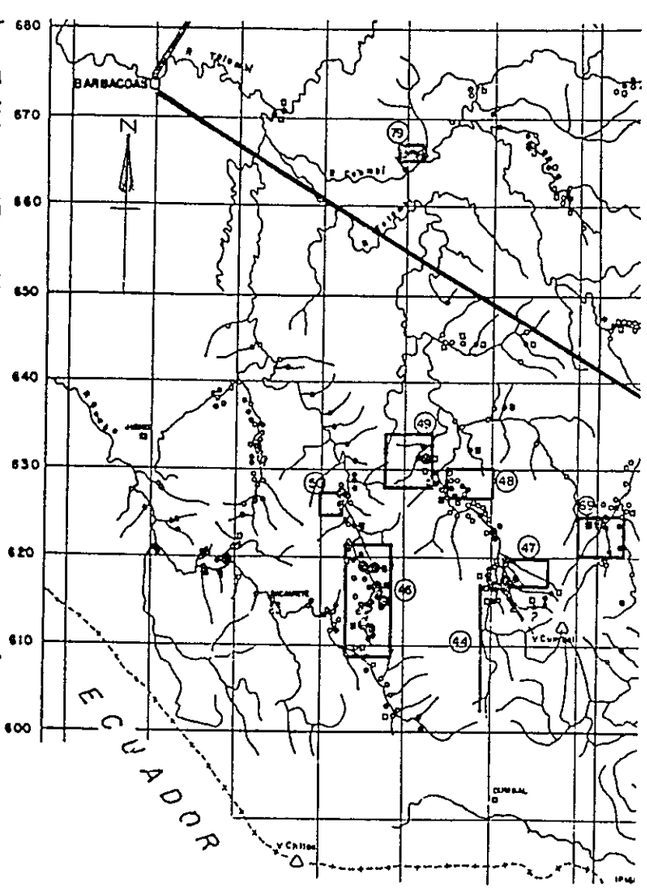
(31) Zona anómala en Cu y/o Mo seleccionada con número

o Ubicación de la muestra de sedimentos

Cortes elaborados para unidades litológicas y por medio de curvas de frecuencia acumulativa

Nº	UNIDAD LITOLOGICA	Cu ppm		Mo ppm	
		a> $\bar{x}$	a> 1	a> $\bar{x}$	a> 1
12	Neovolcanico	15	60	1	2.5
11	Sed Cretáceo-terciarios	19	68	1	5
10	Intrusivos no diferenciados	32	132	1	5.5
9	Sed Cretáceos (Villeta)	16	78	12	7
8	Volcanicos no diferenciados	20	80	1	3
7	Grupo Diabásico Cord C	70	160	1	2.5
6	Grupo Diabásico Cord Occ	107	180	1	2.5
4	Grupo Dagua	69	149	12	2
2	Complejo de Cajamarca	44	130	14	11
1	Igneos pramesozoicos	20	80	1	2.5

0 5 10 15 20 25 30 Km



GEOQUIMICA

Resultados **Pb** y **Zn**

(31) Zona anómala en Zn y/o Pb seleccionada con número.

o Ubicación de la muestra de sedimentos

Cortes elaborados para unidades litológicas y por medio de curvas de frecuencia acumulativa

Nº	UNIDAD LITOLOGICA	Zn ppm		Pb ppm	
		a> $\bar{x}$	a> 1	a> $\bar{x}$	a> 1
12	Neovolcánico	51	130	11	31
11	Sed Cretáceo-terciarios	73	168	12	38
10	Intrusivos no diferenciados	55	125	11	69
9	Sed Cretáceos (Villeta)	89	380	17	85
8	Volcánicos no diferenciados	36	150	16	42
7	Grupo Diabásico Cord C	62	148	10	28
6	Grupo Diabásico Cord Occ.	90	178	18	31
4	Grupo Dagua	80	160	11	28
2	Complejo de Cajamarca	80	240	11	48
1	Igneos pramesozóicos	46	108	10	27

0 5 10 15 20 25 30 Km

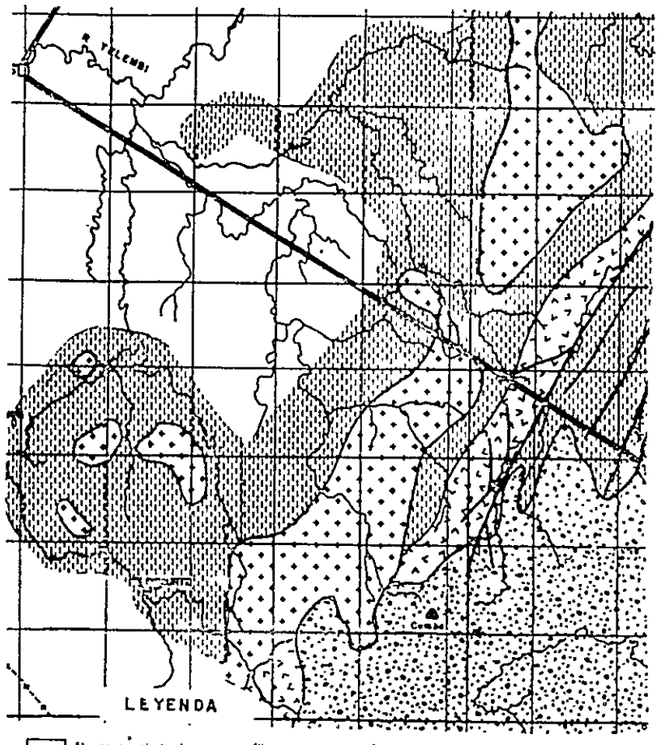
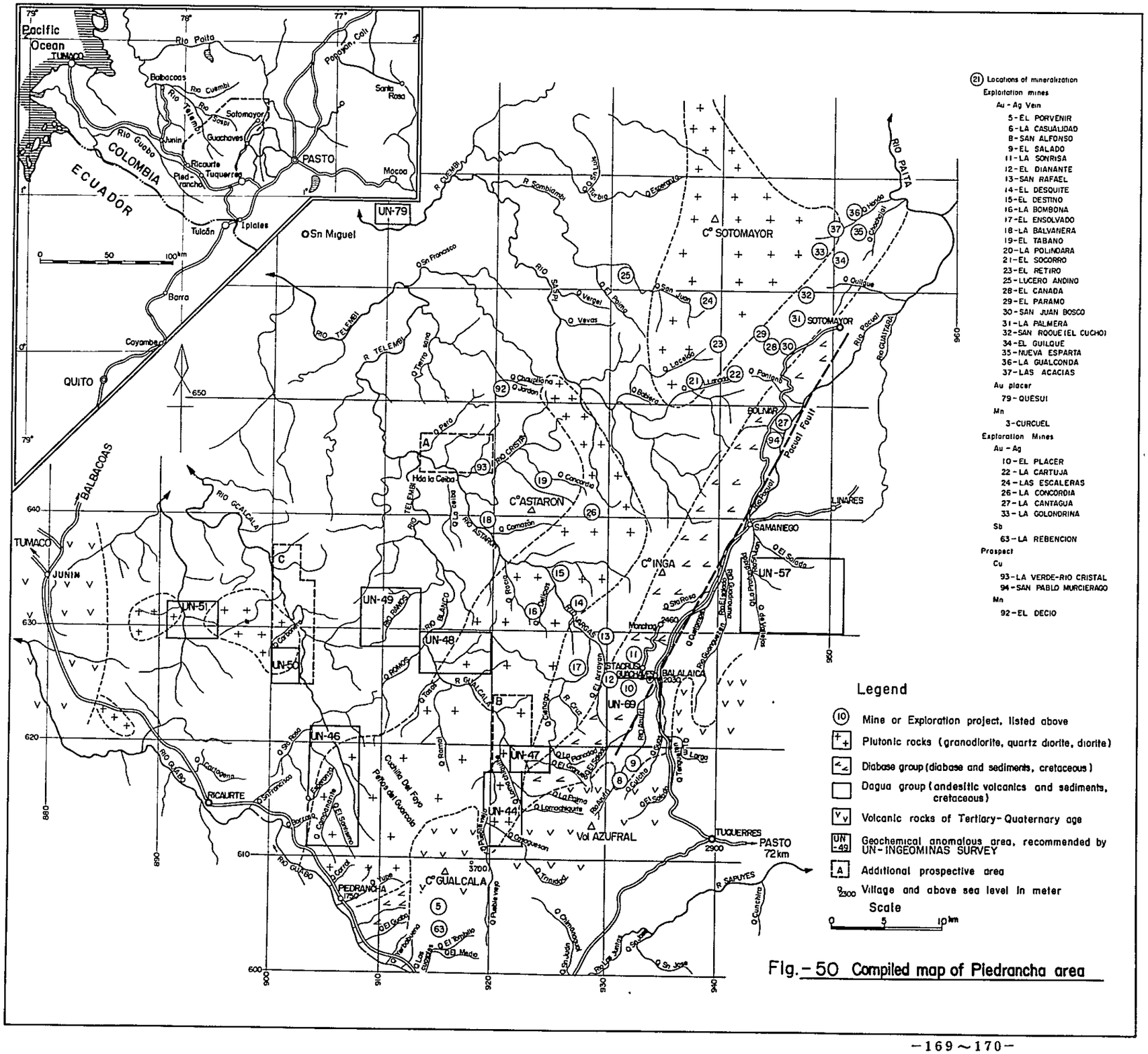


Fig.49 Localities of geochemical anomalies of UNDP 1st phase exploration work in the Piedrancha area.



(21) Locations of mineralization

Exploitation mines

Au - Ag Vein

5 - EL PORVENIR
6 - LA CASUALIDAD
8 - SAN ALFONSO
9 - EL SALADO
11 - LA SONRISA
12 - EL DIANANTE
13 - SAN RAFAEL
14 - EL DESQUITE
15 - EL DESTINO
16 - LA BOMBONA
17 - EL ENSOLVADO
18 - LA BALVANERA
19 - EL TABANO
20 - LA POLINDARA
21 - EL SOCORRO
23 - EL RETIRO
25 - LUCERO ANDINO
28 - EL CANADA
29 - EL PARAMO
30 - SAN JUAN BOSCO
31 - LA PALMERA
32 - SAN ROQUE (EL CUCHO)
34 - EL GUILQUE
35 - NUEVA ESPARTA
36 - LA GUALCONDA
37 - LAS ACACIAS

Au placer

79 - QUESUI

Mn

3 - CURCUEL

Exploration Mines

Au - Ag

10 - EL PLACER
22 - LA CARTUJA
24 - LAS ESCALERAS
26 - LA CONCORDIA
27 - LA CANTAGUA
33 - LA GOLONDRINA

Sb

63 - LA REBENCION

Prospect

Cu

93 - LA VERDE-RIO CRISTAL
94 - SAN PABLO MURCIERAGO

Mn

92 - EL DECIO

Legend

- (10) Mine or Exploration project, listed above
- Plutonic rocks (granodiorite, quartz diorite, diorite)
- Diabase group (diabase and sediments, cretaceous)
- Dagua group (andesitic volcanics and sediments, cretaceous)
- Volcanic rocks of Tertiary-Quaternary age
- UN-49 Geochemical anomalous area, recommended by UN-INGEOMINAS SURVEY
- A Additional prospective area
- 2300 Village and above sea level in meter

Fig.-50 Compiled map of Piedrancha area

Mallama and other villages by narrow passes which does not allow any four-wheel car. Some parts of the passways are the horse-ways. The ores mined in the Pasto area currently produce about 100 kilograms of gold per year; all of which are processed at Pasto by Zona Minera (the Mining Department) and being sold to the federal government.

The eastern part of the objective area has elevations ranging 2,700 to 3,500 metre, located at the south edge of the western mountain ranges of Colombia that has several peaks such as Gualcala, Inga and Sotomayor. The southern and eastern flanks of the mountains in the area, have very steep slope, 10 % in average, forming many falls and cliffs hear the mountain ridges, and rapidly decreasing the elevation toward west. It is only several handred meters at Ceiba ranch mentioned above.

The Pacual river with deep valley streams toward NNE through Samaniego in the east and the Guabo river flows northwest. Most of the streams flow northwest, joining Telembi river in the central area. The major tributaries of the upper Telembi rivers are Gualcala, Telembi and Saspi. Many gold mines are known in the area adjacent to Concordia and Vargas rivers, both of which are the uppermost branches (tributaries) of Telembi river, and also in the upper Saspi area. By the first phase UNDP exploration, Cu-Mo anomalies were detected along the upper Gualcala and Telembi rivers.

Because the objective area has abundant rainfalls and cloudy sky throughout the year, accurate topographic maps have not yet been completed, except for the 1/100,000 drainage pattern map which was produced from radar photographs (SLAR) and was the only avairable base map to us.

7-4-2 History of Investigations and Data

Although the Piedrancha area has been known for its gold deposits, the unfavorable topography and unhealthy climate had not permitted the detailed and systematic exploration. In May, 1973, UNDP-INGEOMINAS commenced the first systematic exploration which included the Piedrancha area at the southwestern edge of the project area.

The primary purpose of the first phase project was the regional geochemical investigation with some geological survey. As a result, some Cu-, Mo-, Pb- and Zn-anomalies were detected in the areas along the upper Gualcala and Telembi rivers as mentioned in the previous section and nine potential areas were chosen for the second phase exploration (Fig.-50, Nos. UN-44, 46, 47, 48, 49, 50, 51, 69 and 79). However, because the limited budget and the economical disadvantages to invest in such a remote and unhealthy area allowed the priority of exploration to more favorable areas other than the Piedrancha area, the second phase exploration was never carried out except for the uppermost area of the Block UN-46 where a geochemical investigation was conducted in 1978 by INGEOMINAS.

The lengthy rainfalls during the survey prevented us from accomplishing the investigation throughout the Piedrancha area. The areas we could conduct the geological investigation of the out-crops and samplings of stream sediments for the purpose of geochemical study were the Guachaves area and the several kilometer recesses of Piedrancha at the southern edge of the project area. Additional informations were acquired through the discussions and examinations on the data and samples collected by the Pasto Zona Minera Office which had provided technical and financial support and supervision for the mining industry in this region. Also,

the natives who were familiar with the local mining affairs in Piedrancha where the mission had temporarily settled its base had provided us further informations and some ore samples.

With the help rendered by Zona Minera Office which offered us a 1/500,000 map showing the locations of mines and project areas of exploration, some important localities and data were plotted on the map, Fig.-50, although it must be noted that accurate transcription was not able due to considerable difference of the topography on these maps.

Among the mines shown in Fig.-50, El Tabano mine is located northwest of Guachaves and is the largest mine in the Nariño Province. Here, production of gold-silver-chalcopyrite ores accompanied by quartz veins (1.5 - 2.0 metre average width) is in operation. The nearby mine, Concordia, had about 150,000 square kilometers of productive area (300 x 500 metre) and had produced roughly 300,000 tons of ores from underground for 30 years. Though the initial production was from the shallow veins in the sedimentary rocks overlying, the diorite body in which productive veins were also uncovered later.

However, the most abundant production are from the placer gold deposits currently mined in the vicinity of Barbacoas by down-stream of Telembi river where the simple and uncostly operation have encouraged the activities of many small firms and individuals. Nariño Mining Co., a joint firm headed by Choco-Pacifico Co., a subsidiary of American Gold and Platinum Co. once had some production at 25 kilometers up from Barbacoas.

7-4-3 Geology and Ore Deposits

i) Outline of Regional Geology

1) Geology

Colombia is divided into three topographic and geologic belts (eastern, central and western belts) which have the largest east-west extent (500 kilometer wide) in northern Colombia and rapidly decrease the extent toward south (Ecuadorian border). In the Pasto area, these belts are only about 150 kilometers wide and adhere each other with the regional structural trends in NE-SW to NNE-SSW. The eastern belt is characterized by Pre-Cambrian metamorphic rocks in the Mocoa area. Paleozoic slates and metamorphics are typical of the Pasto area in the central belt. Basic volcanics and sand/shale interbeds in Cretaceous system dominate in the belt of the west where the Piedrancha area is located. Tertiary and Quaternary andesitic volcanics (lavas, tuffs and volcanic mud flows) which occur in the Pasto area extending south and also in Junin area west of Piedrancha indicate that extensive volcanic activities took place in the southern Piedrancha area. The plutonisms in the southern part of Colombia are evidenced by the batholithes of Triassic/Jurassic and Cretaceous quarts diorites in the east, and Tertiary dioritic and granitic rocks which from batholithes or sills in the west, i.e. Piedrancha area.

The block of the "Mocoa Porphyry Copper Exploration Project" which is to the east of Piedrancha area has the most promising Cu-Mo mineralizations in the region. The project is currently under way by UNDP-INGEOMINAS. The western part of the Piedrancha area has been known for its many vein-type gold deposits in the area surrounding the upper Telembi river and active production from the placer gold deposits is

under operation near Barbacoas. In addition, the manganese ores had been produced at the location about 5 kilometers west of Piedrancha and the production of native sulfure in Chile volcano which borders Colombia from Ecuador is planned.

Geology of the Piedrancha area (upper stream area of Telembi rivers) has not been studied in detail because of the lack of the accurate topographic base maps. But several geological maps which were avairable show that the acidic plutonic rocks intruded to the Cretaceous sedimentary rocks, forming batholithic masses elongated northeast. Though the shape of the plutonic bodies are different in each map, the report of the first UNDP-INGEOMINAS exploration which probably was based on the most recent and reliable informations indicates that a 10 kilometer wide acidic plutonic belt extends about 50 kilometers from Piedrancha through the west of Samaniego as shown in Fig.-49. It is also indicated that the northeastern extention of the plutonic rocks is exposed in the area of about 15 x 20 km, centered by Sotomayor mountain, and extends further north with approximately 5 kilometer width. Three small plutonic masses composed of the same rocks are exposed about 15 kilometers north of Ricaurte in diameters ranging 3 km to 5 km, and one (10 x 2 km) at about 10 kilometers west of Ricaurte.

The main portions of these plutonic bodies consist of diorite, granodiorite and quartz diorite in the form of cupolas, apophysis, and/or dykes of andesitic - dacitic facies in the margins. These marginal branches have the important roles in the mineralizations which took place in both igneous and surrounding sedimentary rocks. (Ref. Recursos Minerales de Colombia, 1978, p.420).

2) Structure

In the eastern part of the area, about 5 kilometers in width "Diabase group" occurs along the west bank of Pacual river which is controlled by a major fault with NNE-SSW trend. This group is primarily composed of diabase interbedded with sandstones and shales. It is reported that the group is in Cretaceous system and is younger than the andesitic clastics (Dagua group) mentioned above.

In the whole area, the Pacual river fault is the only one confirmed by previous field investigations. However the whole geological structure in this area should be investigated further, the structural analysis based on the drainage patterns in the area suggests that the probable fissure zones have a NW-SE trend with a regular spacing of about 10 kilometers. It is also important that the anomalies which were detected by the UNDP-INGEOMINAS geochemical survey coincide with the structural trend (Fig.-51). Especially, it may be noteworthy to say that, in the intersection of the Pacual fault line and the geochemical anomalies' line (UN-49-48-47), there locates the volcan Azufral.

It may be acceptable that such structural trend could controlled the occurrence of the andesitic or dacitic intrusives branched off from the main plutonic bodies, and of the fissure zones which contain gold mineralization.

In Fig.-50, the locations of moderately anomalous zones are shown as A, B and C, which also should be remarked deriving from the UNDP-INGEOMINAS data. In addition to many gold deposits already discovered, it is expected that the northern half of the area still has many possibility to discover new ore deposits by the detailed samplings in the future.

ii) Geology and Mineralized Zone in Surveyed Area

It was able to observe a plutonic exposure near Piedrancha during our field investigation. The granodioritic rock, with milky color and coarse granular texture, is composed of anhedral to subhedral quartz and feldspars (partly K-feldspar) with minor amount of hornblende and biotite. The rock is apparently much acidic than the plutonic rocks in the other project areas, i.e. the dark green quartz diorite (Mandé Batholith) in the Acandi-Murindo-Pantanos area and the dark grey quartz diorite (Ibaqué Batholith) which are investigated already in the field by the mission. This plutonic rock is very fresh and does not show pyritization, nor any other evidences of mineralization.

Although, it has not been recognized any intrusives but Cretaceous sedimentary rocks with weak alteration during the field work in the Guachaves area in the south east, the mission were able to visit the Sonrisa gold deposit area which lies about halfway between Guachaves and Manchag. Here, it was suggested that the mineralization associated with 10 to 20 cm thick quartz veinlets which had N70°W to EW trends has an important relation with the fissure zones accompanied nearby trending in the same direction. The chemical analysis of the sample of stream sediments near an abandoned tunnels showed 1.39 ppm of Au, 5.5 ppm Ag and 206 ppm Cu (Table - 4), indicating good correspondence with mineralizations in the area.

Table - 6 and Fig.-53 (Photos Nos. CO-45 & CO-46) show the microscopic studies of the two samples from upper Telembi river north of Piedrancha.

The sample No.100902 (CO-45) was from a gold-bearing vein and it contains small grains of chalcopyrite in the matrix (quartz). The sample

No. 100903 (CO-46), in the size of fist, was a quartz vein with dacitic porphyry which has excessively been sericitized, and taken possibly from a dike-like mineralized zone. The sample contains a quartz veinlet with sphalerite, chalcopyrite, galena and pyrite. From the occurrence of the quartz veinlets, it is suggested that the mineralization might be occured in cavity-fillings or brecciated fissures. Fine sulfide disseminations are also recognized in the surrounding rock. It must be noted that the sample No. 100903 contains 4.4 ppm of gold as shown in Table - 5.

7-4-4 Summary of Survey Results

The Piedrancha area is considered to have a great potentiality of future discoveries of gold, silver, copper, lead, zinc and molybdenum deposits based on the following evaluations, although the informations and data are very limited because of the unfavorable conditions of climate and transportation during the field investigation.

i) UNDP-INGEOMINAS has revealed many Cu-, Mo-, Pb- and Zn-anomalies in the Piedrancha area.

ii) The northern Piedrancha area has many gold deposits with Cu-, Mo-, Pb- and Zn-mineralizations caused the quartz porphyries which intruded after the emplacement of the granodioritic masses.

iii) The geological condition that these deposits and anomalous zones are closely related to the several major fissure zones indicates the great potentiality of discoveries of some large or medium scale of ore deposits in this area.

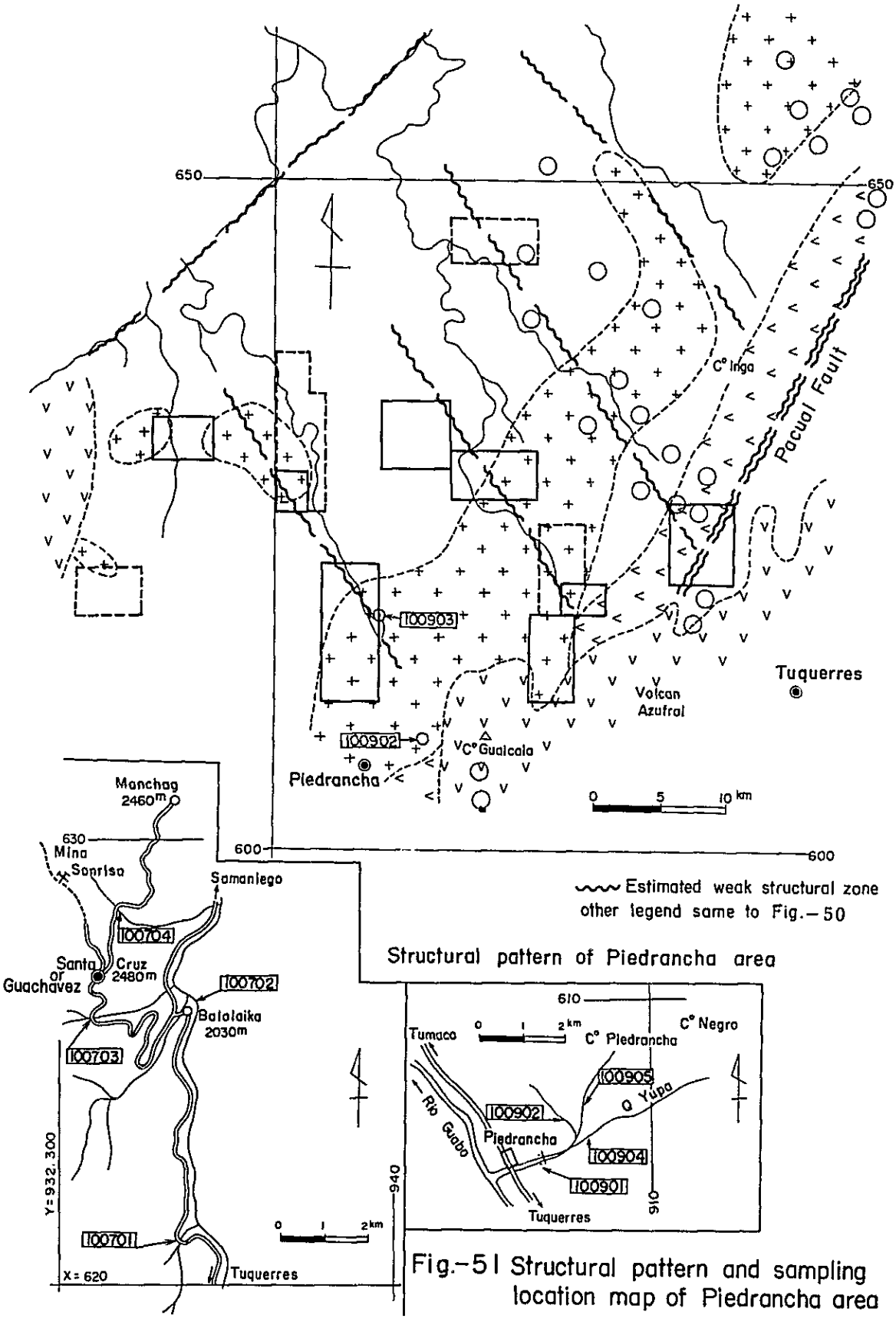
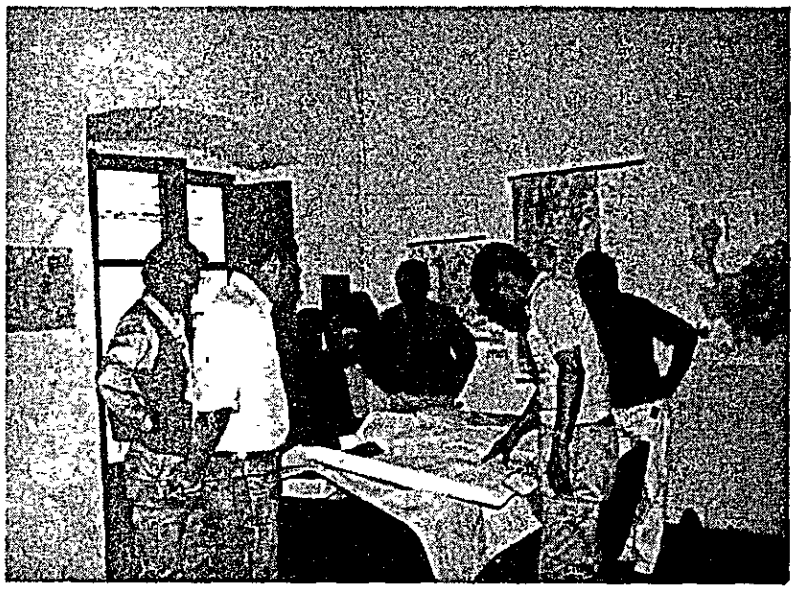


Fig.-51 Structural pattern and sampling location map of Piedrancha area

Photo. 19 Discussion on geological informations of Piedrancha area, at INGEOMINAS Popayán Branch Office

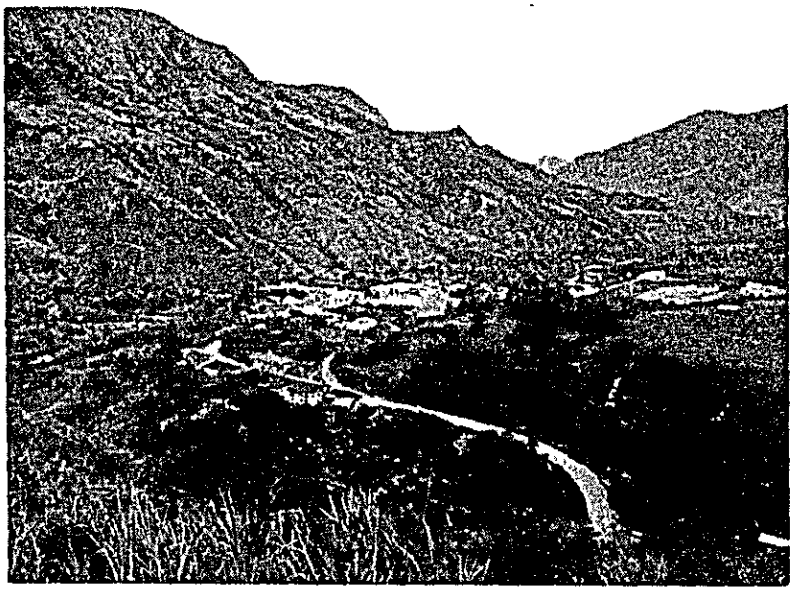


Mr. T. Suzuki
Dr. G.P. Quevedo (Subjefe)
Mr. J. Oikawa
Mr. N. Aizawa
Mr. H. Kamono
Dr. P.A. Marin (Jefe)

Photo. 20 Outcrop of altered andesitic rock in Cretaceous system, at Guachavez district in Piedrancha area

Containing pyrite-quartz veinlet

Photo. 21 A view of Piedrancha village



Looking the west (downstream)

Photo. 22 A view of southern part of Piedrancha area
($1{,}600^{m} \sim 3{,}000^{m}$ above the sea level)

Looking the south

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