REPORT
ON
THE MINERAL EXPLORATION
IN
THE PACHAPIRIANA AREA
REPUBLIC OF PERU

(PHASE Ⅰ)

MARCH 1989

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

PREFACE

In response to the request of the Government of the Republic of Peru, the Japanese Government decided to conduct a Mineral Exploration in the Pachapiriana Area Project and entrusted the survey to the Japan International Cooperation Agency (JICA) and the Metal Mining Agency of Japan (MMAJ).

The JICA and MMAJ sent to the Republic of PERU a survey team headed by Mr. Hiroshi Hama from October 17 to December 30, 1988.

The team exchanged views with the officials concerned of the Government of the Republic of Peru and conducted a field survey in the Pachapiriana area. After the team returned to Japan, further studies were made and the present report has been prepared.

We hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

We wish to express our deep appreciation to the officials concerned of the Government of the Republic of Peru for their close cooperation extended to the team.

February, 1989

Kensuke Yanagiya

KENSUKE YANAGIYA
Presidente
Japan International Cooperation Agency

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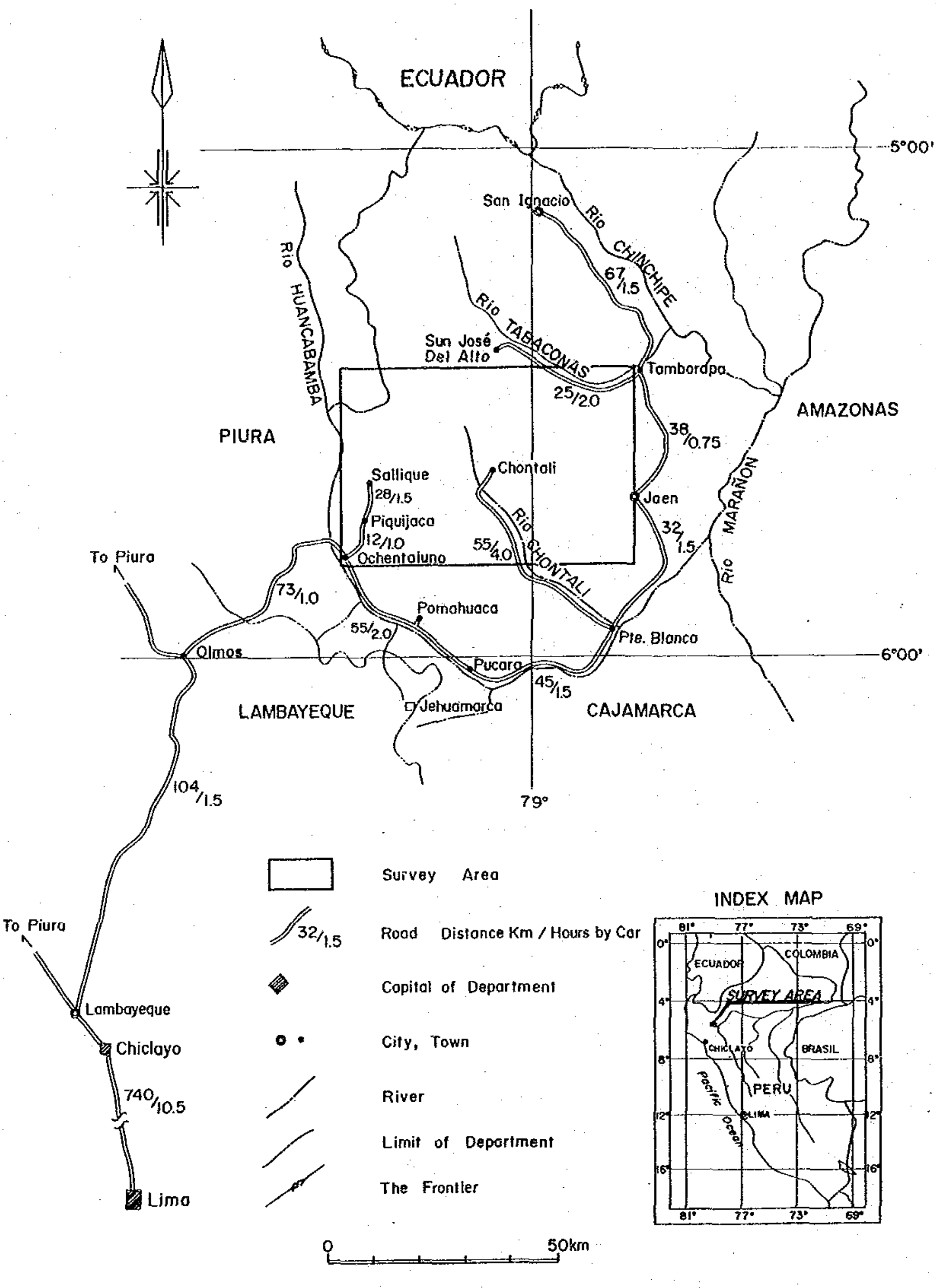


Fig.I－1 (1) Location and Accesibility Map of The Survey Area

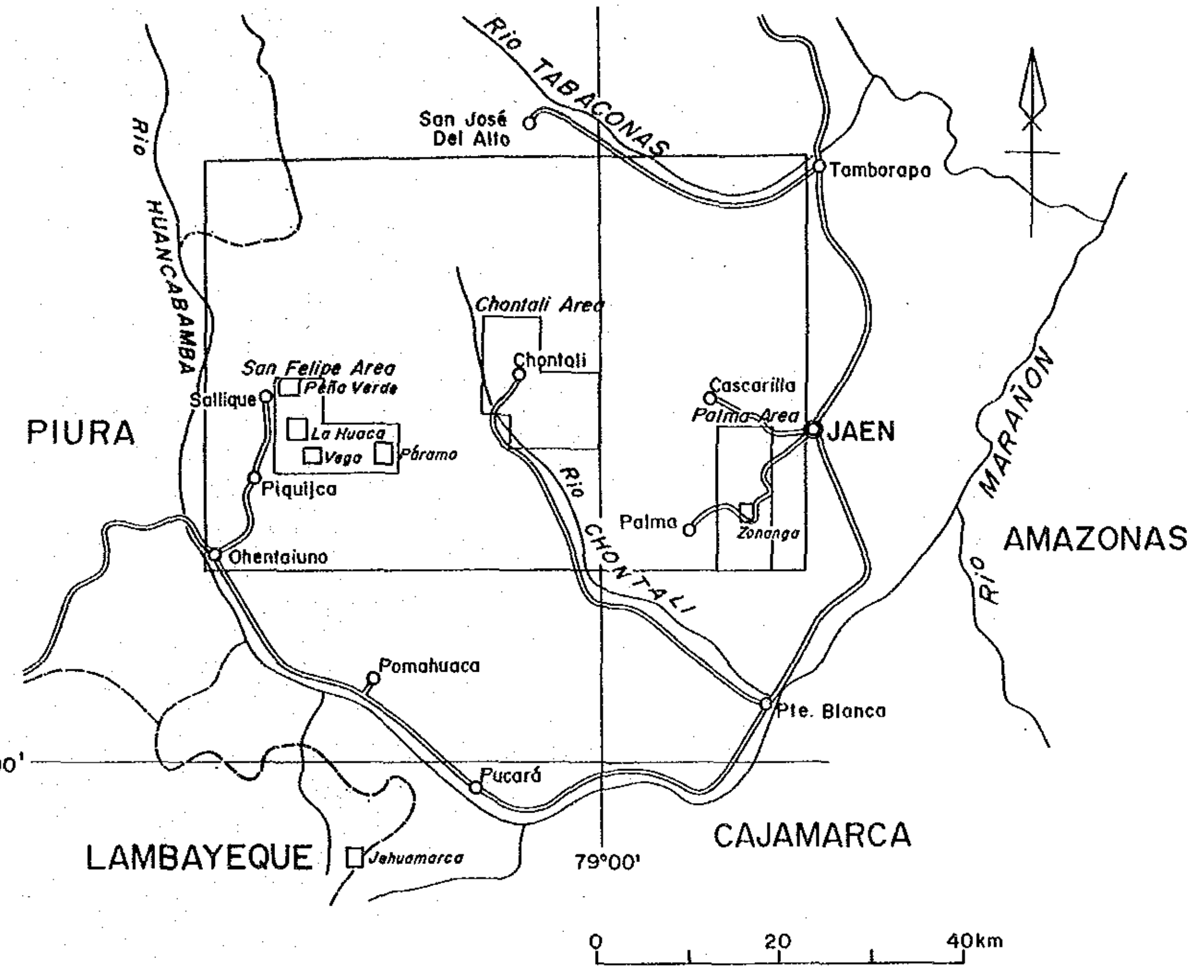


Fig.I－1 (2) Location Map of the Survey Area

SUMMARY

This report summarizes the first year results of the surveys conducted in the Pachapiriana area, Peru. The surveys aimed to reveal potentiality of existence of useful mineral resources in the area through clarification of geological setting in the area. The field survey was carried out from October to December, 1988.

In the surveyed area, as containing geochemical anomalies from a stream sediment and mineralized indications extracted by INGEMMENT (Instituto Geologico, minero y Metalurgico), the first year survey included a semi-detailed geological survey combined with geochemical survey which was conducted over a total area of 300 km² in three regions to verify latent potentiality of mineral resources, and to reveal a geological setting of mineralized indications. An additional detailed geological survey was also conducted over a total area of 25 km² at six known mineralized zones (Fig. I-1(2)). In three of these known mineralized zones, which had been assessed prospective through the result of studying of available data, geophysical survey (using the CSAMT method) was implemented over 25 km² with 102 points dispersed throughout the area.

Through the aforementioned semidetailed and detailed geological surveys, the geological setting of each mineralized zone was uncovered in the San Felipe area (Fig. II-5), where occurrence of such mineralized indications had been known. As the result of these surveys, the possibility of existence of porphyry copper type deposits was conceived between La Huaca and Pena Verde (Table I-2). Indications of promising alteration zone (Table I-2) containing abundant auriferous quartz veins were extracted in the Chontali area (Fig. II-18), and porphyry copper type mineralized alteration (Table I-2)and skarn zones observed in the Palma area (Fig. II-20). This skarn zone was decided to barren by geochemical survey. In Jehuamarca area (Fig. II-22), a distnict alteration zoning was verified.

Geophysical exploration adopting the CSAMT method was conducted in San Felipe over an area of 21 km², and in Jehuamarca over an area of 4 km².

Low resistivity was observed at La Huaca and Pena Verde, where there are known mineralized zone, amid high resistivity volcanic rock distributions in the survey area of San Felipe (Fig. I-16). This low resistivity distribution extends mainly over small-scale monzonite or andesite intrusive dykes, thus coinciding with the silicified and argillized zones distributed at the

surface.

In the Jehuamarca area, whilst the silicified zones distributed at the surface were analyzed to continue as a high resistivity layer forming a mushroom-like shape toward deeper in underground, the analysis also revealed evidence of a low resistivity area occurred the surrounding parts at a specific depth (Fig. II-20, Fig. II-26).

It is assumed from the analyzed geolgical condition that the low resistivity zones collected in both San Felipe and Jehuamarca areas are connected with the trending and scale of the mineralized alteration and/or magmatism deep in the underground, which would relate to mineralized indications.

For the further survey, it is necessary to conduct detailed geological and geophysical surveys in Chontali Area, with respect to extracted prospective mineralized indications and alteration zones found out this year. Second proposal includes further implementation of boring in Jehuamarca to specifically identify mineralized potentials. In addition, this year survey has been extended to the anomalous zones revealed from geochemical exploration previously conducted by INGEMMET and without fail a promising mineralized zones and/or alteration zones that indicate a possibility of existence of ore deposits (Fig. III-1). In the further year, therefore, semidetailed or reconnaissance survey be carried out in the anomalous zones remaining pending survey.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF PLATES

LIST OF APPENDIXES

PART I

GENERAL REMARKS

CHAPTER 1 INTRODUCTION

1-1 Antecedents and Purpose of the Survey

The survey area is situated in a part of the region for which a geochemical survey using stream sediments was carried out under the Northern Geochemical Project (Proyecto Geoquemico del Norte) sponsored by the U.K. The detailed survey for the extracted geochemical anomalous zones was realized partially by INGEMMET itself, and partially by German and French organizations. However, the major part has remained pending due to shortage of funds.

Under these circumstances, INGEMMET requested, through the Ministry of Foreign Affairs of the Republic of Peru, a technical cooperation from the Japanese Government for the follow-up survey in March 1988. In August 1988, a delegation for the preliminary survey and agreement negotiations for this purpose was organized among the Ministry of International Trade and Industry (MITI), Japan International Cooperation Agency (JICA) and the Metal Mining Agency of Japan (MMAJ), and sent to Peru. On August 15, 1988, the scope of work to the Pachapiriana Area Project was signed between the parties.

The purpose of this survey was to verify the potential existence of usable mineral deposits expected in the survey area through various activities, including an analysis of existing data, preparation of lineament extraction based on the LANDSAT image analysis, geological, geochemical and geophysical surveys and boring survey.

1-2 Area, Purpose and Operation of the First Year's Survey

According to the mentioned scope of work concluded among INGEMMET, JICA and the Metal Mining Agency of Japan, the survey encompasses an area of 2,820 km^2. This year, the LANDSAT image analysis was conducted throughout the area while geological and geochemical surveys covered an area of only 304 km^2.

The purpose of the first year survey was the following:

i) lineaments extraction through LANDSAT image analysis of entire survey area (2,820 km^2) and to define the interrelation between such lineaments and existing mineralized indications and extracted geochemical anomalies by INGEMMET; ii) to clarify the geological setting of the known mineralized indications and the origin of the geochemical anomalies with carrying out a geological survey in the known mineralized indications and extracted geochemical anomalies by INGEMMET ; iii) to evaluate the known mineralized zone and the newly extracting one with carrying out the detailed geological survey within the known mineralized zone and the newly extracting promising mineralized zone by this year's survey ; iv) to look for the possibility of an existence of concrete mineral deposits for using geophysical survey (CSAMT method) in the most promising mineralized indications.

The survey was conducted as follows:

A topographical map on the scale of 1/25,000 published by IGN (Instituto Geografico Nacional) was used as the base map for the survey. The survey was carried out by three composite teams of both Japanese and Peruvian engineers in the San Felipe area, and five teams for the Chontali and Palma areas.

The detailed survey was carried out using string measures and clinometers and/or clinocompasses with a scale of 1/5,000 by three teams.

Geochemical survey was carried out together with geological survey. Sampling density was changed according to the mineralized or alteration conditions of each surveying area. Importance was given in sampling the Chontali area in the semidetailed survey, and the Jehuamarca area in the detailed one.

Trenching was conducted at La Huaca in the San Felipe area for its silicified rock distribution zones within the La Huaca detailed survey zone to identify their distribution extent. A peruvian engineer was stationed on the trenching site, being responsible for supervising workers for trenching. Upon completion of the trenches, the site was sketched on a scale of 1/200 by joint effort between the engineers from both countries, then was refilled.

Geophysical survey using the CSAMT method was performed. Required equipment and materials were mainly transported from Japan with partial local procurement of survey articles. In this regard, the work included grounding, wiring and removal of the transmitting station as well as transmission and receiving for tests in San Felipe and Jehuamarca. In the former area, the base camp was set up in the village of Piquijaca. In Jehuamarca, the measurement team camped out on the mountain's summit.

Sampling of rocks for future tests of their resistivity and IP effect was carried out during measurements in the field and labolatory test for the collected rock samples was conducted after returning to Japan.

The survey of this year is summarized as follow:

Table I－1 Quality of The Survey

	Area, Zone	Geological And Geochemical Survey				Geological Survey	
		Area km^2	Survey Point km^2	Trench m	Geological Samples	Area km^2	Survey Points
*	San Felipe	90	95		79		
*	Chontali	120	163.1		245		
*	Palma	90	146.1		180		
	Total	300	404.2		504		
**	Jehuamarca	4	21.3		73	4	31
**	Pena Verde	4	35.4		26	21	71
**	La Huaca	5		359.7	41		
**	Vega	4	16.4		21		
**	Paramo	5	10.3		20		
**	Zonanga	3	18.0		25		
	Total	25 km^2	101.4 km^2	359.7 m	206 Samles	25 km^2	102 Points

(remark; *:Semidetailed, **:detailed)

1-3 Organization of the Survey Group

The representatives from the Japanese government for the preliminary survey and agreement negotiations were dispatched to Peru during the period from August 6 to 18, 1988. The delegation members and their counterparts from Peru are as shown below:

From Japan:

Mr. Yoshio Matsukawa,	Metal Mining Agency of Japan
Mr. Shootaro Kishimoto,	Agency of Natural Resources and Energy, MITI
Mr. Naotaka Adachi,	Metal Mining Agency of Japan
Mr. Hiroyasu Kainuma,	Japan International Cooperation Agency

From Peru:

Mr. Juan Guillermo Hercilla Gonzalez,	INGEMMET
Mr. Gregorio Flores Nanes,	INGEMMET
Mr. Luis Dyarce Gonzalez,	INGEMMET

The survey group was organized by geological and geochemical survey and geophysical survey team, the former being sent during the period from October 17 to December 30, 1988, and the latter from October 27 to December 8, 1988.

The group members from Japan and their counterparts from Peru are as shown below:

From Japan:

Mr. Hiroshi Hama,	MINDECO; leader of the survey team
Mr. Minoru kamezawa,	MINDECO; geological and geochemical survey
Mr. Osamu Mizuyachi,	MINDECO; geological and geochemical survey
Mr. Fukujiro Miyoshi,	MINDECO; geophysical survey
Mr. Takeshi Yoshimoto,	MINDECO; geophysical survey
Mr. Mitsuyoshi Saito,	MINDECO; geophysical survey

MINDECO:Mitsui Mineral Development Engineering Co., Ltd.

From Peru:

Mr. Cesar Vilca Neira,	INGEMMET; general review and geological and geochemical survey
Mr. Emilio Rojas Rivera,	INGEMMET; geological and geochemical survey
Mr. Carlos Jimenes Velasco,	INGEMMET; geological and geochemical survey
Mr. Luis Quispe Aranda,	INGEMMET; geological and geochemical survey
Mr. Armando Galloso Carrasco,	INGEMMET; geological and geochemical survey
Mr. Carlos A. Gamarra Romero,	INGEMMET; geophysical survey
Mr. Walter Pari Pinto,	INGEMMET; geophysical survey

CHAPTER 2 GEOGRAPHY OF THE SURVEY AREA

2-1 Location and Access

The survey area is located in the northern most of Peru, on the border zone with Equador, being situated in the east slope zones of the Western Andes mountain chain. That is, the area faces the back ridge mountains of the Western Andes on the west, and the Great Amazon Plains on the east.

In terms of administrative jurisdiction, the survey area covers three departments and four provinces. The major part of the area belongs to Jaen province, Cajamarca department, with its north-eastern part falling in San Ignacio province of the same department, and its north-western part in Huancabamba province, Piura department. Jehuamarca, the isolated portion of the survey area, is located in Ferrenafe province, Lambayeque department.

Geographically, according to the Universal Transverse Mercator Projection System, the survey area covers an area of 2,186 km² (44 km x 64 km) situated between 9,400,000N to 9,356,000N and 680,000E to 744,000E, and another area of 4 km² (2 km x 2 km) situated between 9,327,000N to 9,325,000N and 693,000E to 695,000E, thus being represented in a total area of 2,820 km².

The access to each base camp set up in the survey area are as shown in Fig. I-2:

From Lima to Ochentaiuno the road is paved. From Ochentaiuno to Jaen, however, the road has been only partially paved by the road construction project planned under the administration of former President Belaunde. Under current President Garcia's administration, the project was suspended and a major part of the road remains unpaved and without surface repair for the paved portion, thus traffic is very difficult during the rainy season. All minor roads were hastily opened by bulldozer and have not been renovated, therefore, passage is difficult even during the dry season.

There are only a scanty number of road in the survey area (see Fig. I-1). The main access roads are actually for riding on horseback. Even such trails are not yet sufficiently developed in the survey area as vast tropical rainforests still remain unexploited. So, we were forced to organize a path clearing group to obtain the survey routes.

2-2 Topography and Drainage System

The major part of the survey area falls in the Sallique mountain range according to the topographic division of Peru, with elevations of 700 meters to 3,800 meters above sea level, and is topographically steep, which proves that the area corresponds to a typical stage of youth terrain. To the west of the survey area, there is the Western Andes mountain range, which forms the watershed of the South American Continent due to the lowlands of Huancabamba falling in between. The east end of the area is situated in the lowlands of Maranon which presents its older stage having gentle rises and falls.

It is said that the Sallique mountain range was separated from the Western Andes by glacial activity, thus leaving traces of glacial terrains such as U-shaped valleys and glacial cirques in its relatively low lands. Characteristic glacial terrains such as aiguilles, horns and grats are preserved throughout the high lands.

All drainage systems in the survey area discharge into the Atlantic Ocean via the Amazon River. Major rivers include the Huancabamba that runs along the west boundary of the survey area from north to south and changes direction to east-west in the southern part of the area, the Chontali that crosses the center of the area with a NW-SE direction, and the Tabaconas that runs along the north flange. All these rivers join the Maranon, one of the major tributaries of the Amazon in Peru.

With its abundant water resources, the Huancabamba is sought as the source of the irrigation channels to cross the Western Andes mountain chain to provide sufficient irrigation to the vast desert extending over the western part of the mountain range. The operation of tunneling for the project, however, has currently been suspended.

2-3 Climate and Vegetation

Climate and vegetation in the survey area show a particularly remarkable variation due to the altitude difference reaching about 3,000 meters.

Above the elevation of 3,000 meters, the distinctive Puna (high Andean plateau) climate is predominant, thus categorized as part of the cold zone.
Its vegetation consists of aciculate plants locally called 'ichu' and low shrubs which, coupled with steep glacial terrains, is disabling land utilization of these zones.

The zones between 1,500 and 3,000 meters above the sea level are subtropical, having high temperatures and humidity, and form a main agricultural zone. A part of the highland subtropical rainforest zones remains uncultivated, forming a virgin area coupled with its topographical steepens. Because field burning is mainly practiced in the cultivated part of these zones, secondary vegetation grows densely in the area left after burned-over. It is said that precipitation is decreasing in the western

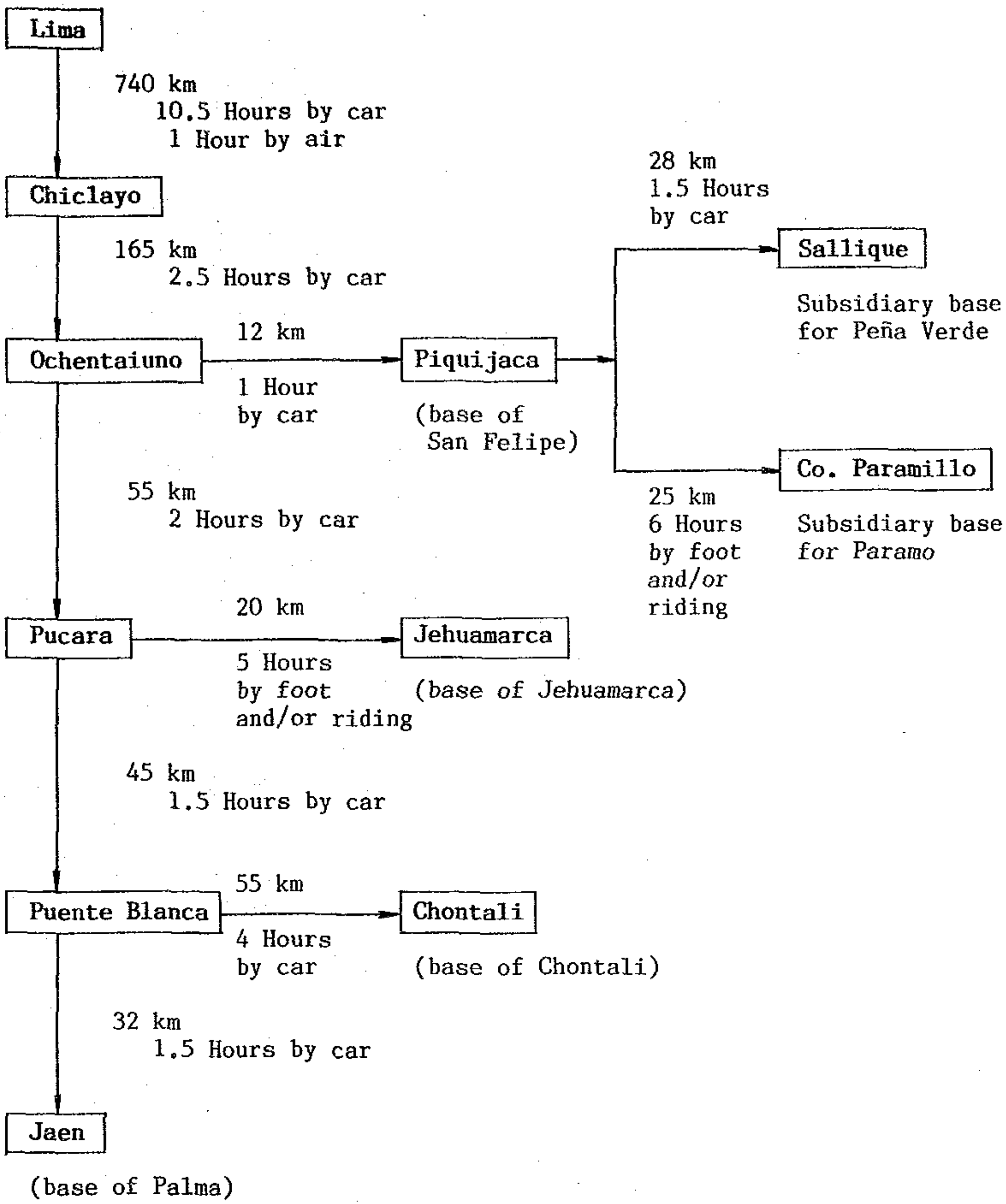


Fig.I－2 Summarized Accesibility in The Survey Area

part of these zones as cultivation advances, gradually making it into a desert, and that there was abundant vegetation downstream the Grande River, a tributary of the Huancabamba, whereas at present what remains is rocky desert.

In old days, the zones below 1,500 meters belong to the high temperature, high humidity tropical rainforest zone. At present, however, after progress in cultivation, the tropical rainforest zones exist only locally along the river basins.

There is a clear distinction between the rainy and dry periods in the survey area. Whilst in the rainy period covering December to March, the annual average precipitation registers 2,000 mm, in the dry period from April to November squallish rainfall occasionally occurs in the eastern part.

As a vast subtropical rainforest zone remaining in the mountainous area assumes the role of a water-holding forest of abundant rainfall in the rainy period, the aforementioned major rivers hold affluent water year-round. These main rivers and their tributaries are cleverly utilized for irrigation of the cultivated area. These irrigation channels were used as important routes for the geological survey this year.

CHAPTER 3 AVAILABLE GEOLOGICAL DATA

3-1 Outline of Antecedents

Though in the past the area of interest has been partially and/or locally surveyed from a geological viewpoint, a regional geological survey had to wait until the quadrangular survey was conducted by INGEMMET (Reyes, L. y Caldos, J., 1987).

With respect to the ore deposit survey, "Proyecto Geoquemico del Norte" was conducted during the period from 1968 through 1970 under the technical assistance of the U.K. government and its follow-up survey was performed by INGEMMET with technical assistance from West German and France governments during from 1971 to 1975, and "Proyecto Integral Chinchipe" which was conducted through 1983 into 1986, are noted among others.

In the "Proyecto Geoquemico del Norte" mineralized indications were found out in Canariaco, La Huaca, La Granja, Jehuamarca, Pena Verde, Paramo and Vega, of which follow-up surveys have been carried out in Canariaco and Jehuamarca by INGEMMET, at La Huaca under the technical assistance of France, and at La Granja under the technical assistance of West Germany. Other mineralized indications were left as is without survey.

In the "Proyecto Integral Chinchcipe", geochemical anomalies were extracted in Tomaque, Huaquilla, Cerro Campaua, El Cedro, Las Pinas, Chontali, Jaen and Zonanga. Follow-up survey for the first four mineralized indications has been commenced in 1986 under the technical assistance of West Germany.

3-2 General Geology and Geological Setting of the Survey Area

An outline of regional geology, including this survey area, is given below after Reyes y Caldos (1987), Wilson (1984) and Davila et al (unpublished). The area situated in a technologically disturbed zone, so-called Huancabamba deflexion zone. This causes a great variation in the sedimentary environment of each geological unit, thus bringing some confusion to correlate geological formation and it requires further study. A geological column in the survey area can be summarized as shown in Fig. I-4. Descriptions are given below for each geological unit in ascending order.

3-2-1 Sedimentary Rocks and Metamorphic Rocks

1) Maranon Complex

This Complex is roughly classified into crystalline schist and gneiss. The former mainly consists of mica schist which is originated of sedimentary rocks, intercalating quartzite and metamorphic arkose sandstone. The latter is tonalitic and/or granodioritic with a banded structure, and can be divided into muscovite-biotite-garnet and muscovite-biotite series.

According to Wilson y Reyes (1964) who named this Complex, an Ordovician system unconformably overlays on this unit (in Pataz,Libertad), and therefore, it can be correlated with the pre-Ordovician system. Metamorphic rocks similar to this Complex distributed in the southern Peruvian coastal area, are given an age of 2 to 0.65 billion years by the Rb-Sr method, and therefore, it is assumed that this Complex would be also correlative with Precambrian Erathem.

They say that the complex distribution in the survey area, appears upstream the Tabaconas River that flows along its northern flange.

2) Olmos Complex

This Complex was named by Baldock (1971) and is correlated with the lower Paleozoic Era. It consists of pelitic and quartz schists with reaching gneiss facies in case of deep facies, originating from pelitic sediments.

In general, lit-par-lit injection quartz are observed, particularly developed in the proximity of the intrusive body.

Although there is no clear evidence proving the geological age of this Complex, it may be correlative with the upper Precambrian Era to Ordovician Period, judging from the fact that it covers the Maranon Complex unconformably , and in turn is unconformably covered by Salas Group.

In the survey area, metamorphic rocks that are distributed in its southwestern part were identified in this Complex.

3) Salas Group

This Group consists of phyllite, pelitic schist and tuffaceous mudstone, with intercalation of quartzite, and unconformably covering on the Olmos Complex. At the base, it occurs basal conglomerate with schist gravels, and it grades into the Rio Seco Formation at the upper part.

This Group is correlative with the lower Ordovician to Siluro-Ordovician period based on the fossils found, although scarce.

This Group is distributed upstream the Huancabamba River in the northwestern flange of the survey area and midstream the Tabaconas River at the center of its north flange.

4) Rio Seco Formation

This Formation consisting mainly of quartzite with phyllite, conformably covers the Salas Group. Although it is not easy to identify its age as no fossils were found, it can be correlated with the Siluro-Ordovician period from its occurrence.

Distribution of this Formation is not clearly identified in the survey area.

5) Oyotun Volcanics

These Volcanics were named by Wilson (1984). They unconformably cover the Olmos Complex, and are conformably covered with the Goyllarisquizga Group. In the western survey area these Volcanics are unconformably covered by the Tinajones Formation.

The lower part of these Volcanics consists of andesite lava and pyroclastics with some occurrences of intercalation of limestone and phyllite, and toward the upper changing to andesite and/or meta-andesite. At the uppermost, pyroclastic rocks become predominant, with intercalation of shale, mudstone and siliceous limestone.

Because its main component is of volcanic rock, fossils are scarcely occurred. However, based on the fossils very rarely found, they can be correlated with the upper Triassic period.

These rocks are the main unit forming the survey area, and their distribution is widespread over the area.

6) Tinajones Formation

This Formation was named by Wilson (1984). It unconformably covers the Oyotun Volcanics and consists of sandy sediments mainly with tuffaceous rocks. Toward its upper part, the intercalating quartzite increases, and then grading to the *quartzite sequence of the Goyllarisquizga Group. To the east of Pucara,* this Formation is absent but Farrat formation is directly sedimented over Oyotun Volcanics.

The Formation has been correlated with the Berriasian and/or Neocomian in age from its yielding of abundant fosils.

In the survey area it occurs at west flange.

7) Goyllarisquizga Group

This Group has been identified to consist of Chimu Formation, Santa Formation, Carhuaz Formation and Farrat Formation (Bellido, 1969). However, in the area is only described quartzite correlated with Chimu Formation and quartzite with intercalation of shale correlated with Farrat Formation, they say that limestone and alternation of sandstone and shale correlated with Santa Formation and Carhuaz Formation respectively are absent.

Goyllarisquizga Group is distributed at the west flange, central part (Chontali area) and north flange of the survey area.

8) Inca Formation

This Formation unconformably covers Goyllarisquizga Group and is conformably covered by the limestone of the Chulec Formation. Its base consists of sandy limestone and calcareous tuff, and banded sandstone is deposited toward the upper. Compact calcareous nodules characteristically occur among the limestone.

Judging from the associated fossils, this Formation corresponds to the lower Albian and is correlative with the Pariahuanca Formation in the central Peru.

The Formation occurs at the western part in the survey area.

9) Chulec Formation

This Formation was named by Benavides (1956) and conformably grades from the underlying Inca Formation and into the overlying Pariatambo Formation. Its lower part consists of marl, and the upper part of limestone containing nodules. Abundant fossils have been yield. Based on these fossils, the Formation is identifiable as middle Albian.

In the survey area, this Formation appears adjointly to the Inca Formation in its western part.

10) Pariatambo Formation

This Formation conformably grades from the underlying Chulec Formation and into the overlying Pulluicana Formation. Its lower part forms an alternation of well bedded limestone and calcareous and tuffaceous shale, toward the upper varying into tuffaceous shale and tuff. The Formation has been correlative with the upper part of middle Albian in age from its yielding of abundant ammonite fossils.

In the survey area, this Formation appears adjoining to the Chulec Formation in its western part.

11) Pulluicana Formation

This Formation was named by Tafur (1950), and conformably grades from the Pariatambo Formation. Its upper part has not been identified, but generally, the Formation is covered by Tertiary volcanics with an unconformity. Overall, it consists of calcareous rocks with interrelation of shale and calcareous sandstone. These rocks have been varied into andesitic volcanics and pyroclastic rocks toward its upper part. Normally, the formation contains abundant fossils, and is correlative with the upper Albian to Cenomanian.

In the survey area, this Formation is distributed adjointly to the Pariatambo Formation in its western part.

12) Llama Volcanics

These Volcanics were named by Wilson (inedited, INGEMMET), and unconformably covers on various geological units and being covered by Porculla Volcanics unconformably.

They mainly consist of andesitic pyroclastic rocks with acidic tuffaceous rocks. In addition, calcareous sandstone, limestone, gypsum and sandstone are accompanied with. It is known that copper, lead and zinc mineralized indications are occurred in these volcanic rocks around Aragoto and Anchalay which are located on the north-west extension of the survey area.

Because of bad-preserved fossils, the age of deposits of these volcanic rocks cannot be accurately determined from such fossils. However, as they unconformably cover on the Chota conglomerate (the upper Cretaceous to the lower Tertiary), they may be correlative with the lower Tertiary, being identified with the lower part of Calipuy Volcanics.

These rocks are not distributed within the survey area, but are found out north-west extension and south outside flange of the survey area.

13) Porculla Volcanics

These Volcanics were named by Baldock (1971), and has an angular uncoformable relationship with the underlying Llama Volcanics and the overlying Shimbe Volcanics.

They mainly consist of andesitic and rhyolitic tuff with intercalation of andesitic tuff breccia and lava. Rhyolitic rock becomes predominant toward the west.

Because of being poor in fossils, there is no clear evidence to identify the age of deposits of these volcanic rocks. Nevertheless, as they unconformably cover the Llama Volcanics, they may be correlative with the lower to middle Tertiary, being identified with Tacaza Volcanics which are distributed in the southern Peru, or the upper of Calipuy Volcanics.

It is reported that these Volcanics are distributed in the valley of the Huancabamba River and downstream the Grande River which is one of its tributaries.

14) Shimbe Volcanics

These rocks are composed of andesite and meta-andesite with pyrite dissemination occasionally, and overlies unconformably on the Porculla Volcanics, and distributed almost horizontally with undulation within 5° to 10°.

Although there is no decisive evidence for determination of the age of deposits, as these volcanic rocks overlie the Porculla Volcanics, they may be correlative with the middle to upper Tertiary, and are assumed to correspond to the Tacaza Volcanics in the south of the country.

These rocks are not distributed within the survey area, but in the north-west extension of the Survey Area.

15) Tamborapa Formation

This formation consists of heterogeneous conglomerate formed of subrounded and rounded gravels, which is composed in various rocks such as intrusive, volcanic, sedimentary and sometimes metamorphic rocks, with loose consolidation, being correlative with the Quaternary sediments.

This Formation is distributed in the eastern flange of the survey area with unconformably covering the Jurassic and Cretaceous Systems.

3-2-2 Intrusive Rocks

Gabbros, diorites and granites are the main intrusive rocks in the survey area. Their ages of intrusion are unknown as there is no an isotopic age determination on these intrusives. However, 100 million years was predicted for the Macara intrusive body which is located in Equatorian Coastal Batholith (Kennerley, 1973). Generally, gabbros and diorites are older than granites which are intruding even into the Porculla Volcanics.

Plutonic rocks such as diorites and granites are distributed with NW-SE or N-S intrusive trends in the southwestern, central and eastern parts of the survey area.

3-2-3 Geological Structure

Geological structure of the survey area is characterized by its situation of which located at the south flange of a distorted zone of general Andean Trend. This distorted zone, so called the Huancabamba Deflection Zone, which corresponds to the area at which the general NNW-SSE direction, the basic characteristic of the Andes, changes direction to the NE-SW trending of the Colombia-Venezuela area. This deflection zone is assumed to have been formed during the Mesozoic tectogenetic movement. This means it is the process of change in the Alpine type geosyncline and/or intercontinental environment rather than in the Andes type continental environment.

Two combinated fault systems are observed in the survey area: one is E-W with NE-NW trending caused by an east-west lateral compressive force, and the other is N-S with NNW-SSE trending by northwest-southeast one. Both these fault systems reflect the tectonic movement at the time when the Huancabamba Deflection Zone was formed.

3-3 Metallogenical Situation of the Survey Area

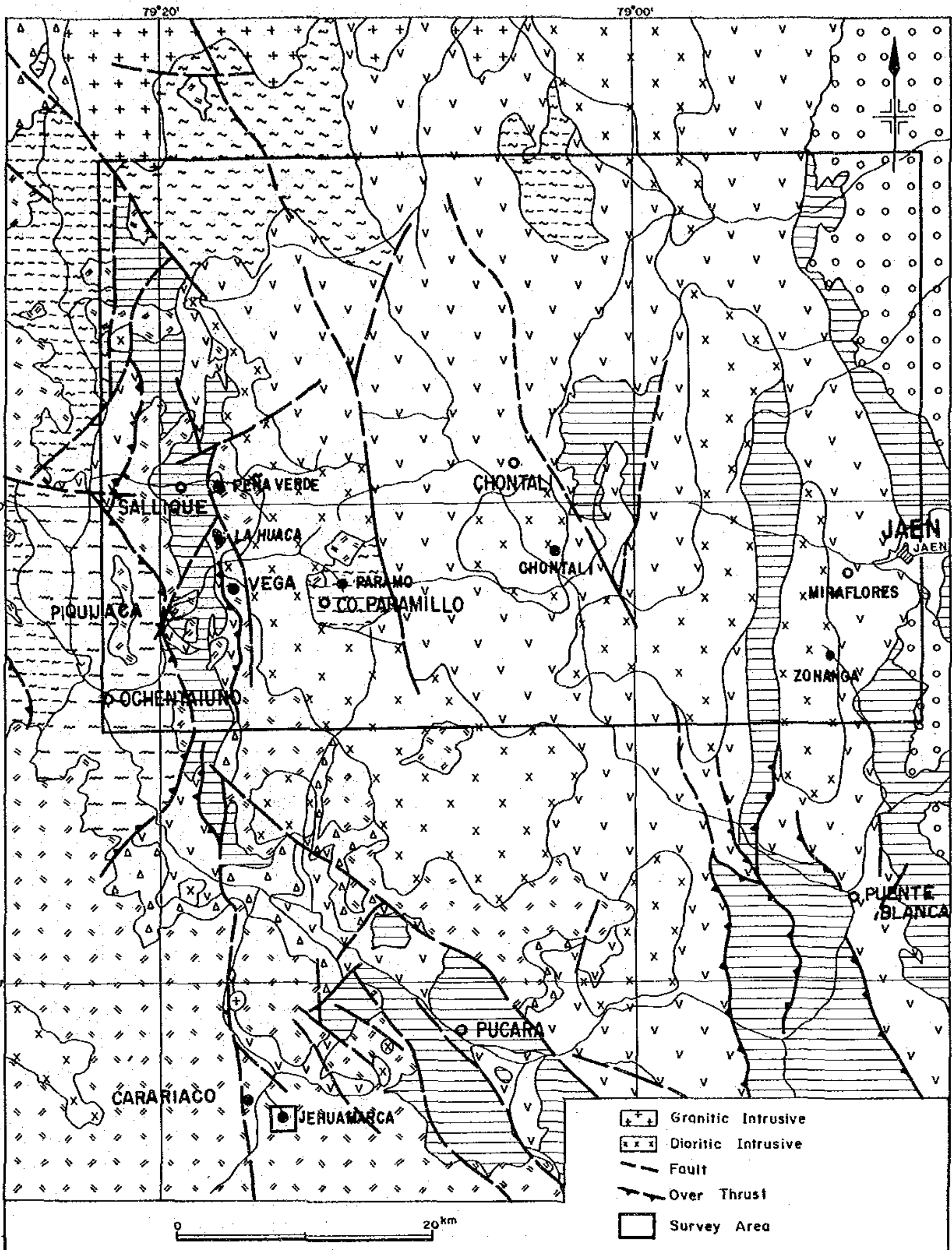
According to metallogenic province of Peru, the survey area is situated at the western metallogenic province, northern cupriferous subprovince and Mesozoic polymetallic subprovince (Ponzoni, 1980).

The northern conpriferous subprovince corresponds to the coastal cupriferous subprovince of the central and southern Peru, nevertheless, important deposits have not been found up to date. The Mesozoic polymetallic subprovince refers to the simple or complex sulfide deposits containing copper, lead, zinc and silver (including occasionally molybdenum, gold and tungsten), which are distributed nearly parallel to the Andean geosynclinal basin from Colombia in the north to Chile in the south via Bolivia. All the major lead and zinc deposits in the country are included in this subprovince.

According to Cobbing et al (1980), the Mesozoic polymetallic subprovince is further subdivided, and therefore, the survey area is subdivided into Michiquillay~La Huaca deposit group (Fig. I-5). In this deposit group, copper mineralization is predominant, because there are porphyry copper deposits such as Michiquillay, La Granja, Canariaco and Turmalina. And in this group polymetallic accompanying with gold and silver vein type deposit is also known such as Hualgayoc and Sorochuco.

In the survey area there are no operating mines in actual, however, it is reported that barite have been mined for use as slurry for oil boring in the south-western flange of the San Felipe area.

In effect, alluvial gold is panned by individuals and/or small groups in the Chontali and Tabaconas Rivers, which suggests the existence of mineralization with containing precious metals, the characteristic of this deposit group previously mentioned.



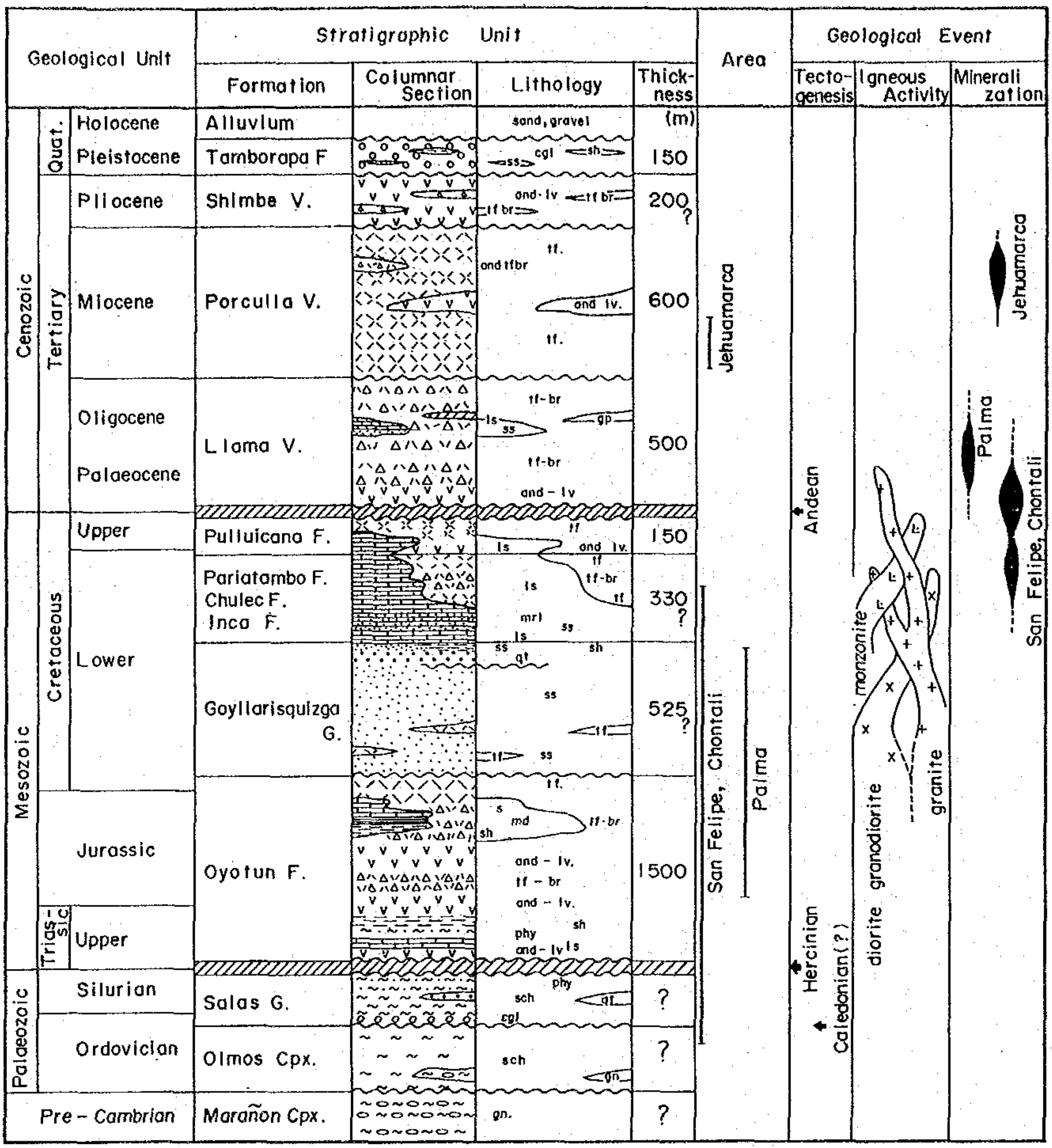
LEGEND

● Mineral Indication   o village

Quaternary	Tamborapa Formation		*Shale, Sandstone, Conglomerate*
Tertiary	Porculla Volcanics		andesite, tuff, tuff breccia
	Llama Volcanics		tuff breccia, Sandstone, limestone, gypsum
Cretaceous	Goyllarisquizga Group		quartzite, Shale, Sandstone, limestone
Jurassic Triassic	Oyotun Volcanics		andesite, tuff, tuff breccia, Shale, limestone
Silurian Ordovician	Salas Group		Phyllite, Schist, quartzite, Conglomerate
Cambrian	Olmos Complex		Schist, gneiss,
Proterozoic	Marañon Complex		gneiss

Fig. 1 – 3 Generalized Geological Map of The Survey Area

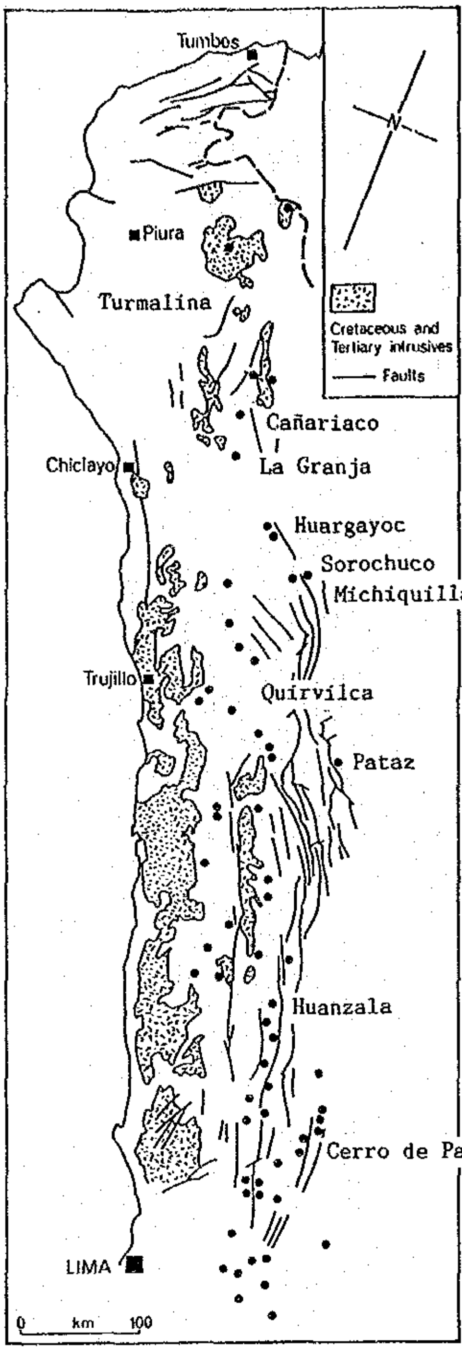
after Wilson (1984), Reyes et al (1987) and Davila et al (inedited)



Abbreviations.

and	andesite	gn	gneiss	md	mudstone	sch	schist
acd	acidic	gp	gypsum	mrl	marl	sh	shale
br	breccia	ls	limestone	phy	phyllite	ss	sandstone
cgl	conglomerate	lv	lava	qt	quartzite	tf	tuff
F.	Formation	V.	Volcanics	G.	Group.	Cpx.	Complex

Fig.I—4 Generalized Stratigraphic Column of The Survey Area



Location of Mines and Major Mineral Deposits

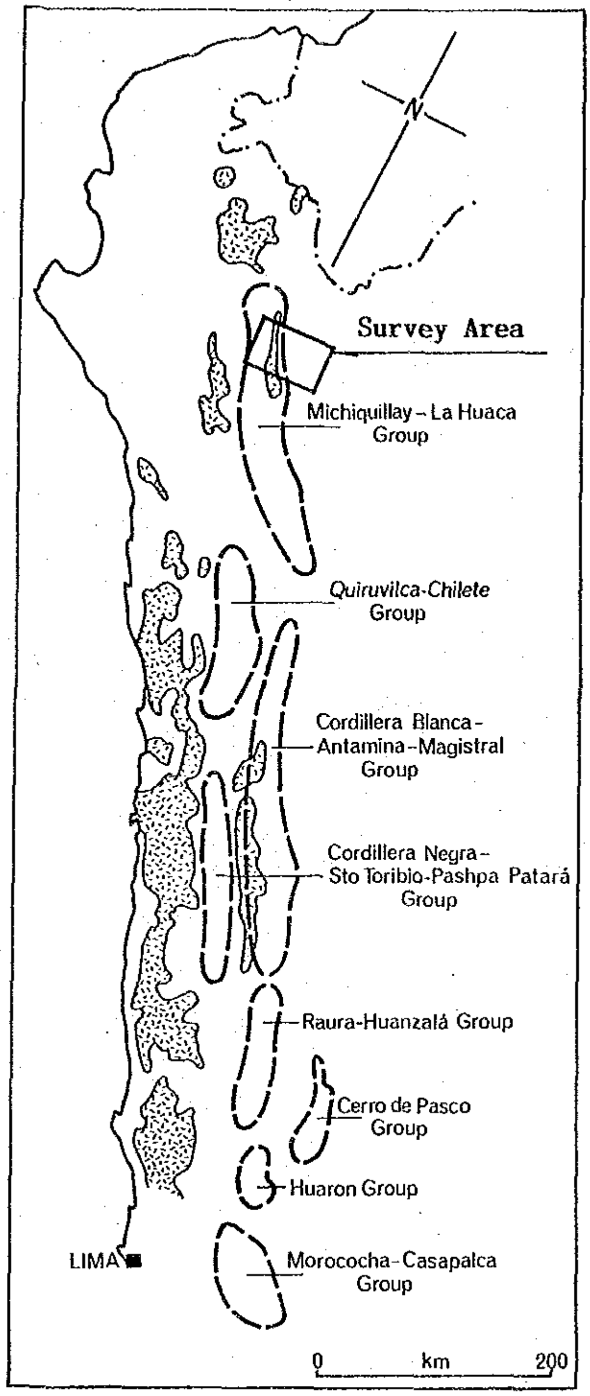


Fig.I−5 *Group of Mineral Deposits within The Mesozoic Polymetallic Province*

After Cobbing et al (1981)

CHAPTER 4 SURVEY RESULTS, COMPREHENSIVE ANALYSIS

4-1 Characteristics and Controlling Factors of the Mineralization

This survey area is regionally located in the Huancabamba Deflection Zone, that is, the area belongs to a distorted zone of the general Andean trend in NW-SE changes to NE-SW trending.

The extracted lineament frequency and its scale based on the LANDSAT image analysis, N15°W trend is distinctive in the region, which is so called Andean trend. The frequency of the lineaments in each semiditaled surveyed area shows that the NNW-SSE trend is predominant both in the Chontali and Jehuamarca areas, and the E-W or N-S lineament in the San Felipe and Palma areas (Fig. II-3) .

According to the field survey, on the other hand, clear fissure system trending NE-SW to NNE-SSW observed in all the areas crossing obliquely with the mentioned lineaments. This may indicate the possible direction of the lateral force that would correspond to the aforementioned major structure, suggesting the cause of the right lateral slip fault observed in the Palma area. Nevertheless, as the depression-like structure of the west side block found in San Felipe area indicates the extension force. It, therefore, will be difficult to explain the entire survey area based on a single force field. Taken in correlation with the compression system in the eastern area and the extension system in the western area, they could indicate the forming process of the Huancabamba Deflection Zone, but we could not reach a firm conclusion this year.

Analyzed in terms of mineralized alteration, the alteration zones were formed along the NE-SW fissure system or those secondary-derived NW-SE fissure system, all found in the field survey. The former was observed in Jehuamarca (Fig. II-22), and the latter in Chontali (Fig. II-18). The mineralized alteration zones found in Zonanga, Palma (Fig. II-22), are the composite type according to an occurrence of the geochemical anomaly, as are those in La Huaca, San Felipe (Fig. II-5) since their monzonite intrusion combine both the NE-SW and NW-SE in trend although apparently the alteration there could be attributable to such intrusion. At Pena Verde alteration zone, the silicified zone expands in a NE-SW direction. Although now these zones have already settled, it is assumed that their alteration occurred along the NE-SW trending fissures originally.

All the case of mineralized alteration mentioned above can be characterized as epithermal. If the relationship between the fissure system and ore mineral is analyzed in each survey area by disregarding the relative situation of each alteration zone, the alteration due to NE-SW trending fissure will relate to base metal mineralization containing Au and Ag (Pena Verde and Jehuamarca), that due to secondary NW-SE trending fissure relates to Au and Ag mineralization (Chontali), and both combined trending fissure to cupriferous mineralization (La Huaca and Zonanga) (Fig. I-6).

4-2 Potentiality of an Existence of Ore Deposits

The survey area contains numerous geochemical anomalous zones with using the stream sediments which were previously sampled by INGEMMET in the "Proyecto Geoquimico del Norte" and the "Proyecto Integral Chinchipe". This year survey was implemented to find out to what origin these anomalies were attributable. As a result, obvious mineralized alteration was verified in the backland of the rivers where is marked geochemical anomaly. Indications of Au and Ag vein type ore deposits in the Chontali area, and of porphyry copper type ore deposits in the Palma area were confirmed, although in these areas there had been no firm mineralization data registered (Perhaps due to the lack of a follow-up study). Therefore, we can conclude that the geochemical anomaly extracted by INGEMMET suggests an existence of mineralized indications.

While no economical ore deposits have been found as yet, the follow-up study of the aforementioned "Proyectos" verified the existence of deposits La Granja and Canariaco ore deposits. In addition, it is reported that a stratiform Au deposit and an epithermal gold deposit have been found in the northern part of this survey area by the "Proyecto Integral Chinchipe:Cordillera del Condor" which is currently under way. It is certain that the area contains promising mineralized area.

The geophysical survey conducted this year confirmed a tree-dimensional distribution of mineralized alteration zones in La Huaca, Pena Verde and Jehuamarca, further verifying the high probability of ore deposits in the survey area. In Chontali and Zonanga, the horizontal distribution of mineralized alteration was verified by geochemical survey, suggesting the possibility of an existence of ore deposits comparable with other known mineralized zone in San Felipe area. It is concluded, therefore, that there is possibility to extract some promising ore deposits when a future detailed survey is conducted.

4-3 Relation between Geochemical Anomaly and Mineralization

Geochemical anomalies obtained this year may be classified into driving from mineralized alteration and indicating specific horizons. Although we feel the data may still be insufficient for the latter, they are assumed to correspond to the anomalous values found by geochemical survey, whose distributions were detected in the Salas Group, Chontali. Almost all the detected mineralized alteration, particularly the geochemical anomaly that suggests the presence of alteration zones, may correspond to the zones distributed in the Oyotun and Porculla Volcanics.

The entire picture of the mineralized zones in the survey area is still inferential. *The expected types of ore deposit corresponding to the geochemical* anomaly are described as below.

It was revealed through of boring survey of BRGM, France, that geochemical anomalies of copper, zinc and lead were arranged outward from the center of each respective alteration in La Huaca, which can be categorized as a porphyry copper type mineralization.

In the alteration zones at Chontali, which are categorizable as epithermal Au and Ag vein type mineralization, no evident geochemical anomaly were observed in the vein distributed zone, but the distribution of anomaly of lead and silver was observed in their adjoining surrounds, thus zonal arrangement in this order can be assumed.

The Jehuamarca alteration zones, classified as a base metal dissemination type mineralization containing gold and silver, cover the whole area of the survey, thus lacking regularity. However, they can be closely related to silicified or combined silicified argillized zones where the mineralization is deemed to have been *caused by geochemical anomaly of gold, silver and lead.*

CHAPTER 5 CONCLUSION AND RECOMMENDATION

5-1 Conclusion

This survey area consists of rocks from Precambrian to Cenozoic. Mineralized alteration occurs in Oyotun and Porculla Volcanics, belonging to Mesozoic and Cenozoic, respectively. The alteration is related to the epithermal mineralization occuring mainly through the NE-SW and its subsidiary NW-SE trending fissure systems. It is characteristically accompanied with clay minerals, such as sericite, smectite, kaolinite and sericite-smectite mixed layers.

Geochemical anomaly which overlaps to silicified and/or combined silicified and argillized zones suggest a possibility of an existence of porphyry copper type, epithermal silver and gold vein type, and auri-argentiferous base metal dissemination type ore deposits; the first were found in La Huaca and Zonanga mineralized alteration zones, the second in the Chontali area, and the last in Pena Verde and Jehuamarca.

Geophysical survey result in Jehuamarca shows a mushroom structure of high resistivity zones indicating silicification in areas of low resistivity indicating argillized zone. These high resistivity zones will be an effective prospecting target as the mineralization there probably corresponds to silicification. In the San Felipe area, low resistivity zones indicating argillization were extracted the form of geophysical anomaly from high resistivity zone indicating no altered volcanics.

As for the analytical results of ore samples from quartz veins at Chontali, average values were 1.37 g/ton Au and 7g/ton Ag (from 17 samples), indicating the potential presence of gold and silver veins. Altered rock samples containing dissemimated sulphides from the mineralized alteration zones at Jehuamarca showed 0.80 g/ton Au, 495 g/ton Ag, 0.42% Pb, 0.69% Zn and 0.4% Cu (average of two samples), thus indicating a possibility of an existence of auri-argentiferous base metal dissemination type deposits.

5-2 Recommendations for the Second Year Survey

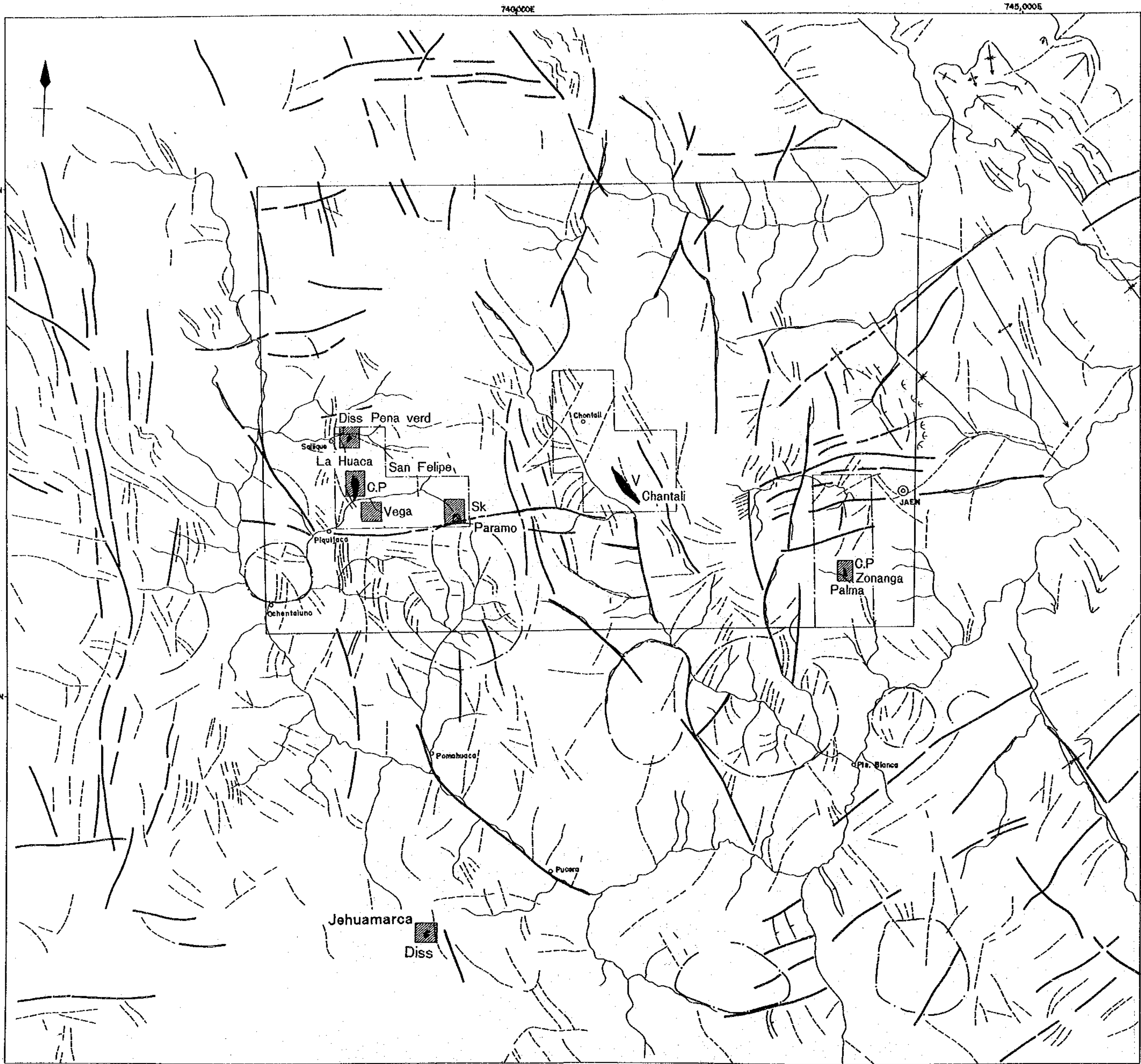
The following surveys are proposed for the second year survey based on the results obtained in the first year:

1) A detailed geological survey and geophysical survey in the Chontali alteration zones extracted from semi-detailed survey areas this year.

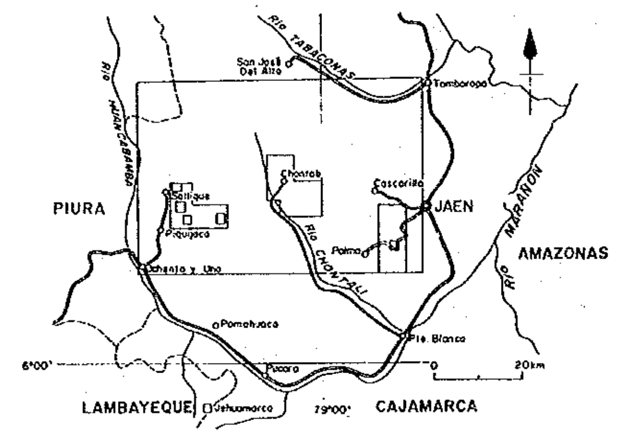
2) Boring survey for the Jehuamarca alteration zones where a clear survey

Table.I—2 Correlation of Fissure System, Alteration Geochemical Arrangements and Expected Ore Deposit

Area		Fissure System	Alteration	Geochemical Anaomary Arrangement Inner Side - Outer Side	Expected Ore Deposits
San Felipe	Peña Verde	NE-SW	Silicification	Ag - Cu	Au. Ag bearing Disseminated type ore deposits
San Felipe	La Huaca	NE-SW, NW-SE combined	Silicification and Argillization combined	Cu - Zn - Pb	Porphyry copper type ore deposits
Chontali		NE-SE	Silicification Argillization combined	Au. Ag - Pb	Hydrothermal vein type ore deposits
Palma Zonanga		NW-SE, NE-SW combined	Silicification Argillization combined	Au.Pb. - Cu.Mo.Zn	Porphyry copper type ore deposits
Jehuamarca		NE-SW	Silicification	Au - Ag - Pb	Au. Ag bearing Disseminated type ore deposits



THE MINERAL EXPORATION
IN
THE PACHAPIRIANA AREA, REPUBLIC OF PERU
(PHASE I)



JAPAN INTERNATIONAL COOPERATON AGENCY
METAL MINING AGENCY OF JAPAN
FEBRUARY 1989

0 20Km

LEGEND
凡 例

- MAJOR LINEAMENTS 線構造(強)
- MINOR LINEAMENTS 線構造(弱)
- CIRCULAR FEATURE 環状構造
- BEDDING 層理
- ANTICLINAL AXIS. 背斜軸
- SYNCLINAL AXIS 向斜軸
- SURVEY AREA 調査地域
- SEMIDETAILED SURVEY AREA 準精査地区
- DETAILED SURVEY AREA 精査地区
- MINERAL INDICATION 鉱徴地

C.P : Porphyry Copper Type
Diss : Dissemination of Base Metal Type
V : Vein Type
Sk : Skarn Type

Fig.I-6 Location Map of Alteration and Mineralized Zones in The Surveyed Area

target was found out this year by geophysical survey

3) A high probability of occurence of mineralization has been verified by the first year survey for the geochemical anomaly based on the stream sediments by INGEMMET. Therefore, it is recommended for the second year that a reconnaissance geological survey be conducted around the north and south of Chontali, Pena Blanca and Tuna principally, in areas which were left unsurveyed, to check for geochemical anomaly there

4) A detailed geophysical prospecting for the alteration zones at La Huaca and Pena Verde where reconnaissance prospecting has been conducted this year (by the SIP or IP method, for example).

5) An additional detailed survey along extension of north and east from the Zonanga alteration zones, and a reconnaissance geophysical prospecting of the entire area (by the CSAMT method, for example).

PART Ⅱ
PARTICULARS

CHAPTER 1 LANDSAT IMAGE ANALYSIS

1-1 Analysis method

1-1-1 Landsat MSS Data

MSS data used in this study are shown in table Ⅱ-1. Fig. Ⅱ-1 is the location map of Landsat Images.

Table Ⅱ-1 LIST OF LANDSAT CCT DATA

PATH/ROW	DATA ACQUISITION	SATELLITE	CLOUD COVERAGE	SUB-SCENE
9 / 64	Oct. 26, '83	Landsat-4	10%	○
9 / 65	Jun. 07, '79	" -3	20%	
10 / 64	May 19, '78	" -3	20%	○
10 / 65	May 19, '78	" -3	0%	

The surveying area spreads in 2 MSS scenes, and 2 other MSS scenes are used for better geological interpretation of this area.

1-1-2 Processing

(1) Fll scene

(a) Data input

MSS original data are put into a computer. Data used are from Brasil, and its brasilian BIP2 (Band Interleaved by 2 Pixels) format is converted to normal BIL (Band Interleaved by Line) format.

(b) Contrast stretch

Histogram of original data shows too low contrast to make an image. So data are enhanced by Linear Contrast Stretch.

(c) Data interpolation

The original data have severe noise in one line, and this line is interpolated with neighboring 2 lines by Bilinear Interpolation.

(d) Geometric correction

Any original satellite data have geometrical distortion, so 4 full scene data are geometrically corrected to project on topographic map. Over 30 GCPs (Ground Control Points) for each scene are chosen from one to a hundred thousands UTM (Universal Transverse Mercator) Topographic map, and distorted original data are corrected to coincide with GCPs by affine transformation. Coefficients of the transformation expression are decided by least squares method.

(e) Image output

Blue, green and red color are assigned to band 4, 5 and 7 respectively to get a false color image.

(2) Sub scene

(a) Data input

Same as full scene

(b) Contrast stretch

Same as full scene

(c) Geometric correction

Same as full scene

(d) Geometrical smoothing in connected parts of mosaicking

After geometric correction of each scene above mentioned, detail distortion remained in the connected part is corrected. Several GCPs are chosen from each image, and one image is corrected by affine transformation to coincide to another image.

(e) Radiometrical smoothing in connected parts of mosaicking

To correct the intensity difference between 2 scenes that comes from the difference of aquisition date, mean and standard deviation of one image are coincided to another image. Then the intensity difference remained along the connect line is erased by the radiometrical smoothing.

(f) Data cut

The sub scene that includes the surveying area is cut from mosaicked data.

(g) Contrast stretch

Sub scene data are enhanced again to get sufficient contrast.

(h) Image output

Blue, green and red color are assigned to band 4, 5 and 7 respectively to get a false color image. A black and white image of band 7 is put out.

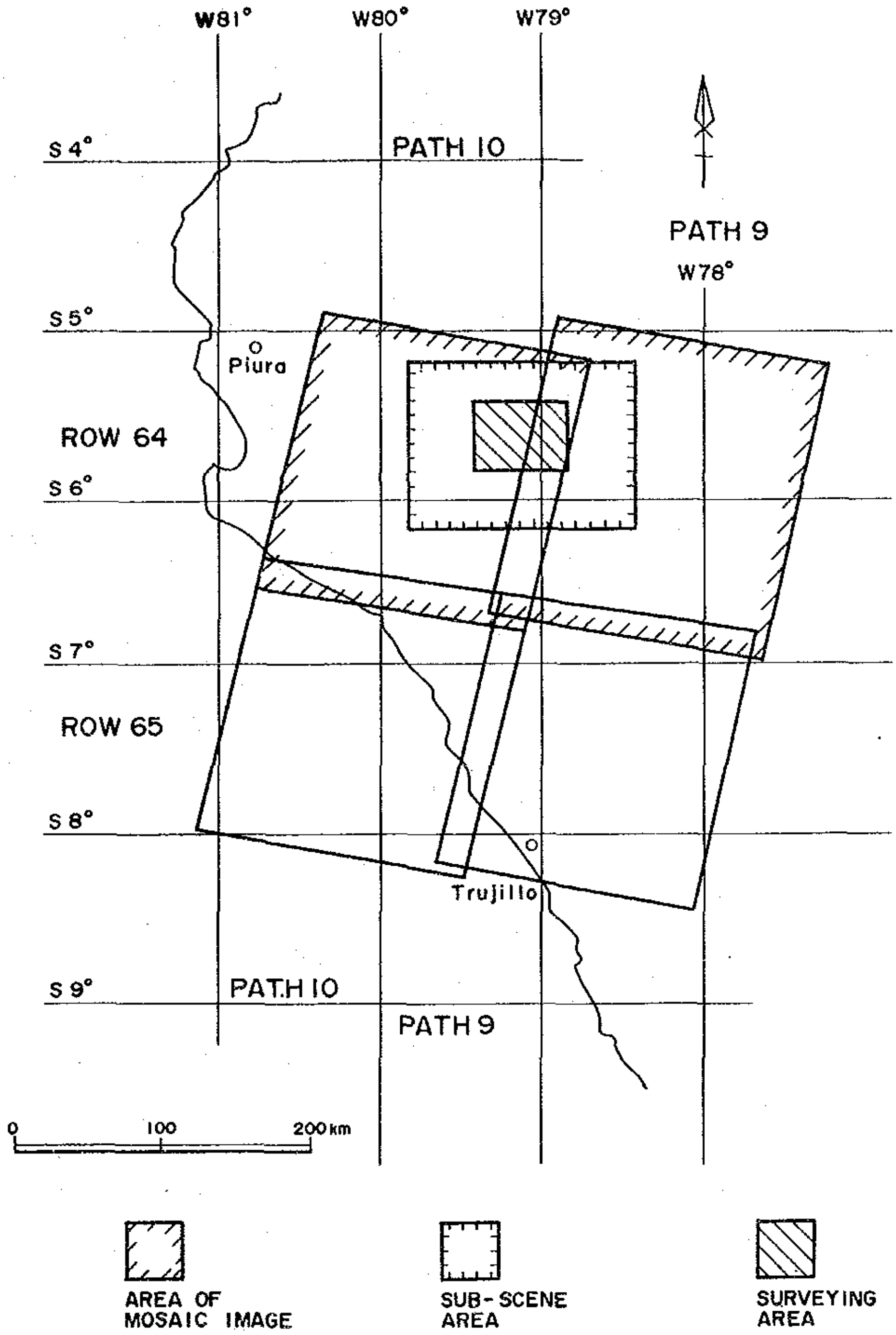


Fig.II-1 Location Map of Landsat Image

1-1-3 Interpretation Method

A false color sub scene image is mainly used for geological interpretation. A black and white image is for pseudo-stereoscopic viewing with a false color image for detail judgement. Linearments, ring structures, stratifications and anticlinal/synclinal axes are drawn in the interpretation map. Linearments are divided into strong and weak.

1-2 Result of Analysis

1-2-1 Linearments

The regional geological structure changes between northern part of Peru and southern part of Equador. The Andes mountain chains that consist of three cordilleras change their trend from NW-SE of south part to NE-SW of north. Sub scene covers the northwesternmost part of Andes which shows NW-SE trend. This trend can be seen on strikes of sedimentary rocks of the northeast corner of the scene, and on directions of strong linearments of south/southeast and north of the surveying area. In the east part of the scene there are anticlinal/synclinal axes which have also NW-SE trend. NE-SW linearments normal to NW-SE are notable in the eastern part. N-S trend can be seen in the west of the Huancabamba river.

In the surveying area NW-SE and NE-SW trends are not remarkable, but N-S and E-W trends are dominant. The latter trend can be seen in lineatments at the west of Jaen, south of Chontali and south of Piquijaca.

Fig. II-3 shows rose diagrams of strong and weak linearments of the surveying area. An upper semicircular shows frequency and a lower semicircular total length. There are 81 strong linearments and the total length of them is about 500km. Mode direction is N15°W in frequency and N5°W in total length and E-W is sub dominant direction. Mode of linearment length is 3～4km.

There are 306 weak linearments and the total length amounts to about 900km. Mode direction is N20°W in frequency and N10W in total length and those value shows 5 degrees westward rotation compared to strong linearments. Mode of linearment length is 1～2km.

1-2-2 Ring Structure

There are 9 ring structures, 5 along the south end of the surveying area, 2 at southernmost part of the scene. The diameter of those structures is 4～15km. Among those, a typical ring can be seen at the southwesternmost of the surveying area. Huancabamba river and Piquijaca river which join at Ochentaiuno make south semicircular, and its branchs make the rest part.

1-3 Review

(1) San Felipe site

Only a few linearments are interpreted in this site because of cloud cover. Linearments interpreted have N-S and E-W direction, an obvious E-W linearment extends from Piquijaca to Chontali site.

(2) Chontali site

NNW～NW direction is dominant which is concordant to the main trend of the Andes mountain chain. NNE～NE can also be seen.

(3) Palma site

There are a few remarkable E-W linearments north part of this site, and the strongest one extends to east of Jaen. NNE strong linearment and NE weak linearment can be seen.

(4) Jehuamarca site

Because of cloud cover, only two linearments are interpreted, and their directions is NNW.

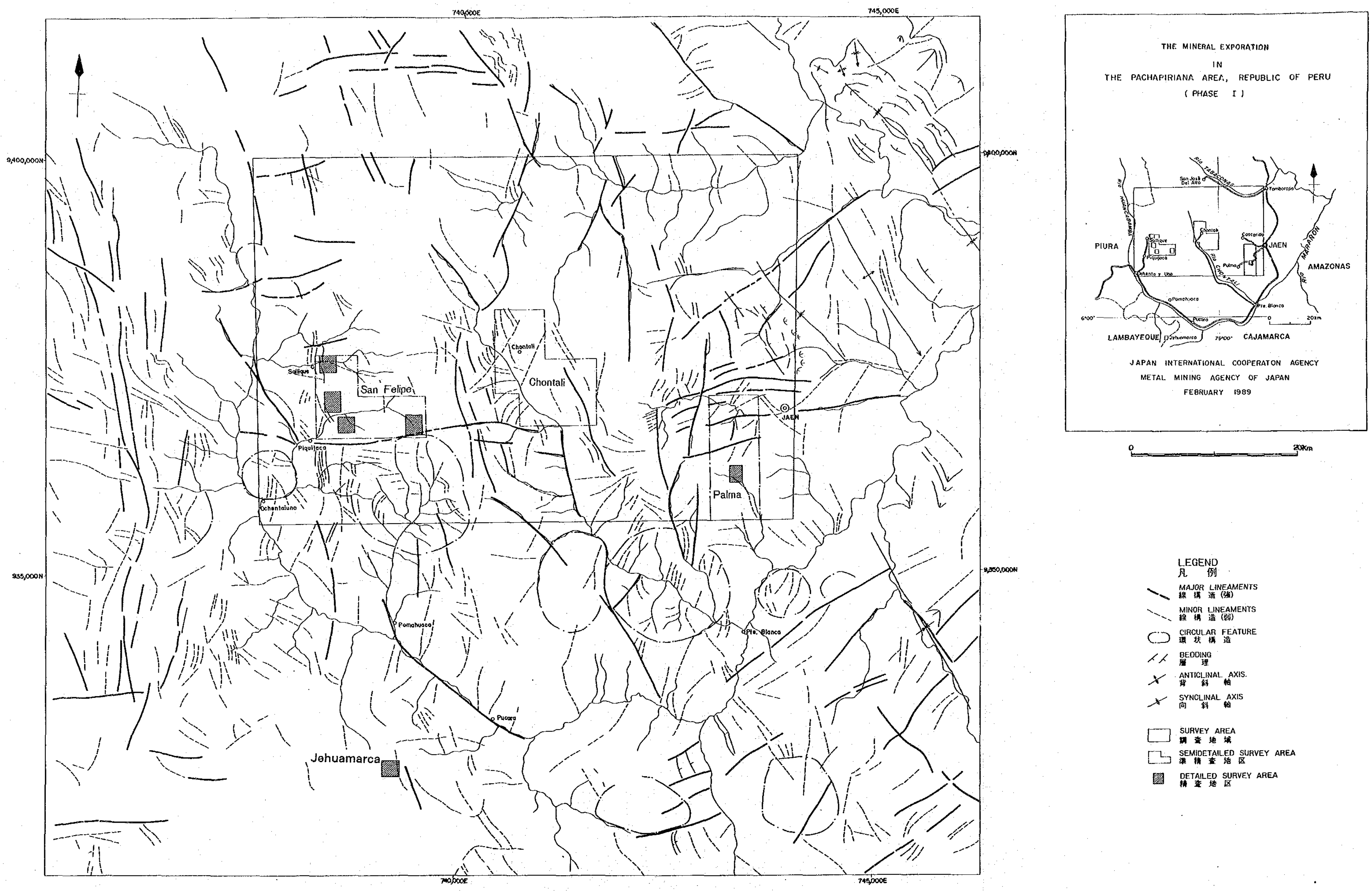
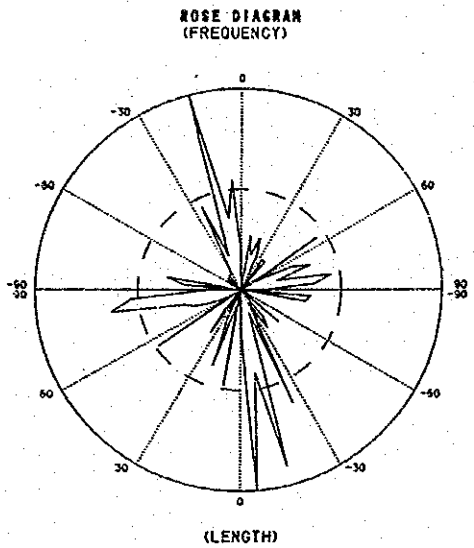


Fig.II−2 Lineaments Map of Landsat Image

ROSEDIAGRAM OF LINEAMENTS

HISTOGRAM OF LINEAMENTS

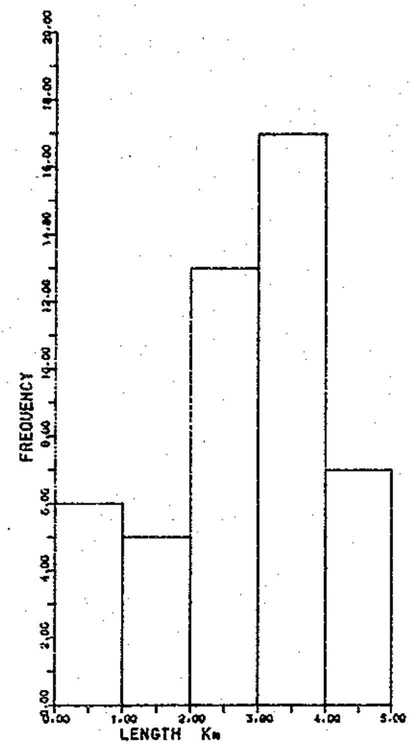
LIST OF LINEAMENTS



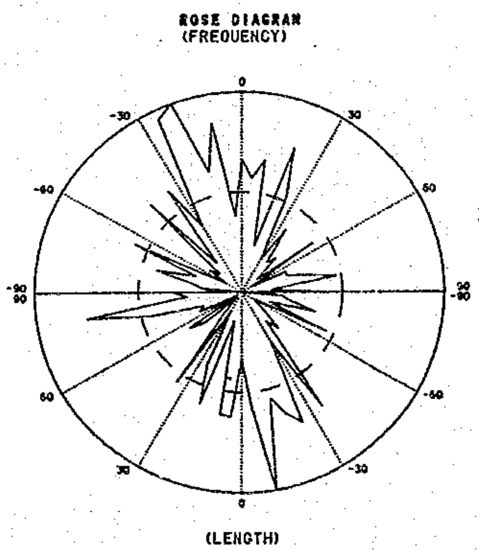
MAJOR LINEAMENTS

NTOTAL = 81
NMAX = 11
MAX-AZIM = -15 (DEG.)

TOTAL-KM = 503.4 (Km)



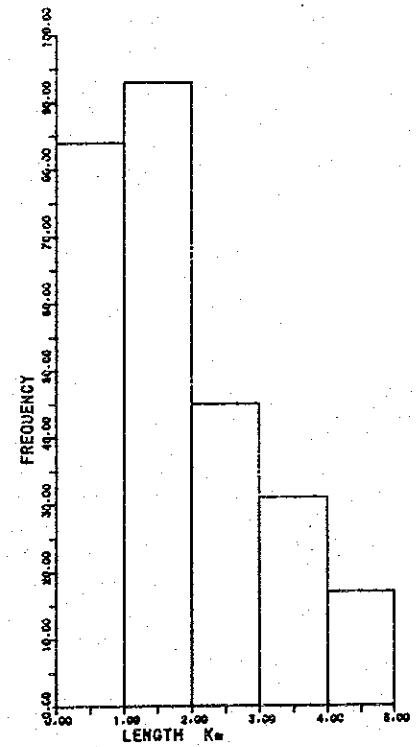
DIRECTION	NUMBER PCS	NUMBER %	LENGTH KM	LENGTH %
N90.0E-N87.5E	1	1	8.8	2
N87.5E-N82.5E	4	5	30.7	6
N82.5E-N77.5E	5	6	36.9	7
N77.5E-N72.5E	2	2	16.7	3
N72.5E-N67.5E	4	5	13.9	3
N67.5E-N62.5E	3	4	8.1	2
N62.5E-N57.5E	1	1	2.4	0
N57.5E-N52.5E	5	6	27.9	6
N52.5E-N47.5E	0	0	.0	0
N47.5E-N42.5E	0	0	.0	0
N42.5E-N37.5E	2	2	7.3	1
N37.5E-N32.5E	2	2	14.8	3
N32.5E-N27.5E	0	0	.0	0
N27.5E-N22.5E	2	2	8.8	2
N22.5E-N17.5E	3	4	23.1	5
N17.5E-N12.5E	2	2	4.7	1
N12.5E-N 7.5E	3	4	27.9	6
N 7.5E-N 2.5E	0	0	.0	0
N 2.5E-N 2.5W	2	2	11.6	2
N 2.5W-N 7.5W	6	7	57.7	11
N 7.5W-N12.5W	4	5	24.4	5
N12.5W-N17.5W	11	14	52.3	10
N17.5W-N22.5W	2	2	6.9	1
N22.5W-N27.5W	5	6	35.8	7
N27.5W-N32.5W	1	1	4.1	1
N32.5W-N37.5W	1	1	13.1	3
N37.5W-N42.5W	1	1	9.8	2
N42.5W-N47.5W	0	0	.0	0
N47.5W-N52.5W	1	1	14.1	3
N52.5W-N57.5W	0	0	.0	0
N57.5W-N62.5W	1	1	2.8	1
N62.5W-N67.5W	0	0	.0	0
N67.5W-N72.5W	0	0	.0	0
N72.5W-N77.5W	0	0	.0	0
N77.5W-N82.5W	4	5	18.7	4
N82.5W-N87.5W	3	4	19.9	4
N87.5W-N90.0W	1	1	8.8	2
SUM TOTAL	81		503.4	



INCLUDING MINOR LINEAMENTS

NTOTAL = 306
NMAX = 21
MAX-AZIM = -20 (DEG.)

TOTAL-KM = 912.1 (Km)



DIRECTION	NUMBER PCS	NUMBER %	LENGTH KM	LENGTH %
N90.0E-N87.5E	9	3	23.9	3
N87.5E-N82.5E	3	1	18.8	2
N82.5E-N77.5E	10	3	53.2	6
N77.5E-N72.5E	7	2	31.4	3
N72.5E-N67.5E	5	2	13.8	2
N67.5E-N62.5E	5	2	15.5	2
N62.5E-N57.5E	1	0	1.4	0
N57.5E-N52.5E	9	3	21.6	2
N52.5E-N47.5E	2	1	16.3	2
N47.5E-N42.5E	5	2	2.0	0
N42.5E-N37.5E	4	1	9.1	1
N37.5E-N32.5E	8	3	38.6	4
N32.5E-N27.5E	4	1	7.7	1
N27.5E-N22.5E	11	4	27.7	3
N22.5E-N17.5E	16	5	41.8	5
N17.5E-N12.5E	5	2	10.4	1
N12.5E-N 7.5E	14	5	43.6	5
N 7.5E-N 2.5E	12	4	43.9	5
N 2.5E-N 2.5W	14	5	23.6	3
N 2.5W-N 7.5W	8	3	40.0	4
N 7.5W-N12.5W	18	6	70.4	8
N12.5W-N17.5W	13	4	38.8	4
N17.5W-N22.5W	21	7	45.4	5
N22.5W-N27.5W	20	7	50.4	6
N27.5W-N32.5W	8	3	20.4	2
N32.5W-N37.5W	13	4	48.8	5
N37.5W-N42.5W	4	1	13.2	1
N42.5W-N47.5W	13	4	18.2	2
N47.5W-N52.5W	3	1	10.7	1
N52.5W-N57.5W	4	1	7.0	1
N57.5W-N62.5W	2	1	4.6	1
N62.5W-N67.5W	12	4	32.3	4
N67.5W-N72.5W	5	2	10.4	1
N72.5W-N77.5W	9	3	26.4	3
N77.5W-N82.5W	5	2	17.1	2
N82.5W-N87.5W	4	1	13.9	2
N87.5W-N90.0W	9	3	23.9	3
SUM TOTAL	306		912.1	

Fig.II-3 Lineaments Analysis

CHAPTER 2 SAN FELIPE AREA

2-1 Geological and Geochemical Surveys

2-1-1 Purpose of the Suevey

The San Felipe area includes mineralized zones at La Huaca, Pana Verde, Vega and Paramo, which were extracted by the "Proyecto Geoquimico del Norte". Of these mineralized zones, in La Huaca a preliminary survey including boring (seven borings with a total depth of 572 meters) was performed by the Bureau de *Recherches Geologiques et Minieres (BRGM), France. For the remaining three* mineralized zones, preliminary surveys were partially conducted by INGEMMET.

This year survey included a semi-detailed geological survey combined with geochemical survey for the purpose of defining the correlation and geological settings of these mineralized zones. A detailed geological survey combined with geochemical survey was also performed to idetify the specific deposit potentials for each mineralized zone. Trenching was also conducted in order to confirm a scale and an occurrence of silicified rocks found in La Huaca.

2-1-2 Survey Procedure

The base camp was set up at the village of Piquijaca situated southwest *of the survey area, and the advance camps were positioned at Sallique and* Cerro Paramillo which are located in the northeast and southeast of the survey area respectively (Fig. I-2 (1)).

Being the first survey of the year in this area, three survey teams were organized pairing the Japanese engineers and their counterparts of Peru so that they could share observations.

Riding routes and irrigation channels, crossing everywhere in the survey area, were mainly used as surveying routes. Path-clearing groups were occasionally formed to penetrate virgin forests in the remaining uncultivated parts of the survey area.

Sampling for geochemical analysis were carried out with the semi-detailed and detailed geological surveys. As the preliminary survey was previously implomentes by INGEMMET, the number of samples per unit area were reduced, and the resulting portion of the allowance was allotted to the semi-detailed survey in Chontali and Palma, and the detailed survey in Jehuamarca and Zonanga.

2-1-3 Analysis Method

We first analyzed the geological structure of the semi-detailed survey area. Based on this result a geological structure of the detailed survey areas was conducted. Airphotographs, Series 359-83-A (1983) and 222-72-A (1972) taken by the National Aerographic Service (S.A.N., Servicio Aerografico Nacional), were used as auxiliary means of analyzing the semi-detailed survey areas, being on a scale of about 1/30,000 and 1/25,000, respectively.

The geochemical samples were sent to C. H. Plenge, S.A., a Peruvian laboratory, to analyze for silver, lead, zinc, copper and molybdenum, and to Chemex Labs Ltd., Canada, for gold.

In the assay results of geochemical samples, distinct characteristics could not be obtained for some semi-detailed survey areas and/or detailed survey zones by statistical processing conducted separately for each individual area and/or zone. The data was processed in a batch for the entire survey area, the cumulative frequency distribution was plotted on normal probability graphs, and the relevant threshold value (A) was extracted as bending point of the cummulative frequency distributinon curve, which would discriminate between the background and anomaly values. This threshold value was compared with the sum (B) of the standard deviation and the average obtained individually from statistical processing of each area. (A) was taken if the comparison resulted (A)<(B), and (B) if resulted in (A)>(B), as the definitive threshold value of each area. Geochemical anomaly distribution map was prepared for each of the above-mentioned element, except molybdenum, based on these threshold values. In calculating the standard deviation per each area, as the values above 1 g/ton Au, 200 g/ton Ag, 2% Pb, 5% Cu and 0.1% Mo which can be deemed as obvious anomaly values responding to the ore grade, the relevant elements were excluded from the statistical processing. Threshold values used for analysis and the statistical data obtained from the calculation using them are shown in Table II-2.

2-1-4 Geology

According to Reyes et al. (1987), it is reported that in the western part of the survey area (including Pena Verde, La Huaca and Vega mineralized zones), the basement is formed by Mesozoic rocks consisting mainly of

Table.II—2 Geochemical Threshold of The Surveyed Area

Area	Statistical element \ Geochemical element	Au ppb Whole Sample	Au ppb Selected Sample	Ag ppm Whole Sample	Ag ppm Selected Sample	Pb ppm Whole Sample	Pb ppm Selected Sample	Zn ppm Whole Sample	Zn ppm Selected Sample	Cu ppm Whole Sample	Cu ppm Selected Sample	Mo ppm Whole Sample	Mo ppm Selected Sample
Whole Area	Number of Sample	710	704	710	706	710	709	710		710	709	710	709
	Mean	43.00	24.73	6.41	3.37	463.92	411.54	220.58		190.86	115.81	10.91	9.40
	Standard Deviation	228.72	74.28	49.50	9.10	1800.55	1138.38	183.42		2018.80	277.12	42.13	12.68
	Threshold		80		7		610	290			200		20
San Felipe	Number of Sample	187	185	187	186	187		187		187	186	187	
	Mean	56.67	31.18	3.87	2.74	538.61		206.10		480.05	195.54	10.78	
	Standard Deviation	255.76	70.42	15.97	4.05	1615.57		188.31		3916.32	448.48	16.27	
	Threshold		80		6.79	610		290			200	20	
Chontali	Number of Sample	245	243	245		245		245		245		245	
	Mean	34.31	23.60	2.58		327.59		253.18		71.48		7.35	
	Standard Deviation	144.34	81.00	3.01		800.25		212.12		87.92		3.34	
	Threshold		80	5.59		610		290		159.40		20	
Palma	Number of Sample	205		205		205		205		205		205	
	Mean	9.93		1.95		226.85		209.61		83.90		11.02	
	Standard Deviation	15.95		3.57		245.26		158.27		190.49		16.68	
	Threshold	25.88		5.52		472.11		290		200		20	
Jehuamarca	Number of Sample	73	71	73	70	73	72	73		73		73	72
	Mean	130.01	54.52	38.31	11.92	1395.89	893.06	179.04		151.10		22.88	8.19
	Standard Deviation	513.12	131.51	149.15	25.47	4660.75	1819.64	99.92		286.60		125.62	6.62
	Treshold		80		7		610	278.96		200		20	

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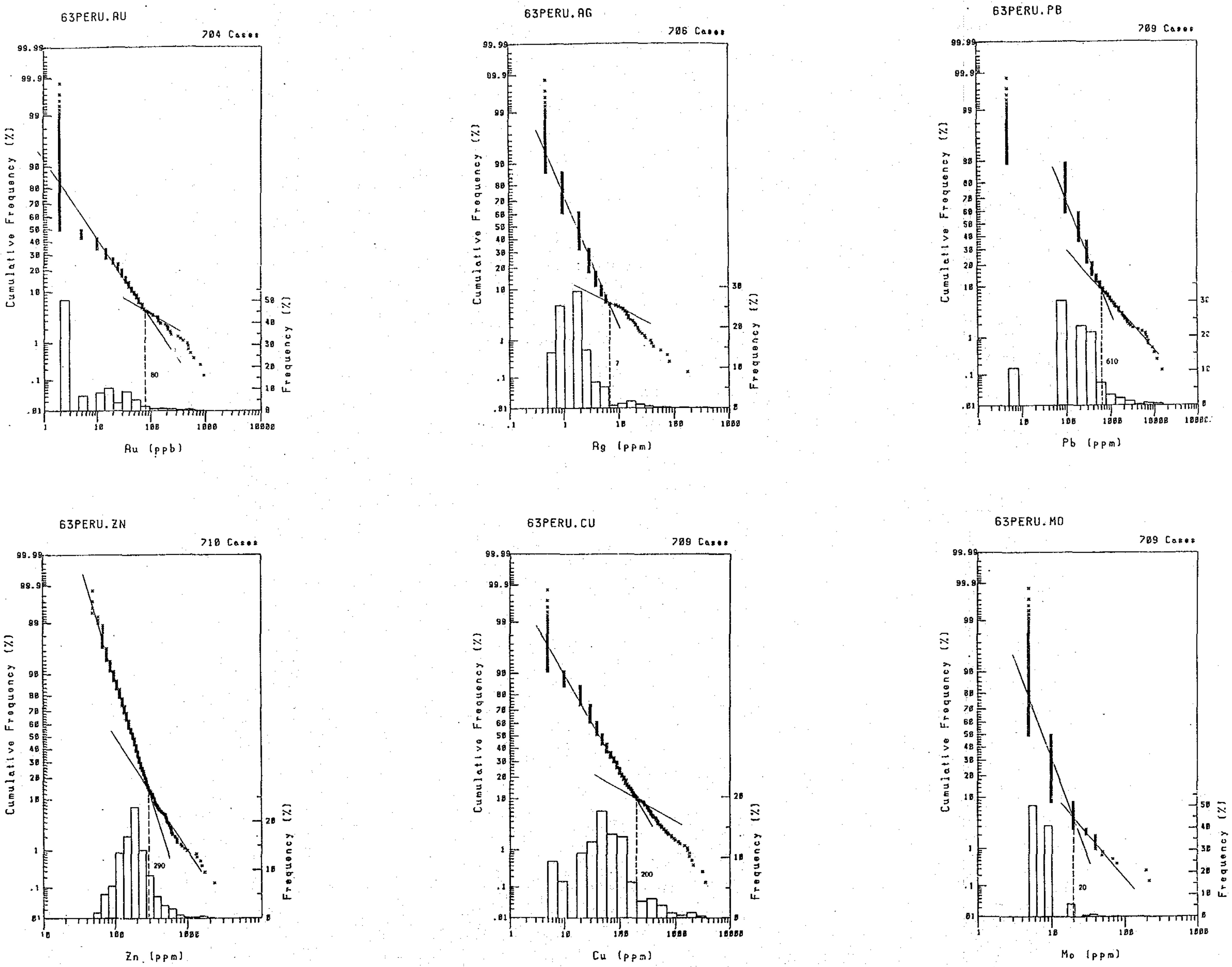


Fig.II−4 Histogram and Cumulative Frequency Diagram

sedimentary rocks, which is unconformably covered by the Tertiary Porculla Volcanics, these geological units are in contact with each other by a fault. In its eastern part (including Paramo mineralized zone), the basement is the Paleozoic Salas Group, which is unconformably covered by Porculla Volcanics, and dioritic intrusive rocks extending in N-S direction are distributed in the middle of the both above (Fig. I-3).

The Mesozoic Rocks extend in N-S direction at the western flange of the survey area, consisting of the Tinajones, Inca, Chulec, Pariatambo and Pulluicana Formations superposed in this sequence from its east flange, and unconformably covered by Porculla Volcanics at the western end. The Tinajones Formation, located at the eastern flange of the survey area, covers the Porculla Volcanics distributed in its eastern part by a thrust fault. Reyes et al. also reported that the mineralized zones extracted by INGEMMET at Pena Verde, La Huaca and Vega are occurred in these Porculla Volcanics.

2-1-5 Survey Results

1) Geological survey

The basement of this survey area is composed of metamorphic rocks that consist mainly of gneiss with minor amount of crystalline schist. This basement rocks are covered unconformably by pyroclastic rocks that contain andesite and/or dacite. Over this, calcareous or tuffaceous sedimentary rocks with interacalated limestone and marl are distributed. Diorite～granodiorite, granite, monzonite, and quartz～granite porphyries intrude into them (Fig. II-5).

At two localities, the eastern flange of detailed survey area in La Huaca (center of the western part of the San Felipe semi-detailed survey area) and the northwestern part of the Paramo zone, were observed metamorphic rocks with foliatin. Judging from their metamorphic grade, it is assumed that they are correlative with Olmos Complex being the facies in the proximity of intrusive rocks.

Olmos Complex is unconformably covered by volcanics. These volcanics in the western region distributed trending nearly north to south, the Olmos Complex is observed in the central part of their distribution area. Overall, therefore, it can be interpreted that the volcanic rocks in the northern part are plunging to north, and those in the southern part to the south from the Complex. Therefore, it can be concluded that there was an uprising of basement near La Huaca. Considering a stratigraphy of the volcanics based on this hypothetic interpretation, andesitic tuff or tuff breccia would be predominant in the lower part, the middle part these pyroclastic rocks would contain a relatively abundant andesitic lava, and finally, intercalated shale and occasionally sandstone would be present in them in the upper part, thus they grades conformably into sedimentary rocks which will be described later (at Cerro Tableon). In the eastern area, on the other hand, andesitic lavas are distributed directly on the Complex with a little amount of tuff or tuff breccia intercalting in it. Supposing that the basement was flat when these volcanoclastics were sedimented, these regional variations of volcanic rock facies would suggest the position of their supply origin. The age of their sedimentation cannot be readily determined because no fossils are available nor were absolute age determination conducted. It, however, may be correlative with the Oyotun Volcanics through the assessment of the mentioned rock facies and the fact that they were covered by Cretaceous sedimentary rocks, and that there were intruded by rocks belonging to the upper the early Cretaceous Period.

The major distribution of sedimentary rocks in the survey area extends in the north-south direction along the western flange of the area, and a few portion presents covering on the Oyotun Volcanics in conformable relation. *All the sedimentary rocks extending in the north-south are in contact with the* Oyotun Volcanics with fault. The quarzite located on the Oyotun Volcanics is about 20m in thickness and is covered with shale. Further up, there are relatively thick tuffaceous and/or calcareous shale and sandstone with intercalated limestone. Ammonites, and other fossils are generally found out among the calcareous rocks. According to the assessment by Ms. Lidia Romero Pittman, INGEMMET, these obtained fossils (Apx. 12) correspond to the upper part of the lower Cretaceous to the lower part of the upper Cretaceous System, and can be assumed to be correlative with the Inca, Chulec, Pariatambo and Pulluicana Formations classified by Reyes (1987).

Intrusive rocks in the area are composed of diorite-granodiorite widely covering the central to eastern parts and intruded with above mentioned geological units; granite intruded as stocks with 0.5 to 1.5 km on the minor axis and 1 to 3 km on the major axis into neighboring of the above mentioned diorite-granodiorite; monzonite-monzonite porphyry as dykes with 10 to 150 meters in width and 50 meters to 3 km in length into the Oyotun Volcanics in the western area, and quartz and granite porphyries and andesite also intruding as dyke with widths reaching from several centimeters to meters.

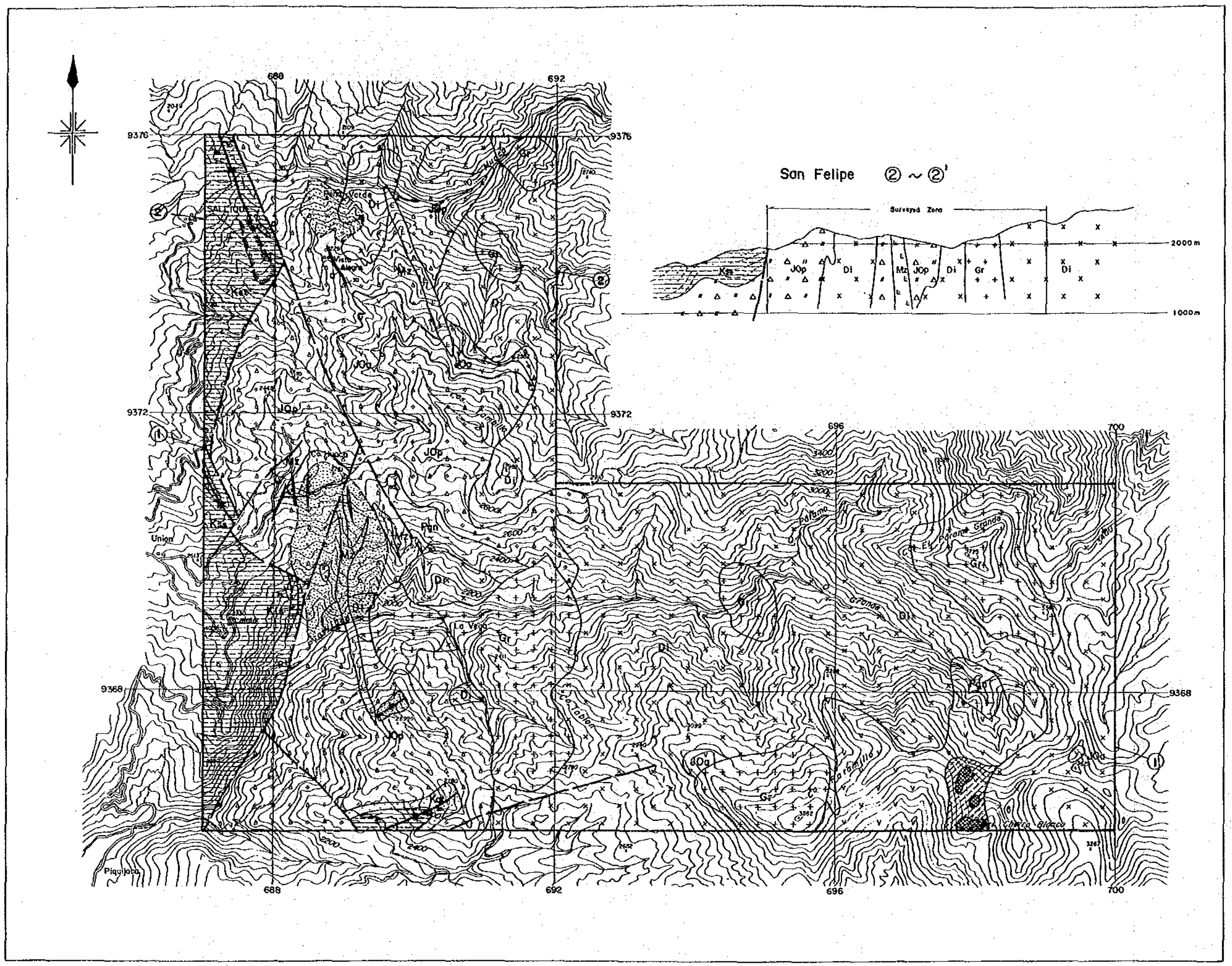
Microscopic observation indicates that the diorite-granodiorite exist-

ing in the area consist of plagioclase, quartz, and biotite (Apx. 1, Sample No. K02505), being equivalent to granodiorite facies. As for granite, those fine-grained are predominant. Granite found along the Grande river shows a faliation characteristically, and around the boundary with the gneiss, containing a numerous xenolith of gneisses, which suggests the gneiss might be assimilated with granite in part. Under the microscope, the samples taken from the granite bodies found along the Grande, exhibit rock facies variation from granodiorite (Sample No. H11005) to tonalite (Sample No. H03008). Although the absolute age of this granite (Sample No. H11005) is estimated at 82.5±4.1 million years (middle Late Cretaceous) by the K/Ar method, a somewhat older age could also be possible since the potassium feldspars were found altered to sericites.

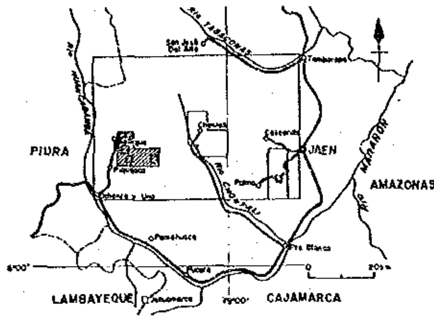
The monzonite here are remarkablly altered in general. Under the microscope, the monzonite (Sample No. H02503) consists of plagioclase, quartz, and altered minerals which are chlorite, epidote, calcite and sericite, and being correlative with from quartz monzonite to diorite. Whilst the absolute age of this sample (Sample No. H02503) is estimated at 78.0±3.9 million years (Campanian, Late Cretaceous) by the K/Ar method, a somewhat older age could be derived since the sample is altered strongly as mentioned above. Quartz-granite porphyries intrude into the aforementioned intrusive rocks and appear mainly in the periphery of the granitic body. Andesite are observed in the whole survey area, with a great variation of its rock facies, thus suggesting a considerably wide range of periods of intrusion. They are roughly divided into those porphyritic and aphanitic, the latter mainly appearing in the distribution area of Oyotun Volcanics.

Remarkable fault fissures run in the distribution area of the Mesozoic rocks located in the western part, formed into the NW-SE and NE-SW trending systems. Both fissure systems involve acutely steep dipping and younger geological units apppaer in a western block of them. Based on the analysis of airphotographs, the continuation of these fault structures is unclear in intrusive rocks spread area; this suggests that they were formed before the intrusion and cotrolled their itrusions.

Alteration occurs with peculiar facies to the respective distribution areas of Oyotun Volcanics and calcareous rocks in the west, and Oyotun Volcanics in the east. Alteration in the western Oyotun Volcanics is attributable to hydrothermal effect and distributed of 2 km in width and 9 km in length trending north-south, containing mineralized zones of Pena Verde, La Huaca and Vega extracted by INGEMMET. From a general view, these alteration



THE MINERAL EXPLORATION
IN
THE PACHAPIRIANA AREA, REPUBLIC OF PERU
(PHASE I)



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METAL MINING AGENCY OF JAPAN
FEBRUARY 1989

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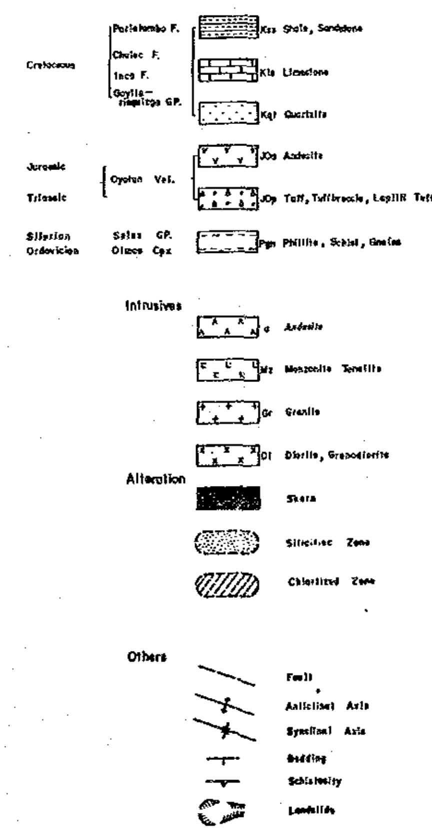

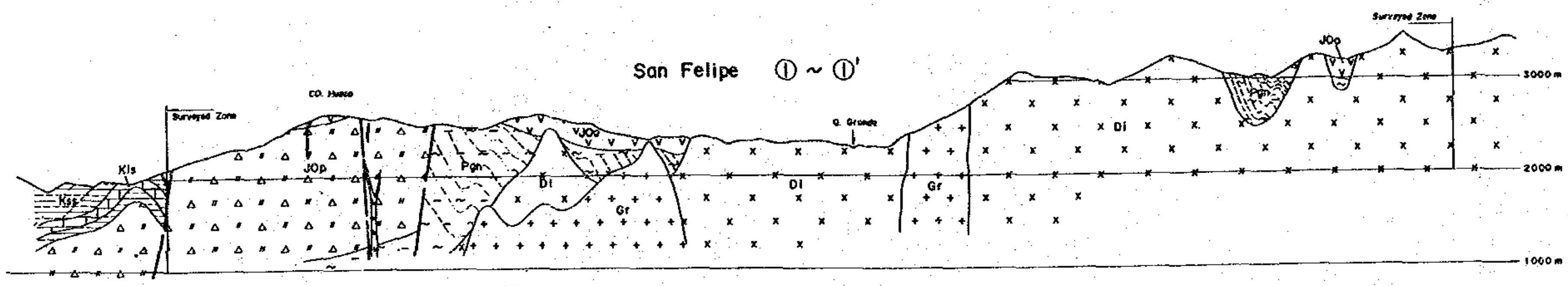

Fig.II−5 Geological Map and Profiles of The San Felipe Area

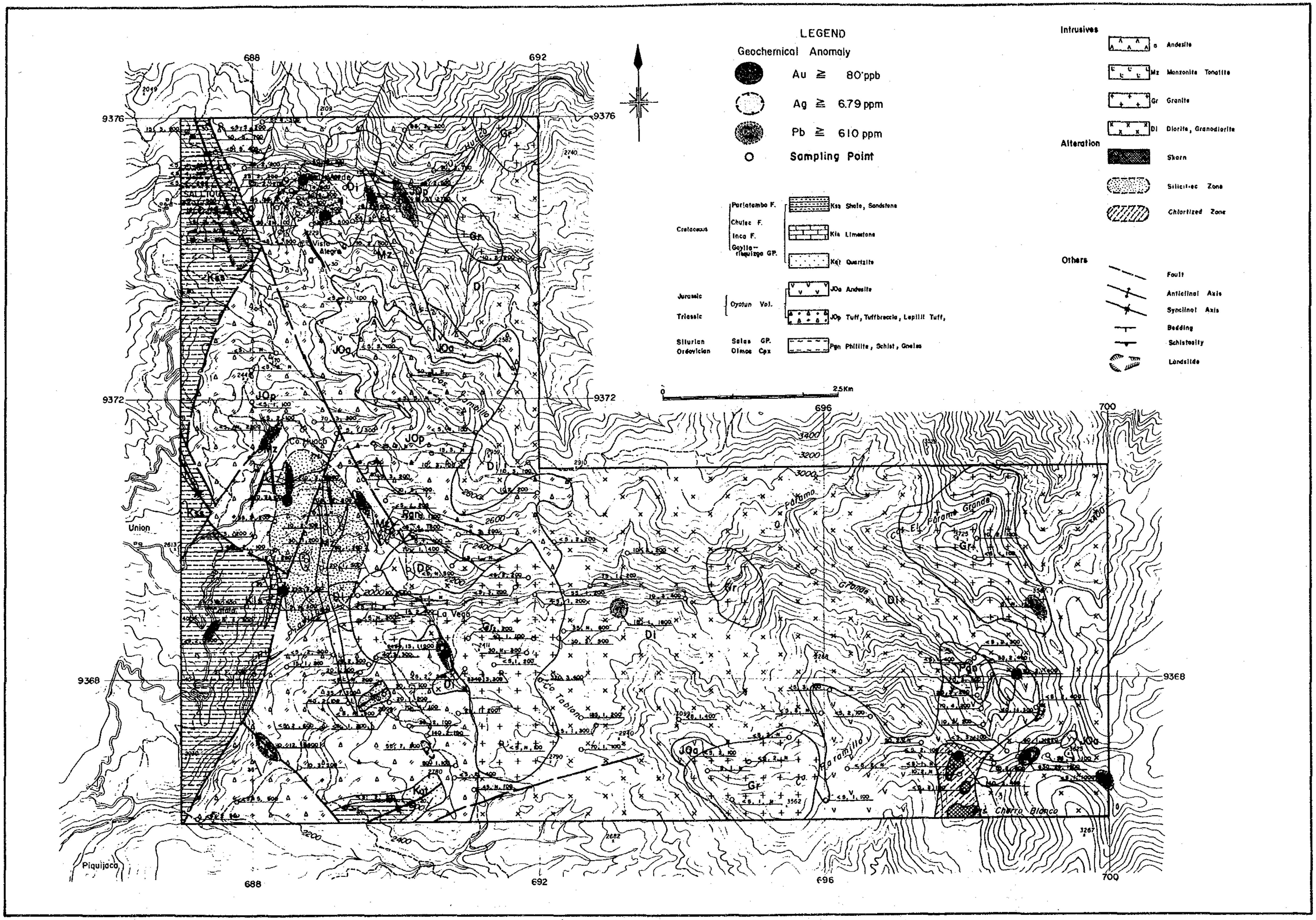

Fig.II−6 (1) Geochemical Map of The San Felipe Area (Au, Ag and Pb)

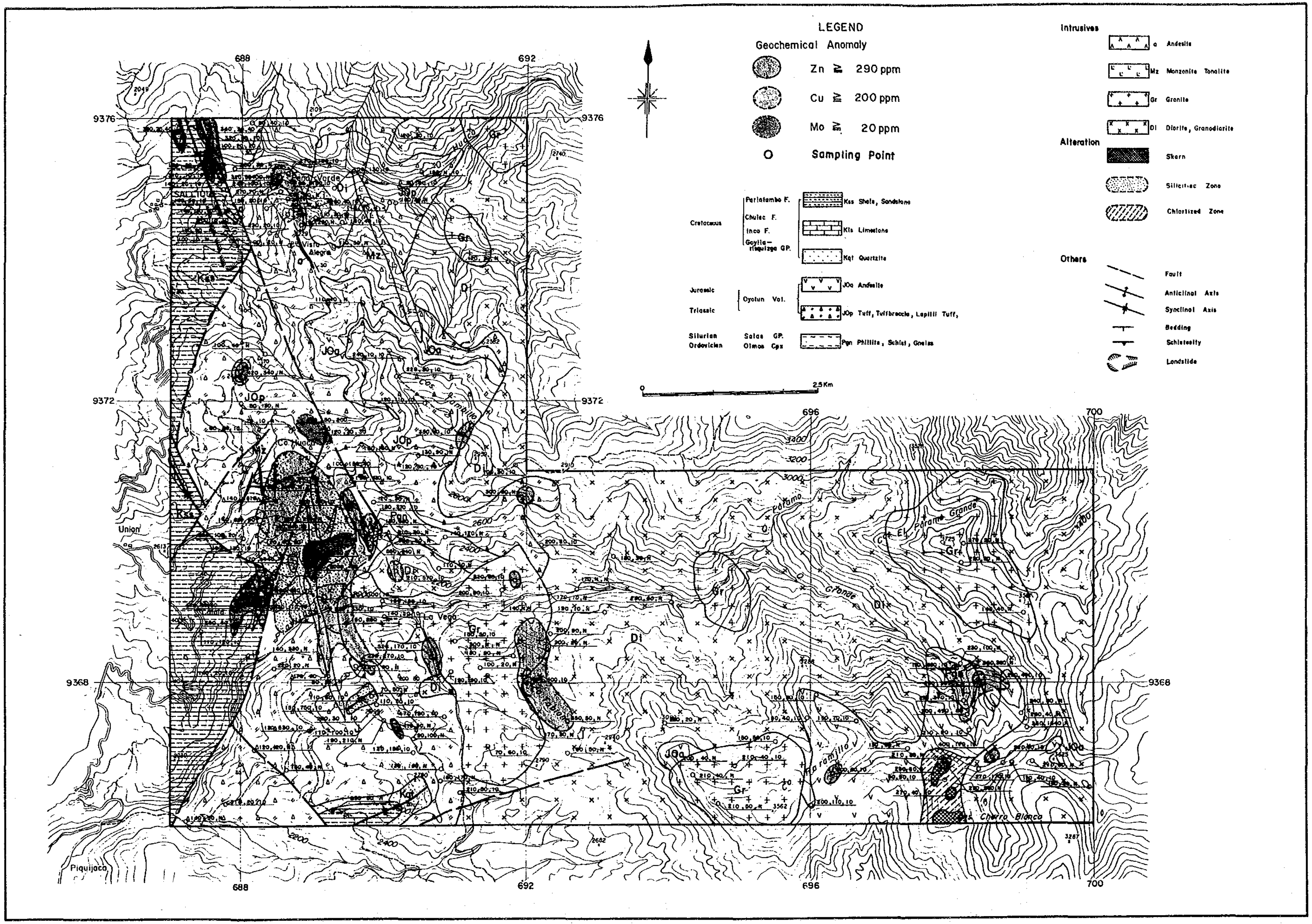

Fig.II–6 (2) Geochemical Map of The San Felipe Area (Zn, Cu and Mo)

zones mainly consist of argillization around Vega (PL.8) in the south, combined silicification and argillization in the center, La Huaca (PL.7), and silicification in the northmost part, Pena Verde (PL.6). These alteration zones may suggest the possibility of their presence in the northern extension of the survey area if they are serially fomed. It is supposed that the alteration would have been generated as the result of post-igneous activities of diorite-granodiorite and/or monzonite, through the said fault fissure systems. That is, a zonal arrangement of silicification, combined silicification and argillization and argillization is verified in the Pena Verde area, particularly around the western periphery of the small-scale diorite-granodiorite body. Another zoning of combined silicification and argillization is also observed, centered at the monzonite distribution area in La Huaca. As the result of an X-ray diffractive analysis (Apx.5), quartz, sericite, smectite, kaolinite, halloysite and chlorite, all of which are clay minerals characteristic to hydrothermal alteration, were detected. The sericite polytype, sampled in the combined alteration zone of La Huaca refers to 2M, which suggests that they were formed in a relatively high temperature facies.

The alteration observed in the eastern Oyotun Volcanics is attributable to the contact metasomatism, which is featured with skarn minerals such as chlorite and epidote. In addition, large amounts of magnetite were found in the same zone, and a very few amount of cubanite coexisting with pyrite were cbserved(Apx. 6 and 7, No H10307). Argillization was observed at the bedding plane and/or along the cracks crossing it in the sedimentray rocks distributed in the western flange of the survey area. Based on the result of an X-ray diffractive analysis (Apx. 5, No M02706), it is supposed that this alteration contains kaolinite, sericite, pyrophyllite, alunite and jarosite, forming the outer zone of the hydrothermal alteration mentioned above.

2) Geochemical surey

Compared with other areas of the survey, cupriferous mineralization was predominant in the San Felipe area, in view of the resultant average values of gold (56.67 ppb), lead (538.61 ppm) and copper (480.05 ppm) contents, higher than those obtained in other areas, in particular, the copper content being more than twice the mean value (190.86 ppm) of the whole area (Table II-2). Analyzing the distribution of anomalous values or zones per each element (Fig. II-6(1),(2)), it is noted that those of gold, lead and silver are extremely sporadic and moreover, on a very small scale. The anomalous values of molybdenum also appeared on a small scale, but have relative unity. Those of zinc