REPUBLIC OF PERU

REPORT ON GEOLOGICAL SURVEY OF THE CORDILLERA ORIENTAL. CENTRAL PERU

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METAL MINING AGENCY

JAPAN INTERNATIONAL COOPERATION AGENCY

GOVERNMENT OF JAPAN

PREFACE

The Government of Japan, in response to the request of the Government of the Republic of Peru, decided to conduct a geological survey for mineral exprolation in central part of Cordillera Oriental of Peru, and commissioned its implementation to the Japan International Cooperation Agency.

The Agency, taking into consideration of the importance of technical nature of the survey work, in turn sought the Metal Mining Agency of Japan for its cooperation to accomplish the task within a period of four years.

This survey has been carried out for four years from 1975 to 1978 (fiscally five years from 1974 to 1978), and it was able to accomplish on schedule under close collaboration with the Government of the Republic of Peru and its various authorities.

This report submitted hereby summarizes the results of the various survey performed during four years.

We wish to take this opportunity to express our heartfelt gratitude to the Government of the Republic of Peru and the other authorities concerned for their kind cooperation and support extended to the Japanese survey team.

February 1979

Shinsaku Hogen
President
Japan International Cooperation Agency

Masayuki Nishiie
President
Metal Mining Agency of Japan

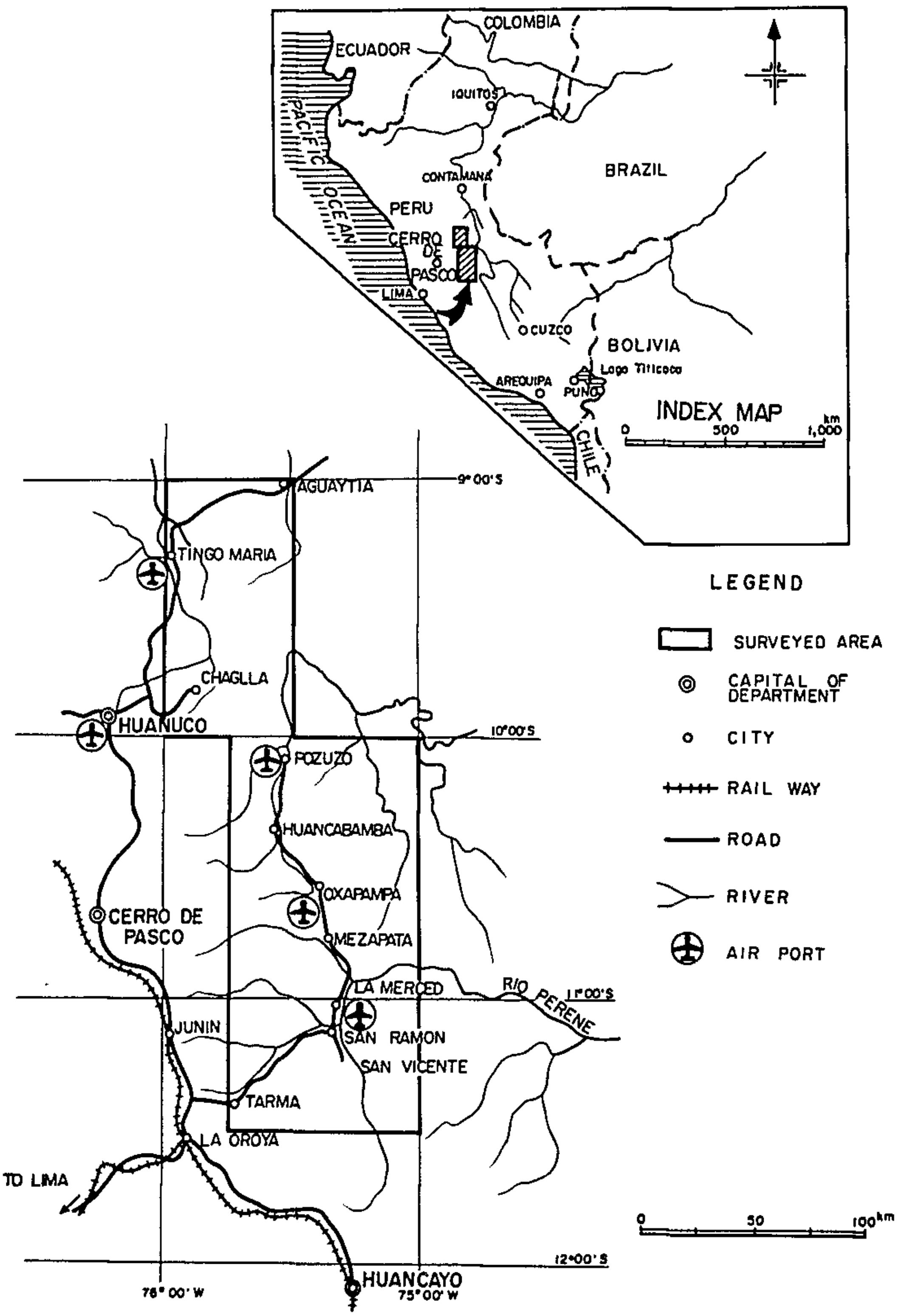

Fig. 1. Location Map of the Surveyed Area

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ABSTRACT

The present survey is a Basic Geological Survey carried out for these four years since 1975 (fiscally five years since 1974), for the Development of Mineral Resources in the central part of the Republic of Peru (Fig. 1). The survey has been performed for the purpose to confirm the distribution and the geological structure of the Pucara Group in which strata-bound lead and zinc ore deposits are emplaced, and to extract favorable areas for the existence of ore deposits.

Therefore the most appropriate methods as geological survey, trenching survey, geochemical survey on soil and rocks, analyses of impurities contained in carbonate rocks, gravity survey,and diamond drilling were employed for the exploration according to the purpose in each aspect. The favorable areas for the emplacement of ore deposits have been selected step by step out of the area of approximate 20,000 km^2 in the central part, through various surveys. In another words, the smaller was focussed the area, the more detailed these surveys were stimulated as follows; At first, the target was narrowed, out of the area of 20,000 km^2, within the restricted area where the Pucara Group is distributed; at the second stage, aimed to the area where dolostone belonging to the Pucara Group is distributed; at the third stage, to the area where dolostone and so-called zebra-structure (dolostone composing stripe pattern of white and black bands) are recognized; at the fourth, to the area where both dolostone and muddy or sandy carbonate rocks are distributed.

Through such surveys, new indications of strata-bound ore deposits were discovered in San Roque and in Tambo Maria, and also the following points have been confirmed.

The Pucara Group is distributed in belt-shape running in NNW-SSE direction in the central parts of the Republic of Peru, and is composed mainly of limestone and dolostone. As the main ore deposits, there are various types of deposits such as strata-bound lead-zinc ore deposits, contact metasomatic copper-lead-zinc ore deposits, vein type copper-lead-zinc ore deposits,and porphyry copper type ore deposits. The strata-bound lead-zinc ore deposits are represented by the San Vicente ore deposits now in operation, as well as by the new discoveries of the mineral indications as aforestated. These indications are classified into banded type, fracture filling type,and disseminated type. Disseminated type mineralization has been found in limestone, while the other types of mineralization are all recognized in dolostone.

It is thought that the dolostone would have been formed through the process of diagenesis after the sedimentation of limestone in a closed back reef environment, in this area. Ore minerals derived from land as metal ions, would have been accumulated penecontemporaneously with the sedimentation of limestone in the reducing low-temperature environment. The dolomitization which occurred later would have played a great role for the concentration of ore minerals. The degree of concentration of ore minerals is recognized to be highest in the banded type mineralization associated with zebra-structure. Therefore, the most favorable area for the emplacement of this type is San Vicente area, where banded type ore deposits have been found. In the San Roque area where indications of fracture filling type and disseminated type have been recognized, it can be said that ore deposits of San Vicente type would be expected if zebra-structure would be found to develop well. This area is necessary for further detailed survey. The following areas may be favorable for prospecting mineralizations, where more detailed investigation is required in future; --- the area from Chontabamba to Pusagno, the area in the northwest of San Ramon, the area in the northwest of Huancabamba and the area in the west of Las Palmas.

Chapter 1 Introduction

1-1 Purpose of the Survey

The purpose of the present survey in the central part of the Republic of Peru is to make clear the distribution and geological structure of the Pucara Group in which the emplacement of the strata-bound ore-deposits are expected, to extract the area of high potentiality of the ore emplacement from the surveyed area, as well as to establish the most appropriate and affective methods for the exploration of this type of ore deposits.

1-2 Outline of the Survey

The surveys shown in Table 1 were carried out during four years, from 1975 to 1978. The surveyed areas of each year are illustrated in Fig. 2. Also, the flow chart of surveys is given in Table 2.

1-3 Members of the Survey Team

The fieldworks and analysis were carried out by the members of the MESCO, Inc. in Japan, in cooperating with Instituto de Geología y Minería of Ministerio de Energía y Minas of the Republic of Peru. The members of the survey teams in each year is shown in Table 3.

1-4 References

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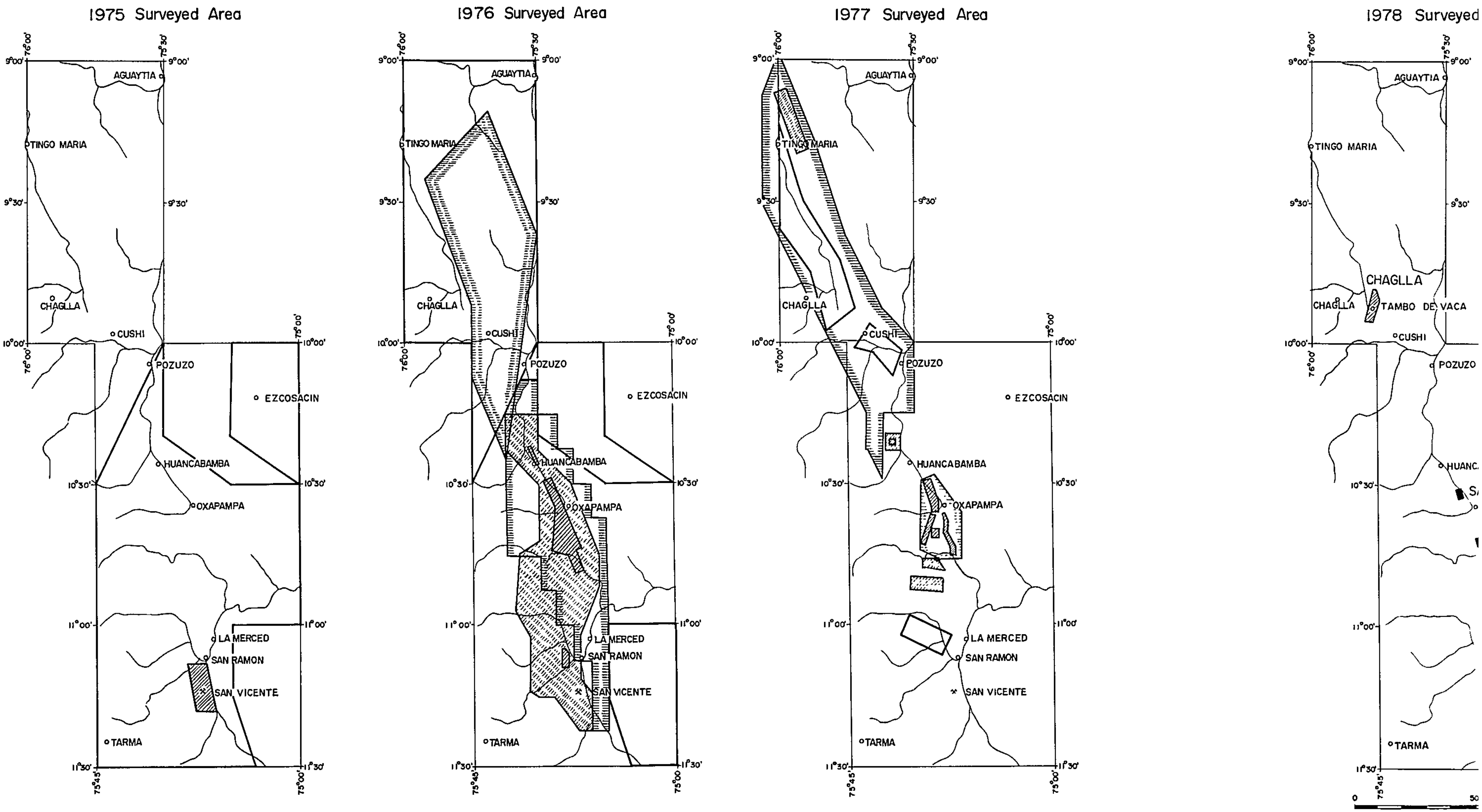

Fig. 2 Areas and methods of the field works carried out from 1975 to 1978

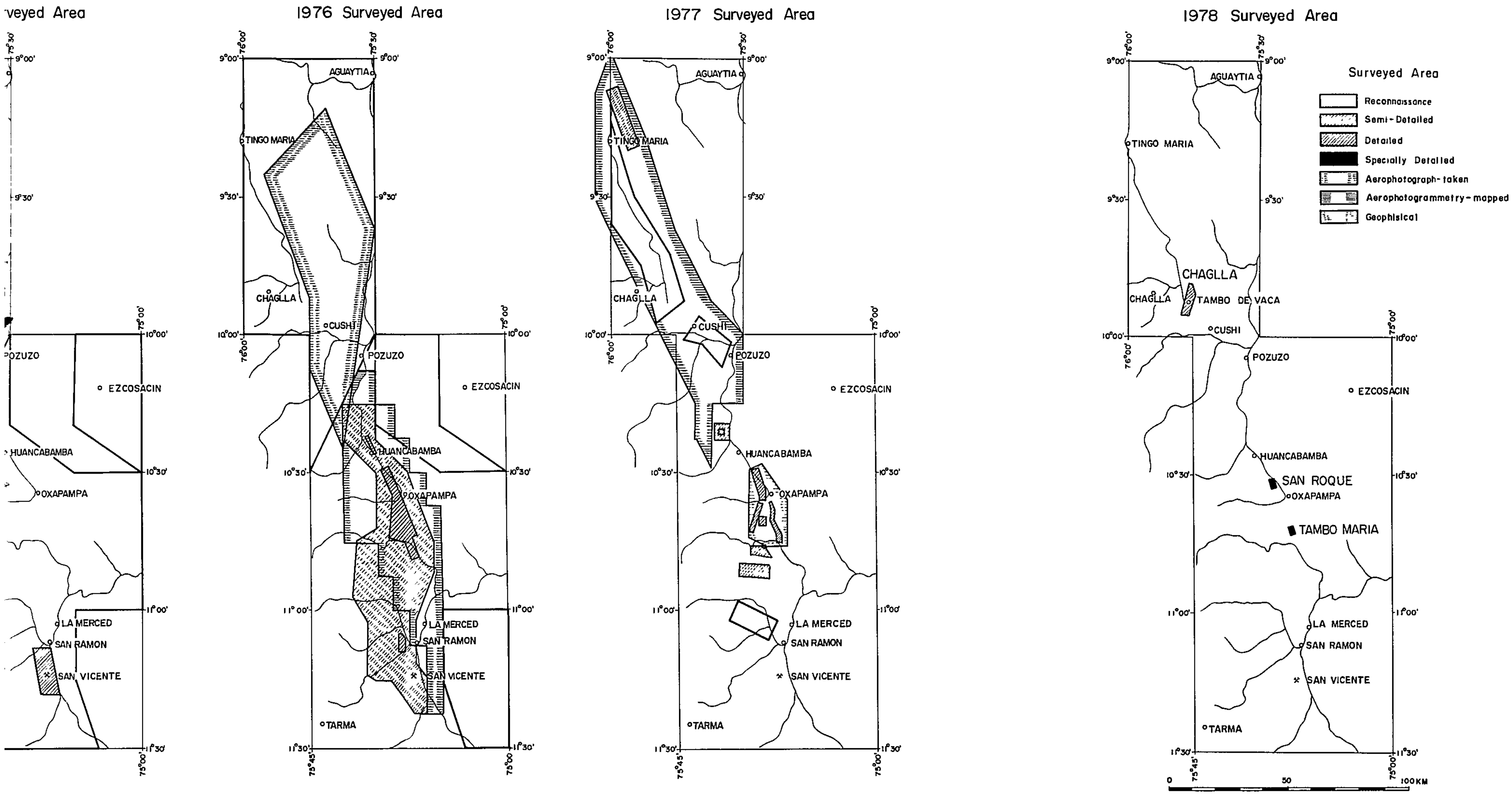

Fig. 2 Areas and methods of the field works carried out from 1975 to 1978

Table 1 Entire field works carried out from 1975 to 1978.

Items	1975	1976	1977	1978
Geological Survey (Km^2)				
Reconnaissance	10,000	10,000	1,000	-
Semi-detailed survey	-	2,000	300	-
Detailed survey	100	259	100	45
Detailed survey combined with trenching survey	-	-	-	15
Trenching Survey (m)	-	-	187	5,626
Geochemical Survey (samples)				
Reconnaissance	2,595	1,702	262	-
Semi-detailed survey	-	2,622	315	-
Detailed survey	412	2,034	1,185	404
Geophysical Survey (Km^2)	-	-	400	-
Drilling (m)	-	-	(4 holes) 968.8	(3 holes) 902.6
Aerophoto Taking (Km^2)	-	3,000	-	-
Topographic Mapping (Km^2)	-	3,000	3,400	-

Table 2 Flow chart of field works carried out from 1975 to 1978

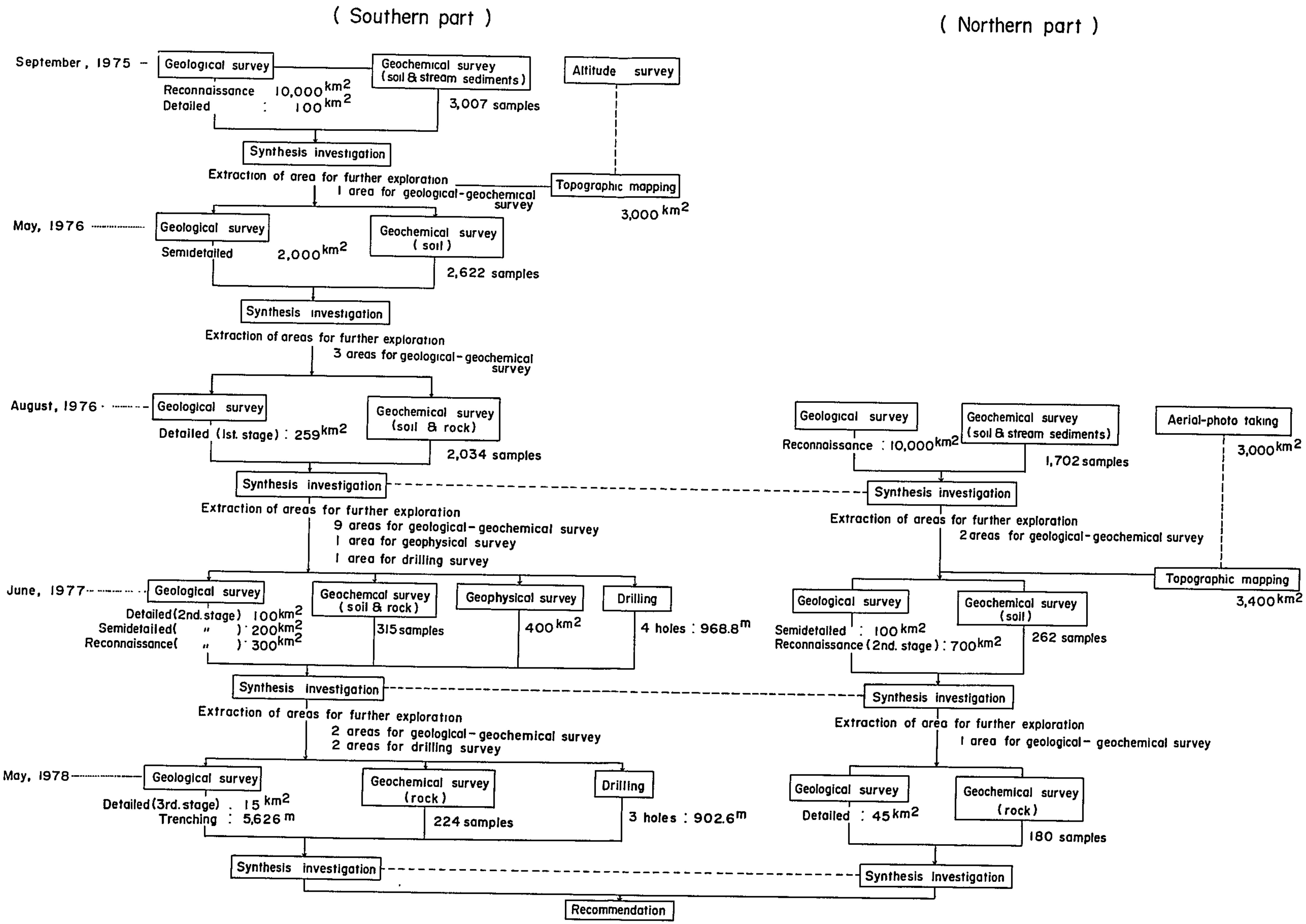

Table 3. List of the Technical Staffs Participated to the Project

	September, 1976	May, 1976	August, 1976	June, 1977	May, 1978
[Japanese Team]					
Leader	Shigeaki Yoshikawa	Shigeaki Yoshikawa	Shigeaki Yoshikawa	Shigeaki Yoshikawa	Shigeaki Yoshikawa
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(Drilling Engineer)				Yoshinobu Sakamoto Katsumasa Tanigawa Ikuo Tanigawa Isamu Nakayama	Katsumasa Tanigawa Isamu Nakayama Tadatoshi Nasu Shigemitsu Watanabe
(Surveyor)	Takashi Aoyama Kunihiko Tsukanaka				
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Chapter 2 Conclusion and View to Future Program

2-1 Conclusion

Various fieldworks and analysis works have been carried out for these four years to accomplish the purpose of the surveys. These works were promoted, due to the necessity, in the direction to elucidate the process of concentration of ore minerals or the formation of ore deposits, and if not, to approach such explication as much as possible. Accordingly, in some cases, new geological interpretation are required on the basis of previous informations or of the data obtained through the present survey. The principal parts of this interpretation are given as follows:

(1) The carbonate rocks, in which the ore deposits are emplaced, were mainly formed in a closed environment of back reef basin.

① It has been confirmed through the geological survey, microscopic studies, and the chemical analysis, that dolomicrite about 10 microns in diameter exists in the dolostone.

② From the existence of such fossils as Echinoids, Brachiopods and algae, it has been confirmed that the carbonate rocks are derived from shallow water sediments.

③ It has been thought that they were accumulated in a reef environment from the results of chemical analysis of strontium.

④ It has been presumed, from the existenee of evaporated residuals such as gypsum or concentrated barium, that the dolostone was formed in a closed reef environment.

⑤ From the analysis of the geological structure, it is thought that such closed reef environment would have been formed with the parts of the Mitu Group which was uplifted into the sedimentary basin of the Pucara Group intermittently, and also played an important role as the basement of barrier reef.

⑥ It is finally interpreted from above-mentioned that calcite and aragonite have been firstly precipitated from sea water under this environment and they have been substituted to dolomite by dolomitization through the process of diagenesis.

(2) The zebra-structure found in the dolostone would have been formed penecontemporaneously with the dolomitization.

① It has been confirmed by the geological survey that the zebra-structure is mostly parallel to the bedding planes of the dolostone, though oblique in some cases, and that the zebra-structure is not always in parallel with tectonic structures.

② It is said that, at the time of the conversion of calcite to dolomite, there would be reduction of volume by 12 to 13 % in maximum (CHILINGAR 1967 etc.), to form space extending almost parallel to the bedding planes. It is elucidated that zebra-structure would have been formed there through the mega-crystallization of dolomite.

(3) Metal elements were brought into sea water as solution from land.

① It has been confirmed, through geological survey, microscopy, X-ray diffraction and others, that the sulphide minerals are not supplied epigenetically by igneous rocks, as there is no alteration associated with igneous activities recognized around the sulphide minerals.

② From geological survey etc., it has been interpreted that these sulphide minerals are not supplied with submarine volcanic activities, as there are no volcanic materials in the Pucara Group of the surveyed area.

③ Accordingly, it is considered that the metallic elements originally contained in the basement rocks such as the Mitu Group would have been supplied as metal ions to the sedimentary basin where the Pucara Group have been accumulated.

(4) The primary sulphide minerals were precipitated simultaneously with calcite etc. in the reducing low-temperature environment.

① The existence of framboidal pyrites, showing that they were formed in low-temperature condition, has been recognized in the limestone, through microscopy and X-ray microanalysis (XMA hereunder).

② As there are also pelitic to psammitic sediments bearing organic materials, the environment in which reducing ions such as CH_4, SO_4, and so on were easily generated, is thought to have been set at that time, as the results of microscopic observations and by the consideration on the sedimentary environment etc.

③ Through microscopy and XMA, it has been confirmed that metal minerals as sphalerite and others would have been formed through simultaneous precipitation with calcite, as they are recognized in the form of anhedral micro-grains filling the spaces amidst the grains of calcite.

(5) Sulphide minerals were concentrated through the transportation of primary sulphides by circulating hypersaline brine into the spaces caused in the process of dolomitization or the formation of the zebra-structure.

① It has been confirmed through geological survey, geochemical survey, microscopy, and XMA that the concentration of ore minerals is remarkably recognized in dolostone while this concentration is only slightly found in limestone.

② It is recognized through microscopic studies that the crystal growth of pyrite and sphalerite was associated with the crystal growth of dolomite.

③ It has been confirmed through geological survey and microscopic observations that the fracture filling type ore deposits were formed through the concentration of sulphide minerals along the planes where the crystal growth of dolomite started.

④ It has been considered through microscopic studies and by the investigations of the San Vicente ore deposits' morphology that the banded type ore deposits associated with zebra-structure were formed by the concentration of sulphide minerals gathered by hypersaline brine.

⑤ It has been confirmed by the measurement of the temperature of fluid inclusions in the dolomite, that the formation temperature of the ore deposits or the concentration of the ore minerals was below 150°C.

2-2 View to Future Program

From the above mentioned evidences, it can be said that at least the following conditions would have been required for the concentration of ore minerals on strata-bound lead-zinc ore deposits in the central part of the Republic of Peru;

1 The existence of the background from where abundant metal ions were supplied to the sedimentary basin.

2 Marine environment where carbonate rocks were sedimented.

3 The environment to reduce metal ions, containing abundant organic matters and terrestrial detritus.

4 Strongly closed back reef environment, where dolomite would be formed.

5 The environment in which zebra-structure would be developed.

Also many indications of mineralization has been discovered, not only the San Vicente ore deposits now in operation, in the survey area. These ore deposits and the mineral indications are estimated as follows;

(1) The San Vicente ore deposits are found to be emplaced in the environment where all the above five conditions are well satisfied, and such area is most favorable for the existence of the ore deposits.

(2) In the San Roque area, where fracture filling type and disseminated type ore deposits are found, the geological conditions are similar to those of the San Vicente area. But no zebra-structure has been found yet, nor has been recognized any banded type ore deposit. It can be said that the banded type mineralization could be expected if zebra-structure would be found in this area.

(3) In the Tambo Maria area and in the Chaglla area, zebra-structure develops remarkably. However, as a little amount of the primary sulphides would have precipitaed, the scale of sulphides' concentration is rather small.

(4) The areas where further discoveries of ore deposits would possibly be expected in future in the survey area,are noted as follows, although the possibility is uncertain as no detailed survey has been conducted yet;

① The area from Chontabamba to Pusagno.

② The area in the northwest of San Ramon.

③ The area in the northwest of Huancabamba.

④ The area in the west of Las Palmas. (Fig. 3(1), Fig. 3(2))

2-3 Methods of Exploration

The surveys for the strata-bound lead-zinc ore deposits have been carried out for these four years in the central part of the Republic of Peru, and the order and the methods of these surveys are shown in the Table 2. As the results of these surveys, new indications have been discovered in the San Roque area, and also an outline of the genesis of this ore deposits' genesis has been clarified.

More detailed investigations and analyses would be required to complete these hypotheses of the ore genesis. But, as the present surveys were performed on explicating the genesis of the ore deposits, and by the discoveries of new mineral indications, the survey methods seem to be appropriate on prospecting. In another words, it can be decided that such survey methods as to delineate more favorable areas step by step, considering the afore-mentioned five conditions to require for the emplacement of these ore deposits, would be desirable for the new exploration for this type.

The survey methods are recommended as follows:

1. First Step; The survey should be carried out to appraise the potentiality for the emplacement of strata-bound lead-zinc ore deposits in the area where the Pucara Group are distributed.

Then, to concrete the above is given as follows:

(1) To confirm the area where the Pucara Group is distributed.

(2) To ascertain the distribution and the stratigraphy of the dolostone in such area.

(3) To clarify the geological structure, especially the geological structure of the basement.

(4) To confirm the regional distribution of heavy metal elements.

To perform these above mentioned, ① geological survey (preliminary --- general survey), ② geochemical survey (soil), and ③ geophysical prospecting (gravity survey), are effective methods. Also, it is useful for the succeeding surveys to investigate the distribution of lead and zinc contents on rocks. In the well-exposed area, geochemical survey on rocks woul be taken for the prospecting in the early stage of surveys.

2. Second Step; As for the next step, in the area where geochemical anomalies on soil are high, that is, the potentiality of ore deposits embedded is high, the survey to evaluate the expectation of the economical concentration of this kind ore deposits, should be carried out. The investigations are given in concrete terms as follows;

(1) To clarify the distribution and the stratigraphy of the ore horizons, especially of the dolostone, and to ascertain the sedimentary environment.

(2) To confirm the metal contents in the country rocks and the degree of concentration, especially the relation to the dolomitization.

(3) To ascertain the distribution of zebra-structure.

For these points, effective methods are ① geological survey in combination with trenching (detailed survey), ② geochemical survey (rocks), and ③ diamond drilling for geological structure. In the areas described in 2-2(4), this stage of survey should be carried out.

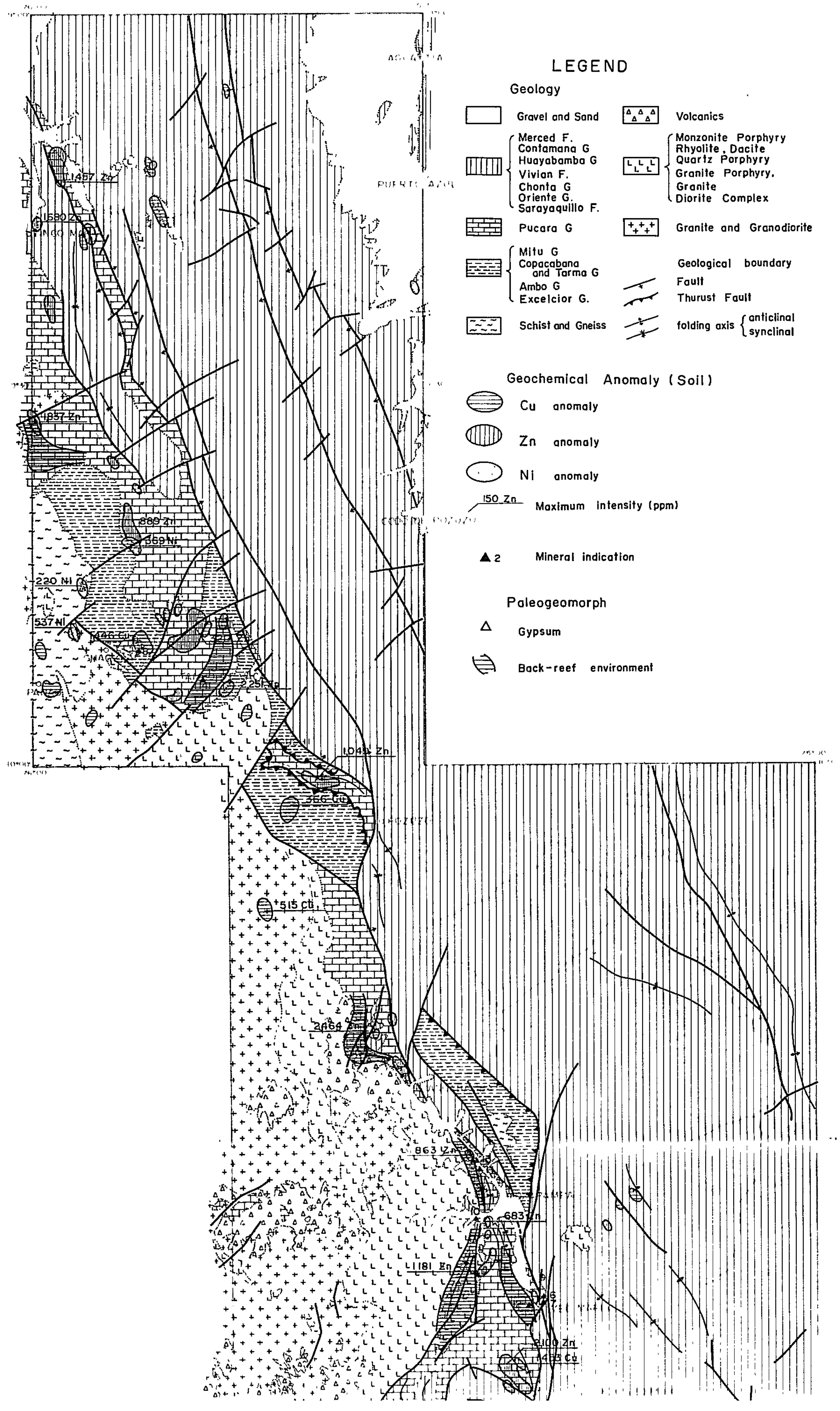
3. Third Step; Finally, detailed surveys to discover ore deposits are recommended to be conducted, in the area where economical concentration of ores would be expected. To state more concretely, the following points would be required in the surveys;

(1) To confirm the state of concentration into the zebra-structure formed in the horizon of high metal content .

For this point, effective methods are ① geological survey accompanied by trenching (detailed survey), ② geochemical survey (rocks),and ③ diamond drilling (detailed survey). In the San Roque area, this stage of surveys should be continued.

As a general, the above-stated surveys would be carried out in stage by stage, but if possible, advanced surveys should be performed. In case of that the second step is overlapped to the first partly, it is desirable to adopt abbreviated analysis method in the field for the geochemical survey on soil.

Lithological and geochemical investigations on the Mitu Group as the basement of the Pucara Group, would be carried out at the first step for the purpose to obtain some informations on the background of strata-bound lead-zinc ore deposits, although no detailed investigation about the Mitu Group has been carried out in the present surveys.



LEGEND
Geology
Gravel and Sand
Merced F.
Contamana G
Huayabamba G
Vivian F.
Chonta G
Oriente G.
Sarayaquillo F.
Pucara G
Mitu G
Copacabana and Tarma G
Ambo G
Excelcior G.
Schist and Gneiss
Volcanics
Monzonite Porphyry
Rhyolite, Dacite
Quartz Porphyry
Granite Porphyry,
Granite
Diorite Complex
Granite and Granodiorite
Geological boundary
Fault
Thurust Fault
folding axis
anticlinal
synclinal
Geochemical Anomaly (Soil)
Cu anomaly
Zn anomaly
Ni anomaly
150 Zn
Maximum Intensity (ppm)
2
Mineral indication
Paleogeomorph
Gypsum
Back-reef environment
1457 Zn
1580 Zn
1857 Zn
889 Zn
869 Ni
220 Ni
537 Ni
1044 Zn
515 Cu
2464
863 Zn
683 Zn
1181 Zn
2100 Zn

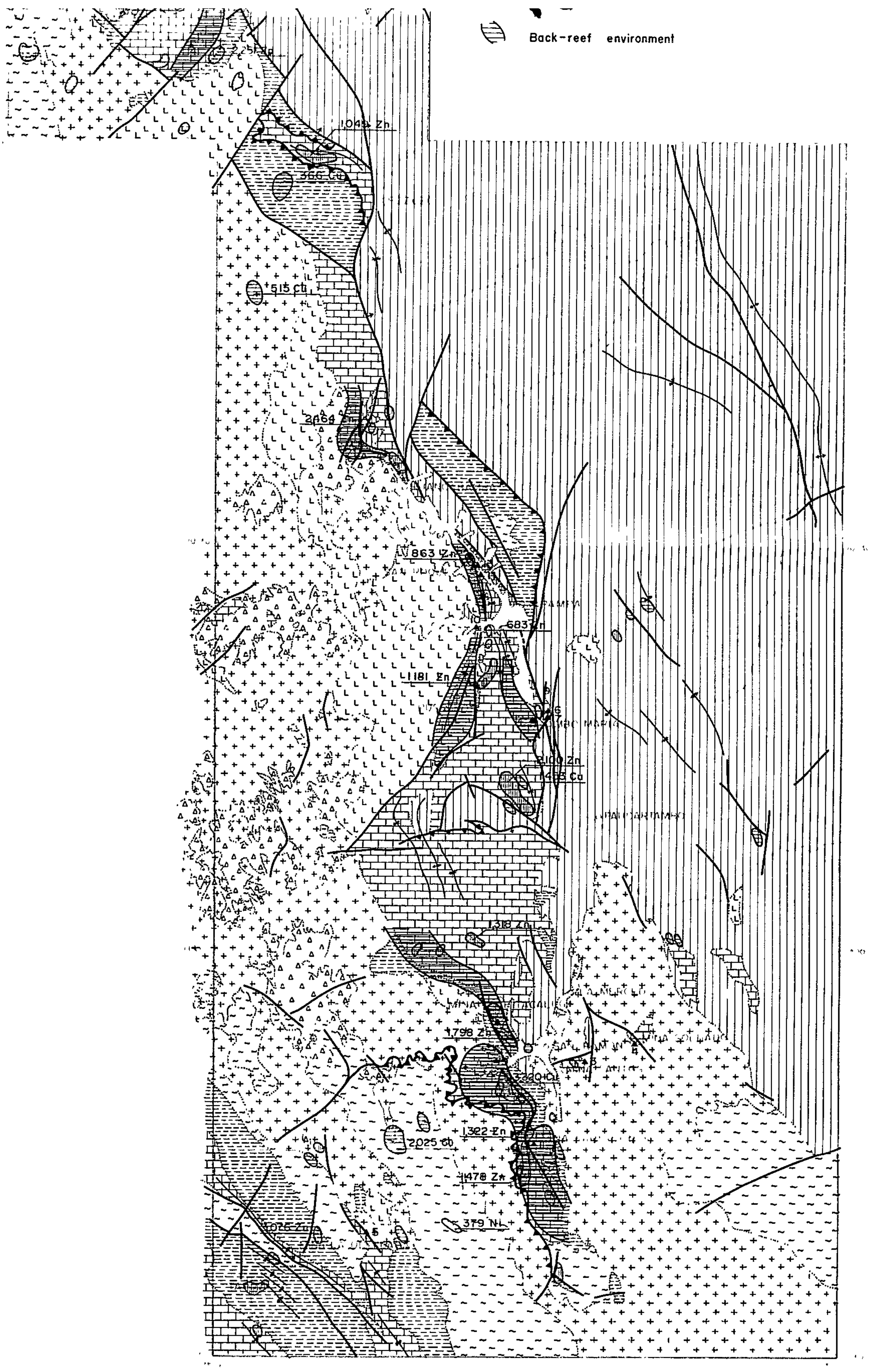
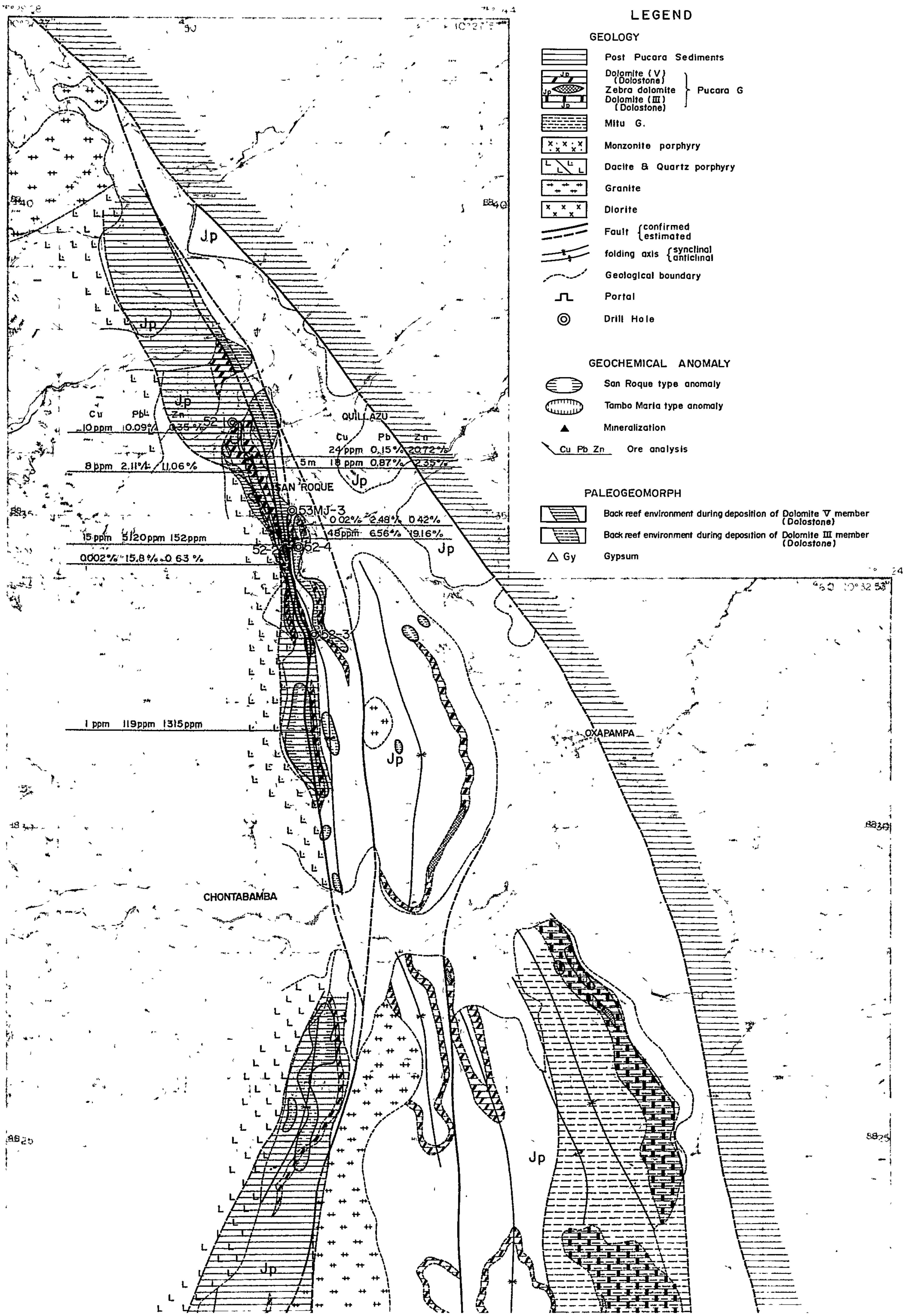


Fig. 3 (1) Schematic Paleoenvironment Illustrating the Correlation to Geology, Geochemical Anomalies and Mineral Showings in the Entire Surveyed Area


LEGEND
GEOLOGY
Post Pucara Sediments
Dolomite (V) (Dolostone)
Zebra dolomite
Dolomite (III) (Dolostone)
Pucara G
Mitu G.
Monzonite porphyry
Dacite & Quartz porphyry
Granite
Diorite
Fault {confirmed / estimated
folding axis {synclinal / anticlinal
Geological boundary
Portal
Drill Hole
GEOCHEMICAL ANOMALY
San Roque type anomaly
Tambo Maria type anomaly
Mineralization
Cu Pb Zn Ore analysis
PALEOGEOMORPH
Back reef environment during deposition of Dolomite V member (Dolostone)
Back reef environment during deposition of Dolomite III member (Dolostone)
Gy Gypsum
QUILLAZU
SAN ROQUE
OXAPAMPA
CHONTABAMBA
Jp
52-1
53MJ-3
52-4
52-3
Cu Pb Zn
10 ppm 10.09% 0.35%
8 ppm 2.11% 11.06%
Cu Pb Zn
24 ppm 0.15% 20.72%
5m 18 ppm 0.87% 2.35%
0.02% 2.48% 0.42%
48 ppm 6.56% 19.16%
15 ppm 5120 ppm 152 ppm
0.002% 15.8% 0.63%
1 ppm 119 ppm 1315 ppm

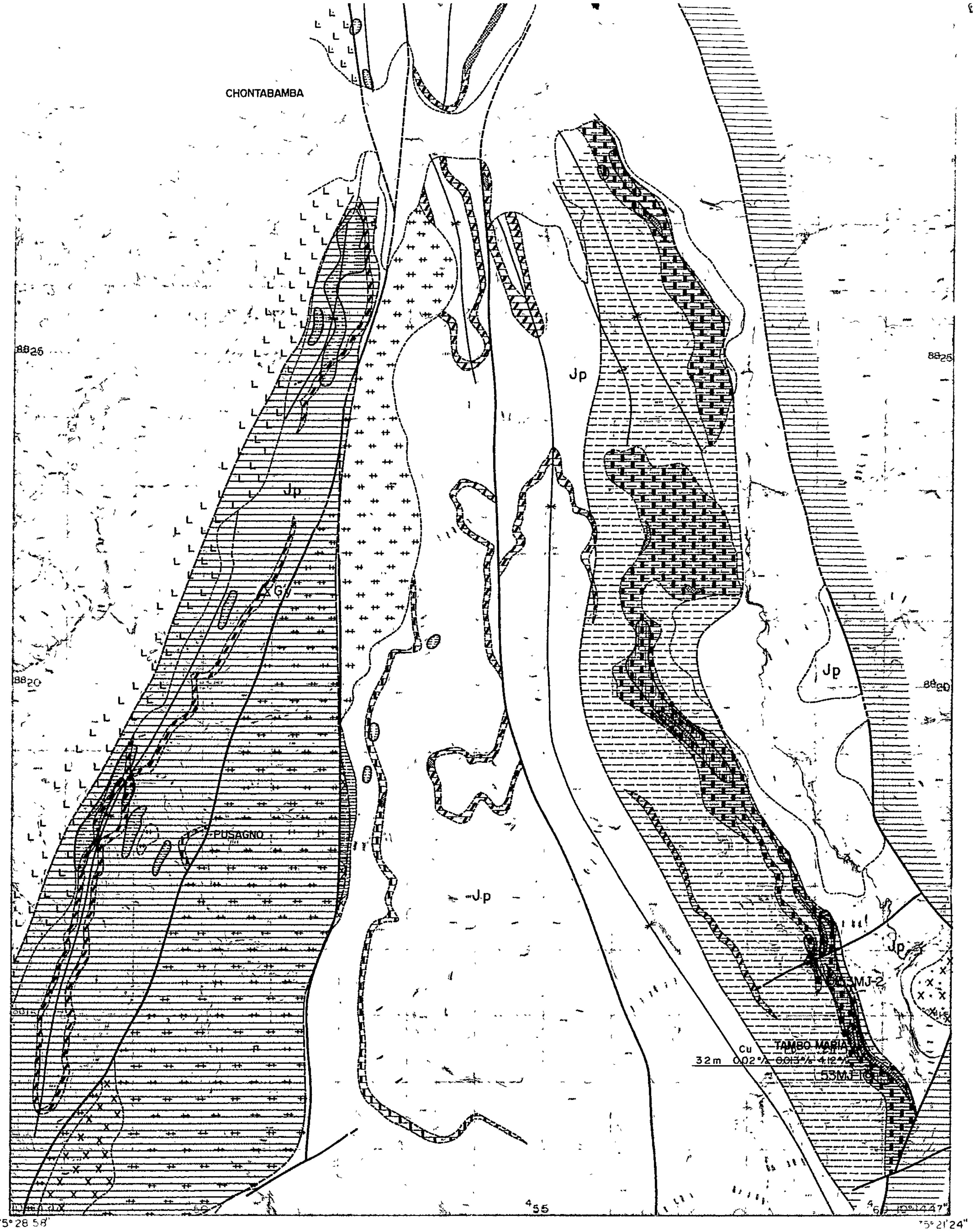


Fig. 3 (2) Schematic Paleoenvironment Illustrating the Correlation to Geology, Geochemical Anomalies and Mineral Showings in the Oxapampa Area

Chapter 3 Outline of the Survey Area

3-1 Location

The surveyed area covers a region extending from the Cordillera Oriental through the Cordillera Subandina toward Amazonian plains, with total range of 20,000 km^2. The region bestrides over three administrative divisions such as Departamento Junin, Departamento Pasco and Departamento Huanuco.

3-2 Topography

The surveyed area may be classified into the topographic provinces of the western highland, the Inter-Andean basins, the eastern highland and the eastern lowland.

(1) Western highland

The western highland is composed of two areas such as the eastern margin of the Cordillera Oriental and steeply sloped terrain developed between this mountains and Inter-Andean basins. The eastern margin of the Cordillera Oriental is composed of Paleozoic rocks, which is build up narrow and long mountain ranges, and in which above 4,000 m sea level, the kars are recognized. In the steeply sloped terrain, the granites are mainly distributed, and stream erosion is extremely intense so that the V-shaped valleys and the dendric stream systems are observed. The topography is generally steep cliffs on sides.

(2) Inter-Andean basins

The Inter-Andean basins are divided into the Coridellera Oriental slope, medial basins, and the slope continued to Cordillera Subandina. The medial basins show more or less gentle topography, and the streams running N-S or NNW-SSE direction are developed at the center of the basin. Along main streams, river terraces well developed are recognized.

In the Chaglla area just corresponding to the roof of the surveyed area, as the Cordillera Oriental connected to the Cordillera Subandina, no basin is developed. The steeply sloped terrains are abundantly formed in each terrain of the both sides in Inter-Andean basin.

(3) Eastern highland

The Cordillera Subandina are composed of Mesozoic sedimentary rocks and Cenozoic sedimentary rocks and the mountain ranges and the V-shaped valleys more or less steeply sloped are formed from Cenozoic sandstone.

(4) Eastern lowland

The area is mostly occupied by the lowland of less than 500 m in altitude, and especially the east area is covered by thick jungles where the topography is flat and the rivers are meandering.

3-3 Accessibility

The accessibility from the City of Lima, the Capital of Peru, to the surveyed area is commonly availed by car. It takes seven hours to cruise at distance of 308 km,from Lima via La Oroya in Andean highlands to San Ramon, the principal city of the southern block. Also, to Tingo Maria of the northern part, it takes 13.5 hours to move at distance of 545 km from La Oroya toward the north in Andean highlands. The domestic air line from Lima to both cities is opened to public.

All the traffic conditions in the surveyed area but the routes toward San Ramon and Oxapampa in the district of Inter-Andean basins are extremely deficient. Near San Ramon and Oxapampa, as branch roads for agricultural and forestry developments are spread so automobiles are able to pass, but except above those areas, road conditions are exceedingly rough. Especially, in the eastern highland of the southeast of Tingo Maria, unexplored area of over 3,000 km^2 are still remained.

An unscheduled flight is able to be available to reach the eastern lowland in the surveyed area, but only mountain paths or boats along large rivers are generally used.

By reason of traffic conditions above mentioned, most field survey was always performed on foot, and the equipments for surveying are transported by car, on horse back, by man, furthermore, by air, on boat and on raft.

3-4 Climate

Climate of these areas may be classified into cold-mountain type in the west, wet-subtropical type in the Inter-Andean basin, and wet-tropical type in the east. The western highland of cold-mountain type has dry and wet seasons by the influence of monsoon. Difference of altitude also affects much to the difference of temperatures in day and night. The minimum temperature in July or August is about 10 degrees below zero in centigrade.

About Inter-Andean basin of the wet-subtropical type, the dry season continues from April to October and the wet season from November to March but not distinct as that of the cold-mountain type. Almost always, the terrain is thickly clouded for the air current including high humidity from the Amaxonian plains, and even in dry season a long rain continues occasionally.

The maximum temperature is about 30 degrees and the minimum about 13 degrees in dry season. It is hot and highly humid throughout a year in the northeastern district of wet-tropical type. The average temperature is about 28°C.

3-5 Vegetation

In the western highland of the cold-mountain type, the highland over 4,500 m above sea level is mostly waste land. The area below 4,000 m above sea level, is the pampas with sporadic growth of tall trees such as eucalyptus. In the area below 4,000 m, the pampas are used for pastures, and potatoes and corns are cultivated locally.

The forests of broad leaf trees grow thick in the Inter-Andean basin of the wet-tropical type and they are cut down as timber. The places after cutting are brought under cultivation, and then fruit culture such as banana, pineapple, orange, and papaya, is promoted extensively. The pampas are utilized for pastures.

The northeastern district of the wet-tropical type climate is thickly covered by jungles which are entirely the primeval forests except some patches along large rivers opened for pastures.

Chapter 4 General Geology

4-1 Outline of the Geology

In the central part of the Republic of Peru, various rocks such as sedimentary rocks, igneous rocks and metamorphic rocks are distributed. The distribution of rocks is arranged in the main direction of NNW-SSE, as represents the general trend on the topography in this area (Fig. 4).

The sedimentary rocks are distributed in the narrow area of the southwestern part and in the broad area of the central to northern part. In the southern part, Paleozoic to Mesozoic formations are well developed on the basement of metamorphic rocks, while, in the central to northern part, the sedimentary rocks are composed of Mesozoic to Cenozoic formations, including the Pucara Group, and the younger formations are developing eastwards mostly in the order of the age.

These formations are classified in ascending order as follows:

Paleozoic formations,	Excelsior Group
	Ambo Group
	Copacabana-Tarma Group
	Mitu Group
Mesozoic formations,	Pucara Group
	Sarayaquillo Formation
	Oriente Group
	Chonta Group
	Vivian Formation
Cenozoic formations,	Contamana Group
	Huayabamba Group
	La Merced Formation
	Quaternary Sediments

These Groups and Formations are followed after BELLIDO's (1969) geological study all over the central part of Peru (Fig. 5).

The igneous rocks are mainly distributed in the direction of NNW-SSE along the Andean range, from near Tarma and San Ramon in the southern part to near Chaglla, through the western part of Oxapampa. The igneous rocks are composed of late Paleozoic intrusive rocks, Mesozoic diorites, granites and porphyries, and Cenozoic Tertiary rocks and intrusive rocks.

The metamorphic rocks are distributed as roof pendant, in the highland between Tarma and San Ramon in the southern part and also in the highland near Panao of the northern part. They are composed of gneisses and schists.

4-2 Geological Structure

Folding structure in the sedimentary rocks has the axis mainly of NNW-SSE direction. The folding is observed violently in the older sediments, but rather gentle in the younger sedimentary rocks.

As for fault structure, NNW-SSE system represented by Tingo Maria-La Merced Tectonic Line running in the Inter-Andean basin is the most remarkable, but other systems of NEE-SWW, NWW-SEE and NNE-SSW are shown developed.

The geological structure associated with the above-stated NNW-SSE system and the rock distribution in correspondence with the topography are thought to have been formed geohistorically in relation to the orogenic movements in the Andean region from Paleozoic to Cenozoic Era. For example, the intrusion of the late Paleozoic granites, representing the fore-running igneous activity in this region, was related to the geo-anticlinal movement in the eastern margin of the Cordillera Oriental, and the following igneous activities would have also been somehow in relation mainly to these granites. Also, the sedimentary rocks of the Mesozoic and later age were accumulated, particularly in the eastern side, in the depression formed along the geo-anticline and therefore the formation of geo-anticline can be regarded to have played a great role on the distribution of the sedimentary rocks. It can be also said that the structures of faulting and folding would have been formed and developed by the lateral pressure of NEE-SWW direction, almost in right angle to NNW-SSE direction.

4-3 Geological History

The oldest rock in the surveyed area is metamorphics distributed in the western highland. They are thought to have been formed during the Precambrian orogenic movements.

The Paleozoic formations distributed in the southwestern part of the surveyed area are accumulated on the basement of metamorphic rocks. This sedimentation begins at first in the Excelsior Group of Devonian Period on the geosyncline formed in the Ordovician Period. The sedimentations of such formation as Ambo Group and Copacabana-Tarma Group is continued until early Permian Period when orogenic movement is activated, repeating weak orogenic movements and transgressions. In the Permian Period, an igneous activity associated with this orogeny is taken place and the granitic rocks that seem to be activated until late Triassic Period are intruded in the western highland with the direction of NNW-SSE.

Also, on account of the upheaval by blocks and the faulting movements caused by the orogeny, Permian Mitu Group was deposited through erosion.

The Mitu Group is composed mainly of terrigeneous conglomerate and it is carried characteristically with the materials of volcanic activity as lavas and tuffs etc.

As geoanticlinal movement occured near western highland in the late Paleozoic to early Mesozoic Era, geosyncline was formed in both sides of it and submarine deposition of the Pucara Group is commenced. It is thought that alternative depositional environments of deep and/or shallow sea have been formed in the basin of the Pucara Group, with relation to geoanticlinal movement of western highland.

After the deposition of the Pucara Group, the sedimentations of the terrigeneous Sarayaquillo Formation, mainly terrigeneous Oriente Group, submarine Chonta Group, and terrigeneous Vivian Formation took place intermittently in the eastern side of the Inter-Andean basin from middle Jurassic to late Cretaceous. During those sedimentations, it is thought that the area of geosyncline structure have been removed gradually to the eastern side. Also, the geoanticlinal movement in the western highland acts most from the middle to late Jurassic Period, accompanying with igneous activities as diorites, granites and porphyries.

Getting into Cenozoic Era, an intense orogeny accompanying igneous activity is occured in the Andean district, while in the surveyed area the sedimentation of the Contamana and Huayabamba Group of Tertiary Period is made in geosyncline with activity of acidic volcanics only. After the second Andean orogeny is activated from Oligocene to Miocene, the sedimentation is terminated, while foldings and faultings are taken place in this area. Activity of acidic volcanics and sedimentation of volcanic conglomerate are promoted in the eastern margin of the western highland, and the small scale of alkali rocks have been intruded along the Tingo Maria-La Merced Tectonic Line. Finally, conglomerate of La Merced Formation are accumulated in the area of Inter-Andean basin.

4-4 Outline of the Ore Deposits

While many metallic ore deposits and mineral indications have been detected in the central part, small scale gypsum deposits are known near Oxapampa as non-metallic ore deposit.

Metallic ore deposits in the surveyed area are classified into the following four types, according to the ore species and the genesis of the deposits (Table 4).

(1) Strata-bound ore deposits in the Pucara Group (Lead and Zinc).

(2) Contact metasomatic ore deposits, formed along the zone between the intrusive rocks and the carbonate rocks of the Pucara Group. (Copper, Lead and Zinc).

(3) Vein type ore deposits in the Mesozoic diorites and the Pucara Group. (Copper, Lead and Zinc).

(4) Porphyry copper ore deposits in the Tertiary monzonite (Copper).

Strata-bound ore deposits were found mainly in the dolostone, as the country rocks, of the Pucara Group, and are represented by San Vicente ore deposits now worked and by Pichita Caluga ore deposits now out of operation, the indications of mineralization at Tambo Maria and San Roque. The ore deposits of this type are the most important in the region.

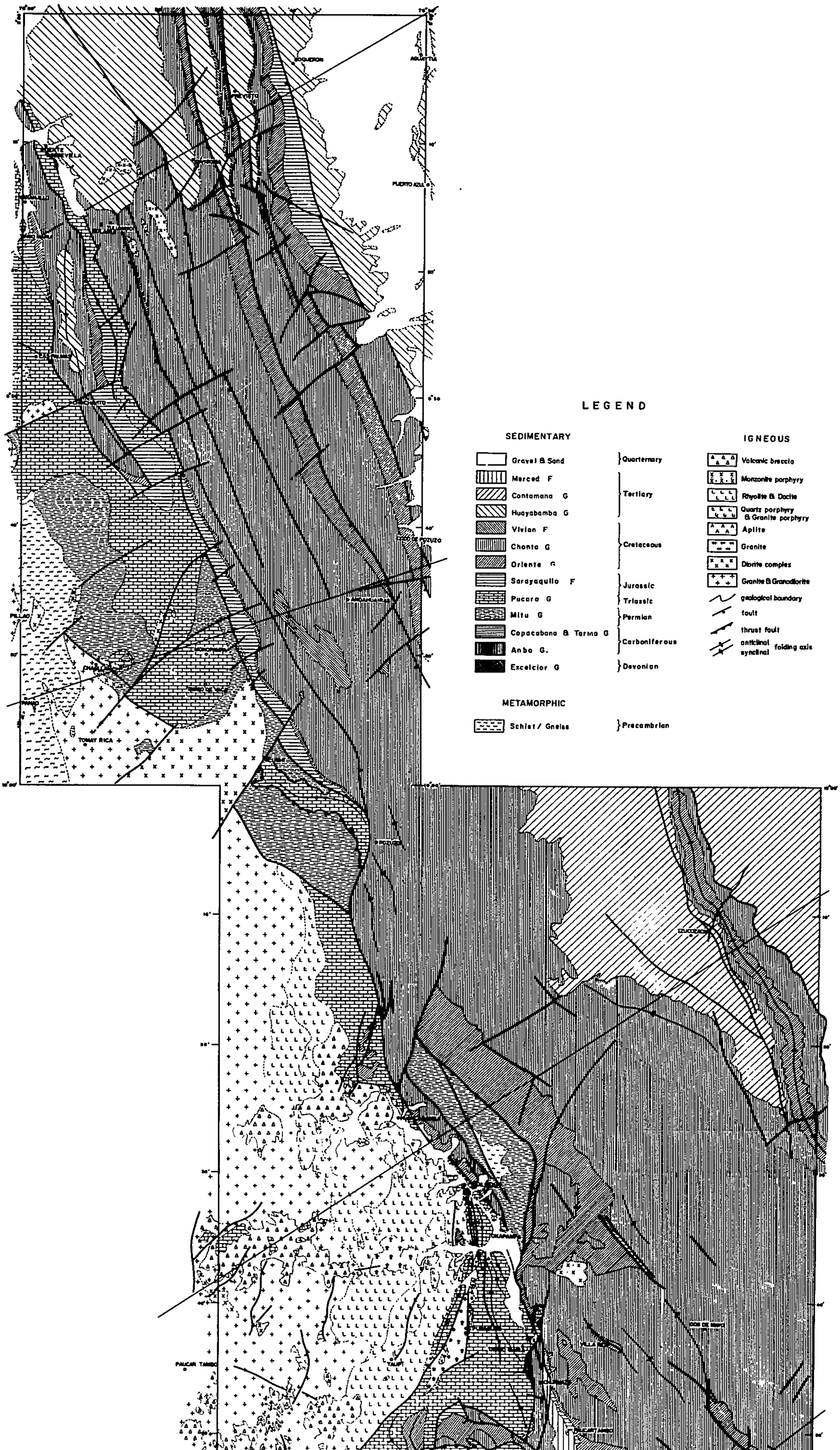
Contact metasomatic ore deposits are found along the zone between the limestone and the granite in the east of San Ramon. The limestone acts as a roof-pendant and is proposed to the Pucara Group, while the granite intrudes at the late Paleozoic Era. Ore deposits of Santos and Soldado, which were once worked, known as the deposits of this type, but they are very small and detailed mapping has not been conducted.

Vein type ore deposits are represented by La Olividada ore deposit (Copper), once operated in the east of Tarma, as well as by indiations known in the areas near Chaglla and San Ramon.

The only indication of the porphyry copper ore deposit is very small dissemination in the monzonite intruded in the east of Tambo Maria.

Meanwhile, as the non-metallic ore deposits, small scale gypsum ore deposits are found in the rocks of the upper Cretaceous Chonta Group of the

Mesozoic Era, in the north of Oxapampa, and in the rocks of the Pucara Group in the west of Pusagno.


LEGEND
SEDIMENTARY
Gravel & Sand
Merced F
Contamana G
Huayabamba G
Vivian F
Chonta G
Oriente G
Sarayaquillo F
Pucara G
Mitu G
Copacabana & Tarma G
Anbo G.
Excelcior G
Quaternary
Tertiary
Cretaceous
Jurassic
Triassic
Permian
Carboniferous
Devonian
METAMORPHIC
Schist / Gneiss
Precambrian
IGNEOUS
Volcanic breccia
Monzonite porphyry
Rhyolite & Dacite
Quartz porphyry & Granite porphyry
Aplite
Granite
Diorite complex
Granite & Granodiorite
geological boundary
fault
thrust fault
anticlinal synclinal folding axis
BOQUERON
AGUAYTIA
PUERTO AZUL
TOMAY RICA
PAUCAR TAMBO

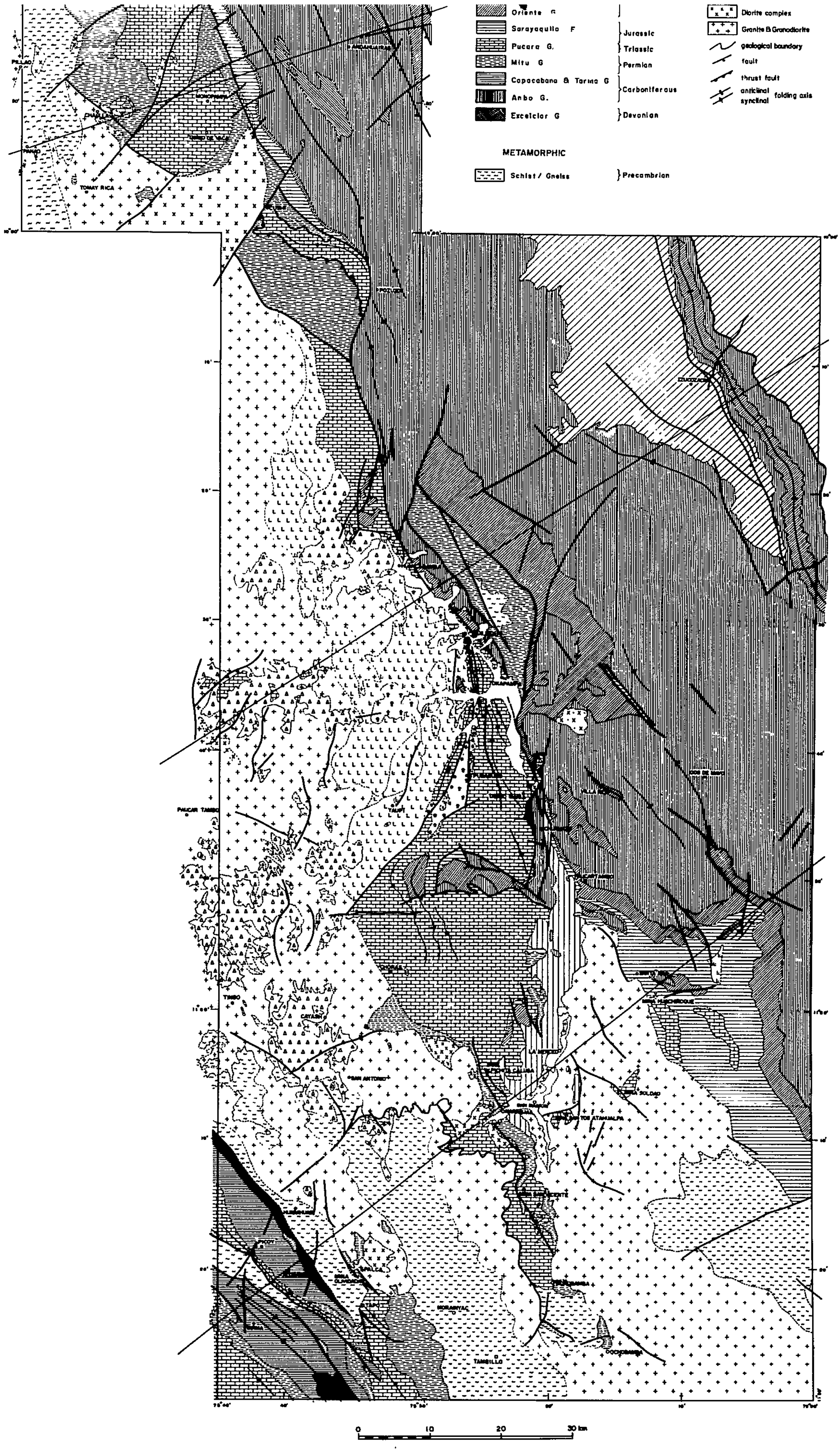


Fig. 4 Generalized Geological Map of the Surveyed Area

Fig. 5 . Generalized Geological Columns of the Entire Surveyed Area

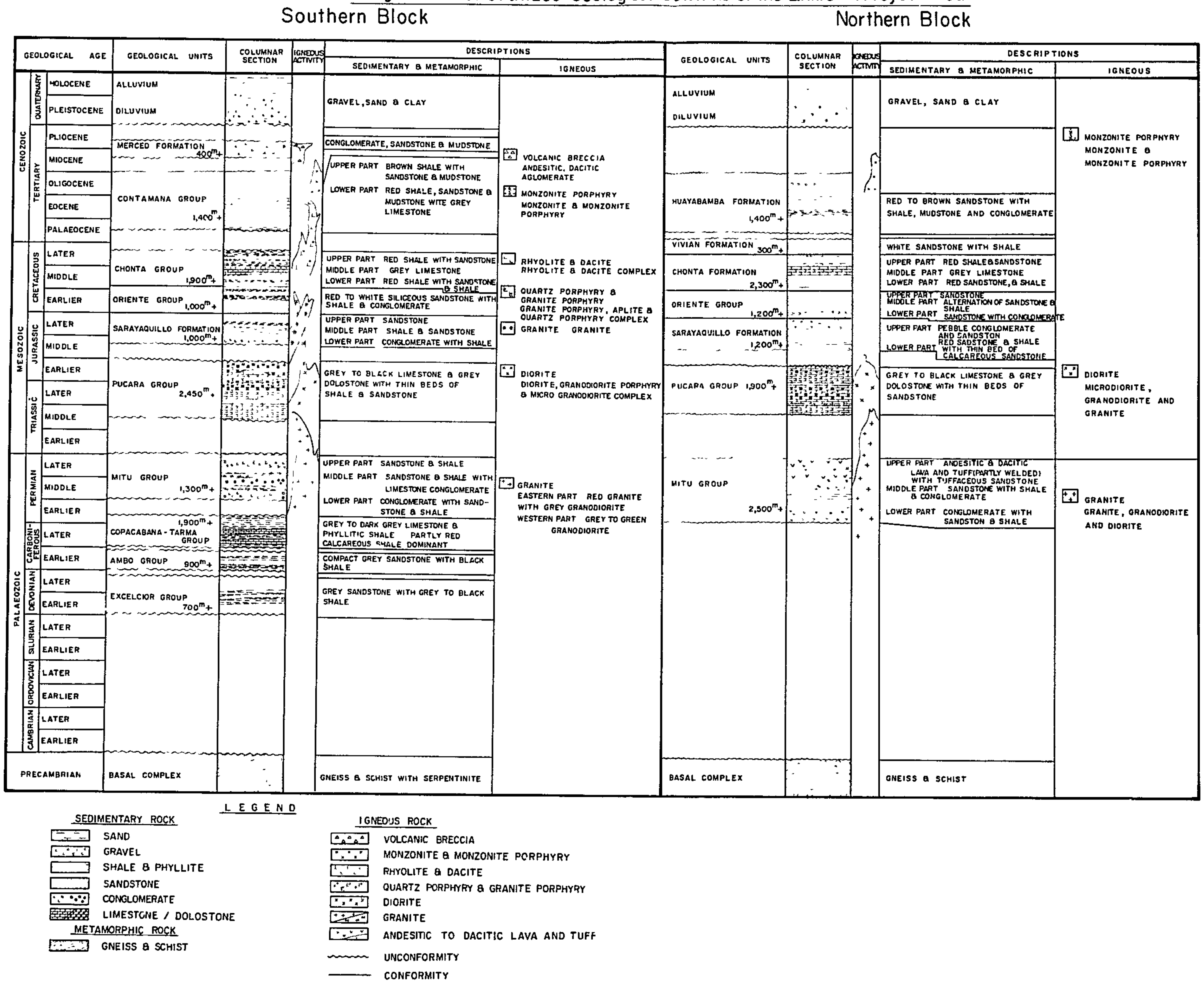


Table 4 List of mineralization in the surveyed area.

No	Area	Location	Kind of Ore	Host Rock Group	Host Rock Rock	Alteration	Related Igneous Rock	Mode of Occurence	Scale of Mineraliza-tion	Direction of Mineraliza-tion	Amount of Unit Ore Body	Unit Ore body Scale	Unit Ore body Thickness Width	Unit Ore body Direction	Grade of Ore	Ore Minerals	Gangue Minerals	Structural Control	History	Note	Sample No
1	SAN RAMON	SAN VICENTE	Zn, Pb, Cu	PU	Do Ls	-	-	ba	3km×500m	N-S 20~50W	10	main 200m×200m	20m	N-S 45~50W	Pb 1% Zn 14%	Sp, Gn> Cp, Py	dol, cal	strata bound	worked product 1200T/D		
2	SAN RAMON	PICHITA CALUGA	Zn, Pb, Cu	PU	Ls	-	Di	ba	200m×75m	N50W NE	2	200m×75m	5m	N50W NE	Pb 5% Zn 15%	Sp, Gn> Cp, Py	dol, cal	strata bound	closed in 1969		
3	SAN RAMON	SANTOS	Zn, Pb, Cu	PU	Ls	Sk	Qp	diss	30m×	E-W S	1	30m×	max 1.5m	E-W S	Pb 1% Zn 13%	Sp, Gn> Py, Cp, Po	epi, gar	intrusive	exploited in 1974		S91202 S91204
4	SAN RAMON	SOLDADO	Zn Pb, Cu	PU	Ls	Sk	Qp	diss	100m×	N50W S65 N40E, S50	2	100m×	max 5m	N40E S50	Pb 1% Zn 12%	Sp, Gn> Cp, Py	epi, gar	intrusive	closed		F103001
5	TARMA	LA OLIVIDADA	Cu	PU	Ls	Sil	-	net	50m×	NW-SE	1	50m×	max 3.5m	NW-SE	Cu 5%	Az, Mal> Sp	cal	NW-SE-fracture	worked product 9 T/M		T91902
6	OXAPAMPA	HONDA	Cu	PU	Ls	Sk	Mo	diss							Cu0.06%	Py, Cp	skarn	intrusive		Surveyed by Japanese Mission (1976)	K244
7	OXAPAMPA	HONDA	Cu	-	Mo	-	Mo	diss							Cu0.08%	Mt, Py> Ht, Cv		intrusive		Surveyed by Japanese Mission (1976)	K264
8	CHAGLLA	CHAGLLA	Cu, Pb	PU	Ls	-	-	vein							Cu0.24% Pb0.016% Zn0.066%	Mal, Gn	cal			Surveyed by Japanese Mission (1976)	A023 A024 A025
9	SAN RAMON	SOUTH PICHITA CALUGA	Cu, Zn	-	Do	epi chl	Di	vein					0.25m		Cu1.90% Zn0.13%	Mal, Cp Py, Sp	cal, qt epi, chl	fault		Surveyed by Japanese Mission (1976)	T008 I082 F072
10	OXAPAMPA	CHONTABAMBA	Pb, Zn	PU	Ls	-	-								Pb 23% Zn 3%	Gn, Sp			closed product 10T	Surveyed by Japanese Mission (1976)	A089
11	OXAPAMPA	SAN ROQUE VALLEY	Pb, Zn	PU	Ls	-	-	diss							Pb15.8% Zn0.63% (C416)	Gn	cal	strata bound		Surveyed by Japanese Mission (1976)(1977)	L319, C416 OF007, M494 OF017
12	OXAPAMPA	TAMBO MARIA	Zn	PU	Do	-	-	ba					32m		Cu0.02% Pb0.013% Zn4.12%	Sp, Sm	dol	strata bound		Surveyed by Japanese Mission (1976)(1977)	S024, S025 S346, S347 S350
13	OXAPAMPA	SAN ROQUE T-2	Zn, Pb	PU	Do	-	-	diss							Pb0.09% Zn0.35%	Sp, Gn	qt, dol	strata bound		Surveyed by Japanese Mission (1978)	L729
		SAN ROQUE T-4	Zn	PU	Do	-	-	diss & fr							Pb0.15% Zn20.72%	Sp	qt, dol	strata bound			S725
		SAN ROQUE T-10	Zn, Pb	PU	Do	-	-	fr							Pb6.56% Zn19.16%	Sp, He, Gn	dol	strata bound			S783
		SAN ROQUE T-28	Zn, Pb	PU	Do	-	-	fr					5m		Pb0.87% Zn2.35%	Sp, Gn	dol	strata bound			L783-1 L783-2 L783-3 L783-4 L783-5
		SAN ROQUE T-29	Zn, Pb	PU	Do	-	-	fr							Pb2.11% Zn11.06%	Sp, Gn	dol	strata bound			L815
14	CHAGLLA	HUARAO CHICO	Pb	PU	Do	-	-	diss								Gn	cal, flu	strata bound		Surveyed by Japanese Mission (1978)	N746
		HUARAO GRANDE	Pb	PU	Do	-	-	diss								Gn	cal, flu	strata bound			N752
		HUARAO GRANDE	Pb	PU	Ls	-	-	diss								Gn	cal	strata bound			D807

Group: PU : Pucara Group

Rock Name:
- Do : Dolostone
- Ls : Limestone
- Mo : Monzonite
- Di : Diorite
- Qp : Quartz porphyry

Alteration:
- Sil : silicification
- epi : epidotization
- chl : chloritization
- Sk : Skarnization

Ore Mineral:
- Az : Azurite
- Cp : Chalcopyrite
- Cv : Covelline
- Gn : Galena
- He : Hemimorphite
- Ht : Hematite
- Mal : Malachite
- Mt : Magnetite
- Po : Pyrrhotite
- Py : Pyrite
- Sm : Smithsonite
- Sp : Sphalerite

Gangue Mineral:
- cal Calcite
- chl : Chlorite
- dol : Dolomite
- epi : Epidote
- flu : Fluorite
- gar : Garnet
- qt : Quartz

Mode of occurence:
- diss disseminated
- fr : fracture filling
- ba : banded
- vein : vein type
- net : network

Chapter 5 The Survey in September, 1975

As the first year's survey, the geological (reconnaissance, detailed) and geochemical survey were carried out in the southern part of about 10,000 km^2 in area, which is a part of the programmed area of 20,000 km^2. Also, the altitude survey was performed for the topographic mapping.

5-1 Methods of the Survey

(1) Reconnaissance

This survey was carried out for the purpose to re-analyze the geological data by SLAR (Side Looking Airbone Rader) mosaics prepared by the Peruvian government, to confirm the distribution and the geological structure of the Pucara Group in which strata-bound ore deposits are expected to emplace, and to collect the informations by which extract the area of high potentiality for the mineral resources.

Survey routes were scheduled to be intersect perpendicularly to the direction of geological structure along the main roads and rivers.

Also, the routes are selected at 10 km intervals in the area where the Pucara Group is distributed and at 20 km intervals in the other areas.

In the field, topographic maps and aerial photos, were used for confirming of ground position, but in the area where no topographic map compiled from aerial photos, the SLAR mosaics were used for geological description.

(2) Detailed geological survey

The survey was carried out in the area of about 100 km^2 as the center of the San Vicente mine which is only worked in the central part of Peru. The purpose of this survey is based on confirming the geological characteristics of the area including representative ore deposits and clarifying the principles of prospecting methods. Survey routes were set at 5 km intervals.

Topographic maps (1/25,000) were used for the confirmation of field position and for the geological description.

(3) Geochemical survey

At the same time for the geological survey, the geochemical survey was carried out.

In the reconnaissance, stream sediments and soil samples were collected to obtain the informations on account a regional ore deposits. 1,095 samples of stream sediments were collected from rivers and streams crossed to survey routes and 1,500 samples of soil were collected at the B_1 bed along survey routes. Also, in the detailed survey 412 soil samples were collected.

After sampling, they were air-dryed and screened, then 10 grams of each sample were prepared for chemical analysis. The samples of the reconnaissance were analyzed by atomic absorption method on three indicater elements such as Cu, Zn, and Ni, and in the detailed survey on Cu, Pb, and Zn.

(4) Altitude survey

On the other side, the altitude survey was carried out in the area where the Pucara Group is distributed, to make up the topographic maps by using the pre-existed aerial photos.

5-2 Results of the Survey

(1) The surveyed area is composed of various sedimentary rocks, igneous rocks, and metamorphic rocks. The sedimentary rocks until the Copacabana-Tarma Group of Carboniferous Period, Paleozoic Era and metamorphic rocks are distributed in the narrow area near Tarma in the southeastern part of the surveyed area.

(2) The Mitu Group of Triassic Period is found along the Inter-Andean basin, near San Ramon, Oxapampa and Pozuzo. Meanwhile, near Tarma the

Mitu Group is distributed only in small scale. This group is deposited through after the orogenic movement of the early Permian Period, and is consisted of conglomerate, sandstone, and shale, with the intercalation of volcanic rocks as lavas and pyroclastics. The conglomerate is reddish brown-brown in color and consists of various well-rounded pebbles such as granitic rocks, volcanic rocks and metamorphic rocks and of sandy-tuffaceous matrices. The intercalated volcanic rocks are well developed in the upper member of this formation. The variation of lithofacies is generally remarkable.

(3) The Pucara Group accumulated from Triassic to Jurassic Period, Mesozoic Era, is distributed in both sides of geoanticlinal structure developed in the western highland.

Near Tarma in the western side, this group outcrops in the small area in NW-SE. In the eastern side, it is distributed in the narrow area from the near San Ramon toward Oxapampa and Pozuzo in a direction of N-S to NNW-SSE. This group is exposed the widest in the northwest of San Ramon, but toward south and north.

Near San Vicente, this group is correlated to the Mitu Group, in parallel unconformity, and is intruded by igneous rocks or is bordered by faults in an other areas.

The Pucara Group consists of carbonate rocks such as limestone, dolostone and others. This group is devided into 3 members near San Vicente mine. Lower and upper members are composed mainly of limestone, and middle member consists of dolostone and dolomitic limestone. In the middle horizon of middle member a few strata is composed of crystalline dolostone, accompanying with a bended structure which is so-called zebra-structure, and brecciated structure.

(4) The granitic rocks are abundantly distributed in the surveyed area, and are thought to intrude in about middle Triassic in association with the orogenic movement of Permian Period. They are devided into two parts such as leucocratic granite distributed from near Tarma toward west of Oxapampa and red exposed near San Ramon. The former is also called Tarma granite or "white granite", and the other is called San Ramon granite or "red granite". Both of them show coarse-medium grained and holocrystalline texture.

According to age determination by K-Ar method, the white granite indicates 244 m. y. and the red granite indicates 195 m. y. Thus, it is thought that granitic rocks intrude mainly from early to later Permian, and some parts of it activate until the middle Jurassic Period.

Other igneous rocks such as diorite, granite, acidic porphyry and volcanics etc, intrude mainly around the eastern margin of Permian granitic rocks, and partially penetrate into the Pucara Group ascribing to the orogenic movement after the middle Jurassic Period in the western highland.

(5) In the surveyed area, a few types of metallic ore deposits are recognized as is fore-mentioned in the section 4-4.

The strata-bound lead-zinc ore deposits represented by the San Vicente mine in the Pucara Group, are emplaced in dolostone. Especially, it is remarkable where zebra-structure and the brecciated structure is developed. Ore minerals are composed mainly of fine grained sphalerite and a little amounts of galena, and they are embedded in parallel to the zebra-structure. The grade of ore in the San Vicente mine shows Pb 1 % and Zn 10 to 20 %. Near the ore deposits,no altered minerals can be seen as the production considered to result of igneous activities. While, the filling temperature of liquid inclusions in dolomite of the country rock indicated at 70°-150°C. These values are similar to that of the Mississippi Valley type lead-zinc ore deposits. Therefore, it is considered that the San Vicente ore deposits is proposed to the same type.

(6) There are Siete Jeringas ore deposits in the south of the San Vicnete ore deposits, and Llanco Cateador ore deposits in the north. The primary fine grained sulphides and the later coarse grained sphalerite which seems to cut a primary sulphides in the form of veinlet are observed in both deposits. Also, the Pichita Caluga ore deposits located in the northwest of San Ramon, are emplaced in parallel with the bedding plane of dolomitic limestone. Ore minerals consist of coarse grained sphalerite, and are recognized more pyrite and chalcopyrite than those of the San Vicente deposits.

In the east of the San Ramon, the limestone of the Pucara Group which is distributed as the roof-pendants on the granitic rocks, and at the contact between the igneous rocks and the limestone, the Santos and Soldado ore deposits are located. Both of them are contact metasomatic deposits, and are associated with copper, lead, and zinc in skarn of mainly epidote and garnet. Those ore deposits are known as the scale of 1-5 m in width and as 30 m in elongation, but they exist out of the detailed survey.

On the other side, the La Olividada ore deposit as the scale of 3.5 m in width and 50 m in elongation is located in the Pucara Group in western highland. This ore deposit is composed mainly of copper and less in amount of zinc.

(7) By the geochemical survey, high values of zinc were recognized in the restricted area where the Pucara Group is distributed. They are especially remarkable around the areas where zinc mineral indications are found and dolostone is distributed. Also, there are rather high values in the areas of Mesozoic diorites and Mitu Group. High values of copper were recognized at the indications and around the diorite intrusives. While, high values of nickel were found only in the metamorphic masses distributed in the western highland.

From the results of the geological survey, it was clarified that the survey for the strata-bound lead-zinc ore deposits should be carried out in the area where the Pucara Group is developed.

Chapter 6 The Survey in May, 1976

This survey carried out at the first and second stage in 1976. On survey in May, 1976, geological and geochemical surveys were carried out in the southern part. Also, topographic mappings by using aerial photos were performed before these surveys.

6-1 Methods of the Survey

(1) Semi-detailed geological survey

This survey was carried out in the area of about 2,000 km^2 where the Pucara Group had been confirmed in its distribution by last year's survey. The purpose of the survey was to clarify the distribution and geological structure of ore-embedded horizon in the Pucara Group and to extract the area for the survey in August, 1976 after this survey. Survey routes were selected at the interval of 5 km crossing perpendicularly to the direction of geological structure. Topographic maps of scale 1 to 25,000 prepared for this survey were used.

(2) Geochemical survey

Soil samples were collected at the same time of the geological survey. After collecting the samples amounted to 2,622, the colorimetric analysis using a Dithizone method was operated contemporaneously for the zinc as an indicator element in the field. The results from these analyses were used for extraction of the area for detailed survey in August, 1976.

Also, the chemical analysis for Cu, Pb and Zn as indicator elements by atomic absorption method was practiced in Japan.

6-2 Results of the Survey

(1) The present surveyed area is composed of the Pucara Group which occupies in the central part, of igneous rocks mainly of granitic rocks in the

western part, and of the post-Pucara groups. Dolostone in the Pucara Group is distribute widely in south of Oxapampa. The dolostone is associated with zebra-structure in places, and this structure is developed especially in the lowest dolostone.

(2) The new zinc mineral indication was found in the zebra-structure of the Tambo Maria area and also the new lead indication, in the limestone of the San Roque area and the new copper in the Paleogene monzonite near Tambo Maria.

The mineral indication in Tambo Maria is similar to San Vicente deposits. Crystals of coarse grained sphalerite are recognized along the white part of zebra-structure which consists of coarse grained, recrystallized dolomite and black fine grained dolomite. Brecciated structure in dolostone is filled by the white, coarse grained dolomite, as well as in the zebra-structure. It is considered that both structures are formed through the process of the segregation in relation to the tectonic movement.

The disseminated mineral indications are located near the intrusives such as granite porphyry, quartz porphyry, etc, but no alteration of country rocks as well as that of the San Vicente ore deposits is recognized anywhere. Both mineral indications of Tambo Maria and San Roque are very weak.

(3) Geochemical samples collected in the surveyed area were analysed by the colorimetry using a Dithizone method for zinc as a indicator. From the results of these analyses, the area, where the detailed survey in August 1976, would be carried out, was selected and those analyses were re-confirmed by the atomic absorption method in Japan.

Also, it was made clear that both lead and zinc elements in soil the similar behavior each other and the high values of them are concentrated in the area of the Pucara Group.

However, there is no high value showing the geochemical anomaly in the Tambo Maria area.

Chapter 7. The Survey in August, 1976

The present survey was continued after that in May, 1976, and was composed of the reconnaissance in the northern part of about 10,000 km^2 and of the detailed survey in the southern part of about 259 km^2. Also, aerial photos were taken in the northern part.

7-1 Methods of the Survey

(1) Reconnaissance

This survey was carried out by the same methods which had been performed in the southern part in September, 1975.

(2) Detailed geological survey

This survey was carried out around the Oxapampa city extracted in May, 1976.

The main purpose of the survey was to elucidate the stratigraphy of the Pucara Group and to make clear the feature of emplacement of new mineral indications which were detected in the Pucara Group on semi-detailed survey. The topographic maps were magnified from the scale of 1/25,000 to 1/10,000 and they were used for the high accuracy. Survey routes were selected at about 2 km intervals and were cleared by wood-cutting.

(3) Geochemical survey

In the reconnaissance, samples of stream sediments (310 pcs) and soil (1,392 pcs) were collected by the same method of the last year. In the detailed survey, 1,840 samples of soil were collected and 193 samples of carbonate rocks were also collected to detect the behaviors of metal elements in them.

Those samples were analysed on 3 indicator elements such as Cu, Zn and Ni for the reconnaissance and as Cu, Pb and Zn for the detailed survey.

(4) Aerial photo-taking

The reconnaissance in the northern part were programmed on the SLAR mosaic. The aerial photo-taking were carried out by the SAN (Servicio Aereo-fotografico Nacional del Perú), because of confirming the ground position and surveying with accuracy. This survey was carried out after the completion of photo-taking.

7-2 Results of the Survey

The clarified conclusions from these surveys were summarized as follows:

(1) The distribution of rocks in the northern part where the reconnaissance had been carried out, is the same as that in the southern part. Igneous rocks and metamorphic rocks are distributed on the southwestern side in the southern part, and sedimentary rocks are exposed on the northeastern side. The igneous rocks consist mainly of plutonic rocks such as granitic rock and diorite etc.

The granitic rocks intrude along geoanticlinal structure in western highland and is distributed from the west of Oxapampa to near Chaglla through the west of Pozuzo. Those rocks are leucocratic and medium-grained. Mafic minerals are poor, but sometimes they occur in aggregates, showing schistose texture. Lithological variation is specially intense in comparison with the southern part, appearing granodiorite, diorite porphyry, micro-diorite, etc. The age determination of this granite by K-Ar method show 208-282 m. y.

The diorite is found in the eastern side of the mass of granite, intruding into the Mitu Group, and the age determination by K-Ar method show 170 m. y.

(2) The Pucara Group is distributed in the central part of the surveyed area, forming a narrow zone in NNW-SSE direction, and correlates in uncom-

formity to Mitu Group. The eastern side of the Pucara Group is bounded from the younger sedimentary rocks by remarkable fault, running from the east of Tingo Maria to Pozuzo.

The formation in the northern part consists of carbonate rocks such as limestone, dolostone, etc. The zebra-structure in dolostone is observed in places.

The Pucara Group in the Oxapampa was devided into three or four strata of the dolostones. It had been clarified that the lowermost of them is correlated to the same horizon of the San Vicente ore deposits by the included fossils. Also, there is a synclinorium structure with axis of the direction of the NNW-SSE or N-S.

(3) As for the mineral indication in the northern part, the vein-formed copper mineralization associated with the igneous rock was recognized only near Chaglla, while, no strata-bound lead-zinc deposits in the Pucara Group was found anywhere.

In the southern part, it had been made clear that the mineral indication of the Tambo Maria which was emplaced with the zebra-structure in the dolostone showed the scale of 30 cm in average width and 2 m in elongation. From the results of the antecedent geochemical survey on soil, there is no high value of Zn near the outcrop. Although the Zn values of geochemical survey is extremely low, there is a tendency that the zinc contents on the carbonate rocks is a little higher from the surroundings toward the mineral indication of the Tambo Maria. From the above data, it could be elucidated that the metallic elements included originally in the carbonate rocks would have been concentrated in the zebra- and brecciated structure of the dolostone in relation to the tectonic movements.

Mineral indications of the San Roque area are recognized in the limestone and dolostone which are distributed along the east of igneous rocks.

There is no alteration of rocks. Therefore, it was considered that the metallic elements would have been added to the carbonate rocks from the igneous rocks by the low temperature mineralization.

(4) In the geochemical survey in the reconnaissance of the northern part, the same results as in the reconnaissance of the southern block have been obtained. Thus, the high values of zinc are generally recognized in the restricted area of the Pucara Group. On the other hand, although the geochemical anomalies could not have been extracted on soil around the mineral indication of the Tambo Maria area, this indication is found in the special anomalies where values of metallic content on carbonate rocks are lower than the average of these contents in the surveyed area. Therefore, it is considered from the above-mentioned that the low anomalies suggest the remove and the concentration of metallic elements.

Chapter 8 The Survey in July, 1977

From the results of surveying had been already carried out, about 10 areas of southern part and northern part were extracted, then, geological survey, geochemical survey, geophysical survey,and diamond drilling were performed in these areas. Also, for accurate surveying, topographic mapping was carried out by using aerial photographs had taken in the year before.

8-1 Method of the Survey

(1) Geological survey

This survey was composed of the second stage of detailed survey in the Oxapampa area and the additional survey in the area where the reconnaissance and semi-detailed survey had been carried out.

(i) Detailed geological survey (the second stage)

This survey was carried out for the purpose of clarifying the relation between mineralized zone and geological structure, and of investigating the stratigraphical correlation of the Pucara Group in four areas such as San Roque area, Tambo Maria area, etc.

The survey routes in unexplored area of the first detailed survey were chosen as their density is about 1 km intervals. Then, the geological map of 1:25,000 were made up. The specially detailed survey of 1:2,500 were also carried out in the Tambo Maria area and the San Roque area for clarifying the stratigraphic correlation finely.

(ii) Semi-detailed geological survey

This survey was carried out in those areas as below:

Huancabamba (Southern part)
Rio Santa Cruz (")
Raymondi (")
Tingo Maria (Northern part)

(iii) Geological reconnaissance

This survey was carried out in the Rio Huallaga area, Pozuzo area and the Rio Oxabamba area.

(2) Geochemical survey

Soil samples were gathered in reconnaissance and semi-detailed survey. In detailed survey, rock samples were picked up for studying the behavior of minor elements on rocks. All these samples were prepared for analysis at the field, and they were analyzed in Japan.

(3) Geophisical survey

In the surveyed area, the Oxapampa area was extracted for the strong possibility of lead and zinc deposits emplaced. The gravity survey for resolving the underground structure including the Pucara Group, and the IP method electrical survey by short electrode intervals to examine the application for the strata-bound ore deposits, were carried out. The gravity survey in the area of 400 km^2 around the Oxapampa was carried out in two systems, the one was a reconnaissance as one survey point every 1 km along survey route, the other was a detailed survey as two survey points every 1 km. The stations were laid along the main roads, paths,and mountains.

Leveling was carried out by automatic level method (trunk road) and by precision barometric altimeters (mountainous district).

Two sets of gravity meters manufactured by La Coste & Romberg Co., were used for measuring of gravity, and a closed observation was carried out every day.

The electrical survey by short electrode interval method was carried out at the 16 measuring stations selected in the San Vicente mine and around the Tambo Maria mineral indication, etc.

(4) Diamond drilling

Adding to these surveys above mentioned, and for obtaining the more exact informations about the Pucara Group stratigraphy and ore deposits, the diamond drillings were carried out at 4 points selected in the San Roque area.

The drilling equipments of TGM-2C and TBS were used for this work.

(5) Topographic mapping

The topographic mapping of 3,400 km^2 covered was carried out before the geological survey around the area where the Pucara Group is mainly distributed in northern part.

8-2 Results of the Survey

The summary clarified by these works is mentioned as below.

(1) The gravitational tendency of the Oxapampa area surveyed coincides with the direction along the regional geological structure i.e. NNW-SSE system.

In this surveyed area, the Mitu Group and the Pucara Group are corresponded to high gravity anomalies (Fig. 6). There are some differents in each Pucara Group stratum i.e. dolostone, limestone, and sandstone. Remarkable high gravity anomalies seem to be observed in the dolostone predominant layer. On the other hand, sedimentary rocks of the post-Pucara Group show low gravity anomalies.

The special direction of N-S or NNW-SSE is presumed to be the underground discontinuity of the density. Then, this direction coincides nearly with the direction of the fault thought on geological survey. Furthermore, the high density zone of 2 to 5 km in width continued along N-S direction from the west Oxapampa to Tambo Maria, was seized and then, this zone seemed to be agreed with the dolostone distribution (400 m in width) of the Pucara Group lain in NNW of strike and SW of dip. Near Pusagno (in the report of 1977, the part of geophysical survey as Maria Tereza), the low density zone of N-S direction is recognized, it is presumed that the granite distributed at west side have intruded to the lower part of the Pucara Group in the east area. The high density zone pursued continuously from the southern part is cut abruptly near the San Roque area, from above mentioned it is presumed that the base rocks exist in shallower place than another areas.

The strata-bound lead and zinc ore deposits in these areas are embedded in close contact with dolostone. Therefore, what dolostone layer was able to seize as the high density zone shows the application for the gravity survey on this type of the ore deposits.

(2) On the electrical survey by short electrode intervals, the measurements were carried out at the mineral indications of the San Vicente, the San Roque, etc. As the indications of apparent resistivity and apparent FE are low, it is clarified that the application of IP method to this type of ore deposits is scarecely valuable.

(3) The diamond drillings for the purpose to clear the stratigraphy of the Pucara Group were carried out at four points in the San Roque area (Fig. 7 (1)). At the hole No. 52-1, up to the depth of 170 m, thick dolostone is recognized. Between 115.25 m and 140.70 m, impregnations of sphalerite and galena are recognized. These metallic minerals replace fossils included and accompany with quartz or calcite veinlets. In the vicinity of 130 m, along 7.7 m length, the average grade shows Pb 0.24 % and Zn 1.1 %, particulary between 129.35 and 130.35 m (1.0 m) the grade shows Zn 4.9 %.

The core of the hole No. 52-2 is composed of volcanic breccia or volcanic conglomerate of the Mitu Group.

The core of the hole No. 52-3 is composed of the alternation of limestone and muddy limestone. Galena is recognized at 100 m and so on, till the bottom of this hole in disseminated form as for sulphide mineral.

Any sphalerite is not recognized megascopically, but only by the chemical analysis, a little high grade horizon of Zn is recognized between 150 m and 200 m. Under the microscope, sphalerite is recognized filling spaces amongst the calcite grains in anhedral form (5 to 20μ).

The core of the hole No. 52-4 is also composed of alternation of limestone and muddy limestone. No sulphide mineral is recognized megascopically, but only by the chemical analysis at 50 m and 125 m, a rather high horizon of Zn is recognized.

(4) From the geological survey and diamond drilling survey, the consideration that the stratigraphical correlation of the Pucara Group in this area is devided into six submembers, was newly made up.

These submembers are designated as the I member to VI member from the lower part. Dolostone in the I member, the III member and the VI member are important for stratigraphy, also is included in the V member. The dolostone of the III member that is distributed from Oxapampa to Tambo Maria, outcrops on the largest geological scale in the surveyed area and shows anticlinorium structure of NNW-SSE direction axis, then this dolostone is distributed also along west side of the igneous rocks. However, in the vicinity of the igneous rocks, this dolostone is weakly developed and the facies tend to be variable.

The distribution of the muddy dolostone of about 170 m in thickness in the San Roque area have been newly confirmed by diamond drillings and so on. This stratum is correlated to the upper horizon of the dolostone in the southern Oxapampa and to the same horizon of the VI member dolostone distributed in the north Tingo Maria area and the Chaglla area. Any dolostone of the V member is tiny in scale and is distributed locally.

The zebra-structure in dolostone is most remarkable in the III member. In the Tambo Maria area, this structure shows maximum 150 m in thickness and 2.5 km in elongation.

(5) The Mitu Group that had not been discovered up to this time was newly recognized at the No. 52-2 drilling and around it in the San Roque area as the Mitu Group was sandwiched by the Pucara Group.

Near here, some faults of NNW-SSE or N-S direction are recognized remarkably. It is presumed that the Mitu Group, the lower formation than the Pucara Group, was caught and put cropped accompanying with the movement of faults.

(6) The dolostone and the limestone distributed in the San Roque area are intercalated with clastic rocks such as muddy or sandy facies and are variable in rock facies by examining the core of diamond drillings.

From the point of the relation between Pb-Zn and rock facies, the horizon highly included two metals exists in the clastic rocks such as muddy to sandy or near by the top of them. Then, sphalerite is generally observed within limestone in micrograin of anhedra (5 to 20μ) and in the recrystallized calcite of limestone or quartz-calcite veins of dolostone, till sphalerite is occasionally recognized by the naked eye in medium to coarse euhedra.

The framboidal pyrite thought to be formed in low temperature, is recognized enoughly.

From the above, it is concluded that the sulphides are primarily precipitated in micrograin of anhedra within the reduction environment where organic matters exist, and then the sulphides were developed with the crystal growth of the mother rock.

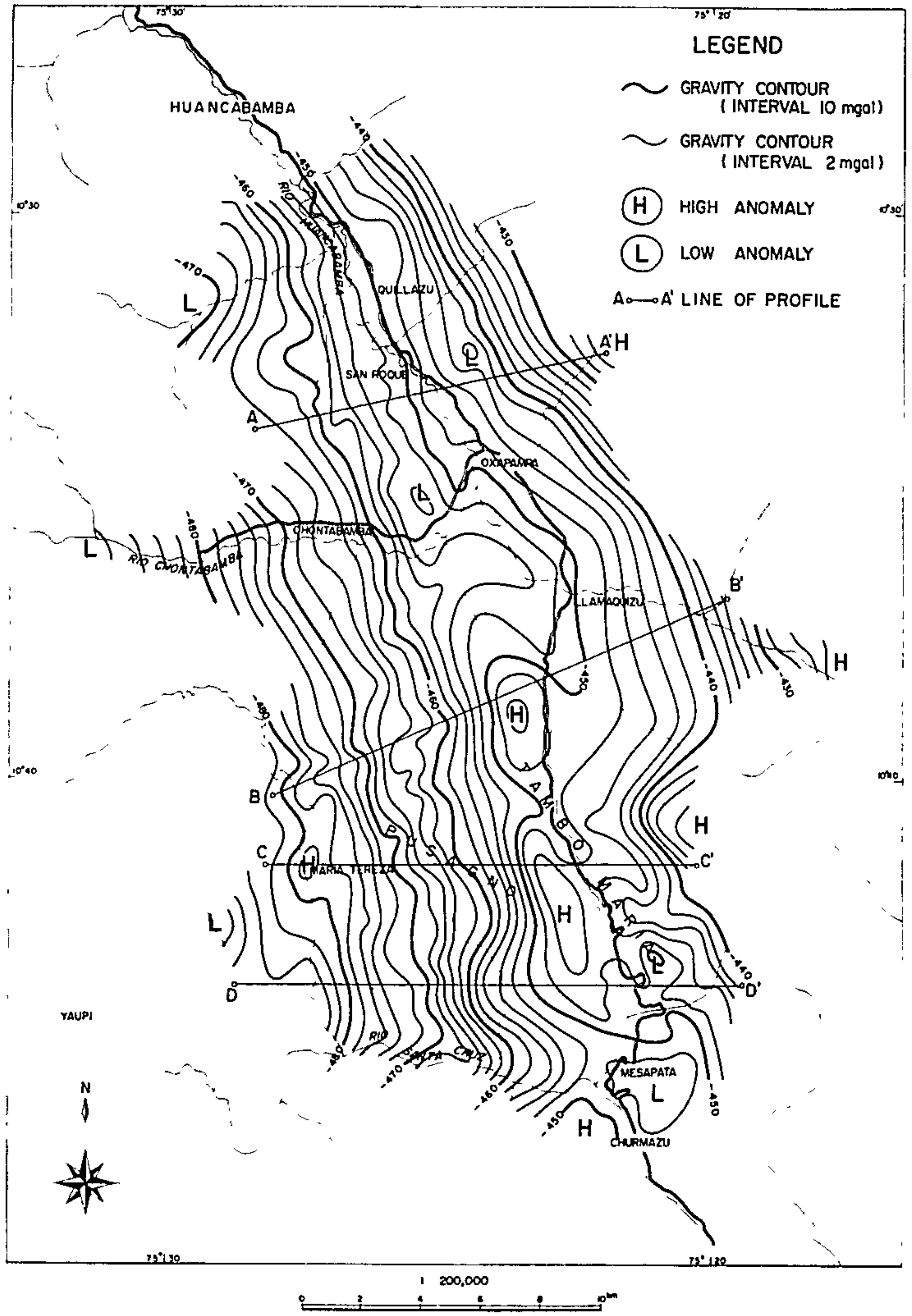
(7) The average values of Pb and Zn included in the carbonate rocks are 50 ppm as Pb and 60 ppm as Zn. These values show higher grade in the vicinity of the volcanic rocks (Pb 88 ppm, Zn 217 ppm), and show lower grade along the dolostone of the III member (Pb 31 ppm, Zn 23 ppm). The values of Zn show about 10 ppm within the special developing of the zebra-structure. The high anomalies of the Pb, Zn value distribute in dolostone, limestone as well as

the Pb and Zn mineral indications are found in these anomalies.

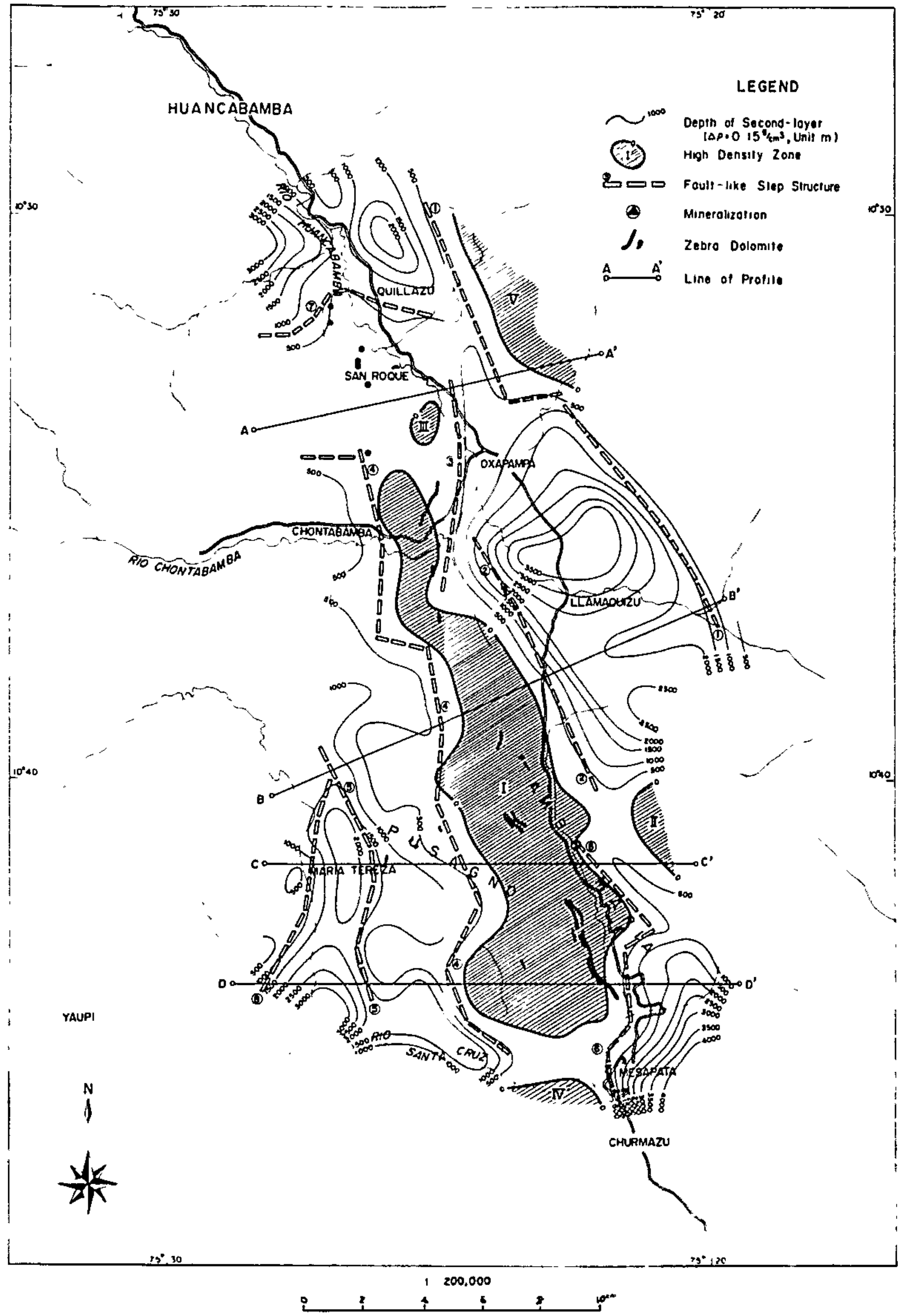
On the otl er side, in high anomalies of the Pb-Zn, the general correlation that values of Zn are higher than those of Pb at igneous rock side, is not recognized,but commonly the reverse correlation is recognized. From this correlation, it is considered that the primary sulphide of Pb-Zn precipitated at the time of sedimentation of limestone, have been recomposed on the diagenesis process and the intrusion of igneous rocks after sedimentation.

In the Tambo Maria where the dolostone of the III member is developed, both values of Pb and Zn are low. The values of Zn are lower than those of Pb within the dolostone where the zebra-structure is developed about 10 km in elongation. On the contrary, at the outer side, the values of Zn are higher than those of Pb. The Tambo Maria ore indication was recognized at the point where values of Zn are lower than those of Pb.

Those above mentioned should be an evidence that the Zn elements included in carbonate rocks were condensed into the zebra-structure related to its formation.



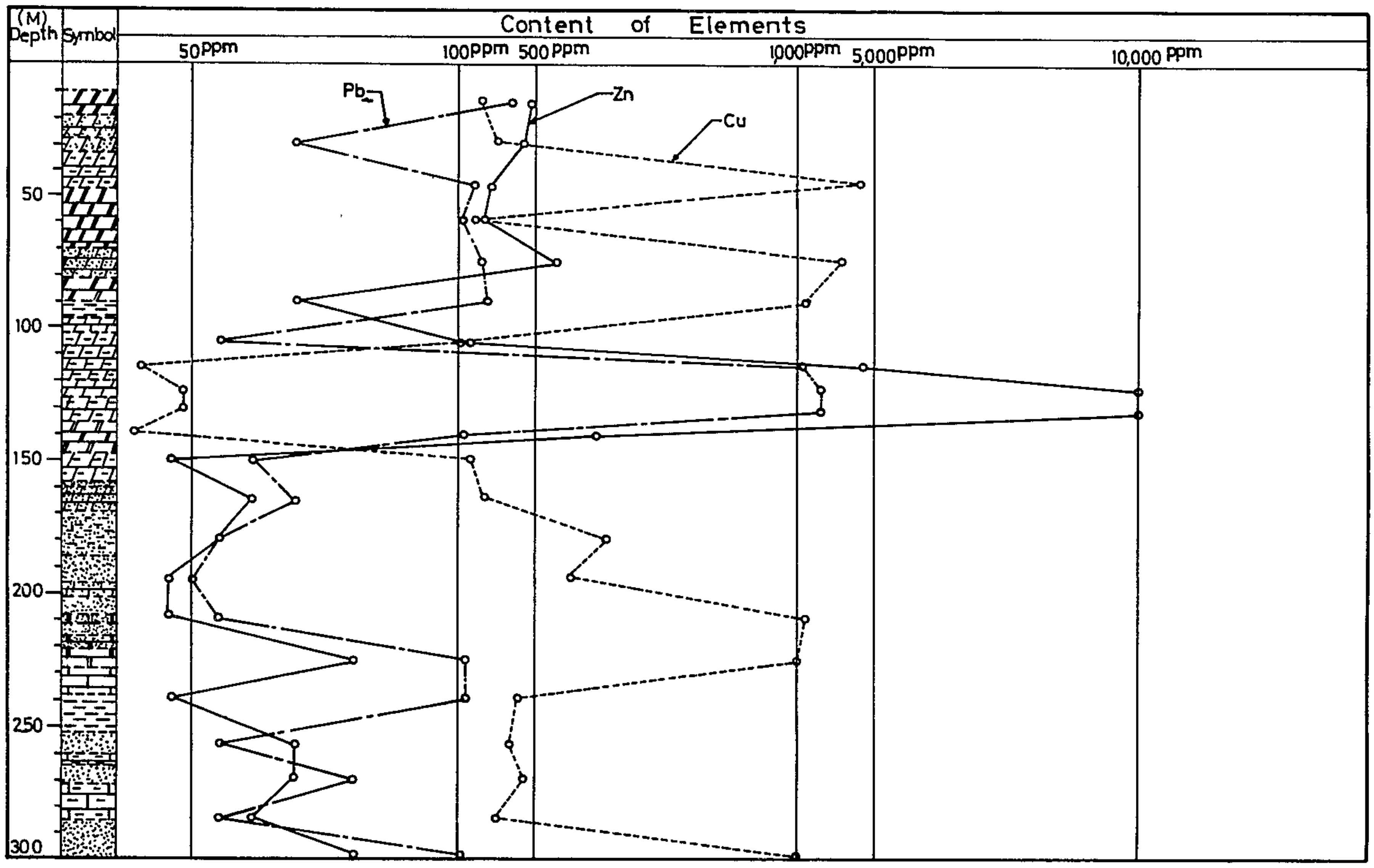
Bouguer Anomaly (ρ = 2.67)



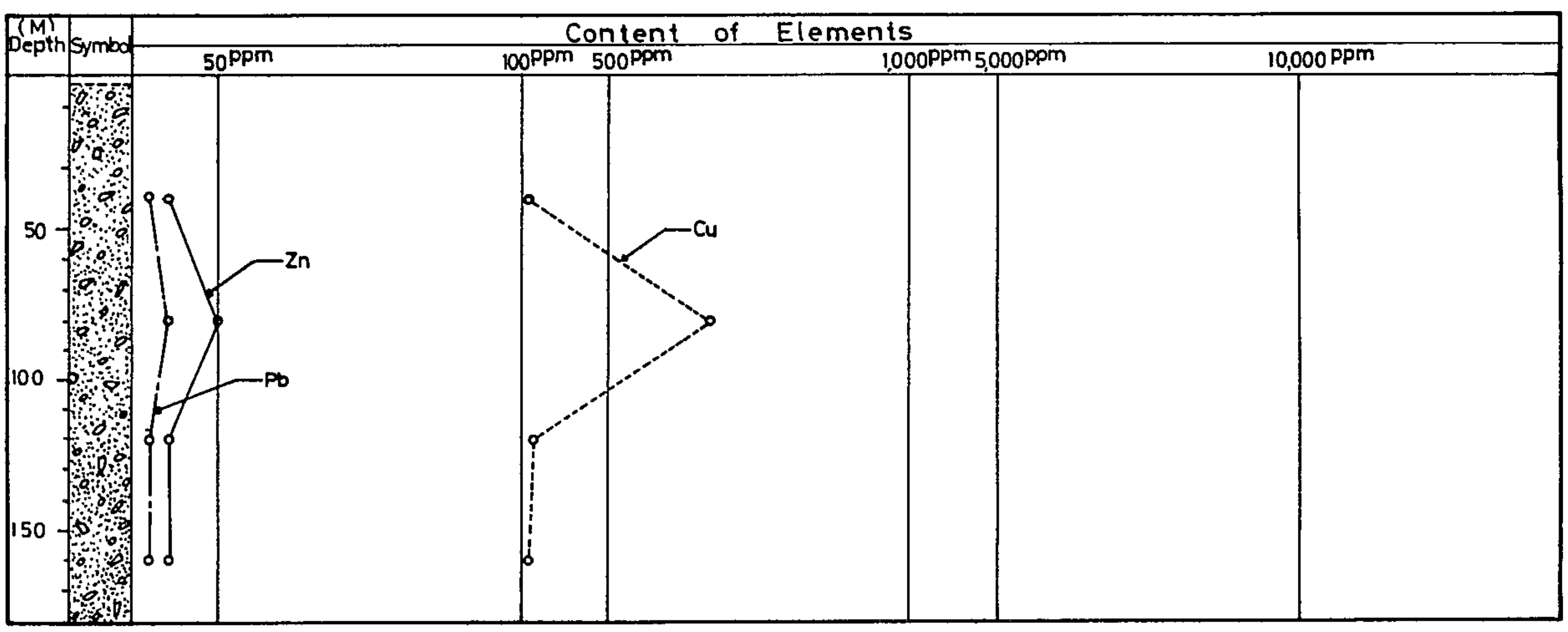
Underground Structure

Fig.6 RESULTS OF GRAVITY SURVEY

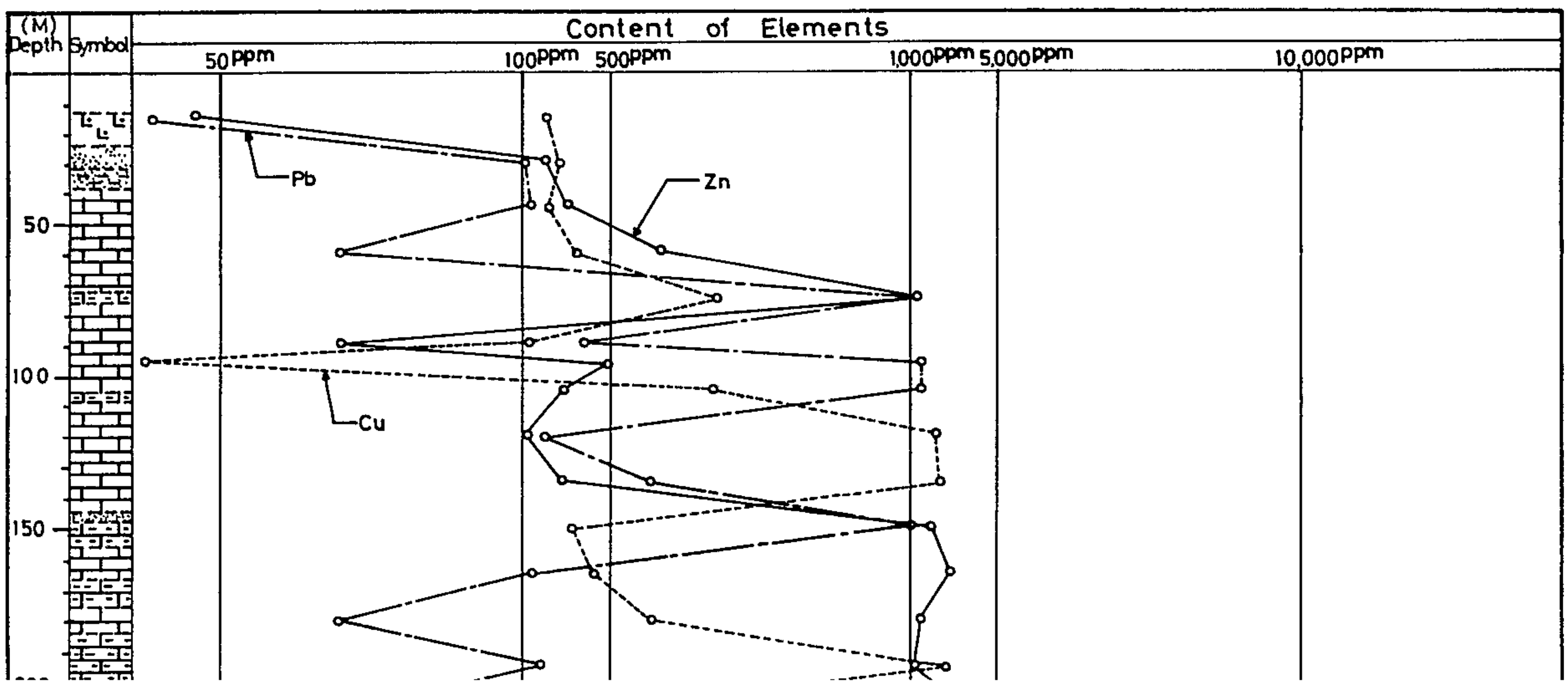
No. 52-1



No. 52-2



No. 52-3



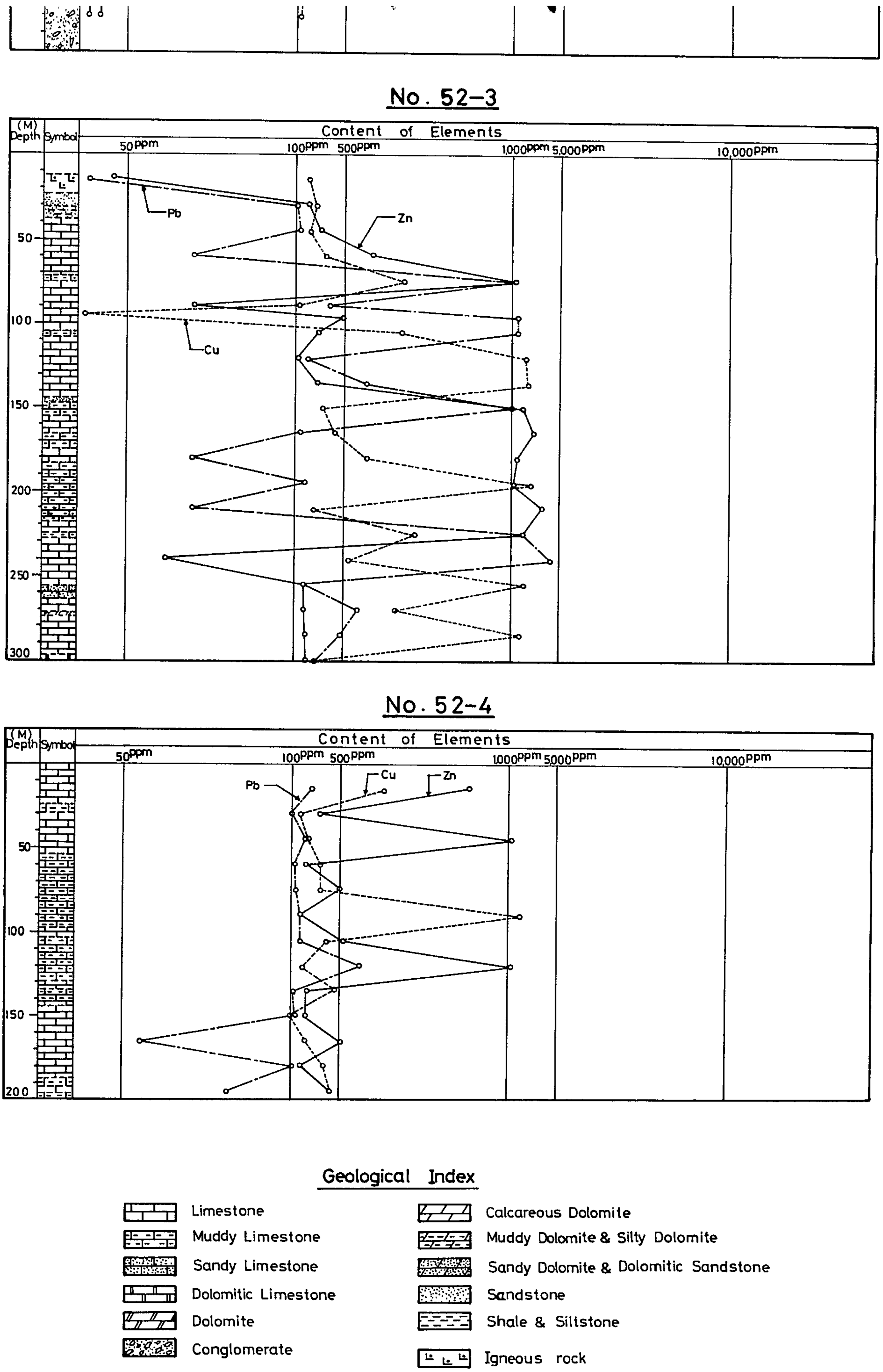


Fig.7 (1) Results of diamond drilling in 1977.

Chapter 9. The Survey in May, 1978

The surveyes of this year composed of geological survey, geochemical survey and diamond drillings were carried out in the San Roque area and the Tambo Maria area of the southern part, and in the Chaglla area of the northern part.

9-1 Method of the Survey

(1) Detailed geological survey

The third stage of detailed survey in the San Roque area and the Tambo Maria area was carried out for the purpose of clarifying the embedded strata of Pb-Zn ore deposits and their controling in strata, and of considering the ore genesis. To perform above mentioned works, the trenches of 5,626 m in total elongation were scooped out.

At digging trenches, the situations of them were carefully selected to clarify the stratigraphy and geological structure of the Pucara Group and to seize the correlation between geochemical anomalies and the mineralized zone. Trenches had been digged by human power. The geological sketches of 1:500 on trenches were drawn, and then the results of them were analyzed for geological mapping with the results of additional geological survey.

On the other side, in the northern part, the same investigation as had been carried out in the southern part was done and the possibilities of ore deposits embedded was examined. The survey routes of 53 km in total length were chosen to cross at right angles to the main geological structure.

(2) Geochemical survey

404 rock samples in total were gathered on carbonate rocks and these samples were prepared for analysis at the field, and then they were analyzed on indicating elements i.e. Cu, Pb and Zn and on minor elements i.e. Sr, Ba, etc. in Japan

(3) Diamond drilling

Three drilling sites were selected for clarifying the finer stratigraphical correlation of the Pucara Group in the San Roque area and Tambo Maria area, then drillings were carried out.

9-2 Results of the Survey

The definite conclusions from this survey are summarized as follows:

(1) Results of drilling

Three drillings were carried out in the San Roque area and the Tambo Maria area for obtaining the informations about the stratigraphy of the Pucara Group and about the horizon embedding ore deposits (Fig. 7 (2)).

The core of the No. 53-MJ1 was confirmed in its composition of dolostone, and also was recognized the zebra-structure and brecciated dolomite. As a very poor mineralization was recognized, so both values of Pb-Zn analyses showed only about 20 ppm.

In the core of the No. 53-MJ2, up to 181.2 m, it is composed of fine to medium grained crystalline dolostone, partially sandy to muddy dolostone and the zebra-structure intercalated. After 181.2 m, the core is composed of the alternation of black muddy limestone and calcareous siltstone including some fossils of ammonite. The mineralizations were recognized at 105 m and 135 m as the very poor pyrite concentration, and between 190 m and 191 m strongly concentrated pyrite is recognized. Also at 190.6 m, the content of Zn show 19,080 ppm, and there, some tiny sphalerite grains 20 to 50μ in diameter, were recognized under microscope.

The core of the No. 53-MJ3 is composed of fine to medium grained crystalline limestone and muddy to sandy limestone, up to 160 m brachiopods, echinoids and algal debris are included abundantly. Though mineralizations of galena were recognized at 58.75 m, 71.1 m, 84.3 m and 123.1 m, but whole values of analysis are low and are about 600 ppm.

All core of No. 53-MJ1 and No. 53-MJ2 can be correlated to the III m mber of the Pucara Group, also that of No. 53-MJ3 can be correlated to the IV member.

(2) Stratigraphy of the Pucara Group

The Pucara Group had been able to be classified as 6 members so-called from the I member to the VI member, up to these surveys. On the contrary to this classification, it is ascertained that the Pucara Group must be classified as 5 members from three drillings in the San Roque area and from the geological survey in the Chaglla area. By this time the horizon which had been identified to the IV member and/or the V member in the Chaglla area was finely devided into from the III member to the V member by index fossils. It has been clarified that dolostone and limestone of the III member are correlated to the same horizon of the ore deposits in the Tambo Maria and San Vicente area. Dolostone in the San Roque area is correlated to the V member. From above mentioned, it is finally described that the Pucara Group is divided into 3 submembers composed mainly of dolostone and limestone, and 2 submembers mainly of muddy to sandy limestone (Fig. 8).

Also the conclusions were considered as follows:

① The I member is proposed to the upper Triassic, also correlated to the Chambara Formation as standard locality.

② The II member is proposed to the lower Jurassic, also correlated to the lower Aramachay Formation as type locality.

③ Over III members are proposed to lower to middle Jurassic, also correlated to upper Aramachay Formation and Condorsinga Formation. Unexactly the boundary of both formations is not decided by this time.

④ The thickness of the Pucara Group is about 1,900 m in northern part and about 2,450 m in southern part.

(3) Occurence of dolostone

Principal dolostones are distributed in the I member, the III, and the V, and among them, the III or the V is remarkable. The dolostone belonging to the III member is alternated with thin layers of calcareous sandstone and calcareous mudstone in the San Vicente area and is relatively homogeneous stratum in another areas. On the other hand, the dolostone of the V member is muddy facies in the San Roque area. Also, the dolostone of the III member is almost crystallized and there, sulphide crystals grow with the dolomite by recrystallization clearly. As compared with this dolostone, the dolostone of the V member is dolomicritic and includes the fossils inhabited at shallow sea, detrital quartz, chalcedonic quartz, clayey materials, etc.

As for the sulphide minerals, only a few microspheres of pyrite and sphalerites were recognized under microscope, but the larger the dolomite crystals are grown up, the more these sulphides are enlarged till being recognized by naked eye.

The dolostone included over 10 % magnesium (here in after Mg) is composed of muddy size (<0.01 m) dolomite grains or of megacrystallized dolomite by recrystallization, thus both forms of dolomite are different with each other only in crystalline state not in Mg content.

According to FRIEDMAN (1967), it is considered that syngenetic dolomite which is formed penecontemporaneously in its environment of deposition as a micrite, grows up in recrystallized affect.

(4) Sedimentary environment of the Pucara Group

Strontium contents included in all carbonate rocks of the surveyed area but muddy to sandy limestone of the II member, are 10 to 390 ppm in analytical value. From these contents it might be confirmed that almost carbonate rocks were deposited in shallow sea reef environment mentioned by CHESTER (1965) etc. Barium sulphate is included from 600 to 3,000 ppm, and these values are extraordinarily higher than those CHESTER (1965) showed. There is a high grade sample over 2 % in barium sulphate.

Also gypsum was discovered in the San Vicente area and Pusagno area. From considering, existence of condensed barium sulphate and gypsum, carbonate rocks would be formed within strongly evapolated environment.

(5) Back-reef environment on the Mitu Group

It is clarified, by trenching survey in the San Roque area, that the Mitu Group of 100 to 400 m in width is sandwiched in parallel to the strike direction of the Pucara Group, and also in the Pusagno area to 30 km south of this area, the survey in 1977 confirmed that the Mitu Group is distributed. Viewing from the point of geological structure, geoanticlinal movement in large scale of NNW-SSE direction axis are developed along western highland and the east part of the Cordillera Oriental.

The Mitu Group in the San Roque area exist horst-like structure in the Pucara Group in fault relation maintaning the distance of 1 to 5 km, from the east of the geoanticlinal structure. Originally, these structures are thought to be raised up by lurked igneous rocks related to the geoanticlinal movement. It is elucidated that the sedimentary basin of the Pucara Group is devided into two parts as the result of above mentioned relation, and the Mitu Group as the basement of barrier reef have caused the changing effect to the sedimentary environment. In other words, the Mitu Group is thought to have played a great role on the formation of back reef environment in need of mineralizing dolomite.

Also in the east of the San Vicente area, the Mitu Group is distributed and the paleoenvironment of this group is considered to be the same sedimentary environment as that of the V member in the San Roque area.

(6) Genesis of Dolomite

A primary dolomicrite was exactly recognized within dolostone of the surveyed area, and this mineral would be formed in the strongly closed back-reef paleoenvironment. Accordingly, the process of dolomite forming is elucidated as follows with reference to the explanation of FRIEDMAN (1967) and others:

① Precipitation of aragonite and low-Mg calcite from sea water including calcium content.

② Substitution to proto-dolomite and high-Mg calcite by Mg bearing hypersaline brines derived from the evapolation of sea water.

③ Invertion and replacement to dolomite through diagenesis.

(7) Formation of the Zebra-Structure

It had been presumed that the zebra-structure observed in dolostone was formed by segregating into spaces caused by structural movement. Now, the zebra-structure is not always concordant to the geological structure. It was reported by CHILINGAR (1967) that open spaces are formed at the maximum ratio of 12 to 13 % as the transition from calcium carbonate to dolomite. These spaces are also the passage of hypersaline brines not so far as they blocked up. Then they are enlarged in scale while the transition is promoted the successive dolomitization. Also, it is explained that the zebra-structure was formed to be caused a continuous enlargement of spaces paralleled to a bedding plane and there was occured the crystallization of dolomite megacrystals. Well, the black parts in the zebra-structure are constituted of dolomite. The dolomitization of these parts is a little later than the formation of white megacrystals in geological time and seems to be performed by connate brines.

(8) Geochemical Anomalies on Rocks

It has been clarified that two types of anomalies, as the one is called San Roque type anomaly corresponding to high values and the other is Tambo Maria type anomaly to low values, are recognized by geochemical survey on carbonate rocks (Chapter 8: Fig. 3 (1), (2)).

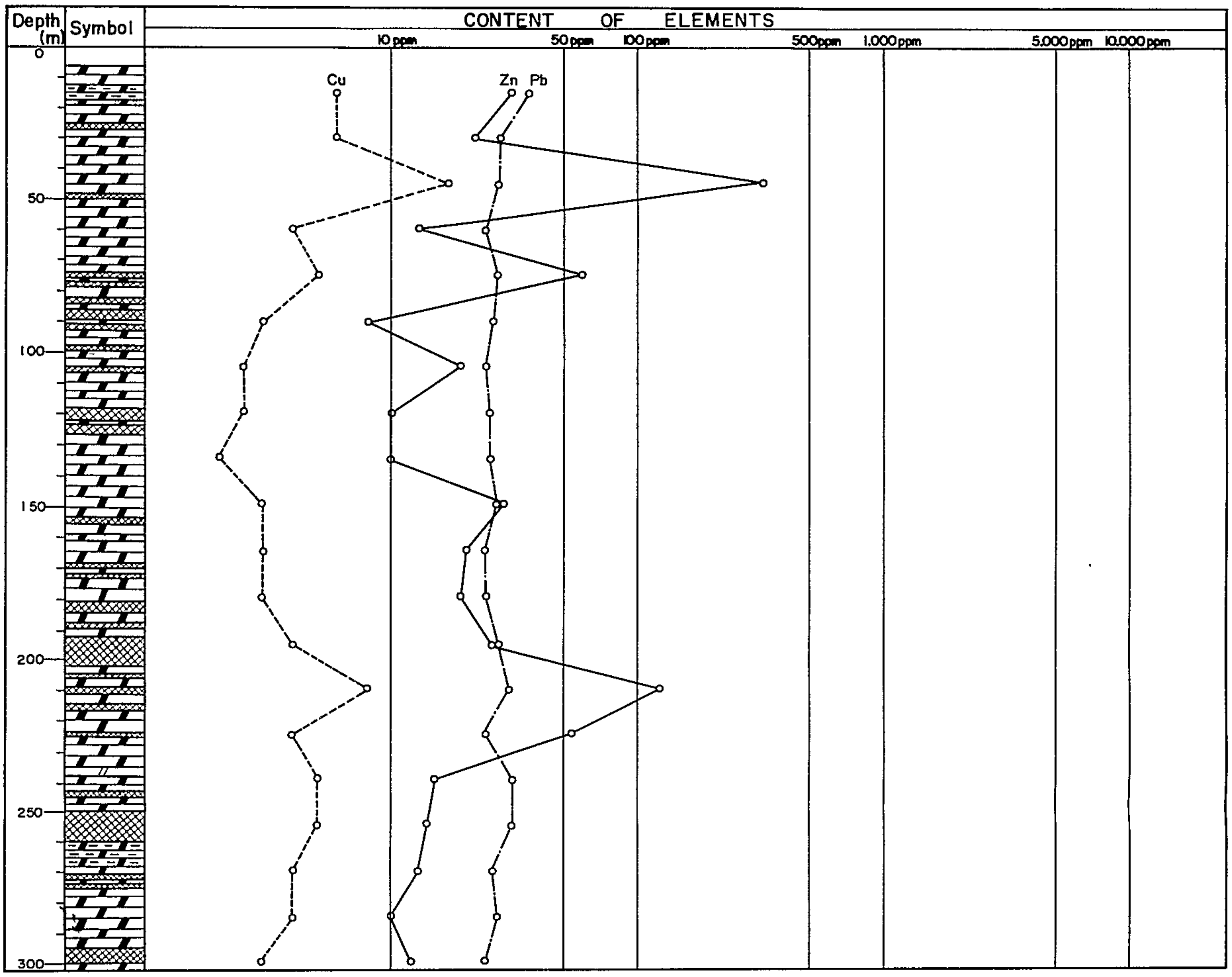
In the north of the San Roque area where the fracture filling type Pb-Zn ore indications were discovered, San Roque type anomalies are recognized on a small scale. On the other hand, in the south where limestone including the disseminated type Pb-Zn indications is mainly distributed, these anomalies are recognized on a large scale. Therefore, it is clarified that the relation to mother rocks in other words, whether limestone or dolostone, becomes different in the scale of anomalies. Dolostone is formed by dolomitization through diagenesis. According to this fact, it is concluded that the transferring of the metallic elements with dolomitization is proved the differences of geochemical anomalies. The Tambo Maria type anomalies are distributed mostly along dolostone and the Tambo Maria ore indication is embedded in the zebra-structure of this dolostone. Such type of anomalies show the remobilization of the metallic elements in association with the formation of zebra-structure.

(9) Genesis of Ore

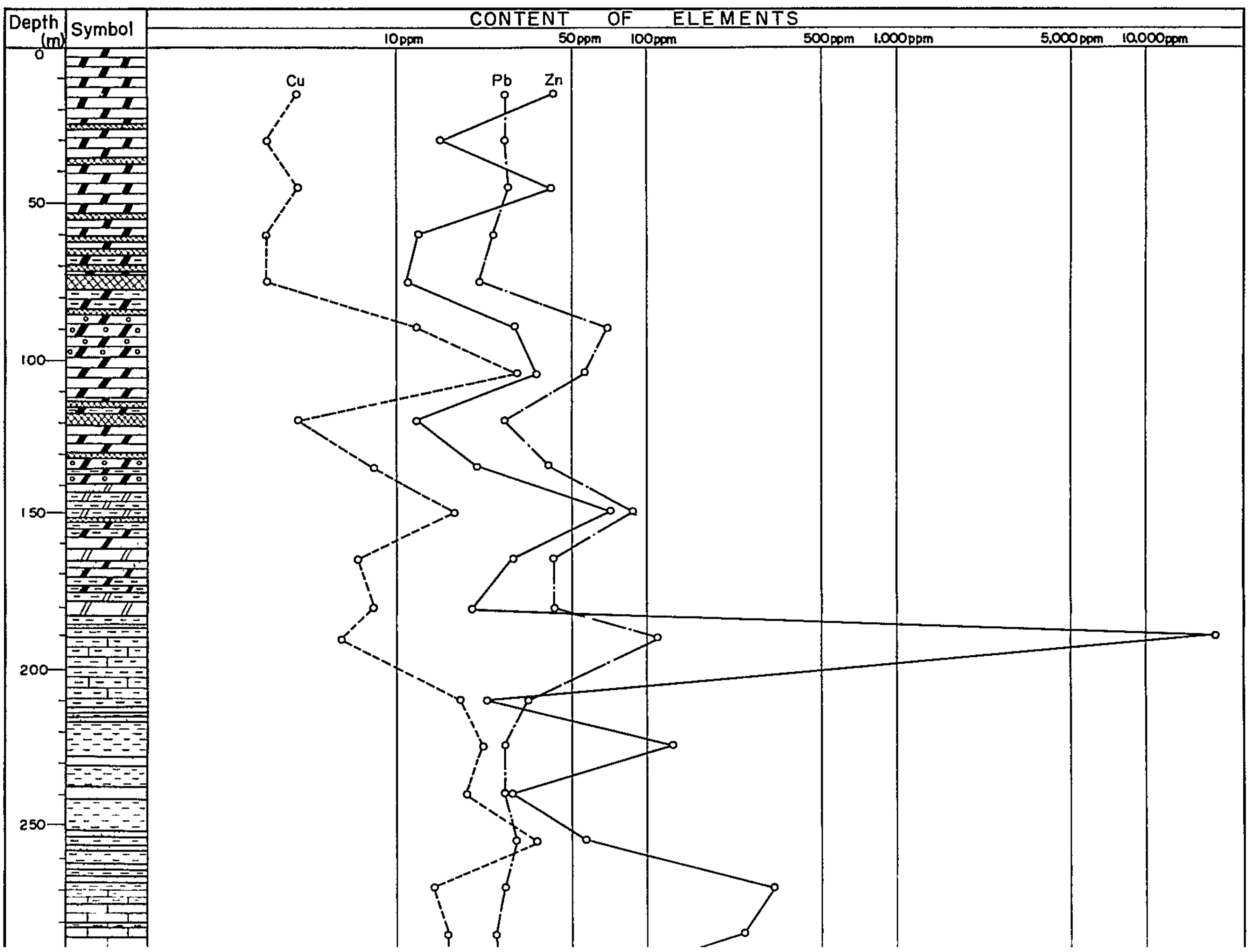
Neither alteration caused by igneous activities nor intercalated volcanic material showing submarine volcanism is recognized around the strata-bound lead-zinc ore deposits in the surveyed area. Therefore, it can be said that ore minerals are not derived from any places where igneous activities including submarine volcanisms are continued, but these minerals as salts or comlex salts are supplied from the metallic elements included in older rocks such as the Mitu Group outcropped in the west side of the surveyed area. The metallic salts seem to be precipitated as primary sulphides at the same time when carbonates are deposited in the weakly acidic or neutral environment where organic materials, sulphuric bacteria, methane gas, and carbon dioxide coexist together.

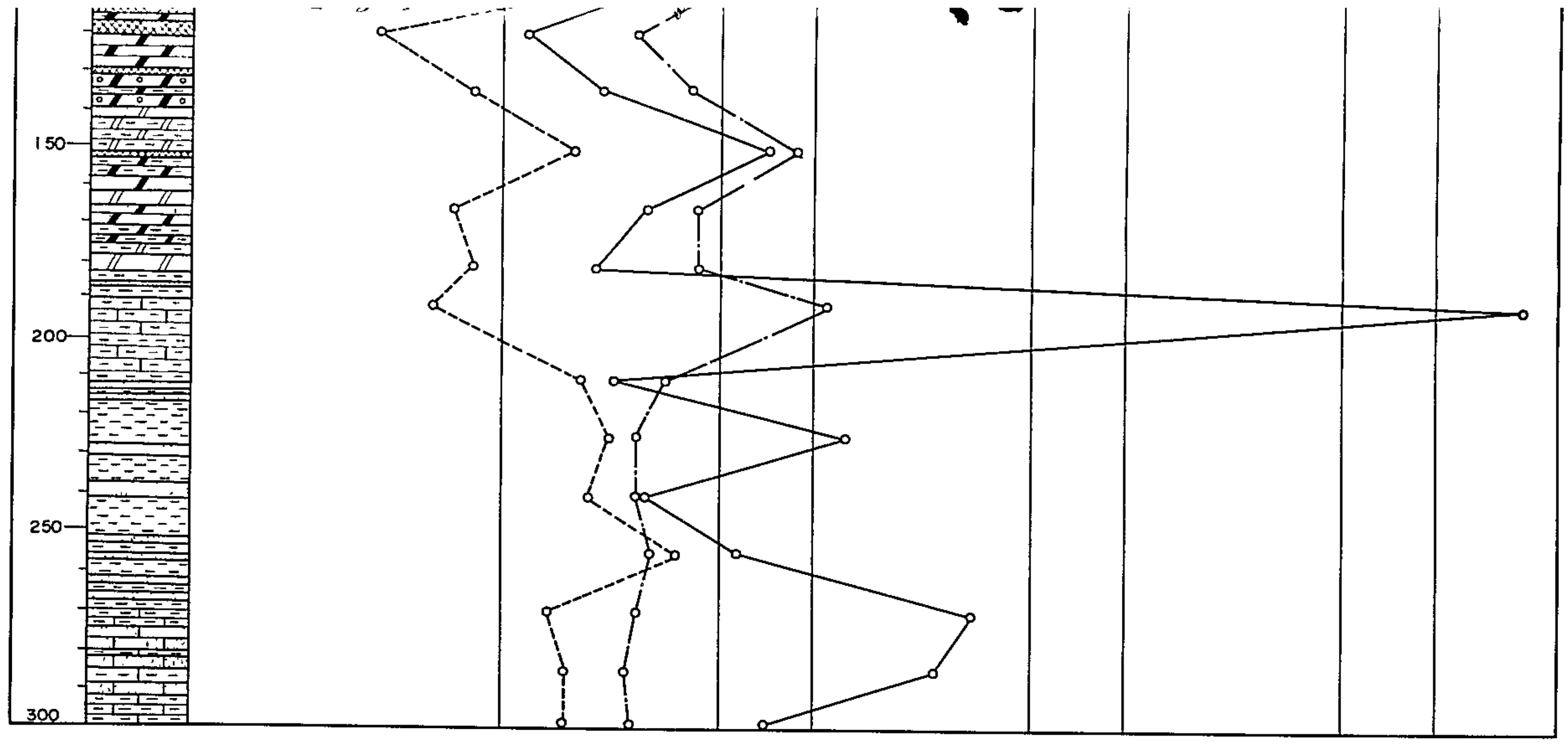
The strata-bound lead-zinc ore deposits in this surveyed area can be classified into three types such as the disseminated type, fracture filling, and banded, from the occurences. Each average value of Zn content in three types shown as n x 10^2 to n x 10^3 ppm, 3 to 4 %, and 10 to 20%. The last value represents the banded type most concentrated. On the other side, from the results of the geochemical survey, it can be thought that the geochemical anomalies are influenced by the presence of the transferring and concentration on primary sulphides. Under microscope, it is clarified that sulphides are gathered and are grown up accompanying with the crystal growth from dolomicrite to dolomite megacrystal in dolostone. In dolomitization, in other words, in the process from aragonite and Mg-bearing calcite to dolomite, an increasing of porosity is well known. Sulphides seem to be transferred through these pores by hypersaline brine and to be condensed. The place for making spaces would be the face on which dolomite crystals are grown up, and this process can be thought to result in the fracture filling type concentration. Also banded type ore deposits seem to be formed in continuation of this process. Finally, it is explained that the sulphide minerals are transported and gathered in spaces where the zebra-structure is continuously formed by hypersaline brine exhausted on compaction, then the enlargement and the forming banded ores are kept on there.

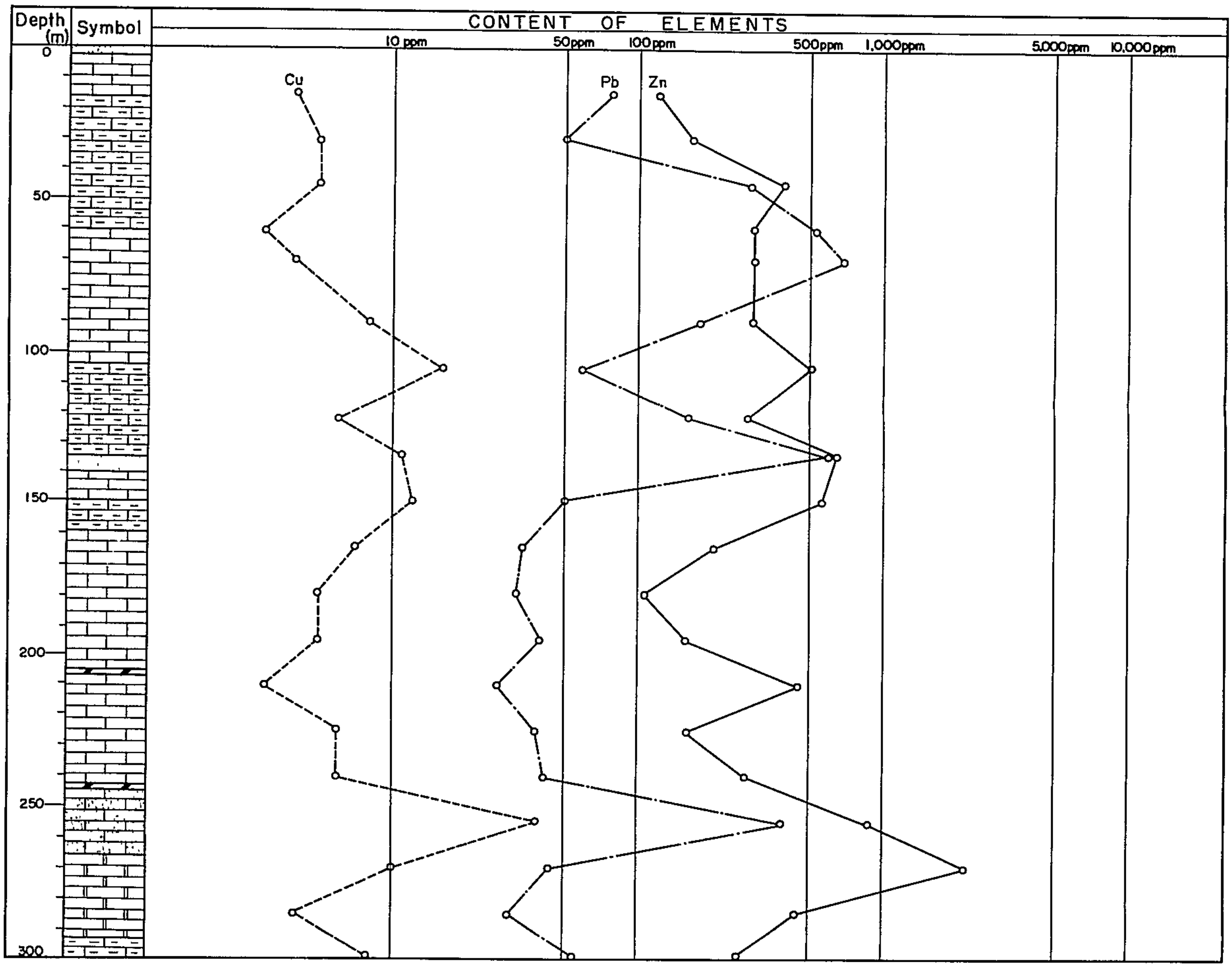
No. 53- MJ 1



No. 53- MJ2







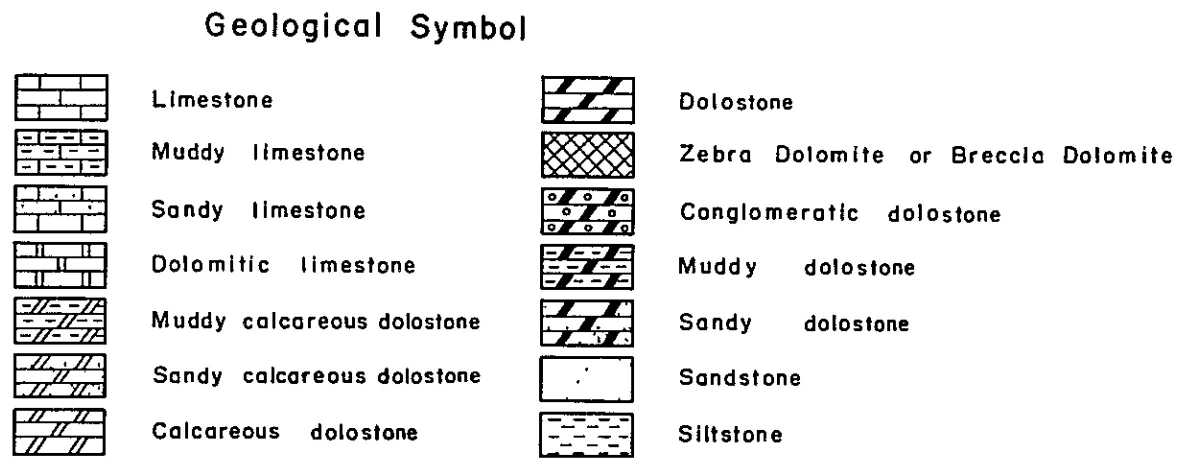


Fig.7 (2) Results of diamond drilling in 1978.

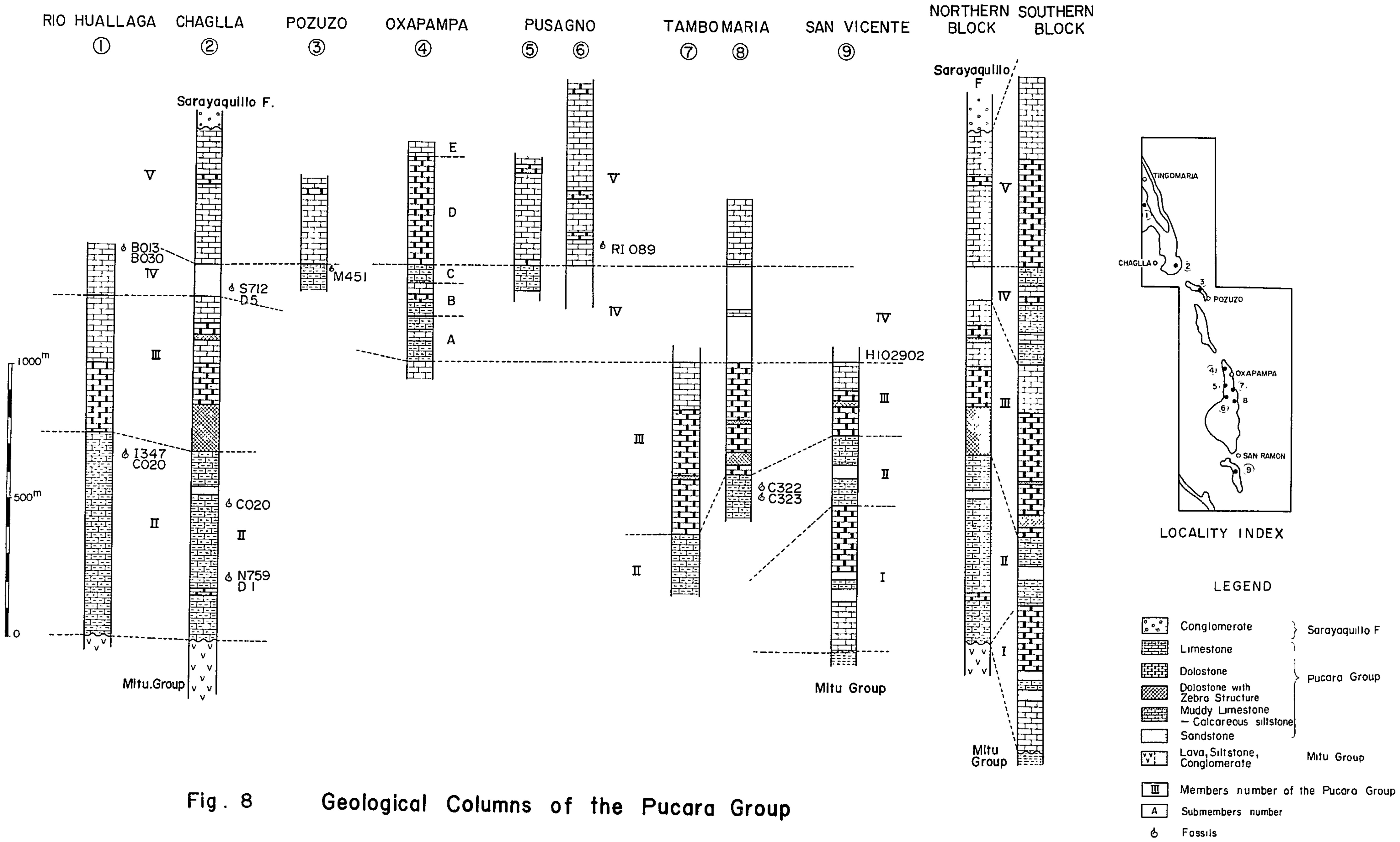
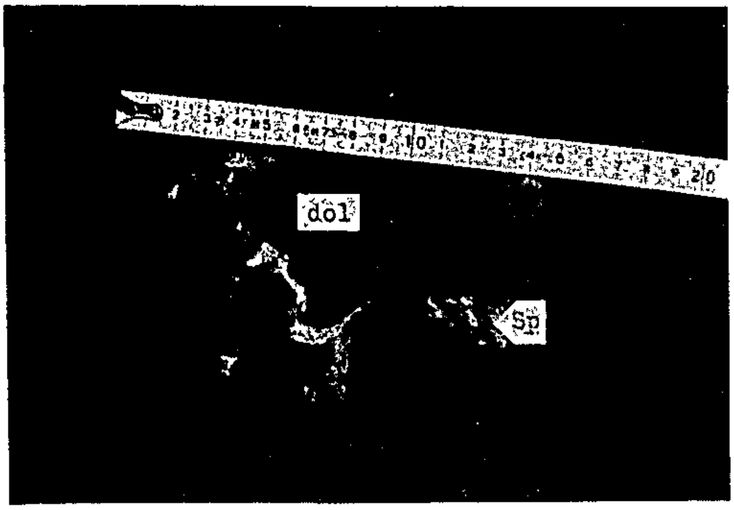


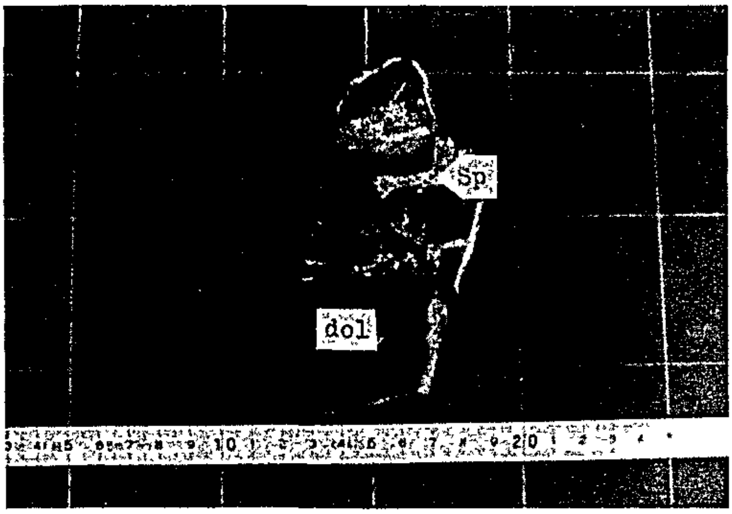
Fig. 8 Geological Columns of the Pucara Group

Fig. 9 Photographs of ores,



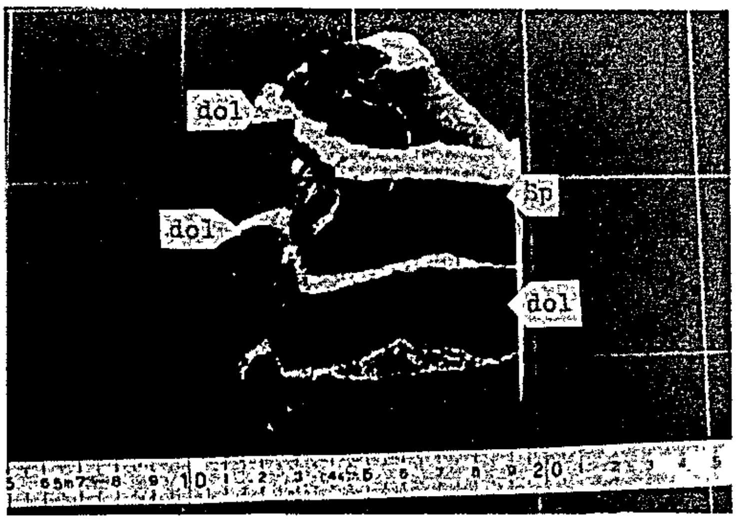
Sphalerite ore of the San Roque trench T-28.

Sp : Sphalerite
dol: Dolostone



Sphalerite ore of the San Roque trench T-28. (Polished)

Sp : Sphalerite
dol: Dolostone



Sphalerite ore of the San Vicente mine. (Polished)

Sp : Sphalerite
dol: Dolomite