REPORT ON THE SURVEY
FOR
[illegible] DEVELOPMENT
IN
[illegible] REPUBLIC OF COLOMBIA

MARCH, 1980

JAPAN INTERNATIONAL COOPERATION AGENCY

REPORT ON THE SURVEY

FOR

MINERAL RESOURCES DEVELOPMENT

IN

THE REPUBLIC OF COLOMBIA

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Preface

In response to the request of the Government of the Republic of Colombia, the Government of Japan with the Japan International Cooperation Agency as the implementing arm has carried out the survey for mineral resources development for fourty two days from September 8 to October 19, 1979, mainly four districts of Colombia.

The development of mineral resources is a priority project of the Republic of Colombia in promoting the local economic development.

The Japan International Cooperation Agency (JICA) formed a mineral resources survey team consisting of four experts with Mr. Naoto Aizawa of Overseas Mineral Resources Development Co., Ltd. (OMRD) as team leader.

The team, in close collaboration with the Government of the Republic of Colombia and its various instrumentalities, was able to complete the survey works on schedule during the given period of stay.

The team reviewed, collected, and interpreted the observed data and collected samples. Presented herewith is the report of the team.
I sincerely hope that the report will be of further help in the mineral resources development and will advance further the frontiers of science and friendship between two countries.

In closing, I wish to express my heartfelt gratitude to the team members for their efforts, the officials of the Government of the Republic of Colombia, the officials of the Japanese Embassy in Bogota for their kind cooperation, and the Ministries of Foreign Affairs and of International Trade and Industry for their unsparing supports in dispatching the survey team.

March 1980

Keisuke Arita
President
Japan International Cooperation Agency

Letter of Transmittal

Mr. Keisuke Arita
President
Japan International Cooperation Agency

Dear Sir,

Here is submitted a report on the Survey for the Mineral Resources Development in the Republic of Colombia.

This survey was carried out at the request of the Government of the Republic of Colombia by the Japan International Cooperation Agency as a part of the technical cooperation of the Government of Japan. The survey mission consisting of four experts surveyed four areas in the northwestern part, central part and southwestern part of Colombia from September 8 to October 19 in 1979.

The survey mission collected as many informations and data as possible in cooperation with various organizations concerned, especially the Instituto Nacional de Investigaciones Geologico-Mineras (INGEOMINAS) of the Republic of Colombia. When the survey was finished, a provisional report of the survey results as listed at the end of the present report was submitted to the INGEOMINAS and a verbal report concerning them was made there.

After returning to Japan, the survey mission carried out the analysis and studies of collected samples considering the survey results and data, and made plans of exploration of promising areas, which are the contents of the present report.

The central and western part of Colombia belongs to the northern end of the Andes which is rich in mineral resources. The area is also expected to be rich in mineral resources. However, exploration of them has not been done practically until recently. Especially mining activity concerning non-ferrous metal mineral resources has been very little so far. The mission really wishes that the present report contributes to the activation of the mineral resources development in the Republic of Colombia.

In carrying out the survey, the team was given plenty cooperation and assistance by the Ministerio de Minas y Energia and the Instituto Nacional de Investigaciones Geológico-Mineras of the Republic of Colombia, the Japanese Embassy in that country, the Government of Japan and the Japan International Cooperation Agency, all of which are sincerely appreciated.

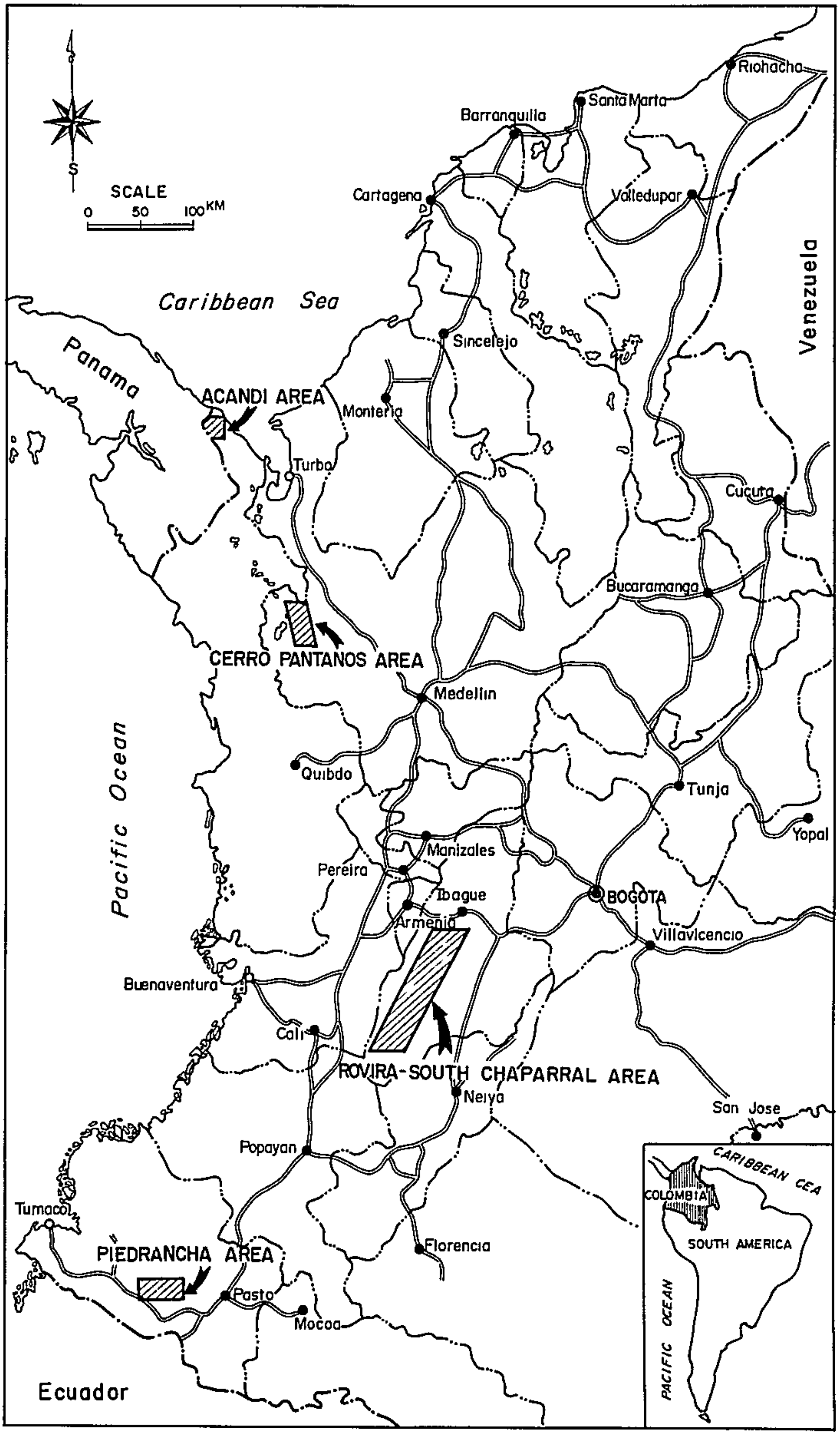
Sincerest best wishes and highest esteem.

Respectfully yours,

March 1980

Naoto Aizawa, Leader
Japanese Survey Team
for
Mineral Resources Development
in the Republic of Colombia

Fig.-1 INDEX MAP OF SURVEYED AREA



Summary

In the Republic of Colombia, four areas, namely, Acandi and Cerro Pantanos in the northwestern part, Rovira-South Chaparral in the central part, and Piedrancha in the southwestern part were surveyed for forty-two days concerning on the Survey for the Mineral Resources Development by a survey team consisting of four experts. After the team returned to Japan, basing on the survey results, collected samples were analyzed and studied.

The purpose of the survey was to study the potentiality of ore deposit and its possibility for development in the above-mentioned four areas and to recommend a guidance for exploration in the potential area in future.

Basing mainly on geological studies on the potentiality of mineral deposits and taking into consideration the possibility of future development in the four areas, it is concluded that two areas, namely Cerro Pantanos and Piedrancha, are hopeful.

The guidances for exploration in future on the above-mentioned two promising areas are recommended in detail respectively in Chapter 2 of the present report.

Report on the Survey for Mineral Resources Development
in
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Chapter 1. Introduction

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1-1-1 Purpose of Survey

Concerning the project of mineral resources development such as copper, lead, zinc, molybdenum, gold and silver in the northwestern part, central part and southwestern part in the Republic of Columbia, a field survey was carried out in four areas in order to study the possibility of the development as well as to evaluate mineral potentiality and to make a exploration plan of promising areas in future.

1-1-2 Selection of Survey Area

As the result of the discussion between the "Feasibility Study Mission of the Basic Study for the Natural Resources Development Cooperation" sent to Colombia by the Japan International Cooperation Agency and the Metal Mining Agency of Japan in July 1978, and the concerned organizations there, the Colombian Government requested formally (by the letter of September 8 1978,)Japan to carry out the exploration of mineral resources. They hoped the exploration to be carried out in the following areas;

i) Serrania de Perija area — Guajira and Magdalena province,

ii) Serrania de Baudo area — Choco province,

iii) South Chaparral area — Tolima province.

However, Serrania de Perija area had been studied already by a Japanese Mission for the survey of mineral resources sent by the Overseas Technical Cooperation Agency in 1965 and 1966, and found to be with little potentiality. Serrania de Baudo area was evaluated to be with low potential of mineral resources from the point of view on the regional geological structure. Basing on these reasons the Japanese side studied various areas including other areas and concluded to propose the following three areas selected among areas which are now in the second phase of exploration supported by the United Nations Development Programme (UNDP);

i) Acandi area (copper mineralized zone) — northern part in Choco province,

ii) Rovira - South Chaparral area (copper mineralized zone) — Tolima province,

iii) Mocoa area (copper, molybdenum, lead and zinc mineralized) — Putumayo province.

The Japan International Cooperation Agency and the Metal Mining Agency of Japan sent the mission again to discuss the areas to be surveyed. Finally it was decided to survey the following four areas;

i) Acandi area

ii) Rovira-South Chaparral area

iii) Piedrancha area — Nariño province

iv) Cerro Pantanos area — Antioquia and Choco province.

Mocoa area proposed by Japanese side was excluded because the Colombia Government is carrying out exploration there in cooperation with UNDP. Piedrancha area of Nariño province was added instead.

Furthermore, Cerro Pantanos area, including Pantanos-Pegadorcito area, about which negotiation is under way with foreign enterprises concerning its exploration and development, was added finally.

1-1-3 Survey Procedures

The present survey was decided to be carried out following the earnest request by the Colombian Government. Exploration stage was different from that for another, consequently each area presented different degree of information concerning geology and mineral deposits. Therefore the following survey procedures were adopted;

i) The study of existing data concerning the exploration of first phase carried out in cooperation with UNDP and the confirmation of the geological bases to select the areas for the second phase.

ii) Concerning the four areas for which the Colombian Government has requested Japanese cooperation, survey of geology and mineral deposit, and a few geochemical samplings will be carried out for potential part of the area. Regional geological-geochemical survey shall be done for some part. Namely, the ground checking of main mineralization and alteration zones and drilling core observation as well as a few geochemical samplings (rock, soil and stream sediment) shall be carried out basing on the existing survey data for the three areas of Acandi, Rovira and Cerro Pantanos. On the other hand, geological and geochemical regional survey shall be carried out around the known geochemical anomaly zone to confirm a mineralization in south Chaparral area and Piedrancha area.

iii) Basing on the survey results of the four areas, the potentiality of mineral deposits and the possibility of their development in each area shall be studied, and the potential order of each area shall be determined.

iv) The most effective exploration method to be adopted for the prospective areas in future shall be planned and recommended.

1-2 Members of the Survey Team

Téam leader	Mr. Naoto Aizawa Overseas Mineral Resources Development Co., Ltd.	Geologist
Member	Mr. Hisashi Kamono Dowa Engineering Co., Ltd.	Geologist
Member	Mr. Junnosuke Oikawa MESCO Inc. Engineering Division of Mitsui Mining & Smelting Co., Ltd.	Geologist
Member	Mr. Tsuyoshi Suzuki Bishimetal Exploration Co., Ltd.	Geologist

Counter part (INGEOMINAS)

• Medellin office	Dr. Eduardo Alvarez	Geologist
• Ibagué office	Dr. Oscar Hernando Pulido	Geologist
• Popayan office	Dr. Pedro Antonio Marin	Geologist
	Dr. Gabriel Paris Quevedo	Geologist

1-3 The Period and Course of the Survey

The field survey was carried out by the following course for forty-two days from September 8 to October 19.

Date order	Month/ date	Day of the week	Course	Content of survey
1	Sept/8	Sat.	Lv. Tokyo	via New York
2	9	Sun.	→ Ar. Bogotá	arrival in Rep. of Colombia
3	10	Mon.	Bogotá city	Japanese Embassy, INGEOMINAS
4	11	Tues.	Bogotá city	Discussion on itinerary of the survey with INGEOMINOS. Collection of data and informations.
5	12	Wed.	Bogotá city	Collection of data and informations.
6	13	Thurs.	Bogotá city	Ditto
7	14	Fri.	Lv. Bogotá → Ar. Medellin	Moving. Collection of data and informations at the Medellin office of INGEOMINAS.
8	15	Sat.	Medellin city	Survey of drilled cores in the areas of Acandi and Pantanos-Pegadorcito
9	16	Sun.	Lv. Medellin → Ar. Turbo	Moving.
10	17	Mon.	Turbo town	Survey of Acandi area
11	18	Tues.	Turbo town	Ditto
12	19	Wed.	Turbo town	Ditto

13	20	Thurs.	Lv. Turbo → Ar. Dabeiba	Moving. Survey of Murindó area.
14	21	Fri.	Dabeiba town	Survey of Pantanos-Pegadorcito area.
15	22	Sat.	Dabeiba town	Ditto
16	23	Sun.	Lv. Dabeiba → Ar. Medellin	Moving.
17	24	Mon.	Medellin city	Discussion on the three areas among the survey team members, and at INGEOMINAS Medellin office.
18	25	Tues.	Lv. Medellin → Ar. Bagotá	Moving. The outline of the survey was reported to INGEOMINAS.
19	26	Wed.	Bogotá city	The survey itinerary was discussed again with INGEOMINAS. Progressive report to Japanese Embassy.
20	27	Thurs.	Lv. Bogotá → Ar. Ibagué Ibagué town	Moving. Survey plan was discussed at INGEOMINAS Ibagué office.
21	28	Fri.	Ibagué town	Survey of drilled cores in Rovira area (Infierno and Los Andes).
22	29	Sat.	Ibagué town	Survey of Infierno area.
23	30	Sun.	Ibagué town	Survey of Los Andes area.
24	Oct/ 1	Mon.	Lv. Ibagué → Ar. San Antonio	Visit to Vieja Mine. Moving.
25	2	Tues.	San Antonio town	Survey of Los Guayabos area.
26	3	Wed.	Lv. San Antonio →Ar. Puerto Sadaña	Moving. Survey of Puerto Saldaña area.
27	4	Thurs.	Lv. Puerto Saldaña → Ar. Neiva	Survey of Puerto Saldaña area. Moving.
28	5	Fri.	Lv. Neiva → Ar. Popayán	Moving.
29	6	Sat.	Lv. Popayán → Ar. Pasto	Discussion and collection of data at INGEOMINAS Popayán office. Moving.

30	7	Sun.	Pasto city	Survey of Piedrancha area - Guachaves district.
31	8	Mon.	Lv. Pasto → Ar. Piedrancha	Collection of data at the Pasto branch of the Ministerio de Minas y Energia. Moving.
32	9	Tues.	Piedrancha town	Survey of Piedrancha area.
33	10	Wed.	Lv. Piedrancha → Ar. Pasto	Moving.
34	11	Thurs.	Lv. Pasto → Ar. Bogotá	Moving.
35	12	Fri.	Bogotá city	The outline of the survey was reported to INGEOMINAS.
36	13	Sat.	Bogotá city	Collection of data.
37	14	Sun.	Bogotá city	Making the progressive report to INGEOMINAS.
38	15	Mon.	Bogotá city	Meeting for the progressive report to INGEOMINAS.
39	16	Tues.	Bogotá city	Report to Japanese Embassy. Visit to the Empresa Colombiana de Minas (ECOMINAS) and INGEOMINAS.
40	17	Wed.	Lv. Bogotá → → Ar. Mexico	Moving.
41	18	Thurs.	Lv. Mexico→	Moving.
42	19	Fri.	→ Ar. Tokyo	Moving.

1-4 Survey

1-4-1 Field Survey

Existing exploration data on survey areas and their vicinities were collected as much as possible. In order to confirm the technical bases of the potentiality of each area, after sufficient discussion with Colombian giologists concerned, in the field survey, the ground checkings were carried out to know the outline of geology, ore deposits and confirm main mineralization, alteration as well as a few sampling of rock, ore and geochemical samples were collected to check the reliability of the existing survey data. Further, the observation of existing drilling cores of main hole at each area was done as an aid to evaluate mineralization and alteration zones.

The concerned organizations and principal persons visited or consulted by the team during the present survey are listed in the following.

i) Instituto Nacional de Investigaciones Geologico-Mineras (= INGEOMINAS)

° Bogotá Head Office;

Address: Carrera 30 No. 51 ∿ 59, Bogotá

Dr. Michel Hermelin

Director de INGEOMINAS

Dr. Carlos Jairo Vesga

Subdireccion Asuntos Regionales de INGEOMINAS

Dr. Luis Jaramillo

Coordinador de Proyectos Basicos de INGEOMINAS

° Medellin Branch Office;

Address: Carretera Robledo, Diagonal Facultad de Minas, Medellin

Dr. Humberto Gonzalez

Jefe Regional Medellin de INGEOMINAS

Dr. Eduardo Alvarez

Profesional Especializado, Subjefe Regional Medellin de INGEOMINAS

° Ibagué Branch Office;

Address: Calle 42, Carrera la. Sur Alto Santa Elena, Ibagué

Dr. Hernando Lozano Quiroga

Jefe Regional Ibaqué de INGEOMINAS

Dr. Oscar Hernando Pulido

Geólogo, Regional Ibaqué de INGEOMINAS

° Popayán Branch Office;

Address: Calle 5a. No. 8-77, Popayán

Dr. Pedro Antonio Marin

Jefe Regional Popayán de INGEOMINAS

Dr. Gabriel Paris Quevedo

Geólogo, Subjefe Regional Popayán de INGEOMINAS

ii) Ministerio de Minas y Energia

° Pasto Branch Office;

(Zona Minera de Pasto)

iii) Empresa Colombiana de Minas

(= ECOMINAS)

° Bogotá Head Office;

Address: Avenida 34, 19-05, Bogotá

Dr. Pedro Pablo Morcillo

Gerente de ECOMINAS

iv) Instituto Geografico Agustin Codazzi

Address: Carrera 30 No. 51, Bogotá

1-4-2 Workings Carried Out in Japan

Of the collected samples, emission spectroanalysis, atomic absorption analysis, making of rock thin sections and ore polished sections, and their microscopic observations were carried out in Japan.

The number of samples is as follows:

i) Emission spectroanalysis

Stream sediments	16 samples
Soils	4 samples

Fourteen elements of gold, silver, chromium, copper, kalium, magnesium, manganese, molybdenum, nickel, lead, zinc, antimony, tin and titanium were analized for all samples.

ii) Atomic absorption analysis

Stream sediments	47 samples	95 components

Four elements of gold, silver, copper and molybdenum were analyzed.

Soils	9 samples	17 components

Four elements of gold, silver, copper and molybdenum were analyzed.

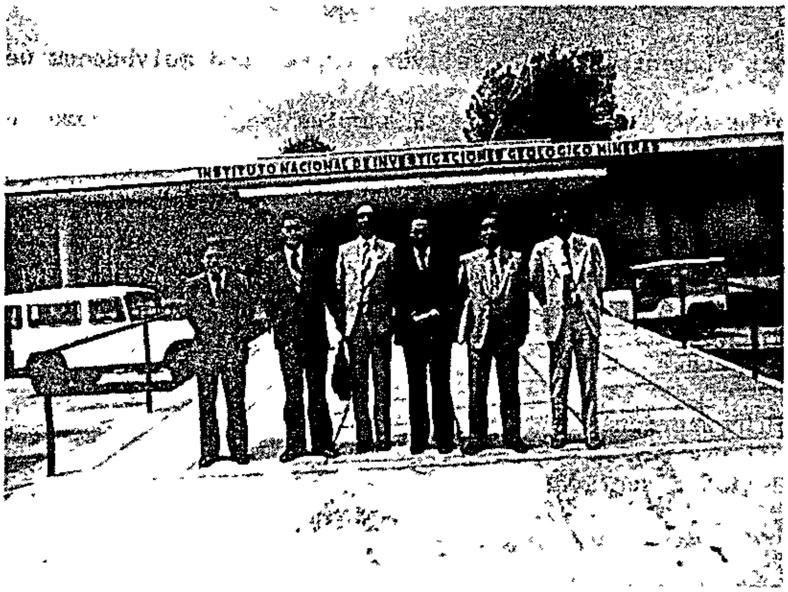
Mineralized rocks	15 samples	45 components

Six elements of gold, silver, copper, molybdenum, lead and zinc were analyzed.

iii) Thin sections 45 samples

iv) Polished sections 10 samples

Photo. 1 INGEOMINAS Head Office in Bogotá



Mr. Y. Ogawa
(MC. Bogota)
Mr. J. Oikawa
Mr. H. Kamono
Mr. N. Aizawa
Mr. K. Hirata
(JICA)
Mr. T. Suzuki

Photo. 2 Discussion on geological informations

Dr. O.H. Pulido
(Ibague Branch
Office)
Mr. H. Kamono
Mr. J. Oikawa
Mr. T. Suzuki
Mr. N. Aizawa
Dr. L. Jaramillo
(Coordinador de
Proyectos Basicos)

CHAPTER 2.

CONCLUSION OF SURVEY AND RECOMMENDATIONS FOR FUTURE EXPLORATION

Chapter 2. Conclusion of Survey and Recommendations for Future Exploration

2-1 Conclusion of Survey

Concerning the above mentioned four areas agreed to survey between the Colombian side and Japanese side in 1979, the potentiality of the existence of ore deposits and the possibility of their development were studied by the field survey and analysis working in Japan. As the results, the potential order has been concluded from the technical view point as follows:

2-1-1 Cerro Pantanos area, 2-1-2 Piedrancha area, 2-1-3 Rovira-South Chaparral area, 2-1-4 Acandi area.

Accordingly, the Japanese mission consider that the first and second areas, namely Cerro Pantanos and Piedrancha, are important to prospect and to develop in future.

The reasons of this conclusion are outlined below:

2-1-1 Cerro Pantanos Area

In the both areas of, a) Pantanos-Pegadorcito and b) Murindó which belong to the Cerro Pantanos area, plutomic rock (Mandé batholith) is found widely which consists mainly of quart diorite of middle Tertiary period intruding in Cretaceous sedimentary rocks. The batholith is intruded by later porphyry with stocks or dykes.

The mineralization is the porphyry copper type one with molybdenum in general accompanying the later activity of porphyry. Porphyry copper in Murindó area accompanies some gold. In both areas, alteration zones, common to porphyry copper type mineralized zone — potassic alteration zone, phyllic alteration zone and propylitic alteration zone etc. — are found widely. The result of geochemical survey shows that there are several Cu-(Mo) mineralization zones with from 1 km to 2 km in diameter corresponding to alteration zoning in each area. The result of drilling in Pantanos area shows typical porphyry copper type mineralization of about 0.5 ∿ 1.0% Cu consisting of chalcopyrite-pyrite below oxidized and leached zone.

From the facts described above, it has been concluded that it is highly possible that porphyry copper type ore deposit of the scale of hundred million tons will be found with the advancement of future exploration in this area including the areas of Pantanos-Pegadorcito and Murindó, and the geographic location of the area is rather good to develop.

2-1-2 Piedrancha Area

This area is lacking convenient means of traffic communication. Especially from the central part to the western part exploration and development have been scarcely done so far. Hence the geological data are insufficient. The present survey was not able to carry out in the field nearby main geochemical anomaly area owing to bad weather, so specific bases for evaluation are very insufficient. Nevertheless the survey team has concluded that this area is very interesting for finding ore deposits of gold, silver, copper, lead, zinc and molybdenum from the following reasons.

i) The geological features is similar to that of the above-described Cerro Pantanos area. Plutonic rock similar to Mandé batholith in middle Tertiary period intruding in the Cretaceous sedimentary rocks is distributed widely. The existence of the later porphyry activity is also found.

ii) The result of the regional survey in first phase by UNDP-INGEOMINAS shows that there exist many geochemical anomaly zones of copper, molybdenum lead and zinc, and also exists an area which have zonal arrangement of elements (with copper and molybdenum inside, surrounded by lead and zinc), characteristic to porphyry copper type ore deposit.

iii) In the northeastern (relatively easily accessible) part, there exist many gold mines mineralized by the quartz porphyry which follows granodioritic intrusion and being accompanied by copper, lead and zinc.

iv) Mineral showings are located relatedly to several fracture zones approximately parallel to the NW-SE direction, consequently the area are in the geological environment capable of forming ore deposits of big scale.

As described above mineral deposits expected in this area are so called porphyry copper type deposits of copper and molybdenum of big or middle scale as well as mineralized breccia zone or mineralized bodies and vein type ore deposit of gold, silver, copper, lead and zinc. Especially ore deposit in this area has a favorable characteristic of high gold content in general. It is judged to be of advantage to develop the area as the location is near the pacific coast.

2-1-3 Rovira-South Chaparral Area

Basing on the findings described below, the possibility of the existence of commercially valuable porphyry copper type ore deposits is evaluated to be small in the vicinities of four surveyed areas belonging to this area. However, small scale skarn type copper ore deposits of high grade may be possible to be found.

On the other hand, as this area is in the geological environment similar to the excellent porphyry copper type copper-molybdenum mineralized zone which is now being prospected in Mocoa region of Putumayo province in the south of Colombia, it is advised to survey again, if possible, around the anomaly zones in this area which was covered by the UNDP-INGEOMINAS survey of first phase. However, the location is considered to be of no advantage to develop because the area is located in inland.

i) Los Andes area; Porphyry copper type mineralization and alteration is observed accompanyed by quartz porphyry intrusion in about Cretaceous and Tertiary period into the late Jurassic Ibagué batholith. However, the mineralization is weak and not uniform in general. Previously drilled cores shows low grade (= 0.09% Cu in average). As these cores are judged to have been drilled at the central part of the mineralized zone, the possibility to find any other commercial ore deposit in this area has been considered to be small.

ii) Infierno area; Similarly as the Los Andes area porphyry copper type mineralization and alteration is evidently observed accompanying quartz porphyry intrusion into the Ibagué batholith. But the copper mineralization is weak in general. The grade of cores drilled previously is as low as 0.1 ∿ 0.2% Cu. The drilling is judged to have been done near the center of the mineralized zone. Therefore the possibility to find any other commercial mineral deposit has been considered to be small in this area.

iii) Los Guayabos area; Skarn type copper mineralized zones are observed at the contact between the Pre-Cambrian calcareous rocks and quartz porphyry from Cretaceous to Tertiary period. Depending on the advancement of the future exploration, it is possible to find ore deposit of several hundred thousand tons as same class as "Mina Vieja" which is now in operation in Tolima province.

iv) Puerto Saldaña area; Porphyry copper type copper-molybdenum-zinc mineralization and alteration is observed accompanying quartz porphyry which intruded into the Ibagué batholith. However, the possibility to find any other promising ore deposit has been considered to be small in this area, because the mineralized zone is judged to be narrow and the main mineralized zone assumed to be existed is supposed to have probably been eroded out already.

2-1-4 Acandi Area

Geology is consisted mainly of volcanic rocks of late Cretaceous period and plutonic rocks such as diorite (similar to Mandé-batholith) intruded in the above-mentioned volcanic rocks in early-middle Tertiary period.

Porphyry copper type mineralization and alteration exists widely accompanying quartz diorite. However, the copper mineralization is generally weak. Previously drilled cores are of low grade (0.15 ∿ 0.25% Cu), and the drillings are judged to have been done near the center of the mineralized zone. Therefore, it has been concluded to be difficult to find any new mineralized zone of high grade in this area in future. Further it can be pointed out as pessimistic bases for this area that rocks in big porphyry copper type mineralized zones in North America, Central America and South America contain generally more K_2O than those in this area, and that the "magmatic evolution" necessary for concentration of copper mineralization solution seems to have been insufficient (little activity of porphyry in the later stage). Consequently, this area is considered to be not hopeful to prospect in future.

2-2 Future Exploration

The followings can be recommended about the future exploration in two promising areas - namely Cerro Pantanos and Piedrancha - where exploration is needed continuously.

2-2-1 Cerro Pantanos Area

i) Pantanos-Pegadorcito area

As the geological study of this area has been done so well by INGEOMINAS, the outline of mineralization can be understood. Mineralization in this area is accompanyed by porphyry intrusion controled by fissure system and they tend to be concentrated near the boundary between porphyry and other rocks. Therefore, it is highly possible that the mineralization zones exist as blocks. Taking these into consideration, the following procedures are recommended for future exploration.

1) First phase exploration;

a) Detailed geological survey:

In order to make clear the boundary of each rock and geological structure, geological survey shall be done again in more detail and geological structure map shall be drawn. As distribution of outcrops is not so good due to weathering in general, it is recommended for the purpose to adopt such methods as trenching and pit survey with a portable drill machine.

2) Second phase exploration;

a) Geochemical survey:

Copper-molybdenum anomaly zones shall be limited exactly by systematic geochemical soil sampling method.

b) Geophysical survey:

Carrying out geophysical survey with the IP method, it may be effective to estimate the model of the existence of mineralization zones by simulation.

3) Third phase exploration;

a) Diamond drilling exploration:

For the promising zone determined by the procedures described above, approximately five to ten information drillings shall be carried out to confirm mineralized zone.

b) Synthetic evaluation:

Correlation of surface and subsurface geology, shall be done to drive the final evaluation on the mineralized zone.

ii) Murindó area

For this area, geochemical survey has been done sufficiently so far by INGEOMINAS and several promising copper-molybdenum-gold anomalies have been limited, but geological study that is the base of prospecting is not sufficient contrary to the case of Pantanos-Pegadorcito area. Therefore, the following procedures are recommended for future exploration.

1) First and second phase exploration;

a) Detailed geological survey:

For the whole area, detailed geological survey shall be carried out with trenching and a portable drilling machine to make clear the distribution of rocks and alteration zones, and geological structure. Thus,

• the occurrence of porphyritic rock facies existing in quartz diorite and its correlation with the mineralization shall be made clear,

• the correlation between the distribution of rocks and alteration zones and the geochemical anomalies shall be clarified,

• the structural control on the mineralization shall be clarified.

b) Geophysical survey:

• Magnetic survey - Existing data of magnetic survey shall be studied again and utilized as an aid for detailed geological survey. Magnetic survey shall be done in wider area if necessary.

• IP survey - Using the existing data of IP survey, simulation shall be carried out to examine the model of the mineralized zones. If necessary to increase the accuracy, additional IP survey shall be done in the area where the IP was already done and its vicinity.

2) Third phase exploration;

a) Diamond drilling exploration:

For the promising area determined by the procedures described above, information drillings of about five to ten shall be carried out to confirm anomalous zone.

b) Synthetic evaluation:

Correlation of surface geology and subsurface one by drilling shall be done to drive the final evaluation on the mineralized zone.

2-2-2 Piedrancha Area

The following steps shall be needed for the exploration of ore deposits in this area where detailed survey has almostly not been carried out so far.

i) First phase exploration;

1) Preparation of accurate base maps: in 1/50,000 scale, using avairable drainage pattern maps, aerospace photographs, radar photographs and others. However, it is strongly recommended as the best way, to take new aerophotographs over the area for accurate topographic maps.

2) Geological and geochemical reconnaissance survey: general geological investigation and geochemical samplings along the main streams in the upper Gualcala and upper Telembi areas where many ore deposits and mineralizations have been known.

3) Investigation of known ore deposits: investigation of a few mines in operation to recognize the characteristic features of mineralization in the Piedrancha area.

Referred to all informations provided from the first phase exploration, it will be selected one or two areas with the best potentials, for second phase.

ii) Second phase exploration;

1) Detailed geological and geochemical survey:

In the promissing areas selected as mensioned above, conduct the detailed field works including geochemical grid-sampling of soils, and geological survey by trenching, pitting and others.

2) Geophysical survey:

Certain suitable geophysical method shall be carried out to estimate the extent and depth of the inferred mineralizations.

A few exploratory drillings may be effected, depending on the probability determined by the previous works.

iii) Third phase exploration;

1) Diamond drilling exploration:

To determine the approximate size and tone of the ore deposits, several diamond drillings, after reviewing the avairable data and determining the optimum locations, depths and directions of the drilling holes, shall be gone on.

2) Supplemental geological survey and the final evaluation:

Correlation of surface and subsurface geology and, if required, additional field works including trenching, shall be done to derive the final evaluation on the ore deposits.

CHAPTER 3.

GENERAL OUTLOOK OF THE REPUBLIC OF COLOMBIA

Chapter 3. General Outlook of The Republic of Colombia

3-1 Principal Status

Country Name:	Republic of Colombia
Area:	1,139,000 km^2 (about 3 times of Japan)
Population:	26,000,000 (1978) annual rate of growth 2.4%
Official Language:	Spanish
Capital:	Bogotá
National Income per Capita:	648 US$ (assumed 1978)
Official Current Rate for one US dollar:	41.04 pesos (Jan. 1979)
Date of Independance:	July 20th, 1810
Regime:	Constitutional republicanism
Diet:	Bicameralism
Sovereign:	Dr. Julio César Turbay Ayala
Rate of Inflation:	19.7% (1978)
Minimum Wages:	115 pesos per day for an urban employee (Jan. 1979)
Gross Trading Value:	6 billion US$ (Exports: 3 billion, Imports: 3 billion 1978)
Principal Exporting Articles:	Coffee beans (68% of total exports in 1978) Banana, Cotton
Principal Importing Articles:	Crude Oil, Gasoline (12% of total imports in 1978), Machineries
Export Import rate for Japan:	1 : 4 (assumed 1978)
Holdings of Foreign Currencies:	2.5 billion US$ (end of 1978)

3-2 Nature, Inhabitant and Environment

3-2-1 Natural features

The Andes run through the South American Continent along the Pacific coast, splitting into three mountain subsystems; eastern, central and western, in Colombia. They enclose sporadic plateau of 1500 m to 3000 m above the sea level. Of the rivers, Magdalena, Cauca and Putumayo are important with multiple uprivers of Amazonas in east lowland.

Mountains, involving the plateau regions, occupy 41% of the land and the rest are flat land and forest.

3-2-2 Climate

The climate is variable owing to seasons and regions. A temperature of more than 28°C continues through the year at lowland and coastal region, on the other hand, it is slightly cold at plateau regions of 2,500 m to 2,000 m above the sea level. It is mild and comfortable with a temperature of more or less than 20°C at regions of 1,000 m to 2,000 m above the sea level.

There are rainy and dry seasons. A period of the former is March to May and September to November, and the rest is of dry season. A precipitation, varying by regions, is the most abundant in October and November in general, and an average rainfall throughout the country is from 1,400 to 2,000 mm a year. According to the condition of climate, most people have been living at plateau regions where it has been comfortable and main cities have been constructed at plateaus of 1,500 m to 3,000 m above the sea level.

3-2-3 Inhabitant

A population of 26 million people consists of 20 percent of white man, 58 percent of breed between white man and native, 14 percent of mulatto, 3 percent of breed between native and negro, 4 percent of negro and 1 percent of native. An annual rate of natural growth in 1977 reached at the level of 2.4%.

3-2-4 Commodity prices

In the reference to commodity prices, an increase rate of living costs index for office workers and that for other labourers in 1977 were 29.5% and 29.3% respectively, however in 1978 these figures decreased to the stable level of 19.7% and 17.8% respectively. It is forecasted that the rate would follow a level of 12% to 15% during 1979.

3-2-5 Electric power and transportation

The country is rich in resources of water power and fuel. 70% of total electric power of 13,423 Mkw generated in 1977 is hydraulic and 30% is of steam power, and generally most of power stations have individually a capacity of less than 10,000 kw. The government installed some hydraulic power stations with large capacity and furthermore a project of construction of coal thermal power station at the Caribbean coast was started.

Railways, being state-operated, have a total length of 3,436 km which is short as compared with the land area. Roads total up to 510,000 km for the extension, about 15% of which are paved. Air service network is well developed and is the best in South America. AVIANCA, the biggest in Colombia has the scheduled international air lines to American and European continents with domestic services.

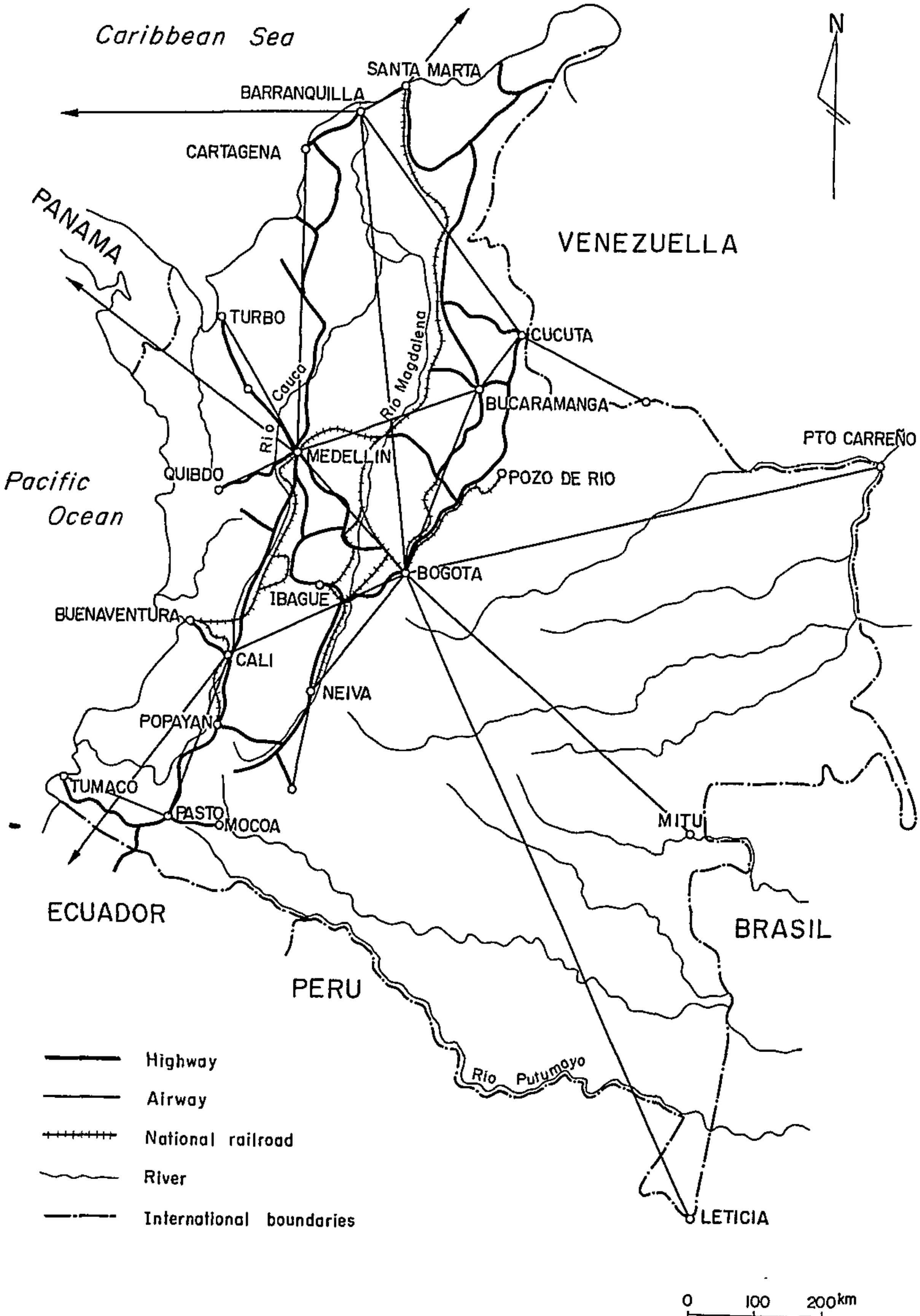


Fig.- 2 Traffic map of Colombia

3-2-6 Main cities

1) Bogotá

Bogotá, capital of Colombia, is located at a plateau of 2600 m above the sea level in the Eastern Cordillera, and is a center of activities of administration, economy and culture. A population is 4,500,000.

2) Medellin

Medellin, capital of Antioquia Province which is an important producer of coffee, is situated at a basin of 1,500 m above the sea level in the Central Cordillera, and is a center of industrial activities. A population is 1,800,000 that is second in Colombia.

3) Cali

Cali, situated on Cauca plain of 1,000 m above the sea level, has been developed as a trading center of agricultural products and an industrial center, owing to be closed to Buenaventura which is favorable harbor on the Pacific coast.

4) Barranquilla

Barranquilla, located at the mouth of Magdalena river, is the biggest commercial harbor on the Caribbean coast and a terminal of water carriage to inland.

Barranquilla has been developed as a center of commercial and industrial activities owing to setting up a free trade zone. A population is approximately 1,000,000.

5) Bucaramanga

Bucaramanga has been developed as capital of Santander Province where domestic petroleum has been produced almost exclusively. A population is 450,000.

3-3 Economy

3-3-1 General characteristics

The economy has been substantially of monoculture depending on an industry of coffee. 68% of total export value in 1978 was that of coffee. Other important industries which followed the coffee were agriculture and stock farming related to suggar, rice, cotton and livestock.

But, the traditional economic structure has been considerably improved owing to the positive policy for the promotion of export of industrial products planed by the government.

It is assumed that a title rate of economic growth and national income per capital in 1978 is 8% and 648 US$ respectively. Table-1 shows distribution ratio of gross domestic product value by sectors and Table-2 shows a balance of international payments.

3-3-2 Agriculture and forestry

26.8% of total national product value in 1978 and more than 70% of total export value are those of agricultural products. Coffee beans, cotton, banana, livestock products, sugarcane and cigars are the important agricultural products. Coffee production during the period from 1978 to 1979 is estimated at more than 12,000,000 sacks.

Cotton is one of the agricultural products which have a great reserve of power for export. The government has tried to increase the plantation area to rise the production, but it seems difficult to attain the object owing to the world market condition.

Forest covers two third of the land and useful lumber resources such as tropical mahoganies, oak tree and cedar are know, but a development of the forest has not yet advanced because of difficult access. 0.4% of total domestic product value in 1976 is that of forestry.

3-3-3 Fishery

The country is faced to the Pacific Ocean and the Caribbean Sea having about 3,000 km of shore line, and is rich in marin resources such as lobstar, bonito, sardine and grey mullet in the Pacific coast owing to a confluence of a warm and cold current. On the other hand, Magdalena river and other rivers are rich in fresh-water fishes. Recently coastal fishery has been developed. Buenaventura on the Pacific coast and Cartagena on the Caribbean coast are famous as the most important fishing port.

0.8% of total domestic product value in 1976 is that of fishery.

3-3-4 Manufacturing Industry

A ratio of product value of manufacturing industry to total domestic product value is 21.8% that is of second rank following that of agriculture and dairying sector. An average annual growth rate of manufacturing industry in 1970 - 1974 was remarkable and rose to 9%.

The manufacturing industry has a variety from foods to heavy machineries, of which foods, textiles, leather products, cement, timber and manufacturing machineries have been reserving the power of export.

3-4 Relationship to Japan

3-4-1 Diplomatic relations and trading

The diplomatic relations between Colombia and Japan was started after concluding a Treaty of Amity, Commerce and Navigation in 1908. The relations was ruptured by the outbreak of the World War II, but was restored in 1954. Now, Reciprocal Treaty of Immunity of Visa and Agreement of Technical Cooperation are kept between the two countries contributing to a promotion of personal interchange and economic and technical cooperations.

However, an unbalance of trade between Colombia and Japan has been the most important economic outstanding question. In the first half of 1978, an import value from Japan was 139 million US dollars, 90% of which are those of steel, machineries and chemical products, and an export value to Japan was 38 million US dollars, 90% of which are those of coffee and emerald.

3-4-2 Economic and technical cooperation

A loan of 12.3 billion Yens is scheduled to realize for the construction of a multiple purpose dam at Cauca river where a control of a flood and a construction of hydraulic generating stations have been required.

As a gratuitous supports, a navigation-fishery training ship of 220 tons and facilities of training center which were worth totally 500 million Yens were provided to Colombia in 1978.

For the technical cooperations, Japanese specialists have been sent and Colombian trainees have been received in Japan through an official channel of Japan International Cooperation Agency. Accumulative results up to 1978 are 46 persons of Japanese specialists-dispatch and 210 persons of Colombian trainees-receipt. Furthermore, Colombia has received 34 Japanese missions of total 183 persons.

The technical cooperation has been increasing.

Table-1 Distribution Ratio of Gross Domestic Product Value by Sectors

(unit %)

Sector	1974	1975	1976
Agriculture & Dairying	25.7	26.4	26.8
Fisheries	0.8	0.7	0.8
Forestry	0.4	0.4	0.4
Mining	1.2	1.2	1.1
Manufacturing	21.5	21.4	21.8
Construction	5.3	4.8	4.2
Commerce	17.4	17.5	18.0
Transportation	5.0	4.4	4.8
Communications	0.9	1.0	0.9
Finance	3.4	3.5	3.2
Public Utilities	1.2	1.2	1.3
All Other	17.2	17.5	16.7
Total	100.0	100.0	100.0

Table 2 International Income and Expenditure

(unit: 1 million dollars)

	1974	1975	1976
Total Current Receipt	1,484.9	1,918.1	2,548.9
Merchandise Exports	1,214.5	1,413.7	1,652.3
Service Receipts & Other	270.4	504.4	896.6
Total Current Payments	1,597.0	1,888.0	1,867.2
Merchandise Imports	1,049.9	1,317.4	1,236.2
Service Payments & Other	547.1	570.6	630.9
Total Current Account Balance	-112.1	30.1	681.7
Capital Transfers	15.4	86.9	-62.8
Net Official Monetary Movements	-96.7	117.0	618.9

CHAPTER 4.

MINING INDUSTRIES IN COLOMBIA

Chapter 4. Mining Industries in Colombia

4-1 General

As the potential of mineral resources in this country is expected to be enormous, it could be pointed out that the exploration works for the promising areas have not been carried out sufficiently yet by various means.

It could not proclaim to be magnificent the current mining activities which cover old famous emerald mining, recoveries of precious metals such as gold, silver and platinum, and the developments of coal and oil. Also the productions of iron, lead, zinc and copper as well as mercury, manganese and chromium are recorded but the amount is small except the iron.

The percentage of output from mining industries in the total domestic turnover has been declined from 3.9% of 1960 to 1.3% of 1975. Even though, emerald production keeps the top in the world, gold has the top in the countries of South America, the tenth in the world, and platinum production takes at the fourth of the world. Ore reserves for coal has been estimated as 18,000 million tons which is the biggest figure in the countries of South America. Also the potentials of nickel ores and phosphates are expected as very large being under the negotiation for the exploitation with international enterprises.

Though the reserves for crude oil have been estimated as 900 million barrels at 1974, the exhausting of previous oil field has pushed the country to be an oil importer since 1975.

Table-3. Main Mineral Production in Colombia

(except Petroleum and Emerald)

Minerals & Ores	1960	1970	1975
Gold	433,900	201,500	308,700
Platinum	20,900	26,300	22,100
Iron ore	655,000	453,000	595,000
Lead (conc)	1,000	600	300
Zinc (conc)	500	400	-
Copper (conc)	-	200	-
Coal	2,600,000	2,500,000	3,800,000
Cokes	-	465,000	420,000
Limestone	2,700,000	5,007,000	7,800,000
Clays	-	709,000	850,000
Gypsum	70,000	189,000	200,000
Salt	303,000	560,000	1,536,000

Unit: Gold, Platinum (troy ounce)
Others (ton)

4-2 Minerals and Their Conditions of Exploration and Exploitation

4-2-1 Oil and natural gas

Known major oil fields are situated at the northeastern district of the province of Norte de Santander near the border to Venezuela and at the district of midstream of Magdalena river.

The oil exploration programmes are running at the areas of both upstream and downstream districts of Magdalena river, southeastern district of the province of Nariño, of the district near the border to Ecuador, and of the district between upstream of Meta river and the border to Venezuela at the east side plane of Eastern Cordillera.

The rate of crude oil production during the period from January to May May, 1978 has been 133 thousand barrels per day which has 3.6% less than the average rates of 1977. As the reserves have been dropped down to 900 million barrels, Empresa Colombiana de Petroleos concentrates the effort for the new discovery of oil especially at the district of midstream of Magdalena river.

The production rate of natural gas of 1978 is 396 million cubic feet per day which is 18% more than the rate of previous year. It has been caused by the development of new gas field at Ballenas, northeastern district of the province of Guajira since the end of 1977. The maximum capacity for this gas field has been expected as 400 million cubic feet per day.

Fig.-3 shows localities of oil fields and exploration areas.

4-2-2 Coal

Coal is embedded in the strata of from upper Cretaceous to Palaeogene. The coal field is distributed along Sierra de Perija and Eastern Cordillera as well as the district of Rio Cauca basin. Moreover, it is recorded that the coal outcrops scatter at the north of the province of Córdova, the province of Antioquia and the central and south districts of the province of Cauca.

The coal from Cundinamarca and Boyacá have a good quality for coking. It is also said that the coal from Guajira, Antioquia and Cauca are suitable for steam industries. Total production of coal at 1977 had 4,200 thousand tons. The reserves of all have been estimated as 18 billion tons which proclaims the top rank in the countries in South America.

Cerrejon coal field has reserves of 300 million tons for open pit mining and 1000 million tons for underground mining. Chicamocha coal field has 2,160 million tons and Cogna-Samaca coal field has 1,600 million tons of coking coal.

The joint venture of American Company and Empresa Colombiana de Carbon (CARBOCOL) has been established to develop the north part of Cerrejon coal field. The project has been expected to export 5 million tons per year of coal for fuel use. Also CARBOCOL has a blue-print of open pit mining of 1,000 tons per day at the center of Cerrejon coal field to supply the coal for cement plants at the coast of Caribbean sea, and the connecting road from minesite to Barranquilla and Cartagena is now under the construction. CARBOCOL has another agreement with Rumanian company to carry out the exploration work at Subachoque district, province of Cundinamarca for coking coal.

Fig.-4 shows localities of coal fields

4-2-3 Precious metals and stones

i) Gold and silver

Gold is produced from veins and placers. The production during 1976 reached 297,900 troy ounces of which three quaters were supplied from placers. Most of gold veins under current productions are situated in Central Cordillera. The mineralization being related to acidic - intermediate igneous bodies is associated with galena, sphalerite, pyrite, chalcopyrite, etc. Two stages of mineralizations are known. One is related to pre-Tertiary plutonic bodies intruding into Palaeozoic metamorphic rocks. The province of Antioquia has Cretaceous Antioquia batholith at the northern half of Central Cordillera and produces 40% of gold from veins of this occurrence and 30% from placers derived from them.

Second is related to plutonic or hypabyssal bodies of Tertiary period which distribute around the Western and Central Cordillera. The procuration from this occurrence comes up to 12% of total from veins as well as placers at south-eastern district of Quibdo city.

Silver is produced only as by-product of the gold. The production during 1976 reached 105,700 troy ounces of which 77% from Antioquia, 5% from Choco and 9% from Santander.

Fig.-5 shows the localities of gold and silver occurrences.

ii) Platinum

From the ranking of platinum production in the world, South Africa is the first, U.S.S.R. is the second, Canada is the third and Colombia comes at the fourth. The production during 1976 reached 16,800 troy ounces of which 98% from the province of Choco, west of Western Cordillera. The ore deposit is a placer being derived from dunite, serpentine or pyroxenite which contains micro grains of platinum as impregnations by orthomagmatic segregations and crops out along the western slope of Western Cordillera.

Nearly the half of the production have been made by mechanized dredging of large companies and the rest of the production has been carried out by small companies or persons who live in the localities.

Fig.-6 shows localities of platinum ore deposits and showings.

iii) Emerald

Emerald occurs in the calcite dolomite veins being controlled by shears and fractures in the marine sediment of lower Cretaceous black shale. Paragenesis of minerals are quartz, albite, pyrite, barite, etc. The important producing mines are Muzo, Chivor and Coscuez at Boyacá of Eastern Cordillera, and Buenavista at Cundinamarca. They are concentrated in two spots, north and east of Bogotá city.

The production during 1926 ∿ 1964 had 6,500 thousand carats of which 22% had from Muzo. Total value of exports of emerald during 1960 ∿ 1977 reached 208,200 thousand dollars. Japan imports 41% of them whereas U.S.A. shears 28% in recent years.

Fig.-7 shows localities of emerald ore deposits and showings.

4-2-4 Non ferrous metals

i) Copper

The types of known copper ore deposits are porphyry copper, veins and contact metasomatic types, but none of them have been said as large. Mines under the operation are Santa Anita and Roble at Choco of vein type, and Mina Vieja and El Sapo at Tolima of contact metasomatic type. The production during 1977 had 2,600 tons of metal equivalent and the concentrates had sent to foreign smelters.

The indications of porphyry copper deposits are known around the boundary between the lower Cretaceous volcanic sequences and Tertiary intrusions in western slope of Western Cordillera, or the eastern margin of upper Jurassic Ibagué batholith, or the boundary between Triassic-Jurrassic Payandé formation and Mocoa batholith in eastern slope of Central Cordillera.

Extensive geochemical surveys have been carried out in the provinces of Choco and Antioquia during 1970 ∿ 1972 by support of the U.S. government. As the result of this survey, indications of copper mineralization had been discovered in Murindó and Pantanos-Pegadorcito areas. Instituto Nacional de Investigaciones Geologico-Mineras (INGEOMINAS) had succeeded the follow-ups. OMRD of Japan has carried out geological brief survey at Pantanos-Pegadorcito area in 1973.

The first phase survey under United Nations Development Programme (UNDP) had been carried out together with the survey of INGEOMINAS during 1973 ∿ 1976 at the south of Western and Central Cordillera as well as Darien-Baudo district near the border to Panama.

Five areas of interest, Rovira, Mocoa, Patascoy, Piedrancha and Acandi had been recommended for the second phase program. It has been carried out on the three of these recommended areas, Acandi, Rovira and Mocoa. The main part of program has been nearly completed for the second phase program except diamond drilling at Mocoa now. It is expected to continue the work at Mocoa to the third phase program from 1980. The further exploration-exploitation works for Pantanos-Pegadorcito is now under the negotiation between Empresa Colombiana de Minas (ECOMINAS) and U.S. oil company, AMOCO.

Various vein type copper ore deposits are known at areas of Eastern, Central and Western Cordillera but the scales are rather small. Only Roble and Santa Anita situated in Western Cordillera are producing copper. The lode of Roble which contains pyrite, chalcopyrite and Pyrrhotite as well as quartz associated with andesite dikes intruded into upper Cretaceous chert formation has 104 thousand tons of reserves of Cu 7%. Santa Anita lode also comprises mainly of pyrite and chalcopyrite veins in the diabase and the reserves are estimated as 715 thousand tons of Cu 2.6%.

Mina Vieja, El Sapo and Los Guayabos copper ore deposits in province of Tolima are all contact metasomatic type ore deposit being occurred at the contact of Trias-Jurassic limestone and Ibagué batholith. Mina Vieja has 400 ∿ 500 thousand tons of reserves and is producing crude ore of Cu 1.9%, Au 5 g/t at the rate of 250 tons per day. The total production of flotation concentrates with Cu 25 ∿ 29% comes up to 270 tons per month. The skarn zone at El Sapo has 2 ∿ 10 meter width and is operated in a small scale manner such as a hand picking concentration. The ore reserves of Los Guayabos became to be expected as the same scale for those of Mina Vieja from the result of recent investigation.

Cerro de Cobre at Cundinamarca which has ceased production now is also hydrothermal metasomatic and vein type ore deposit in the limestone. The ore reserves for this ore deposits are expected 1,620 thousand tons of Cu 1.19%.

Fig.-8 shows the localities of copper ore deposits, prospects and indications.

ii) Lead and zinc

A number of outcrops of veins, networks or metasomatic ore deposits of lead and zinc are known along the Eastern or Central Cordillera, but none of them has been developed for the production of lead or zinc. The production of lead has made at Cueva Oscura, Cundinamarca as by-product of gold and silver. Zinc is also recovered as by-product at mines of Junin district, Cundinamarca. The production amount of lead during the year of 1977 had 376 tons of metal equivalent in the concentrate being shipped for foreign smelters.

Fig.-9 shows the localities of lead and zinc occurrences.

iii) Nickel

Six nickel bearing laterite deposits are discovered at the north, Córdova and Antioquia as the result of the extensive exploration works since 1956 by Richmond Oil Company or Hanna Mining Company of U.S.A. as well as joint venture of INGEOMINAS and American Company since 1973.

Cerromatoso being situated at the center of Córdova is expected to be economical out of other five lateritic nickel deposits. They are all weathered residual products from ultrabasic rocks such as peridotite or dunite of Cretaceous period. Cerromatoso is expected to have a reserves of 14 million tons with Ni 2.5%.

The joint venture that Empresa Colombiana de Niquel (ECONIQUEL) has 45%, Billiton Company has 35% and Hanna Mining Company has 20% to exploit the deposit at Cerromatoso has been established.

Planeta Rica laterite deposit with reserves of 9,720 thousand tons (Ni 1.27%) and Uré deposit with reserves of 2,000 thousand tons (Ni 1.3%) being located near to Cerromatoso are expected hopefully to become economical if the plant is set up at Cerromatoso.

Fig.-10 shows localities of nickel ore deposits.

iv) Mercury

The mineralization of mercury is mainly known in the zone widely spread along Central Cordillera from Medellin to Pasto. It is said that the most promising indications are at Nueva Esperanza and El Cinabrio, also the result of exploration work at the western district of Central Cordillera, province of Caldas by INGEOMINAS indicates the possibility of new discovery of mercury deposit.

Nueva Esperanza is only one mine which is operating since 1948 being produced 220 thousand tons of mercury up to 1975.

The ore deposit is a lode which contains quartz, calcite and native mercury with the width from several centimeters to 2 meters.

El Cinabrio had been operated previously by both open pit mining and underground operation. The ore deposit is a vein which contains quartz, calcite and cinnabar in the schist of Palaeozoic system.

Fig.-11 shows the localities of mercury occurrences.

4-2-5 Iron

Though various types of ore deposit of iron has been known in this country, two mines of sedimentary oolitic limonite ore deposit and another two mines of hydrothermal metasomatic ore deposit are under the operation. The production amount varies year by year as 836 thousand tons at 1967 and 595 thousand tons at 1975.

The ore deposits of sedimentary oolitic limonite bed type are known at Paz de Rio in Boyacá, Sabana Larga in Casanare, Mal Nombre and Rio Luisa in Tolima. Paz de Rio steel work company has been established after the discovery of the mine at 1942 and started the domestic production of steel. The thickness of the bed varies from 0.4 m to 7 m with average grade of iron 46%. Proven with probable ore reserves comes up to 53,200 thousand tons and possible ore reserves have been expected to be 50 million tons which covers the main part of the total proven and probable ore reserves in Colombia 96,550 thousand tons.

Mal Nombre which consists five layers of limonite and geothite beds with the width varies 0.4 ∿ 0.8 meters each in limestone is producing 300 tons per month by open-pit mining.

Sabana Larga mine has low grade ore which rounds Fe 30% and it is expected to be economical if new technology for iron smelting has been introduced. Rio Luisa has been evaluated as no economical value because the poor thickness of 0.5 m average and low iron content of 22∿36% even though the area of distribution is quite large.

Hydrothermal metasomatic type ore deposits in limestone sequences are known at Pacho, Las Mercedes and Ubala, in the province of Cundinamarca. Pacho is only one under the operation in small scale.

The indications of magmatic differentiation iron ore deposits are known in the Ibagué batholith as well as intrusive igneous body at Norte de Santander. Both ore deposits are regarded as non economical because of the poor grade and scale of the deposits.

Laterite iron ore deposits are known at the north of Central Cordillera. Cerromatoso laterite nickel ore deposit, Córdova is expected to become iron mine if new technology for iron treatment is introduced.

Pericos ore deposit, at Cundinamarca which is a supergene enriched type of previous low grade iron ore is operating in small scale shipping the ore to Pacho y Color iron-foundry together with the ore from Pacho mine.

Iron ore deposits of vein type are known at Eastern and Central Cordillera but the size and scale are all very small.

Fig.-12 shows localities of iron occurrences.

4-2-6 Uranium

The occurrence of uranium is known in the fluvial deposits of various system from Palaeozoic to Tertiary as well as in the rocks of pegmatitic group and in the sediments of phosphate rock of Cretaceous. Localities are scattered mainly in the Eastern Cordillera, provinces of Santandel, Boyacá, Cundinamarca, Meta, and in the Central Cordillera, provinces of Antioquia, Caldas, Tolima, and Huila. In the rocks of Pre-Cambrian shield at Guainia and Vaupes, it is expected to be uranium ore deposit of conglomerate type. Expected U_3O_8 amount in Colombia reaches 40 thousand tons at this stage.

Important uranium occurrence is a sandstone type in the terrestrial sediments and the promising radioactive anomalous areas are known in Jurassic sediments at Zapatoca and Permian sediments at Quetame. The radioactive anomaly being detected in the Cretaceous phosphate rocks at Berlin, Cardas is expected as promising.

Systematic exploration works for uranium at this country had started since 1970 by Instituto de Asuntos Nucleares (IAN). In 1977, Empresa Colombiana de Uranio (COLURANIO) which is established as the organization to explore, to enrich and to cast the uranium fuel for the reactor has taken over the exploration works for uranium from IAN which has reformed as research organization.

Minatom Co. of France is continuing the exploration work of second stage reducing the area of exploration licence at the district of Sumpaz-Chivor, Ocaña and Berlin including Quetame Mountain district following the first stage exploration work as regional. Also Spanish governmental organization (ENUSA) has started exploration works at three districts in the Eastern Cordillera and two districts of Guainia and Vaupez at the area near to the border to Brazil.

Without any connections to these activities, the joint exploration work by International Atomic Energy Agency (IAEA) and United Nations Development Programme (UNDP) is carrying at Cordoba district airbone radioactivity detection. IAEA has budget to supply materials and finance of 400 thousand dollars until the end of 1980 as well as sending a geologist to the drill site at Zapatoca.

Japanese specialists (geologists) sent from Japan International Cooperation Agency (JICA) for the technical cooperations had carried out the survey at Zapatoca area several years. Power Reactor and Nuclear Fuel Development Corporation of Japan (PNC) has schedule for the exploration work at the area of Valledupar, near the border to Venezuela.

Fig.-13 shows localities of uranium mineralized areas.

4-2-7 Others

i) Phosphates

Exploration works for the phosphates had started by the organization of Colombian Government since 1942, and proved the occurrences of marine sediments of phosphate, guano or apatite ore deposits.

Only marine sediments of phosphate has economical value among those occurrences. The important deposits of this type which occur as ore beds in marine sediments of lower Cretaceous sub-geosyncline basin are known at provinces of Norte de Santander, Santander, Boyacá and Huila.

Reserves are estimated as 744 million tons where in the sum of proven and probable reserves are 393 million tons. Production of phosphate rock during 1975 is 16,400 tons. The biggest reserves which has 340 million tons of reserves with the thickness of 0.5 ∿ 5 m and P_2O_5 5 ∿ 27% grade are known at the district of Tunja and Pesca-Sogamoso, in province of Boyacá for which Boyacá Phosphate Company has been established to exploit them.

Fig.-14 shows localities of phosphates occurrences.

ii) Chromium

Mineralization of chromium is known at Antioquia, Córdova and Sucre. The ore deposit of Santa Helena mine being situated in south east of Medellin, Antioquia which is only the mine under the production is lenticular chromite body being segregated magmatically from serpentine in Central Cordillera. As the chromite contains 20 ∿ 23% of Al_2O_3, the product is shipped for ceramic industry as fire brick use. Reserves remaining are estamated as 10 thousand tons with Cr_2O_3 32 ∿ 36% where previous production has figured up 10 thousand tons.

Fig.-15 shows localities of chromium occurrences.

iii) Manganese

Santa Bárbara mine being situated at the south of Medellin had been discovered after the world war II and had an operation by Paz de Rio Steel Company and Medellin Iron Foundry but the record of production is not available. The ore deposit is a bed of manganese dioxide with the thickness of 5 ∿ 7 m finely alternated with cherts of Pre-Cambrian sequences. Because the size as well as the continuity of the bed are poor, it is said that the economical exploration of this ore deposit is rather difficult.

The ore deposit of Mallama mine being located at the east of Piedrancha, Nariño is a nodule or kidney shaped body of manganese dioxide in schist formation with grade ranges from 11 to 53% of Mn. Though the reserves are unknown, the mine is producing the ore in small scale.

Fig.-16 shows localities of manganese ore deposits and showings.

iv) Aluminium

Occurrences of bauxite are known at Antioquia, Valle de Cauca and Cauca along the stream of Cauca River as well as at Norte de Santander each. Bauxite ore deposits at San Antonio being situated between Cali and Popayán and at Morales-Cajibio district are expected as promising. These deposits are both a weathered product of pyroclastic materials of Plio-Pleistocene volcanoes. The reserves are estimated as 400 million tons with grade of Al_2O_3 38%. It is expected to gain 100 million tons of bauxite concentrate with a grade of Al_2O_3 55 $\sim$ 59% by ore beneficiation.

The current production of bauxite which arounds 5,000 tons per year is too small against the domestic demands. The main reason for the delay of exploitation of bauxite ore deposits is said that the technical problems are still remaining in the process of concentration or purification to exclude the impurities of silica or iron. To solve the problem, U.S. has started the research works since 1976 for the technical advice.

Fig. 17 shows localities of bauxite ore deposits and showings.

v) Rock salt and gypsum

Both rock salt and gypsum are found in the marine sediments of Cretaceous to Miocene system.

Rock salt occurs mainly in the area of Eastern Cordillera, being enormous of the amount. Productions in 1975 are 795 thousand tons being produced from Zipaquirá mine and Nemocón mine in Cundinamarca, at north of Bogotá. Zipaquirá has reserves of proven 98 million tons and possible 130 million tons. Reserves of Nemocón are estimated at 60 million tons of proven.

Gypsum occurs mainly in the area of Eastern and Central Cordillera as many small spots with poor quality and quantity. Productions of Gypsum in 1975 had 200 thousand tons from Villanueva mine and Los Santos mine at Santander, south of Bucaramanga. Reserves for those mines are known as 195 thousand tons for Villanueva and 737 thousand tons for Los Santos.

Fig.-18 shows localities of Rock salt and Gypsum occurrences.

vi) Limestone

Limestone occurs mainly in the area of Eastern and Central Cordillera as many large scale deposits with reserves ranging from one to several hundred million tons. The formation of limestone is known from Palaeozoic to Pliocene system. Production in 1975 of which 75% has been consumed for cement industries had 7,800 thousand tons. The cement is one of the most important materials to be exported from this country as well as emerald, coal or cokes.

Fig.-19 shows the distributions of limestones.

vii) Geothermal energy

It is possible to expect the presence of superheated vapour for electric generation somewhere because of the existence of volcanoes with many fumaroles or hot springs along the zone of Central Range, and mud volcanoes and hot springs with various salinities along the zone between Cartagena and Barranquilla.

The exploration work for geothermal energy being named as Ruiz Geothermal Project has been started since 1968 for the area of 15,000 km^2 at the provinces of Caldas, Risaralda and Quindio.

Fig.-20 shows the area of Ruiz Geothermal Project with localities of various volcanic activities.

4-3 Organization of Mining Administration

The Ministerio de Minas y Energia has seven individual sections.

4-3-1 Instituto Nacional de Investigaciones Geologico-Mineras (INGEOMINAS)

This is an organization for exploration work, research and survey of mineral resources except oil and uranium. It does not take participate in the exploitations of mines. The main activities are exploration works or researches for metallic mineral deposits, coal, phosphate rock, limestone and rock salt deposits, etc. The head office is situated at Bogotá with branch offices at Medellin, Bucaramanga, Sogamoso, Ibagué and Popayán.

Total number of geologists engineers are about 80.

4-3-2 Empresa Colombiana de Petroleos (ECOPETROL)

This is an organization of exploration as well as the exploitation works for oil reserves. The current main activities are exploration works at the area out of exploration licences being held by many foreign oil companies.

4-3-3 Instituto de Asuntos Nucleares (IAN)

This was an organization which administrated the exploration works for uranium ore deposits previously. Since the establishment of COLURANIO in October, 1977, it has been reformed to be a research organization for the technological advices.

4-3-4 Empresa Colombiana de Uranio (COLURANIO)

The aim of this organization includes exploration works for uranium ore deposits, the exploitation of the mine, concentration and enrichment of uranium as well as the casting of uranium fuels for the reactor. The business of uranium exploration works has been taken over from IAN.

4-3-5 Empresa Colombiana de Carbon (CARBOCOL)

This is an organization to exploit the coal. At the north of Cerrejon coal field, it has joint venture with Company of U.S.A. to exploit the mine. Also it has a plan to exploit the central part of Cerrejon coal field as open pit mining.

4-3-6 Empresa Colombiana de Niquel (ECONIQUEL)

The negotiation to exploit the nickel bearing laterite deposit at Cerromatoso has been established among Billiton Company, Hanna Mining Company and this organization, ECONIQUEL.

4-3-7 Empresa Colombiana de Minas (ECOMINAS)

The negotiation between ECOMINAS and AMOCO has been going for the exploitation of porphyry copper ore deposit at Pantanos-Pegadorcito where had been carried out the exploration work by INGEOMINAS.

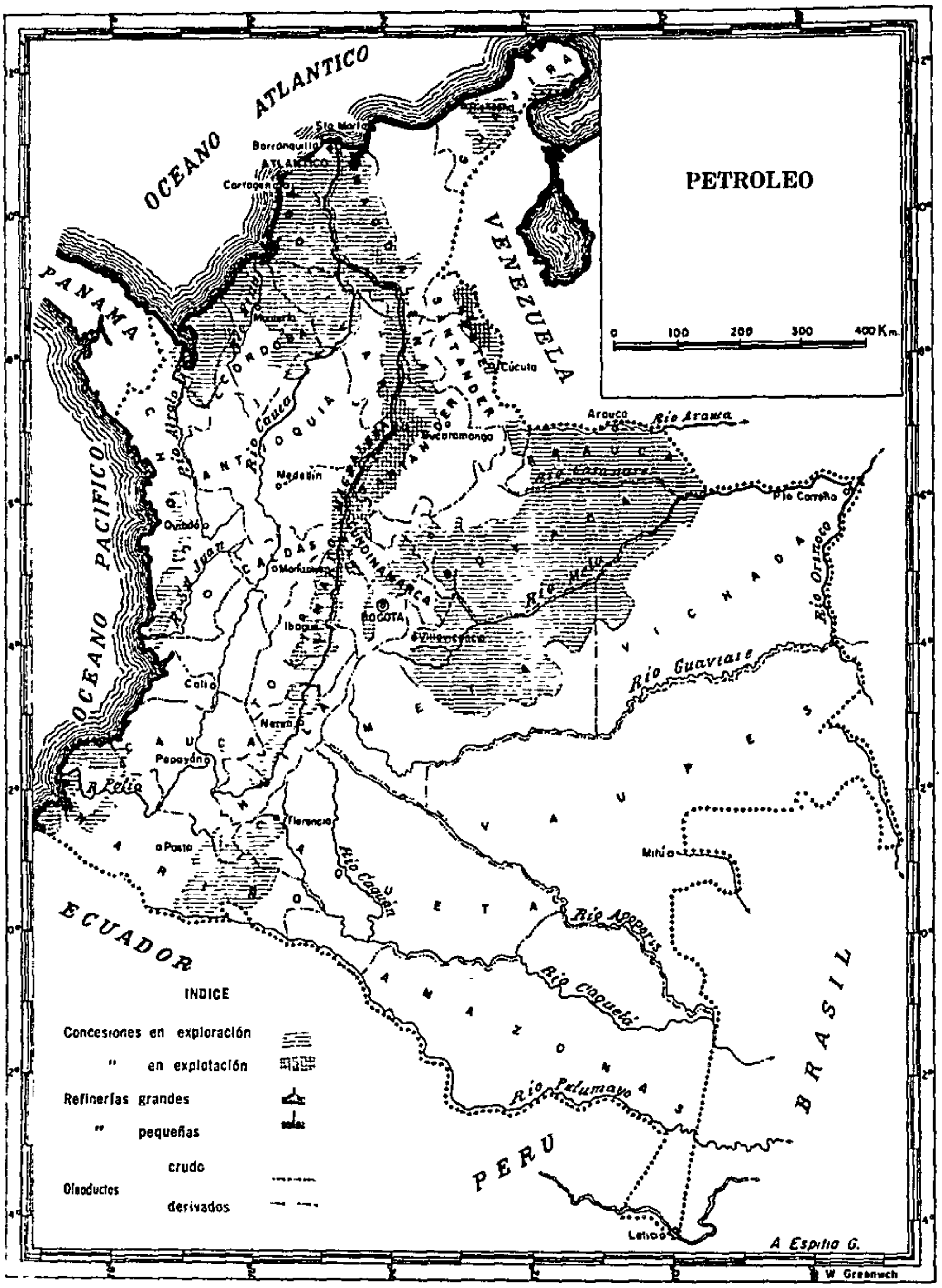
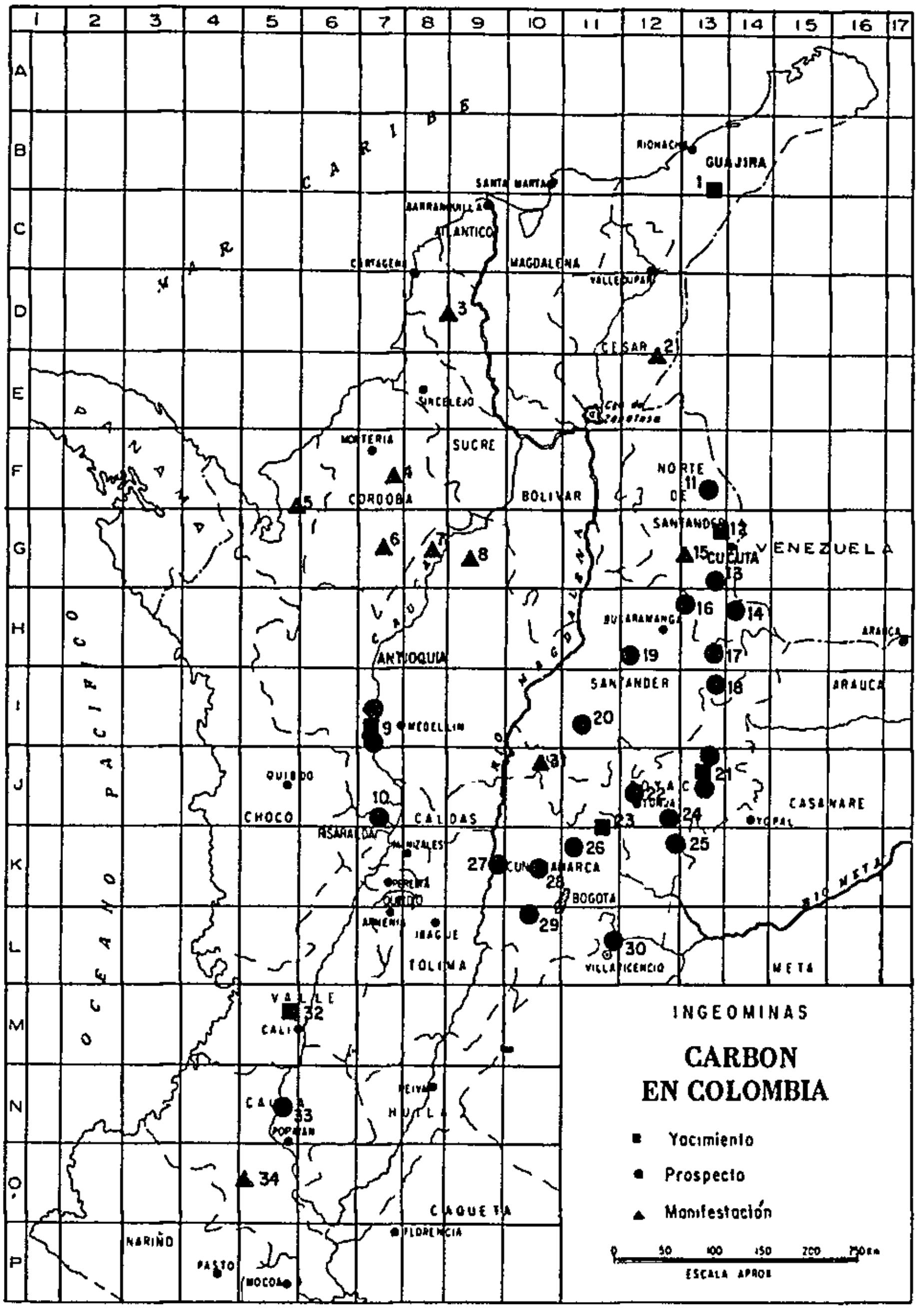
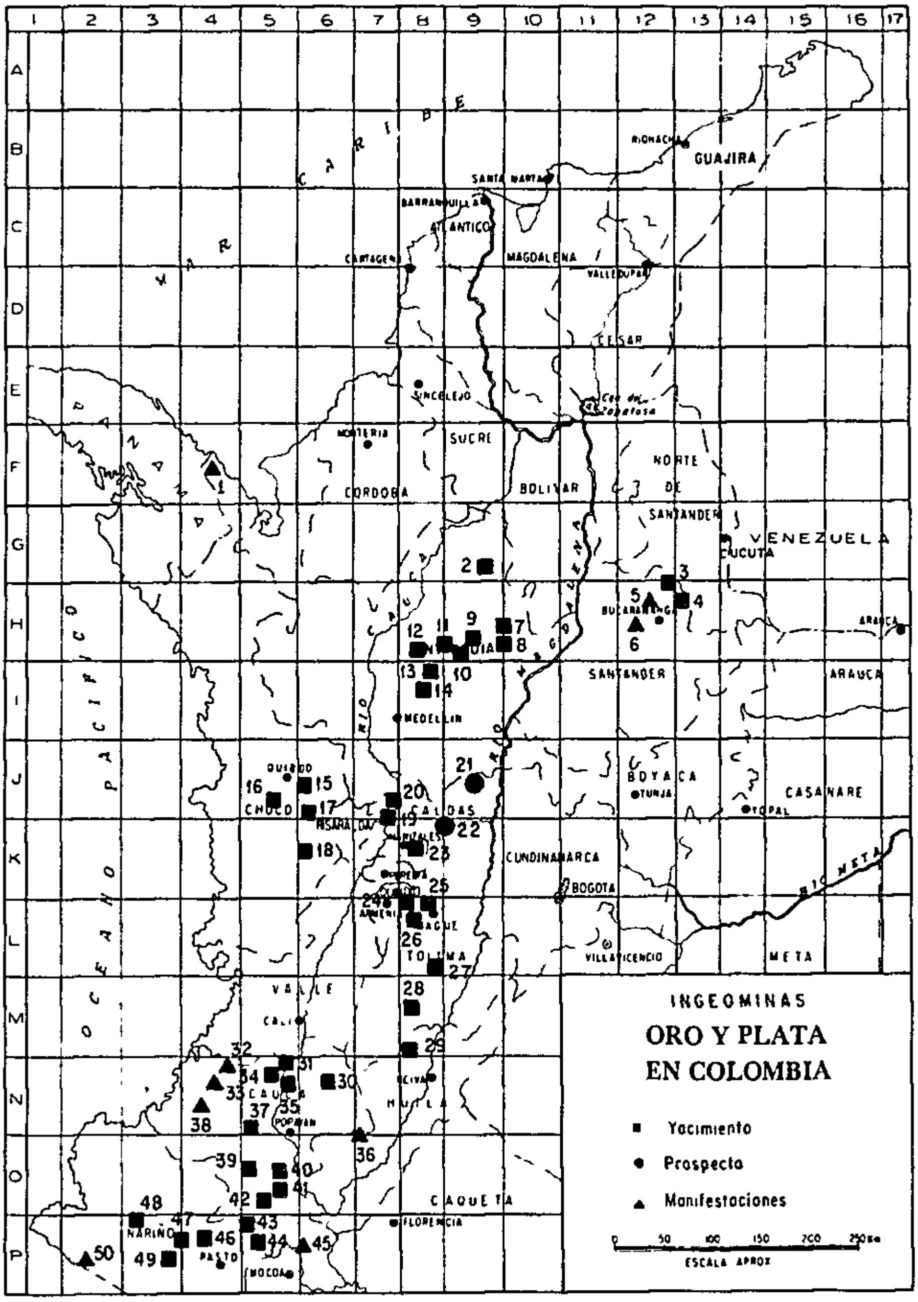


Fig.- 3 Location map of concessions of petroleum exploration and exploitation



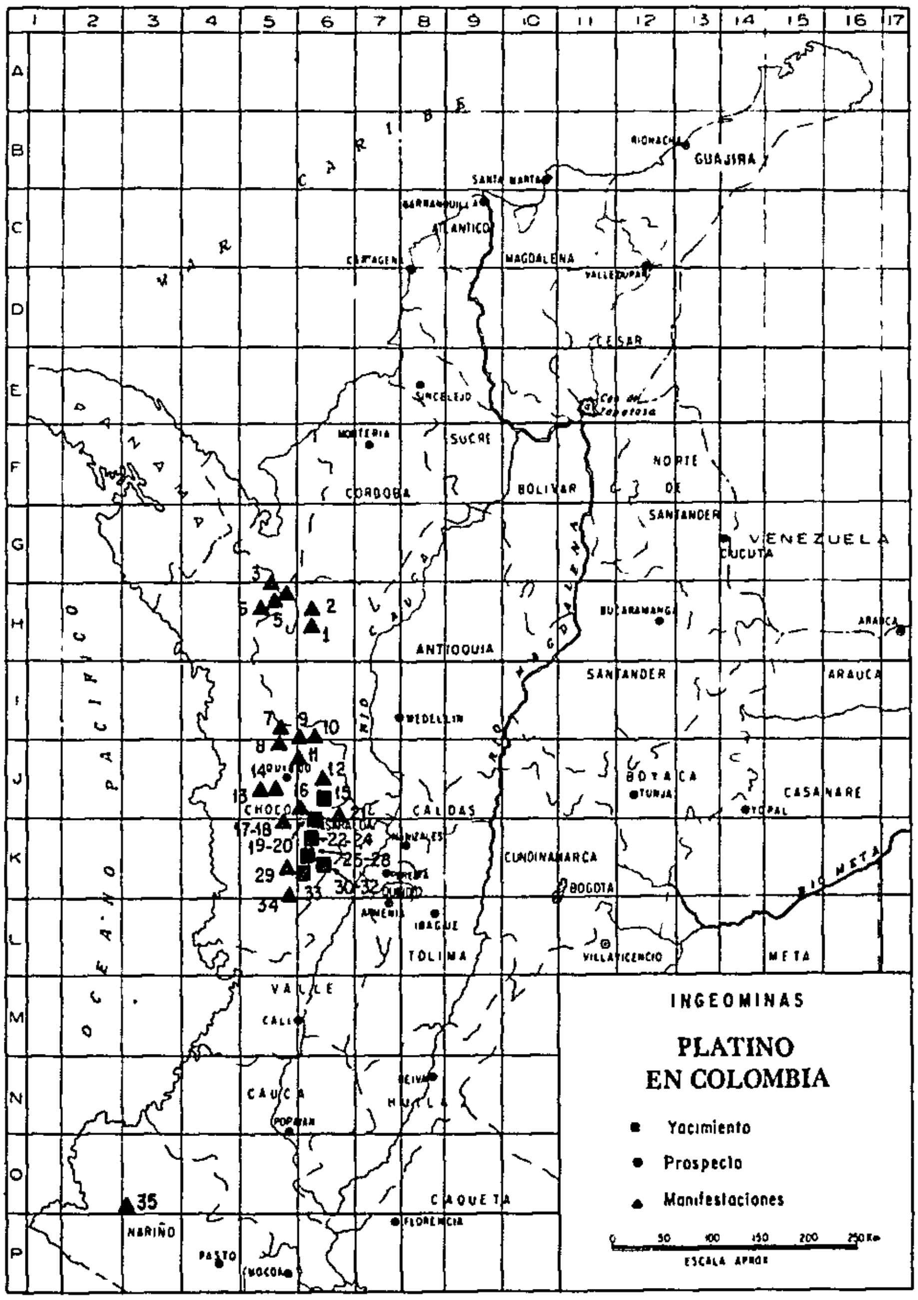
1. Cerrejón, 2. La Jagua de Ibirico, 3. San Jacinto. 4. Ciénaga de Oro, 5. Urabá-Mutatá-Chigorodo, 6. Alto San Jorge, 7. Tarazá-Río Man, 8. Purí-Cacerí, 9. Amagá-Sopetran, 10 Riosucio-Quinchía, 11. Catatumbo, 12. Zulia, 13. Pamplona-Doña Juana, 14 Toledo-Herrán, 15. Salazar, 16. Mutíscua, 17. Páramo del Almorzadero, 18. Miranda-Molagavita, 19. San Vicente de Chucurí-Lebrija, 20. Landázuri, 21. Chicamocha - Morcá - Paz de Rio - Jericó, 22. Tunja-Paipa-Duitama, 23. Cogua - Samacá, 24. Sueva-Umbita-Laguna de Tota, 25. La Balsa-Suesca-Chocotá, 26. Río Frio, 27. Pubenza - Dindal, 28. Subachoque-La Pradera, 29. Fusagasugá-El Salto, 30. Guatiquía, 31. Territorio Vasquez, 32. Valle del Cauca, 33 Suarez-Playón-Dinde, 34. Mercaderes, 35. Chimbiquete.

Fig.- 4 Location map of coal fields



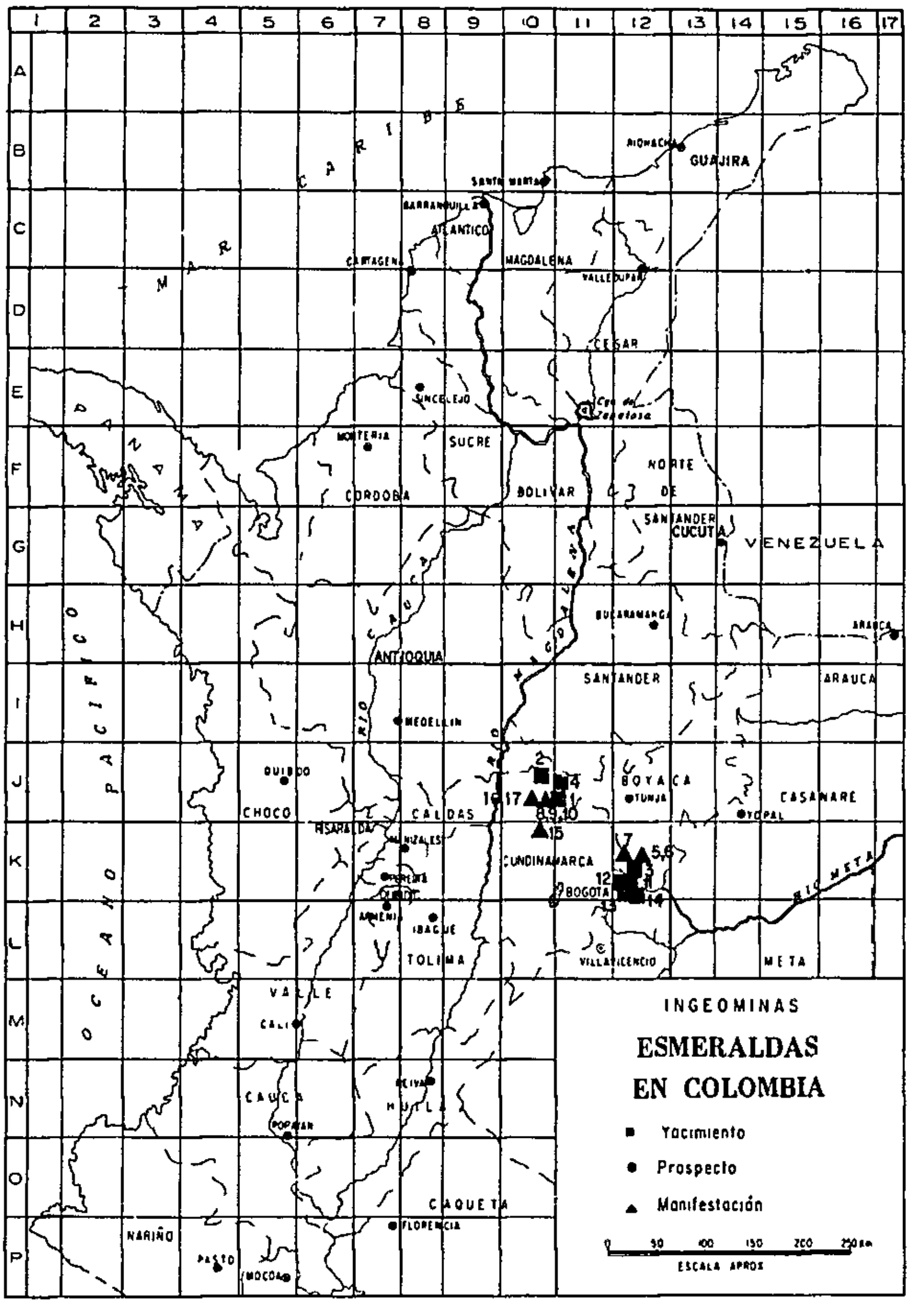
1. Acandí, 2. Distrito Bagre y Pato, 3. California, 4. Vetas, 5. Aluviones Río Suratá, 6. Aluviones Río de Oro, 7. Remedios, 8. Santa Isabel, 9. Viborita, 10. Amalfi, 11. Anorí, 12. Berlín, 13. Guadalupe, 14. Gómez-Plata, 15. Río Atrato, 16. Río Quito, 17. Bagadó, 18. Río San Juan, 19. Marmato, 20. Supía, 21. Samaná, 22. Manzanares, 23. Manizales, 24. Salento, 25. Ibagué, 26. Cajamarca, 27. Rovira, 28. Ataco, 29. San Luis, 30. Munchique (Santander de Quilichao), 31. Suárez, 32. Río Naya, 33. Río Micay, 34. Paso de Bobo, 35. La Teta, 36. Río La Plata, 37. Munchique (Tambo), 38. Río Timbiquí, 39. Río Patía, 40. La Vega, 41. Almaguer, 42. Bolívar, 43. San Pablo, 44. La Cruz, 45. Río Caquetá, 46. El Tambo, 47. Samaniego, 48. Barbacoas, 49. Santa Cruz, 50. Río Mira.

Fig - 5 Location map of gold and silver ore deposits and showings



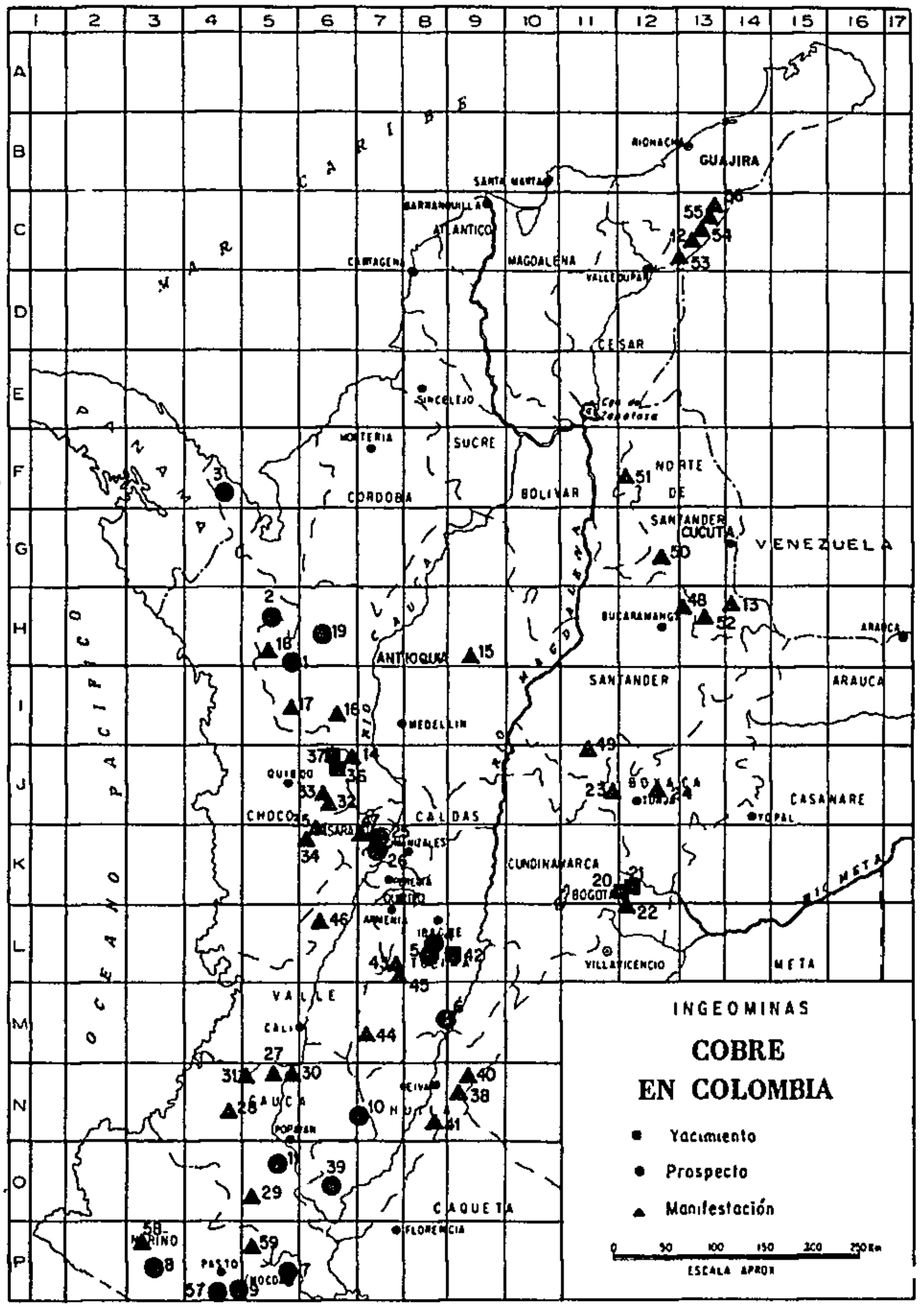
1. Río Sucio, 2. Río Sucio, 3. Río Sucio, 4. Río Jiguarandó, 5. Río Jiguarandó, 6. Río Jiguarandó, 7. Río Bebará, 8. Río Bebaramá, 9. Río Bebaramá, 10. Río Bebaramá, 11. Río Nequí, 12. Río Lloró, 13. Río Quito, 14. Río Quito, 15. Río Andágueda, 16. Río Arteguí, 17. Río Quito, 18. Río Quito, 19. Río San Juan, 20. Río San Juan, 21. Río San Juan, 22. Río Iró, 23. Río Iró, 24. Río Iró, 25. Río Condoto, 26. Río Condoto, 27. Río Condoto, 28. Río Condoto, 29. Opogodó, 30. Río Tamaná, 31. Río Tamaná, 32. Río Timaná, 33. Río Nóvita, 34. Río Nóvita, 35. Río Barbacoas.

Fig.- 6 Location map of platinum ore deposits and showings



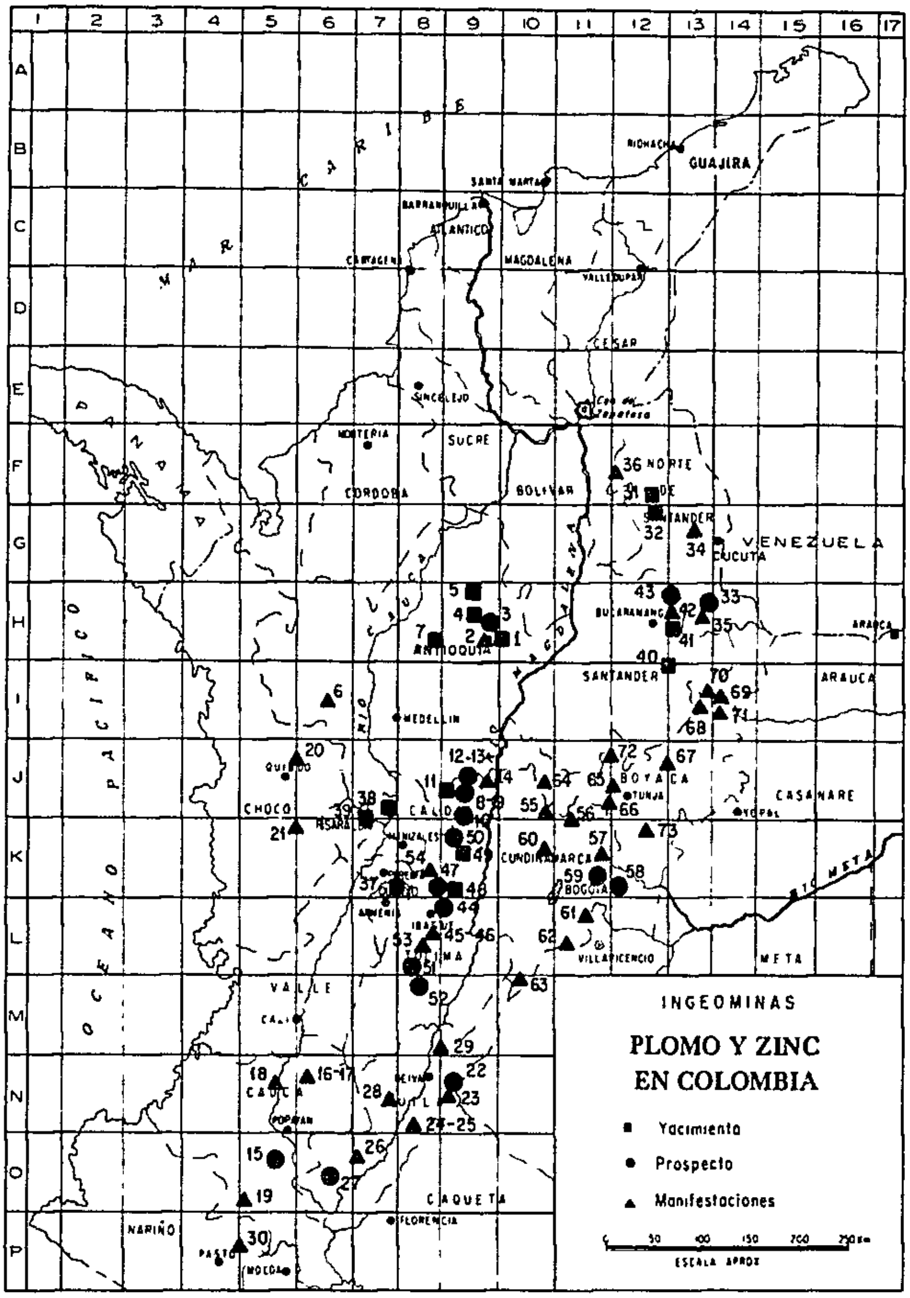
1. Yacimiento de Muzo, 2. Yacimiento de Coscuez, 3 Yacimiento de Chivor, 4 Yacimiento de Peñas Blancas, 5 Manifestacion Pavaranado, 6 Manifestación Sagrada Familia, 7. Manifestación Achiote, 8. Manifestacion La Corona, 9. Manifestacion La Calichona, 10 Manifestacion Perjamo, 11. Yacimiento de Buenavista, 12. Yacimiento de Mundo Nuevo, 13 Yacimiento Vega de San Juan, 14. Yacimientos Las Cruces, El Toro y El Diamante, 15. Manifestación El Peñón, 16 Manifestacion Aposentos, 17. Manifestacion La Mina.

Fig.-7 Location map of emerald deposits



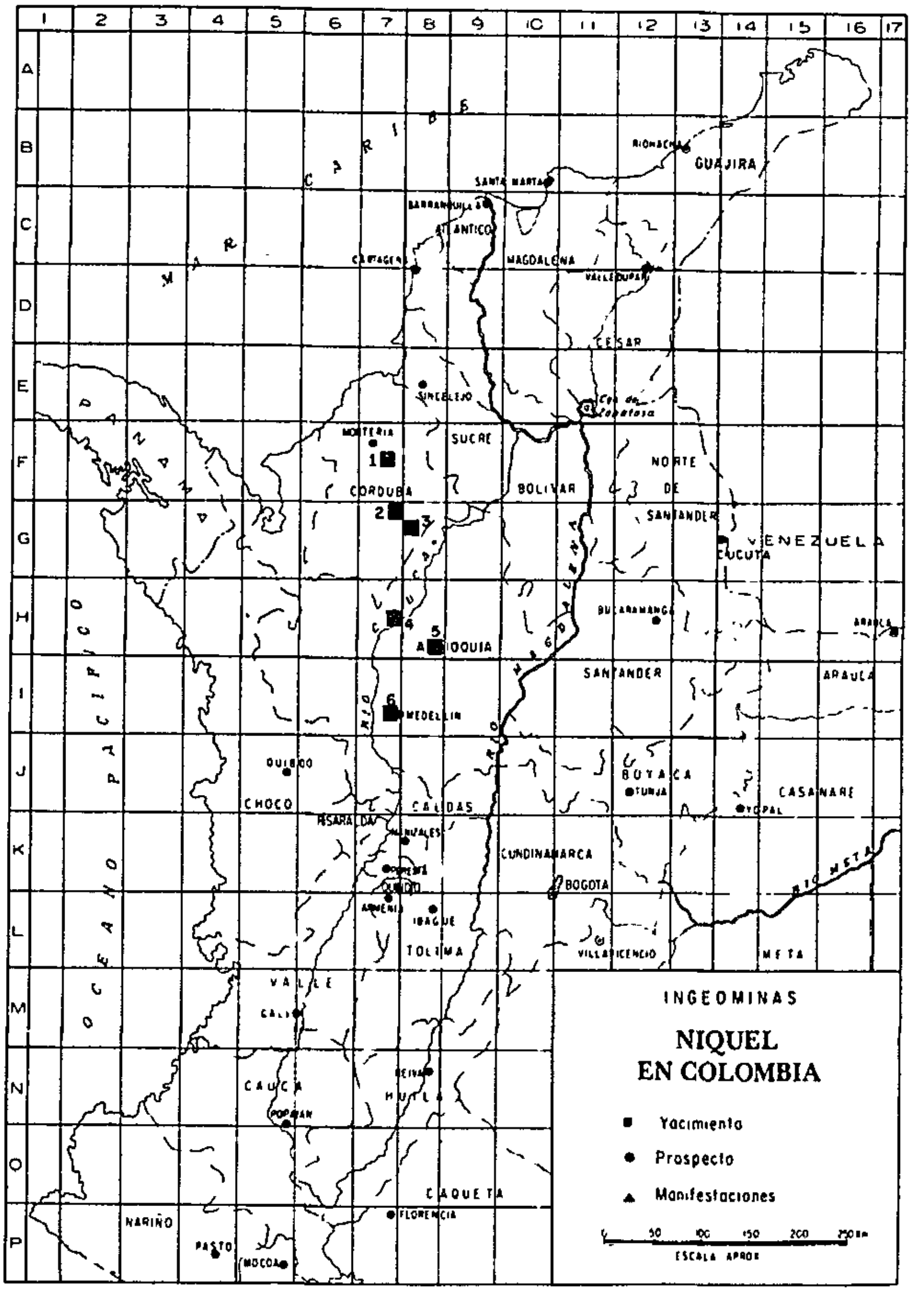
1. Pantanos-Pegadorcito, 2. Murindó, 3. Acandí, 4. Infierno-Chilí, 5. Andes, 6. Dolores-Natagaima, 7. Mocoa, 8. Piedrancha, 9. Patascoy, 10. El Pisno, 11.Piedrasentada, 12. Campoflorido, 13. Cerro El Cacho, 14. Cerro Plateado de Salgar, 15. La Clara de la Unión, 16. Páramo de Urrao, 17.Mandé, 18. Ciénaga del Tadía, 19. La Esperanza, 20. Cerro El Cobre, 21. La Colonia, 22. Farallones de Medina, 23. Gachantivá, 24. Moniquirá, 25. La Plumbagina, 26. El Tascón, 27. Suárez-Piedraimán, 28. Mechengue, 29. Cerro Gordo, 30. La Teta, 31. Río Naya, 32. Río Cuchadó, 33. Río Anguedé, 34. Quebrada Mambú, 35. Sitio López, 36. Santa Anita, 37. El Roble, 38. Cerro Neiva, 39. Granates, 40. El Suspiro, 41. El Hobo, 42. Mina Vieja, 43. Los Guayabos, 44. Puerto Saldaña, 45. San Antonio-Río Tetuán, 46. El Dovio, 47. Belén de Umbría, 48. La Baja, 49. Bolívar-Vélez, 50. Cáchira, 51. El Carmen, 52. El Tuto, 53. Serranía de Perijá: Los Portales, 54. Serranía de Perijá: El Dulce, 55 Serranía de Perijá· Cerrito-Ojo, 56. Serranía de Perijá: El Salado, 57. Cinco (5) Prospectos: Monopamba, Alisales, Blanca, Afiladores y Los Cedros, 58. Barbacoas, 59. Buesaco.

Fig.- 8 Location map of copper ore deposits and showing



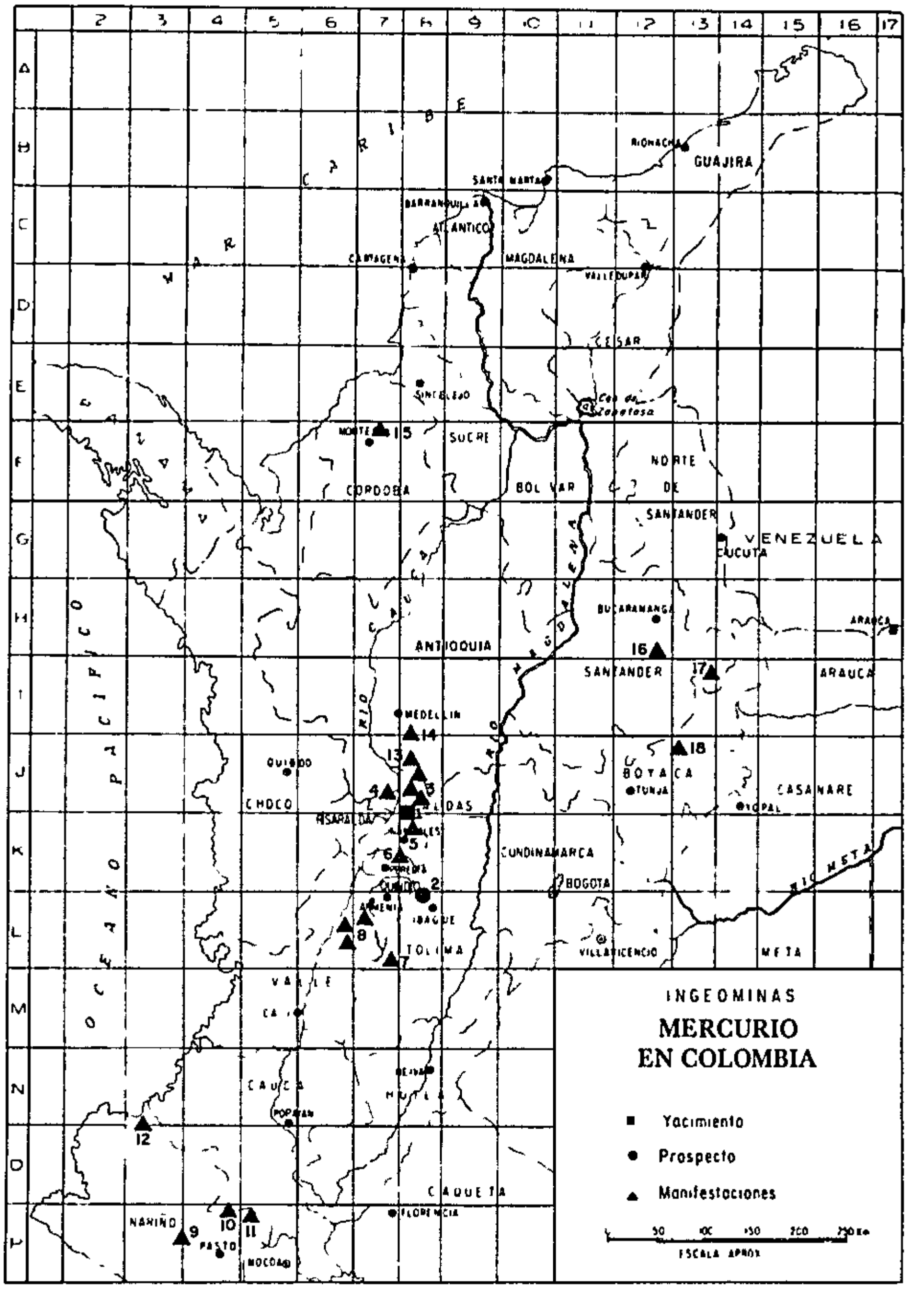
1. Remedios, 2. Remedios, 3. Segovia, 4. Segovia, vereda Fraguas, 5. Zaragoza, 6. Urrao, 7. Anorí, 8. Samaná, 9. Samaná, 10. Marquetalia, 11. Pensilvania, 12. Samaná, 13. Samaná, 14. Berlín, 15. Piedra Sentada, 16. Santander de Quilichao, 17. Santander de Quilichao, 18. Buenos Aires, 19. Mercaderes, 20. Quibdó, 21. Tadó, 22. Neiva, 23. Neiva, 24. El Hobo, 25. Gigante, 26. El Pital, 27. San José de Isnos, 28. Teruel, 29. Villavieja, 30. Buesaco, Berruecos y Mallana, 31. Hacarí, 32. Abrego, 33. Cácota, 34. Sardinata, 35. Silos, 36. El Carmen, 37. Salento, 38. Riosucio, 39. Quinchía, 40. Umpalá, 41. Tona, 42. California, 43. California, 44. Anzoátegui, 45. Rovira, 46. Rovira, 47. Anzoátegui, 48. Anzoátegui, 49. Líbano y Falan, 50. Fresno, 51. San Antonio, 52. Chaparral, 53. El Valle, 54. Cajamarca, 55. Paime, 56. Ubaté, 57. Gachetá, 58. Ubalá y Gachalá, 59. Junín, 60. Supatá, 61. Quetame, 62. Guayabetal, 63. Sumapaz, 64. Otanche, 65. Villa de Leiva, 66. Ráquira, 67. Nobsa, 68. Soatá, 69. Chiscas, 70. Güicán, 71. Güicán, 72. Toguí, 73. Zetaquirá.

Fig.-9 Location map of lead and zinc mineralized areas and showing



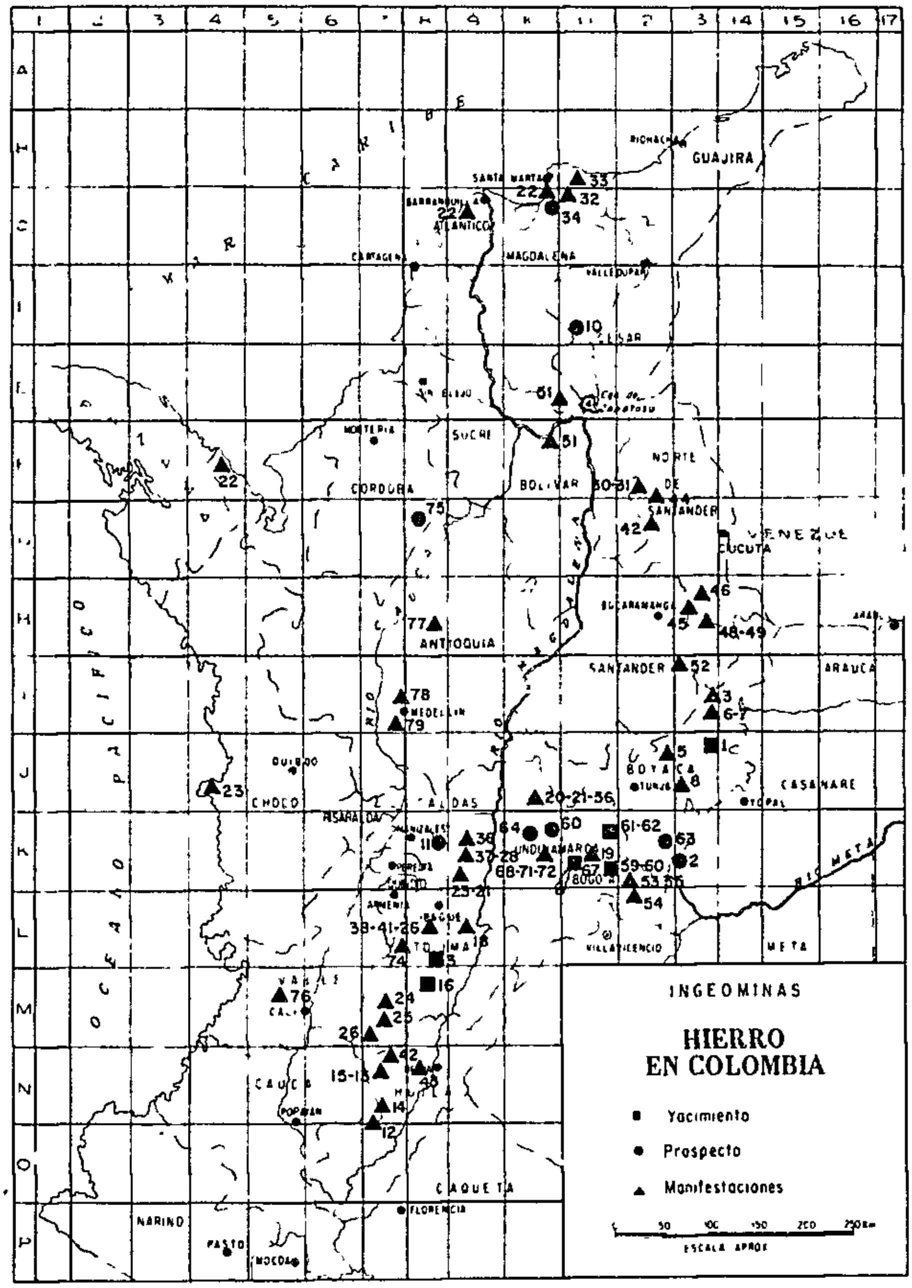
1. Planeta Rica, 2. Cerromatoso, 3. Uré, 4. Ituango, 5. Morropelón, 6. Medellín.

Fig.- 10 Location map of nickel mineralized areas



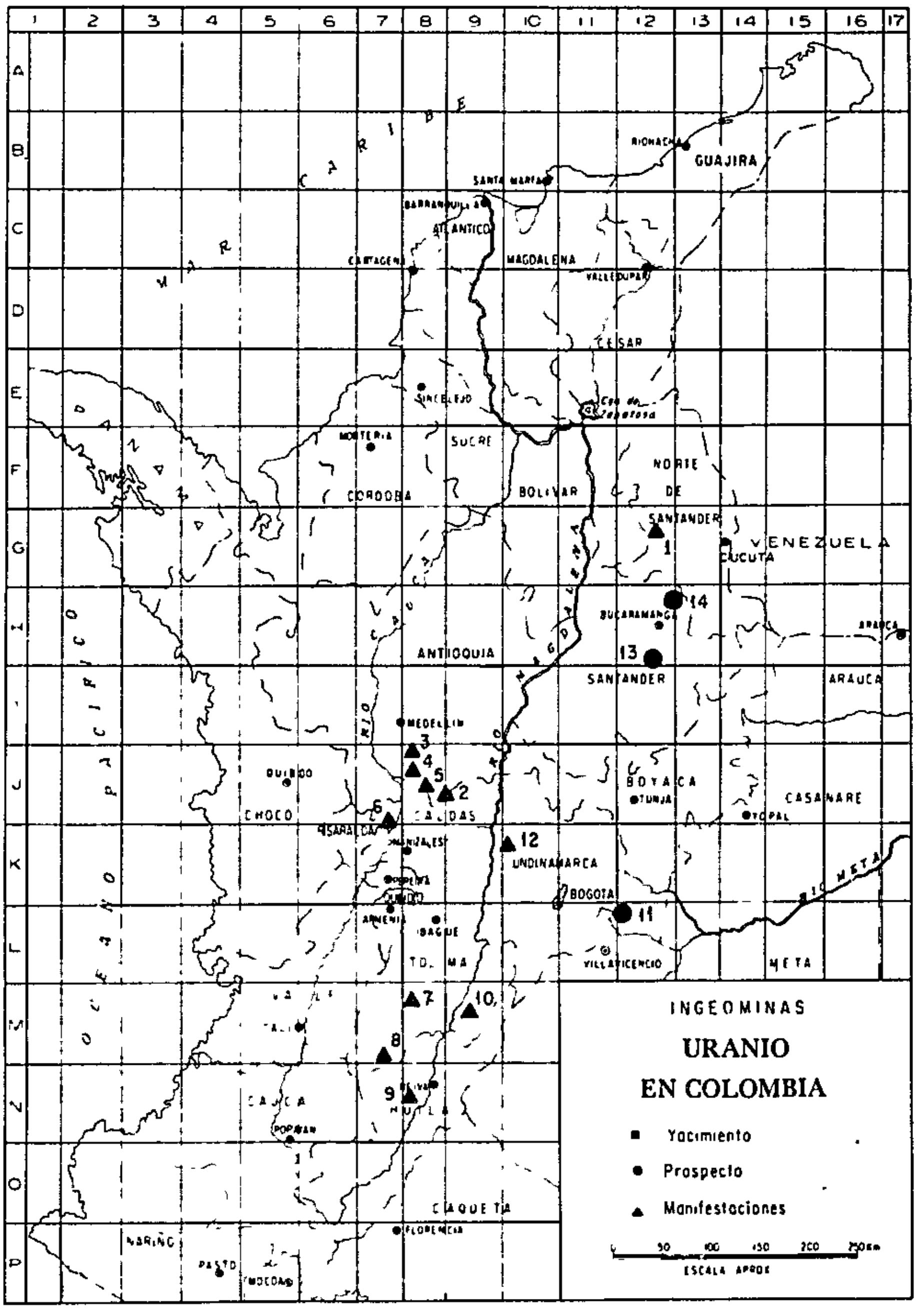
1. Aranzazu, 2. Cajamarca, 3. Salamina-Pácora-Aguadas, 4. Supía, 5. Manizales, 6. Santa Rosa de Cabal, 7. Rovira-Miraflores, 8. Tuluá-Bugalagrande-Sevilla, 9. Samaniego, 10. La Unión, 11. La Cruz, 12. Iscuandé, 13. Fredonia, 14. Retiro, 15. Montería, 16. Piedecuesta, 17. Enciso, 18. Nobsa.

Fig.-11 Location map of mercury ore deposit and showings



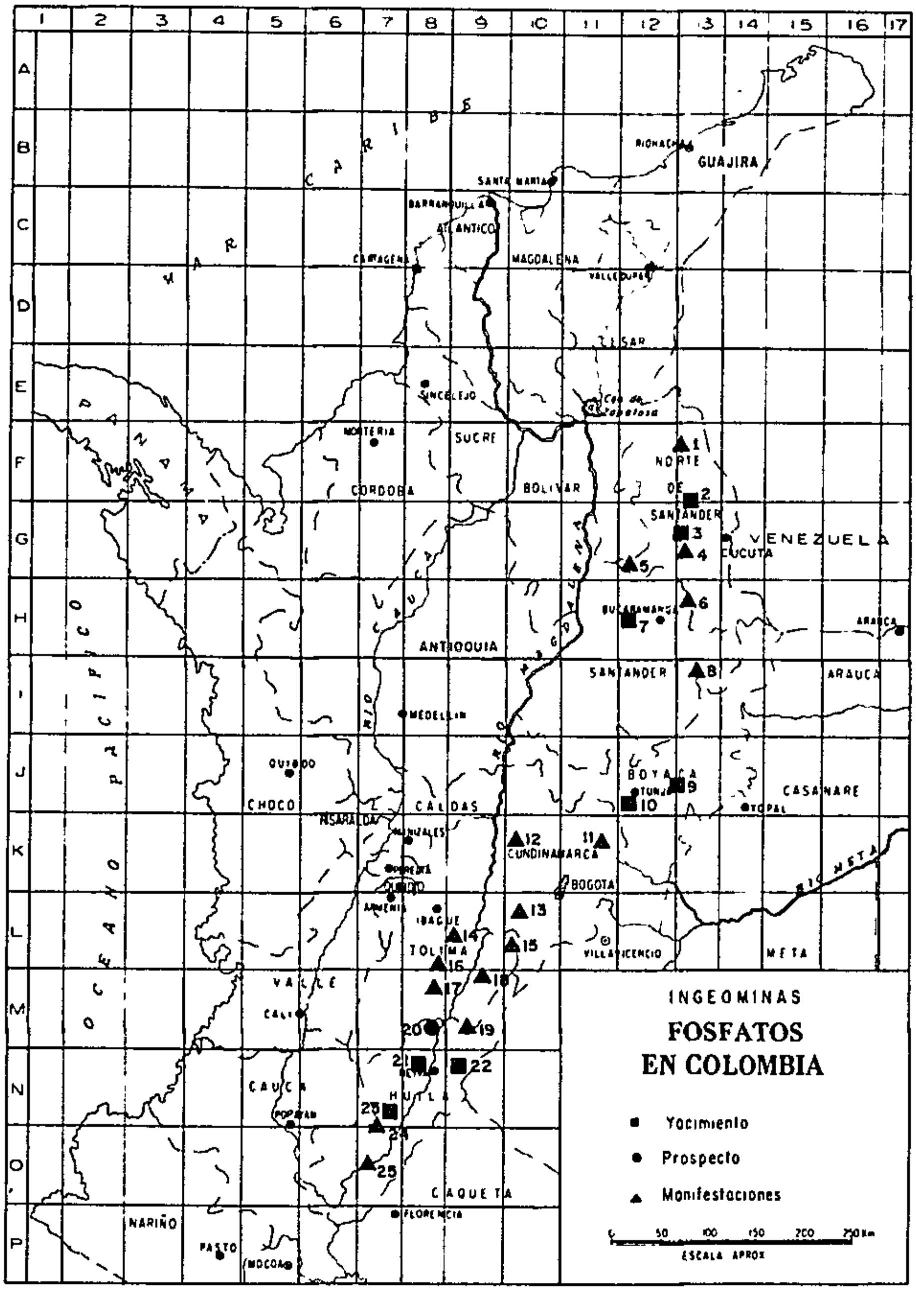
1. Paz de Río, Boyacá.
65. Algodonales, Pacho, Cundinamarca.
67. Pericos, Guasca, Cundinamarca.

Fig.- 12 Location map of iron ore deposits and showings



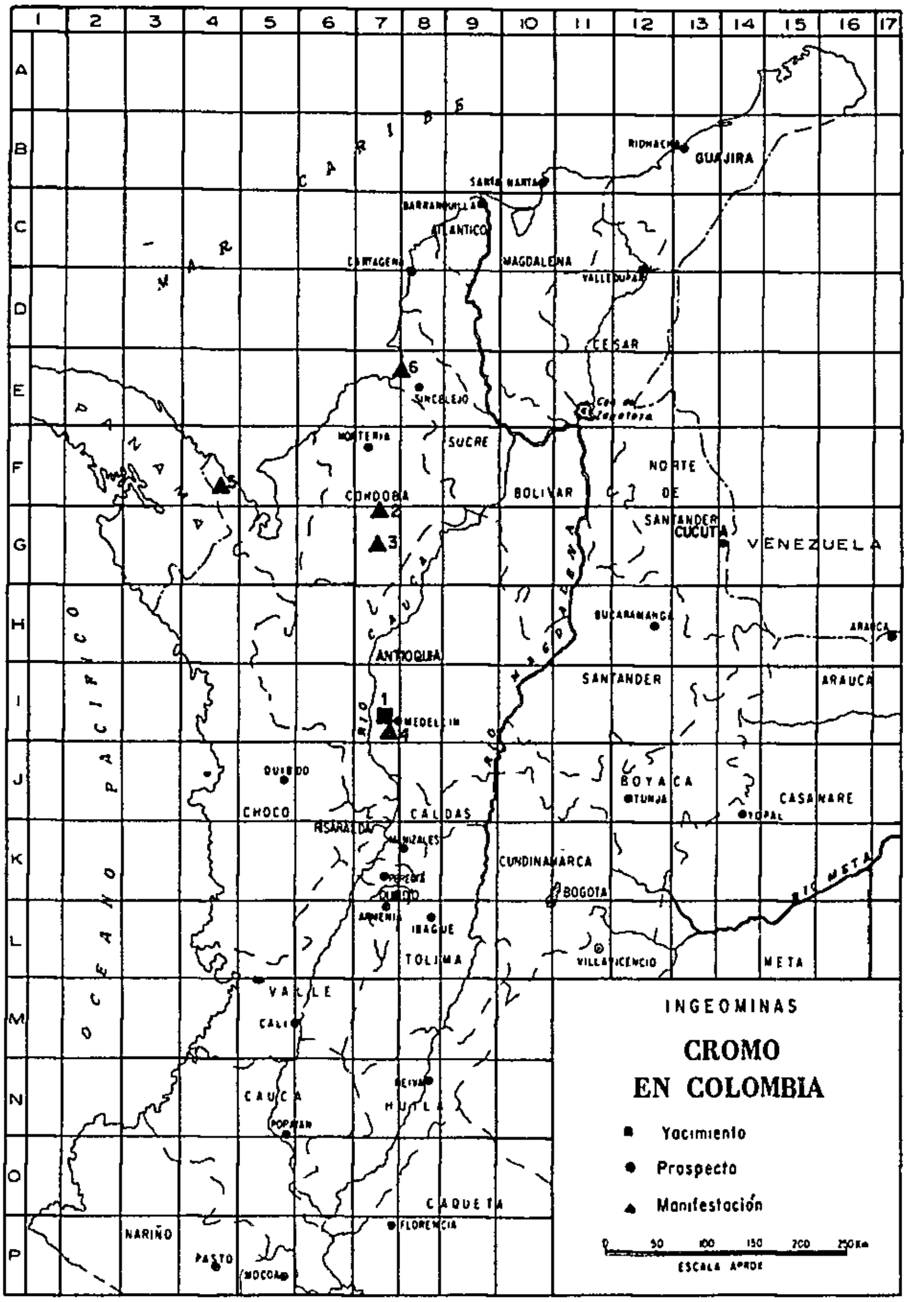
1. Ocaña, 2. Berlín, 3. La Unión, 4. Montebello, 5. Abejorral, 6. Irrá, 7. Chaparral, 8. Gaitana, 9. Palermo, 10. Natagaima, 11. Quetame, 12. Guaduas, 13. Zapatoca, 14. California, 15. Guainía, 16. Vaupés. (15 y 16 fuera del mapa).

Fig.-13 Location map of uranium mineralized areas



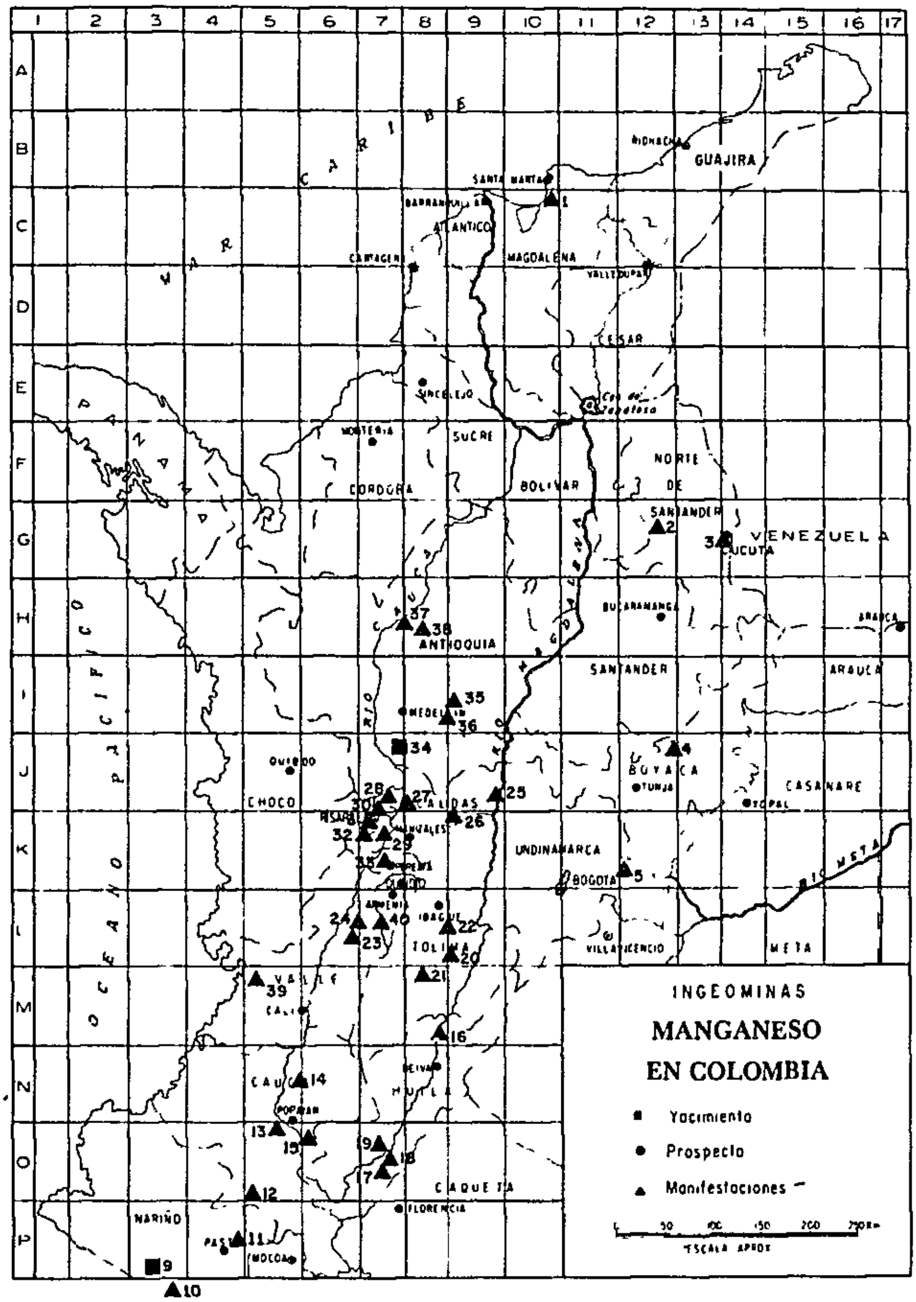
1. Orú - Tresaguas, 2. Sardinata, Lourdes, Arboledas, Salazar, Gramalote, 3. Bochalema, 4. Pamplona, Mutiscua, 5. San Alberto, 6. Suratá, 7. Conchal, Azufrada, San Vicente de Chucurí. 8. Cerrito, Molagavita, 9. Pesca, Sogamoso, 10. Tunja, 11. Cucunubá - Machetá, 12. Alto del Trigo, 13. Pandi, Boquerón, 14. San Luis, 15. Icononzo, Melgar, Villarrica, Pandi, 16. Ortega, 17. Coyaima, 18. Cerro Telecom, 19. Las Delicias, La Aurora (Alpujarra), 20. Palermo, 21. Alpe, Mapatá, 22. Baraya, Tello, 23. Teruel, Yaguará, Tesalia, 24. La Plata, Pital, 25. Elías, Timaná.

Fig.-14 Location map of phosphorous ore deposits and showings



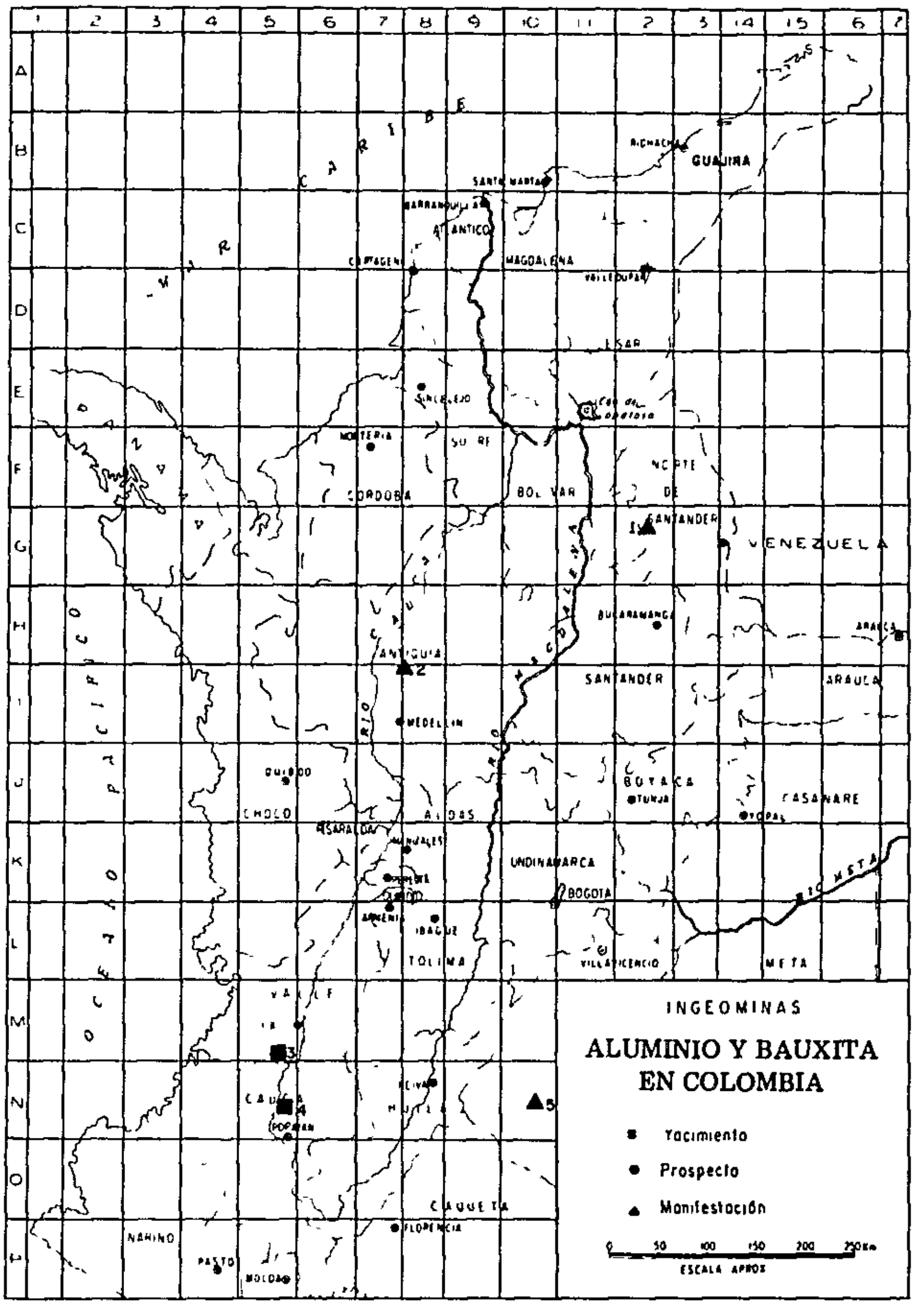
1. Santa Helena, 2. Cerros Sabanas y Querezas, 3. Cerro Matoso, 4 Serpentinas de Medellin, 5. Arenas Negras de Acandı, 6. Arenas Negras de Tolu y Coveñas

Fig.-15 Location map of chrome ore deposit and showings



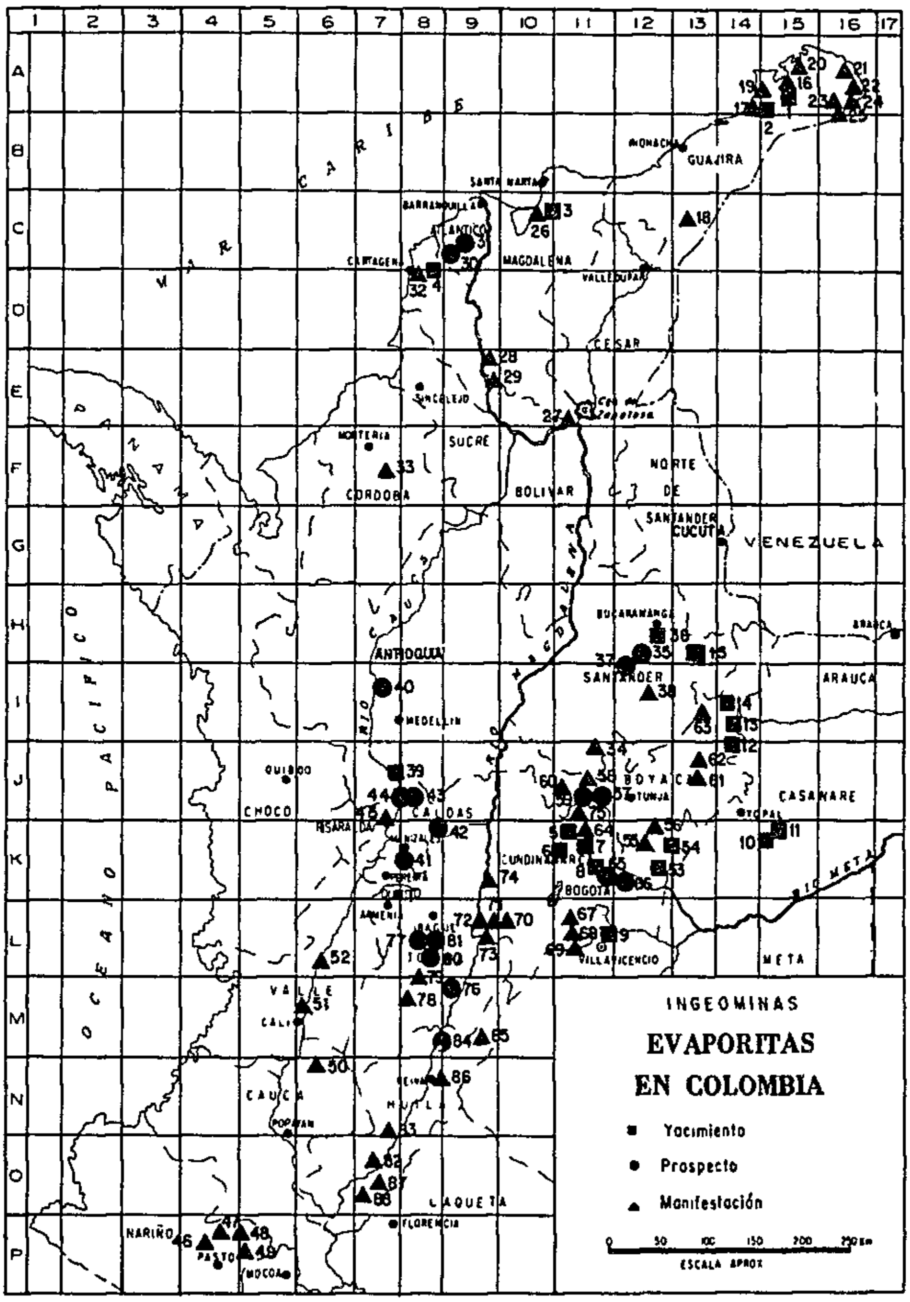
1. Ciénaga, 2. Abrego, 3. Rosario, 4. Santa Rosa de Viterbo, 5. Ubalá, 6. San Martín, 7. San José del Guaviare, 8. Río Apaporis, 9. Mallama, 10. La Victoria, 11. Buesaco, 12. Bolívar, 13. Tambo, 14. Morales, 15. Coconuco, 16. Villa Vieja, 17. Altamira, 18. Agrado, 19. Garzón, 20. Ortega, 21. Chaparral, 22. Rovira, 23. Tuluá, 24. Andalucía, 25. La Dorada, 26. Manzanares, 27. Salamina, 28. Riosucio, 29. Mistrató, 30. Apía, 31. Viterbo, 32. Santuario, 33. Pereira, 34. Santa Bárbara, 35. El Peñol, 36. Carmen de Viboral, 37. Ituango, 38. Yarumal, 39. Anchicayá, 40. Sevilla.

Fig.-16 Location map of manganese ore deposit and showings



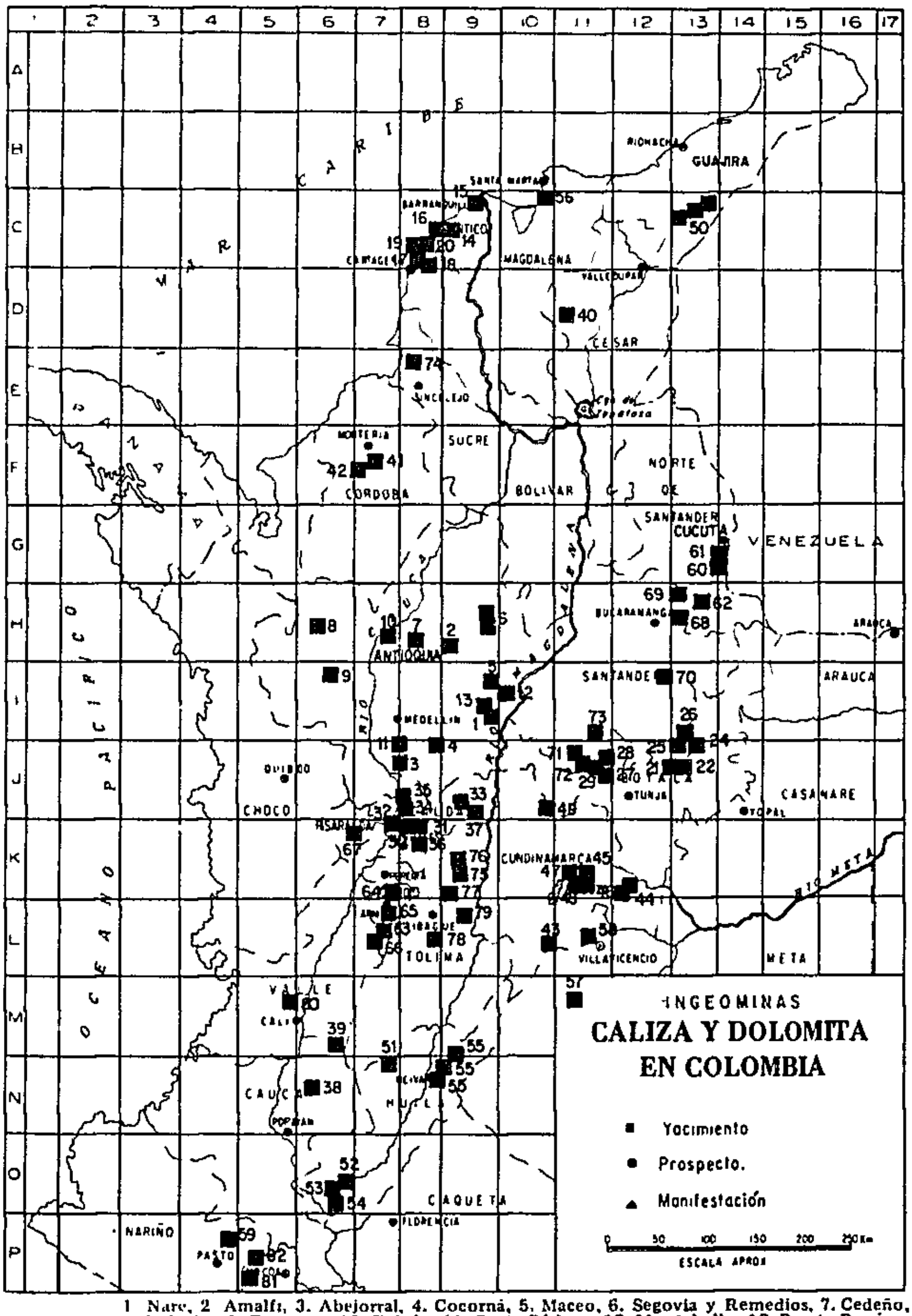
1. Abrego, 2. Llanos de Cuivá, 3. San Antonio (Alto Cauca), 4. Morales - Cajibío (Alto Cauca), 5. La Macarena.

Fig.- 17 Location map of bauxite ore deposits and showings



5. Nemocón, Cundinamarca.
6. Zipaquirá, Cundinamarca.
35. Villanueva, Santander.
36. La Mesa de Los Santos, Santander.

Fig.–18 Location map of rock salt and gypsum ore deposits and showings



1 Nare, 2 Amalfi, 3. Abejorral, 4. Cocorná, 5. Maceo, 6. Segovia y Remedios, 7. Cedeño, 8 Dabeiba, 9. Frontino, 10. Toledo, 11. Santa Bárbara, 12. Montebello, 13. Puerto Berrio y Jordan 14 Luruaco y Arroyo de Piedra, 15. Villa Santos, 16. Colina de Morisca, 17. Albornoz, 18 Turbaco, 19 Cuchilla de Canalete, 20. Loma de Piedra, 21. Tibasosa, 22. Nobsa, 23 Corrales, 24. Beteitiva, 25 Cerinza, 26. Belén, 27. Gachantivá, 28-29. Carretera Barbosa-Moniquira, 30 Neira, 31 Manzanares, 32. Filadelfia, 33. Samaná-La Dorada, 34. Salamina, 35 Pácora, 36 Villa Maria, 37. La Victoria, 38. Pitayó, 39. Corinto, 40. Hda. Durania, 41 La Cantera, 42 La Floresta y Sena, 43. Paramo de Sumapaz, 44. Ubala y Gachala, 45. Palacio, 46. Rio Blanco-Quebrada Chocolatal, 47. Pueblo Viejo 48. Puerto Arturo - La Calera, 49. Paime, 50 San Juan del Cesar-Cuestecita, 51. La Lupa, 52. La Cantera, 53 Hda. Versalles y La Calera San Jose, 54. Palestina, 55. Baraya-Tello-Caguán, 56. Ciénaga, 57. San Martin, 58 Servita, 59. Buesaco, 60. Chinacota, 61 Cucuta - Pamplona, 62. Mutiscua, 63. Puentetabla, 64. Salento, 65 Calarcá, 66 Génova, 67 Apía, 68. Tona, 69. California-Surata, 70. Curiti, 71. Sucre, 72 Puente Nacional, 73 Vélez, 74. Toluviejo, 75 Venadillo, 76. Lérida, 77. Líbano, 78 Al sur de Ibague, 79 Piedras - Coello - Suarez, 80 Vijes, 81. Pasto, 82. Puerto Asis

Fig.- 19 Location map of limestone and dolomite

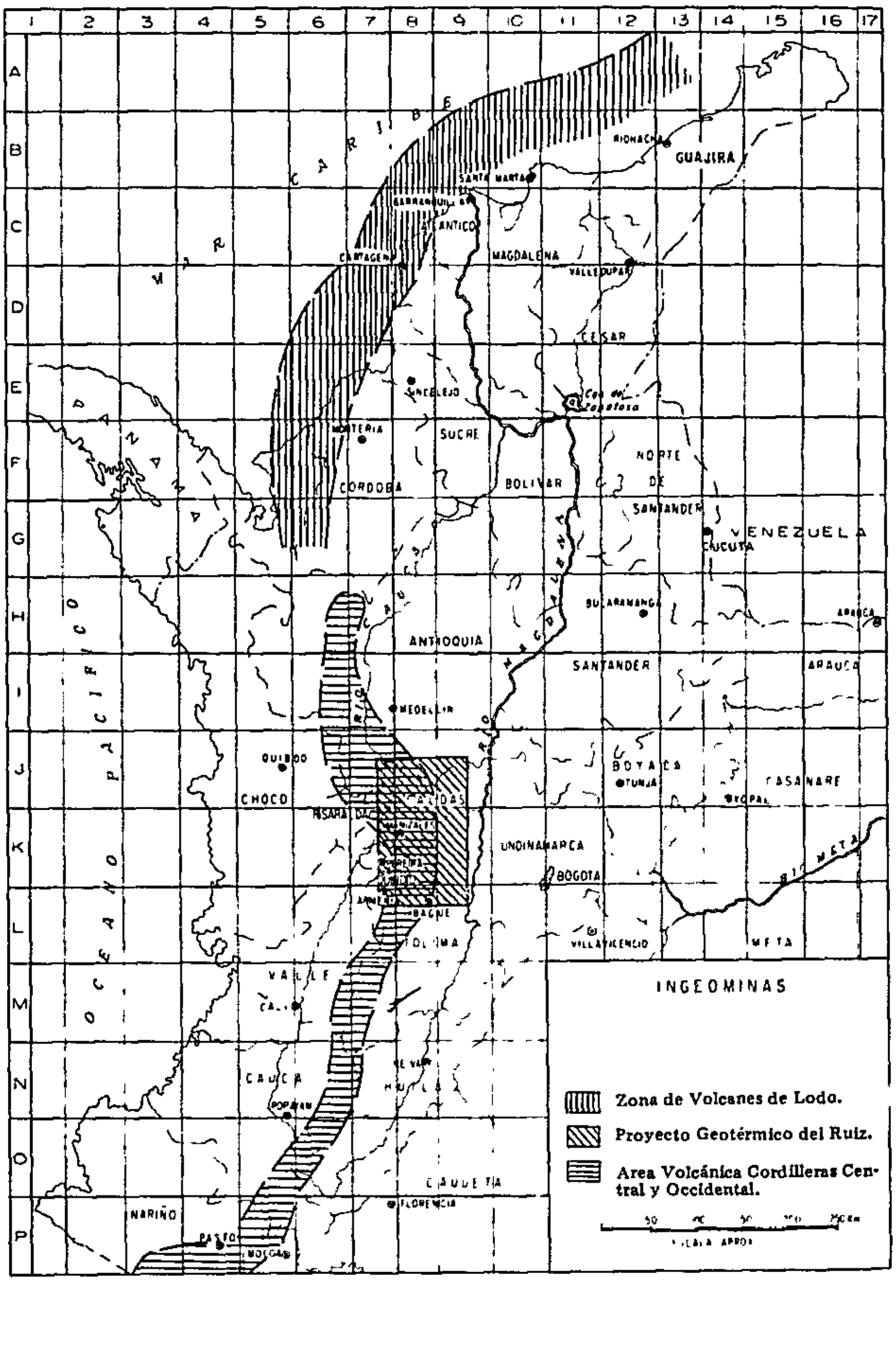


Fig.- 20 Location map of mud volcanos, Ruiz Geothermal project and volcanic zone

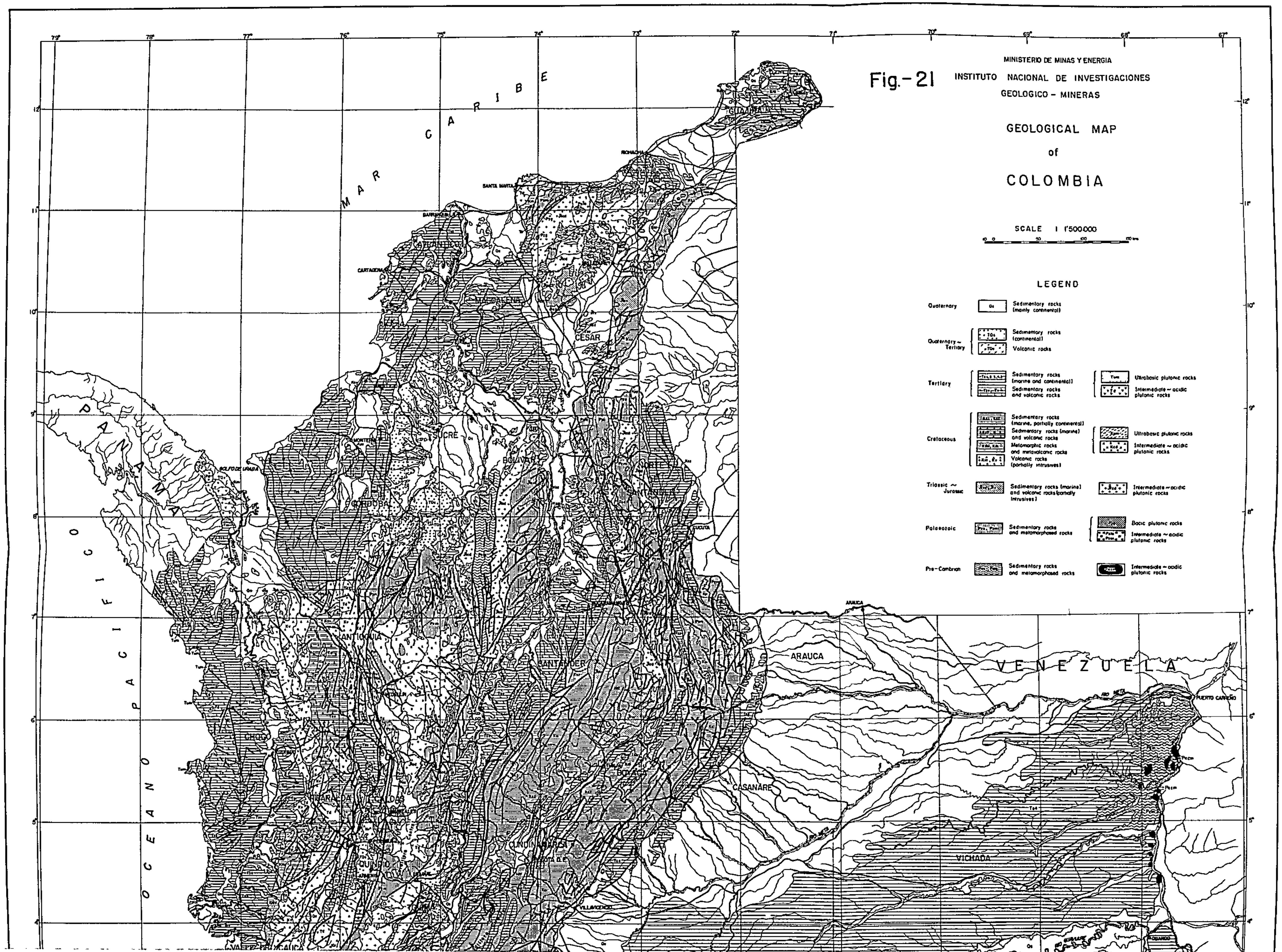
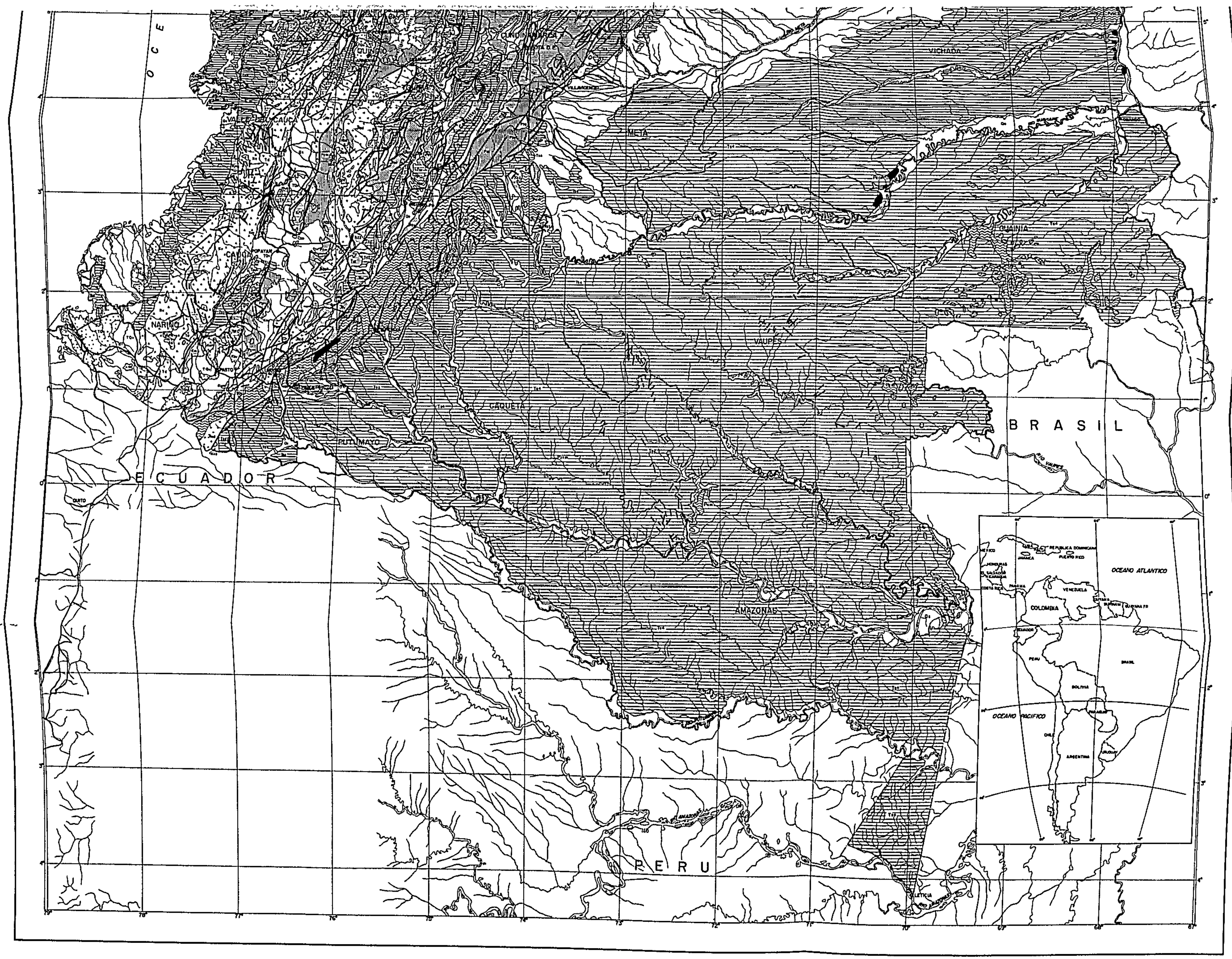


Fig.- 21
MINISTERIO DE MINAS Y ENERGIA
INSTITUTO NACIONAL DE INVESTIGACIONES
GEOLOGICO - MINERAS
GEOLOGICAL MAP
of
COLOMBIA
SCALE 1 1'500.000
LEGEND
Quaternary
Sedimentary rocks (mainly continental)
Quaternary ~ Tertiary
Sedimentary rocks (continental)
Volcanic rocks
Tertiary
Sedimentary rocks (marine and continental)
Sedimentary rocks and volcanic rocks
Ultrabasic plutonic rocks
Intermediate ~ acidic plutonic rocks
Cretaceous
Sedimentary rocks (marine, partially continental)
Sedimentary rocks (marine) and volcanic rocks
Metamorphic rocks and metavolcanic rocks
Volcanic rocks (partially intrusives)
Ultrabasic plutonic rocks
Intermediate ~ acidic plutonic rocks
Triassic ~ Jurassic
Sedimentary rocks (marine) and volcanic rocks (partially intrusives)
Intermediate ~ acidic plutonic rocks
Palaeozoic
Sedimentary rocks and metamorphosed rocks
Basic plutonic rocks
Intermediate ~ acidic plutonic rocks
Pre-Cambrian
Sedimentary rocks and metamorphosed rocks
Intermediate ~ acidic plutonic rocks
MAR CARIBE
OCEANO PACIFICO
PANAMA
VENEZUELA
GUAJIRA
CESAR
MAGDALENA
SUCRE
BOLIVAR
CORDOBA
ANTIOQUIA
SANTANDER
CHOCO
BOYACA
CASANARE
ARAUCA
VICHADA
CUNDINAMARCA
RISARALDA
QUINDIO
TOLIMA
CARTAGENA
SANTA MARTA
RIOHACHA
MONTERIA
VILLAVICENCIO
PUERTO CARREÑO


OCE
CUNDINAMARCA
VICHADA
VALLE DEL CAUCA
META
GUAINIA
CAUCA
NARIÑO
PASTO
VAUPES
CAQUETA
PUTUMAYO
BRASIL
ECUADOR
QUITO
AMAZONAS
PERU
LETICIA
OCEANO ATLANTICO
OCEANO PACIFICO
COLOMBIA
VENEZUELA
BOLIVIA
ARGENTINA

CHAPTER 5.

OUTLINE OF GEOLOGY AND STRUCTURE IN COLOMBIA

Chapter 5. Outline of Geology and Structure in Colombia

Roughly speaking, the geology of Colombia can be classified into two groups, namely the eastern stable block consisting of the Pre-Cambrian system which belongs to the Guayana shield and the Andean Orgenic zone formed during and after Palaeozoic era. The Guayana shield which makes up the main body of the South American Continent with the Brazilian shield consists of rocks intruded with granite and highly metamorphosed rocks from Archaean to Proterozoic eons.

The geosynclinal sediment during and after Palaeozoic era is distributed along the Colombian Andes folded mountains approximately in the direction of N30°E in the western half of Colombia and shows belted distribution of three sedimentary facies such as eugeosynclinal, miogeosynclinal and continental from west to east.

5-1 Geological Distribution

5-1-1 Pre-Cambrian system

Colombia is located at the western periphery of the Guayana shield. In Colombia the distribution area of the Pre-Cambrian system is not wide; the Eastern mountains, the Central mountains, the Santa Marta mountains, Guajira peninsula and the Amazon basin are its main distribution area.

Rocks consist of highly metamorphosed rocks such as migmatite, granulite, charnockite and amphibolite, weakly metamorphosed rocks such as acidic-basic paragneiss and paraschist and granitic rocks intruding them.

5-1-2 Palaeozoic group and thereafter

i) Palaeozoic group

This ranges from Cambro-Ordovician to Permian system and consists of eugeosynchinal sediments, miogeosynclinal sediments and epicontinental sediments.

Eugeosynclinal sediments consist of basic volcanic rocks represented by ophiolite, slate, phyllite, quartzite and others, they were metamorphosed into green schist and black schist, and distributed from the central part to the western part in Colombia.

Miogeosynclinal sediments consist of black shale, sandstone, conglomerate, limestone and others, they are distributed from central to eastern part in Colombia, generally not metamorphosed and show little igneous activity. Epicontinental sediments consist of red sandstone, siltstone, conglomerate and others, partly including limestone and they are distributed from eastern part to plain of the Amazon basin.

ii) Mesozoic group

a) Triassic and Jurassic system

During these periods the continental sediment was formed on a large scale in the eastern part, and the eugeosynclinal sediment was formed with volcanic activity in the western mountain areas in Colombia. In the eastern area the characteristic thick and wide sediment was formed such as conglomerate, sandstone and siltstone, which are called the red continental sediment of molasse type. In the western mountain area there are distributed the flysh type sedimentary rocks such as basic volcanic rock, siltstone, sandstone, chert and others.

b) Cretaceous system

In the western mountain area eugeosynclinal sediment was formed. On the other hand miogeosynclinal sediment was formed from the eastern mountain area to its east side.

In the western mountain area basic submarine volcanic activity were predominant, basalt, andesite, its lava flow, and pyroclastic rocks are widely distributed, and the flysh type sedimentary rocks of chert with limestone, black shale, and greywacke are distributed. In the eastern

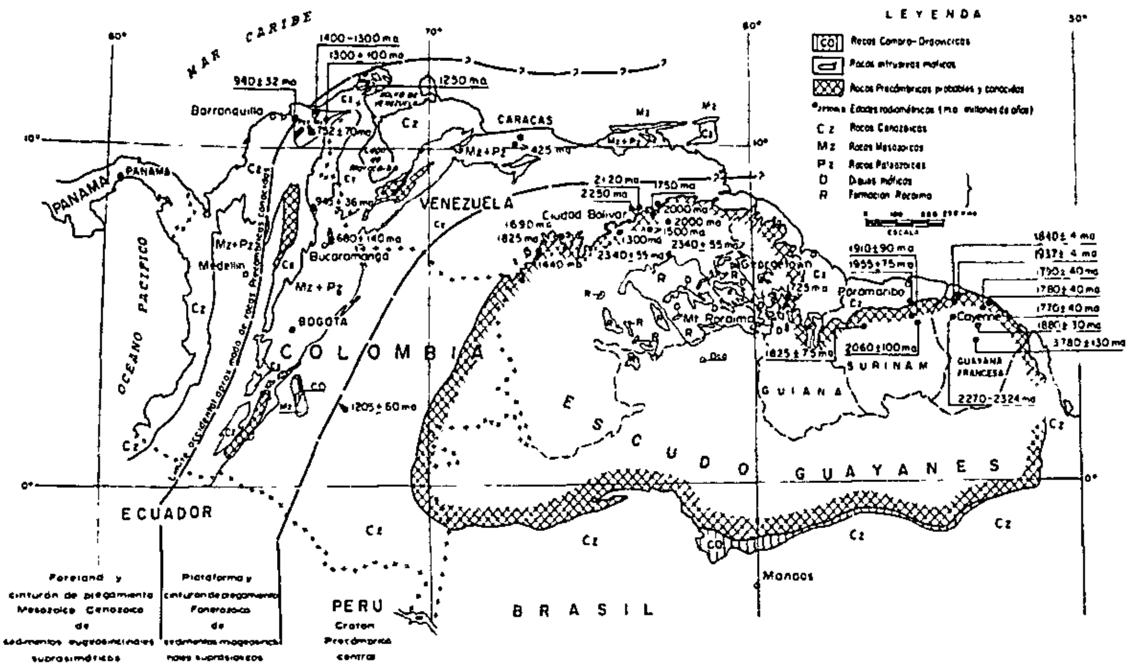


Fig 2- Distribución de rocas Precambricas y Cambro-Ordovicicas, de edades Precámbricas conocidas, y de las subdivisiones tectónicas mayores de la parte septentrional del continente sudamericano.

Fig.-22 Rock Distribution in Precambrian, Cambro-Ordovician, and Major Tectonic Zones in the Northern Part of South American Continent

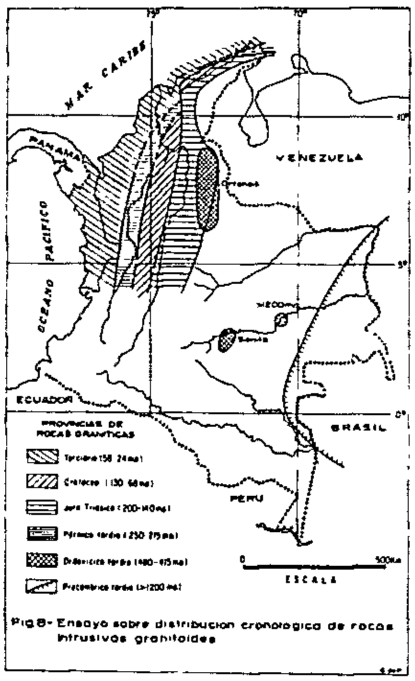


Fig 8- Ensayo sobre distribucion cronologica de rocas intrusivas granitoides

Fig.-23 Geochronologic Distribution of Granitic Rocks in Colombian Andes mountain area there are a number of small scale miogeosynclinal sedimentary basins, sedimentary rocks of black shale, sandstone, conglomerate and chert partly accompanied by phosphate rock are distributed, but few volcanic rocks are found. Further, sedimentary rocks of epicontinental ∿ continental sediment are distributed in the area from the eastern mountains to the eastern plain.

iii) Cenozoic group

a) Tertiary system

Marine deposit is distributed only in the area near the present sea·shore, which show the deep sedimentary facies of thick layers of mudstone, siltstone, sandstone and chert partly accompanied by conglomerate and limestone.

However, most of the Tertiary system is the molasse type continental sediment consisting of conglomerate, sandstone, siltstone and others often accompanied by limestone, which is distributed in many inland basins in the upheaved Andes mountain area.

b) Quaternary system

Volcanic rocks such as andesite, basalt and tuff from the end of Tertiary to Quaternary period, are distributed in the central part to the southern part of the central mountains. Alluvium is found in the northern plain, valley along the rivers of Magdalena and Cauca, and the southern sea·shore. Diluvium is widely distributed in the northern plain, area near sea·shore and along main rivers.

5-2 Igneous Activity

5-2-1 Plutonic igneous activity

Plutonic igneous activity in Colombia is roughly divided into the following cycle;

i) late Pre-Cambrian period

ii) late Ordovician period

iii) the end of Palaeozoic era

iv) late Triassic to Jurassic period

v) Cretaceous period

vi) Tertiary period (middle Eocene and the Oligocene to miocene epoch).

i) The plutonic igneous activity of the Pre-Cambrian period which accompanied the two orgenic movements at about 1,350 m.y. and 950 m.y., consists mainly of granulite and partly of migmatite owing to anatectic magma.

ii) The plutonic igneous activity of the late Ordovician period which accompanied the orogeny, is found in the eastern area and the eastern mountains. Typical plutonic rocks of this period consists of such alkali-syenite in Guaviare area of the eastern plain and orthogneiss in Santander Massif of the eastern mountains.

iii) The plutonic igneous activity of the end of Palaeozoic era is found mainly in the central mountains. Typical rocks of this era consists mainly of acidic plutonic rocks found in the areas of Pugui and Amagá in the southern part of Medellin.

iv) The plutonic igneous activity from late Triassic to Jurassic period started with intermediate-acidic batholith activity which accompanied the Triassic orogenic movement found in the eastern mountains and Santa Marta mountains and continued to the Jurassic one distributed in the eastern periphery of the central mountains, the eastern mountains and Santa Marta mountains.

v) During late Cretaceous period ultrabasic rocks such as peridotite and serpentinite intruded along the main axis part of the orogenic zone at the western mountain area, and at the central mountains various granitic plutonic rocks such as quartz diorite, granodiorite and quartz monzonite represented by Antioquia batholith are distributed.

vi) The plutonic igneous activity of the Tertiary period are small batholith like intrusion which accompanied the folding of Santa Marta mountains and Guajira peninsula at early to middle Tertiary and narrow igneous body intruded along the eugeosyncline in the central mountains and the western mountains at the middle Tertiary. The intrusions of some ultrabasic and basic rocks such as peridotite, pyroxenite and gabbro in the western mountains are also found.

5-2-2 Volcanic activity

Basic volcanic activities accompanied by ophiolite are found in the eugeosynclinal zone which is located in the central mountains area as the center and spans partly to the west from Cambro-Ordovician to first half of Permian period.

Basic volcanic activities are found in the eugeosynclinal zone in the western mountains from Triassic to Jurassic period. Vigorous submarine basic volcanic activities are observed also in the western mountains in Cretaceous period.

Basalt, andesite and their pyroclastic rocks are found in various places along coast in Tertiary, and the activities of andesite, basalt and their tuff are found in the central ∿ southern part of the central mountains in Quaternary period.

5-3 History of Geological Development

Paleo-metamorphism which occurred before 3,000 m.y. is observed in the oldest part of the central Guayana shield, afterward the metamorphism occurred again during 2,250 m.y. and 1,850 m.y. Thus, the craton seems to be had stabled after activities of granitic magma twice at least.

Peri-continental eugeosyncline was formed along the northwestern periphery of the Guayana sield at the beginning of the Palaeozoic era. After the orogenic movement of the late Ordovician period, another orogenic movement accompanied by strong alteration and the intrusion of granitic rock occurred at the end of the Palaeozoic era and formed the zone of crystalline schist and the paleo-central mountains.

The intrusions of large acidic igneous bodies such as Santa Marta batholith in northern Colombia and Ibaqué batholith in central ∿ southern Colombia occurred along the palaeozoic orogenic arc in early ∿ middle Mesozoic era, continously. The second peri-continental eugeosynclinal zone was folded intensely by the orogenic movement at the end of the Cretaceous period. As the results of these orogenic movements, the central mountains, the western mountains, the Santa Marta mountains and the northwestern Guajira peninsula were formed.

In the Tertiary, granitic plutonic rock intruded on a small scale at various places along the axis of the orogenic zone, being accompanied by orogenic movements, into the Santa Marta mountains and the Guajira peninsula at the middle Eocene, and into the western mountain area in the Oligocene ∿ early Miocene. The eastern mountains were formed it which during the Andean orogeny at the middle Tertiary, namely, the Guayana shield in the eastern side of the central mountains was relatively stable platform after the intermittent pericontinental miogeosynclinal marine sedimentation in the cryptozoic eons. But it was given very strong marginal flexures- folding by the orogenic movement at the beginning of the Miocene and high angle reverse faults inclined eastward and partially transcurrent faults were formed along which the eastern mountains were uplifted.

i) The late Palaeozoic era —the formation of the paleo-central mountains

ii) The late Mesozoic era —the formation of the central mountains and the western mountains

iii) The middle Tertiary period — the formation of the eastern mountains

The Bouguer anomaly observed in the westernmost part of Colombia and abyssal ∿ hypabyssal sediment covering basic volcanic rock in the easternmost part of Panama suggest that the Isthemus of Panama was the Oceanic crustal origin and was connected with the Andes Cordillera during the Andean orogenic movement.

Fig.-27 Sedimentation and Orogeny in Phanerozoic Eons in Colombian Andes and its Adjacent Area

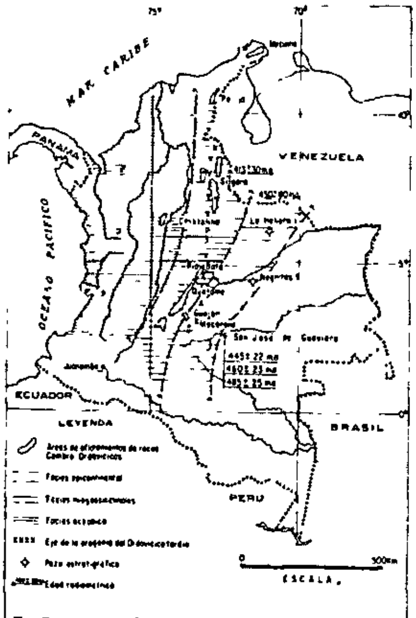


Fig 3 - Localización de afloramientos del Cambro-Ordovícico y del eje de la orogenia del Ordovícico tardío. Paleografía y facies sedimentarias según Burgl (1967)

Fig.-24-1 Cambro-Ordovician

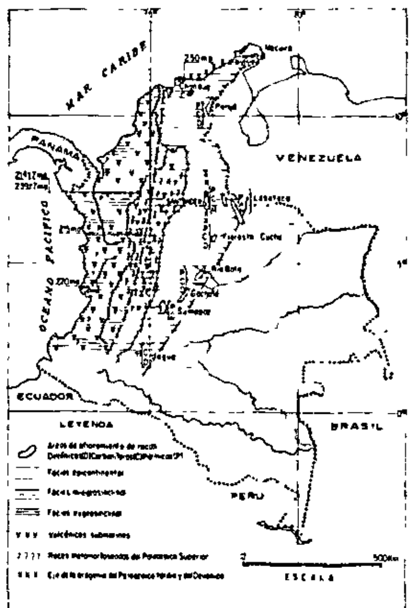


Fig 4 - Localización de los afloramientos del Paleozoico Superior, de las rocas metamorfoseadas de las orogenias del Devónico y Paleozoico tardío. Paleografía modificada según Burgl (1967)

Fig.-24-2 Late Palaeozoic

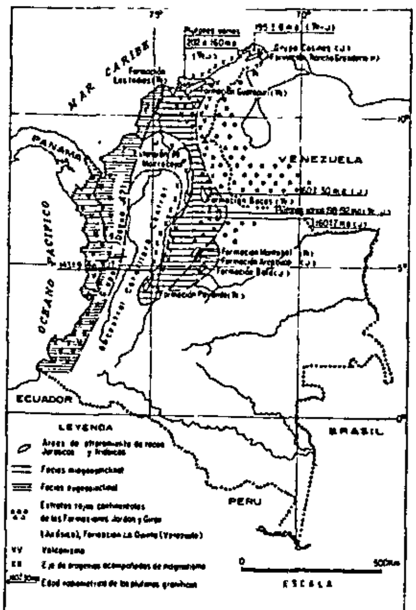


Fig 5 - Localización de los afloramientos marinos del Triásico y Jurásico, y de los ejes del magmatismo plutónico

Fig.-24-3 Trias-Jurassic

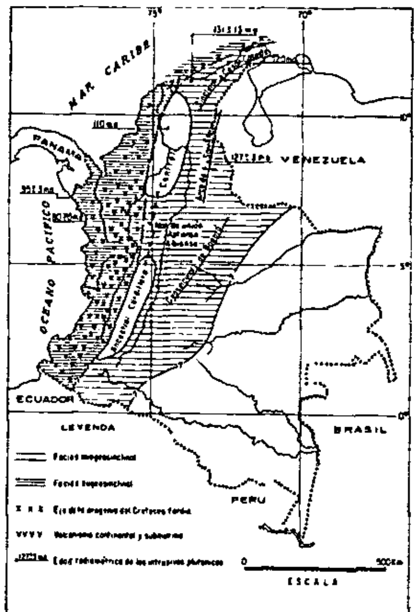


Fig 6 - Localización de la orogenia y del magmatismo del Cretáceo tardío. Interpretación de la paleografía de los mares del Cretáceo

Fig.-24-4 Late Cretaceous

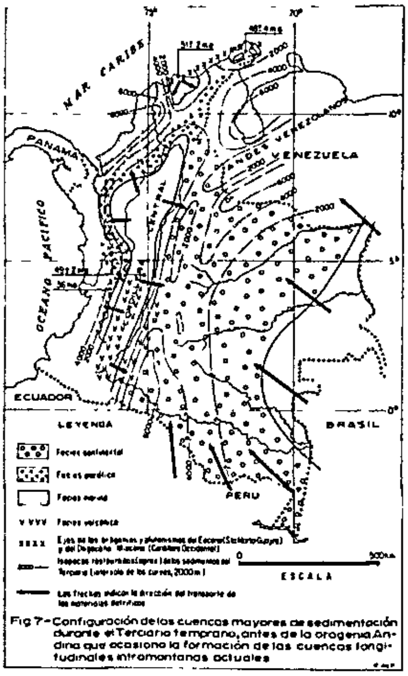


Fig.-24-5 Early Tertiary (Pre-Andian Orogeny)

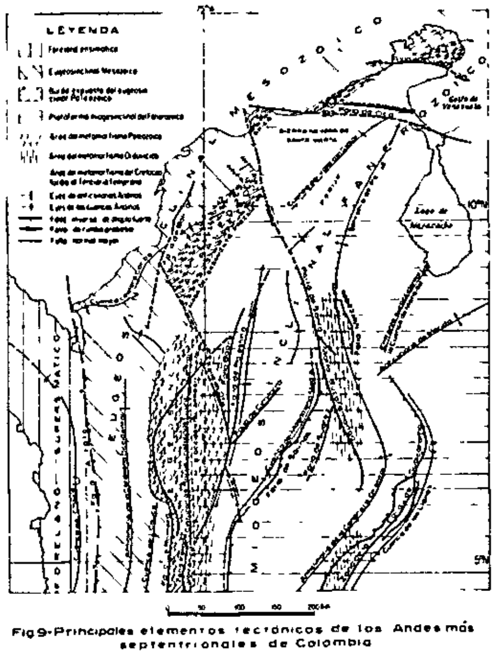


Fig.-25 Tectonic Elements in the Northern Part of Colombian Andes

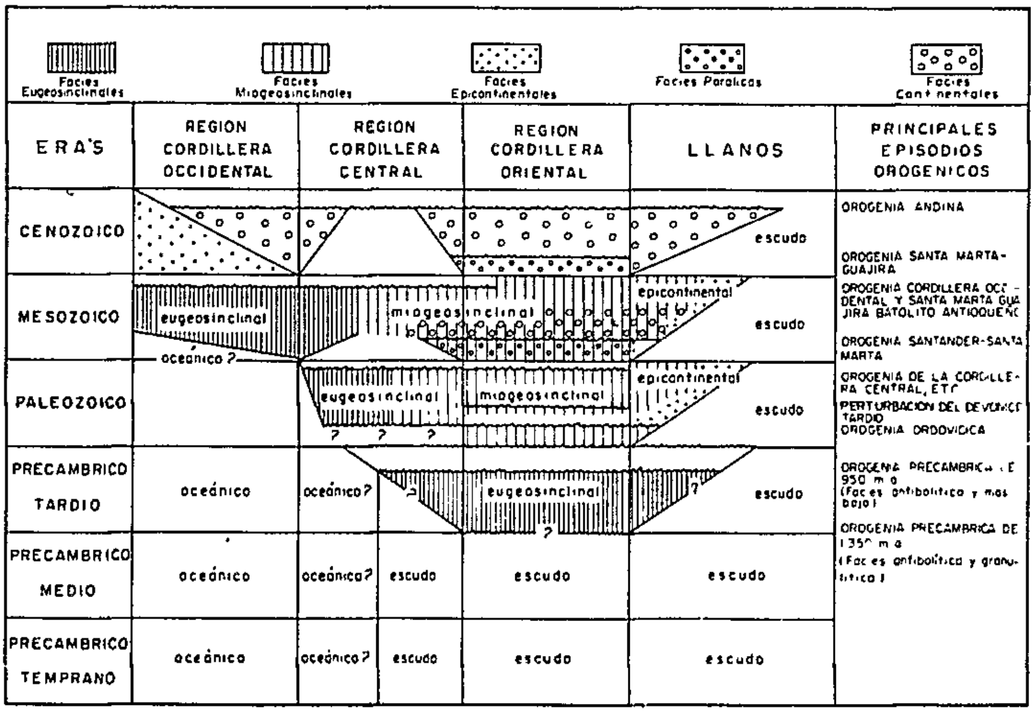


Fig.-26 Westward Progressive Movement of Eugeosynclinal Axis with Continental Accretion in Colombian Andes

CHAPTER 6.

OUTLINE OF GEOLOGY AND ORE DEPOSITS IN NORTHWESTERN AND GENTRAL COLOMBIA

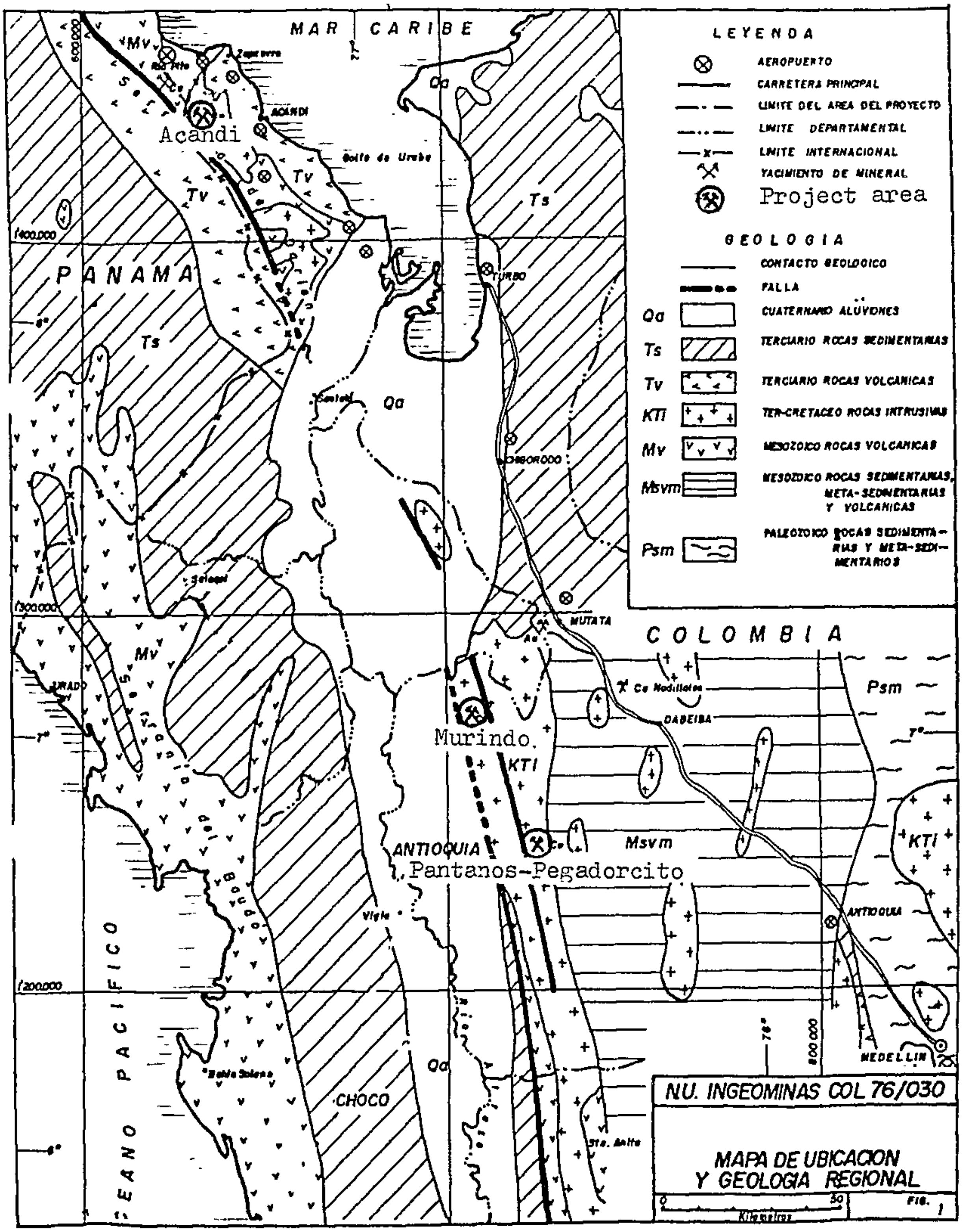


Fig.27 Location map of Acandi,Murindo,and Pantanos-Pegadorcito area

Chapter 6. Outline of Geology and Ore Deposits in Northwestern and Central Colombia

6-1 Geology and Ore Deposits in Northwestern Colombia

6-1-1 Geology

Palaeozoic system consisting mainly of metamorphic rock and batholithic plutonic rocks which intruded into the above mentioned Palaeozoic system are distributed in the eastern side of the Cauca river, and Cretaceous sedimentary rocks containing engeosynchnal basic volcanic rock are distributed widely in the western side of the Cauca river. The Cauca river changes its flow direction to northeast at about 90 km north of Medellin city. The Tertiary marine sediment spans from about 30 km north of the point where the Cauca river changes its flow direction to the coast of the Caribbean Sea. The Atrato river in the western area flows through the low land area including swampy region, where the diluvium of the Quaternary is distributed, but basic volcanic rocks of the end of the Cretaceous period are exposed again near the coast of the Pacific Ocean.

The Palaeozoic rocks occupying the central mountains consist of quartz-sericite schist, greenschist, amphilolite, amphibolite schist, zoisite schist and low grade metamorphic rocks which retains the original rock texture.

The geology of the western mountains consists of basic volcanic rocks in eugeosynclinal condition that started in the Cretaceous period, which are widely distributed from the northwestern coast area of Colombia to Ecuador covering the western area of Colombia. The bottom member of these rocks is occupied by ultrabasic igneous rocks called "Cauca Ophiolite Complex" of marine sediment origin, on which the basic volcanic rocks is overlying. The Dagua group (called the Cañasgordas group in the northwestern area in Colombia) consisting of the alternation of sandstone and shale and Diabasic rocks, are deposited on the above mentioned basic volcanic rocks. This group also crops out partially in the pacific coast area.

6-1-2 Igneous Activity

In the northwestern area the igneous rock of the end of the Palaeozoic era (250-215 m.y.: the Permian period) distributed west of the central mountains is the first intrusive rock, east of which the igneous activities of the Jurassic and Triassic period ranges north to south. The Cretaceous intrusive rocks lie between those two zones, namely eastern part of the centr tral mountains. Especially to the east of Medellin it is distributed as the intrusive rock of a large scaled batholith (Antioquia batholith) of the size about 70 km in east and west, about 100 km in north and south. The intrusive plutonic rock of the Tertiary period is the long narrow "Mandé batholith" which lies west of the western mountains from north to south.

The igneous rock of the end of the Palaeozoic era which is closely related to the formation of metamorphic rocks, consists of the quartz dioritic and quartz monzonitic intrusive gneissic body.

The igneous rock of the Jurassic and the Triassic period consists mainly of quartz diorite having hornblende dominantly and being accompanied by diorite and quartz dioritic rocks.

The igneous activity in the east of the central mountains is completely different from that of west of the mountains during the Cretaceous period. Quartz diorite or granodiorite is mainly found in the eastside. In Tertiary period.quartz dioritic rock intruded into the above mentioned rocks as batholith, soon after their solidification quartz porphyry and dacitic rocks intruded. The intrusions of Tertiary acidic igneous rocks are also found in the central mountain area.

6-1-3 Geological structure

The Romeral fault running from north to south near the Cauca river is the boundary between the central mountains consisting mainly of rocks of the palaeozoic system and the western region consisting of the Cretaceous formation. In western area of fault, there are many faults of north-south system and a little number of ones of NW-SE system, and NE-SW system. Strongly continuous Murindó fault runs from north to south about 100 km west of Romeral fault. The fault is extended along the distribution of the Tertiary quartz dioritic batholith (Mandé batholith), which suggests the existence of weak tectonic zone before the intrusion of the batholith. As NW-SE fault structure, a zone of faults having several km wide is developed in the direction of NW and runs near Medellin.

Further, in the north being devided by the Uraba bay, the eastern part is bent eastward as a whole and the western part is bowed westward and reaches Darien area in Panama passing the Accandi area.

6-1-4 Ore Deposits

Main ore deposits and showings suggesting ore deposits in the northwest of Colombia, namely provinces Antioquia, Choco and Cordoba are as follows;

i) Ore deposits related to ultrabasic igneous rocks

1) Nickel: Cerro-Matsso ore deposit

This is the biggest laterite nickel ore deposit in this country located about 200 km north of Medellin of which the ore reserve and grade are said to be 14,000,000 tons and 2.5% Ni, respectively. The country rock is ultra-basic ferromagnesian rocks such as hartzburgite, dunite which intruded at the end of the Cretaceous period. In the vicinity, there are showings suggesting ore deposits such as Planeta Rica and Uré, though of low grade (Ni 13% ±) with 0.05% Co as a by-product.

2) Platinum: Colombia is the fourth biggest producer of platinum in the

world of which about 98% is produced near Quibdo in Choco province. It is also produced near Dabeiba in the north. These are alluvial deposits originated in ultrabasic rocks which intruded in the Cretaceous period.

3) Chromium: The showings of Salunas and Querezas in Cordoba province suggest the existence of chromium. Chromite is concentrated near the boundary between Peridotite and Gabbro.

4) Asbestos: There is Las Brisas ore deposit about 120 km north of Medellin. It consists of a number of horizontal vein type deposits in serpentinite of the Cretaceous period in the central mountains.

ii) Ore deposits related to acidic igneous rocks

1) Gold:

Acidic igneous rocks of two types have the correlation with gold ore deposit.

a) Intrusive rocks before Tertiary period.

These are found in great number near about 100 km northwast of Medellin, which are dissemination or vein type ore deposits accompanied by a small amount of copper, lead or zinc formed at the contact between Antioquia batholith and metamorphic rocks.

b) Intrusive rocks in the Tertiary period

Vein type gold ore deposits formed at the periphery of quartz diorite, granodiorite, porphyry and others, which contain a small amount of zinc and lead.

Many alluvial gold ore deposits are distributed downstream of each of the above mentioned two types ore deposits. Alluvial gold ore deposits scattered in the south of Quibdo in Choco province are from the b)-type ore deposit zone.

2) Copper

Although there is no copper mine in operation in this area, several showings which suggest the existence of tremendous copper ore deposits have been found by a series of systematic survey since 1972, among which those in areas Pantanos-Pegadorcito, Murindó and Acandi are remarkable. These are so called "Porphyry Copper" type ore deposits accompanying Tertiary acidic igneous rocks which intruded into the Cretaceous rocks in the west. Molybdenum is contained in them and gold in some of them.

3) Lead and Zinc:

Lead and zinc production are known at areas Remedio, Segovia and others about 150 km northeast of Medellin, which is the by-product of gold above mentioned. There are few ore deposits that produce mainly lead and zinc.

6-2 Geology and Ore Deposits in Central Colombia (Central and Southern Part of Tolima Province)

The district at the south of Ibagué city, a capital of Tolima province covers the central and southern areas in the province occupying the drainage basin of main and branches of Saldaña River which is a branch of Magdalena River. The geology of the district consists mainly of sedimentary rocks of Pre-Cambrian and Paleozoic groups, Trias-Jurassic, Cretaceous and Tertiary systems to surface cover of Quaternary system being intruded in part by igneous rocks of late Jurassic period or the younger.

6-2-1 Metamorphic and Sedimentary Sequences

The rock of gneiss or amphibolite of Pre-Cambrian sequences exposes in several outcrops at the area southeast and south of Ibagué city as small scale. These rocks are also found in the quartz diorite of Ibagué batholith as a xenolith.

Paleozoic strata consist mainly of quartz-sericite-graphite schist and chlorite-actinolite-quartz schist which are exposed at highlands along Central Mountain Range.

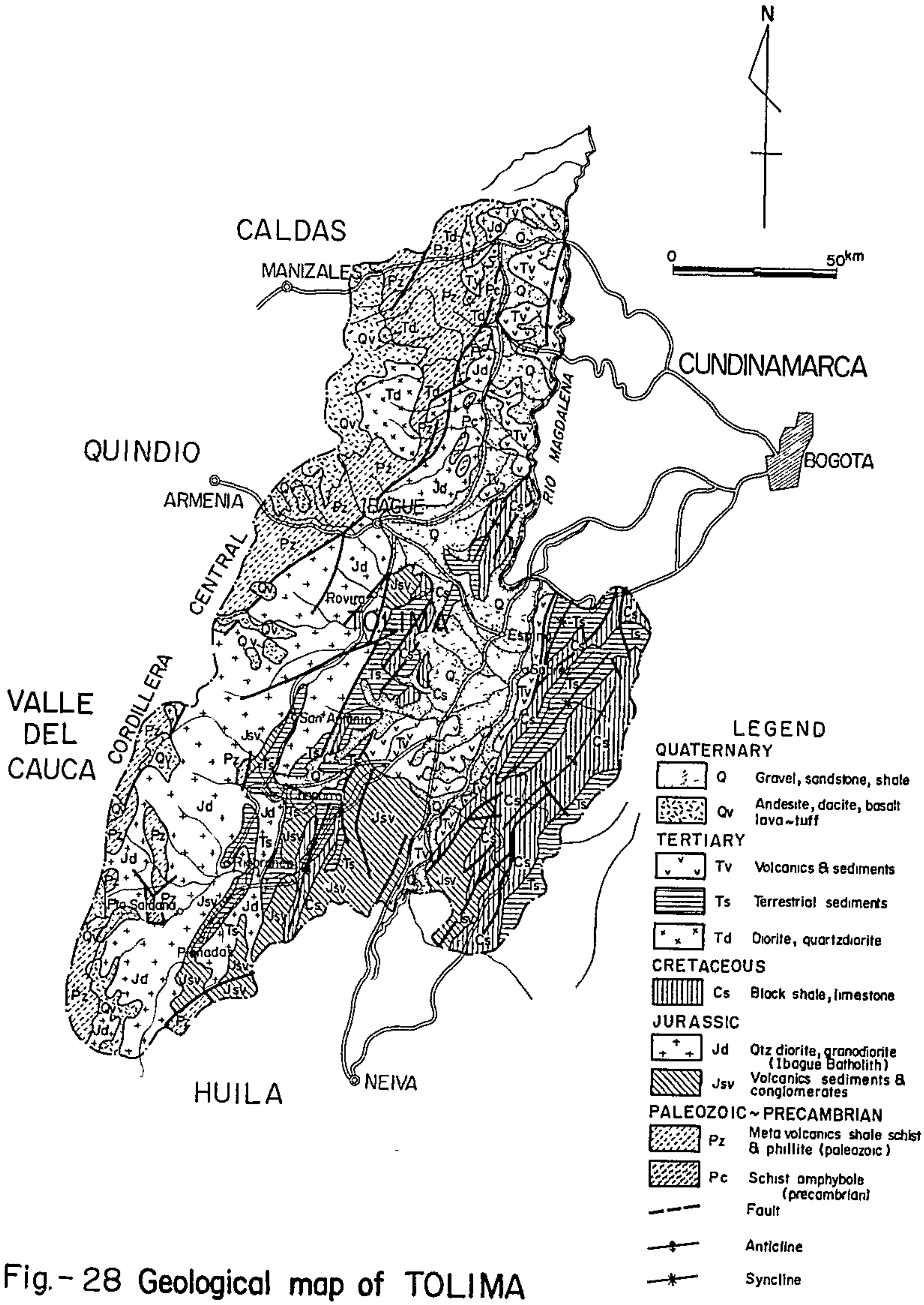


Fig.-28 Geological map of TOLIMA

Trias-Jurassic strata consist of three formations of Pre-Payandé, Payandé and Post-Payandé from lower to upper being distributed at the area south of Ibagué from Payandé to Chaparral along the direction of northeast - southwest. Pre-Payandé formation consists mainly of conglomerate, sandstone and shale. Main rock species of Payandé formation is mainly limestone being distributed along a narrow zone of northeast - southwest trending which has a fault contact of NE-SW trend to rocks of Tertiary, Post-Payandé and Ibague batholith in many places. Post-Payandé formation consists mainly of terrigenous shale with many dacitic or andesitic lava flows being widely distributed at the area of Huila to the south.

Cretaceous sedimentary rock consists mainly of black shale, limestone, calcareous sandstone and slate being distributed in the narrow zone at the east of the area of Trias-Jurassic sequences as parallel to them. The contact between sequences of lower Post-Payandé and Tertiary are seen as fault of NE-SW trend in many places.

Tertiary sedimentary rocks are fluviatile mud, sand and gravel being distributed along the zone of NE-SW trending from Payandé, southeast of Ibague to the south of Chaparral with fault contact of NE-SW strike to the rocks of older sequences or Ibagué batholith.

Quaternary surface cover consists mainly of mud flow deposits, agglomerates and diluvium. Ibague city is located at the west edge of large plateau which is made of mud flow deposit and agglomerate having a slope dipping gently toward southeast.

6-2-2 Igneous Rocks

Ibagué batholith which is a large intrusive quartz diorite mass of upper Jurassic period crops out in the area of about 400 km extension of NNE strike with the width of 45 km from the north of Ibagué city to the south of Cauca province forming up the main part of Central Mountain Range together with the rocks of Paleozoic group. Quartz diorite has facies changes from quartz monzonite to granodiorite with absolute dating age of 143 ± 5 million years (upper Jurassic period) by Dr. Barrero and Dr. Vesga.

Intrusive rocks of Cretaceous period are porphyritic andesite masses with partial dioritic facies being scattered in the area of the contact between Ibagué batholith and Paleozoic sequences with a trend of NE - SW.

Intrusive rocks of Tertiary period at this area are dikes of andesitic or dacitic porphyry crossing both the rocks of Ibagué batholith and Paleozoic sequences at the west and southwest part of Ibagué batholith. But the details are still unknown because of the poor access.

6-2-3 Geological Structure

General geological trend of this are is NE - SW being parallel to the direction of Central Mountain Range.

All the folding axes of sedimentary and metamorphic rocks, the shape of distribution of Ibagué batholith, the distribution of intrusive masses of Cretaceous and Tertiary periods and the groups of faults have NE - SW direction forming a central part of Central Mountain Range with the Ibagué batholith and Paleozoic sequences at the west. Intrusive rocks of Cretaceous and Tertiary periods are scattered in the highland of west margin of Ibagué batholith.

6-2-4 Ore Deposits

Though the indications of mineralization have been known in many places, most of them with several exceptions are not to be the target of exploration.

At this moment, the productions are made by following four mines: the mine at Santa Rosa, producing gold from placer ore deposits, mines at Mina Vieja, San Luis and at El Sapo, Valle de San Juan producing copper from skarn type ore deposits and the mine at Mal Nombre, Coyaima producing iron ore from the limonite bed.

i) Gold and silver

Gold and silver quartz veins in quartz diorite of Ibague batholith as well as placers being derived from them are known around the area of Saldaña River drainage basin near Chaparral in small scale.

Santa Rosa mine in Chaparral area is only one mine under the operation being producing placer gold by manual method without any informations about the amount of production.

ii) Copper

The occurrences of contact metasomatic copper ore deposit, vein type ore deposit and porphyry copper ore deposit are known on the flank being located at the east of Central Mountain Range. Contact metasomatic type ore deposits which are Mina Vieja and El Sapo locating at southwest of Payandé, that is southeast of Ibagué city, and Los Guayabos indications north of San Antonio at the south with two other indications are located near the contact between dacite porphyry mass of post Ibagué batholith and calcareous rocks of Payandé formation. (or pre-Cambrian system).

Mina Vieja having 400 ∿ 500 thousand tons of reserves is producing 250 tons per day of crude ore with grade of Cu 1.90%, Au 5 g/t, 270 tons per month of floatation concentrates with Cu 25 to 29% contents.

El Sapo having skarn zone of 2 ∿ 10 m in width is producing a high grade copper ore by hand picking method.

The potential of ore reserves at Los Guyabos is expected as the same scale for those of Mina Vieja from the result of the investigation work of this time.

Two other indications of the same types are known but the scales of them are rather small.

Copper quartz veins with the width of less than 30 cm are known at more than 30 localities in the quartz diorite mass of Ibagué batholith being estimated as small.

The mineralization zones of porphyry copper are known at Los Andes district, northwest of Rovia and Infierno district, southwest of Rovira being situated in the rocks of Ibagué batholith and stocks of quartz porphyry and dacite porphyry which has intruded in the Ibagué batholith. The results of diamond drilling for those indications show the low content of copper.

The mineralization zone of copper and molybdenium at Puerto Saldaña, southwest of Chaparral is evaluated as veins and networks being controlled by the fault in the Ibagué batholith with the size of 2,000 m x 70 m by the recent survey of INGEOMINAS.

As the result of brief investigation at this time, this mineralization zone at Puerto Saldaña has a mineralisation with hydrothermal alteration resembling to those of porphyry copper type ore deposits.

Detailed descriptions for Los Andes, Infierno, Los Guayabos, Puerto Saldaña and the mine at Mina Vieja are given in Chapter 7-3 of the present report

iii) Molybdenium

The mineralization of molybdenite is known in quartz diorite of Ibague batholith as small veins with quartz and pyrite and also in the rocks of xenolith of chert, limestone or gneiss being included in the Ibague batholith.

At Santo Domingo, Rovira, the mineralization zone with networks of thin veins (1 ∿ 2 cm in width) of quartz, pyrite molybdenite and chalcopyrite is known in quartz diorite of the area for 10 ha. An outcrop of small vein of quartz, pyrite, molybdenite with the width of 20 cm is known in quartz diorite at Los Andes, Rovira, too.

As the alteration of potash feldspar is reported in the wall rock of small veins at those two localities of molybdenite mineralization by the survey of INGEOMINAS, it must be careful for the evaluation of possibility of those indications to be the outcrops of porphyry copper ore deposits.

iv) Lead

Quartz galena veins with small amount of pyrite, sphalerite and chalcopyrite are known in quartz diorite of Ibagué batholith at the north of Chaparral and at the south of Rovira, but their potentialities are estimated as small.

v) Zinc

Zinc ore deposit of contact metasomatic type is known near at the contact zone between limestone of Payandé formation and quartz diorite of Ibagué batholith at El Bosque, north of Rivira.

Other four ore deposits of the same type as well as the fissure filling type in part are also known near the contact zone of those two rock units at the south of Rovira. Also small veins of sphalerite with quartz, pyrite and galena in both quartz diorite of Ibagué batholith and schists of Paleozoic group. These are all thought to be small.

vi) Iron

Two localities of hematite ore bed in Cretaceous sequences and five localities of specularite veins in quartz diorite of Ibagué batholith and three localities of magnetite lens of magmatic segregation in quartz diorite are known. Only one locality is under the operation at Mal Nombre mine, east of Chaparral, being producing 300 tons per month from open pit. Five ore beds of limonite and goethite are known in Cretaceous limestone having thickness ranging 40 ∿ 80 cm each.

Rio Luisa mine, 25 km southeast of Ibagué city has oolitic limonite bed thick in 50 m Cretaceous shale having trends of N40°E that is parallel to the general trends of the area. As the iron content of this oolitic limonite bed has 22 ∿ 36% Fe in average, it has been evaluated as not economical though it has a large distribution.

Other occurrences are all very small.

vii) Antimony

Five ore deposits of antimony are known closely together at the border area of province of Valle de Cauca. Because the content of gold in stibnite quartz vein in Paleozoic schists is high, showing Au 97 to 135 g/t, three occurrences of Orinoco, Pajarito and El Diamante are regarded as to be promising though the widths of the vein are rather narrow, 1 ∿ 10 cm.

viii) Mercury

Mercury occurrences are known at El Cinabrio, in the west of Cajamarca and La Luisa, in the west of Rovira. El Cinabrio had been worked by open pit mining as well as underground method where no access now. The ore was a cinnabar vein with quartz and calcite in Paleozoic schists.

Small drops of native mercury occurs in the soil at the surface of La Luisa mine. Geology of the area consists mainly of quartz diorite of Ibagué batholith with many dikes of andesite. It is said that the occurrence of native mercury is controlled by the structure of fault system around the area.

Photo. 3 INGEOMINAS Medellin Branch Office

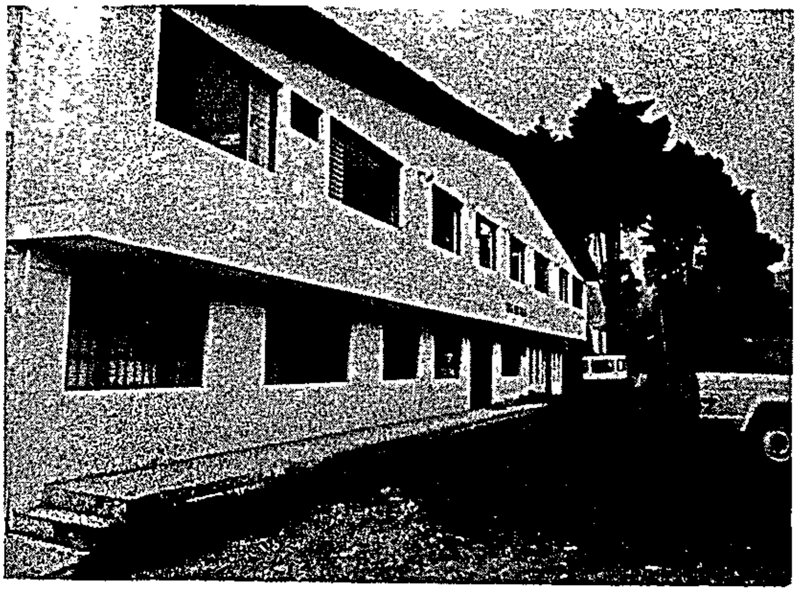


Photo. 4 Discussion on geological informations of Acandí and Cerro Pantanos areas, at INGEOMINAS Medellin Branch Office

Mr. H. Kamono

Mr. N. Aizawa

Mr. T. Suzuki

Dr. H. Gonzalez (Jefe)

Mr. J. Oikawa

Dr. E. Alvarez (subjefe)