REPORT
ON
THE SECOND INVESTIGATION OF ORE DEPOSITS
IN COLOMBIA

JUNE 1966

GOVERNMENT OF JAPAN

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PREFACE

In compliance with the request of the Government of the Republic of Colombia, the Japanese Government had dispatched the Survey Team for Mineral Resources in Colombia for the duration of about three months from December 1964.
The Survey Team, under the leadership of Mr. Yoshikazu Horikoshi, carried out field surveys throughout the country, indicated promising areas, and also emphasized the necessity of detailed investigations of such areas.

In 1965, upon receiving another request from the Colombia Government for dispatching the survey team again, the Japanese Government decided to continue the project and entrusted the Overseas Technical Cooperation Agency with the enforcement of the task.

Thereupon, the Overseas Technical Cooperation Agency organized a survey team which consisted of six members, led by Mr. Yoshikazu Horikoshi, Director of the Overseas Mineral Resources Development Co., Ltd., as was in the previous occasion.
The Team was dispatched to Colombia for a period of forty-five days from late January to the middle of March, 1966.

The Survey Team, collaborating with the Colombia Government officials concerned, investigated the areas centering on the Guajira and Gachala regions.
The results of the investigations are summarized and presented here as the Report on the Second Investigation of Ore Deposits in Colombia.

Should this report help acceleration of mineral resources development in Colombia and contribute to the economical interchange, as well as friendly relations, between Colombia and Japan, our pleasure would be immeasurable.

In conclusion, our heartfelt gratitude is expressed to the officials of the Colombia Government and many other people who rendered generous assistance and cooperation to the Survey Team in accomplishing the assigned task.

June, 1966

S. Shibusawa

Shinichi Shibusawa
Director General
Overseas Technical Cooperation Agency

CONTENTS

Ⅰ. Introduction

I. Introduction

(What were already mentioned in the Report of the First Survey Team are all omitted in this report. Hence the reader is requested to refer to the First Report.)

1. Purpose of dispatch of the Second Survey Team

In compliance with the request of the Government of the Republic of Colombia, the Japanese Government had dispatched the First Survey Team to make an extensive reconnaissance of mineral resources in Colombia for about two months from the end of December 1964. The Survey Team reported their results in the "Report on the Investigation of Ore Deposits in Colombia, Overseas Technical Cooperation Agency, May 1965". In the report the Team expressed some opinions pertaining to promotion of exploitation of mineral resources in Colombia, and pointed out several areas which have a large possibility of mineral resources, and also advised the Colombia Government to proceed the geological surveys of these areas on priority basis.

After the first investigation, the Colombia Government made another request to the Japanese Government in January 1966, asking for assistance in further investigation of mineral resources. Thereupon, the dispatch of the second mission for the investigation of mineral resources in Colombia was determined.

Making effective use of the experience of the previous investigations, the Second Survey Team restricted its sphere of activity to the areas of copper ore deposits, and carried out field surveys for a period of nearly forty days. (Refer to Fig. 1.)

2. Organization of the Survey Team

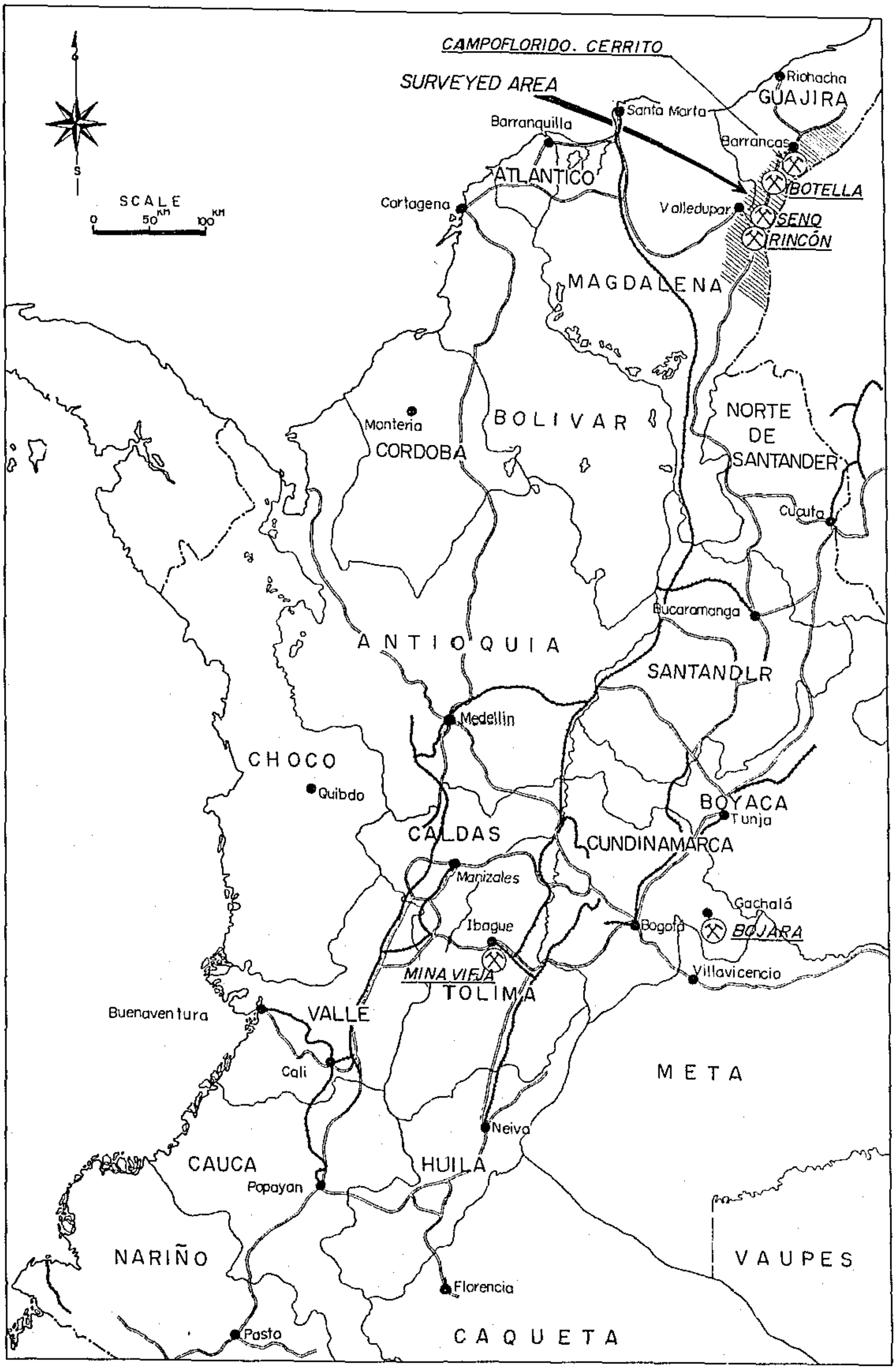
Leader:

Yoshikazu HORIKOSHI, Director of the Overseas Mineral Resources Development Co., Ltd.

Members:

Taiji OGAWA, Assistant chief of the Operation Department of the same company.

Fig I INDEX MAP OF SURVEYED MINE



Shiro FUKUNAGA, Non-regular staff member of the same company. (Member of the Ishihara Industry Co., Ltd.)

Tomiya NITTA, Ditto. (Member of the Mitsui Metal Mining Co., Ltd.)

Iwao IRIE, Ditto. (Member of the Toho Zinc Co., Ltd.)

Akira YATSUJI, Member of the Operation Department, Overseas Mineral Resources Development Co., Ltd.

3. Itinerary of the Survey Team

Date	Activity
Jan. 31 (Mon)	Left Haneda at 10:00. Changed plane at San Francisco.
Feb. 1 (Tue)	Reached Bogota at 7:00. Visited Ministry of Mines and Petroleum, and Japanese Embassy; made preliminary arrangements for the investigation.
Feb. 2 (Wed)- 4 (Fri)	Visited Servicio Geologico Nacional. Collected references and data on the areas to be investigated.
Feb. 5 (Sat)	Made preparations for survey trips.
Feb. 6 (Sun)	Left Bogota by plane and arrived at Barranquilla.
Feb. 7 (Mon)	Visited Branch Office of Servicio Geologico Nacional. Collected referential materials.
Feb. 8 (Tue)- 9 (Wed)	Studied the referential materials.
Feb. 10 (Thu)	On a small plane surveyed the southern part of the Guajira area.
Feb. 11 (Fri)	On a small plane surveyed the northern part of the Guajira area.
Feb. 12 (Sat)	Left Barranquilla (Horikoshi, Ogawa, Yatsuji and Irie by plane; Fukunaga and Nitta by jeep) and arrived at Valledupar.

Date	Activity	
Feb. 13 (Sun)	Made plans for survey work.	
Feb. 14 (Mon)	Surveyed the southern part of the Guajira area.	
Feb. 15 (Tue)- 16 (Wed)	Horikoshi, Fukunaga and Yatsuji carried out surface survey of northern Guajira area.	Ogawa, Nitta and Irie carried out surface survey of southern Guajira area.
Feb. 17 (Thu)	Left Valledupar and drove to Barrancas.	Continued surface survey of the southern area.
Feb. 18 (Fri)	Surface survey of northern Guajira area.	Same as above.
Feb. 19 (Sat)	Same as above.	Same as above.
Feb. 20 (Sun)	Left Barrancas and drove to Valledupar.	Indoor work and consultation with the northern survey team.
Feb. 21 (Mon)	On a small plane continued the survey of the northern Guajira area. Left Valledupar and drove to Barrancas.	Surface survey of the southern Guajira area.
Feb. 22 (Tue)- 24 (Thu)	Surface survey of the northern Guajira area.	Same as above.
Feb. 25 (Fri)	Left Barrancas and drove to Valledupar.	Same as above.
Feb. 26 (Sat)	Left Valledupar and flew to Cartagena.	
Feb. 27 (Sun)	Studied the referential materials and made preparations for survey work.	

Date	Activity	
Feb. 28 (Mon)	Horikoshi and Yatsuji flew from Cartagena to Barranquilla. Visited Servicio Geologico.	Ogawa, Fukunaga, Nitta and Irie flew from Cartagena to Bogota.
Mar. 1 (Tue)	Horikoshi and Yatsuji flew from Barranquilla to Bogota.	Ogawa, Fukunaga, Nitta and Irie collected and studied referential materials.
Mar. 2 (Wed)	*Discussed survey plans and collected referential materials for the areas to be surveyed.*	
Mar. 3 (Thu)-4 (Fri)	Preparations for survey trips.	
Mar. 5 (Sat)	Horikoshi, Fukunaga and Irie left Bogota and travelled to Gachala by car and on horseback.	Ogawa, Nitta and Yatsuji drove from Bogota to Ibague.
Mar. 6 (Sun)-8 (Tue)	Surveyed the Gachala area.	Surveyed the Vieja mine.
Mar. 9 (Wed)	Left Gachala and drove to Bogota.	Left Ibague and drove to Bogota.
Mar. 10 (Thu)	Arranged the obtained data.	
Mar. 11 (Fri)	Visited Ministry of Mines and Petroleum and also Servicio Geologico Nacional, to bid farewell. Arranged the materials; sent back the tools and equipments to Japan.	
Mar. 12 (Sat)	Visited Japanese Embassy to bid farewell. Made preparations for returning to Japan.	
Mar. 13 (Sun)	Packing and preparation for the homeward journey.	

Date	Activity
Mar. 14 (Mon)	Left Bogota at 13:00.
Mar. 16 (Wed)	Returned to Haneda at 17:55.

4. Acknowledgements

In accomplishing the assigned task, the Survey Team received the full-scale cooperation from the Government of Colombia, through the office in charge Servicio Geologico Nacional or Inventario Minero of the Ministry of Mines and Petroleum. In our field trips, there were many localities to which we were accompanied and guided by the technical experts of the Servicio Geologico Nacional, and collaboration with these people made the investigation work all the more effective. Despite the fact that the areas investigated were located in a rather remote part of the country, we were able to attain our object within a short period of time. This was possible only through the kind help and cooperation of the Government of Colombia and our deepest appreciation is expressed here.

Our sincere thanks are also due the officials of the Japanese Embassy and a great many of the Japanese residents in Colombia, for their kind guidance and assistance in keeping contact with the offices concerned, in collecting referential materials, and in many other ways as well.

Names of the Colombian officials who cooperated with the Team in the investigations are mentioned below.

Ministry of Mines and Petroleum

Minister	Dr. Carlos Gustavo Arrieta
Vice Minister	Dr. Aurelio Martinez Canaval

Servicio Geologico Nacional

Chief	Dr. Dario Suesecun Gomez
Secretary-general	Dr. Carlos Gomez
Technical official	Dr. Vincente Mutis Jurado
Technical official	Dr. Ignacio Cucalon

Technical official	Sr. Fernando Syala
Servicio Geologico Baranquilla	
Chief	Dr. Andres Jimeno Vega
Technical official	Dr. Jaime Cruz

Ⅱ. Ore Deposits Investigated by the Team

II. Ore Deposits Investigated by the Team

1. Copper indications in the northern region (Guajira and Magdalena)

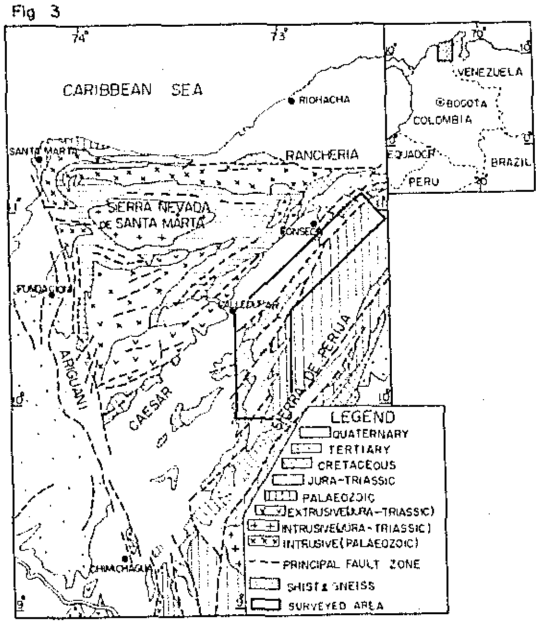
Object of investigation

In the northern part of Colombia, where the Departments of Magdalena and Guajira border on Venezuela, a branch of the Andes forms the Perija mountain range. The northwest foot of this range has been known since old days for numerous indications of copper deposit, some of which were investigated by the First Survey Team. Occurrence of porphyry copper deposit has also been reported in a few references. Therefore, we decided to investigate the region as extensively as possible.

Outline of structural geology (refer to Fig. 3)

Speaking of structural geology, the region is represented by a structural valley which is called the Caesar-Rancheria Valley, stretching for a distance

Fig 3



GENERAL TECTONIC MAP OF THE SIERRA NEVADA DISTRICT

SCALE 1:2000000

ACCORDING TO DR. ROBERTO WOKITTEL.
BOLETIN GEOLOGICO. VOL.V. No.3 F49

of 250 km in a direction of NE 30^{o} or so. Some of the faults that formed this valley are cutting through Oligocene strata, which suggests that the valley was born in the Tertiary period. Later, in the Quaternary period, two thrust faults, one running E-W along the northern coast and the other N-S extending from Santa Marta to Chimichagua, pushed up a mass of older rocks and formed the Sierra Nevada de Santa Marta, a triangular independent massif as high as 5,800 m above sea level.

The Perija range has, in the lowland at the foot of its northwestern slopes along the Caesar Valley, a large number of copper indications. Nevertheless, no plutonic rocks are found. Known igneous rocks are widely distributed andesites of Jura-Cretaceous age and small dikes and bodies of liparite of a somewhat younger age occurring chiefly in the northeastern area. Another characteristic feature is that the strata constituting the mountain range and varying in age from Paleozoic to Tertiary do not present folding structure; the strata are thrown down toward the Caesar Valley by simple faults of a NE-SW trend. According to our observation from an airplane, the Perija range, its highest peaks being about 3,500 m, is composed of almost always horizontal strata which hardly show any evidence of disturbance by igneous intrusion or some other causes. In other words, it seemed unlikely that the source or major bodies of the numeous deposits of copper oxides distributed at the foot of the range would be found in the inner part of this mountainous region. Thereupon, we decided not to carry out investigations in the inner land.

Outline of ore deposits

Fig. 2 shows the distribution of copper indications which became the object of investigation this time. The copper indications, distributed in the areas of supposedly Triassic to Jurassic or Cretaceous formations, are mostly of green copper oxides occurring in vein or in bedded form. Ore minerals are malachite, chrysocolla and azurite, rarely accompanied by native copper, cuprite and secondary bornite and chalcocite. Almost no copper sulfides of primary origin have been observed.

The country rock is locally affected by silicification, chloritization, epidotization or kaolinization, accompanied by quartz and calcite. In many cases, the ore deposits are apparently of in situ formation, but absence of iron sulfides is also a noticeable characteristic of the ore deposits in this region, which suggests that the mineralization was weak and of an unusual type. In some of the copper deposits it was observed, though in limited parts, that copper oxides have precipitated, replacing organic carbonaceous matter. This fact may indicate that the formation mechanism of these deposits bears some resemblance to that of the so-called Coro Coro type copper deposits. We conducted an extensive airborne survey over the both sides of the Caesar Valley, and noticed several zones of alteration and gossan. In the later field survey, however, they proved unpromising for any workable ore deposits, so that they are not described here.

A. *Cerrito - Campoflorido region*

This region includes several areas of copper indication, such as Cerrito, El Ojo, Carbonalito, Campoflorido and Rio Duluce. Ore deposits occur in a transitional area (200 - 300 m. in elevation) between the mountainous part and the plain at the foot of the western slope of the Perija mountain range, and constitute a zone trending NE-SW with a width of several kilometers. The ore deposits of the region can be classified into the following three types:

a) Copper oxides infiltrating into muddy sandstone, sandstone or some other rocks.

b) Copper oxides, accompanied by quartz and epidote, occurring in association with quartz porphyry.

c) Copper oxides, accompanied by such gangue minerals as quartz, calcite, epidote and kaolin, occurring in faults or crushed zones.

Deposits of type a) are numerous in the northern area (Cerrito, El Ojo, Carbonalito), whereas types b) and c) are abundant in the southern area (Campoflorido, Rio Duluce).

i) Cerrito

Kind of ore: Cu

Date of investigation: Feb. 22 - 23, 1966

Investigated by: Horikoshi, Fukunaga, Yatsuji

Location and communication: (See Fig. 2)

The mineralized zone, located at an elevation of about 220 m, is about 10 km east of Barrancas and can be reached in about one hour and thirty minutes by jeep from Barrancas, but the condition of the road is extremely poor.

Geology: The area is composed of alternating beds of muddy sandstone, sandstone and conglomerate, which may be assigned to Jurassic age. In both lithology and the characteristic dark-red color, the beds are similar to those of the Carbo-

Table 1

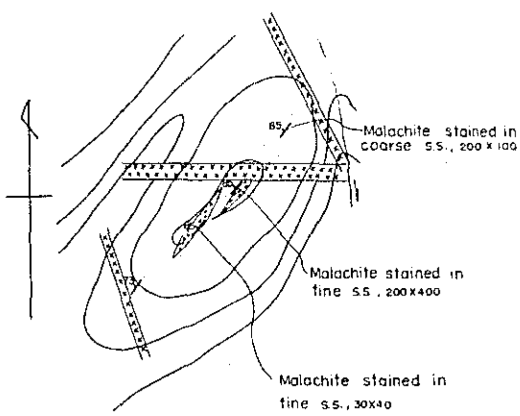
Locality	Strike	Dip	Width(m)	Length(m)	Remarks
1	N25°E	85°N	0.5	2.0	Malachite impregnation in sandstone.
2	N50°E	80°N	0.3	1.0	Same as above.
3-a	N50°E	⊥	0.5	1.0	Same as above.
3-b	N50°E	⊥	1.0	2.0	Same as above.
3-c	N55°E	75°N	1.0	7.0	Same as above.
4-a	N35°E	85°N	0.5	0.3	Same as above.
4-b	N35°E	85°N	2.0	4.0	Same as above.
4-c	N35°E	85°N	2.0	1.0	Same as above.
5	N60°E	⊥	1.0	10.0	Malachite impregnation in crushed part of alternation.

(Note: Locality No. 4 is the Los Magueyes outcrop.)

nalito area. The strike of the beds in N 35° - 70° E and the dip is 70° N to vertical; the dip is reverse to that in the Carbonalito area. The Jurassic formation is locally intruded by quartz porphyry dikes, 2 - 5 m wide and several meters long, showing two directions of intrusion, E-W and NW-SE (Fig. 4).

Ore deposit (Fig. 2): The ore deposits are malachite impregnations in the sandstone of the above-mentioned alternation, or in the crushed part of the alternation. Such impregnations are observed at nine localities in five areas. As listed below, all impregnations are very small in scale and low in ore grade, Cu being only 0.2% or so.

Conclusion: The ore deposits may have been formed in situ, but the possibility of their further extension is very small and the ore grade is too low. Therefore, the area is not worthwhile exploitation.



ii) El Ojo

Kind of ore: Cu

Date of investigation: Feb. 22, 1966

Investigated by : Horikoshi

Location and communication: (See Fig. 2)

Fig. 4 LOS MAGUEYES, CERRITO

Scale 1:2000

Fine ~ coarce sand stone
Conglomeratic
Quartz porphyry
Malachite stained part

The mine is located two hours from Barrancas by jeep. The latter half of the road is very poor, having partially collapsed. The copper indications are found in the hills near the village of El Ojo (Fig. 5).

Geology and ore deposit: The area is composed of a probably Jurassic beds alternated of sandstone and mudstone, locally intercalated with conglomerate. Pebbles of the conglomerate comprise andesite breccia, sandstone, quartzite and quartz porphyry. The beds strike NW 50° - 70° and dip about 35° NW. At the top of the hills are found small stocks of andesite.

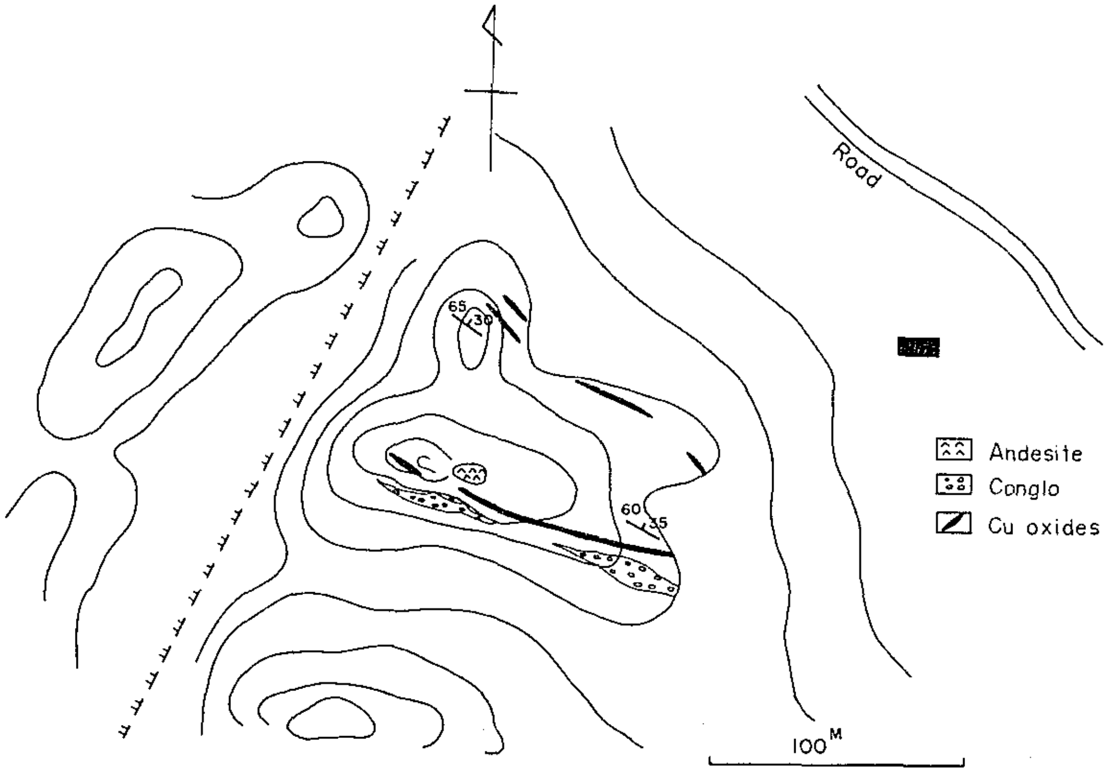


Fig 5 EL OJO

The copper indications consist essentially of copper oxides which show vein-like distribution occurring as spots or thin films in the fissures of the sandstone where silicification or epidotization is remarkable. Thickness of the vein-like portion at the outcrop is less than 1 m, irregularly pinching and swelling; the extension in strike direction does not exceed 100 m. The average ore grade of the vein is estimated at about Cu 1%. Malachite is the principal ore mineral; azurite and native copper are also found though rarely.

The ore vein is discontinuous in the west due to fault. Its eastern part is covered with surface soil. What they call copper outcrops in the southeast have proved to be chlorite-rich parts, and so their exploitation is out of the question.

Conclusion: Since silicification or epidotization of some extent is always recognized near the vein, the copper mineralization may have taken place in situ, but the mineralization is weak and little can be hoped for further development.

iii) Carbonalito

Kind of ore: Cu

Date of investigation: Feb. 22, 1966

Investigated by: Fukunaga, Yatsuji

Location and communication: (See Fig. 2)

Situated at an approximate elevation of 250 m, the mineralized zone is 9 m east-southeast of Barrancas, and can be reached in about one hour and fifty minutes by jeep from Barrancas.

Geology and ore deposit (Fig. 6): This area ia composed of a probably Jurassic alternation of muddy sandstone, sandstone and conglomerate. Each member of the alternation is generally dark-red, but sometimes grayish where the rock is bleached by precipitated copper oxides. The muddy sandstone often contains carbonaceous matter, 4 - 5 cm long, parallel with the bedding plane, and in many cases copper oxides are precipitated around this carbonaceous matter. The sandstone is usually fine- to medium-grained. Pebbles of the conglomerate are 1 - 3 cm in diameter, comprising andesite, quartz porphyry, sandstone, etc. The alternation is locally displaced but strikes generally N 18° - 50° E and dips 55° - 70° S.

The ore deposits occur where malachite, locally azurite, impregnated the Jurassic muddy sandstone and sandstone, or occasionally conglomerate. Each of the impregnations is of a very small scale, generally being 0.3 - 2 m x 0.3 m x 2.5 m in dimensions. These impregnations are aligned almost straight for a distance about 300 m in the direction of N 35° E, as illustrated in Fig. 6. Such linear distribution of the impregnated parts indicates that a structure line exists in this direction along which the mineralization had taken place. The ore grade of the respective impregnations is Cu = tr. to 0.3% or so.

Conclusion: The ore deposits are very small in scale and low in grade, so that they cannot become the object of exploitation.

iv) Campoflorido

Kind of ore: Cu

Date of investigation: Feb. 17 - 18, 1966

Investigated by: Horikoshi, Fukunaga, Yatsuji

Location and communication: (See Fig. 2)

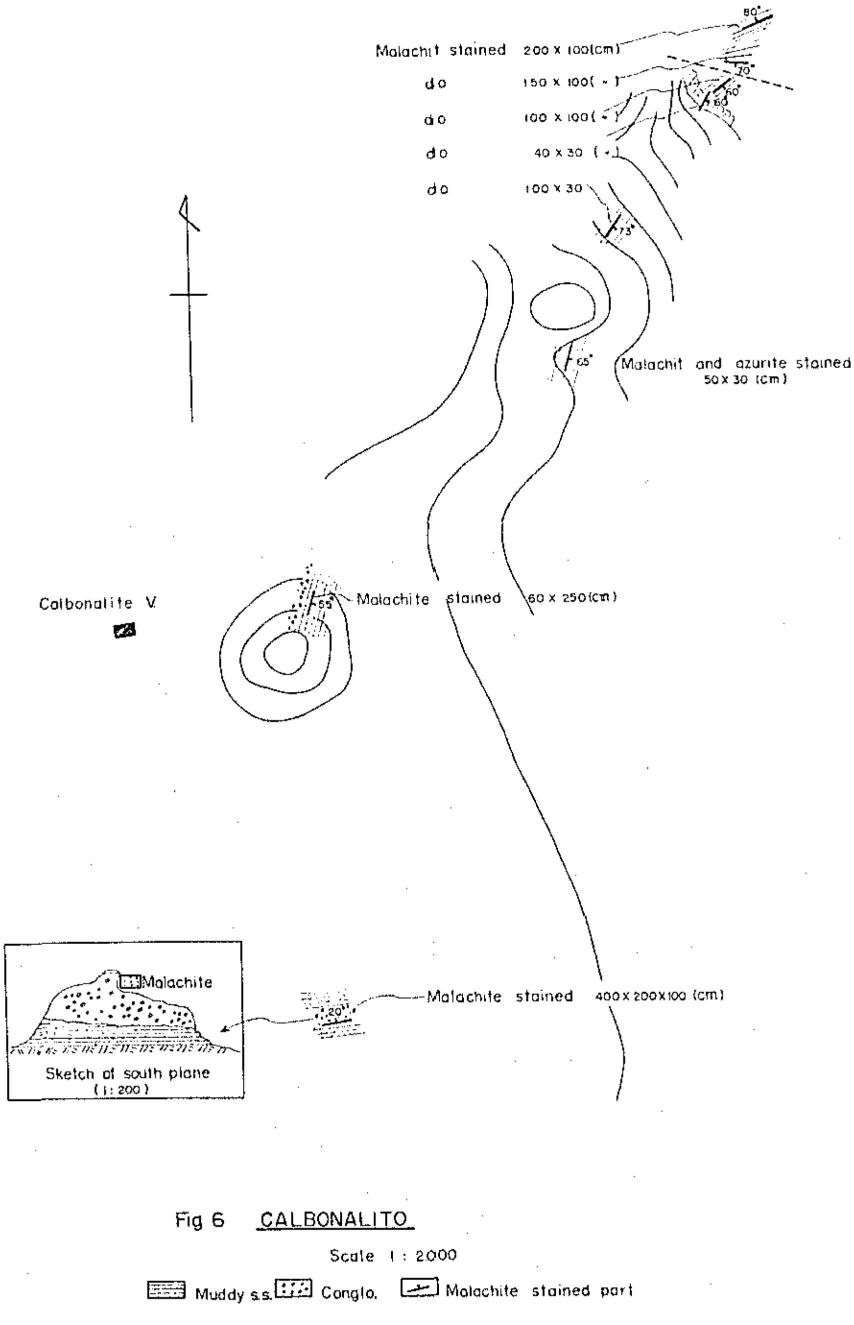


Fig 6 CALBONALITO

Scale 1 : 2000

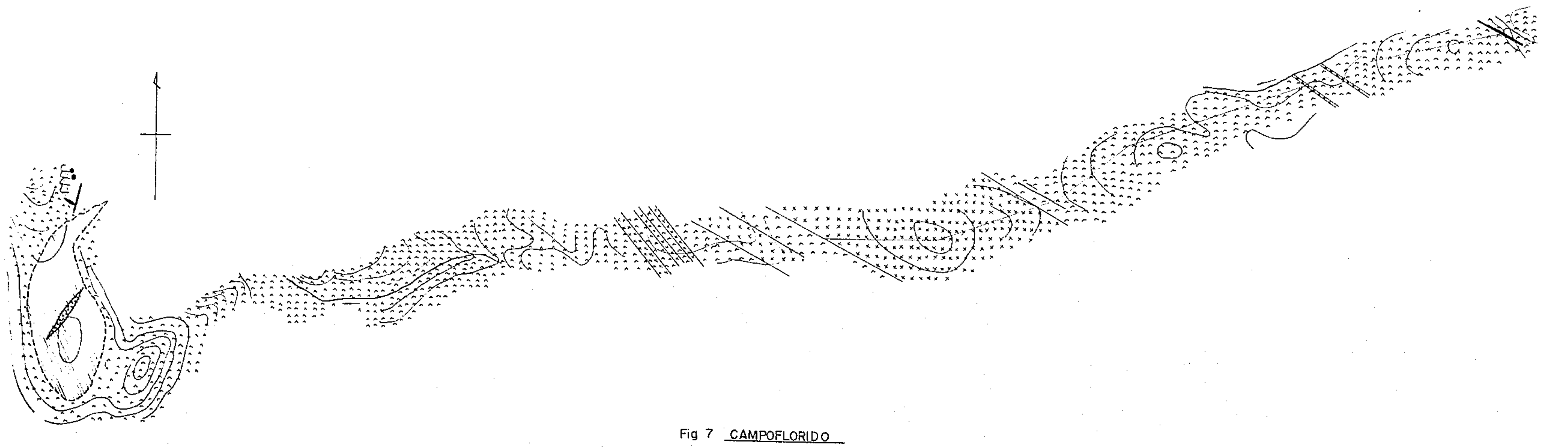


Fig 7 CAMPOFLORIDO

Scale 1:2000

Andesite Quartz porphyry Ore deposit

Occurring at an elevation of about 300 m, the mineralized zone of Campo-florido is about 10 km southeast of Barrancas and can be reached by jeep in one hour from Barrancas.

Geology and ore deposit (Fig. 7): The geology consists of andesite lava and andesite breccia, which are intruded by quartz porphyry. The andesite and andesite breccia are generally hard, but are partially kaolinized due to mineralization or intrusion of quartz porphyry. The andesite and andesite breccia, supposed to be of Jurassic age, strike N 20° E and dip about 80° N. Intrusion of the quartz porphyry is controlled by two directions, one is almost N-S and the other is NE-SW. The dikes of NE-SW trend are larger in number than those of N-S trend; the structure controlling the former may be ascribed to shearing, and that for the latter to tension. The dikes are 3 - 70 m wide, and less than 100 m long. The quartz porphyry is hard, poor in quartz phenocrysts, and is generally affected by silicification, epidotization and kaolinization on account of the mineralization.

The ore deposits comprise two types; one is the so-called porphyry copper deposit where copper oxides, such as chalcocite, native copper and malachite that are accompanied by quartz and epidote, occur as spots in the above-mentioned quartz porphyry, and the other type is represented by films of copper oxides that have soaked into cracks of the quartz porphyry. In general, these two types co-exist. A noteworthy ore deposit within the investigated area is located in the west (Fig. 7). It is roughly oval in shape, being 70m in longer diameter and 30 m in shorter diameter, forming a small mound about 4 m in relative height. This ore body occurs at the junction of the N-S structure line and the NE-SW structure line. The highest grade is Cu 9% and the average value is Cu 0.2%. Besides, mineralized dikes of quartz porphyry, less than 1 m in width and trending NE-SW, are found at two localities but they are not worthy of discussion because of the low grade of ore and the small scale.

Conclusion: From the evidence of silicification, epidotization and kaolinization in ore bodies, the ore deposits must have formed in situ. The fact that the copper minerals are associated with quartz porphyry is significant in elucidating the relationship between the mineralization and the igneous activity of this area. However, the mineralization is not very prominent here, so that one cannot expect to find ore deposits of economic value.

v) Rio Duluce

Kind of ore: Cu

Date of investigation: Feb. 19, 1966

Investigated by: Horikoshi, Fukunaga, Yatsuji

Location and communication: (See Fig. 2)

Situated at an elevation of about 300 m, the mineralized zone of Rio Duluce is about 11 km southeast of Barrancas, and is reached in one hour and fifteen minutes by jeep from Barrancas.

Geology and ore deposit (Fig. 8): The geology of this area consists of an alternation of andesite lava, medium-grained sandstone and conglomerate. The alternation is intruded by quartz porphyry which occurs as stocks or dikes of various sizes. The alternation strikes N 25° E and dips about 25° E; displacement of the constituent beds is not conspicuous. Pebbles of the conglomerate are mostly andesite and quartz porphyry, 1 - 3 cm in diameter. On the west side of the mineralized zone the largest intrusive body of quartz porphyry is found; it is a stock about 700 m x 300 m, elongated in the direction of NE-SW, and forms a 360 m high mass. Other bodies of quartz porphyry are dikes or stocks of a smaller scale, mostly 3 - 0.4 m wide and 2 - 4 m long, and are scattered numerously throughout the mineralized zone. The intrusion of the quartz porphyry is controlled by two prominent structure lines, one is roughly N-S and the other is NE-SW.

As shown in Table 2, almost all the ore deposits of this area stretch in the direction of N-S or NE-SW. They are veins of a small scale, being 3 - 0.2 m wide and 20 - 1.6 m long. Ore minerals are copper oxides, chiefly malachite, occurring as thin films of impregnation in the crushed zone (fault) of andesite, sandstone and conglomerate or in the cracks of small bodies of quartz porphyry. The copper minerals are almost always associated with quartz, chlorite, kaolin

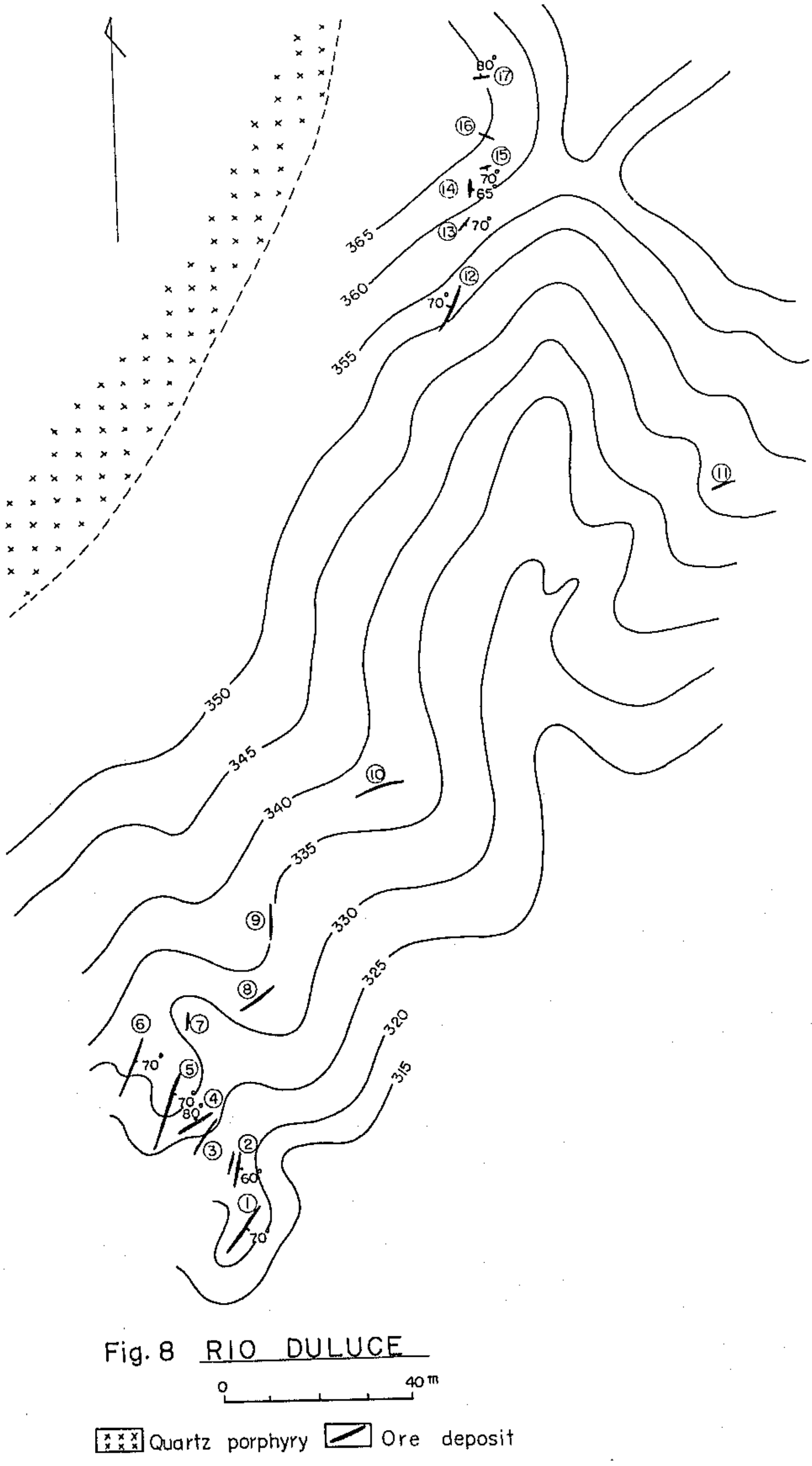


Fig. 8 RIO DULUCE

Table 2

Rio Duluce Deposits

Deposit No.	Strike Dip	Width (m)	Length (m)	Ore mineral	Gangue mineral	Country rock
1	N20°E 70°E	0.5	14		Quartz net.	Andesite
2	N10°E 60°E	0.2	6		Quartz	do.
3	N35°E	0.2	13		do.	
4	N60°E 80°W	0.2	9		do.	Conglomerate
5	N20°E 70°E	2.0	2.0	Malachite	do.	Conglomerate Sandstone
6	N20°E 70°E	1.8	15	do.	do.	Conglomerate
7	N10°E	1.8	4.0	do.		Quartz porphyry
8	N55°E	0.3	10.0	do.	Quartz	Andesite
9	N-S	3.0	5.0	do.(tr.)	Quartz Chlorite	Conglomerate
10	N70°E	3.0	15.0	do.	Quartz	do.
11	N70°E	3.0	7.0	do.(tr.)	do.	Quartz porphyry
12	N25°E 70°N	4.0	12.0	do.	Chlorite	Conglomerate
13	N30°E	1.4	2.0	do.	Quartz	Quartz porphyry
14	N-S 65°E	3.0	2.0	do.	do.	do.
15	N75°E 70°S	1.1	1.6	do	Quartz Kaolinite	do.
16	N70°W	1.5	1.6	do.	do.	Andesite
17	N80°E 80°N	0.4	4.0	do.	do.	Quartz porphyry

and calcite. The ore grade is generally very low, Cu being trace to about 0.2%.

Conclusion: In both scale and ore grade, the ore deposits of this area are not worthwhile exploitation. However, the fact that mineralization is not recognized in the large bodies of the quartz porphyry, whereas the minor bodies derived from the larger ones or the small structure lines around the larger bodies show the effects of mineralization, is interesting in clarifying the relationship between the igneous activity and the mineralization.

B. Villanueva - Urumita - San Diego region

An eastern branch of the Andes, forming the boundary between Venezuela and northeastern Colombia (Guajira and Magdalena), is called Serrania de Perija. At its northwestern foot (200 - 900 m above sea level) where the mountains plunge into the Caesar Valley, several indications of copper have been known since old days. Among them the existence of low-grade but large-scale "yacimientos de diseminacion en porfidos" (porphyry ore) is reported. * With its big possibility of copper deposits, this region has been ranked next to the Gachala region.

For a period of nearly two weeks, we investigated the copper deposits in the southern part of the region, an area of approximately 1,500 km^2, extending from Villanueva to Codazzi for about 50 km with a width about 30 km. Mines and copper indications thus investigated are seventeen in number, as listed below from north to south. (See Fig. 2)

A) (Southeast of Villanueva) Botella.

B) (South of Urumita) Loma de Corazon I, II, Porta Chuel I, II, Gallinazo, Plancito, Fatigosa, Magueyal.

C) (East of San Diego) Oveja.

D) (Southeast of San Diego) Seno, La Riga, Zeppelin.

E) (Southeast of San Diego) San Jose I, II, Quinta-Frio.

F) (Southeast of San Diego) El Rincón.

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* Comilacion des Los Estudios Geologicos Oficiales en Colombia, Tomo X. Servicio Geologico Nacional.

The above-mentioned deposits and indications will be described later, but the deposits can be classified into the following three types:

1) Chalcocite veins occurring in andesitic rocks. The ore grade is high but the scale is small. (Botella)

2) Aggregates of small veins of Cu-bearing quartz-epidote, occurring in the alternation of andesitic lava, tuff breccia and sandstone. In many cases they present a bedded form but the ore grade is generally very low so that they ought to be called copper indications rather than ore deposits. (Oveja, Seno, etc.) Majority of the deposits are of this type.

3) Green Cu-veins disseminated in brecciated quartz veins intruding the red sandstone. They are arranged en echelon. As a source of copper oxides, as well as of copper sulfides underneath, deposits of this type are worthwhile exploration and exploitation. (El Rincon)

The geology of the region is represented by the Jurassic-Triassic Quinta formation which generally strikes NE-SW and gently dips to NW. Near the axis of a syncline formed by gentle folding, the formation is overlain by the Cretaceous formation which consists chiefly of limestone.

At the western foot of Serrania de Perija, such igneous rocks as dacite, andesite and microgabbro are distributed, generally concordant with the surrounding geologic structure. These rocks are mostly lavas, partly intrusive necks, all being members of the Quinta formation.

The ore deposits are supposed to have been formed in relation to the activity of these igneous rocks; localization of the deposits is limited in or around the igneous rocks. From north to south the igneous rocks change their nature from acidic to basic, and grade from effusive into hypabyssal. Following these changes, the ore deposits gradually improve southward in both scale and grade.

None of the ore deposits is being worked at present, and any deposits worthy of immediate exploitation are not found. However, El Rincon located in the southern end of the investigated area may be worthwhile exploration, because the total reserves of copper oxides and copper sulfides are estimated at about 200,000 tons there.

vi) Botella

Kind of ore: Cu

Date of investigation: Feb. 22, 1966

Investigated by: Ogawa, Nitta, Irie

Location: 9 km southeast of Villanueva City, Guajira Province, and on the north bank of the Villanueva River.

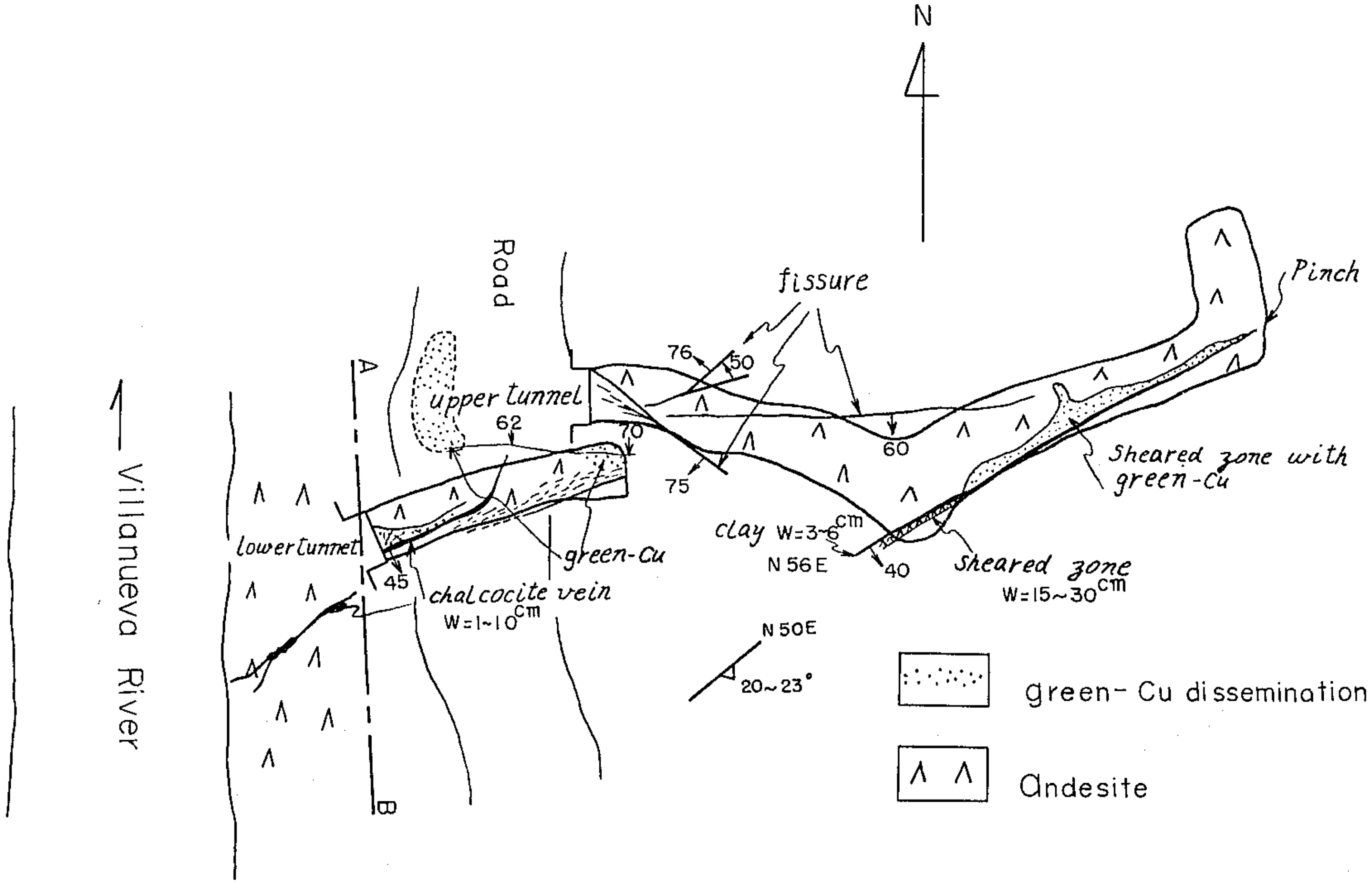
Communication: Villanueva City $\frac{\text{(by jeep)}}{\text{5.7 km}}$ Sta Cruz $\frac{\text{(on foot)}}{\text{6.3 km}}$ — Botella mine.

Geology and ore deposit: At the western foot (680 m above sea level) of Serrania de Perija, the Jurassic-Triassic Quinta formation is distributed. Ore occurs in the flow of an andesitic rock (striking N 50° E and dipping 20° - 23° SE) which belongs to the Quinta formation. The ore deposit is a vein type deposit, composed of small veins of chalcocite and green Cu-minerals, chiefly malachite, disseminated around the former. The andesitic rock near the ore deposit is slightly bleached.

There are two old tunnels. One was driven from the river level, and is 8.5 m long (Lower Tunnel). The other was driven from the road about 3 m above the former, and is 26 m long (Upper Tunnel). (See Fig. 9)

In the lower tunnel a chalcocite vein, with a 2 - 3 cm average width partially widening to 10 cm, extends from the entrance of the tunnel for about 4 m, and pinches out forward. The ore grade of the vein is estimated at Cu 15%. Near the entrance and the face, weak disseminations of green Cu-minerals are observed. Between the entrance and the river, chalcocite occurs in fine veins or lenses, 7 - 8 cm in maximum width, and * hereabout disseminated green Cu-minerals are also found; high-grade portions of the disseminations may be estimated about Cu 20%.

The upper tunnel has hit the sheared zone (striking N 56° E and dipping 40° S, with a width 15 - 30 cm) after cross-cutting for a length of 12 m from the entrance, and from there a drift was made for a length of 14 m. However, the sheared zone is pinching out at the face. In this sheared zone and on its foot



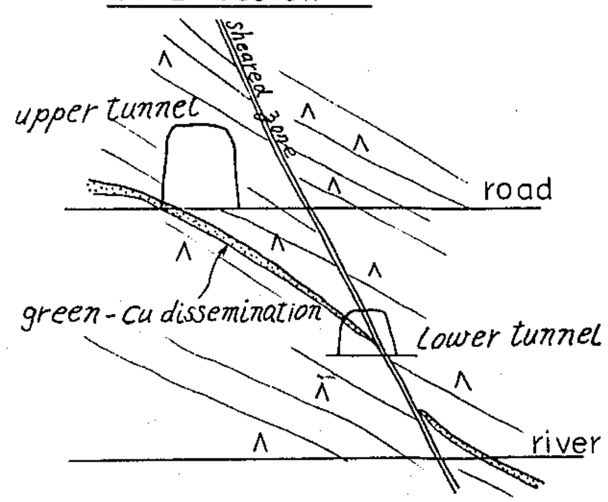


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Fig 9 MINA BOTELLA

wall, green Cu-minerals are disseminated with an average width of 20 cm, partially as wide as 1 m. The dissemination is 11 m in extension and the ore grade may be Cu 8 - 10%. Dissemination disappears where the sheared zone has pinched out. Another dissemination of green Cu-minerals is observed on the road surface in front of the adit; it covers an area of about 6 m x 1 - 1.5 m and the copper grade is estimated at 8%.

The ore deposit here supposed to be formed when the mineral solution, originated from the intrusion of the porphyritic rock which is distributed in the neighborhood, ascended along the strongly sheared zone (with a general strike N 56°E and a dip 40°S) and precipitated. The green Cu-impregnation as observed in front of the adit may be explained as follows: Part of the mineral solution branched off from the strongly sheared zone and entered another weaker sheared zone, 20 - 30 cm wide (with a strike N 50° E and a dip 20° - 23° SE), along the flow of andesitic rock and impregnated the rock; this sheared zone is shorter than the former. The dissemination looks large but this is because the dip of the sheared zone along the andesitic flow is gentle so that the 20 - 30 cm wide vein is widely exposed on the ground surface (refer to Section A-B in Fig. 9). Estimate of the ore grade mentioned above is based on the paper of Dr. Roberto Wokillel.

Conclusion: The chalcocite vein as observed in the lower tunnel is 4 m long and 2 - 3 cm wide; the green Cu-impregnation along the sheared zone of the upper tunnel is 11 m in extension and 20 cm in width. The both deposits are of a small scale. Extension of the green Cu-impregnation on the ground surface in front of the upper tunnel is not hopeful.

vii) Area south of Urumita

Kind of ore: Cu

Date of investigation: Feb. 23 - 24, 1966

Investigated by: Ogawa, Nitta, Irie

Location: 3 - 7 km south of Urumita City, Guajira Province

Communication: Valledupar City —(by jeep) 18 km— Las Paz City —(by jeep) 30 km—

— Urumita City $\frac{\text{(by jeep or on horseback)}}{\text{3 - 7 km}}$ Mine

Geology and ore deposit: The western foot (450 - 900 m above sea level) of Serrania de Perija, south of Urumita City, has been known since old days for some copper indications. Based on the literature and spoken information, as well as on the knowledge of our guide, we investigated the following eight indications which are supposed to include almost all the copper indications in this area (Fig. 2).

A) (Northeast side of Rio Urumita) Loma de Corazon I, II, Portachelo I, II.

B) (North side of Ay. Marquesote) Gallinazo, Plancito, Fatigosa.

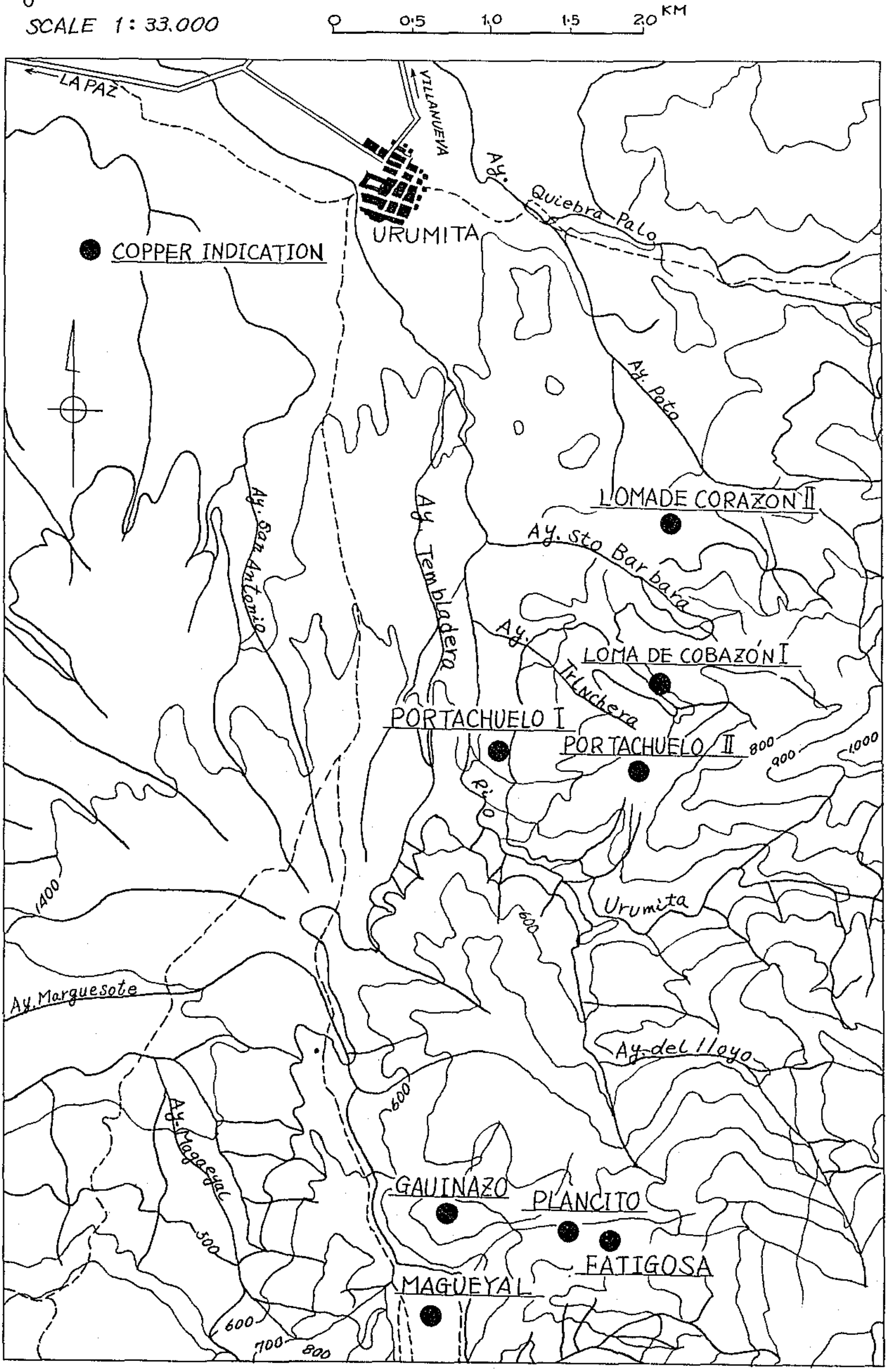
C) (South side of Ay. Marquesote) Magueyal.

The geology of the area is represented by the Jurassic-Triassic Quinta formation composed of an alternation of andesite lava, tuff breccia and red sandstone. The formation strikes generally NE-SW and the dip is NE where the formation is gently folded. As is the case with some ore deposits found in the vicinity of San Diego City about 25 km south of Urumita City, the ore deposits of this area are aggregates of green copper-disseminated quartz-epidote veins. These veins are supposed to have been formed when a Cu-bearing residual solution, in the process of its segregation, filled small fissures of the andesite or infiltrated from the andesite into the red sandstone. Most of them are lenticular or wedge-shaped, but patches are also found on rare occasions. The veins are generally of a small scale, being several centimeters in width and several tens of centimeters in length; even the largest ones are several tens of centimeters in whidth and several meters in length. Ore minerals are malachite, chrysocolla, azurite, bornite, chalcocite, cuprite and native copper, which are disseminated in the quartz-epidote veins. No primary sulfide copper minerals are recognized.

Each of the mineralized zones is several tens of centimeters in width and about 100 m in length. Despite the fact that the quartz-epidote veins are more or less obliquely intersecting the structure of the country rock and are steep in dip, the direction of extension of the mineralized zone as a whole is concordant

Fig 10 LOCALITY MAP OF COPPER INDICATIONS IN THE SOUTHERN AREA OF URUMITA

SCALE 1 : 33.000



with the country rock, thus presenting in many cases a bedded appearance.

The ore grade is low, being probably less than Cu 0.2% even in the quartz-epidote veins, because of the weak dissemination of Cu. The scale of the ore deposits is also very small. When all the mineralized zones were taken into account, the percentage of quartz-epidote veins would be only about 5%. The country rock shows evidence of slight alteration such as epidotization and kaolinization, but Cu-dissemination is hardly recognized. Considering these facts, the average ore grade of the total mineralized zones would be as low as Cu 0.01%.

Conclusion: The ore deposits are aggregates of small veins in andesitic lava and red sandstone, and are stratified concordantly with the country rock. With their small scale and low grade, these veins should be regarded as copper indications rather than ore deposits, and so they are of no economic value.

viii) Oveja

Kind of ore: Cu

Date of investigation: Feb. 14, 1966

Investigated by: Ogawa, Nitta, Irie

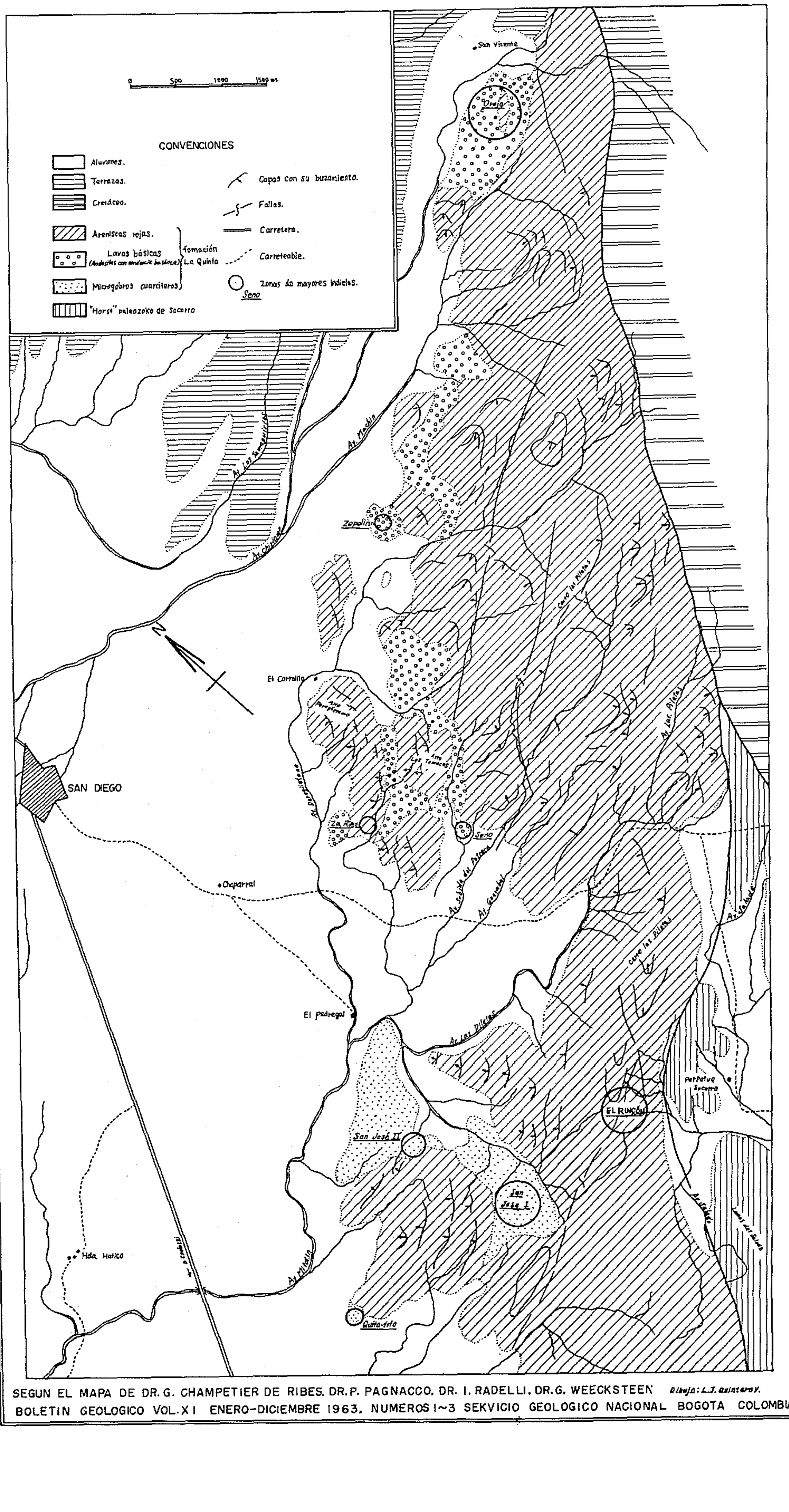
Location: 9 km east of San Diego City, Magdalena Province

Communication: Valledupar City —(by jeep) 24 km— San Diego City —(by jeep) 7 km— · —(on foot) 3 km— Oveja

Geology and ore deposit: The ore deposits are aggregates of small lenticular veins of Cu-bearing quartz-epidote in the alternation of andesite lava, tuff breccia, tuffaceous sandstone and red sandstone, belonging to the Jurassic-Triassic Quinta formation which is distributed along the western foot (approximately 550 m above sea level) of Serrania de Perija.

The general trend of the formation near the ore deposits is N 15° - 20° E in strike and 35° - 40 ° NW in dip. Mineralization is found in the red sandstone along its boundary with the overlying andesite lava. The mineralized zone is about 400 m in strike extension, about 20 m in thickness, and presents a bedded appearance concordant with the country rock (Fig. 12).

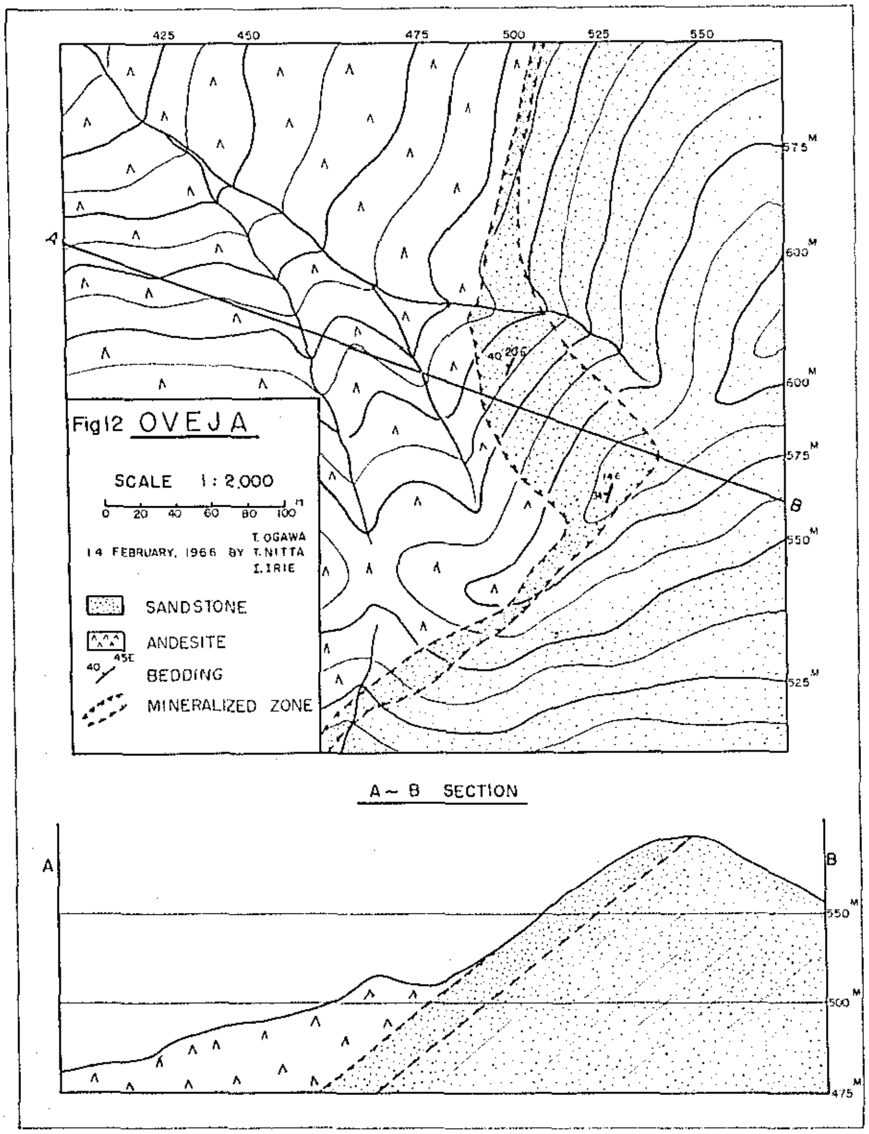
Fig 11 MAPA GEOLOGICO DE LA ZONA CON INDICIOS DE COBRE
SAN DIEGO (Magdalena)



SEGUN EL MAPA DE DR. G. CHAMPETIER DE RIBES. DR. P. PAGNACCO. DR. I. RADELLI. DR. G. WEECKSTEEN Dibujo: L.J. Quintero V.
BOLETIN GEOLOGICO VOL. XI ENERO-DICIEMBRE 1963. NUMEROS 1-3 SERVICIO GEOLOGICO NACIONAL BOGOTA COLOMBIA

Ore minerals are malachite, chrysocolla, azurite, bornite, chalcocite and native copper, disseminated in lenticular veins or wedge-shaped masses of quartz-epidote, with a width of several centimeters to several tens of centimeters and a length of several tens of centimeters to several meters. Primary sulfide Cu-minerals are not found.

These Cu-bearing quartz-epidote masses may have formed when the Cu-bearing residual solution, following the solidification of the andesite which made the hanging wall, infiltrated into the pre-existent red sandstone on the foot-wall side and filled the fissures of a small scale.



The ore grade of the quartz-epidote masses is generally lower than Cu 1%, although on rare occasions it is as good as Cu 4 - 5%; Cu-dissemination is hardly observable in the red sandstone which is the country rock. Accordingly, presuming the ratio of ore to the whole area of mineralization as about 5%, the average ore grade would be very low, perhaps less than Cu 0.05%.

A considerable number of boulders of ore are found on the ground surface, and are particularly abundant in depressions, giving an impression as if the ore grade is high. However, this may be a result of differential erosion by which the less resistant red sandstone, the country rock, was washed away, leaving behind the hard quartz-epidote masses.

Conclusion: The ore deposits are aggregated small lenticular veins of Cu-bearing quartz-epidote occurring in the red sandstone beneath the andesite. Extension of the mineralized zone is about 400 m, but the ore grade is very low, probably less than Cu 0.05% on the average. Therefore, the ore deposits of this area have no economic importance.

ix) Seno, La Riga, Zeppelin

Kind of ore: Cu

Date of investigation: Feb. 14 and 21, 1966

Investigated by: Ogawa, Nitta, Irie

Location: 3.5 - 5 km southeast of San Diego City, Magdalena Province

Communication: Valledupar City —(by jeep) 24 km— San Diego City —

—(by jeep) 5 km— Seno
—4 km— La Riga
—5 km— Zeppelin

Geology and ore deposit: Ore deposits are aggregates of small lenticular veins of Cu-bearing quartz-epidote occurring in an alternation of andesitic lava, tuff breccia, tuffaceous sandstone and sandstone, belonging to the Jurassic-Triassic Quinta formation which is distributed along the western foot (200 - 250m above sea level) of Serrania de Perija.

The Quinta formation generally strikes N 60° E and dips 25° - 45° NW.

It is locally disturbed but on the whole it shows a monotonous inclination.

Ore minerals are malachite, chrysocolla, azurite, chalcocite, bornite, cuprite and native copper, disseminated in quartz-epidote masses which are lenticular veins or wedge-shaped with a width of several centimeters and a length several tens of centimeters, the largest ones being 30 cm in width and several meters in length. No primary sulfide Cu-minerals are found.

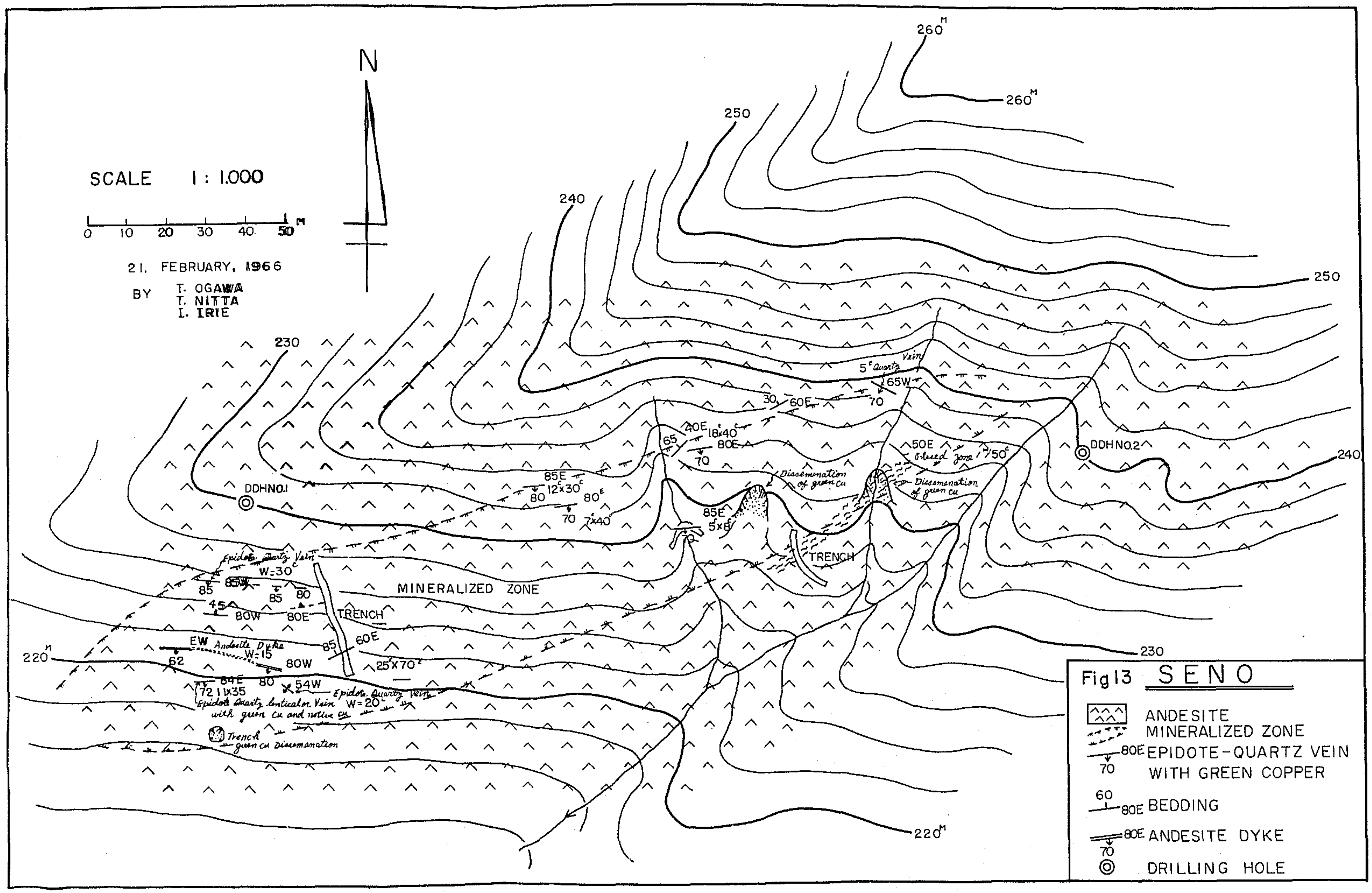
The origin of these Cu-bearing quartz-epidote masses is supposedly the same as in the neighboring deposits such as Oveja, San Jose I, II and Quinta Frio. That is, the Cu-bearing residual solution of the andesite which is the country rock, has segregated along the small fissures. The trend of the quartz-epidote veins is nearly E-W, striking N 80° W - N 80° E, and somewhat obliquely intersects the country rock; their dip is 70° - 80° S, reverse to that of the andesite, the country rock. However, the direction of the mineralized zone as a whole is concordant with the structural trend of the country rock, and mineralization is noticed along a certain horizon of the andesitic strata. Hence, the ore deposits can be called bedded deposits (Figs. 13, 14).

The deposits at Seno are about 250 m in extension and about 40m thick; those at Zeppelin are about 200 m long and 20 m thick. At La Riga, one vein striking N 58° W, and dipping 80° N, with a width 40 cm and a length 3 m, is found at the mountain foot, and three veins, striking N 75° W, dipping vertical, 15 cm wide and about 1 m long, are sporadically exposed on the ridge about 50 m above the former locality. No appreciable mineralized zone is recognized at La Riga.

Downward extension of the mineralized zone is not promising here. In about 1963, the Servicio Geologico Nacional carried out three test borings at Seno (we could recognize only two locations of them, as shown in Fig. 13) but failed to discern a mineralized zone.

The ore grade of the quartz-epidote masses alone is partially as high as Cu 4 - 5%, but the average grade of the whole mineralization would be very low, probably less than Cu 0.1%, since the alteration of the andesitic country rock is weak and Cu-mineralization is hardly discernible.

Conclusion: Ore deposits are small-scaled segregation veins in andesitic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21. FEBRUARY, 1966
BY T. OGAWA
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I. IRIE
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MINERALIZED ZONE
TRENCH
DDH NO.1
DDH NO.2
Epidote Quartz Vein
Dissemination of green cu
Fig 13 SENO
ANDESITE
MINERALIZED ZONE
EPIDOTE-QUARTZ VEIN WITH GREEN COPPER
BEDDING
ANDESITE DYKE
DRILLING HOLE

rock. The mineralized zone is apparently bedded, being concordant with the country rock, but the Cu grade is very low. Thus, the ore deposits of this area have no economic value.

x) San Jose I, II and Quinta-Frio

Kind of ore: Cu

Date of investigation: Feb. 17, 1966

Investigated by: Ogawa, Nitta, Irie

Location: 6 - 7.5 km south of San Diego City, Magdalena Province

Communication: Valledupar —(by jeep) 24 km— San Diego City

—(by jeep) 4.5 km— El Pedregal —(on foot, 1.5 km)— San Jose II
  El Pedregal —(on foot, 3 km)— San Jose I
—(by jeep) 8 km— San Martin —(by jeep) 2 km— Quinta-Frio

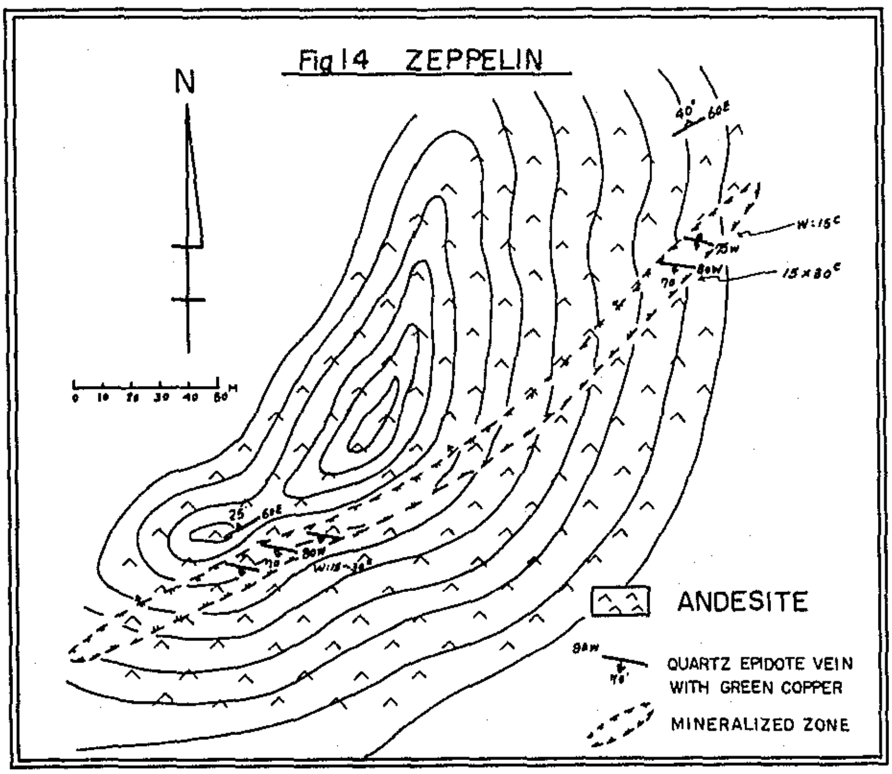


Fig 14 ZEPPELIN

Geology and ore deposit: Ore deposits are aggregated lenticular veins of Cu-bearing quartz-epidote, occurring in the Jurassic-Triassic Quinta formation which is distributed on the western foot of Serrania de Perija. The Quinta formation comprises the following members; a) conglomerate, b) sandstone and volcanic rocks, c) sandstone, d) sandstone intercalated with tuff, and e) sandstone, tuff and basic lava. The formation strikes generally NE and dips NW. The ore of San Jose I occurs in quartz-bearing microgabbro, that of San Jose II is found in the alternation of andesite lava and andesitic tuff breccia, and that of Quinta-Frio is found in the alternation of andesite lava, andesitic tuff breccia and red sandstone. Ore minerals are malachite, chrysocolla, azurite, chalcocite, bornite, cuprite and native copper, which are disseminated in the lenticular veins (mostly striking ENE and dipping 70^{o} – 90^{o} SE) with a width several to several tens of centimeters and a length several tens of centimeters to several meters, or in the wedge-shaped or spherical masses of quartz-epidote. No primary sulfide Cu-minerals are observed. Since no igneous rocks are found to have caused the mineralization penetrating the above-mentioned Quinta formation, the Cu-bearing quartz-epidote masses may have originated in segregation from the country rock, which is gabbro or andesite, in the process of its solidification. In general, the boundary between the quartz-epidote masses and the country rock is distinct; alteration of the country rock is very weak and no Cu-dissemination is recognized.

The scope of the mineralized zone is 100 m x 100 m at San Jose I, 100 m x 150 m at San Jose II and 100 m x 200 m at Quinta-Frio.

The ore grade of the quartz-epidote masses is generally low, but some parts contain several percents of Cu. An analysis of quartz-epidote samples that were collected at San Jose I by random sampling has revealed the following result: Total Cu 0.59%, Soluble Cu 0.53%, Pb 0.06%, Zn tr., Au tr., and Ag 4 g/t.

The ratio of quartz-epidote mass to the whole zone of mineralization is about 5%, hence the average grade would be very low when calculated as, Cu grade 0.59% x occurrence ratio 5% = average grade 0.03%. These quartz-epidote masses should be called copper indications rather than ore deposits.

It ought to be noted here that the mineralized quartz-epidote masses are more resistant to erosion than are the surrounding country rocks, thus resulting in the abundant occurrence of ore boulders on the ground surface, which gives one a misleading impression as if the content of ore is large.

Conclusion: The ore deposits of this area have no economic value, since they are merely aggregates of small-scaled low-grade segregation veins in the andesitic rocks. They should be called copper indications rather than ore deposits.

xi) El Rincon

Kind of ore: Cu, Ag

Date of investigation: Feb. 16, 1966

Investigated by: Ogawa, Nitta, Irie

Location: 7.5 km southeast of San Diego City and 2 km northwest of the village of El Rincon, Department Magdalena

Communication: Valledupar City —(by jeep) 24 km— San Diego City —(by jeep) 12 km— El Rincon —(on foot) 2 km— Mine

Geology and ore deposit: The ore deposits occur on the southern slope (about 400 m above sea level) of Cerro Las Piletas. Geology of the neighborhood, according to literature, is represented by a red sandstone which belongs to the Jurassic-Triassic Quinta formation. The red sandstone presents a monoclinal structure, striking N 70° E and dipping 10° - 20° NW.

The ore deposits are veins in this sandstone. Extension of the mineralized zone is 400 m or more. There are about ten veins, varying in width from 15 cm to 3 m. These veins can be roughly divided into four groups, A through D. Each group has an extension of 100 to 150 m, striking N 45° - 80° W and dipping 70° - 80° SW. The groups are arranged en echelon, from A to D in ascending order (Fig. 15).

Ore minerals are copper oxides, such as malachite and chrysocolla, which are disseminated in brecciated quartz veins. No sulfide minerals are found.

The widest vein, C, shows the trace of prospecting by trenching at two places, but other veins remain intact. Estimation of ore grade from the outcrops alone is difficult, but the result of analysis of two samples collected at the trench sites is given below for reference.

Sample	Length (cm)	Total Cu (%)	Soluble Cu (%)	Au(g/t)	Ag(g/t)
No. 1	300	1.39	1.39	0.2	36.0
No. 2	200	1.15	1.06	tr.	49.0

As far as the observation at the trench sites goes, the ore grade on the ground surface is low but seems to improve slightly at 1-2 m below the surface. Taking this tendency into account, the average grade can be estimated as follows: Total Cu 1.40%, Soluble Cu 1.30%, and Ag 40 g/t. In estimating the scope of the ore deposits, the biggest problem lies in presumption of the depth of the oxidation zone. Since this area has no exploited mine as yet, any data for the depth determination are not available. Therefore, considering the climatic condition and other factors, we have tentatively set the depth at 30 m and calculated the probable reserves of copper oxides as shown in the following table:

Group	Number of vein	Extension (m)	Average width of vein (m)	Plane area (m^2)	Depth (m)	Volume (m^3)	Specific gravity	Reserves (t)
A	3	100	0.4	120	30	3,600	2.7	9,720
B	2	130	0.7	182	30	5,460	2.7	14,742
C	1	100	1.5	150	30	4,500	2.7	12,150
D	1	150	0.5	75	30	2,250	2.7	6,075
Total	7			527	30	15,810	2.7	42,687

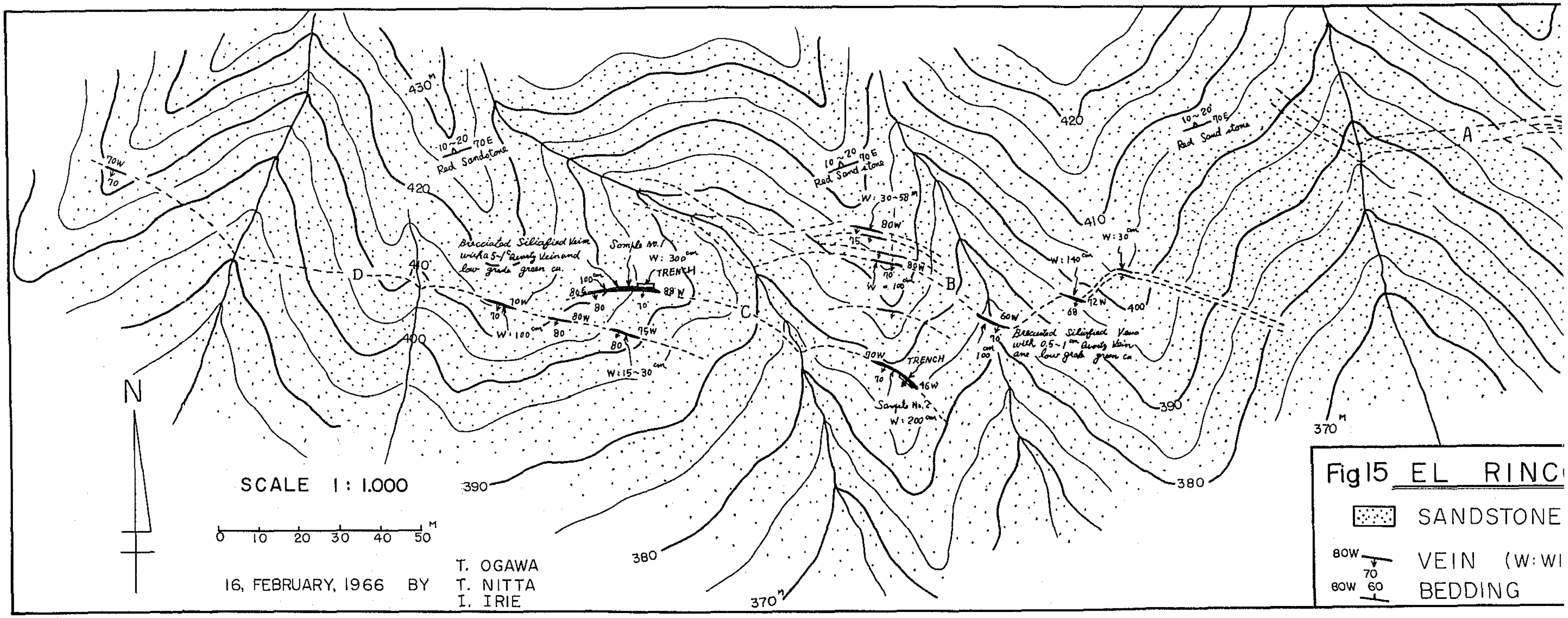


Fig 15 EL RINC

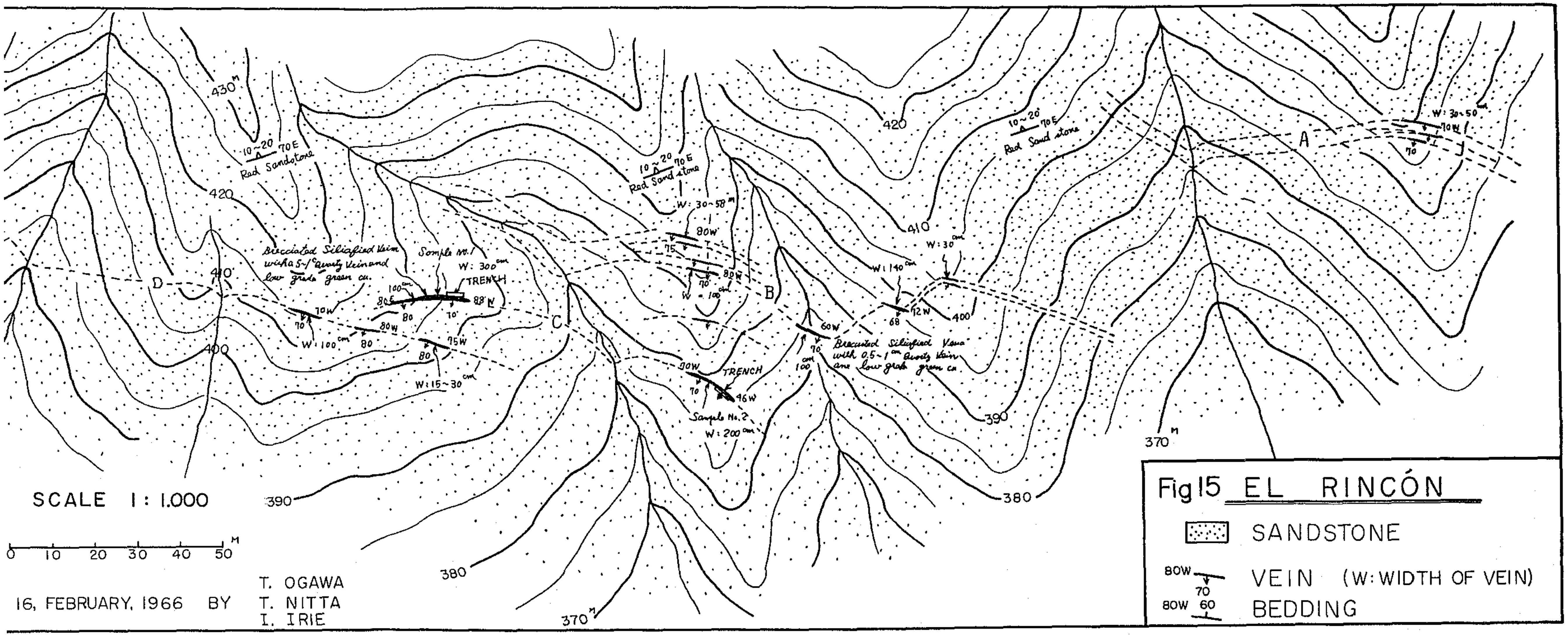


Fig 15 EL RINCÓN

Judging from the scale of outcrops and the result of analysis, especially from the high grade of Ag, presence of a zone of sulfide minerals is duly expected beneath the zone of copper oxides. Besides, the topography and hydrology are favorable for prospecting in this area. If firstly a promising grade of sulfide ore was confirmed by conducting several test drillings to a depth of 50 - 100 m, then by driving a cross-cut for some 100 m length which would hit the vein at about 60 m below the outcrop. By drifting the vein from there, the mode of occurrence of ore deposit would be known rather easily. Supposing the depth of sulfide zone as 100 m, the probable reserves of copper sulfides can be estimated at about 150,000 tons.

Conclusion: The ore deposits are about ten green copper veins, 15 cm - 3 m wide, arranged en echelon in the red sandstone. Their total extension attains to 400 m or more. Under existing circumstances, the reserves of copper oxides are estimated at 43,000 tons and the ore grade may be, Total Cu 1.4%, Soluble Cu 1.3% and Ag 40g/t. In both scale and grade, the deposits are somewhat deficient for payable mining, but there is a hope in prospecting in the strike extension and in the underlying sulfide zone. Topography also favors the prospecting. Should a promising grade of sulfide ore be ascertained, about 150,000 tons of probable reserves would be expected. Accordingly, this area is worthy to take into consideration as a possible source of copper to be consumed within the country.

So far as our knowledge goes, these deposits have not been reported in literature nor have become a subject of any information on this area. In fact, we have encountered the deposits only by chance while investigating the mines of the neighborhood. We have named the mine El Rincon after the nearby village.

2. Copper indications in the Gachala region

The town of Gachala, 1,750 m above sea level, stands on a relatively flat plateau along the Rio Mura. The Gachala region as a whole, however, shows a fairly mountainous aspect, being generally highet than 2,000 m above sea level. Especially its southeastern part, the area between Gachala and Medina, is dotted with peaks as high as 3,000 - 4,000 m, and is characterized by a rugged topography. As this highland is constantly wrapped in thick fog, the climate is very humid, giving rise to luxuriant growth of trees, so that the land is covered with jungle similar to the tropical rain forests.

The geology of the Gachala region is composed of limestone, muddy sandstone, calcareous slate and calcareous sandstone; no outcrops of igneous rocks are observed. On the basis of fossils, the limestone has been assigned to the Carboniferous age and the calcareous slate to the Cretaceous age. During the survey in the vicinity of Bojara we collected molluscan fossils. Through the cooperation of Drs. T. Hanai and T. Hamada of The University of Tokyo, the fossils were studied later and based on these fossils the strata of the Bojara area were confirmed as Upper Carboniferous (Pennsylvanian) in age. The fossil localities are shown in Fig.17.

The fossils identified by Dr. Hamada are listed in Table 3.

Table 3

Name of fossil	Known horizon of occurrence
Brachiopoda	
Productus (s. str.) sp.	Lower Carboniferous (Visean) to Upper Carboniferous (Westphalian)
Punctospirifer sp.	Lower Carboniferous to Permian
Echinaria sp.	Upper Carboniferous (Middle to Upper Pennsylvanian)
Phricodothyris sp.	Lower Carboniferous to Permian
Bryozoa	
Fenestella (s. l.) sp.	Ordovician to Permian
Pelecypoda	
Enchondria sp.	Upper Carboniferous (Pennsylvanian)

As to the geologic structure, there are faults of NE-SW trend cutting through both Carboniferous and Cretaceous formations, and several noticeable anticlines with a NE-SW axis. These two structures, situated close to each other, are supposed to have resulted from a serial tectonic movements.

Along the faults and anticlines are found a large number of ore deposits of copper, lead, emerald and sulfur. The mode of occurrence of these ore deposits suggests that the mineralization in this region took place along the weak lines in the NE-SW direction of the faults and the anticlinal axis. Genetically speaking, the ore deposits may be intimately related to one another. It was previously reported that the copper deposits of this region comprise bedded type and vein type. However, our investigation in Alto Bojara and its vicinity has disclosed that what was believed to be a bedded ore deposit is a calcareous horizon of the country rock, which was impregnated selectively in the process of mineralization, thus resulting in the bedded appearance. The most famous copper mine of the Gachala region is Cerro Del Cobre where 1,620,000 tons of crude ore (Cu 6%) are believed to occur (Fig. 16).

This time we have investigated the copper deposits in Alto Bojara and its vicinity, and the investigation has proved significant in elucidating the relation between the bedded type deposits and the vein type deposits.

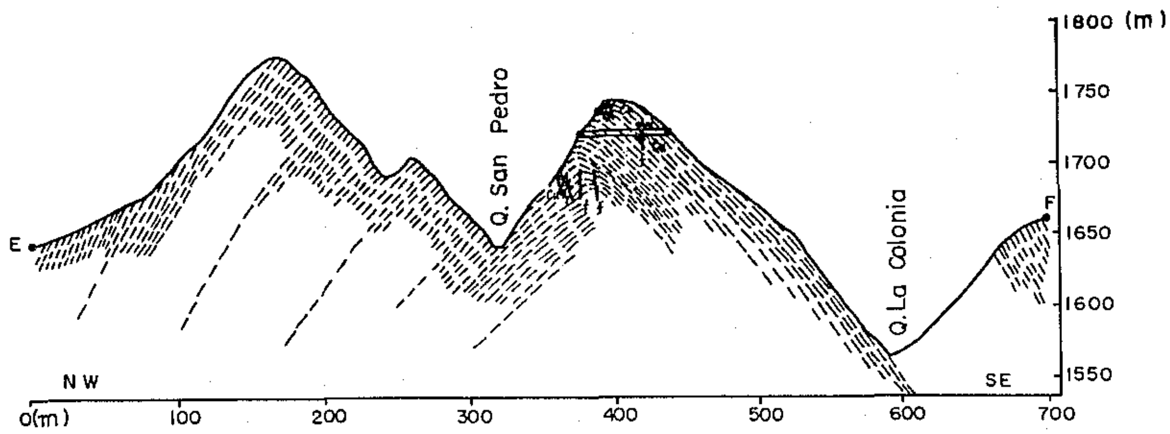


Fig 16 Idealized Profile of Q. SAN PEDRO-Q.La COLONIA.

Showing Occurence of Copper Deposit

(from the reference No)

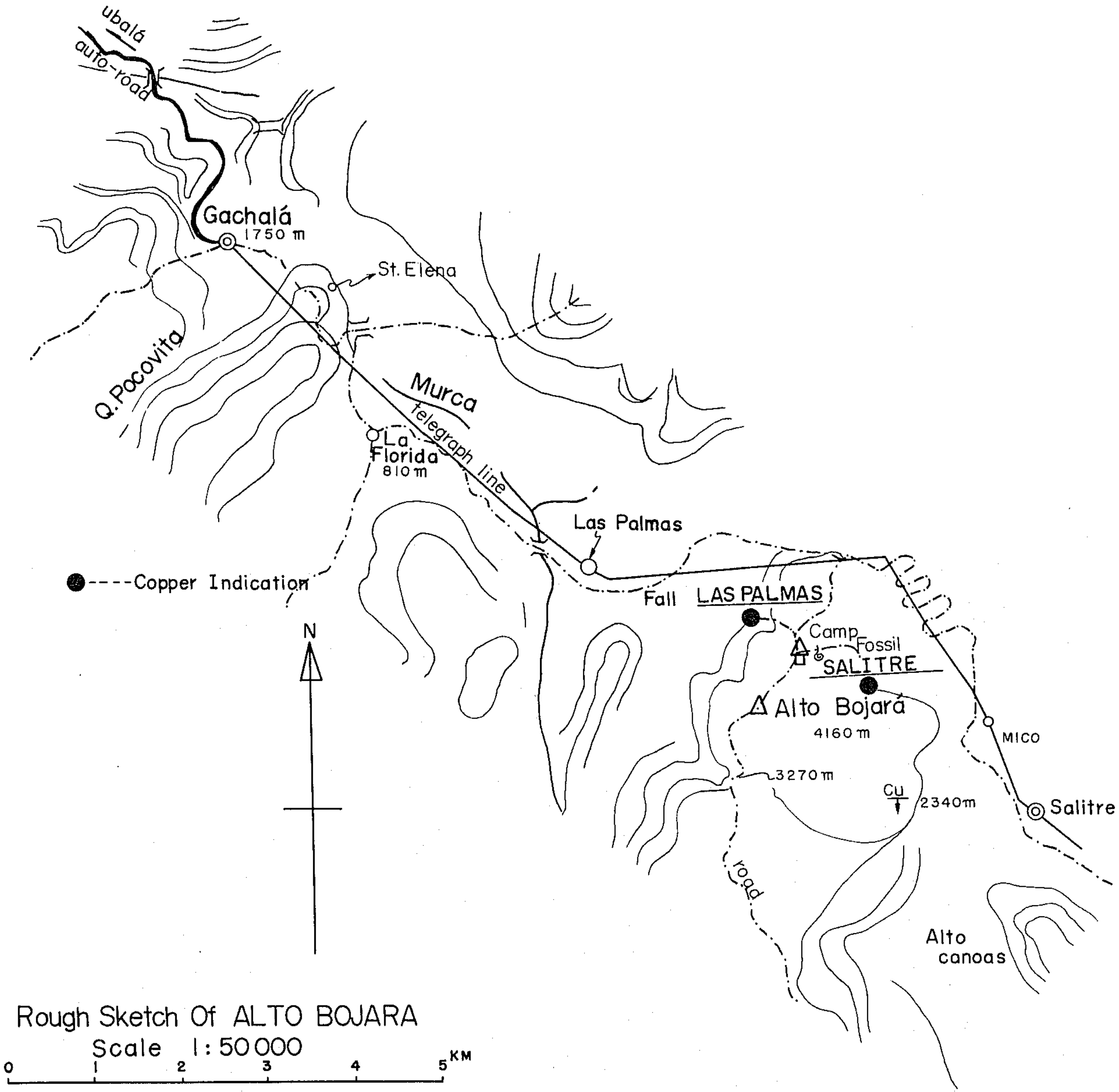


Fig 17 Rough Sketch Of ALTO BOJARA

Scale 1:50000

0 1 2 3 4 5 KM

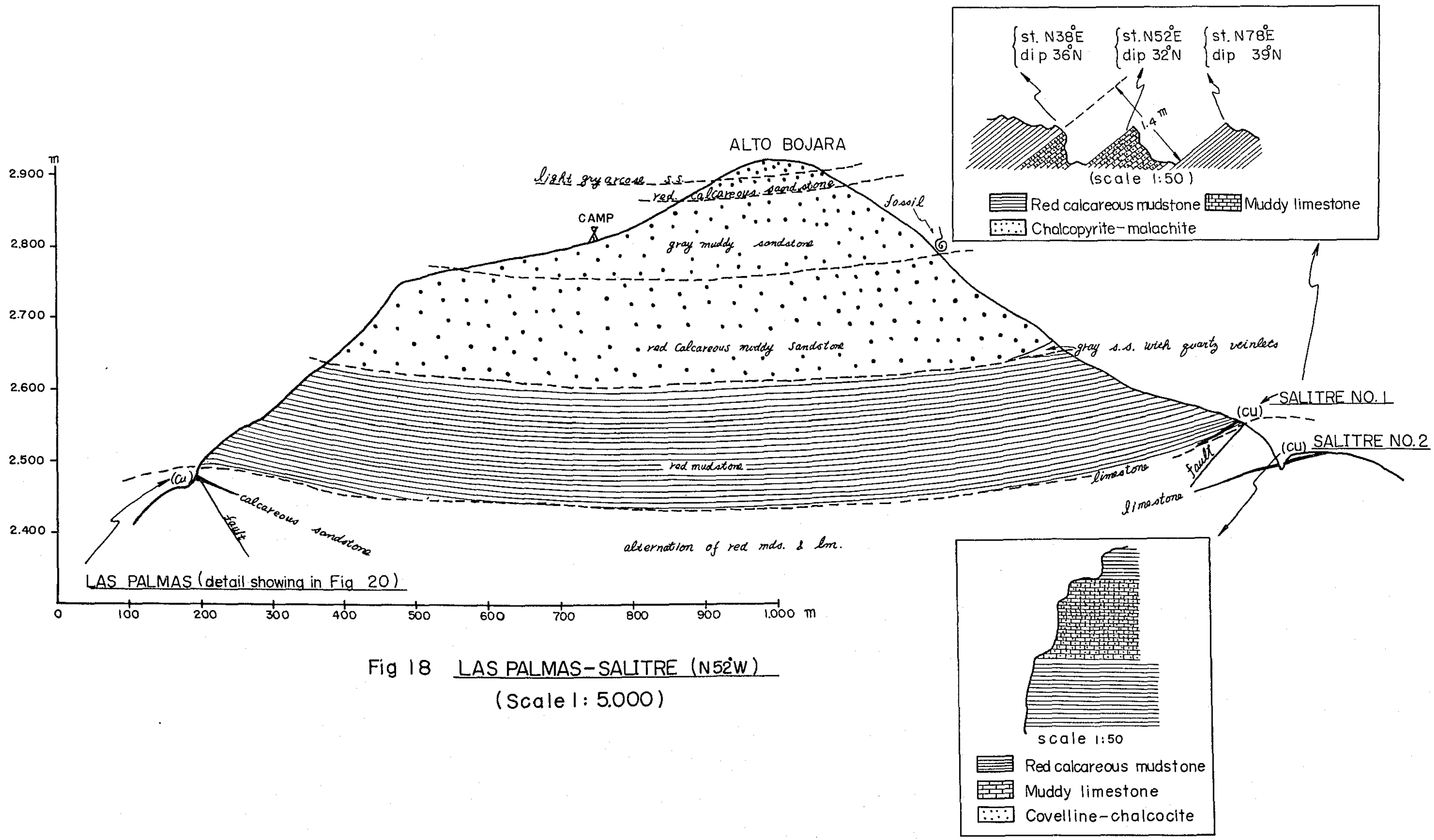


Fig 18 LAS PALMAS-SALITRE (N52°W)
(Scale 1: 5.000)

Alto Bojara area

Kind of ore: Cu

Date of investigation: Mar. 6 - 7, 1966

Investigated by: Horikoshi, Fukunaga, Irie

Location and communication: (See Fig. 17)

The massif of Alto Bojara rises 4,160 m above sea level. Ore deposits are found on its slope at 2,450 m to 2,550 m in elevation, and about 9 km southeast of Gachala. A mountain hut where we stayed several days is situated on the slope at 2,800 m above sea level. To reach the hut from Gachala it takes five hours on horseback.

Geology and ore deposit (Figs. 18 - 20):

The Alto Bojara massif has its ridge-line extending nearly N-S, and the slopes on the east and the west are 20° - 30° in gradient, becoming steeper from about 2,500 m upward.

The geology of this area consists, in descending order, of medium-grained sandstone (thickness 300 m or more), red calcareous mudstone (average thickness 175 m), and alternation of mudstone and limestone (thickness unknown).

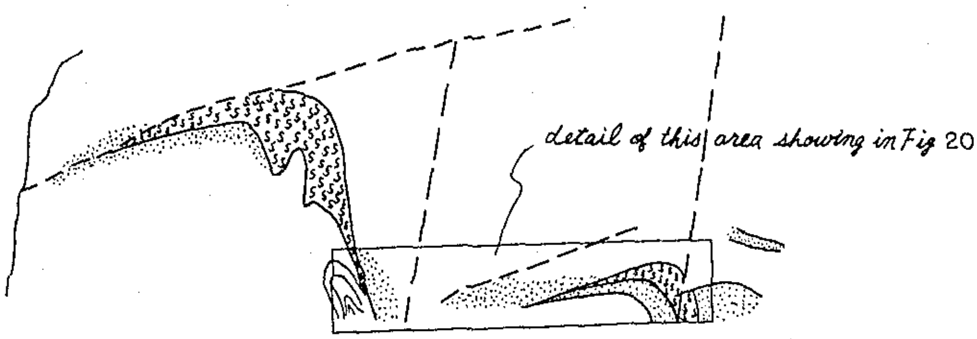


Fig 19 The Rough Sketch of LAS PALMAS O.C.

0 5 10 m

Mineralized zone

Chrushed zone

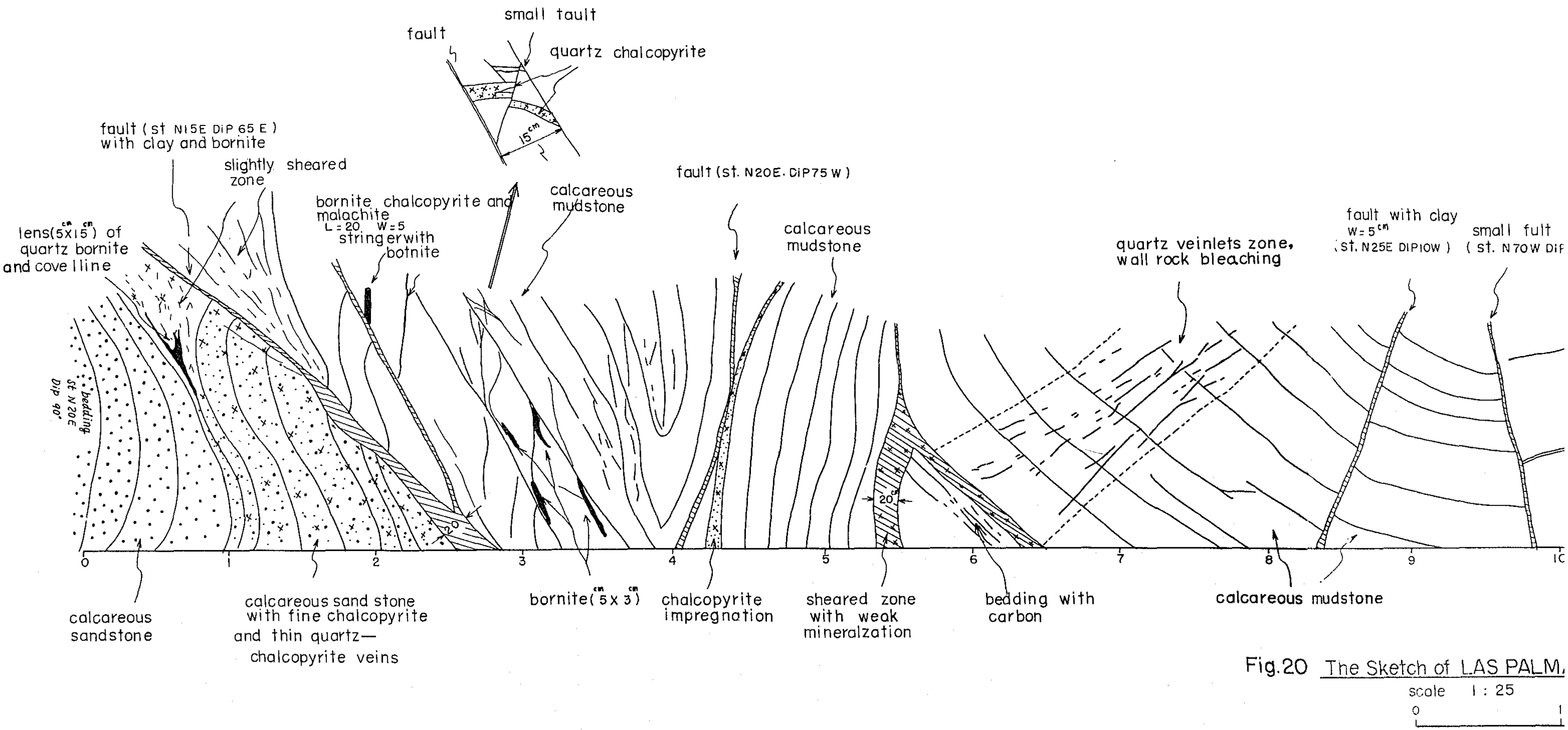
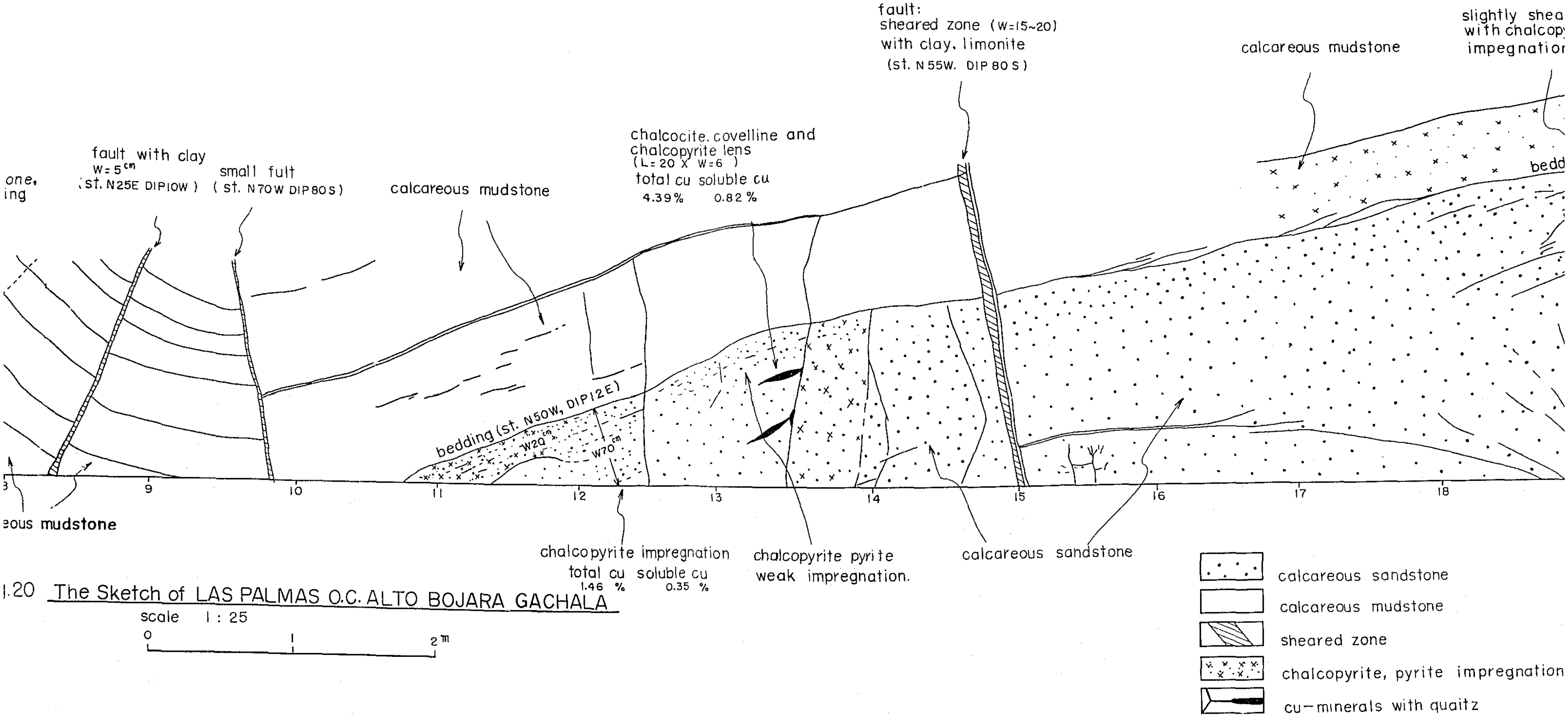
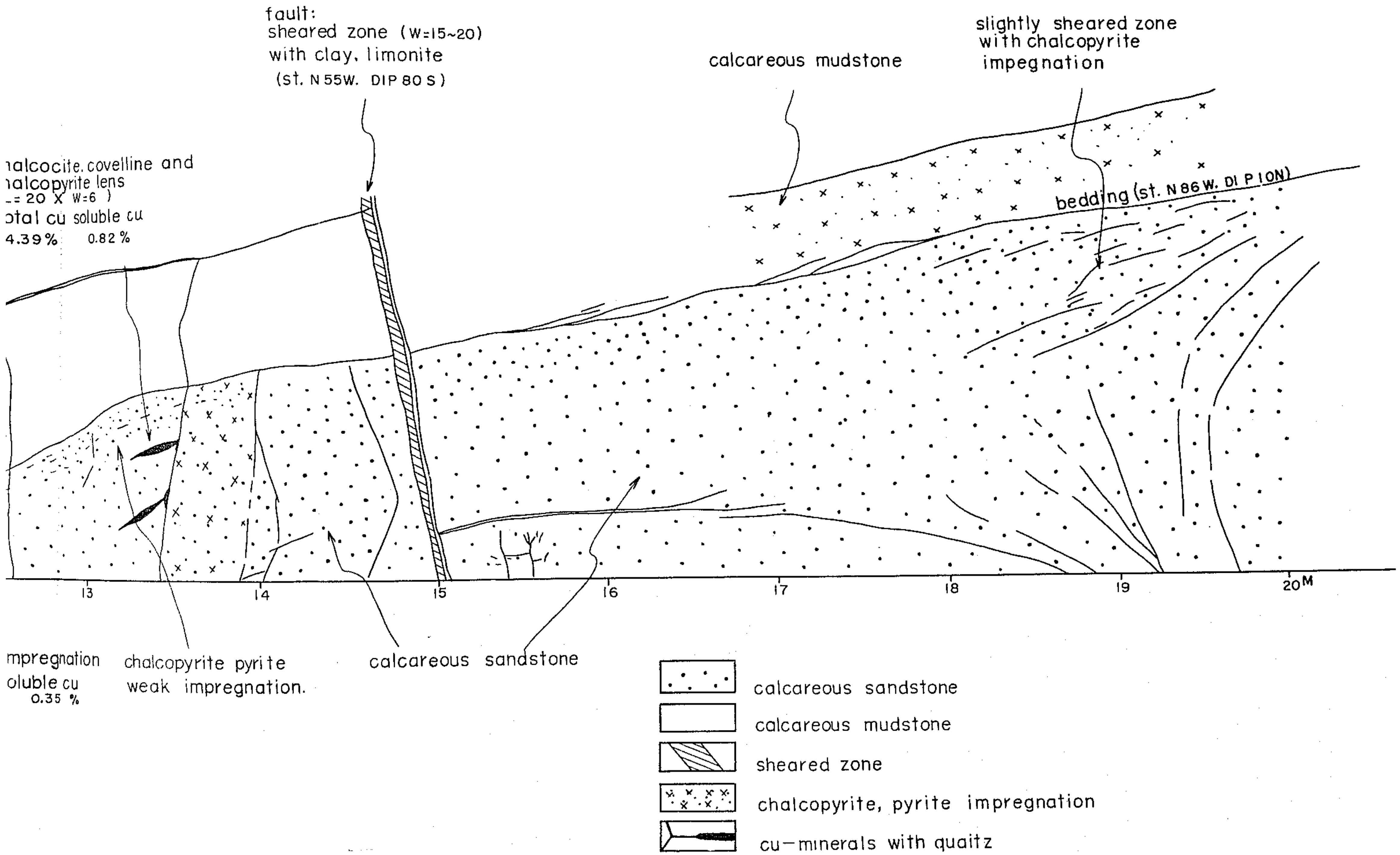


Fig.20 The Sketch of LAS PALM.



.20 The Sketch of LAS PALMAS O.C. ALTO BOJARA GACHALA


fault:
sheared zone (W=15~20)
with clay, limonite
(st. N 55W. DIP 80 S)
calcareous mudstone
slightly sheared zone
with chalcopyrite
impegnation
bedding (st. N 86 W. DI P 10N)
ıalcocite, covelline and
ıalcopyrite lens
= 20 X W=6)
otal cu soluble cu
4.39 % 0.82 %
13
14
15
16
17
18
19
20M
mpregnation
oluble cu
0.35 %
chalcopyrite pyrite
weak impregnation.
calcareous sandstone
calcareous sandstone
calcareous mudstone
sheared zone
chalcopyrite, pyrite impregnation
cu-minerals with quaitz

The sandstone in the uppermost part is subdivided into arkose sandstone, red calcareous sandstone and gray muddy sandstone, in descending order, as shown in Fig. 18. The fossils in Table 3 were found in a shale intercalated within the gray muddy sandstone. By these fossils the geologic age of the area was assigned to Upper Carboniferous. The red mudstone is interbedded with limestone which increases downward so that the lowermost part becomes an alternation of red mudstone and limestone. At an elevation of about 2,500 m the thickness of each limestone bed is around 1 m. The strata strike E-W to N 55° E and dip about 20° N. On the whole, no disturbance of the strata is noticed. In the vicinity of Las Palmas where ore deposits occur, the strata are markedly disturbed by faults and folds, as shown in Fig. 20.

Investigation was made on the following three outcrops:

a) Las Palmas outcrop

This outcrop, located at an elevation of 2,475 m on the northwestern slope of Alto Bojara, forms a cliff facing southwest, with an extension of about 50 m and a height about 20m. The calcareous mudstone and calcareous sandstone that constitute the cliff are mineralized along faults. Bedformed impregnations are found chiefly in the calcareous sandstone. There are two kinds of faults; the structural faults along the bedding plane striking NW-SE and dipping 10° E, and the faults of NE-SW and NW-SE systems with a steep dip, which may have been derived from the former. These faults are accompanied by pyrite, chalcopyrite, chalcocite, covelline and quartz, but on account of the small scale the minerals cannot be the subject of exploitation. The calcareous sandstone is impregnated with chalcopyrite, chalcocite and covelline but the impregnated portion is less than 1.5 m in thickness and its extension is limited, because it occurs only around the above-mentioned faults. An analysis of a 70 cm thick part of the impregnated sandstone has revealed, Total Cu 1.46% and Soluble Cu 0.35%. Copper minerals of the same kinds as those in the impregnations are found locally in lenses of 20 cm long and 6 cm wide.

b) Salitre outcrops I and II

The Salitre outcrops are located on the northeastern slope of Alto Bojara. Elevation of outcrop I is 2,550 m and that of outcrop II is 2,500 m. Outcrop I is an impregnation of chalcopyrite and malachite in the 1.4 m thick muddy limestone which is intercalated within the red mudstone; extension of the impregnation is 13 m and the Cu content is less than 1 %. The bed (ore body) strikes N 52° E and dips 32° N. Outcrop II is also an impregnation of chalcopyrite and malachite in the 2 m thick muddy limestone intercalated in the red mudstone. Its extension is several meters and the ore grade is below 1 %. The bed (ore body) strikes N 66° E and dips 18° N.

Conclusion: Our investigation has disclosed that the ore deposits of this region are impregnations caused by a mineral solution which, flowing along the faults, acted on the calcareous rocks, thus resulting in the bedded appearance. Therefore, a chance of discoverying extensive bedded ore deposits is very slim in this region. The vein deposits are also too small in scale to be economically exploited. However, as stated before, the whole mineralization of the region is evidently controlled by the NE-SW trending structural faults and anticlines, so that further and more detailed investigations along this geologic structure may lead to a discovery of the center of mineralization and superior ore deposits.

3. Copper indications in the Ibague region (Department Tolima)

Outline

In the neighborhood of Ibague City about 135 km west of Bogota (198 km in road distance), a number of ore deposits have been known. They are believed to be genetically related to the Jurassic intrusives penetrating the Mesozoic calcareous formation which is distributed along the eastern foot of the central mountain range. The principal ore deposits are El Sapo, El Tiempo, El Tigre, Pavoreal, La Fortuna, Las Venecias, El Guineal and Mina Vieja, which are pyrometasomatic Au-Ag-Cu-Pb-Zn skarn deposits occurring along the contact between limestone and the above-mentioned Jurassic intrusives.

Some of these deposits were once worked on a small scale when the country was under the control of Spain; traces of old excavation and smelting are still recognized, although none of the mines is being operated at present. However, there is a large possibility of discovering Cu, Pb and Zn deposits of a fairly large scale by proceeding with the exploration. We were informed that Mina Vieja, located at about 4 km west of the village of Payande which is 25 km southeast of Ibague City, was explored in 1961-1962 by Boliden of Sweden, and the ore reserves were estimated at 456,000 tons with Cu 1.7 %. We have enforced a minute investigation of Mina Vieja because it seemed to represent the mines of this area. The result is described below in detail.

Mina Vieja

Kind of ore: Au, Ag, Cu, Fe

Date of investigation: March 6 - 8, 1966

Investigated by: Ogawa, Nitta, Irie

Location and communication: (See Fig. 21)

The mine is located at Long. 75° 08' W and Lat. 4° 18' N, about 4 km west of Payande in the San Luis district, Dept. Tolima. Payande is about 25 km southeast of Ibague City which is 198 km from Bogota in road distance.

The transportation route is as follows:

Mina Vieja —(by truck) 4 km— Payande —(by truck) 8 km—

Buenos Aires —(about 300 km by truck) (or about 900 km by rail)— Buenaventura Port

History: It is reported that the high-grade parts of the mine were once worked on a small scale when the country was under Spanish control, and several sites of old excavation are noticed. Scattered slag near the entrance of Camino de Mina Vieja suggests that smelting was also performed on a small scale. Since then the mine remained abandoned until July of 1961 when Boliden of Sweden started exploration by boring. By December 1962, 29 test drills were bored, which revealed the ore reserves as 456,000 tons and the ore grade as Au 0.9 g/t, Ag 33 g/t, Cu 1.7%, Fe 26.7% and S 1.8% (according to Dr. Djorn Tornavist). Nevertheless, no further development of the mine has been attempted because, as a copper producer, the mine is small in scale and low in ore grade.

Mining concession: The registered mining concessions are two; Mina Vieja and its western neighbor, each being 1,800 m north-south and 240 m east-west, covering an area of 4.32 hectares. Procedures for registration are now under way for 19 other lots in the vicinity.

Geology (Fig. 21): The geology of the mine area is represented by the Upper Triassic Payande formation, consisting chiefly of limestone, and the Jurassic granodiorite intruding the former. These rocks are related to the formation of the Mina Vieja deposits. In the surrounding area are distributed the pre-Payande formation, consisting of conglomerate and graywacke, and the biotite-hornblende granodiorite of pre-Mesozoic intrusion, but these older rocks bear no direct relation to the deposits.

The Payande formation is composed mostly of pale bluish-gray or black limestone, intercalated with sandstone which is further intercalated with slate and black chert. The total thickness is 600 m. The general trend of the formation is NNE-SSW with an ESE dip, but the trend becomes somewhat complex near the ore deposit as will be mentioned later. The granodiorite occurs as a mass, about 5 km in diameter, in the north of the mine, but near the mine the rock is elongated in the direction of SSW for a distance of 3 km with a 600 - 800 m width. Mafic minerals of the granodiorite are biotite and hornblende, but near the ore deposit the rock becomes migmatitic and leucocratic partially containing sphene. Dikes of andesite and quartz porphyry intrude the above-mentioned rocks near the ore deposit. There are several dikes of andesite, generally trending WNW-ESE with a width of 30 cm. As to the quartz porphyry, there is only one dike which trends ENE-WSW with a width of 4 m, intruding the granodiorite in the south of the ore deposit. The relationship between these younger igneous rocks and the ore deposit is not known.

Ore deposit (Fig. 22): The ore deposit is located on the south slope, 900 - 1,000 m above sea level, of Rio Frio at about 4 km west of the village of Payande. The deposit is a pyrometasomatic Au-Ag-Cu-bearing hematite-magnetite-garnet skarn which was formed along the contact between the granodiorite and the limestone on its northwest side. It occurs at a bend of the contact of the grano-

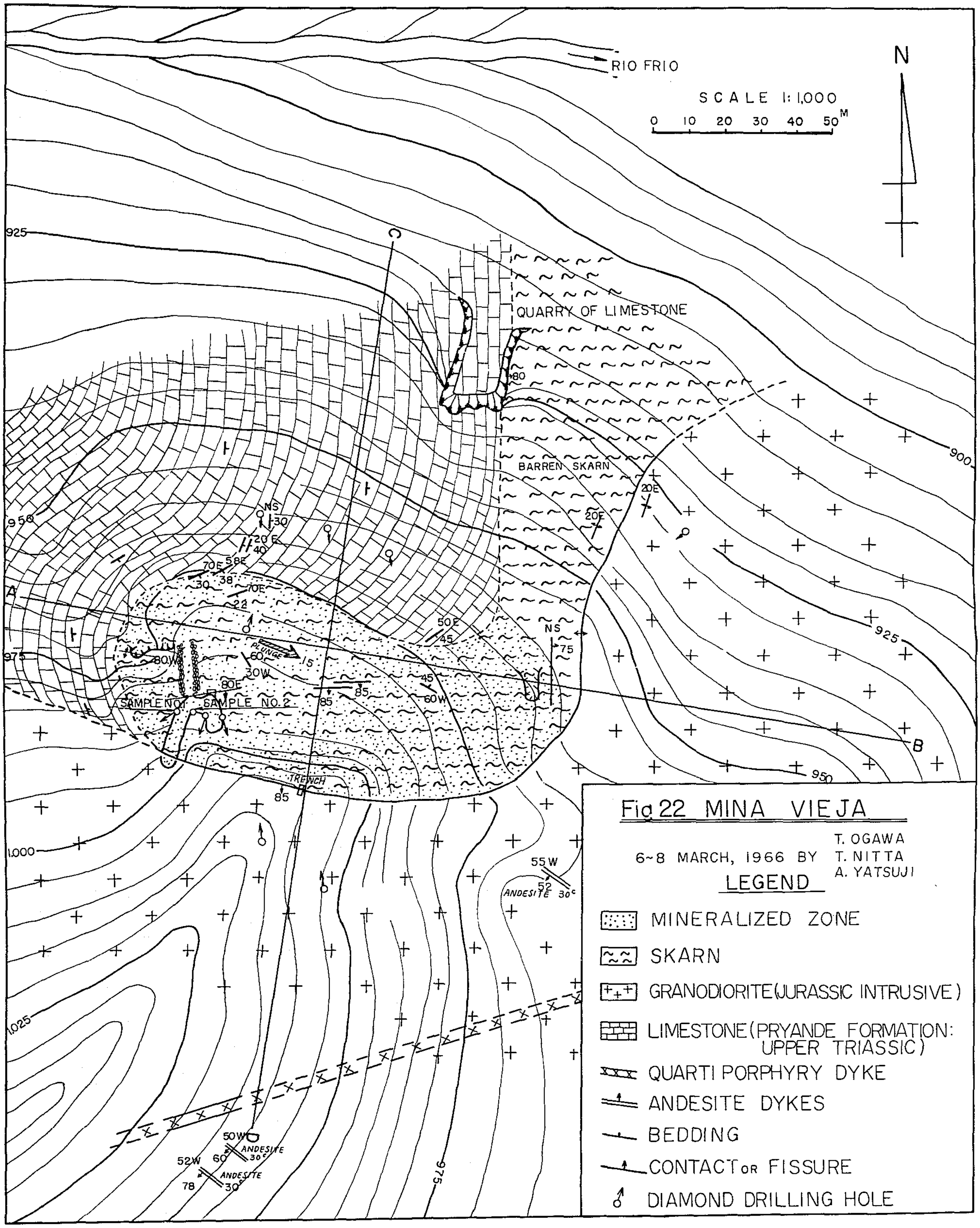


Fig 22 MINA VIEJA
6~8 MARCH, 1966 BY T. OGAWA T. NITTA A. YATSUJI
LEGEND
MINERALIZED ZONE
SKARN
GRANODIORITE(JURASSIC INTRUSIVE)
LIMESTONE(PRYANDE FORMATION: UPPER TRIASSIC)
QUARTI PORPHYRY DYKE
ANDESITE DYKES
BEDDING
CONTACT OR FISSURE
DIAMOND DRILLING HOLE
RIO FRIO
SCALE 1:1,000
0 10 20 30 40 50 M
N
QUARRY OF LIMESTONE
BARREN SKARN
SAMPLE NO.1
SAMPLE NO.2
TRENCH
PLUNGE
ANDESITE
900
925
950
975
1,000
1,025

diorite where the rock changes its trend from E-W to N-S. (The general trend of the granodiorite is NNE-SSW, but this is considered to be a composite trend of E-W and N-S systems.)

The skarn is 200 m long and 30 - 50 m wide, in which the mineralization is recognized as a zone of 120 m long and 50 m wide along the north side of the contact striking N 80° W and dipping 85° S. Toward the northeast from the above-mentioned bend, the mineralization becomes weaker. The limestone strikes generally N-S and dips 30° - 40° E, but as it approaches the ore deposit the strike changes to NE and further to ENE. On the north side of the ore deposit, the boundary between the limestone and the skarn shows a strike N 60°-70° E and a dip 30° - 40° SE, whereas on the south side the trend of limestone partings and ore stringers shows a NW strike and a NE dip, thus forming a small syncline. The shape of the skarn itself is controlled by this folding structure and becomes canoe-shaped, with a gentle plunge, about 15°, to ESE. Consequently, no great expectation can be laid on its downward extension (Fig. 23). The shape of the goaf of the old excavation which must have advanced along the high-grade portion would coincide with this structural trend. The plunge of the ore deposit becomes steeper as it approaches the N-S trending contact, and finally it becomes almost vertical where the mineralization is so weak that the skarn is nearly barren.

Based on this structure of the ore deposit, the scale of the deposit is calculated as,

length 120 m x width 50 m x thickness 20 m x
specific gravity 4 = 480,000 tons

which roughly agrees with the result of prospecting by Boliden.

Ore minerals are chiefly chalcopyrite with fair amounts of magnetite and hematite. Garnet is the principal skarn mineral, accompanied by small amounts of epidote, chlorite, quartz and calcite. The result of analysis indicates that minor amounts of galena, sphalerite and Ag-minerals are also contained.
The oxidation zone lies generally at a very shallow depth; green copper is observed in some parts of the outcrop, but in most cases presence of chalco-

pyrite is detected from the ground surface.

In order to estimate the ore grade, we collected two samples for analysis from the old excavation sites in the southwestern part of the ore deposit (Fig. 22). The result is given below.

Sample	Length of sample	Cu(%)	Pb(%)	Zn(%)	Au(g/t)	Ag(g/t)
No. 1	1 m	1.96	0.11	0.22	0.4	15.0
No. 2	1 m	3.65	0.29	0.09	0.7	68.0

From this analytical result and the result of our investigation, the ore grade estimated by Boliden as Cu 1.7%, Au 0.9 g/t, Ag 33 g/t and Fe 26.7% seems reasonable.

Conclusion: Mina Vieja is a pyrometasomatic garnet skarn Cu deposit, with probable reserves 480,000 tons and ore grade Cu 1.7% and Ag 33 g/t. Hydrological and topographical situations are favorable for mining, but the long distance between the mine site and the nearest port (300 km by truck or 900 km by rail), as well as the small scale of the deposit and the low grade of ore, would lessen the possibility of exporting the mine products to foreign countries. On the other hand, the mine would be workable enough if the products were to be consumed only within the country for such purpose as manufacturing agricultural chemicals. It is also possible that the ore reserves in and around the barren skarn may increase when the details of the localization mechanism of the ore deposit and the geologic structure of the mine area are clarified by future minute investigations.

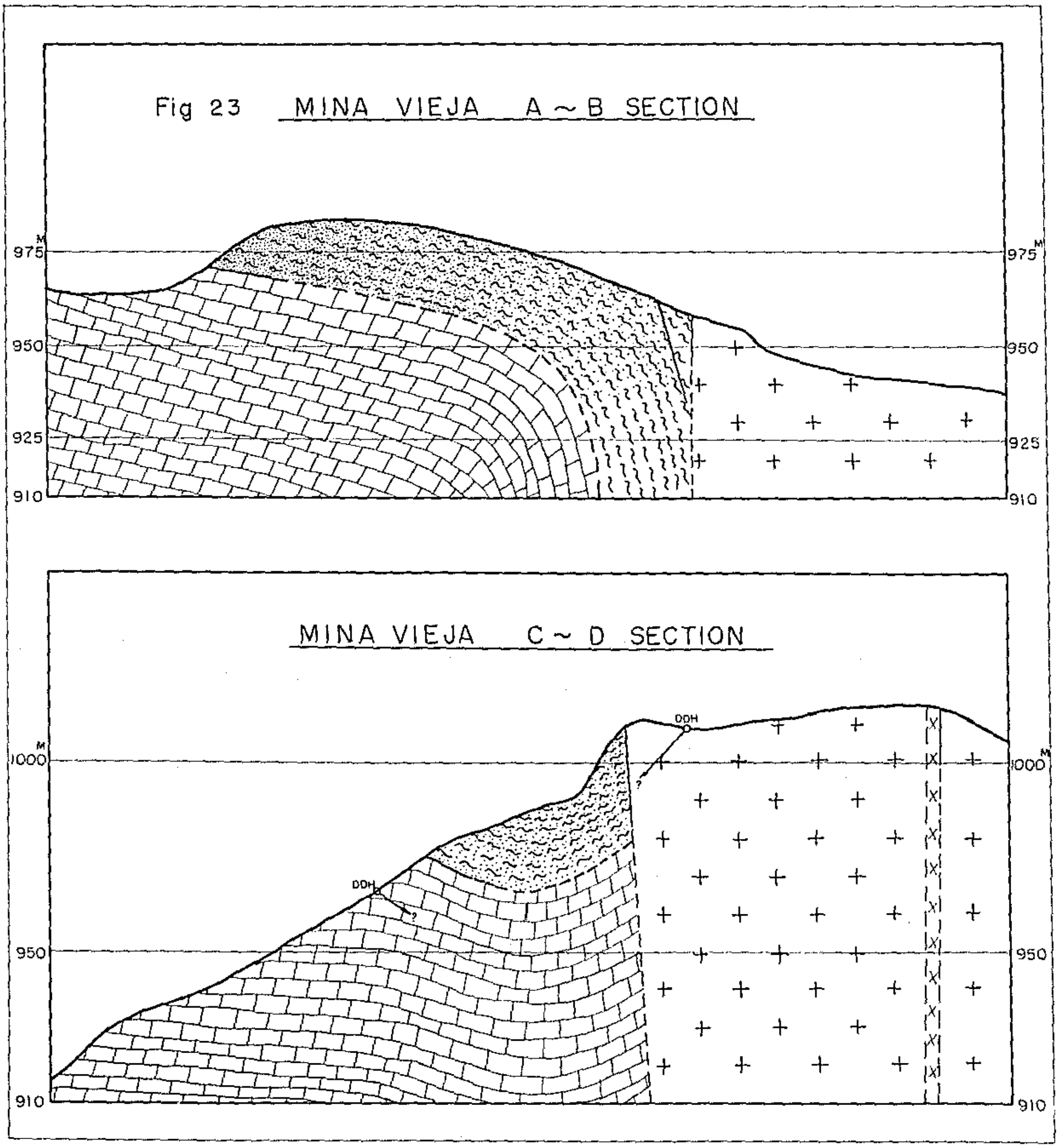


Fig 23 MINA VIEJA A ~ B SECTION

MINA VIEJA C ~ D SECTION

Ⅲ. Summary and Conclusion

III. Summary and Conclusion

The Investigation Mission has accomplished investigations of copper deposits or copper indications in about twenty areas in the country of Colombia by conducting field trips with six members for about forty days. Each of the investigated areas has been described in the preceding sections. The results of our investigations will be summarized and explained here as a conclusion of the present report.

In the Departments Magdalena and Guajira, northern Colombia, we investigated many copper indications but none of them proved hopeful for immediate exploitation. However, outcrop of El Rincon looks very promising; since the outcrop has not been explored yet, enforcement of its prospecting is advisable. This outcrop cannot be expected to develop into a large mine, but it can contribute more or less to the copper production in Colombia. Therefore, it is desired that the prospecting is carried out in such a way as mentioned before.

Geology and ore deposits of this region change their character from north to south, that is, from Guajira toward Magdalena. In the northern part of the region, exposures of liparite and other acidic igneous rocks are abundant and formation of copper deposits seems to be related to these rocks, whereas in the south most of the igneous rocks are basic, such as andesite and diorite, and ore deposits occur in association with the basic rocks. The copper deposits in the north are, in many cases, sporadic minor ore bodies, mainly of malachite, and the effect of mineralization is very weak in the surrounding rocks. In the south the ore bodies are more continuous, the kinds of copper minerals are more numerous, and the country rocks evidently show the effect of mineralization. Considering these phenomena from the viewpoint of ore deposition, the southern part of the region seems to have the nature of a relatively deeper zone than in the north, hence it would be interesting, as well as necessary, to investigate an area farther south of the already investigated area.

As to the Gachala region, the mineralization affected at the intersection of several anticlines and fault fissures, and mineralized a certain horizon forming ore deposit there. Accordingly, in spite of the large number of known deposits, their distribution is limited and a sphere of possible distribution can be easily surmised. Geological survey of such possible area would be of the first importance in the Gachala region. The anticlines and fissures are believed to have formed in relation to the deep-seated igneous intrusion to which the mineralization is also related, so that discovery of workable deposits can be expected if further investigations could detect the center of mineralization. The Alto Bojara area we have investigated this time is covered with thick jungle which impedes field work, and yet it is an important area that requires further geological survey.

In the Ibague region we investigated only Mina Vieja as a representative mine of the region. This mine, as already described, is interesting as a middle-class copper mine in Colombia. Immediate commencement of development of the mine, without placing too great expectations, is desired. There are some other mines in this region, although the limited time has unabled us to investigate them. But they are known to have the same character as Mina Vieja, and it is obvious that the ore deposits of the Ibague region occur in the contact zone between the limestone and the granodiorite. Should the geologic structure of this extensive zone be clarified in the future, discovery of larger ore bodies may become possible.

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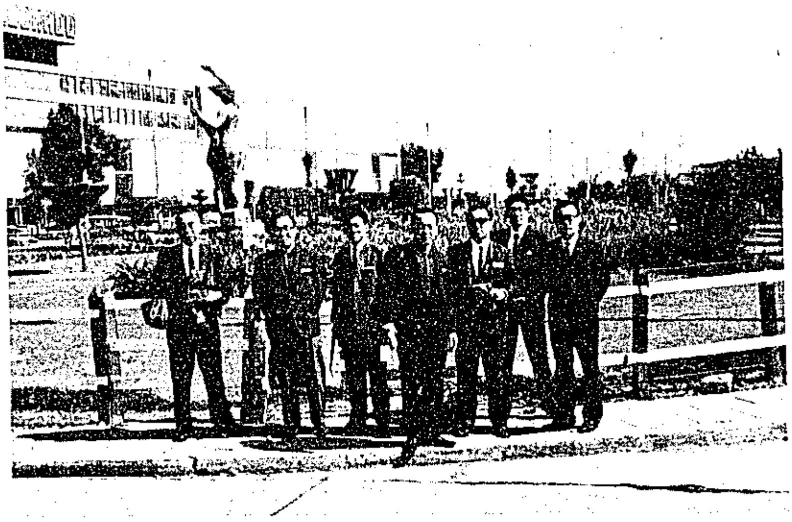


Photo 1. Members of the Survey Team at the Bogota Air-port.

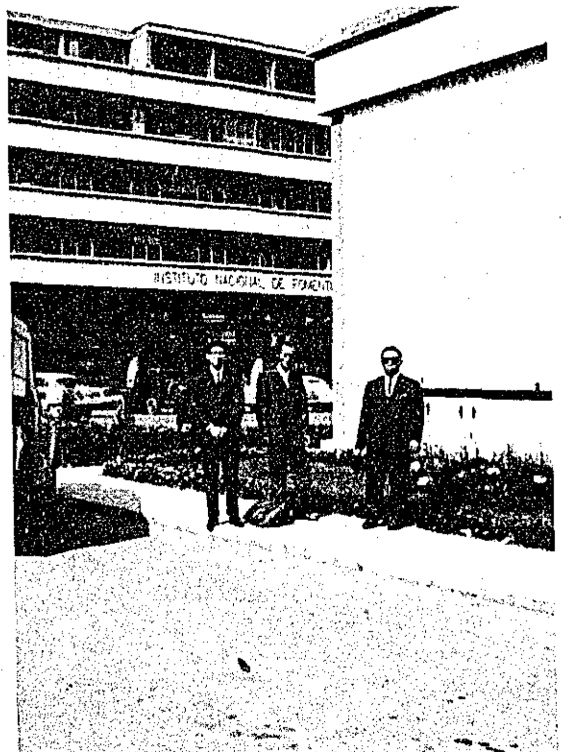


Photo 2. In front of the Ministry of Mines and Petroleum.

Photo 3. Mr. Vincente Mutis of the Inventario Minero, who kindly helped the Team members at all times.

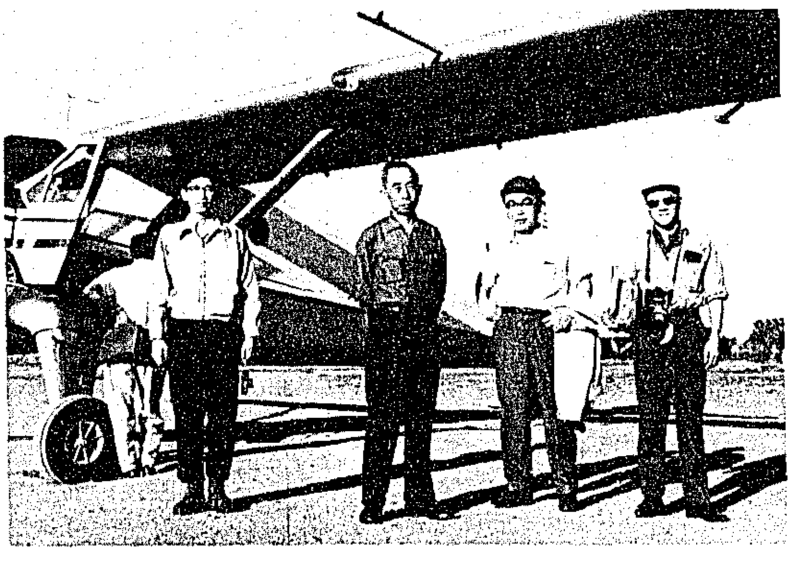


Photo 4. With the small airplane used in the airborne survey.

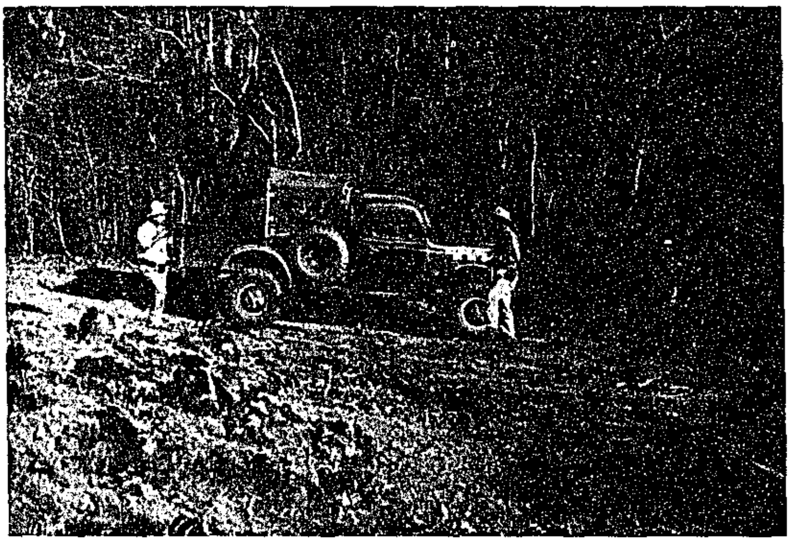


Photo 5. Vicinity of Cerrito outcrop No. 1.

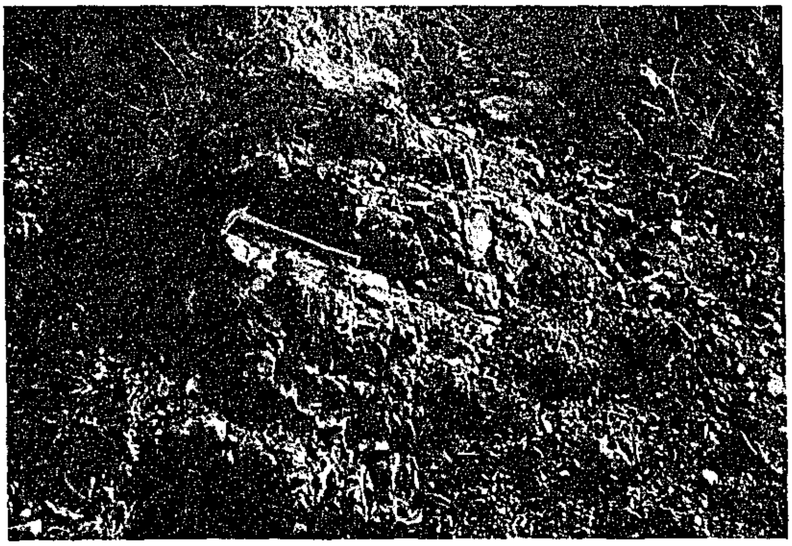


Photo 6, Cerrito outcrop No. 1, showing malachite impregnation (0.5 m x 20 m) in sandstone.

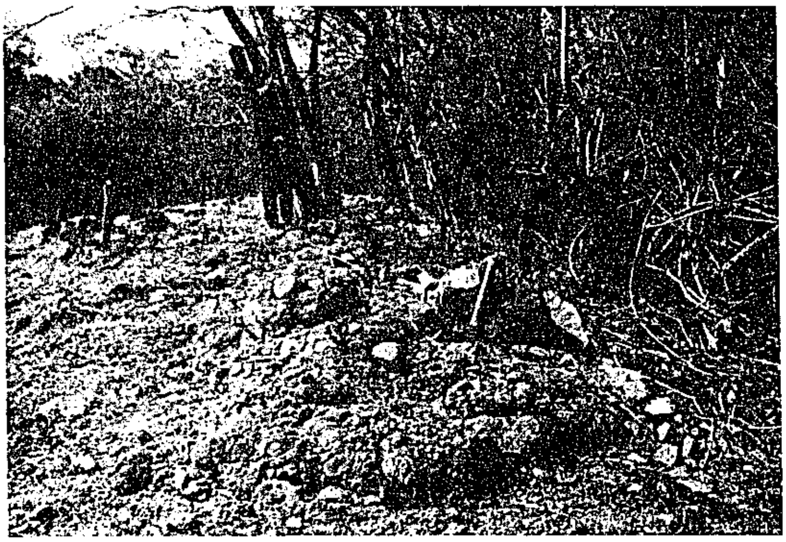


Photo 7. Cerrito outcrop at Los Magueyes, showing malachite impregnation (2.0 m x 4.0 m) in sandstone.

Photo 8. The third outcrop from the north of Carbonalito, showing malachite impregnation (0.4 m x 0.3 m) in shale.

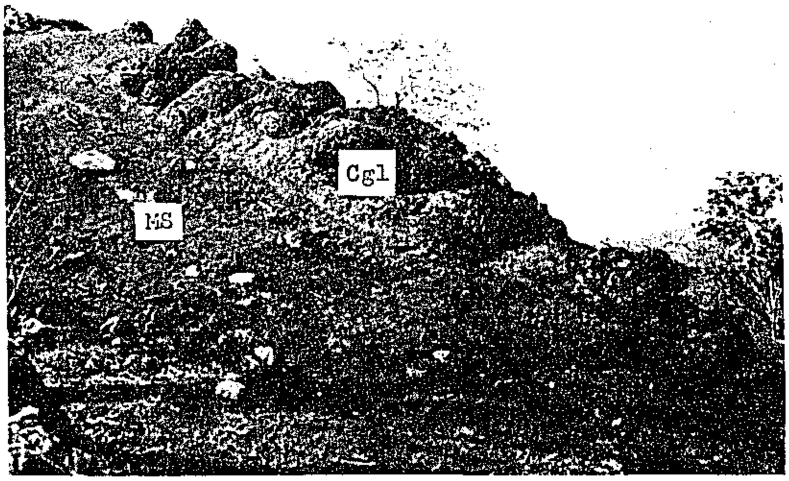


Photo 9. The seventh outcrop from the north of Carbonalito, showing malachite impregnation (0.6 m x 2.0 m) in the boundary between conglomerate (Cgl) and muddy sandstone (Ms).

Photo 10. The southernmost outcrop of Carbonalito, showing malachite impregnation (4.0 m x 2.0 m x 1.0 m) in the projecting conglomerate.

Photo 11. Vicinity of the western outcrop of Campoflorido.

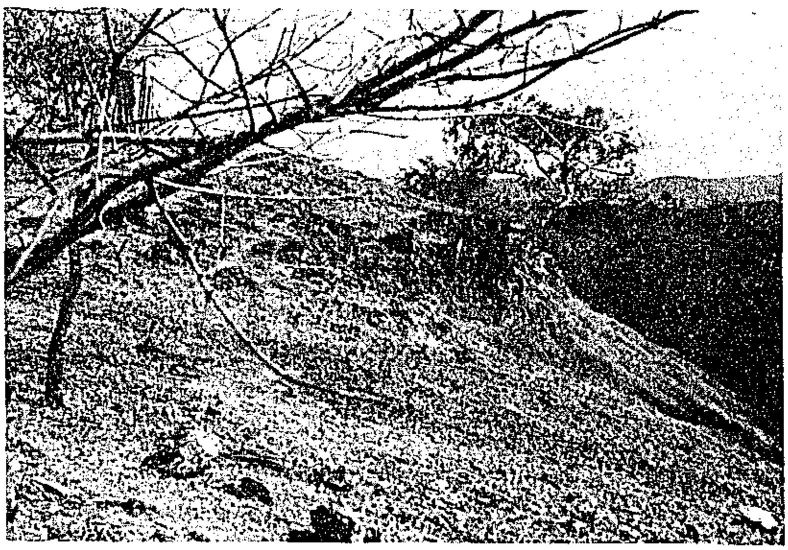


Photo 12. Western outcrop of Campoflorido. Quartz porphyry accompanied by copper oxides forms a small mound (3.0 m x 75.0 m).

Photo 13. Outcrop of San Jose II. Cu-bearing quartz-epidote vein is seen below the hammer.

Photo 14. Outcrop of La Riga; the largest Cu-bearing quartz-epidote vein, 30 cm wide and 3 m long.

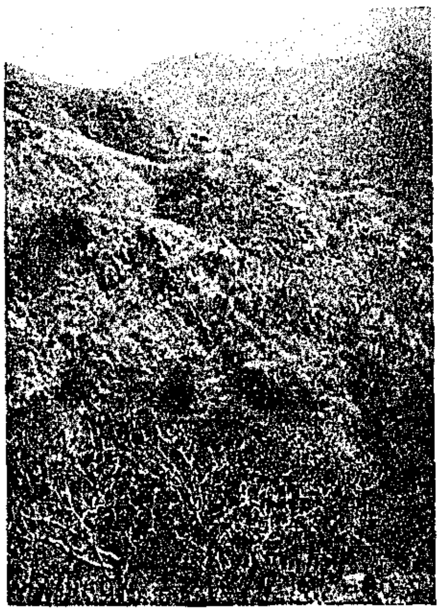


Photo 15. Outcrop of El Rincon; projecting black vein continues forward to the ridge.

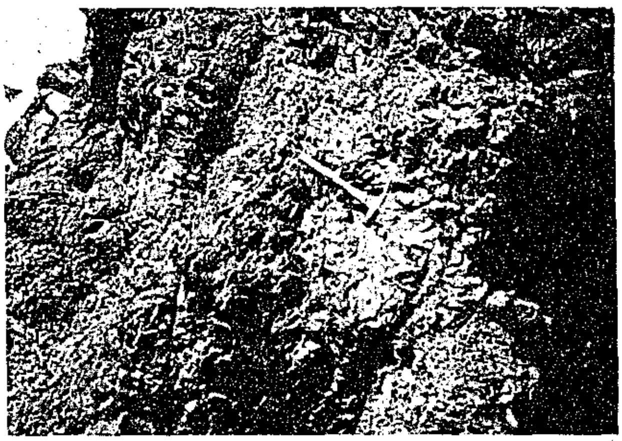


Photo. 16. Outcrop of El Rincon C-vein, 300 cm wide with Cu 1.39 %.

Photo 17. Town of Gachala.

Photo 18. Start on horseback from Gachala for Alto Bojara.

Photo 19. A mountain hut at elevation of 2,800 m on the slope of Alto Bojara.

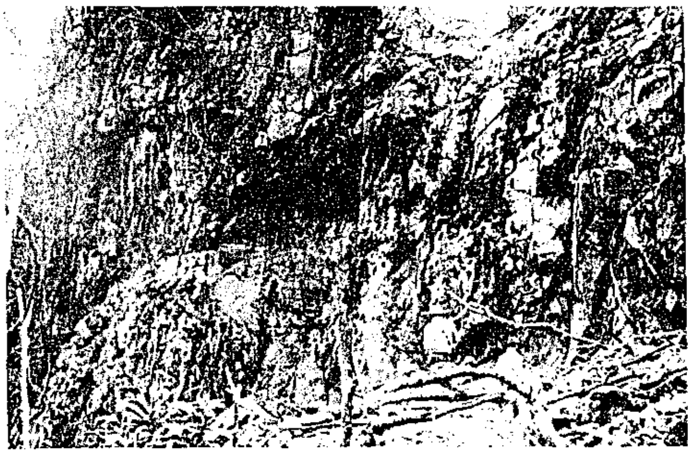


Photo 20. Las Palmas outcrop. A fault (ore vein) of a fairly steep dip is developed. The calcareous sandstone (70 cm - 2.0 m thick) below the outcrop shows impregnation.

Photo 21. Las Palmas outcrop. Side view of Photo 20.

Photo 22. A panoramic view of Mina Vieja. Granodiorite on the left side of the summit, and limestone on the right side beyond the skarn zone.

Photo 23. Outcrop of Mina Vieja. The cliff in the front of Cu-garnet skarn represents the contact with granodiorite.

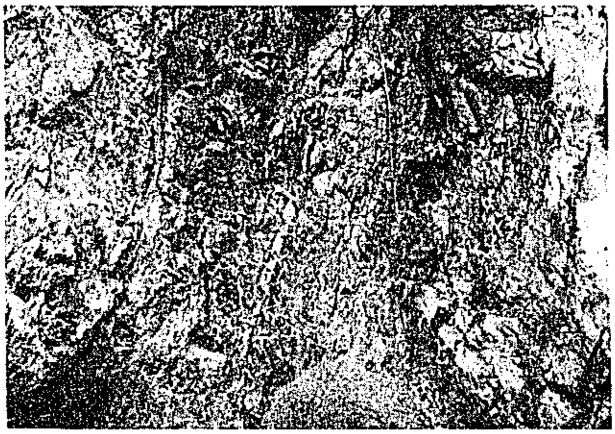
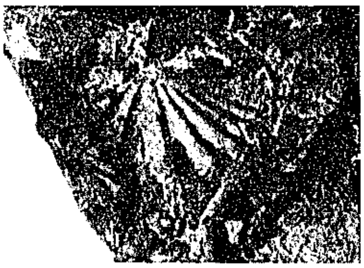


Photo 24. Contact between granodiorite (on the left) and Cu-garnet skarn (on the right) at Mina Vieja.

Photo 25. The boundary between the Mina Vieja ore body and the limestone on its north side.
Upper part: Skarn
Lower part: Limestone

Photo 26.

1



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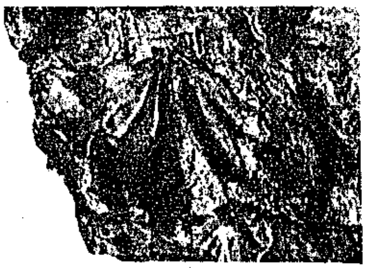


1,2. Punctospirifer sp.

3

4

3. Euchondria sp.

4. Productus sp.
(Clay model)

F

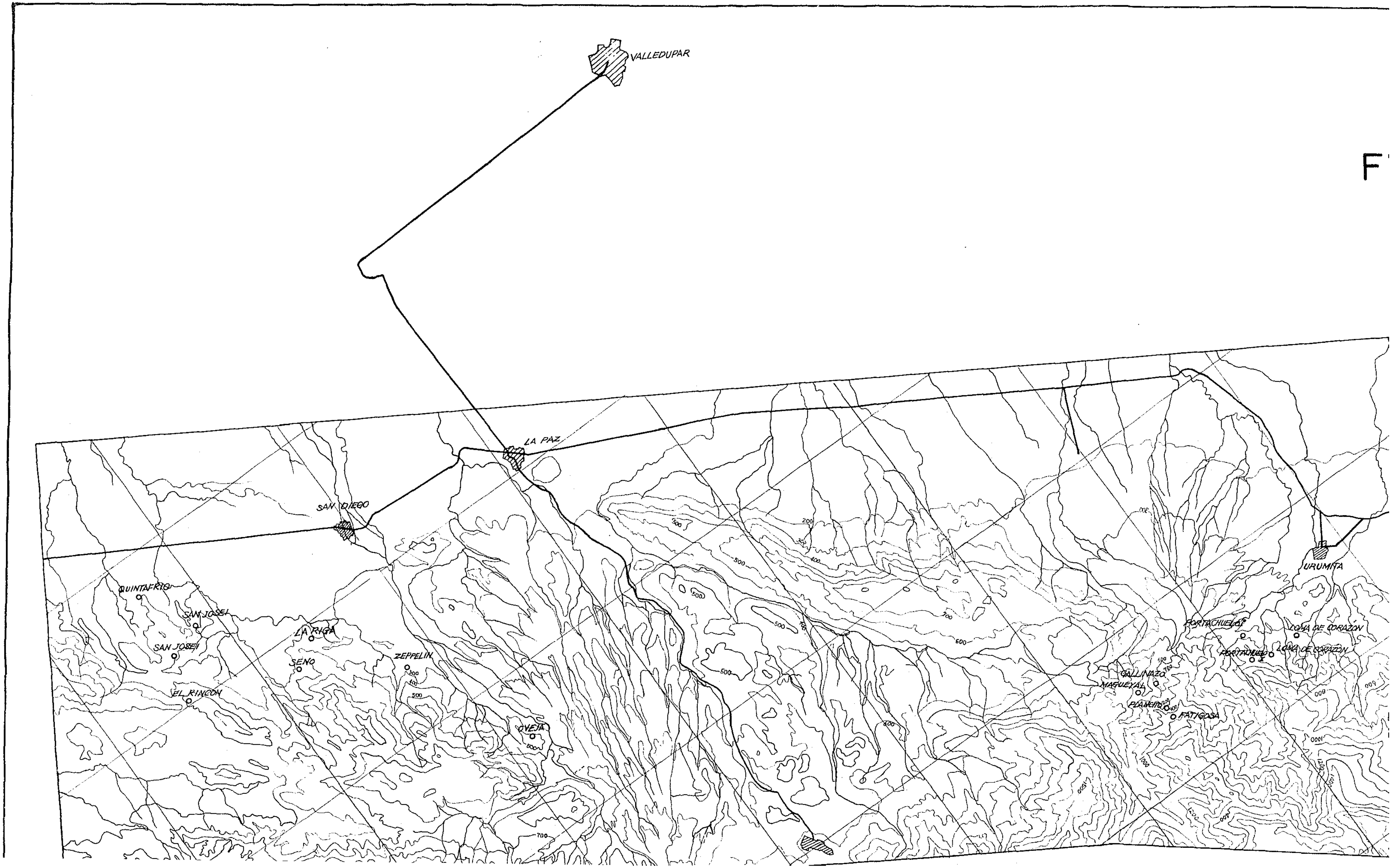
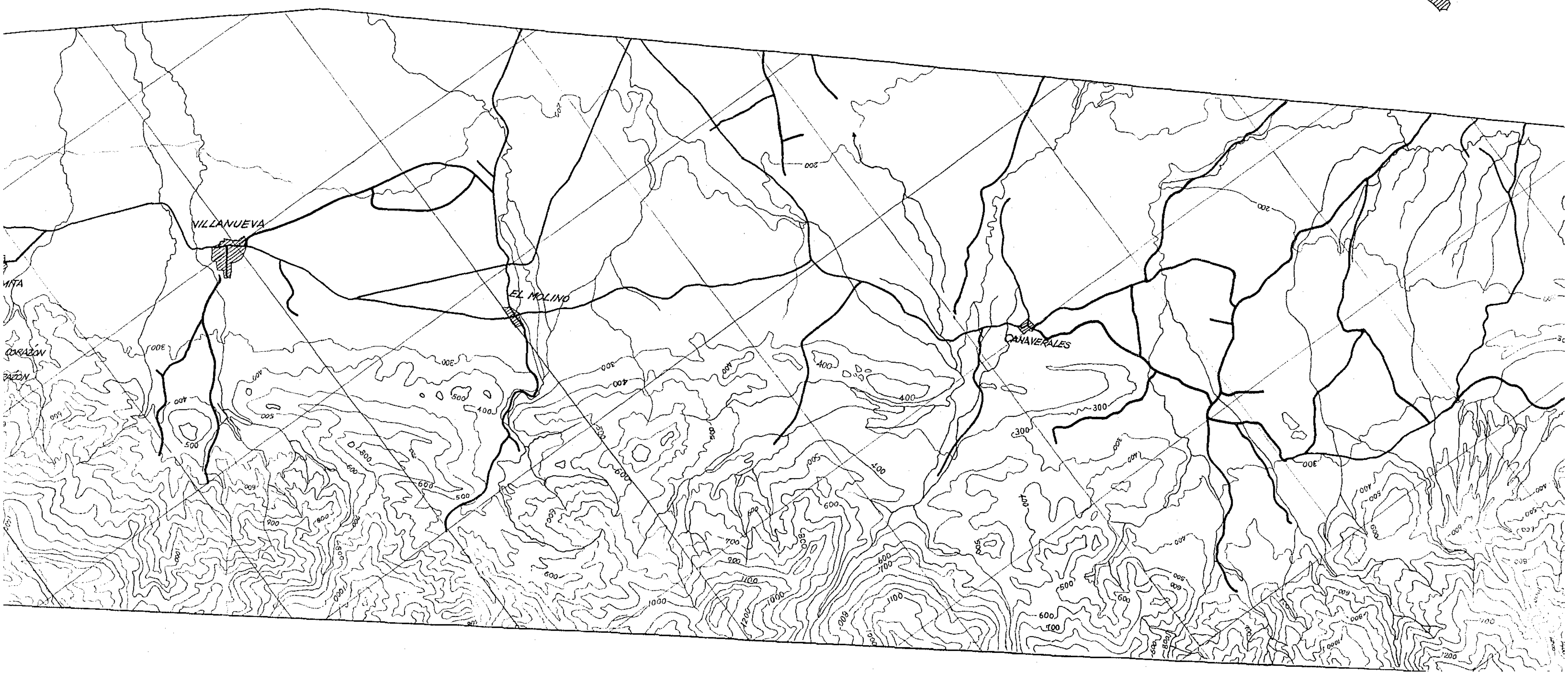
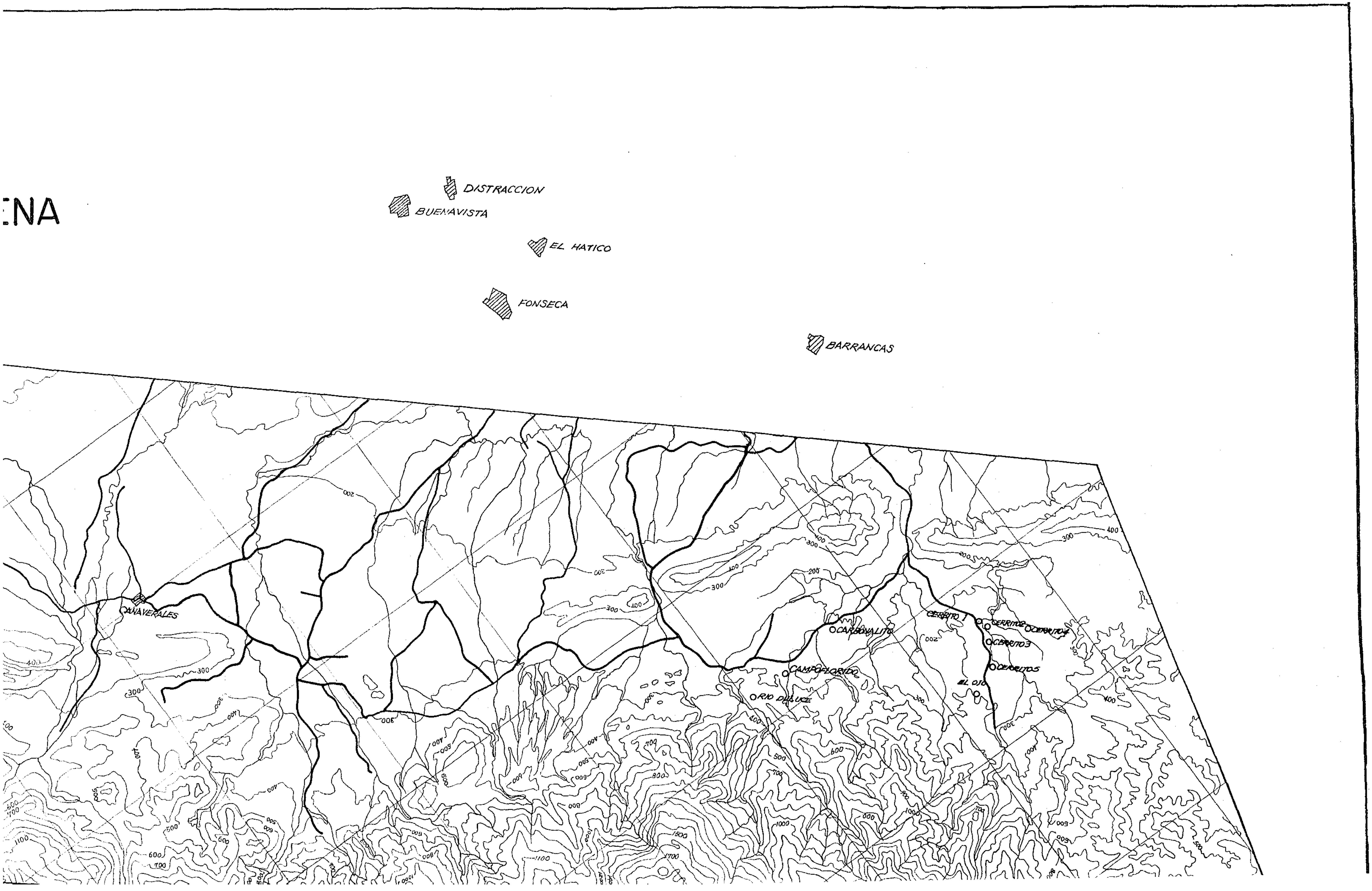
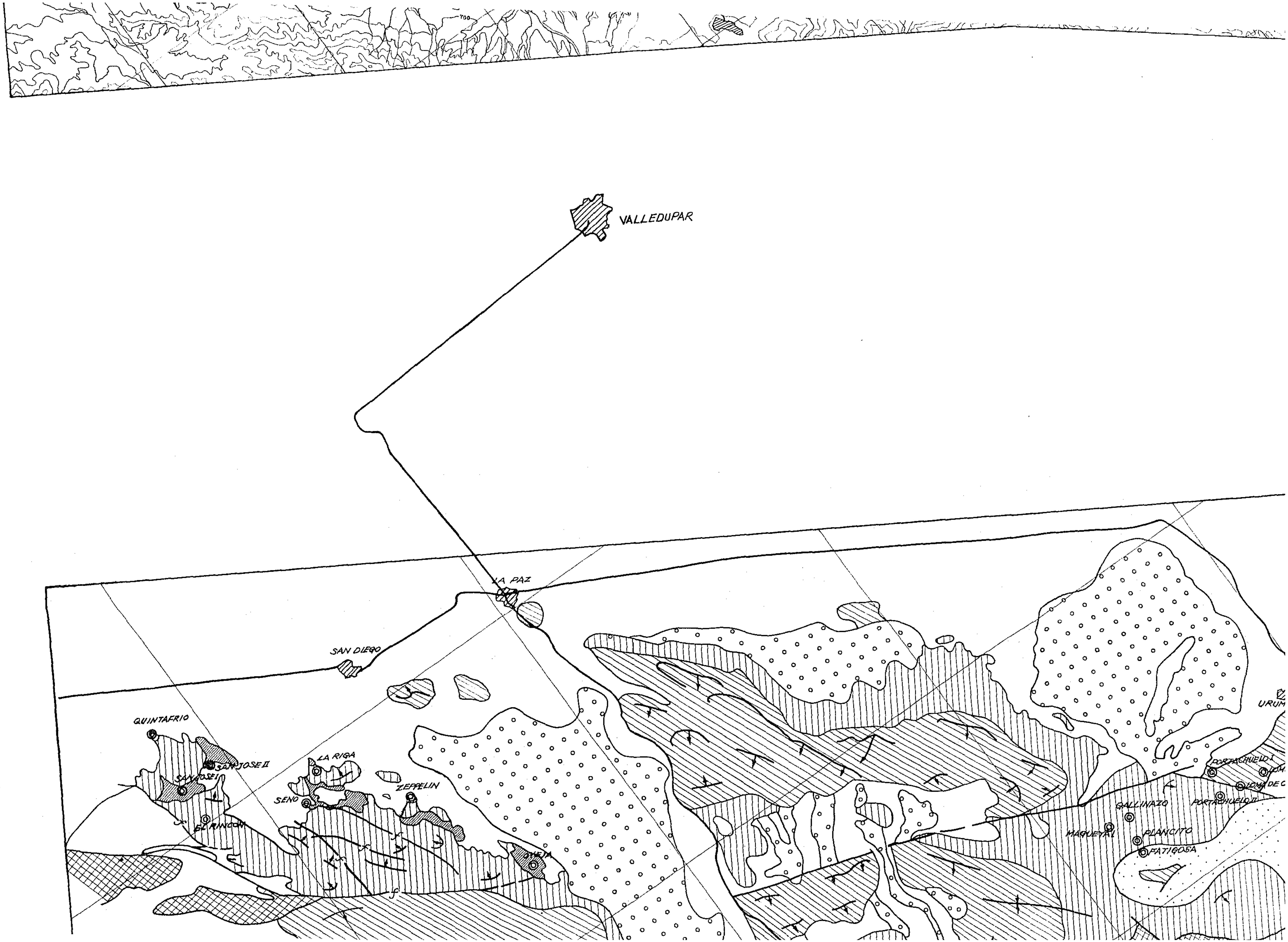
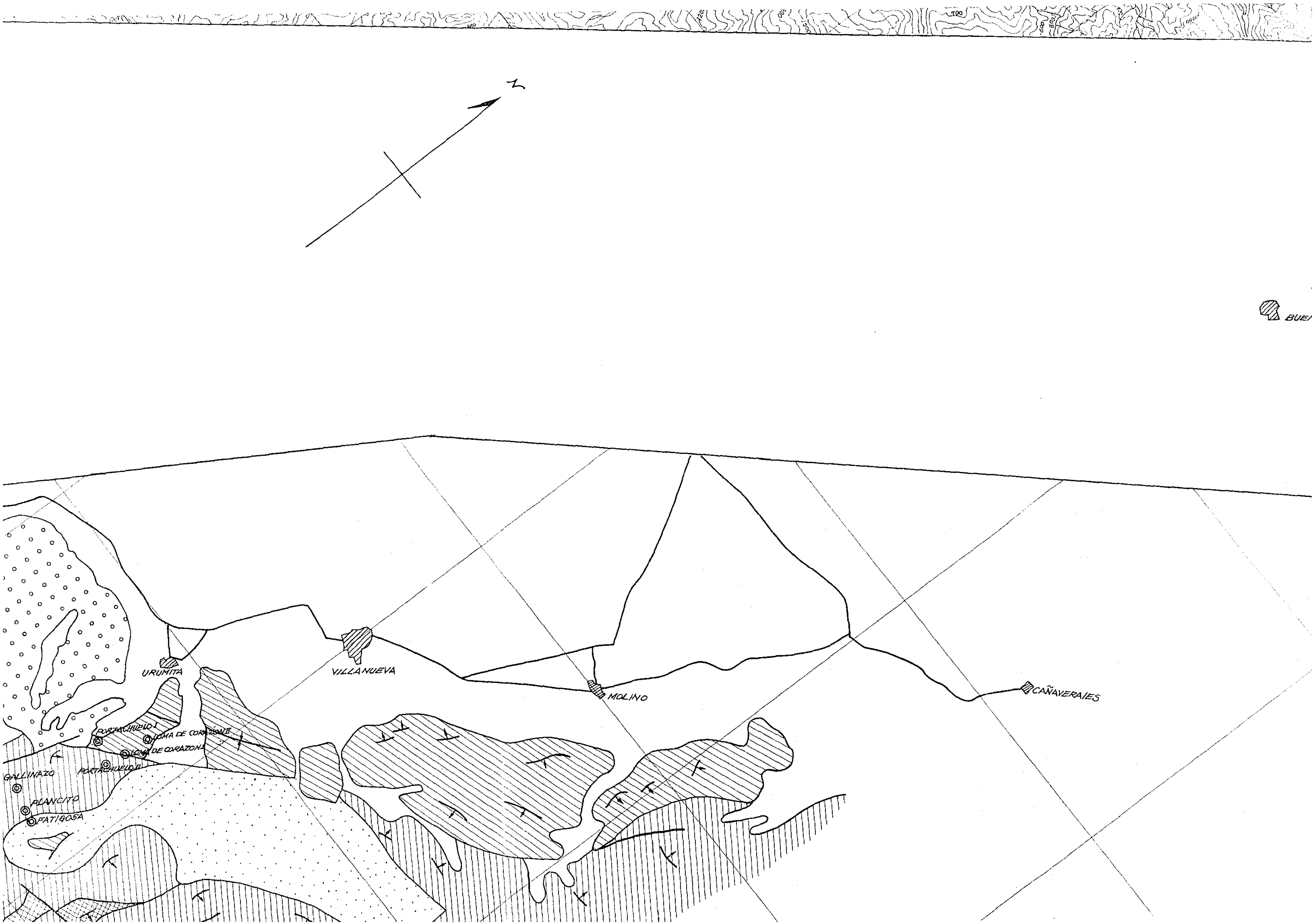

VALLEDUPAR
LA PAZ
SAN DIEGO
URUMITA
QUINTAFRIO
SAN JOSE I
SAN JOSE I
LA RIGA
SENO
ZEPPELIN
EL RINCON
OVEJA
PORTACHUELO I
LOMA DE CORAZON
LOMA DE CORAZON
GALLINAZO
MAGUEYAL
FATIGOSA

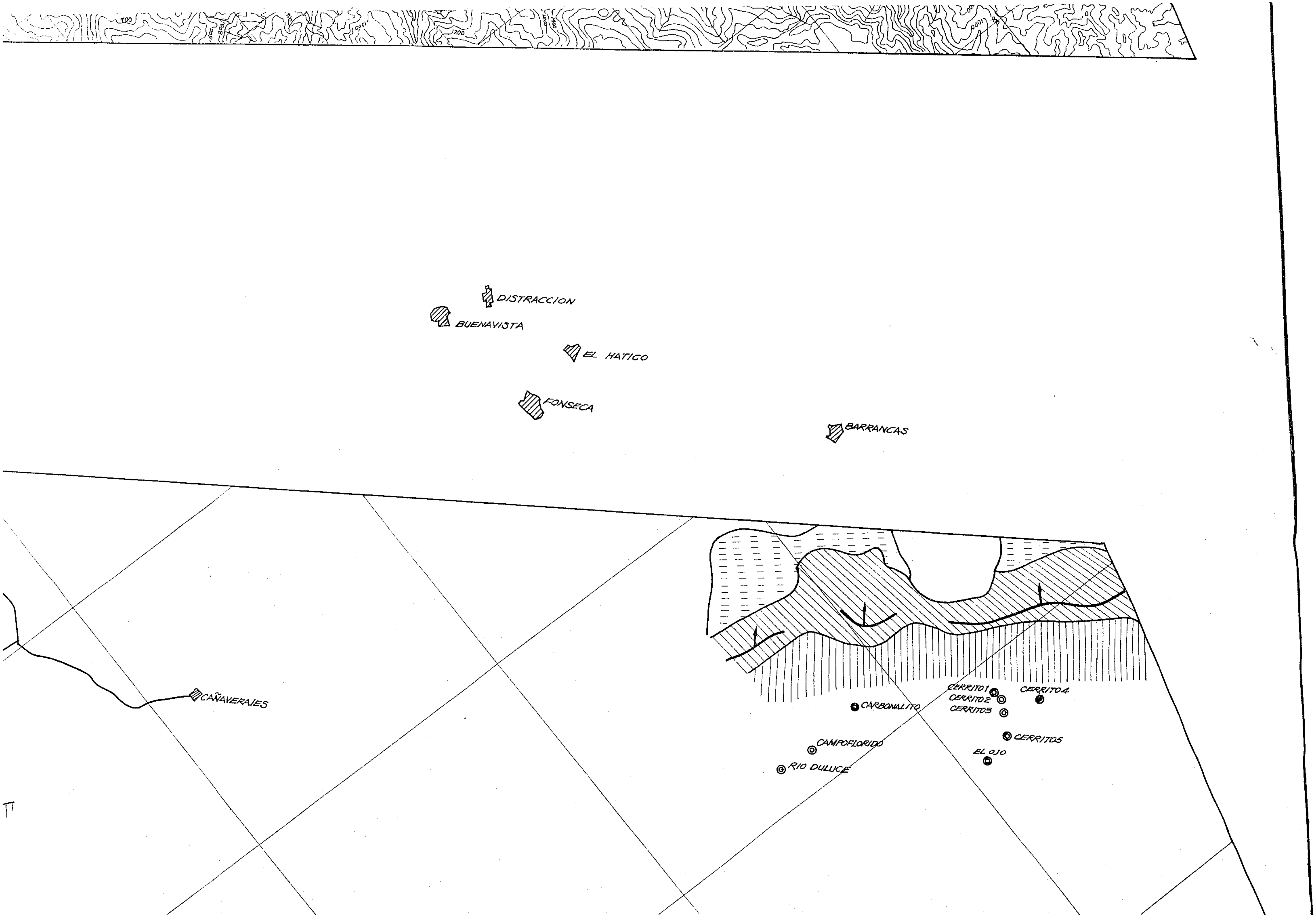
Fig 2 Index Map of Surveyed Mines in the DEPARTMENTS GUAJIRA-MAGDALENA




ENA
DISTRACCION
BUENAVISTA
EL HATICO
FONSECA
BARRANCAS
CAÑAVERALES
CARBONALITO
CAMPOFLORIDO
RIO DULCE
CERRITO 1
CERRITO 3
CERRITOS
EL OJO

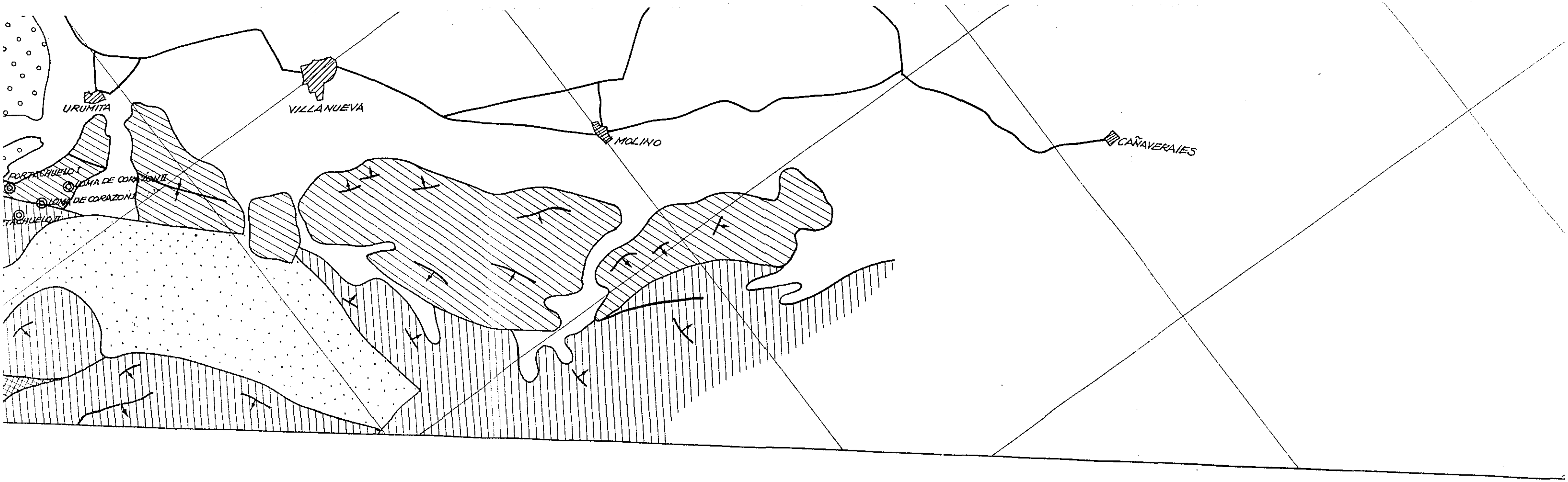

VALLEDUPAR
LA PAZ
SAN DIEGO
QUINTAFRIO
SAN JOSE II
SAN JOSE I
EL RINCON
LA RIGA
SENO
ZEPPELIN
OVEJA
GALLINAZO
PORTACHUELO I
PORTACHUELO II
PLANCITO
PATIGOSA


URUMITA
VILLANUEVA
MOLINO
CAÑAVERAlES
PORTACHUELO I
LOMA DE CORAZÓN II
LOMA DE CORAZÓN I
PORTACHUELO II
GALLINAZO
PLANCITO
FATIGOSA



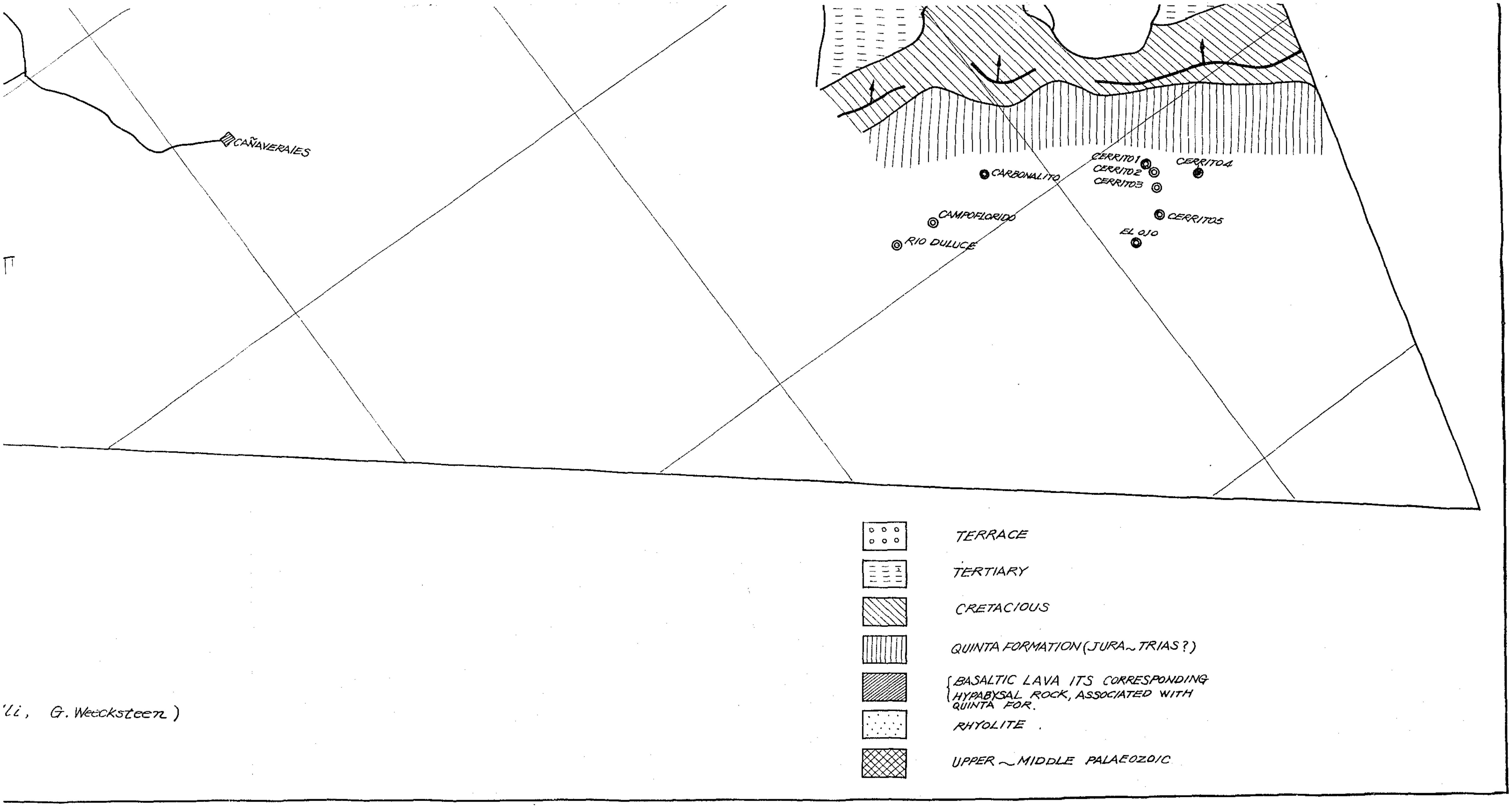
700
1200
DISTRACCION
BUENAVISTA
EL HATICO
FONSECA
BARRANCAS
CAÑAVERAIES
CERRITO1
CERRITO2
CERRITO3
CERRITO4
CARBONALITO
CERRITO5
CAMPOFLORIDO
EL OJO
RIO DULUCE

SAN DIEGO
QUINTAFRIO
SAN JOSE II
SAN JOSE I
EL RINCON
LA RIGA
SENO
ZEPPELIN
PORTACHUELO I
GALLINAZO
PORTACHUELO II
MAGUEYAL
PLANCITO
FATIGOSA



SCALE 1 : 100.000

(According to Dr G. Champetier de Ribes, P. Pagnacco, L. Radelli, G. Weecksteen)


CAÑAVERALES
CERRITO1
CERRITO2
CERRITO3
CERRITO4
CERRITO5
CARBONALITO
CAMPOFLORIDO
RIO DULUCE
EL OJO
TERRACE
TERTIARY
CRETACIOUS
QUINTA FORMATION (JURA ~ TRIAS ?)
BASALTIC LAVA ITS CORRESPONDING HYPABYSAL ROCK, ASSOCIATED WITH QUINTA FOR.
RHYOLITE
UPPER ~ MIDDLE PALAEOZOIC
'li, G. Weecksteen)

MINISTERIO DE MINAS Y PETROLEOS
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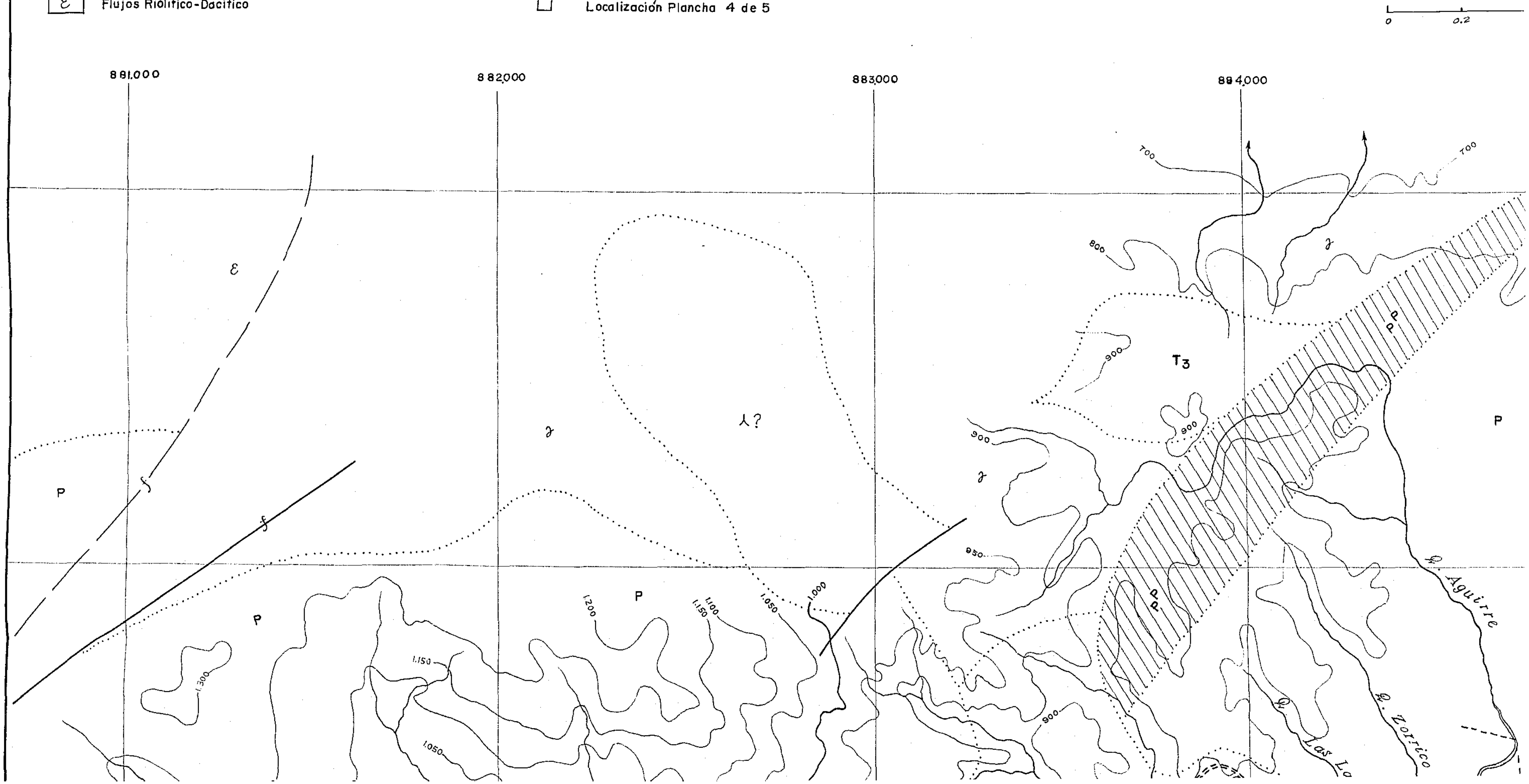
Fig 21 PLANO GEOLOGICO DE PAYANDE-MINA

ESCALA 1:10.000
INFORME N 1.346
PLANCHA 3 de 5
Base Geológica W. Nelson—Otros datos J. Morer
Proyectó E. Nicholls V. Dibujó A. Espitia G.
Octubre de 1.959

- Q — Cuaternario
- T3 — Terciario
- λ — Intrusiones Jurásicas
- K — Post Payande
- E — Flujos Riolitico-Dacitico
- P — Payandé
- pP — Prepayande
- γ — Intrusiones Paleozoicas
- Cuarzo
- Falla buzamiento
- Dirección y buzamiento de estratos
- Direccion y buzamiento de diaclasas
- Contacto anormal y su buzamiento
- Localización Plancha 4 de 5



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ANO GEOLOGICO DE PAYANDE–MINA VIEJA

ESCALA 1:10.000

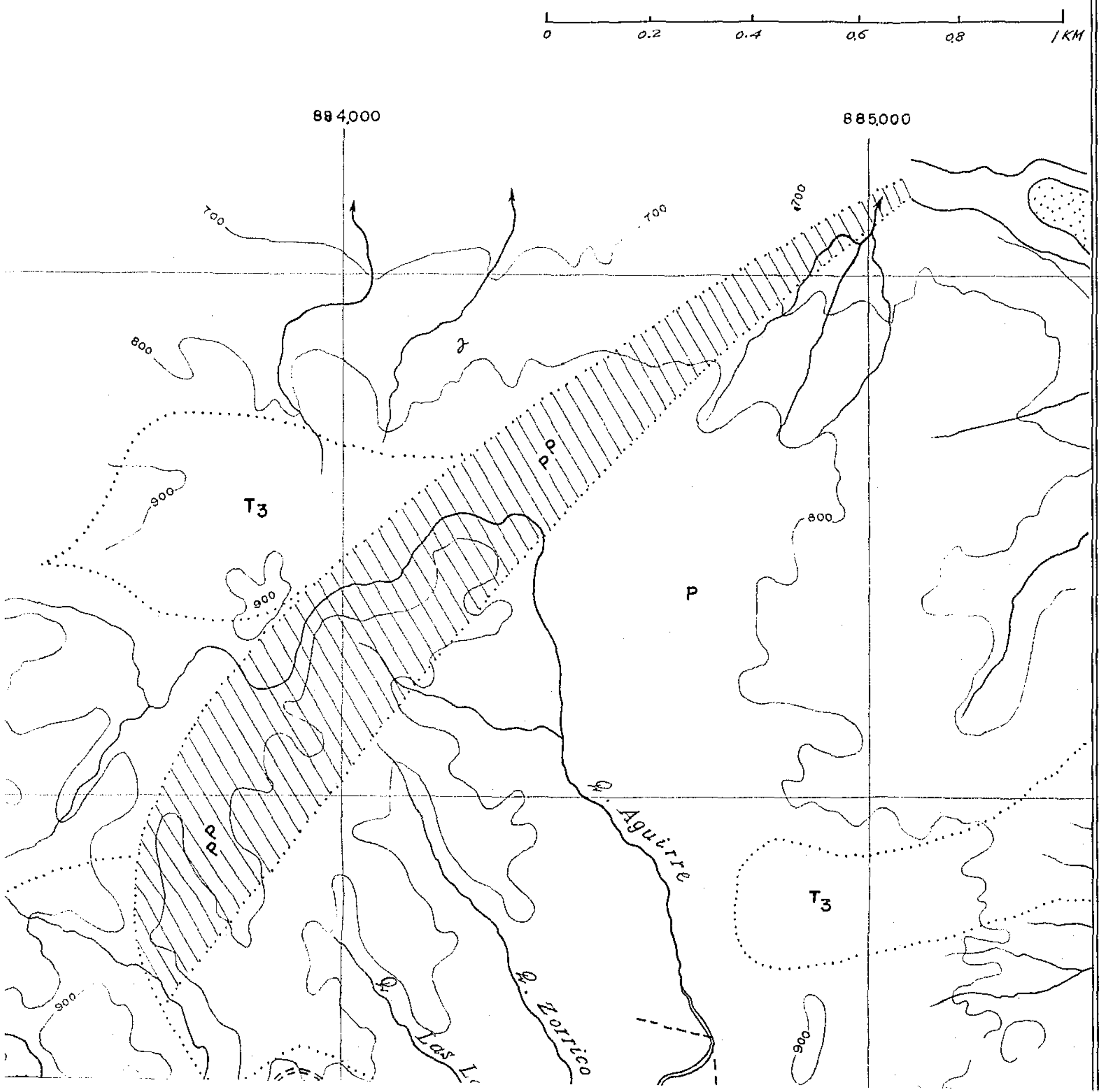
INFORME N 1.346

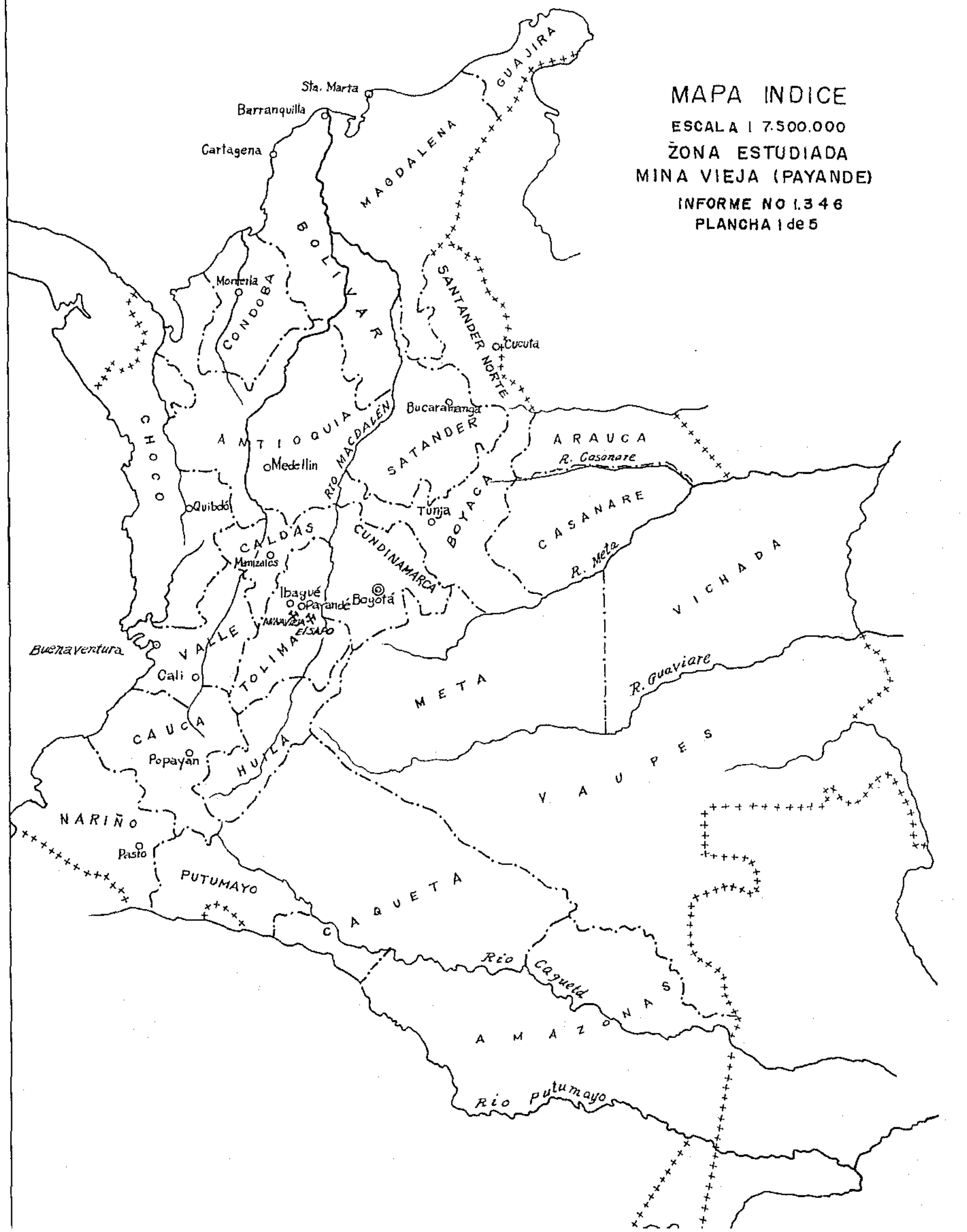
PLANCHA 3 de 5

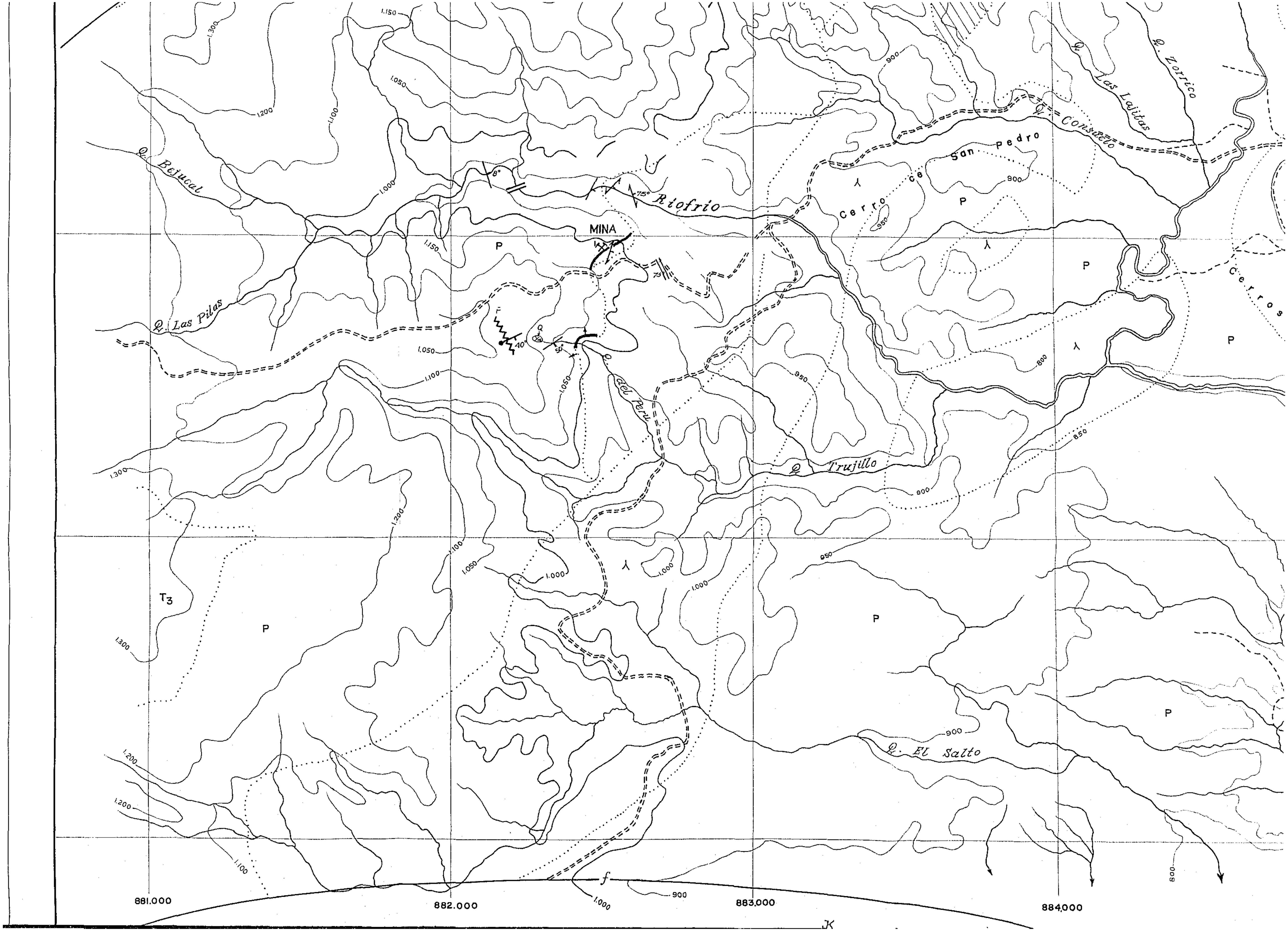
Base Geológica W. Nelson–Otros datos J. Morer

Proyectó E. Nicholls V. Dibujó A. Espitia G.

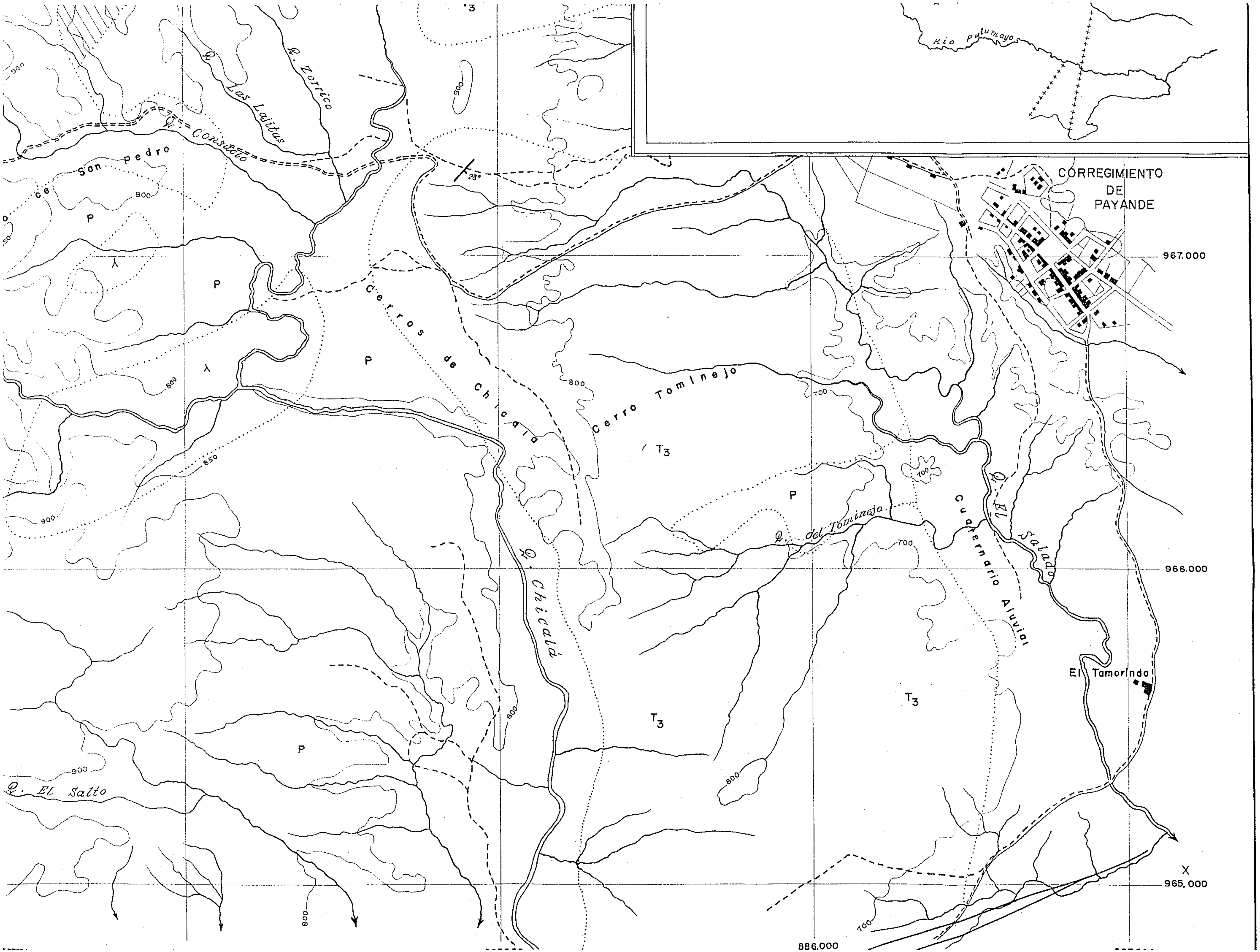
Octubre de 1.959



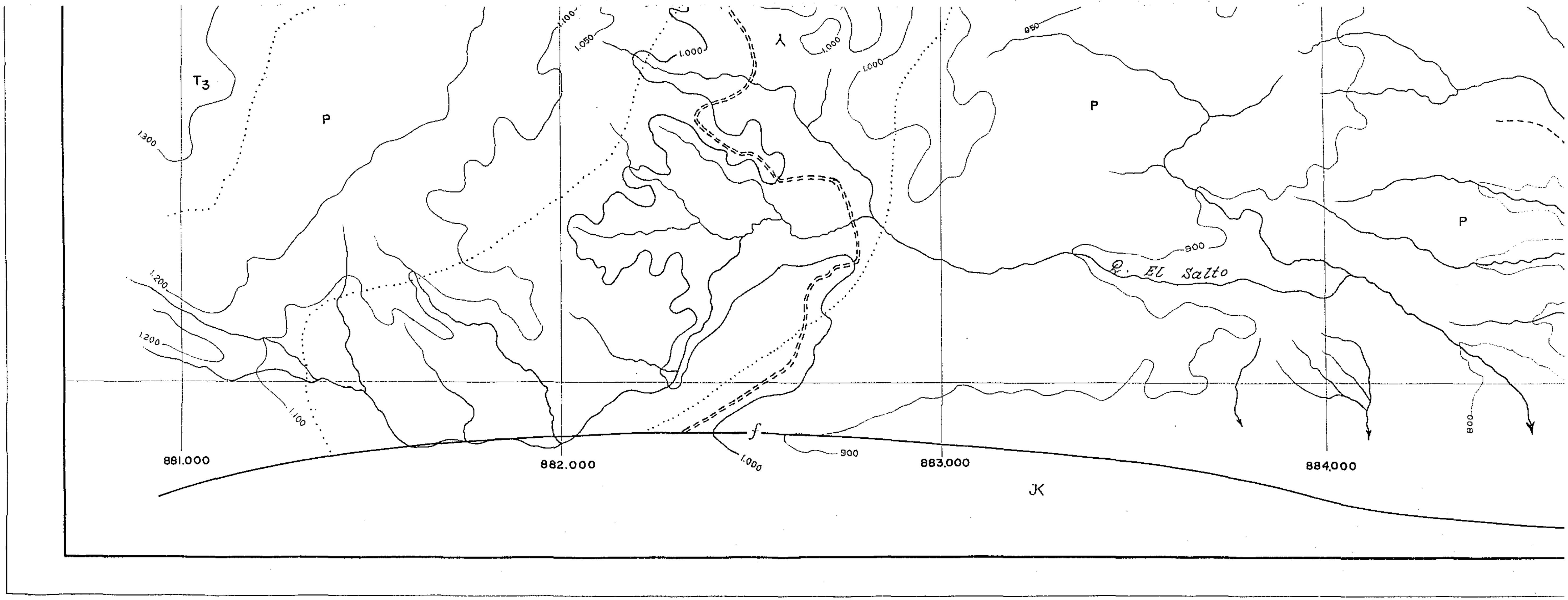




Q. Bejucal
Q. Las Pilas
Riofrio
MINA
Q. del Peru
Q. Trujillo
Q. El Salto
Q. Consuelo
Q. Las Lajitas
Q. Zorrico
Cerro de San Pedro
Cerros
T3
P
881.000
882.000
883.000
884.000
1.300
1.200
1.150
1.100
1.050
1.000
950
900
850
800



Rio Putumayo
Q. Zorrico
Q. Las Lajitas
Q. Consuelo
San Pedro
23°
CORREGIMIENTO
DE
PAYANDE
967.000
Cerros de Chicalá
Cerro Tominejo
T3
P
Q. del Tominejo
Q. El Salado
Cuaternario Aluvial
Q. Chicalá
966.000
El Tamarindo
Q. El Salto
965.000
886.000
900
850
800
700



T3
P
λ
P
P
JK
Q. El Salto
f
1.300
1.200
1.200
1.100
1.100
1.050
1.000
1.000
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950
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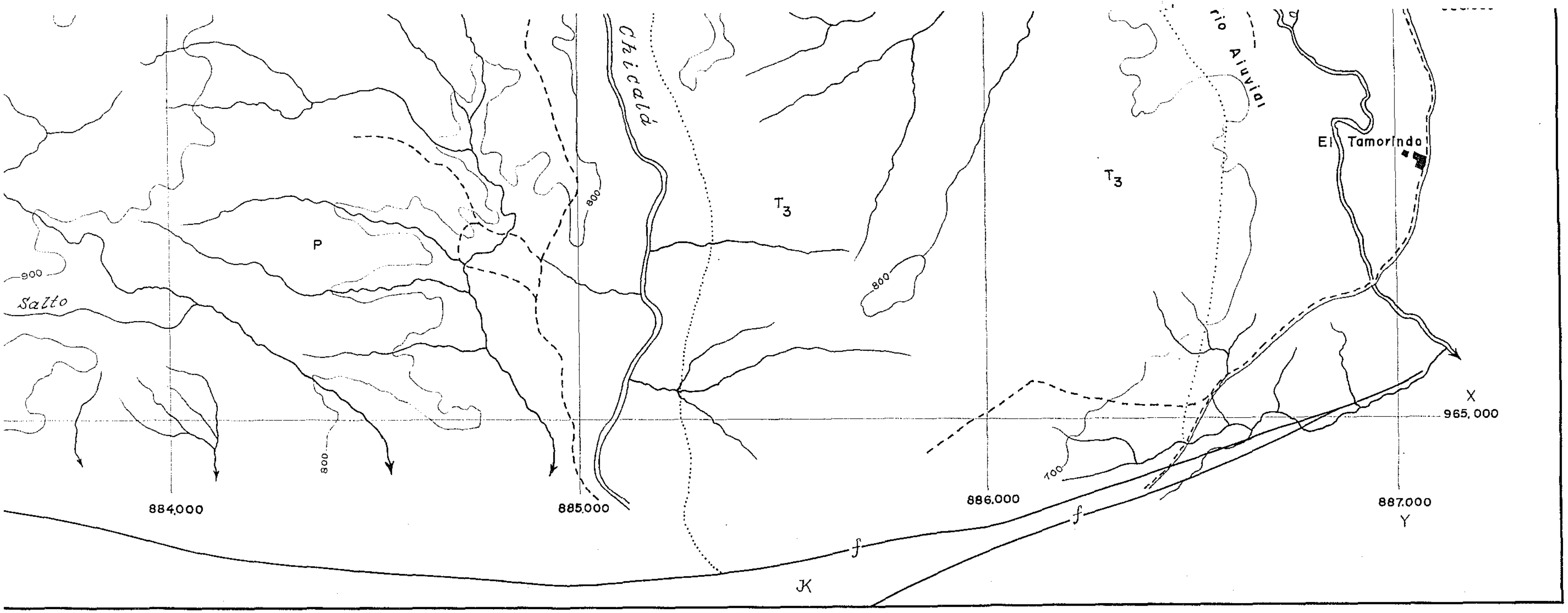
882.000
883.000
884.000



Chicalá
rio Aluvial
El Tamarindo
T_3
T_3
P
Salto
900
800
800
800
800
700
884,000
885,000
886,000
887,000
965,000
X
Y
f
f
K