REPUBLIC OF PERU

REPORT ON GEOLOGICAL SURVEY

OF

THE OYON AREA

PHASE Ⅲ

MARCH 1982

METAL MINING AGENCY OF JAPAN

JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

The Government of Japan, in response to the request of the Government of the Republic of Peru, decided to conduct collaborative mineral exploration in the Oyon area and entrusted its execution to Japan International Cooperation Agency (JICA) and Metal Mining Agency of Japan (MMAJ).

Between 22 May and 7 November, 1981, Metal Mining Agency of Japan dispatched a survey team headed by Mr. Jinichi Nakamura to conduct the Phase III of the project.

The survey had been accomplished under close cooperation with the Government of the Republic of Peru and its various authorities.

This report is a compilation of the survey of the Phase III, and after the completion of the project the consolidated report will be submitted to the Government of the Republic of Peru.

We wish to express our appreciation to all of the organizations and members who bore the responsibility for the project, the Government of the Republic of Peru, Instituto Geologico, Minero y Metalurgico, and other authorities and the Embassy of Japan in Peru.

February 1982

Keisuke Arita
President
Japan International Cooperation Agency

Masayuki Nishiie
President
Metal Mining Agency of Japan

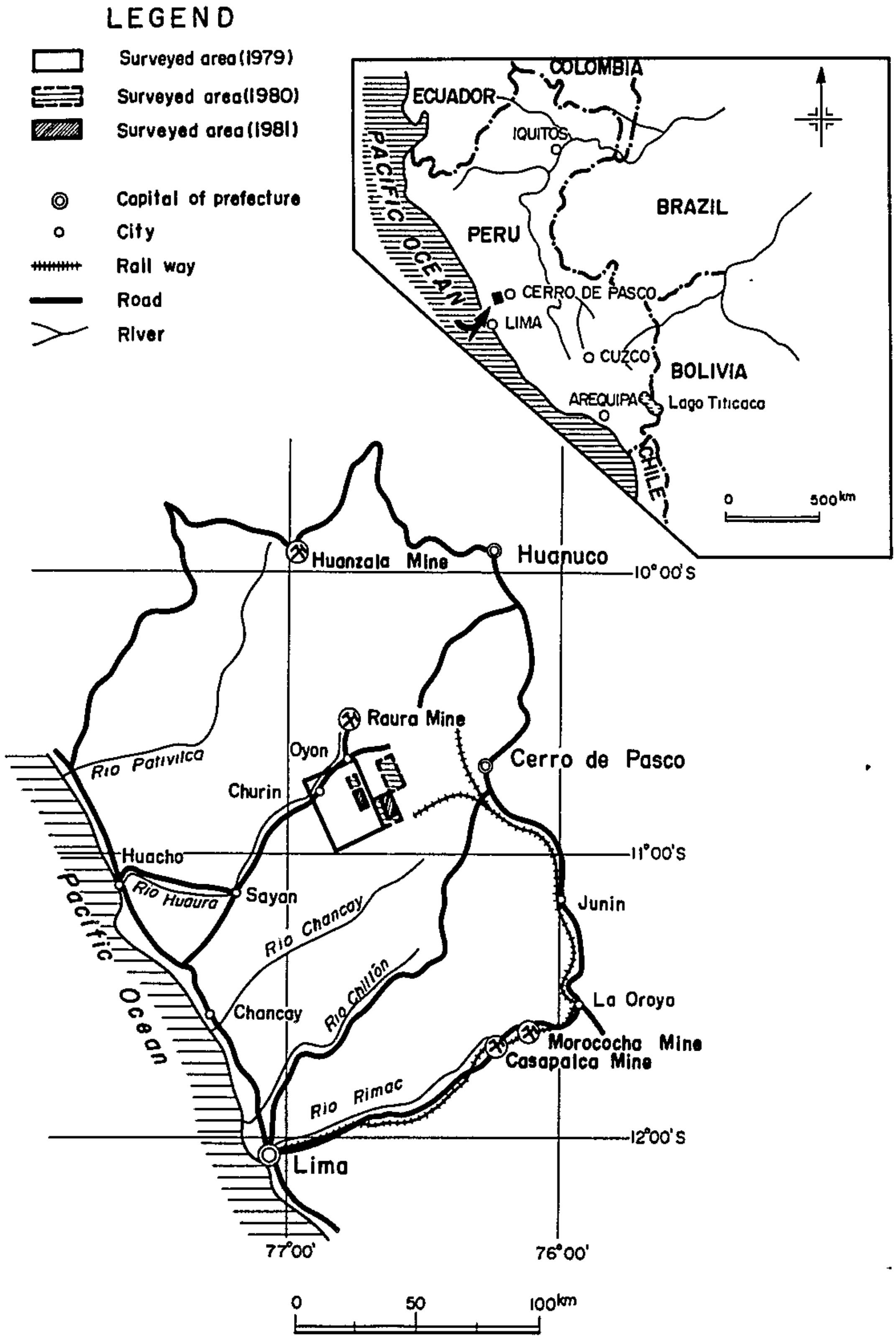

Fig. 1. Index Map

ABSTRACT

This geological survey is the third year plan of the Japan-Peru co-operation project for basic geological studies for development of mineral resources, which was carried out in the Oyon area, the Republic of Peru. It was aimed at clarifying geological structure, its relationship to mineralization, and then to establish future exploration criteria.

By the regional geological survey of C area during the first year, Iscay Cruz area was selected as an area that has mineralization potentiality. During the second year, the same survey was carried out in A and B areas. Mineralization showing was found in Cochaquillo-Chagapata area of the B area. Besides, detail geological survey, geophysical prospecting and drilling exploration were applied to about 40 Km^2 of the Iscay Cruz area. Detail of the mineralized zone was sketched out, and distinct geophysical anomalies were detected. Drilling, totaling 564 m, 3 holes, was made at two localities, and penetrated into high grade lead-zinc orebody occurring in iron sulfide deposits and disseminated lead-zinc orebody in siderite bed.

In this year, geological survey was done for 40 Km^2 area in B area. Detailed mapping of mineralized outcrop, geophysical prospecting and drilling exploration were continued to the Iscay Cruz area. One hundred-seventy days were spent for the field work from May 22 to November 7, 1981. Days spent for the individual works are 32 days for road construction, 82 days for geological survey, 44 days for geophysical prospecting and 160 days for drilling exploration. The geophysical prospecting consists of IP method with 7 measuring lines totaling 10.5 km and EM method with 8 measuring lines totaling 10 km. The drilling was made on 9 holes at 9 localities and the total length is 2,090 m.

The Oyon area is located at steep and high mountains of the West Andes

near its watershed. The area is underlain by Cretaceous sedimentary rocks, which have been severely folded against the Andean, NNW-SSE axis. Tertiary volcanic rocks cover them uncomformably. They are intruded by Tertiary or younger intrusive rocks.

In the Iscay Cruz area, mineralization is seen discontinuously for 12 km in calcareous rocks of Santa formation, whose thickness varies from 40 to 80 m. The mineralization in composed of copper-zinc skarn type, lead-zinc massive sulfide type and lead-zinc disseminated type in siderite bed. These ore deposits seem to show a horizontal zoning around intrusive body, thus may be considered to have formed by the same series of igneous activity.

From this year's study on the mineralized outcrop of the Iscay Cruz area, mode of occurrence of the ores and alteration halo, and dislocation of the Santa formation by faulting were better understood. By IP method, it was found that the sub-surface FE anomaly in the southernmost, Antapampa area continued more than 1,500 m in the N-S direction and plunged southward. EM prospecting was able to detect concealed Santa formation under younger sediments in Tinyag-Cunsha Punta area. This formation is expected to be mineralized.

Three drill holes were made in Limpe area, near the central part of the Iscay Cruz area. All reached to commercial grade of orebody. Amongst, DDH-5 penetrated through 23 m thick orebody with 163 g/t Ag, 2.92 % Pb and 27.15 % Zn. DDH-7 was aimed at searching for lower extention of skarn outcrop in Tiyag area. The skarn zone was detected for 114 m, among which two horizons totaling 26 m were mineralized to average 2.38 % Cu and 19.58 % Zn ores. The other drillings were 3 holes in Cunsha Punta area and 2 holes in Antapampa area. All but DDH-8 cut through mineralized and altered zones.

Cochaquillo deposit was examined in detail by the detail geological survey of B area. This ore deposit has a large-scale skarn zone but is low grade. Small-scale high-grade ore, which is characterized by silver and lead, tends to occur sporadically. However, much better potentiality is expected in depth of the fringe zone. This potentiality should be examined in near future.

Throughout the three years project including this year, the project was accomplished by finding a high-grade orebody in Iscay Cruz area. The ore reserves is expected to be large. The next step will be highly accurate exploration seeking for commercial-base ores and feasibility to develop the ores.

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GENERAL REMARKS

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Chapter 1 Introduction

1-1 Purpose of the Survey

In the Oyon area, the geological survey, geophysical prospecting and drilling exploration were carried out for the purpose of clarifying the geological structure and finding the geological environment, in which the ore deposits are expected, and the indications of mineralization as a guide to the further exploration.

These surveys were performed in cooperation with Instituto Geologico, Minero y Metalurgico (INGEMMET). The data of the operated mines in the neighboring areas were also examined in the analyses on the obtained data of the survey.

1-2 Outline of the Survey

1) Scope of the Survey

The surveyed Oyon area is situated at steep mountain slope in the Western Andes near the continental divide. The area is divided into three areas, A, B, and C areas. As the first year survey, geological and geochemical surveys were carried out in the C area for about 700 km^2 (refer to Fig. 1). As the result of the surveys, a remarkable mineralization indication was found in the Iscay Cruz area.

In the second year, detailed geological survey, geophysical prospecting, and drilling exploration were adopted to the Iscay Cruz area, and regional geological survey and geochemical survey were carried out in the A and B areas. As the results of the surveys, outline of the Iscay Cruz mineralized zone was clarified and distinct anomalies of FE (frequency effect) and AR (apparent resistivity) were observed in the central and southern parts. Lead-zinc disseminated deposit in siderite bed was discovered in the northern part, and galena-sphalerite concentrated massive pyrite deposit was found in the central part by drilling exploration. Cochaquillo and Chagapata mineralized zones were also confirmed in the B area.

In this year, corresponding to the third phase, the survey works were reinforced and detailed mapping on outcrops, geophysical prospecting, and drilling exploration were continued in the Iscay Cruz area. For the B area of 40 km^2 detailed geological survey was carried out (refer to Fig. 2).

2) Geological Survey

Mineralization indication found in the Iscay Cruz area extends about 12 km in the direction of north to south. Detailed mapping was carried out out for main outcrops in the central and southern parts where high grade ores of lead and zinc are expected. Further detailed geological survey was executed in the B area of 40 km^2 and its surrounding areas.

Special emphasis was laid on the clarification of inner geological structure of outcrops and features of mineralization in the detailed mapping. While, it was emphasized to clarify relationship between geological structure and mineralization in the detailed geological survey. Samples of ore and rock were collected with the geological survey, and various studies by means of chemical analysis, microscopic observation, X-ray diffraction, electron probe microanalysis, and isotopic dating were performed for important samples.

3) Geophysical Prospecting

Geophysical prospecting by means of IP (induced polarization) method was carried out in Antapampa area for the purpose of clarifying the details, its shape, scale and depth, of the FE and AR anomalies observed in the second year survey. EM method was applied in Cunsha Punta to Chinchaycocha area where the surface is covered by young sediments.

Main line parallel to the mineralized zone and 6 cross lines by IP method totaling 10.5 km were measured. 8 cross lines by EM method totaling 10 km were also measured.

4) Drilling Exploration

Nine drillings totaling 2,090 m were performed at 9 places in the central and southern parts of the Iscay Cruz area in order to determine the subsurface geological structure and occurrence of mineralization. All cores obtained by drilling were examined and logged, and for the mineralized portion, halves or one-quarters were collected and assayed. Microscopic studies and X-ray diffraction were done on them as needed.

For the transportation of machineries and supplies, access road was constructed to extend for about 12 km.

1-3 Organization of the Survey Team

Japan Side Planning and Negotiation

Kyuzo	Tadokoro	MMAJ*
Toshio	Koizumi	MMAJ
Zenji	Kita	MMAJ
Junnosuke	Oikawa	MESCO, Inc. **

Peru Side Planning and Negotiation

Francisco	Sotillo	INGEMMET
Gregorio	Flores	INGEMMET
Augusto	Zelaya	INGEMMET

Japanese Survey Team

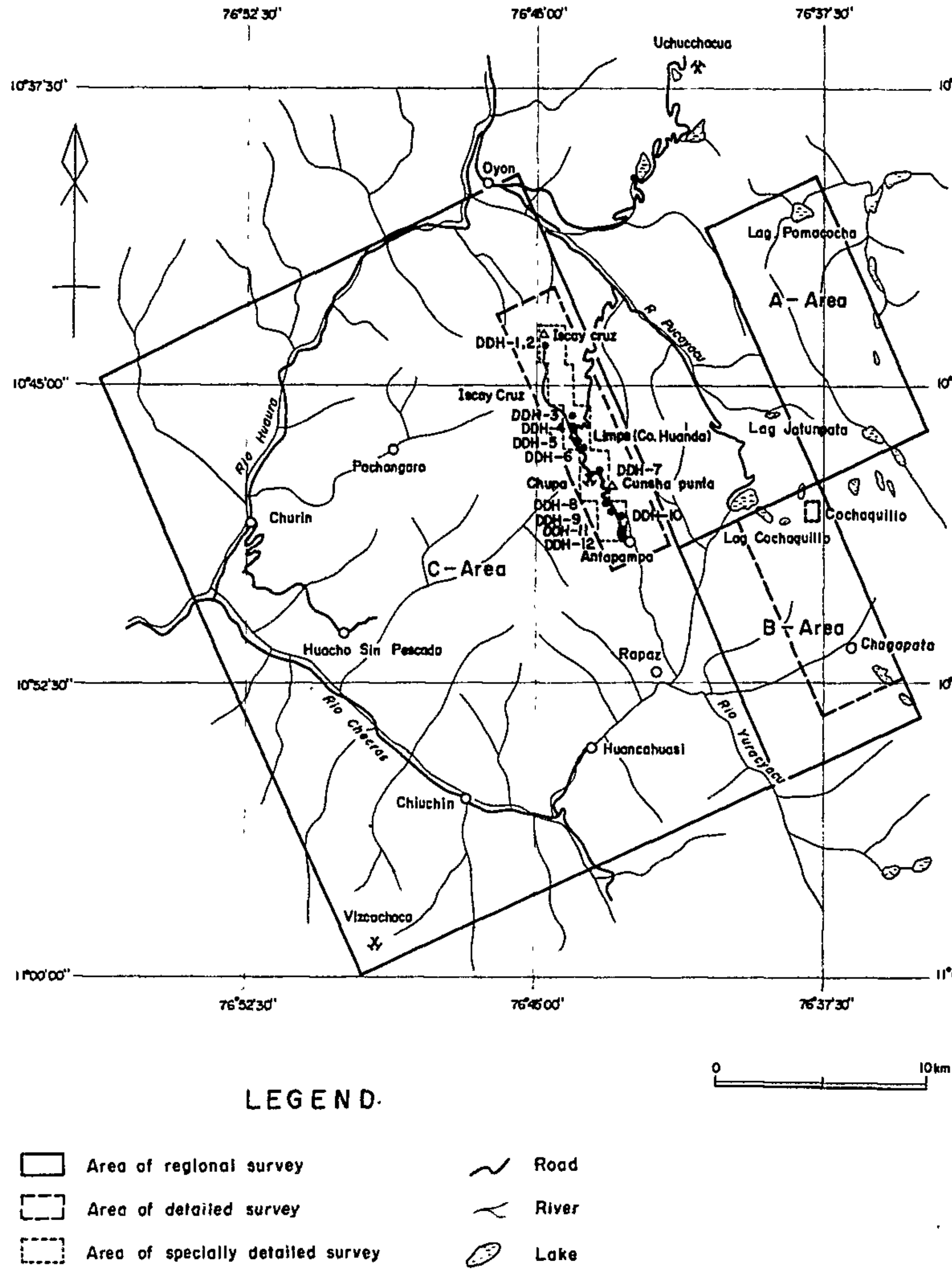
Leader	Jinichi	Nakamura	MESCO, Inc.
Geological survey	Yukichi	Tagami	"
"	Kazuyasu	Sugawara	"
Geophysical prospecting	Eiji	Tanaka	"
"	Saburo	Tachikawa	"
"	Kazuto	Matsukubo	"
Drilling work	Nobuhiko	Yamamoto	"
"	Shigeo	Sekiguchi	"
"	Takayuki	Tsuda	"
"	Soji	Kannari	"
"	Tetsuo	Yoshida	"
"	Yuji	Katabe	"
"	Eiji	Nakatsubo	"
"	Katsumasa	Tanikawa	"

Peruvian Survey Team

Leader	Fernando	Llosa	INGEMMET
Geological survey	Cesar	Vilca	"
Geophysical prospecting	Emilio	Rojas	"

* Metal Mining Agency of Japan

** Engineering Division of Mitsui Mining & Smeling Co., Ltd.



LEGEND

Area of regional survey	Road
Area of detailed survey	River
Area of specially detailed survey	Lake
Mine / abandoned mine	Ridge
Town and village	Drilling hole

Fig. 2. Location Map of the Surveyed Area

Chapter 2 General Circumstances of the Surveyed Area

2-1 Location and Accessibility

The surveyed area lies 100 km north of Lima, the capital of the Republic of Peru.

There are 2 routes leading to the surveyed area from Lima, one is to pass through Huacho, and the other is a shortcut to attain directly Sayan through Chancay (Fig. 3). The two-lane pavement road, the Pan-American High Way, is available from Lima to Huacho, and the road from Huacho beyond 15 km of Sayan is paved. The shortcut from Chancay, however, is not all paved. From Lima to Sayan, it is 178 km by the former route and 137 km by the latter. However, it takes almost same hours, 3 hours and 10 to 20 minutes, by the both routes.

From Sayan to Churin the road along Rio Huaura is rough and it takes about 2 hours to drive 61 km. From Churin to Oyon, it is 32 km and takes 1 hour and 20 minutes. To attain the Iscay Cruz area, on which the detailed surveys were carried out, the route from Oyon via Pampahuay is easiest. From Oyon to Pampahuay, it is 10 km and takes 30 minutes. From Pampahuay to Iscay Cruz, a new access road of 20 km distance passing through a pass about 5,000 m above sea level has been constructed, and it takes about 1 hour and 30 minutes by car, though it is dangerous because the road is not yet stable and it requires repair all the time.

2-2 Topography

The surveyed area lies in the Cordillera Occidental, a main range of the Western Andes, and is situated in the source of Rio Huaura which belongs to the drainage system of the Pacific coast. The area forms steep mountainous topographical feature.

The sea level ranges from 2,300 m at the lowest part of the valleys to 5,300 m at the summit of the highest mountain, attaining 3,000 m in the difference. Relatively flat plane named the Puna surface is developed from 4,200 m to 4,800 m, and the difference in topography is clearly observed bounded by this plane. The glacial topography consisting of steep peaks is formed above 4,800 m and the plane shows the stage of maturity, being deeply cut by valleys below 4,200 m (see Fig. 4).

The detailed survey areas, both of Iscay Cruz and Cochaquillo, are located at uplands more than 4,600 m above sea level. All places above 4,800 m near the continental divide are covered by snow and glacier.

The topography and drainage system in this area reflect the geological structure: the Jumasha formation consisting of massive limestone forms the highest peaks stretching in the NNW-SSE direction, then the Chimu formation of quartzite forms the mountains of indermediate height, and the Carhuaz formation composed of shale and sandstone forms lower cols. The drainage systems of NNW-SSE and ENE-WSW directions are well developed and cross to each other. The drainage system of NNW-SSE reflects the folding structure, distribution trend of the formations and thrust faults developing in parallel with the folding axes, while that of NNE-SSW reflects the fracture system.

2-3 Climate and Vegetation

1) Climate

The climate in the highland is so-called Andean highland climate. The temperature variation within a day is conspicuous. It rises over 20°C in the daytime and falls below 0°C at night.

The climate during a year is controlled by the seasonal wind from the Amazon side and is divided into two seasons, that are the dry season from May to September and the rainy season from October to April. In the rainy season rainfall, which turns to snowfall above 4,000 m, attains considerable amounts near the continental divide. As the height decreases toward west, the climate becomes dry and mild.

2) Vegetation

The kinds of plant in this area are limited owing to the dry and cold climate. A kind of cactus, such as Huacro, Chuco, and Viscayna, comes out at an upland from 3,000 m to 4,000 m above sea level. Only special alpine herbage, such as Ichu o Paja, Piriulla, and Chapcha, grows at a mountaninous place above 4,000 m.

2-4 Inhabitants and Industries

1) Inhabitants and Their Lives

The area belongs to Provincia Cajatambo in Departamento Lima in the administrative organization. The inhabitants are mainly indio. They have settled villages in the basins along the valleys since Inca time, and are living in selfsufficient by old-fasioned farming and cattel breeding. The transportations between villages depend on horse and foot.

The area is steep in topography and has cold climate in the higher places and dry climate in the lower places, and therefore the lands suitable for farming are restricted. Small scale farming is engaged on the slopes with water channels, which is limited by the elevation of 4,000 m. Grazing is only carried on the plateaus above 4,000 m.

2) Industries

Although there are no operating mines in the Oyon area, modern metal mines such as Raura mine, Uchucchacua mine, and Chanca mine are operating in the neighboring area. Production rates of these mines are 1,100 t/d, 200 t/d (under an increase in production to 500 t/d), and 200 t/d, and numbers of employees are 800, 200, and 450 persons, respectively. Each production scale is small and moderate but more than 10,000 people including employees families are depending their lives on these mines.

Development of these mines is a core of industrial activity and brings a great impact and the most stable earnings to the communities which are located in the steep mountain range and depend on old-fasioned farming and grazing.

Coal mining has been carried since long time ago, but the scale is small remained a handicraft and the weight in the local economy is not high. There are hot springs at Churin and Chiuchin, and tourism is prospecting at these places as resort zone.

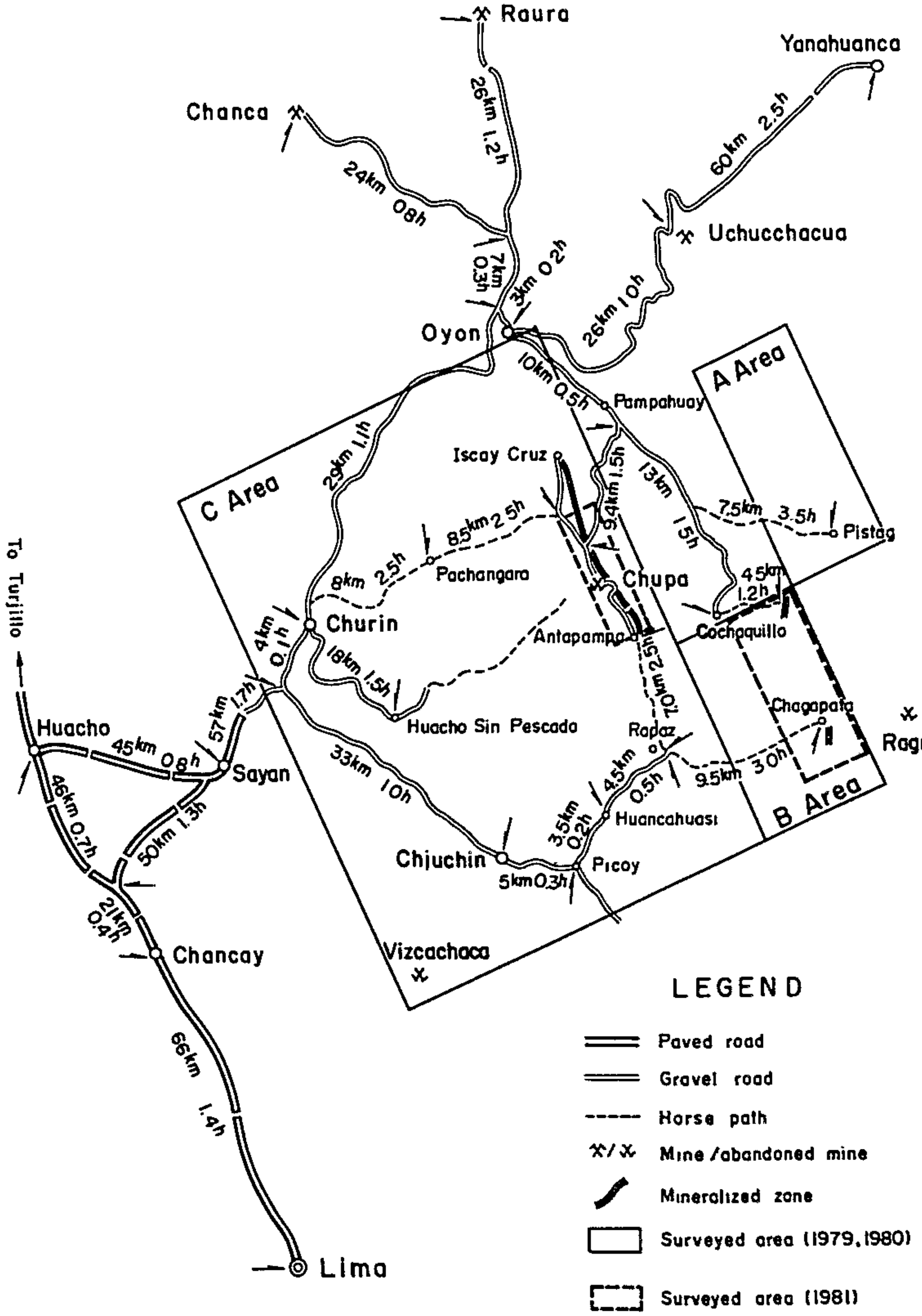
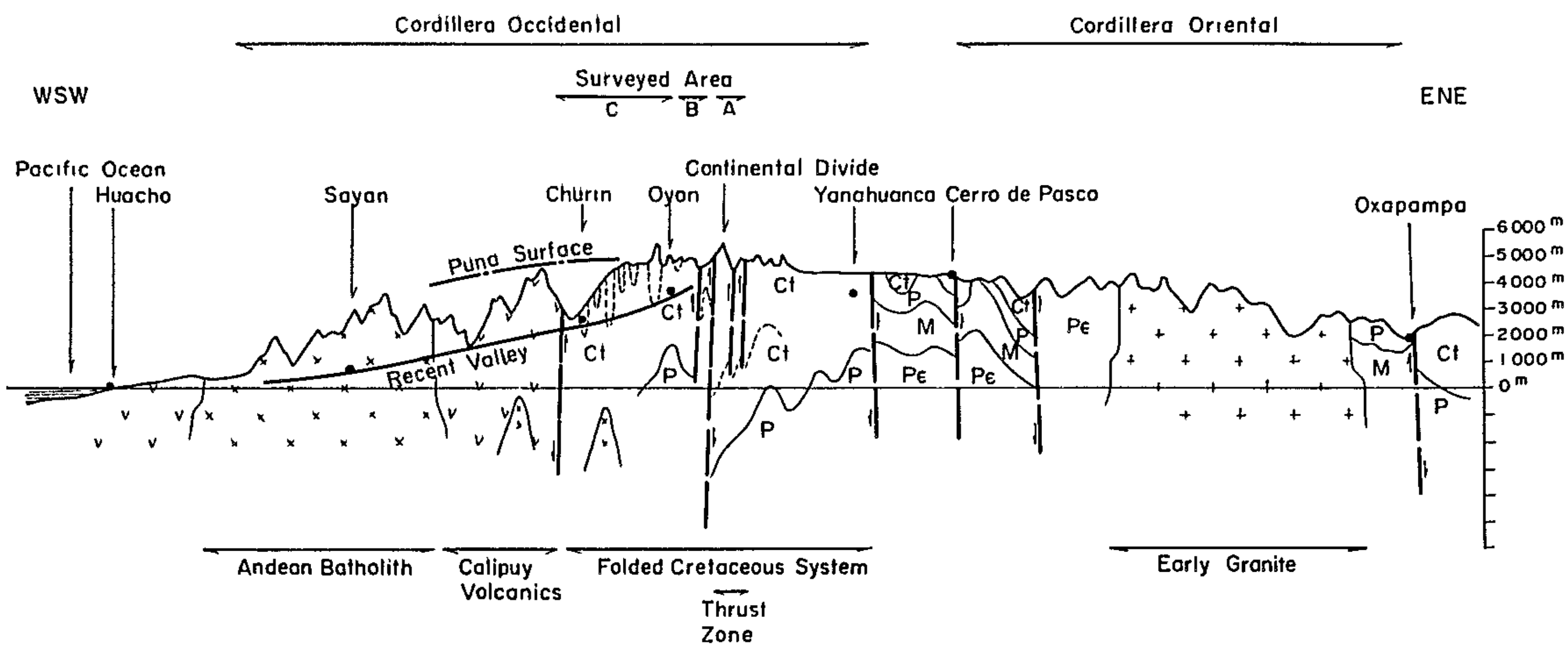


Fig. 3. Access Map of the Surveyed Area



Ct Cretaceous
P Jurassic & Triassic (Pucara Group)
M Permian (Mitu Group)
Pє . Precambrian

Fig. 4. Schematic Profile of the Central Andes Area

Chapter 3 The Situation of Mining Industry in Peru

The Republic of Peru is endowed with abundant mineral resources such as gold, silver, copper, lead, zinc and iron. Mining is one of the most important industry of Peru throughout the history.

Contribution from the mining industry to GDP (gross domestic production) of the country is usually a little less than 10 %. The percentage of people working in the mining industry is about 2 % of the total workers in the country. These figures may be considered to be low; however, the mining industry makes a great contribution to the country's income. Export of mineral commodities including petroleum, for example, exceeds 50 % by value in the total export of the country. This percentage reaches 60 % in recent years. The foreign currency thus obtained is efficiently used for development of the country and is significant source for modernization of Peru.

As is seen in the next tables, international trade balance of Peru was negative since 1974, for lowering of international price of mineral commodities due to world-wide recession. However, the national balance was much improved since 1978, following the price increase in the international market of major mineral commodities. Development of mineral resources in Peru will become increasingly important in future to supply raw materials to the western countries including Japan; hence the country will obtain fund, capital goods and technology for the domestic development.

1) Trade Balance of Peru and Export-Import by Items

(Unit $1 million)

	1974	1975	1976	1977	1978	1979	1980
Export							
Marine products	259	208	201	215	238	331	289
Agricultural products	330	387	282	337	281	362	258
Mineral products	723	547	690	901	912	1,458	1,755
Oil products	28	44	53	52	180	646	810
Others	165	105	133	221	330	677	751
Total	1,505	1,291	1,359	1,726	1,941	3,474	3,863
Import							
Consumption goods	155	199	176	173	104	170	615
Raw material semiprocessed goods	919	1,172	1,032	1,050	734	894	928
Capital goods	610	782	675	469	458	744	934
Others	223	238	217	472	305	283	619
Total	1,908	2,390	2,100	2,164	1,601	2,091	3,096
Trade balance	Δ403	Δ1,099	Δ741	Δ438	340	1,383	767

(From data of Banco Central de Reserva del Peru)

2) Quantity of Mineral Products Exported from Peru

	Unit	1977	1978	1979	1980
Copper	1,000 MT	331	344	373	351
Iron ore	1,000 LT	6,122	4,778	5,749	3,782
Silver	1,000 OZ	39,910	41,628	41,880	34,991
Lead	1,000 MT	172	176	164	152
Zinc	1,000 MT	434	437	418	470
Oil	1,000 BL	4,104	13,775	23,570	22,600

(From data of Banco Central del Reserva del Peru)

3) Export of Mineral Products from Peru

(Unit $1 million)

	1974	1975	1976	1977	1978	1979	1980
Copper	301	156	227	392	408	668	675
Iron ore	75	52	63	90	74	85	94
Lead	57	42	64	173	207	389	105
Silver	140	146	145	82	90	145	568
Zinc	150	151	191	164	133	171	193
Total, mineral products	723	547	690	901	912	1,458	1,635

(From data of Banco Central de Reserva del Peru)

Chapter 4 Outline of the Survey Results

4-1 Geological Survey

1) Detail Geological Survey of B Area

B area is located to the west of thrust fault zone where sedimentary rocks from lower Cretaceous, Oyon formation to upper Cretaceous, Jumasha formation form a composite-folded structure with a NNW-SSE trend. Calipuy volcanic rocks of Tertiary age crop out topographically high portions overlying unconformably the Cretaceous sedimentary rocks. Reverse fault of NNW-SSE direction, ENE-WSW fault which is diagonal to the thrust fault, and E-W fault are observed. Diorite, granodiorite and granite intrude into the sedimentary rocks as stock and dike at many places. Many skarn and vein type deposits, containing silver, copper, lead, zinc and iron, are known to occur around the intrusive rocks.

The most representative is Cochaquillo deposit. This ore deposit is skarn type replacing parts of limestone of Pariahuanca and Chulec formation which show an overturned structure. The size of mineralized skarn reaches 300 m by 500 m. The southern part is garnet skarn containing magnetite and disseminated chalcopyrite, and is considered as center of the mineralization. The southern edge of the orebody is cut by fault and Calipuy volcanic rocks are present beyond the fault.

Toward north of the garnet skarn zone, amount of magnetite decreases and pyrite and silver content increase. The northern edge is unmineralized limestone. Green skarn occurs as vein-like form between the garnet skarn and limestone zones. Here, galena, sphalerite and pyrite disseminate accompanying silver. The following assay values are based on channel sampling on the outcrop, which indicates high amount of silver and lead (cf. Fig. 1-8).

	Number of samples	Total length(m)	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)
Green skarn	42	91	102	0.11	3.92	2.41
Pyrite-garnet skarn	23	78	141	0.17	1.31	0.82
Magnetite-garnet skarn	32	116.5	56	0.23	0.20	0.13

In addition to Cochaquillo deposit, there are known Pirihuya and Yanacocha Ag-Pb-Zn vein type deposits of Jatunpata area to the north of the surveyed area, and Chalgoac and Uchucumachay Ag-Pb-Zn skarn deposits of Chagapata area in the south. They are all in small size.

2) Detail Geological Mapping in Iscay Cruz Area

Mineralization in this area is seen in limestone of Santa formation, discontinuously for about 12 km along this formation. The Santa formation is 40 m to 80 m thick and is distributed along narrow, NNW-SSE zone. Its eastern side is quartzite of Chimu formation, which is exposed on cliff, and the western side is shale and sandstone of Carhuaz formation which forms topographically a saddle. The Santa formation dips steeply toward west in the northern part and southern end but toward east steeply in the central and southern parts.

Around Cunsha Punta pass which is located in central-southern part of the area, felsic dike of ten or more intrudes into quartzite of Chimu formation and sandstone of Oyon formation, following more or less their bedding plane. These dikes and surrounding rocks are severely altered, brecciated and pyrite disseminated. Hence mineralization of this area is considered to be related with this felsic intrusion.

In the area to the south of Cunsha Punta pass, thickness of Santa formation is disturbed, because of two sets of reverse faulting, N-S, 75°E and N30°W, 60-70°E, occurring between Chimu and Carhuaz formations. Furthermore, drilling results on DDH-9 and DDH-10 suggest that the Santa formation is dislocated from 300 m to 400 m at a maximum by low-angle thrust fault. In Antapampa area, it was found that internal structure of Santa and Carhuaz formations is not conformable. Thus, strike-slip, reverse faults are assumed between the two formations.

Mineralization types of Iscay Cruz area consist of fine galena-spharelite disseminated, manganiferous siderite ore bed and its oxidized black gossan, galena-sphalerite-rich massive pyrite orebody, and chalcopyrite-sphalerite-pyrite-magnetite skarn orebody. Around felsic intrusive bodies of Cunsha Punta pass, there occur copper-zinc skarn deposits of Chupa and Tinyag. Zinc-rich iron sulfide orebodies exposed to the south of Cunsha Punta pass and Limpe pass are far from the intrusive rocks. In the outermost zone of Iscay Cruz pass and Antapampa area, there occur lead-zinc disseminated, manganiferous gossan and siderite bed. This variety of mineralization is considered to have formed by limestone replacement processes of magmatic and hydrothermal solutions delivered by the felsic intrusion. However, center of the igneous activity may not be one place, and the mineralization is also controlled by ENE-WSW fault system and NNW-SSE strike-slip fault; thus composite nature of the orebodies is formed. The orebodies are limited to occur in Santa formation, but the ore grade varies from place to place (cf. Fig. 1-6).

4-2 Geophysical Prospecting

1) IP Method

IP method with cross-measuring lines was adopted in Antapampa area where black gossan is exposed in a wide extent. Then, FE (frequency effect) and AR (apparent resistivity) anomalies were detected. The anomalies correspond to Santa formation. Size of the anomalies extends more than 1,500 m in N-S direction; its FE value is 4-7 % and AR value is 5-100 Ωm.

These anomalies becomes distinct in the deeper level and also strong toward the south.

2) EM Method

This method was adopted to outline subsurface bedrock geology which is covered by younger sediments in Cunsha Punta and Chinchaycocha areas. Results of the EM prospecting using VLF (very low frequency) wave are summarized as follows.

(1) Clear in-phase component curve, which indicates highly conductive mass, was obtained in a zone equivalent to Santa formation at north of Cunsha Punta pass. This confirms existence of the Santa formation underneath the younger sediment and this formation is expected to be mineralized or altered. EM anomalies were also seen in Oyon and Chimu formations of dike-intruded parts, which are distributed to the east of Santa formation.

(2) To the south of Cunsha Punta pass, EM anomalies were observed from Santa formation to Chimu formation, which occurs to the east of Santa formation.

(3) In Chinchaycocha area, weak anomalies were detected in assumed Farrat formation and along extension zone of reverse fault which separates Chimu formation from Carhuaz formation.

4-3 Drilling Exploration

Nine drillings whose total length is 2,090 m, were performed at 9 localities in Limpe, Tinyag, Cunsha Punta and Antapampa areas. High grade ores were discovered in Limpe and Tinyag areas; highly mineralized horizons were detected in Cunsha Punta and Antapampa areas.

1) Limpe Area

Three drill holes, DDH-4, 5 and 6, were set on strongly FE anomalous zone in Limpe area. Including DDH-3 of the last year, all penetrated through high-grade ores. Analytical results of the major ore zones are given below.

	Depth (m)	Interval (m)	No. of Samples	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)	Net Wid. (m)
DDH-3	104.6-108.6	4.0	4	89	0.03	6.74	14.17	2.57
DDH-4	61.3- 76.1	14.8	15	13	0.07	0.04	14.49	7.40
do.	84.9-104.7	19.8	16	10	0.10	0.30	7.78	9.90
DDH-5	95.6- 99.6	4.0	3	32	1.64	4.38	20.09	2.07
do.	181.0-204.0	23.0	23	163	0.14	2.92	27.15	11.91
DDH-6	194.4-200.4	6.0	6	29	0.33	0.03	39.36	3.01
do.	209.0-215.3	6.3	6	24	0.08	0.59	10.07	3.16
Weighted average based on individual holes		19.5	73	64	0.20	1.57	18.35	10.0

All the ores are sphalerite-rich massive pyrite, in which galena and chalcopyrite are locally disseminated.

2) Tinyag Area

DDH-7 was drilled to find lower extension of skarn outcrop exposed about 300 m south of Lags. Tinyag. Mineralized skarn was detected for 114 m. Almost all the skarn contain disseminated sphalerite, chalcopyrite, pyrite and magnetite. High grade portions and their assay are as follows.

	Depth (m)	Interval (m)	No. of Samples	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)	Net Wid. (m)
DDH-7	56.0- 63.0	7.0	5	5	0.21	0.01	19.71	4.43
do.	116.0-135.0	19.0	15	9	3.18	tr	19.53	12.03
Weighted average		26.0	20	8	2.38	tr	19.58	16.5

3) Cunsha Punta Area

In order to check lower extension of strongly mineralized outcrop of Santa formation, DDH-8, 9 and 10 were drilled in this area. All the holes encountered low-angle thrust fault, so that the Santa formation was not detected underneath the outcrop but Carhuaz formation. The Carhuaz formation is strongly mineralized by network-vein and disseminated manner of sphalerite and pyrite. This suggests that high potentiality would exist in near-by Santa formation which is possibly concealed below the Chimu formation, just east of the present site. Major mineralized zones of Carhuaz formation are listed below.

	Depth (m)	Interval (m)	No. of Samples	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)
DDH- 9	9.5-11.1	1.6	1	10	0.05	0.1	3.90
DDH-10	59.2-64.2	5.0	3	11	0.04	0.06	3.11
do.	65.9-70.0	4.1	4	13	0.08	0.05	5.38

4) Antapampa Area

In order to explore lower extension of black gossan and to know character of subsurface FE anomaly, DDH-11 and DDH-12 were carried out in this area. According to DDH-11, rocks underneath the gossan are manganiferous siderite and dolostone. Therefore the black gossan is identified as oxidized products of these rocks. The manganiferous siderite and dolostone contain about 3 % Zn, due to dissemination of fine-grained sphalerite.

Through DDH-12, the following zonation was found from surface to the depth.

(upper) Unmineralized limestone - dolomite·siderite - Zn·Cu·hematite - pyrite - Cu·hematite·pyrite - Cu skarn (lower)

The major mineralized zones have the following assay values, in which copper is dominant, especially in the deeper part, as compared with mineralizations in other areas. Copper and zinc tend to occur with hematite.

	Depth (m)	Interval (m)	No. of Samples	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)
DDH-12	122.8-128.1	5.3	2	12	0.12	0.10	4.89
	137.4-141.6	4.2	2	16	0.52	0.15	3.35
	142.4-144.8	2.4	1	34	1.89	tr	0.20
	237.5-247.2	9.7	5	94	3.08	0.01	0.33
	281.2-285.4	4.2	2	35	2.73	tr	0.40

Chapter 5 Conclusion and Outlook for Future

5-1 Conclusion

1) Iscay Cruz Area

By regional geological survey of the first year, this area was considered prosperous for lead-zinc mineralization. During the second year, detail geological survey and geophysical exploration were performed, and drilling was done to confirm results of these studies. These works led to the conclusion that distinct mineralization showing followed to occur in Santa formation of NNW-SSE trend for about 12 km and existence of massive lead-zinc deposit became highly possible within area.

In this year, the detail geological survey and geophysical prospecting were continued in Iscay Cruz area, and systematic drilling was carried out. As the results, high-grade lead-zinc massive sulfide deposit was discovered in Limpe area, and high-grade copper-zinc skarn deposit was confirmed in Tinyag area. In addition, strong mineralization was also noticed in Cunsha Punta and Antapampa areas.

Ore deposits of this area occur in Santa formation and are considered as replacement type related to felsic igneous activity. The mineralized area is centered by Cu-Zn skarn deposits and fringed by Pb-Zn massive sulfide deposits, then further by Pb-Zn manganiferous siderite bed or copper dissemination. These ore deposits may have been formed by both contact metasomatism of post-magmatic stage and hydrothermal replacement of hydrothermal stage. Incidentally, structural control of the ore deposits is similar to that of Huanzala deposits, and the ore mineral assemblage resembles that of Huanzala and Cerro de Pasco deposits.

All the geological, geophysical and drilling data, so far obtained, indicate that the Iscay Cruz area is highly potential for high-grade copper-lead-zinc deposits.

2) B Area

This area is situated to the west of thrust fault zone, which coincides with the West Andes watershed. By regional geological survey of the second year, silver-lead-zinc showing was widely recognized in this area. Thus, detail geological survey of this year was carried out. Skarn deposits of Cochaquillo and Chagapata and vein deposits of Jatumpata were examined in detail, among which the Cochaquillo deposit has the largest potentiality, having extension of 300 m by 500 m. However, most part of the ore deposit is low grade or barren garnet skarn, and high grade ores scatter as small scale lenses in green skarn of vein form. Observation of the outcrop suggests no immediate interest to go on exploration. However, marginal zone of the garnet skarn and lower extension of the green skarn may turn out to be high-grade ores, which should be considered in future.

5-2 Outlook for Future

The initial object was accomplished in Iscay Cruz area by finding of high-grade Cu-Pb-Zn ore deposits in Limpe and Tinyag areas. Highly accurate geological survey and exploration are suggested as the next step for this area, in order to obtain enough ore reserves for the development.

1) Limpe Area

Along the length of 730 m, four drill holes were made. All cut through high-grade lead-zinc ores. The next step should be to continue surface grid-drilling to the northern and southern extensions, and also to drill intermediate points between holes already made in this year. Tunnel exploration is recommended in the central part, additional underground drilling would give three dimensional distribution of the ore grade, and thus outlines workable orebody.

2) Tinyag Area

Only one drilling was made in this area, which penetrated through high-grade copper-zinc orebody. Thus this area has a large room for future exploration. It is recommended to continue surface drilling to the northern and southern extensions of the discovered hole.

3) Antapampa Area

Two drill holes were made in this area, and copper-dominant mineralization was confirmed. Since lead-zinc mineralized zone is expected around the copper mineralized zone, additional drilling is suggested in the area of concealed FE anomaly, which was widely detected in this year.

4) Cunsha Punta Area

Three holes were drilled in this area. It was found that the mineralized horizon of Santa formation was dislocated to the east below Chimu formation by low angle thrust fault. This area is close to center of felsic magmatism, and strong mineralization is seen in not only Santa formation but also Carhuaz and Chimu formations. Geologically a large potentiality is expected in this area. Detail geological survey and geophysical prospecting are necessary to examine geological structure of this area.

5) Northern Iscay Cruz Area

Although black gossan is exposed discontinuously for 5.4 km from Lag. Quellaycocha to Canaypata, only two drill holes have been made in this area. The lower part of the black gossan is usually composed of manganifeous siderite containing small amount of lead and zinc. However, copper-bearing pyrite and hematite masses are seen at Antapampa. Center of the mineralization may not be one place, thus mineralization zoning may be irregular. It is suggested therefore to add drilling even in this area, paying attention to the geological structure.

6) Chupa Ore Deposit

Lower extension of the known orebody below the lowest working adit, 4560 m level, should be explored.

7) Ore Deposit and Mineralogical Studies

Oxidized outcrop of the high-grade lead-zinc pyrite massive sulfide deposit in the Limpe area consists of hematite dissemination in silicified rocks, black gossan with oxidized products of manganiferous siderite, and faintly disseminated galana and sphalerite in dolostone. Hematite and black gossan spread out on surface outcrop cannot be considered as oxidized products of pyrite. Thus, the two products may be different even at the primary stage.

Establishment of relationship between weak surface showing and underground strong mineralization is urgent requirement for future exploration. Thus ore genesis study and mineralogical research of both primary and secondary constituents have to be strengthened.

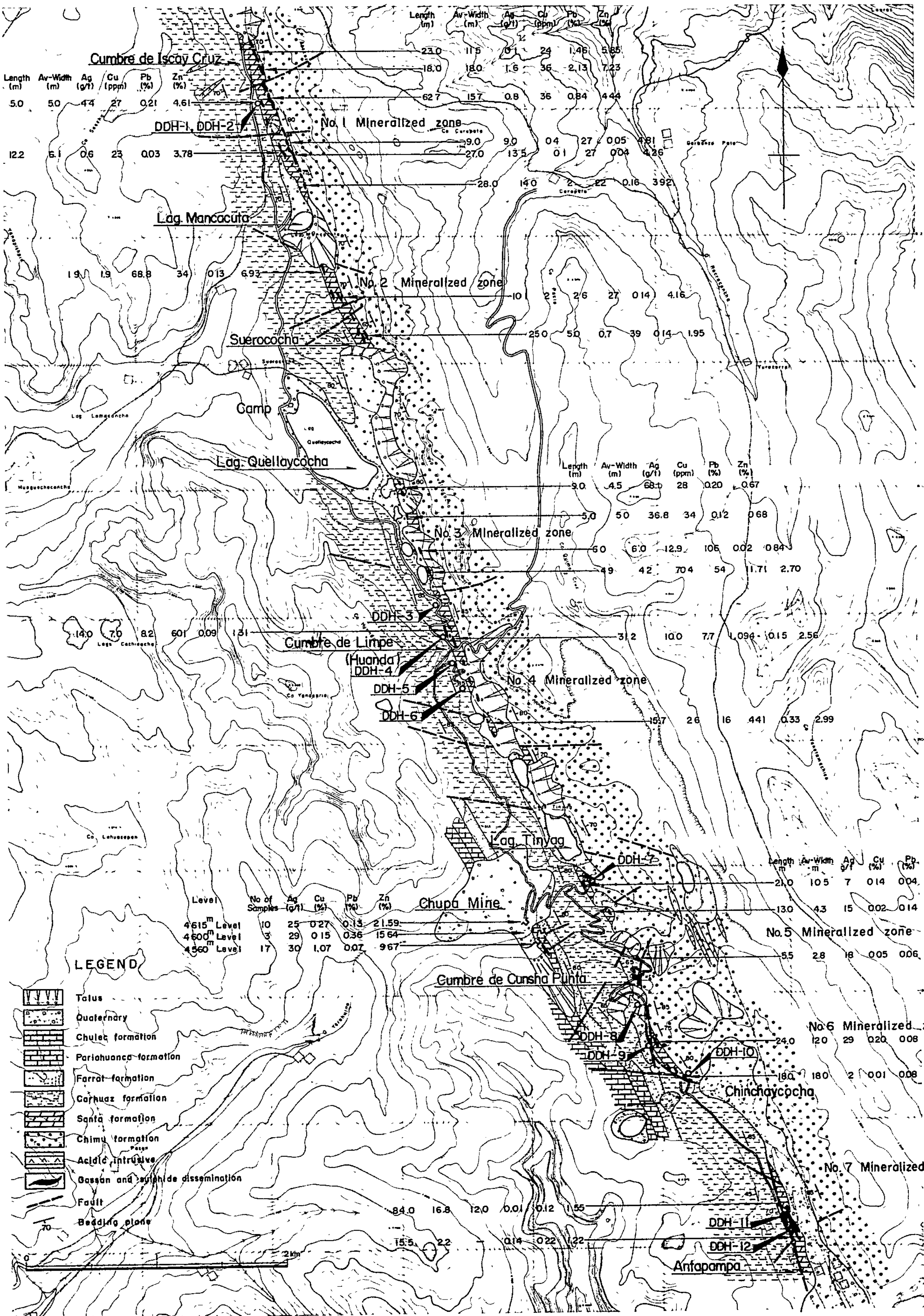


Fig. I-6. Mineralized Zone of the Iscay Cruz Area

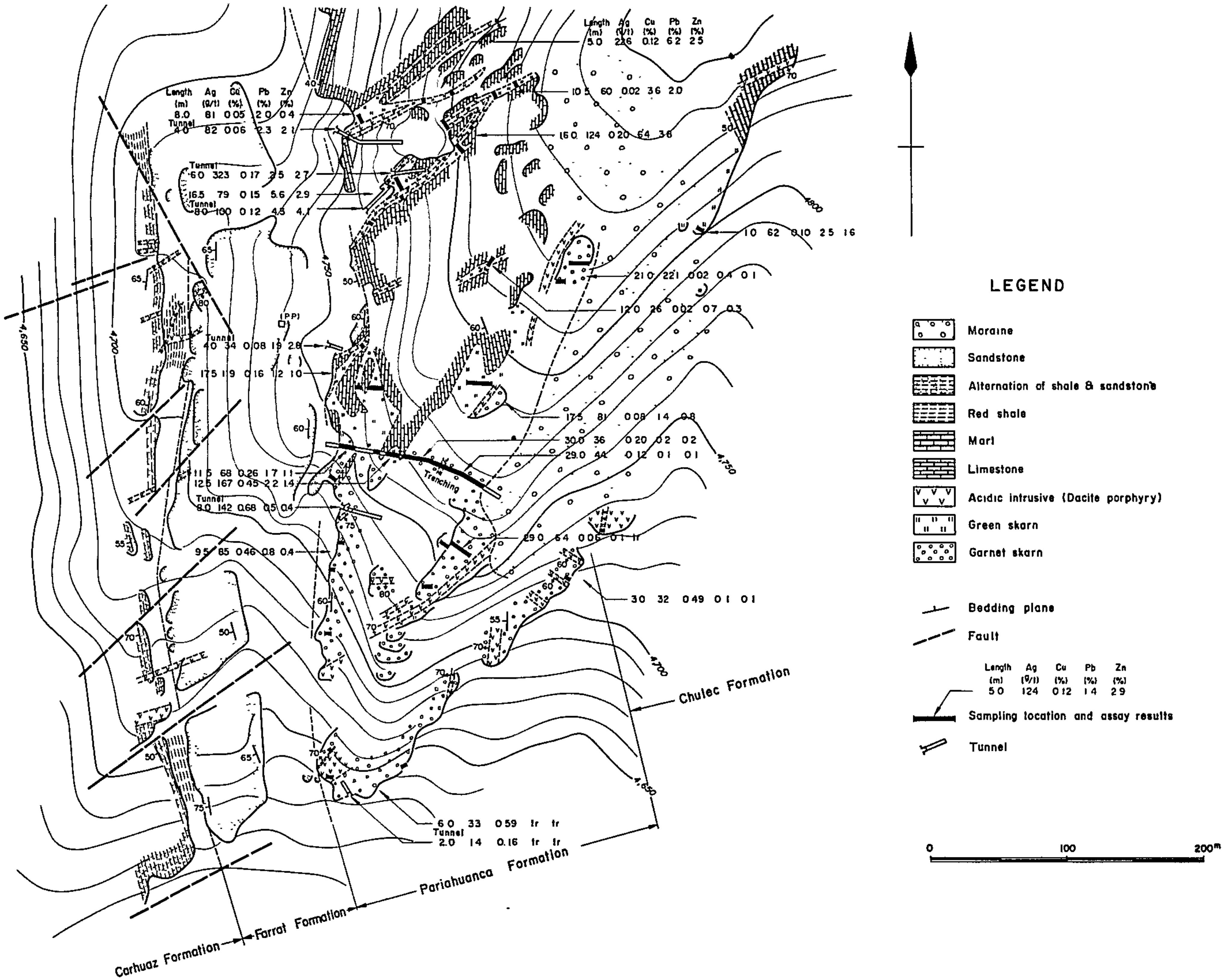


Fig. I-8. Mineralized Zone of the Cochaquillo Area

PARTICULARS
PART I
GEOLOGICAL SURVEY

PART I GEOLOGICAL SURVEY

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Chapter 1 Outline of the Survey

1-1 Purpose of the Survey

Although there is no developed metal mine in the surveyed Oyon area, several mineralized zones of silver, copper, lead, and zinc, such as Iscay Cruz, Chupa, and Cochaquillo, are known. In the adjacent area, there are several producing mines such as Raura, Uchucchacua, and Chanca.

The purpose of the survey is to clarify general feature of the mineralized zones, to confirm the relationship between geological structure and mineralization, to inquire the possibility of mineral reserves existence, and consequently to establish valuable guideline for the further exploration by the way of detailed geological survey and various studies in the Iscay Cruz area and in the B area.

1-2 Scope and Period

1) Location and Scope

The surveyed Oyon area lies 100 km north of Lima and upstream of Rio Haura including a mountain ridge of the Andes and the continental divide.

The B area, in which detailed geological survey was carried out this year, is located at the riverhead of Rio Checras, a branch of Rio Huaura, occupying an area of 40 km^2 adjacent to the continantal divide. To reach the surveyed area, walking about 15 km along the valley is needed from Huancahuasi.

The Iscay Cruz area, in which detailed geological mapping was carried out, is located about 12 km south-southeast of Oyon. The central and southern part of Iscay Cruz stretching about 8 km was selected for the subject of investigation this year. Last year, a new access road was constructed through a pass of 5,000 m above sea level and now it becomes easy to enter the area.

2) Period

82 days were spent for the field work and 159 days for the laboratory work.

Field work : from June 15, to September 4, 1981

Laboratory work: from september 5, 1981, to February 10, 1982

1-3 Method of the Survey

A cooperative survey team consisting of three Japanese geologists and two Peruvian geologists was formed in Lima. A field office at Churin and a base camp at Oyon were established. Three or two survey teams were organized at Churin and the work was divided among them. Each survey team consists of Japanese and Peruvian geologists, two or four laborers and another horse driver.

All survey areas are located in the central part of Andes mountain range with steep topography and even the lowest part has elevation of 4,600 m. At this altitude, there is always danger of high altitude sickness with headache, loss of body strength, low appetite and lack of sleep. For this reason, to maintain good health and adaptation to high altitude, the best considerations and enough preparation period are needed. For this altitude, oxygen vessel is very necessary.

Both survey areas are far from village and isolated, connected only by horse trails and almost unexplored region. Long distance caravan is necessary to approach the B area. All surveys were conducted by mobile camp system, and many horses were used to move the camp and to transport supplies, and for survey activities. Without horse, survey activity is extremely difficult.

The topographical maps of the scale 1/10,000 were used for the detailed geological survey in the B area. In the Cochaquillo mineralized zone, the survey was done in the scale of 1/2,000 using the pocket compass. In the Iscay Cruz area, the detail mapping in the scale of 1/500 was carried out for the main outcrops. At the outcrops of ore minerals, ore samples for assaying were obtained by means of channel sampling with 10 cm in width and 2 - 4 m in length, and massive ore samples were also collected for the various studies. Trenching survey totaling 200 m in length was conducted as a supplemental means to clarify the geological succession and mineralizing condition.

1-4 Method of Data Analysis

Followed up the field works, the laboratory works were carried out on the various samples, and field data were investigated carefully. The laboratory works were almost performed in Japan and a part of them was done in Peru. The main items are as follows:

(1)	Microscopic observation of thin sections:	20 samples
(2)	Microscopic observation of polished sections of ore:	10 samples
(3)	Chemical analysis of ore (Ag, Cu, Pb, Zn):	157 samples
(4)	X-ray diffraction:	20 samples
(5)	Electron probe microanalysis:	3 samples
(6)	Determination of isotopic age:	3 samples
(7)	Complete analysis of igneous rocks:	4 samples
(8)	Analysis of rock-forming elements (Ca, Mg, Mn, Fe, Si, Ba, Sr, Co):	10 samples

Chapter 2 Geology

2-1 Outline of Geology

2-1-1 Geologic Outline of Oyon Area

The Oyon area blongs stratigraphically to the zone of Cretaceous sedimentary basin (la Zona de la Cuenca Cretacea) by Cobbing (1973), and is structually situated in the folding-thrusting zone (la Zona de Plieqes y Sobreescurrimientos) by Wilson (1967).

In this area thick Cretaceous sedimentary rocks are widely distributed. Their lithology is significantly different in the lower part and the upper part to each other; the lower part is composed mainly of clastic rocks such as siliceous sandstone and shale, the upper part calcareous rocks associated with dolostone and shale, and the uppermost part red formation. This sequence indicates an evolution of sedimentary basin in Cretaceous time and corresponds to a cycle in sedimentary environment, continental-marine-continental.

In the present report the stratigraphic classification and the name of the formations are referred to Cobbing (1973) and Wilson (1967). The clastic rocks of the lower part is divided into the Oyon, Chimu, Santa, Carhuaz and Farrat formations, and the calcareous rocks of the upper part into the Pariahuanca, Chulec, Pariatambo, Jumasha, Celendin and the uppermost red Casapalca formations in ascending order. These formations are unconformably covered by the Calipuy volcanics in Tertiary and are intruded by tonalites, dacites, granite porphyry and others (Fig. I-1).

The Cretaceous sedimentary rocks suffered intensely a structural movement in consequency of the Andean Orogeny to form composite folds with NNW-SSE trend. Anticlines and synclines appear at intervals of 2 to 3 km, sometimes several tens meters, so that the same stratum is repeatedly exposed at the surface. Usually the folds have acute angle at the axis. In many cases the upper strata are folded in between the lower strata, and the latter are interbedded in the former as plug. At the central part in the orogenic zone thrust faults parallel to the fold axis are developed. The total vertical displacement of the two main faults at intervals of about 2 km attain approximately 1,500 m. The west block thrust into the east block, and this part makes a continental divide. To the east of the thrusting fault, the faults belonging to the same system are developed at intervals of 1 to 2 km and make a imbricate structure (Fig. I-2).

2-1-2 Geologic Outline of A Area and B Area

1) A Area

The A area covers a part of the Rumi Cruz mountains (Cordillera Rumi Cruz) forming the continental divide and its eastern flanks, and the Jumasha and Celedin formations are distributed in this area. In the both sides of the Rumi Cruz mountains, a thrust fault divides the geologic structure of this area into two parts. This area is also situated in the western part of a great anticlinal structure, and therefore the both formations mentioned above dip west. The faults with NNW-SSE trend belonging to the same system as the thrust fault are developed regularly and make a imbricate structure.

2) B Area

The B area covers a part of the Rumi Cruz mountains and the region on the west of the Callejon mountains (Cordillera Callejon) which is situated on the southern extension of the thrusting fault mentioned above. Cretaceous sediments from the Oyon formation to the Jumasha formations are distributed, forming a composite folded structure. The Calipuy volcanics covers unconformably both formations.

The thrust fault of NNW-SSE direction runs along the western edge of the Callejon mountains, and the western block composed of the lower Cretaceous formations such as Chimu and Carhuaz formations thrusts up to the eastern block composed of the upper Cretaceous Jumasha formation.

In the B area located to the west of the thrust zone, many ENE-WSW and E-W trending faults are developed, and many igneous bodies from granitic to dioritic composition in the forms of stock and dyke intrude into the Cretaceous sedimentary rocks. The intrusives are occasionally accompanied with silver, copper, lead, and zinc mineralization, and form several mineralized zones such as Cochaquillo and Chagapata.

3) C Area

The C area, occupying the greater part of the Oyon area, is located to the west of the thrust zone and the continental divide. The lead and zinc mineralized zone of Iscay Cruz is embedded in the Santa limestone located in the eastern part of the C area.

In this area, the Cretaceous system from the Oyon formation to the Jumasha formation is widely distributed and forms a composite folded structure trending to NNW-SSE direction. The Tertiary Calipuy volcanics appears in the western part by fault relation with the Cretaceous sedimentary rocks. Intrusive rocks are mainly composed of tonalite, dacite, quartz porphyry, and porphyrite.

2-1-3 Geological History of the Oyon Area

The Oyon area is situated in the central zone of the Western Andes (Cordillera Occidental) is composed mainly of intensely folded Cretaceous sedimentary rocks. On the east of this area the Eastern Andes consisting mainly of Paleozoic sedimentary rocks and pre-Cambrian metamorphosed rocks runs, while on the west Tertiary volcanic rocks are continuously distributed and the Andean batholith intrudes into this volcanic rocks.

In the Cretaceous time geological movements in this area reached a climax. A boat-shaped basin separated from ocean was developed at the western margin of the area, consisting of Paleozoic, Triassic and Cretaceous formations which have deposited to surround the South American Continent. In this basin the sediments with various lithology were formed. At the early stage of Cretaceous age a considerable amount of clastic material was brought from the land lying to the east of the basin, and clastic sediments containing coal beds were formed. At the middle stage of Cretaceous the transgression progressed and thick strata of limestone were formed. At the later stage of Cretaceous the retrogression proceeded and red formation was formed.

At the later stage of Cretaceous age the volcanic activity took place along the western margin of the basin and reached a climax in Tertiary. A large amount of andesitic lava and volcanic ash flow was erupted, and thus the volcanic arc was formed. These volcanic rocks are distributed from north to south in the Territory of Peru attaining 2,000 km. On the west of the volcanic arc, a large batholith crops out. This botholith is considered to form a spine of the Western Andes and to be a base of volcanic rocks, and was exposed by later erosion.

When the magma that brought about the volcanic activity on the surface is cooled in the crust, plutonic body is formed. The violent volcanic activity in Tertiary is a characteristic feature of the Andean Orogeny, and a large amount of lava was erupted and many plutonic bodies intruded. As a result, the crust was considerably expanded and strong compression and upheaval were produced. It is thus considered that these compression and upheaval caused the strong folding and uprising in the thick sediments in the Eastern and Western Andes. According to plate tectonic theory, the magma was continuously supplied by partial melting of subducting plate.

2-2 Sedimentary Rocks

Outline of the Cretaceous formations that are distributed in the most part of the Oyon area is described in this part (Fig. I-3).

2-2-1 Lower Clastic Group

1) Oyon Formation

The Oyon formation, the lowest formation in the Oyon area, is distributed underneath the Chimu formation in NNW-SSE trend along the axis of anticline. This formation is composed mainly of the fine alteration of dark grey sandstone and shale and carries coal beds in the upper part. The fine-grained and poorly sorted nature and presence of coal bed of this formation suggests deposition in swamps.

2) Chimu Formation

The Chimu formation is most widely distributed in this area as well as the overlying Carhuaz and Jumasha formations. The thickness is from 600 m to 700 m in general. The formation consists mainly of white to pale grey and fine to medium-grained siliceous sandstone containing same intercalated blackish sandstone and sandy shale. The Chimu formation forms the rugged mountains consisting of massive and tough rocks and is easily distinguished by the topography from other formations. Cross bedding and ripple mark are recognized in the sandstone and fragments of plant fossile have been only discovered in the formation. Judging from the lithology, sedimentary structure and contained plant fossils, this fromation is regarded as delta and flood plain deposit.

3) Santa Formation

The Santa formation is distributed in a long and narrow belt covering the Chimu formation. This formation consists mainly of fine-stratified bluish grey limestone associated with sandy limestone and marlstone accompanied with dolostone and nodueles of chert. The formation is usually

100 m to 150 m in thickness. The Santa formation forms steep cliffs in contact with the rock wall composed of the Chimu quartzite, and sometimes it is interbedded as a plug in the overlying Carhuaz formation. The abundance of fragments of shells and the absence of pelagic invertebrates suggest the deposition in a near-shore environment.

4) Carhuaz Formation

The Carhuaz formation is widely distributed along the saddle part of mountain which consists of the Chimu and Jumasha formations. The formation is mainly composed of alternation of sandstone and shale and subordinate thin beds of limestone. In the uppermost and middle parts, bright red shale, which can be used as a key bed in the field survey, is remarkably developed. Because of the flexible and incompitent nature of the rocks, thickness of the formation is extremely variable depended upon the situation in the folded structure, usually 500 m to 800 m. The presence of plant fossils and coaly layers indicate a shallow marine environment of the deposition.

5) Farrat Formation

The Farrat formation is distributed in a narrow zone interbedded between the underlying red shale of the Carhuaz formation and overlying massive limestone of the Pariahuanca formation. This formation is composed of light color and medium-grained siliceous sandstone in the lower part, and pale grey and medium-grained calcareous sandstone in the upper part. Conspicuous development of cross bedding in the sandstone suggests deltaic or fluviatile conditions along the seashore. The thickness is about 100 m to 120 m.

2-2-2 Upper Calcareous Group

1) Pariahuanca Formation

The Pariahuanca formation consisting of massive limestone in contact with the underlying Farrat formation is distributed in long and slender to surround the mountain chain consisting of the Jumasha formation. This formation topographically forms the small projections distributed continuously in a narrow zone, and this character is able to be used as the most useful key bed in the analysis of aerial photographies. The formation becomes thin towards east and thick towards west. The thickness usually ranges from 80 m to 100 m. Since the formation carries fossils mostly broken into fragments and no pelagic fossils, it may have accumulated in the neritic sea near the shore. The deposition of this formation shows the beginning of the Albian transgression on a large scale.

2) Chulec Formation

The Chulec formation, together with the overlying Pariatambo formation, is distributed to surround the mountain chain made up by the Jumasha formation and forms a topographical depression between Jumasha and Pariahuanca formations. The formation consists of pale brownish marlstone and its thickness is about 200 m. The study of fossil fauna shows that the lower part of the formation represents near-shore facies and the upper part slightly deeper water condition. This indicates that the marine transgression progressed from the west and the sea became gradually deeper toward this direction.

3) Pariatambo Formation

The Pariatambo formation is distributed surrounding the mountain chain which is composed of the upper Jumasha formation. The formation consists of thin alternation of limestone, marlstone, and shale. All of these rocks are bituminous and show dark grey to black color. Limestone of several centimeters in thickness and marlstone or shale of several millimeters are alternated and rectangular cracks to bedding plane are developed in the formation showing a brisk-like structure. Near the axis of syncline intra-formational foldings are repeated. The thickness is about 150 m. The lithologic types and faunal assemblages suggest that the sea became shallower eastward and euxinic conditions prevailed at that time.

4) Jumasha Formation

The Jumasha formation is distributed along the axis of syncline with NNW-SSE trend, forming prominent steep mountain chain brightening in light grey. Thus, the mountain chain made up by this formation, being a contrast to the rugged mountains composed of the Chimu formation, makes the landscape in this area diversified. The formation consists of grey massive limestone and embraces marlstone beds of several tens meters in thickness about 150 m above the bottom of the formation. The Jumasha formation is widely distributed on the east of the thrusting zone forming the continental divide. According to the survey results of the A area, its thickness seems to be more than 1,400 m based on the relation between the upper Celendin and lower Pariatambo formations. The sedimentation environment is supposed to be the offing with weak currents, judging from the lithology and contained fossils.

4) Celendin Formation

The Celendin formation is distributed on the east side of the continental divide. So far the Oyon area, the distribution of this formation is limited to the A area, and is absent in B and C areas due to erosion.

The formation consists mainly of pale yellow to pale brown marlstone and carries thin limestone seams and patches. It easily suffers weathering and is eroded at the surface. Therefore, it is distributed in the collapse and basin structure formed by fault sticking to the Jumasha formation. The thickness is about 200 m in the A area.

This formation covers conformably the Jumasha formation and in turn is covered by the Casapalca red formation which indicates a continental environment. It forms uppermost part of the limestone belt which continues from the Pariahuanca formation, and represents the final stage of marine sedimentation in the Western Andes.

2-2-3 Casapalca Formation

The distribution of the Casapalca formation is restricted to the east of the thrust zone, that is the southernmost part of the A area and on the east of the B area. This formation is easily weathered and eroded. Therefore, it was completely removed at the upheaval parts of the blocks and remains at the depressed parts of the blocks, usually forming basins and planes together with the Celendin formation.

The Casapalca formation is usually characterized by red formation consisting of conglomerate, sandstone, shale and limestone. However, from the southernmost part of the A area to the eastern part of the B area limestone and dolostone is abundant. On the basis of structural analysis, it is estimated that the thickness of the formation attains more than 1,000 m.

The red formations corresponding to the Casapalca formation are widely distributed in the whole western Andes area, and their lithology and thickness vary from place to place. The existence of this formation indicates the finality of marine environment and the commencement of continental environment of the post-Santonian stage, and that the sedimentary basin was localized. The Casapalca formation covers uncomformably the Celendin formation and is uncomformably covered by Calipuy volcanics.

2-3 Calipuy Volcanic Rocks

(1) Distribution: The calipuy volcanic rocks covering the Cretaceous sedimentary rocks are distributed in the extensive area along the Pacific coast of the Western Andes. In the Oyon area, these rocks are restricted

in the B area and in the western part of C area. The volcanic rocks are in contact with the sedimentary rocks by the fault in C area, while they cover unconformably the latter in B area.

(2) Stratigraphy: The volcanic rocks consist mainly of andesitic lava, tuff breccia and agglomerate. The stratigraphy of these volcanic rocks are clarified in Cerro San Camilo area of the B area shown as follows;

the upper part	150 m+	andesite and tuff breccia
	150 m	andesite
the middle part	200 m	alternation of agglomerate, tuff breccia, sandstone and shale.
the lower part	400 m+	agglomerate, partly tuff breccia and and welded tuff.

(3) Structure and thickness: The volcanic rocks have a weak folding structure, showing conspicous contrast to intensive folding in the Cretaceous sedimentary rocks. Distribution of the volcanics abutting against the secimentary rocks is controlled by the erosional topography of the sedimentary rocks. The thickness of the volcanic rocks attains more than 900 m in the B area and the upper part is eroded out, while it attains 3,000 m in appearance in the western marginal part of C area.

(4) Evaluation of the age determination: The K-Ar age, using samples of andesitic lava overlying directly on the alternation zone near the summit of Cerro San Camilo, is 9.5 ± 0.5 million years (refer to Table I-2). This corresponds to Pliocene time.

The rocks are greenish grey and contains phenocrysts of plagioclase and amphibole. However, optical observation indicates that mafic minerals are altered and partially replaced by chlorite and epidote, so that the age-determination by isotope ratio was carried out on the bulk rocks. Therefore, it is possibly considered that the age obtained is possibly younger than the real age. However, the Calipuy volcanics include the rocks produced by the volcanic activity for long period, and therefore, it is probable to interpret that this rock represents the last stage of volcanic activity.

2-4 Intrusive Rocks

2-4-1 Granodiorite and Diorite of the Cochaquillo Area

(1) Shape and extent: Granodiorite and diorite intrude into the Carhuaz formation and the agglomerate of the lower part of Calipuy volcanic rocks about 2 km east of Lag. Cochaquillo, showing a stock form and 0.8 km x 1.8 km extent. Both rocks vary gradually from granodiorite to diorite in lithology forming the same body.

(2) Lithology: The granodiorite is medium to fine-grained and consists mainly of plagioclase with subordinate amount of quartz, orthclase and amphibole. The diorite is also medium to fine-grained and increases in amphibole content.

(3) Bulk composition: Fig. I-4 is quartz - K-feldspar - plagioclase diagram for the CIPW norms calculated from the bulk compositions (shown in Table I-1). The norms of salic minerals of granodiorite (NO-633) is plotted near the boundary between granodiorite and quartz-monzonite classified by Bateman et al (1976). The diorite (NO-373) is plotted near the boundary between granodiorite and diorite.

(4) Evaluation of the age determination: The K-Ar age of granodiorite using separated amphibole is 18.4 $\pm$ 3.7 m.y., and that of diorite using whole rocks is 11.1 $\pm$ 0.6 m.y.

This difference may be ascribed to rejuvenation due to the alteration of diorite, although there is a possibility that the difference is caused by the different stage of solidification within the same body.

2-4-2 Granodiorite and Granite Porphyry of Chagapata Area

(1) Shape and extent: Granodiorite intrudes mainly into the Chimu formation as a stock form of 0.8 km x 2.3 km extent. Granite porphyry occurs as dikes in the Cretaceous sedimentary rocks and Calipuy volcanic rocks.

(2) Lithology: The granodiorite is medium to fine-grained and contains phenocrysts of biotite and amphibole. Under the microscopy the rock is hollocrystalline and shows porphyritic texture consisting mainly of plagioclase, quartz, orthoclase and biotite. In places orthoclase includes plagioclase, and amphiboles are altered to chlorite. The granite porphyry is fine-grained and contains plagioclase and biotite as phenocryst. Under the microscopy the rock consists mainly of plagioclase, orthoclase, quartz and biotite. The groundmass is cryptocrystalline.

(3) Bulk composition: Both normative compositions of granodiorite (NO-350) and granite porphyry (NO-652) are plotted in the region of granodiorite, although granite porphyry occupies near the boundary with quartz-monzonite.

(4) Evaluation of the age determination: The K-Ar ages using separated biotites of granodiorite and granite porphyry are 9.0 ± 0.5 m.y., and 6.2 ± 0.3 m.y., respectively. These years suggest the youngest age of igneous activity in the Oyon area.

2-4-3 Igneous Rock Series

In MFA [Mgo-($FeO+Fe_2O_3$) - (Na_2O+K_2O)] diagram (See Fig. I-5) igneous rocks of the Oyon area are plotted along a straight line, with a few exceptions. This fact indicates that the igneous rocks differing in rock composition, mode of intrusion and age of intrusion may have been derived from the same magmatic source and experienced similar crystallization differentiation. The differentiation trend is consistent with that of typical calc-alkalic rock series. In the process of differentiation, contents of (Na_2O+K_2O) and SiO_2 increase in the residual liquid, while content of ($FeO+Fe_2O_3$) decrease consistently.

Dacite (SO-176) and andesite (AO-116), both of which intruded at early stage, are exceptions and show similar composition to tholeitic series. Welded tuff (NO-652) seems also to belong to tholeitic series, though it is contaminated through sedimentation.

2-5 Geological Structure

The geological structure in this area is characterized by intrafolial fold, thrust fault parallel to the fold axis, conjugate shear faults oblique to the fold axis, and tension fault which cross with the fold axis at right angle. These are formed by the strong compressive force and emergence force of blocks produced through the Andean orogenic movement.

2-5-1 Fold Structures

The Cretaceous sediments in this area make a composite fold structure with an axis of NNW-SSE direction, and the Chimu formation forms anticlinal part, while the Jumasha formation forms synclinal part.

The cycle of folding is usually 2-3 km, and sometimes it becomes several tens meters. The fold axis is horizontal, and according to Cobbing (1973), extends to 100 km. The dip of fold plane is usually 80° -70° to the west and occasionally 80° -70° to the east. The structure at the axial part usually show acute angle, and in such a case at the synclinal part the upper strata are folded in between the lower strata, while at the anticlinal part the lower strate are sandwiched in between the upper strata, showing plug shape.

In competent strata such as Chimu formation flexual-slip folds with faults parallel to bedding plane are developed. In this case fine-grained sandstones and sandy shales sandwiched between siliceous sandstones are considerably crushed, which may be caused by the bedding plane faults. On the other hand, in incompetent strata such as Pariatambo formation flexural-flow folds are developed and the thickness of strata varies considerably, depending on the shape of fold and the position at which the strata lie. The cycle of folding is in short range, and when the axial part has acute angle, thickness of strata varies considerably. Thickness of strata decreases usually at the wings of fold, while increases at the axial part.

2-5-2 Faults

In this area three fault systems are found: the first fault system with NNW-SSE trend is parallel to the fold axis; the second system with NE-SW and WNW-ESE trends crosses obliquely the first system; the last system with ENE-WSW trend crosses rectangularly the fold axis.

1) NNW-SSE System

In the westernmost part of the A area and the eastern part of the B area, two series of thrust faults, the west Rumi Cruz thrust and the east Rumi Cruz thrust, are running parallel to the Rumi Cruz and the Callejon, mountains, both of which form the continental divides. The distance between the two thrusts is about 2 km and the vertical displacement attains approximately 1,500 m. The block of the west side to the faults, consisting of lower formations such as the Chimu formation, thrusts up to the upper formations consisting of the Jumasha, Celendin and Casapalca formations. On the both sides of the thrust faults, the faults belonging to the same system of the thrust faults, such as the Ruco fault, the Cutacocha fault and the Picoy fault, are developed. In the area on the east of the east Rumi Cruz thrust, the faults of the same system are developed, forming imbricate structure.

2) NE-SW System and WNW-ESE System

The two fault systems, which cross obliquely the fold axis, are

characterized by the horizontal displacement. The Shapra fault, about 10 km northwest of Oyon and the Otuto fault, about 5 km southeast of Oyon, are typical among the faults with NE-SW system. The Viroc fault to 3 km southwest of Oyon and the Cuchpange fault to the 13 km of Oyon belong to the WNW-ESE system. These faults are mainly characterized by horizontal displacement, and the block on the east is displaced toward west. Apparent displacement attains 1 km. The faults of both systems are typical conjugate fault, and have a close relation to the formation of the fold structure in this area. The Viroc fault forms echelon shape and the drags of strata are observed.

3) ENE-WSW System

This fault system is developed in echelon shape and crosses rectangularly fold axis. It has a characteristic of tension fracture, being randomly displaced. The Cochaquillo fault is a typical one. The fracture of this system is related to the intrusion of dikes and mineralization.

4) Bedding Fault

The strata are strongly folded, and at the part where flextural-slip folds are developed many bedding faults are formed. Although the displacement in each fault is small, it is considered that the displacement as a whole attains a considerably large amount. The folds, therefore, show saw-shape at the axial part. The dips of bedding fault are horizontal or very steep, and the fractures which are nearly horizontal and cross rectangularly the bedding faults occur at intervals of several tens to several hundreds meters. The strata are displaced to several meters by these fractures.

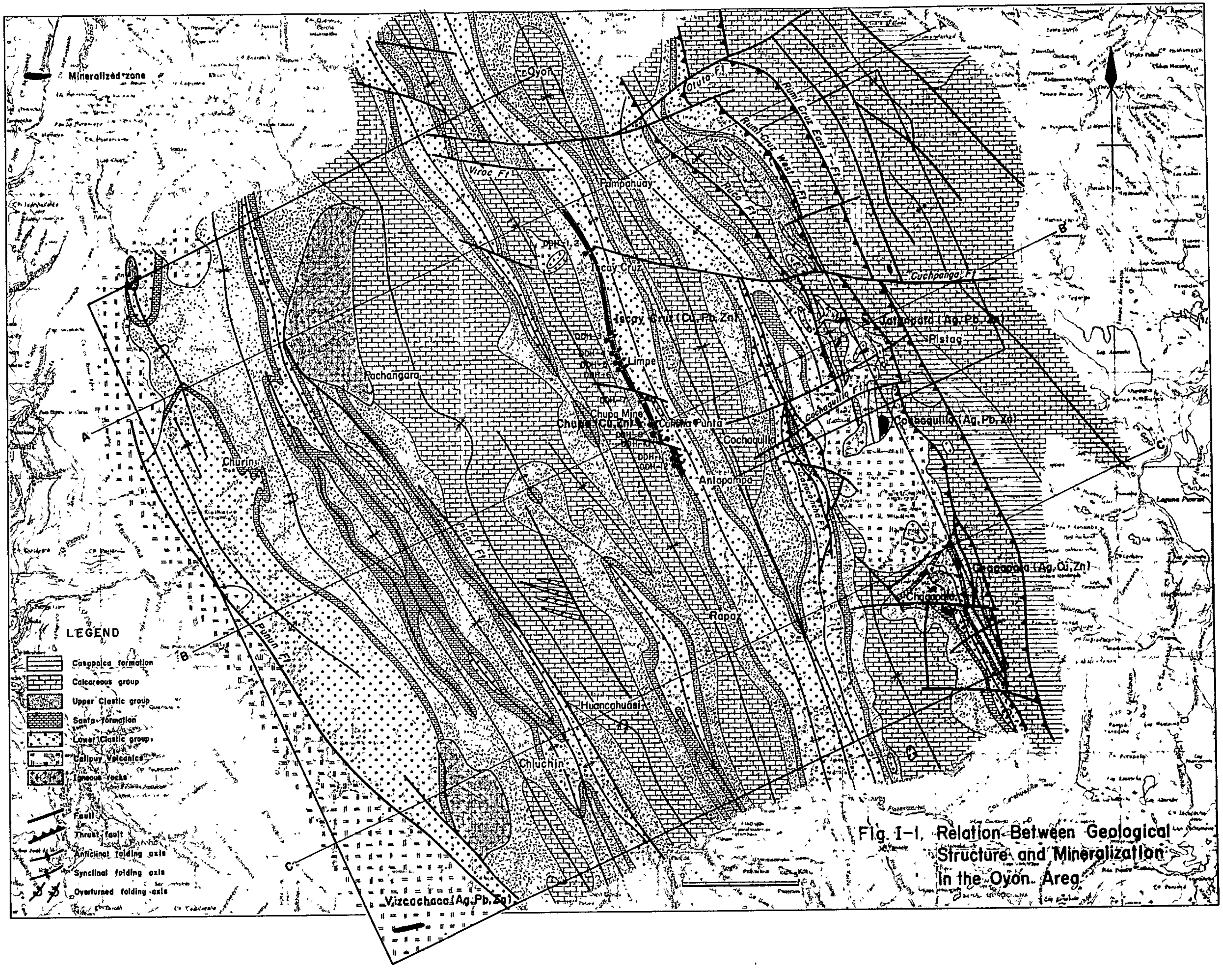
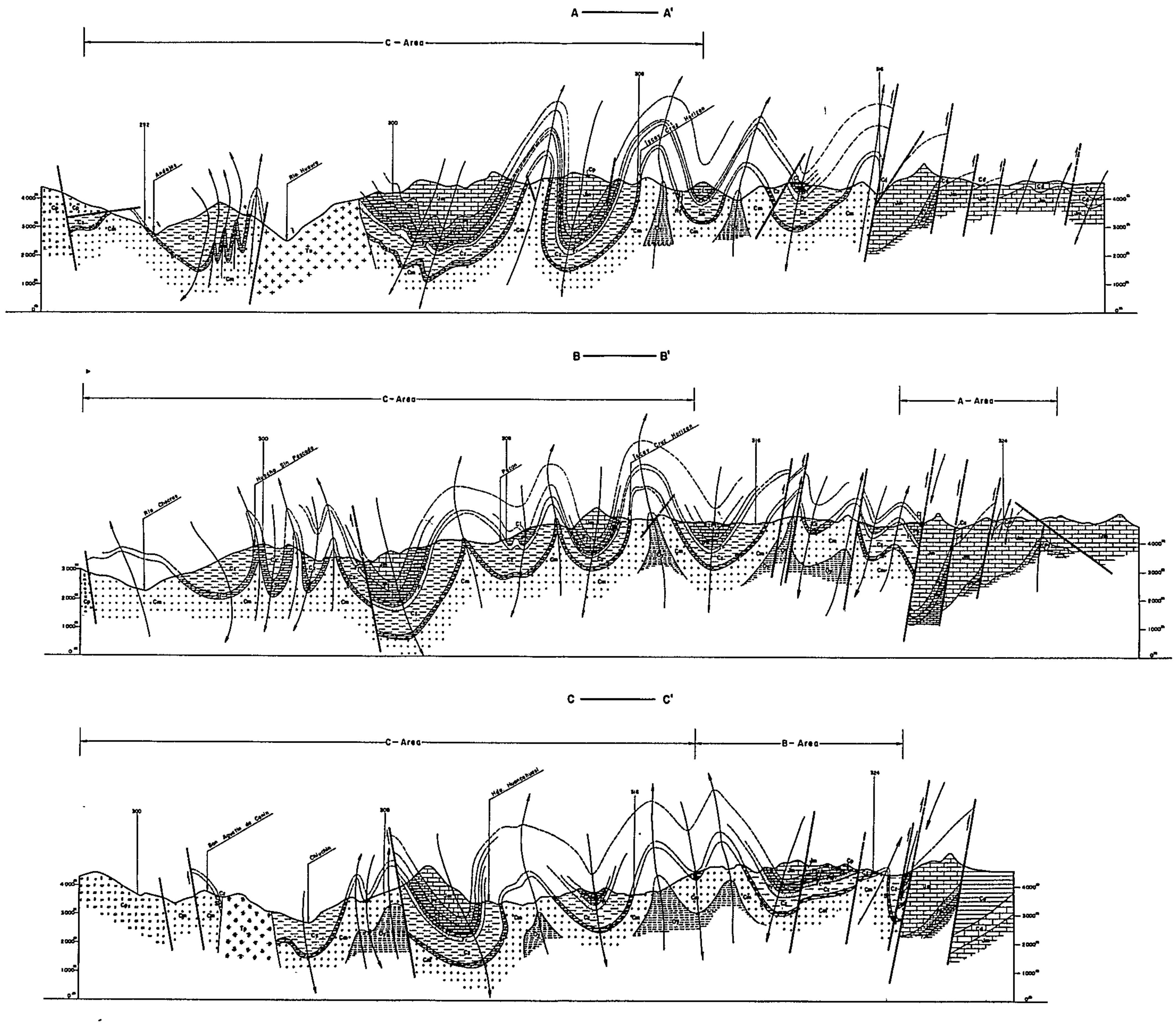


Fig. I-1. Relation Between Geological Structure and Mineralization in the Oyon Area



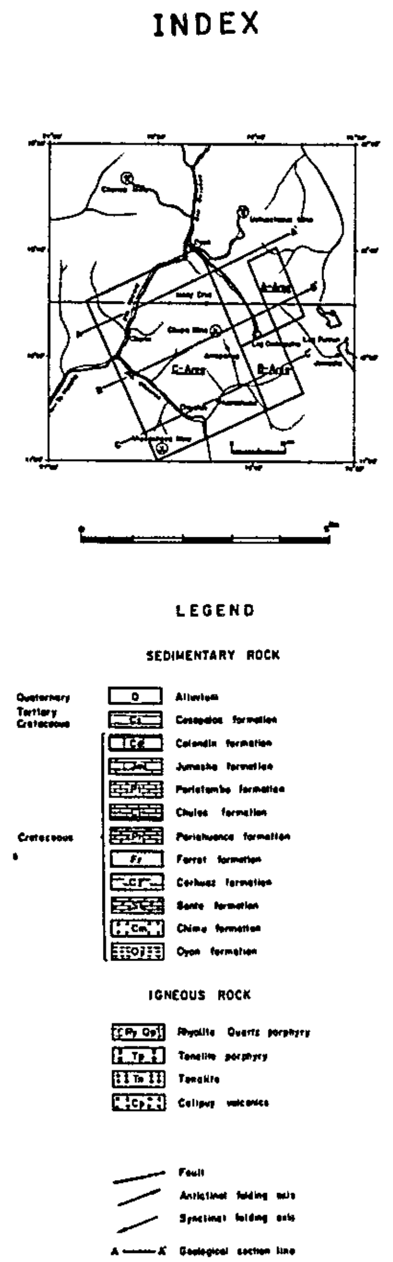


Fig.I-2 Geological Profile of the Oyon Area

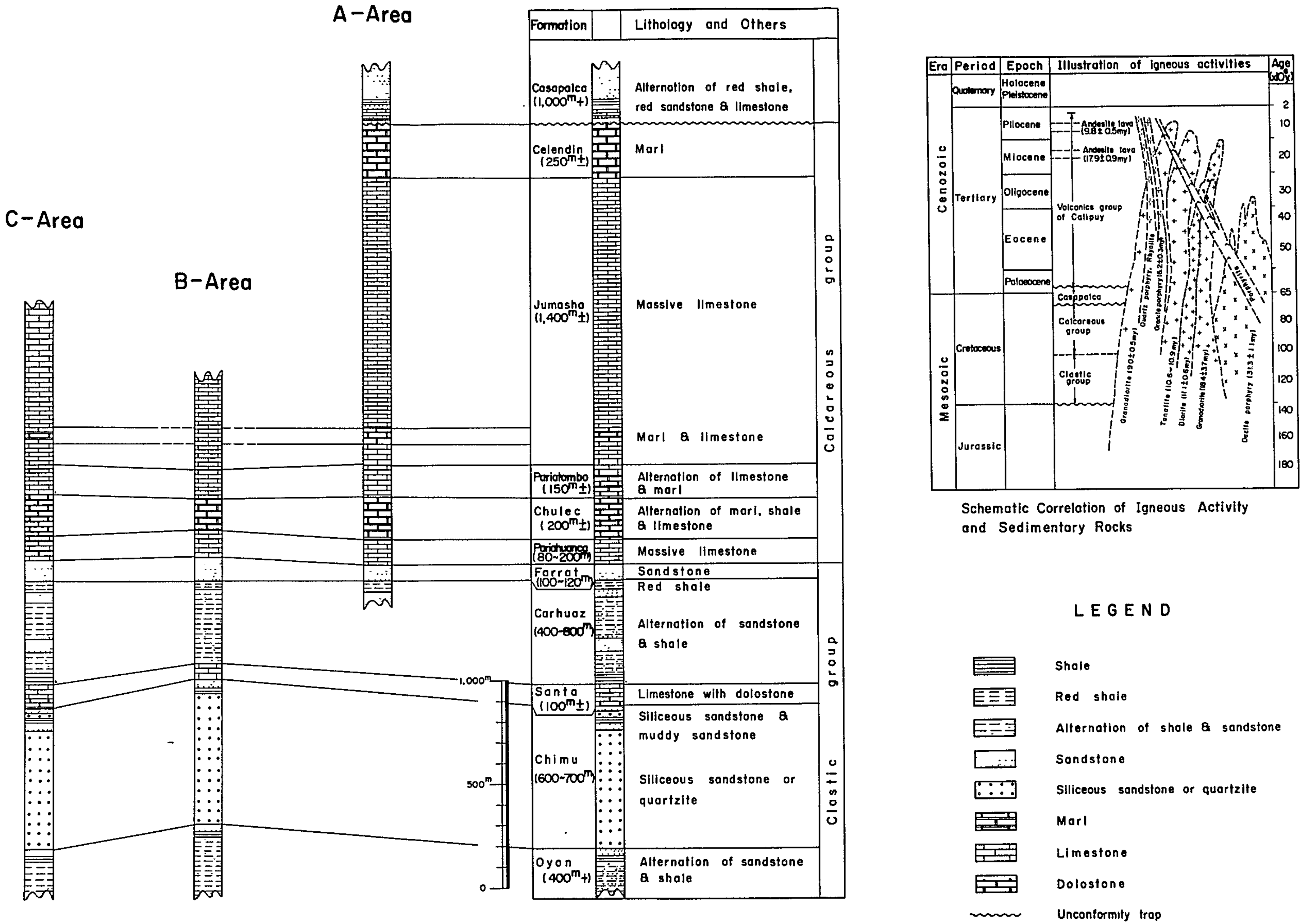


Fig. I-3. Geological Column and Igneous Activity in the Surveyed Area

Table I-1 Assay Values and Normative Composition of Igneous Rocks

Component		NO-625 Andesite	NO-633 Granodiorite	NO-647 Welded tuff	NO-652 Granite por.
Assay Values	SiO_2	60.82 (%)	67.32 (%)	68.84 (%)	67.97 (%)
	TiO_2	0.86	0.60	0.39	0.23
	Al_2O_3	17.38	16.73	16.17	16.62
	Fe_2O_3	2.38	1.63	0.96	0.83
	FeO	3.09	2.03	1.08	2.78
	MnO	0.10	0.03	0.03	0.03
	MgO	3.03	1.30	0.56	0.36
	CaO	4.40	1.76	2.75	3.42
	Na_2O	3.10	2.95	3.47	2.53
	K_2O	3.02	3.08	4.35	3.22
	P_2O_5	0.24	0.16	0.10	0.13
	H_2O^+	2.03	1.13	0.23	0.90
	H_2O^-	0.41	0.23	0.18	1.08
	Total	100.86	98.95	99.11	100.10
Normative Composition	Q	17.11	33.26	25.63	32.18
	C	1.61	5.87	1.01	3.12
	Or	18.13	18.65	26.04	19.39
	Ab	26.65	25.58	29.75	21.82
	An	20.58	7.88	13.16	16.43
	Sub-Total	84.09	91.23	95.58	92.93
	En-Hy	7.67	3.32	1.41	0.91
	Fs-Hy	2.51	1.48	0.61	4.17
	Mt	3.51	2.42	1.41	1.23
	Il	1.66	1.17	0.75	0.45
	Ap	0.56	0.38	0.23	0.31
	Sub-Total	15.91	8.77	4.42	7.07
Ratio	Q	20.75	38.97	27.10	35.83
	Or	21.98	21.85	27.54	21.59
	Ab+An	57.27	39.19	45.37	42.58

Table I-2 Isotopic Age of Igneous Rocks

	Field No. (Rock Name)	Location	Mineral	Isotopic Age (m.y.)	$Ar^{40}/gm \times 10^{-5}$	$\%Ar^{40R}$	%K
1979	AO-116 (Andesite)	G3	whole rock	17.9±0.9	0.113 0.108	52.1 55.3	1.57 1.59
	CO-121 (Tonalite)	G1	biotite	10.9±0.5	0.215 0.225	43.8 51.0	5.17 5.16
	CO-122 (Tonalite)	G1	biotite	10.6±0.5	0.267 0.258	56.6 47.8	6.36 6.32
	SO-176 (Dacite por.)	G1	biotite	31.3±1.6	0.133 0.129	39.2 36.2	1.09 1.04
1980	NO-350 (Granodiorite)	G4	biotite	9.0±0.5	0.162 0.164	45.3 43.8	4.60 4.66
	NO-373 (Diorite)	G4	whole rock	11.1±0.6	0.101 0.102	31.9 35.8	2.33 2.35
	NO-376 (Granite por.)	G2	whole rock	22.4±1.1	0.457 0.463	75.2 72.2	5.24 5.28
	NO-334 (Rhyolite)	G4	whole rock	- *	-	-	-
1981	NO-625 (Andesite)	G4	whole rock	9.8±0.5	0.088 0.089	33.9 35.6	2.31 2.32
	NO-633 (Granodiorite)	G4	hornblende	18.4±3.7	0.037 0.038	14.8 9.1	0.52 0.52
	NO-652 (Granite por.)	G4	biotite	6.2±0.3	0.172 0.175	37.6 42.7	7.21 7.24

Constants used

$\lambda_\beta = 4.962 \times 10^{-10}$/year

$\lambda_\beta = 0.581 \times 10^{-10}$/year

$K^{40} = 1.167 \times 10^{-4}$/atom/K

Notes

Ar^{40R} : Radiogenic Ar^{40}

m.y. : million years

Analyses were performed by Teledyne Isotopes, Westwood, New Jersey, U.S.A.

* Cleaning remains are not enough for measurement.

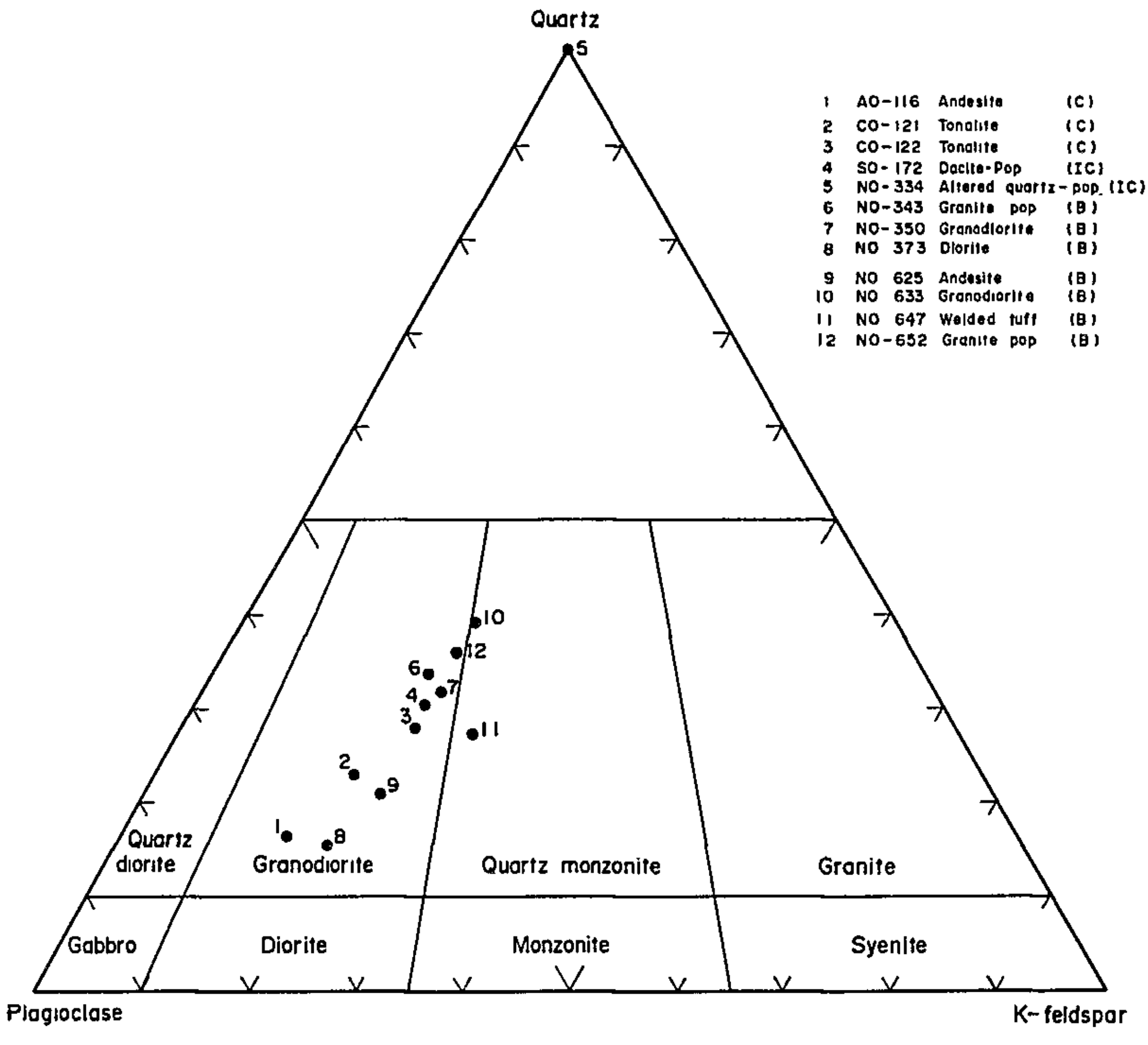


Fig. I-4. Q-Kf-Pl Diagram for Normatic Composition of Igneous Rocks

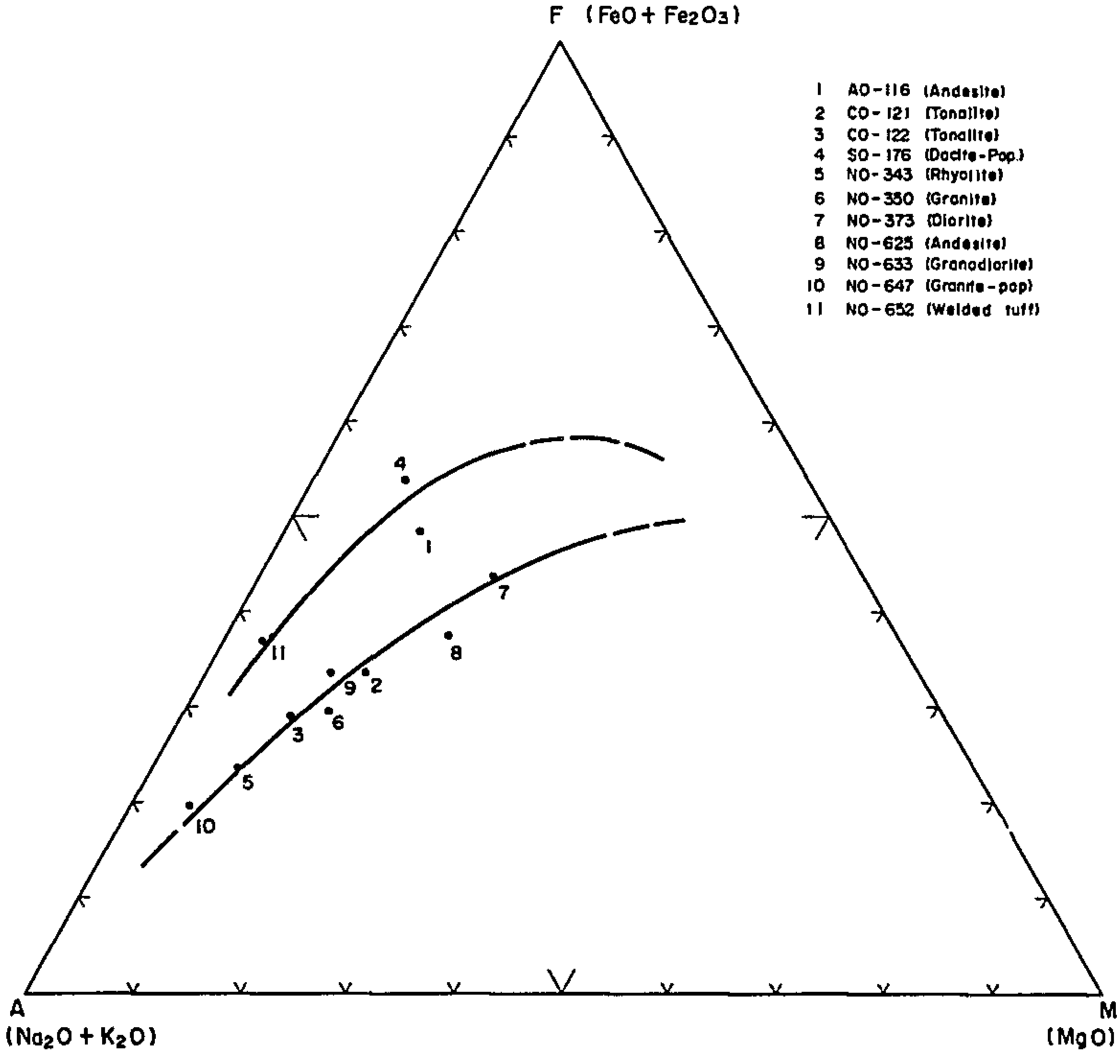


Fig. I-5. MFA Diagram for Magmatic Differentiation of Igneous Rocks

Chpater 3 Ore Deposits

3-1 Outline of Ore Deposits

The Oyon area belonging to Polymetallic Sub-province of Andean Plateau (Sub-Provincia Polimetalica del Altiplane) in Metallogenetic Province of Western Andes (Provinca Metalogenica Andina Occidental) proposed by Bellido, et al. (1969), is surrounded by the mineral-rich areas as follows; Huanzala and Raura mines on the north, Cerro de Pasco mine to the east, and Huaron and Santander mines to the south. Adjoining to the north of the survey area, three operating mines, namely Raura, Chanca and Uchucchacua mines are in existence.

In the Oyon area, Iscay Cruz, Chupa, Cochaquillo and Vizcachaca ore deposits or mineralization indications are present but are undeveloped. The following are present conditions of those ore deposits or mineralization indications.

(1) In the Iscay Cruz area, there is large scale mineralization indications but it is low grade. Exploration works were suspended because high grade portion was not discovered.

(2) In the Chupa ore deposit, exploration tunnel was driven in the past and high grade part was discovered but it was abandoned due to small reserves.

(3) Pitting exploration was done in the Cochaquillo ore deposit but high grade portion was not discovered so exploration is suspended now. In surrounding areas, there are many mineralization indications.

(4) At the Vizcachaca mine, small scale mining was done in the past but high grade part was not encountered so it is now abandoned.

The ore deposits in the Oyon and adjoining areas are classified as follows, according to the kinds of ore, shape and genesis.

(1) Copper, lead and zinc contact metasomatic ore deposits in Cretaceous

limestone.

Part of Ruaura, Chupa, part of Iscay Cruz, and Cochaquillo ore deposits.

(2) Silver, lead and zinc fissure-filling ore deposits in Cretaceous limestone.

Uchucchacua and part of Raura ore deposits.

(3) Silver, lead and zinc fissure-filling ore deposits in Tertiary volcanics and intrusives.

Chanca and part of Raura ore deposits.

(4) Lead, zinc and pyrite massive hydrothermal replacement ore deposits in Cretaceous limestone

Iscay Cruz ore deposit.

3-2 Iscay Cruz Mineralized Zone

1) Outline

Mineralization indications of the Iscay Cruz area extend discontinuously about 12 km distance from Canaypata about 6 km south of Oyon to Antapampa about 18 km south of Oyon (see Fig. I-6). Mineralization in this area occurs in calcareous rocks of the Santa formation, which constitutes a west wing of anticline whose axial part consists of the Oyon and Chimu formations.

The Santa formation is from 40 m to 80 m in thickness, and extends long and narrow in NNW-SSE direction usually in contact with steep cliff of Chimu quartzite formation. Dip of the Santa formation is almost vertical. It dips steeply west in the northern and southernmost parts, and steeply east in the central part forming on overturned structure.

Mineralization indications consist of black gossan containing Pb and Zn, gelena and sphalerite concentration in massive pyrite bodies, sphalerite concentration within skarn, and dissemination of gelena and sphalerite in dolostone. Talus and glacial sediments are widely distributed covering the surface in this area, and outcrops are exposed intermittently among these recent sediments.

As for the alteration of host rocks, silicification, sideritization, dolomitization, argillization, and brecciation are remarkable. Acidic intrusives such as quartz porphyry or rhyolite are suggested to be related to mineralization. Surrounding the intrusives, strong brecciation, pyritization, sericitization, and silicification are observed.

WNW-ESE trending faults, which are considered to be tension fault and related to mineralization, are densely developed oblique to the folding axis. Displacements by these faults are usually less than 20 m. Moreover, thrust faults and bedding plane faults are developed and effect the thickness of strata in this area.

3-2-2 Northern Part of the Iscay Cruz Area (Cumbre de Iscay Cruz Area)

For a distance of 5.4 km from Canaypata via Cumbre de Iscay Cruz to Lag. Quellaycocha, the mineralization indications are mainly black gossan in limestone and dolostone.

1) Canaypata

At Canaypata about 2 km north of Cumbre de Iscay Cruz, there occur few beds of dolomitic gossan in the Santa limestone ranging from 1 m to 2 m in width. Four samples were taken and assay results are as follows. This outcrop is the northernmost indication of the Iscay Cruz area.

	No. of Samples	Cu (ppm)	Pb (%)	Zn (%)
Average	4	3	0.06	0.51

2) Cumbre de Iscay Cruz (No. 1 Mineralization Indication)

On south slope of Cumbre de Iscay Cruz, there appears black gossan outcrop for a distance of 1.2 km. The gossan outcrops are in two parallel rows and on the foot wall (east) side maximum width is 25 m, and hanging wall (west) side maximum width is 7 m.

The black gossan is composed mainly of geothite, quartz, and kaolinite, with subordinate amounts of siderite, barite, and calcite. Main ore minerals are chalcophanite, with small amounts of sulfide minerals.

High grade part is located in the vicinity of the pass, and up to 1 % in Pb and 6 % in Zn. According to the channel sampling of 194.9 m in total length, average grade of all outcrops in this area is as follows:

	No. of Samples	Total Length (m)	Aver. Width (m)	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)
Average	53	194.9	13.0	3	30	0.71	4.76

It has been proved by the minerological data obtained from the drilling performed in this area that the gossan on the surface is an oxidation product of manganiferous siderite which is disseminated with minute crystals of galena and sphalerite.

3) Suerococha (No. 2 Indication)

From Lag. Mancacuta to the pass of Suerococha, there are exposures of black gossan and dolomitic gossan in limestone and dolostone. Scale of gossans range from few meters to few tens meters and their assays are as follows:

	No. of Samples	Total Length (m)	Aver. Width (m)	Ag (g/t)	Cu (ppm)	Pb (%)	Zn (%)
Average of 6 outcrops	16	37	6.2	5	35	0.14	2.55

3-2-3 Central-northerm Part of the Iscay Cruz Area (Limpe Area)

This area extends 3.3 km from Lag. Quellaycocha, via Cumbre de Limpe, to Lags. Tinyag. Mineralization indications in this area are characterized by concentration of hematite, massive pyrite orebody accompanied with galena and sphalerite, and dissemination of galena and sphalerite in limestone and dolostone.

1) Northern part of Cumbre de Limpe (No. 3 Indication)

Along the eastern bank of small lakes to the south of Lag. Quellaycocha, there appear small dark-brown and black gossans in six places among the talus and glacial sediments. Scale of outcrops are ranging from few meters to over tens meters. Dissemination of sphalerite in dolostone, occurrence of massive pyrite orebody, and concentration of galena and sphalerite around the pyrite body are found in this area. Assay result of the mineralized parts is as follows:

	No. of Samples	Total Length (m)	Aver. Width (m)	Ag (g/t)	Cu (ppm)	Pb (%)	Zn (%)
Average of 5 outcrops	14	24.2	4.8	48	49	2.24	1.06
High grade part	1	1	1	974	tr	49.25	0.75

The second year, drilling was performed at the place of 400 m north of Cumbre de Limpe, where is the southernmost end of this area. As the results, a massive pyrite and pyrrhotite orebody was encountered for a length of 14.3 m. The average grades are 48 g/t in Ag, 2.8 % in Pb, and 7.2 % in Zn. The highest grade part of 4 m yields such high figure as 89 g/t in Ag, 6.7 % in Pb, and 14.2 % in Zn.

2) Cumbre de Limpe (No. 4 Indication)

In the area that is Cumbre de Limpe as center, dolomitic, hematitic, and sideritic gossans are distributed for a distance of 350 m. There are two mineralized beds, each of which is about 10 m in width. The gossans in this area are characterized by the abundance of hemetite or specularite with minor amount of magnetite. Dissemination of chalcopyrite, galena, and sphalerite is also observed. Under microscopy, sphalerite contains a lot of chalcopyrite dots, and exsolution structure is observed in it. Average grade of the mineralized parts is as follows:

	No. of Samples	Total Length (m)	Aver. Width (m)	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)
Average	22	45.2	9.0	8	0.09	0.13	2.17

The Santa formation in this area is about 70 m in width and overturned dipping 80° to 90° to the east. Along the foot wall side in the Santa formation, there developes a breccia zone, in which strong alteration and dissemination of abundant hematite are noted. It is considered that the breccia zone is caused by igneous activity and has a close relation to mineralization.

3) Southern Part of Cumbre de Limpe

Several small outcrops are exposed in the talus sediments. Dissemination of pyrite, pyrrhotite, and marcasite accompanied by gelena and sphalerite is observed. As for oxide minerals, not only chalcophanite but also smithonite are identified by X-ray diffraction. Average grade of four outcrops is as follows:

	No. of Samples	Total Length (m)	Aver. Width (m)	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)
Average of 4 outcrops	9	15.7	3.1	16	0.21	0.33	2.99

3-2-4 Central-southern Part of the Iscay Cruz Area (Cunsha Punta Area)

This area extends for a distance of 3.3 km from Lags. Tinyag, via Cumbre de Cunsha Punta to Chinchaycocha. Main mineral indications of this area are skarn disseminated with chalcopyrite and sphalerite to the south of Lags. Tinyag, and dark-brown gossan with pyrite and sphalerite to the south of Cumbre de Cunsha Punta. The Santa formation is overturned in this area dipping 75° to 85° to the east, and occupies apparent lower situation to the Chimu formation.

1) Tinyag (No. 5 Indication)

The skarn outcrop located about 0.3 km south of Lags. Tinyag is about

25 m x 40 m in scale and surrounded by glacial deposit. Main skarn minerals are tremolite-actinolite, garnet, epidote, and quartz. Main ore minerals are chalcopyrite, sphalerite, pyrite, and magnetite. High grade part is more than 10 % of Zn. Assay result of this skarn is shown below:

	No. of Samples	Total Length	Aver. Width	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)
Average	7	21	10.5	7	0.14	0.04	2.06
High grade part	1	1	1	25	0.65	0.05	13.00

2) Northern Part of Cumbre de Cunsha Punta

In the area to the south of Tinyag skarn outcrop to the pass of Cunsha Punta, only two small outcrops of dark-brown gossan, which is porous due to leaching and consists mainly of quartz, are found, since the surface is covered by thick glacial and talus sediments. The assy result of this gossan is as follows:

	No. of Samples	Total Length (m)	Aver. Width (m)	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)
Average of 2 outcrops	7	18.5	3.1	16	0.03	0.12	0.03

The Chupa ore deposit is located about 0.6 km west of this horizon, and acidic dikes intrude into the Oyon and Chimu formations about 0.6 km east of this horizon. The Chimu quartzite suffers from strong silicification and sericitization, and the Carhuaz shale and sandstone are widely disseminated with pyrite and limonite.

3) Cunsha Punta (No. 6 Indication)

A dark-brown gossan zone occurs in the Santa limestone about 0.5 km south of Cumbre de Cunsha Punta. Extention of the zone is about 100 m in length and 20 m in width. Concentration of sphalerite and pyrite in several meters lens-shape is seen in the gossan. Average grades of this gossan are shown below, and the high grade part is up to 30 % in Zn.

	No. of Samples	Total Length (m)	Aver. Width (m)	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)
Average	8	24	12	29	0.20	0.08	1.94
High grade part	1	-	-	84	0.65	0.18	32.43

According to the survey of this year, existence of thrust fault is confirmed along the Santa formation. The thrust fault is composed of NNW-SSE direction paraller to the strata and N-S direction oblique to the strata, and affects the thickness of the Santa formation. Both faults are dipping 60° to 75° to the east, and cut and dislocate the Santa formation. The Santa formation disappears about 1 km south of this outcrop due to the thrust faults, and the Chimu and Carhuaz formations come in contact abutting on the faults.

4) Chinchaycocha

About 0.3 km south of the above mentioned outcrop, there is an outcrop of brecciated black gossan, in which dissemination of sphalerite is found occasionally. The extention is about 30 m in width and 50 m in length. Between the two outcrops, limestone with small scale gossans affected by the fracture of E-W system is seen successively. Grades of the gossan are as follows:

Average	No. of Samples	Total Length (m)	Aver. Width (m)	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)
Average	6	18	18	2	0.01	0.08	1.79

3-2-5 Southern Part of the Iscay Cruz Area (Antapampa Area, No. 7 Indication)

At the western slope of Antapampa, black gossan with a width of 30 m extends about 250 m, forming the southernmost indication of the Iscay Cruz area. This gossan is mainly composed of quartz and goethite, accompanied by hematite. Grades on the surface are as follows:

	No. of Samples	Total Length (m)	Aver. Width (m)	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)
Average	38	99.5	11.1	12	0.03	0.14	1.50

Two beds of dark-brown gossan, that is regarded to be altered from sulfide minerals, are occurring in the black gossan. The Santa formation dips steeply 75° to 85° to the west, though the Carhuaz formation dips gently 30° to 60° to the west. Therefore, a thrust fault is inferred running between the Santa and Carhuaz formations.

3-3 Chupa Ore Deposit

Chupa ore deposit is located about 600 m west of Tinyag skarn outcrop within the Iscay Cruz mineralized zone. It is a skarn deposit formed by replacement of a part of limestone belonging to the Pariahuanca formation and mainly accompanied by zinc and copper minerals. It was explored in the past with two levels of tunnels and high grade portion was encountered but due to small reserves, it was abandoned (see Fig. I-7).

The pariahuance formation, which is massive limestone with a thickness of about 100 m, is the host rock of deposit. It is located on the east wing of syncline formed by the west side Jumusha formation as axis. Strike is NNW-SSE and dip is 75° to 85° to the east forming overturned structure. On the east side, Farrat sandstone occupies apparent upper position and on the west side Chulec marl and limestone occupy apparent lower position. Near the deposit, well developed fault system of ENE-WSW is present. It is in echelon formation, displacing beds few meters to each side. Near the deposit its strike is changed to E-W direction.

Mineralization is strongly controlled by this fault system. Ore deposit is also affected by stratigraphical structure and extends along bedding. However, high grade parts occur near the faults. Size of the orebody on the surface (elevation about 4,680 m a.s.l.) is about 20m x 70m, on upper level (elevation 4,615 m) is about 80m x 20m and on the lower level (elevation 4,560 m) is about 18m x 90m. On 4,600 m level 100 m north of above main orebody, there is small orebody of about 10m x 20m.

Skarn minerals are mainly composed of tremolite, hedenbergite, siderite, and quartz, accompanied by chlorite, epidote and lievrite. Ore minerals are mainly composed of sphalerite, pyrite and minor amounts of chalcopyrite, pyrrhotite and magnetite. Observation of polish sections shows that sphalerite holds a large number of dots and lattice of chalcopyrite showing exsolution structure. Bismuthinite was identified by election probe microanalysis. Assay results of 2-meters channel samples taken at randum on three levels are as follows:

Level	No. of Samples	Length of Sampling (m)	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)
4615 m	10	20	25	0.27	0.13	21.59
4600 m	3	6	29	0.15	0.36	15.64
4560 m	17	34	30	1.07	0.07	9.67

Igneous rock is not found nearby but it is considered that mineralization belongs to the same type as the Iscay Cruz area, exactly due to the activity of acidic igneous rock.

3-4 Cochaquillo Ore Deposit

Cochaquillo ore deposit is large scale skarn-type deposit situated at the northeastern part of B area, 4,800 m above sea level about 3 km to the east of Lag. Cochaquillo, and on the western slopes of the continental divide.

The mineralized zone is about 300 m x 500 m and to the south it is cut by fault and covered by Calipuy volcanic rocks. Surface outcrop may reveal a half portion of the northern orebody. Pitting exploration was done formerly but high grade portion was not encountered.

The host rocks are mainly limestone of Pariahuanca formation and partly marlstone of Chulec formation. These formations occupy the eastern wing of a synclinal structure, which is of overturned structure with strike of N-S and dip of 50° to 60° west. The lower siliceous sandstone of Farrat formation is apparently distributed at the upper part to the west side.

In the vicinity of the ore deposit, fracture system of NE-SW and E-W trends are predominantly developed, resulting in displacement to strata. Many dikes of these directions are found. The dike rocks are probably dacite porphyry (SO-514 and NO-630), although original rocks are not clear because they suffer from sever alteration. Granodiorite and diorite porphyrys (NO-633 and NO-373) of stock or dike form intrude into the Carhuaz formation and Calipuy volcanic rocks about 1 km west of the deposit. These porphyries give an effect of the thermal metamorphism such as hornfelsization on the adjacent rocks and suffer themself from alteration and dissemination of pyrite.

The central part of the ore deposit is of garnet skarn. The garnet skarn is considerably disseminated with magnetite and pyrite (CQ-386, CQ-391). In general, there is a tendency that cupper is rich in the part of abundant magnetite, while silber is rich in the part of abundant pyrite.

Green skarn of vein form occurs in the marginal part of garnet skarn zone and in the transitional part to unmineralized limestone to the north. In this green skarn, galena, sphalerite and pyrite are concentrated with high grade silver (CQ-301, CQ-353, CQ-356 and others).

Green skarns are found in several places controlled by the acidic dikes. The skarn veins are NE-SW trend and usually 3 - 8 m in width, 100 m in extension. Green skarn contains usually 6 - 8 % of Pb and Zn, and occasionally high grade lenses up to 15 % of Pb and Zn are found. According to X-ray powder diffraction and microscopic observation, skarn minerals consist principally of hedenbergite, tremolite, chlorite, epidote, and quartz (CQ-301, CQ-356 and others). Cerussite, as an oxide mineral, was detected by electron probe microanalysis.

Assay values based on channel sampling on the outcrops are summarized as follows, which indicate high amount of silver and lead in comparison with copper and zinc.

	No. of Samples	Total Length (m)	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)
Green skarn	43	91	102	0.11	3.92	2.41
Py-Gn skarn	23	78	141	0.17	1.31	0.82
Mt-Gn skarn	32	116.5	56	0.23	0.20	0.13

Fig. I-9 is a ternary diagram of Cu-Ag-(Pb+Zn) for mineralized outcrop whose assay values on channel sampling are given in Fig. I-6. From this diagram, mineralized zones can be divided into three types as follows, based on the distributions of skarn minerals and grades of metal elements;

(1) Inner zone; Cu is concentrated in magnetite-rich garnet skarn.

(2) Intermediate zone; Ag is concentrated in pyrite-rich garnet skarn.

(3) Outer zone; Ag, Pb, and Zn are concentrated in green skarn.

The Calypuy volcanic rocks, that cover the mineralized zone to the southern and eastern parts, are intensively altered and disseminated with pyrite. Many porphyric dikes intrude the volcanic rocks and suffer also from intensive hydrothermal alteration. Laumontite was detected by the X-ray powder diffraction.

3-5 Mineralized Zone of B Area

B area is situated at the west side of the thrusting fault zone. Igneous activity was intensive in the area, and intrusive rocks such as granodiorite, granite porphyry and dacitic porphyry intrude into the Cretaceous sedimentary rocks. Skarn and vein type ore deposits are formed around the intrusives. The Cochaquillo ore deposit is representative of the area, another main mineral indications are described below.

1) Pirihuya (Fig. 1-10 (1))

Mineral indication of Pirihuya, situated at about 0.6 km south of Lag. Jatunpa, are cataclastic vein in the limestone of Pariahuanca formation which intruded by granodiorite. Galena, sphalerite and pyrite are main ore minerals. The vain is N-S direction with a dip of 80°E, and extends for 110 m intermittently with the maximum width of 0.5 m.

Assays of ore are as follows:

	No. of Samples	Total Length (m)	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)
Outcrop	2	0.9	158	0.01	4.68	13.52

2) Yanacocha (Fig. 1-10 (2))

The mineral indications of Yanacocha, situated at about 1.2 km southeast of Lag. Jatunpata, are vein-type occurring in the Carhuaz formation composed of an alternation of shales and sandstone. Main gangue minerals are rhodochrosite and quartz. Galena, sphalerite and pyrite are main ore minerals (SO-504). The trend of vein varies from N 45°E to 70°E and EW dipping 50° to 70° south. The width is usually 0.2 - 0.5 m and 1.5 m in maximum.

Assays of ore are as follows:

	No. of Samples	Total Length (m)	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)
Outcrop	5	14.0	73	0.12	2.8	2.51

3) Chalgoac (Fig. 1-10 (3))

Mineral indication of Chalgoac, situated at about 0.6 km north of Chagapata, are skarn-type deposit, replacing limestone in the Santa formation with gentle dip. Main skarn minerals consist of muscovite, tremolite, chlorite dolomite and quartz. It was confirmed by X-ray diffraction that the ore minerals consist mainly of sphalerite and pyrite with subordinate amounts of zinc oxide minerals such as smithsonite, hemimorphite and hydrozincite.

The Santa formation in this area strikes N 10° - 30°E and dips 20° - 30°E. Granodiorite occurs 200 m southeast of the ore deposit. Beneath the outcrop tunneling was carried out for 13 m. Judging from observations in the tunnel the ore deposit shows complicated structure and seems to be 3 - 4 m in thickness and 10 m x 10 m or more in extension.

Assay results for samples from the tunnel are as follows:

	No. of Samples	Total Length (m)	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)
Underground	8	24.5	50	0.36	0.08	9.77

4) Uchucumachay (Fig. 1-10 (4))

Mineral indication of Uchucumachay, situated at about 1.3 m southeast of Chagapata, is of skarn deposit, replacing limestone in the Santa formation. The Santa formation striks NS and dips 20° - 30° E. The deposit is embedded below the boundary of shale and extends about 20 m on strike side with 2 m thick.

Main skarn minerals are garnet, chlorite and quartz, while ore minerals are mainly galena, sphalerite and pyrite. Assays on the samples collected from the pit and ore pile are shown below:

	No. of Samples	Total Length (m)	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)
Pit	4	4.0	627	0.62	7.15	1.78
Pile	2		1645	0.66	18.60	7.20

Table I-3 List of Mineralized Zones in the Surveyed Area

Area	Zone	Location	Kind of Orea	Host Rock		Type of Minera-lization	Mode of Occur-rence	Scale of Mineralized Zone	Scale of Unit Orebody		Direction	Grade of Ore	Ore Minerals	Gangue Minerals	Remarks
				Forma-tion	Litho-logy				Length	Width					
C	Iscay Cruz	IC-No.1	Pb,Zn	St	Ls,Do	rep	dis	1,200m	140m	25m	NNW-SSE	Cu 30ppm Pb 0.71% Zn 4.76%	Zn-Ox, Sp, Gl	Ge,Qt, Sid,Dm	Low grade Pb,Zn dis ore in siderite is confirmed by drilling
		IC-No.2	Pb,Zn	St	Ls,Do	rep	dis	650m	50m	23m	NNW-SSE	Cu 35ppm Pb 0.14% Zn 2.81%	Zn-Ox, Sp,Gl	Ge,Qt, Sid,Dm	
		IC-No.3	Pb,Zn	St	Ls,Do	rep	mas	800m	30m	5m	NNW-SSE	Cu 49ppm Pb 2.24% Zn 1.06%	Sp,Gl, Py,Po	Dm,Sid, Qt,Ge	High grade Pb,Zn ore is confirmed by drilling
		IC-No.4	Pb,Zn	St	Ls,Do	rep	mas	1,000m	80m	12m	NNW-SSE	Cu 0.20% Pb 0.13% Zn 2.17%	Sp,Gl, Py,Po	Hm,Sid, Qt,Ge	High grade Zn ore is confirmed by drilling
		IC-No.5	Pb,Zn	St	Ls	skarn	dis	100m	100m	20m	NNW-SSE	Cu 0.14% Pb 0.04% Zn 2.06%	Sp, Py,Mt	Tr,Ga, Qt	Cu,Zn dis in skarn mas is confirmed by drilling
		IC-No.6	Cu,Zn	St	Ls,Do	rep	mas	450m	100m	20m	NNW-SSE	Cu 0.65% Pb 0.18% Zn 1.94%	Cp,Sp, Py	Qt,Ge	Dislocation of St formation by thrust is clarified
		IC-No.7	Pb,Zn	St	Ls,Do	rep	diss	300m	250m	24m	NNW-SSE	Cu 0.03% Pb 0.14% Zn 1.50%	Zn-Ox	Ge,Qt, Hm, Sid	Cu dis in Hm, Py and skarn bodies are confirmed by drilling
		Chupa	Cu,Zn	Ph	Ls	skarn	mas	170m	90m	22m	NNW-SSE E-W	Cu 0.68% Pb 0.10% Zn 15.63%	Cp,Sp, Py,Po	Tr,Hd, Qt	Explored by tunnelling.
	Chiu-chin	Vizca-chaca	Ag, Pb,Zn	Cp	Volc	fr-fil	vein	100m	50m	1m	N80°E	Cu 0.05% Pb 7.6 % Zn 11.0 %	Gl,Sp	Qt	Abandoned
B	Jatun-pata	Pirihuya	Ag, Pb,Zn	Ph	Ls	fr-fil	vein	110m	110m	0.5m	N-S	Ag 158g/t Pb 4.68% Zn 13.52%	Gl,Sp, Py	Qt,Cal	
		Yanacocha	Ag, Pb,Zn	Cz	Sh,Ss	fr-fil	vein	70m x 50m	70m	0.5m	ENE-WSW	Ag 73g/t Pb 2.81% Zn 5.51%	Gl,Sp, Py	Rdc,Qt	
	Cocha-quillo	North	Ag, Pb,Zn	Ph(Cl)	Ls	skarn	mas, dis	200mx300m	100m	8m	NE-SW	Ag 102g/t Pb 3.92% Zn 2.41%	Gl,Sp, Py	Hd,Tr, Chl,Qt	Surveyed by pitting
		Middle	Ag, Pb,Zn	Ph(Cl)	Ls	skarn	mas, dis	100mx300m	100m	200m	N-S	Ag 141g/t Pb 1.31% Zn 0.82%	Gl,Sp, Py	Ga,Tr, Chl,Qt	
		South	Ag,Cu	Ph(Cl)	Ls	skarn	mas, dis	200mx300m	200m	200m	N-S	Ag 56g/t Cu 0.23% Pb 0.20%	Cp,Py, Mt	Ga	
	Chaga-pata	Chalgoac	Ag,Zn	St	Ls	skarn	mas	100m	20m	4m	NNE-SSW	Ag 50g/t Cu 0.36% Zn 9.77%	Sp,Py, Zn-Ox	Tr,Mus, Chl,Qt	
		Uchcu-machay	Ag,Pb	St	Ls	skarn	mas	300mx200m	20m	2m	N-S	Ag 627g/T Pb 7.15% Zn 1.78%	Gl,Sp, Py	Chl,Qt, Ga	

St: Santa
Cz: Carhuaz
Ph: Pariahuanca
Cl: Chulec
Cp: Calipuy

Ls: Limestone
Do: Dolostone
Sh: Shale
Ss: Sandstone
Volc: Volcanics

rep: replacement
fr-fil: fracture-filling
mas: massive orebody
dis: dissemination

Zn-Ox: Zn-Oxides
Sp: Sphalerite
Gl: Galena
Cp: Chalcopyrite
Py: Pyrite

Po: Pyrrhotite
Mt: Magnetite
Tet: Tetrahedrite
Hm: Hematite

Ge: Goethite
Qt: Quartz
Dm: Dolomite
Sid: Siderite
Chl: Chlorite

Tr: Tremolite
Hd: Hedenbergite
Ga: Garnet
Rdc: Rhodocrosite
Cal: Calcite

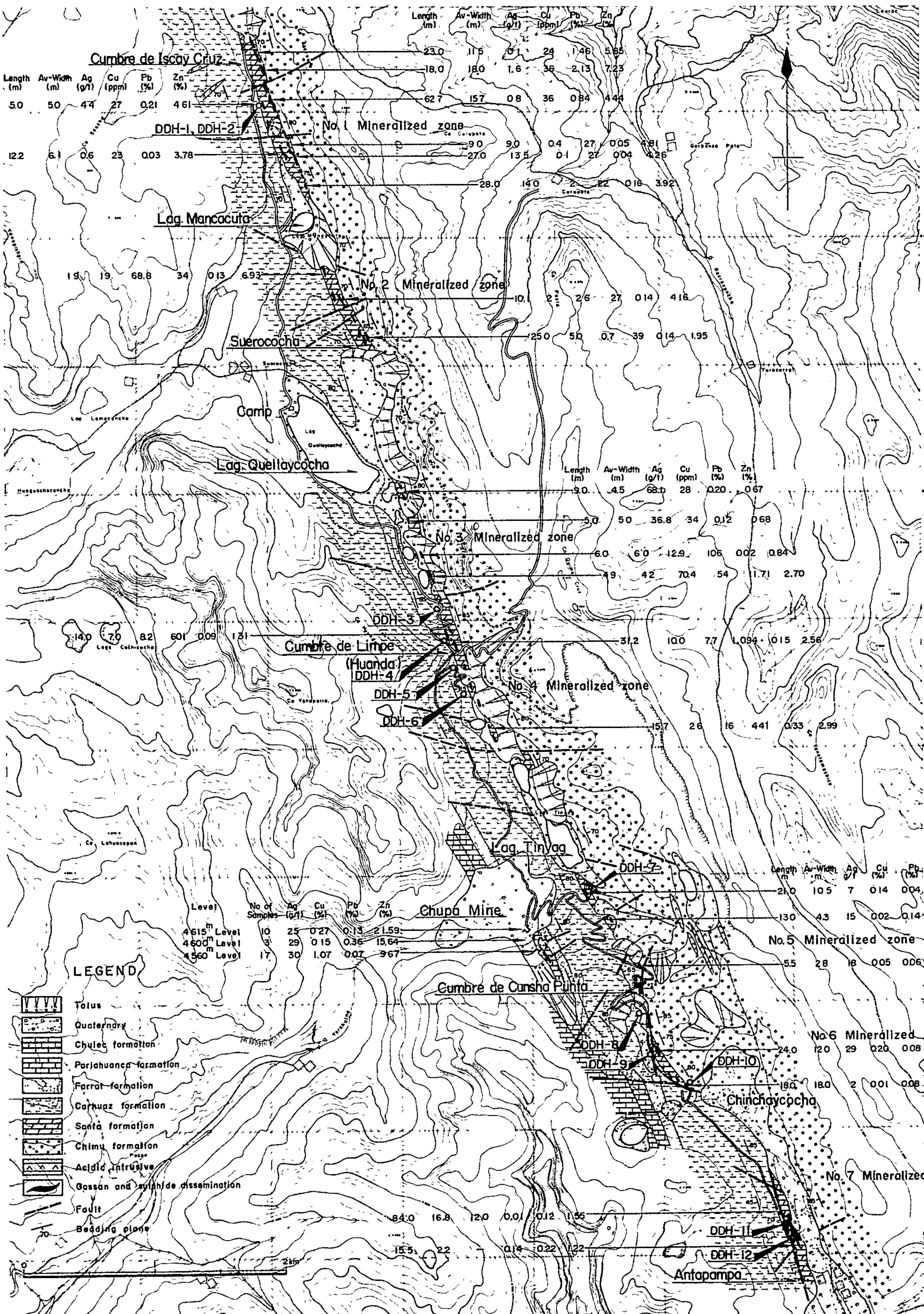


Fig. I-6. Mineralized Zone of the Iscay Cruz Area

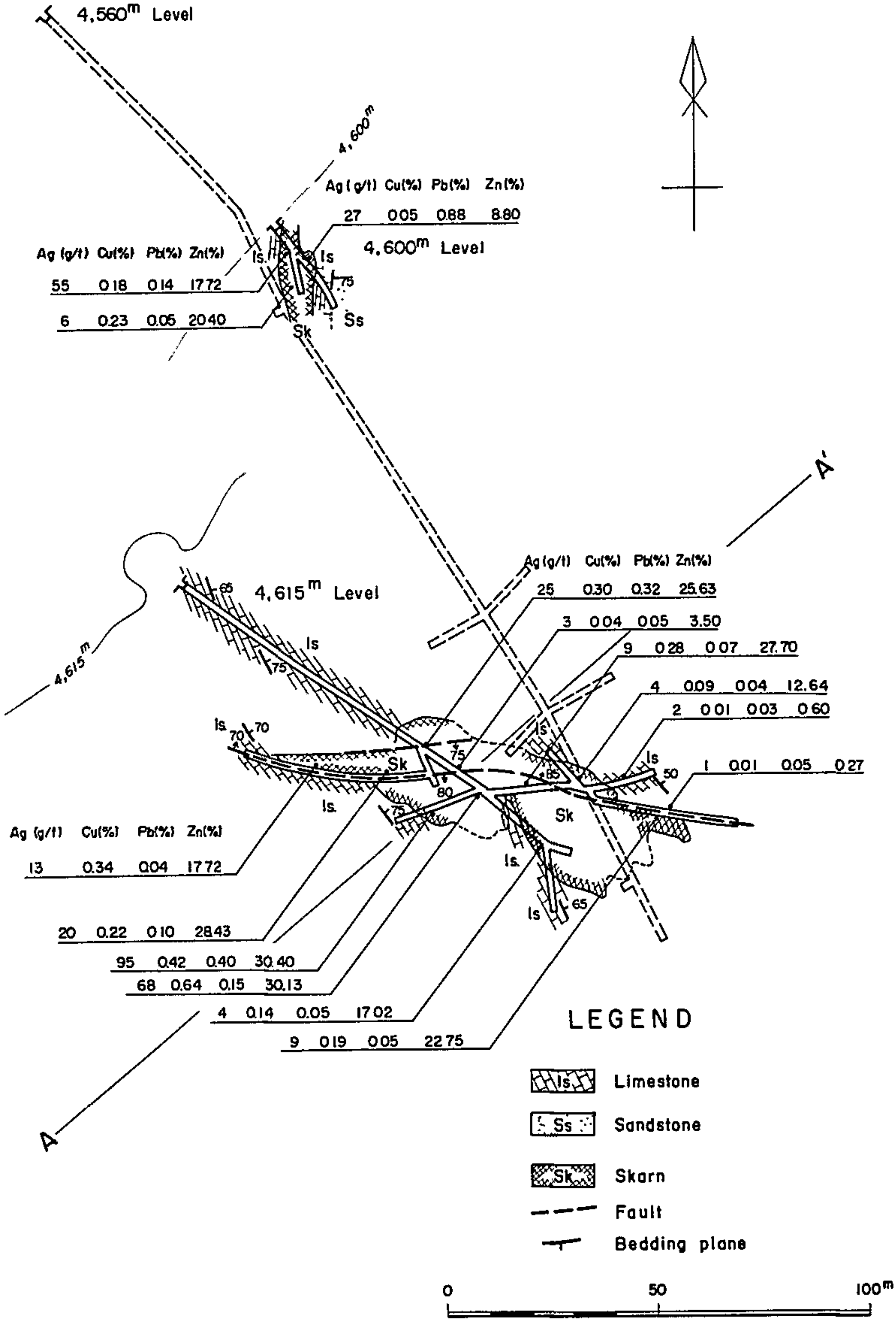


Fig. I-7. Geological Survey Map of the Chupa Mine

(1) 4,615m Level

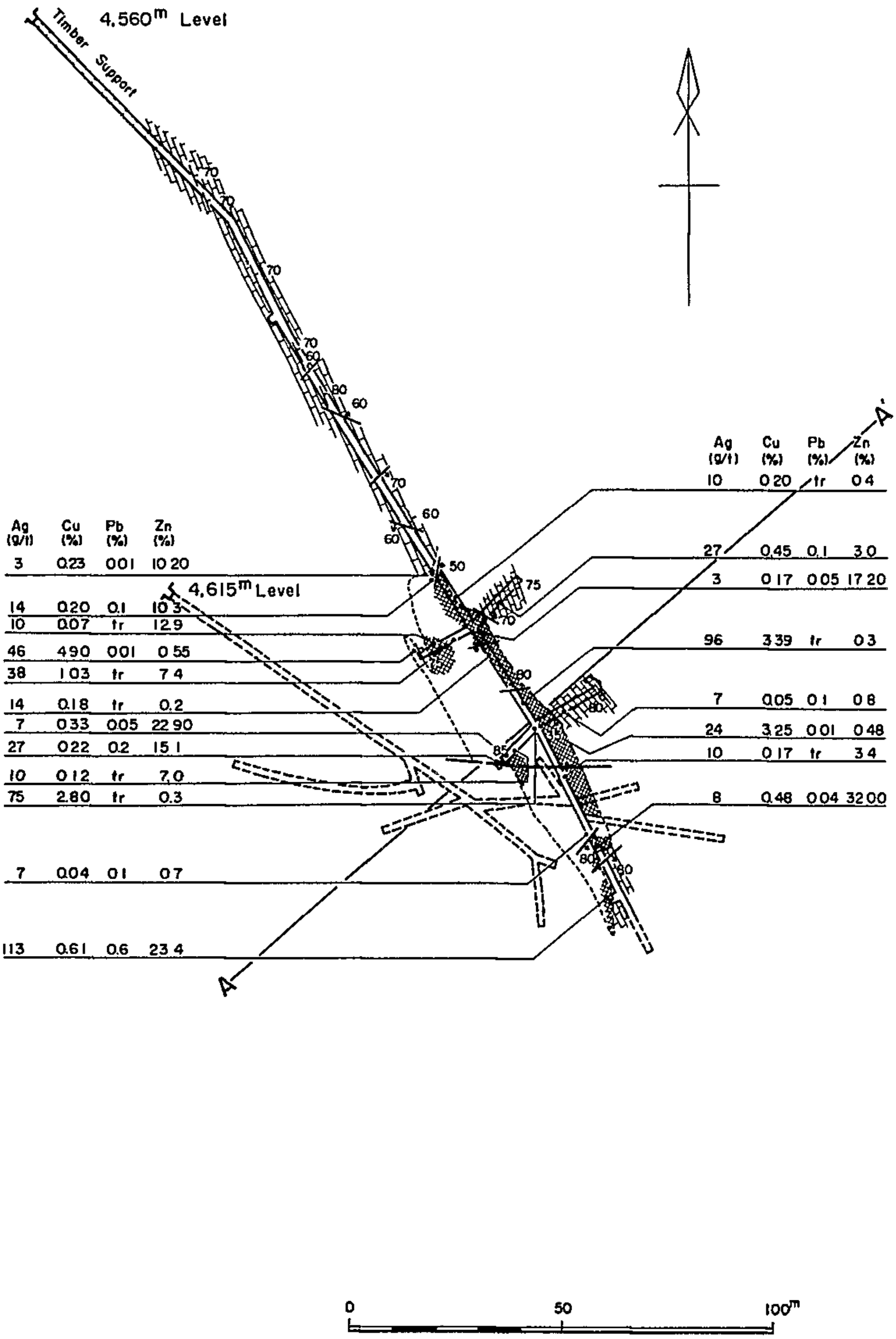


Fig. I−7. Geological Survey Map of the Chupa Mine

(2) 4,560m Level

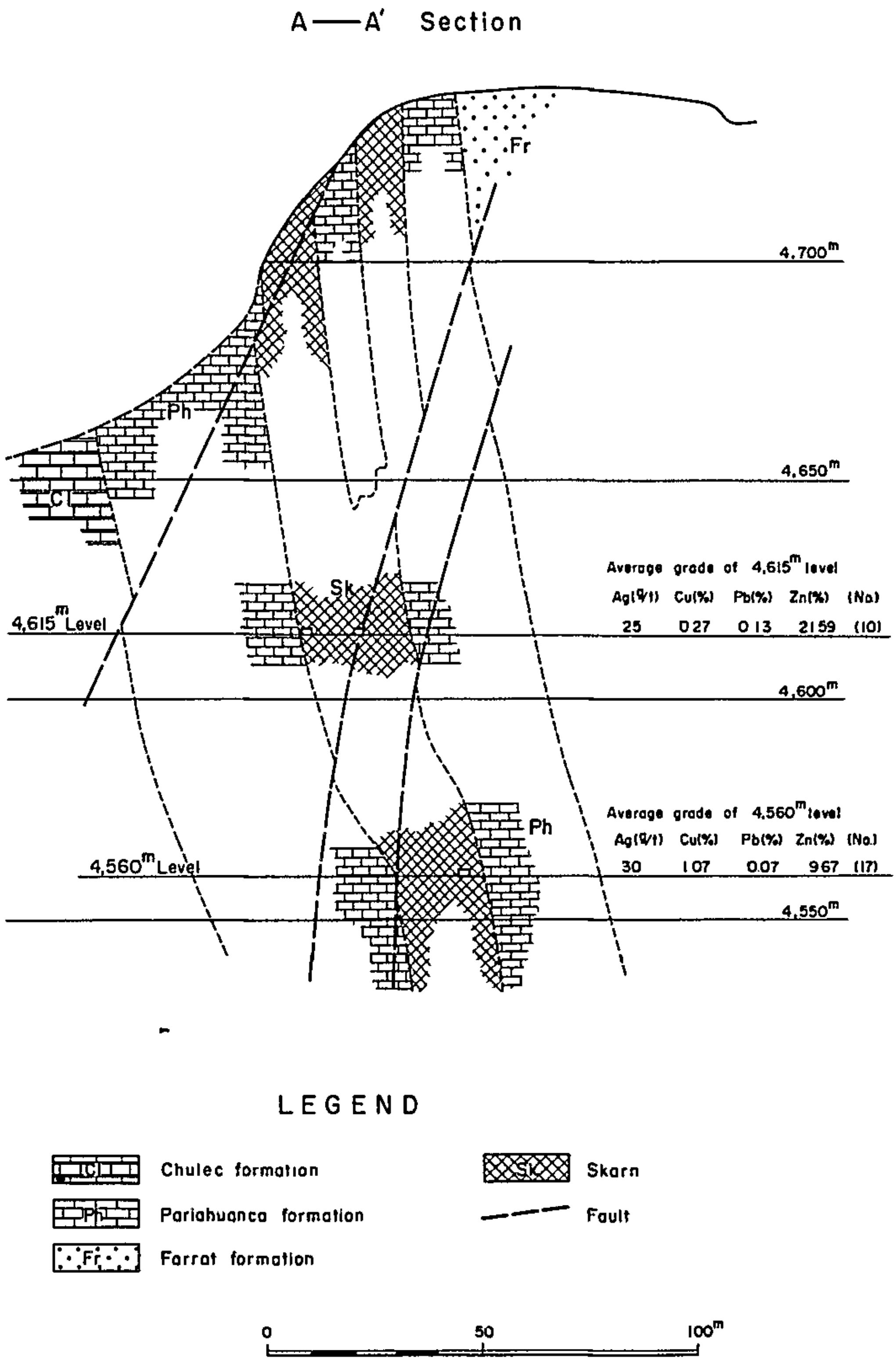


Fig. I-7. Geological Survey Map of the Chupa Mine

(3) Section, WSW - ENE

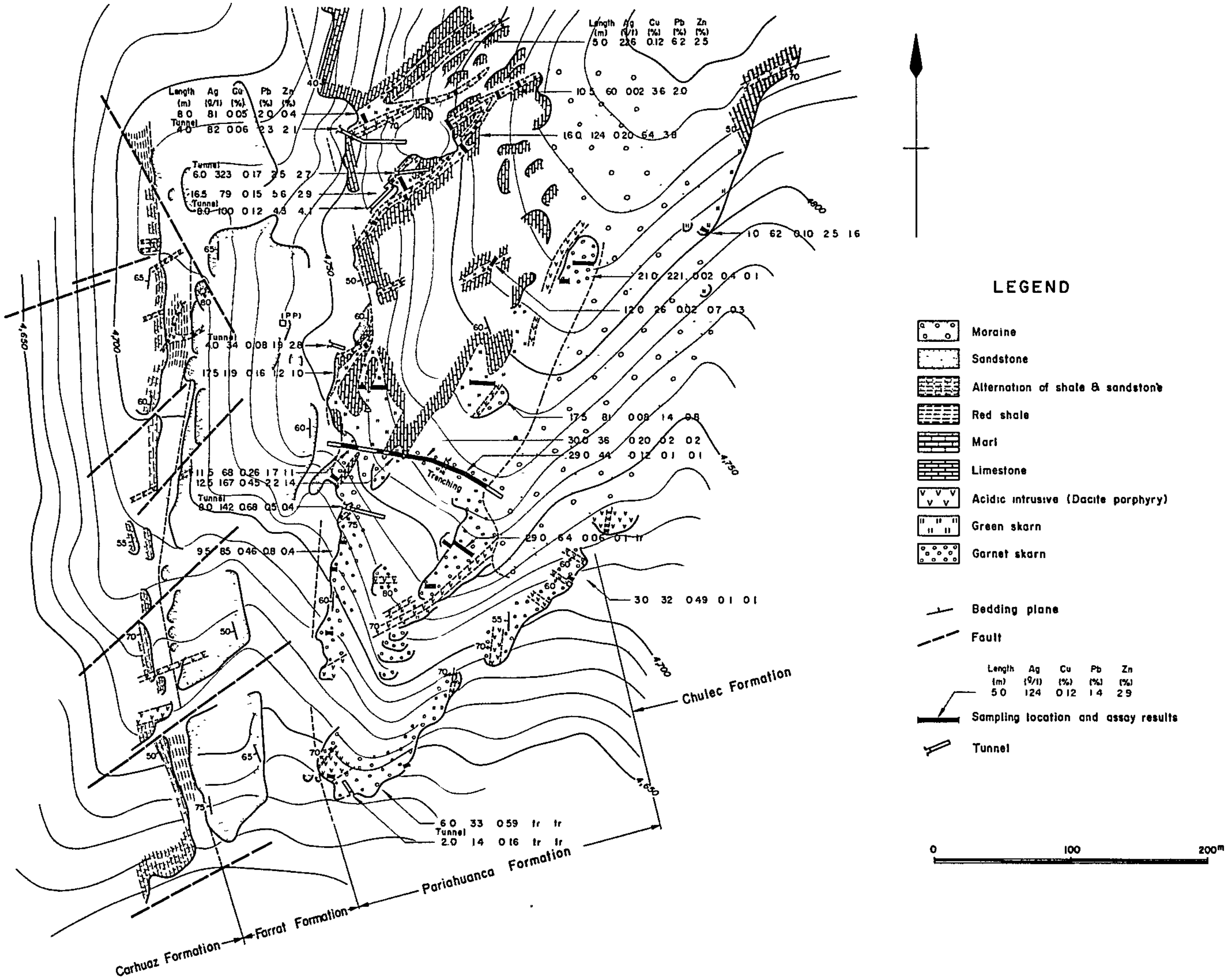
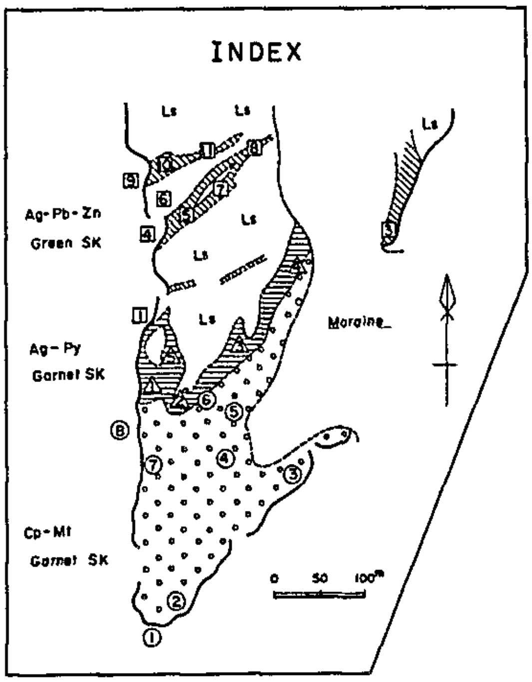


Fig. I-8. Mineralized Zone of the Cochaquillo Area



Used data are from Fig I-8

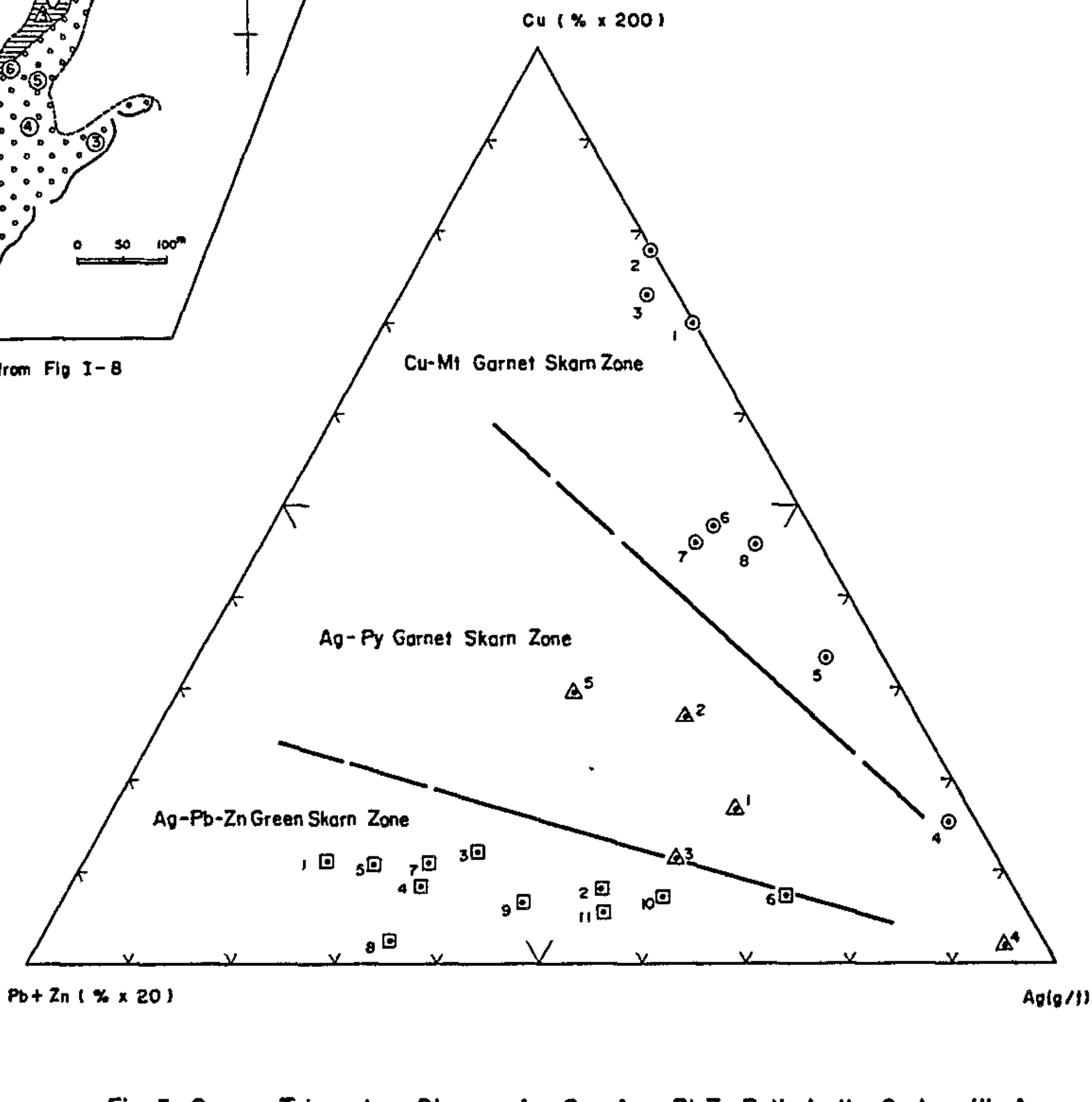


Fig I-9. Triangular Diagram for Cu-Ag-Pb·Zn Ratio in the Cochaquillo Area

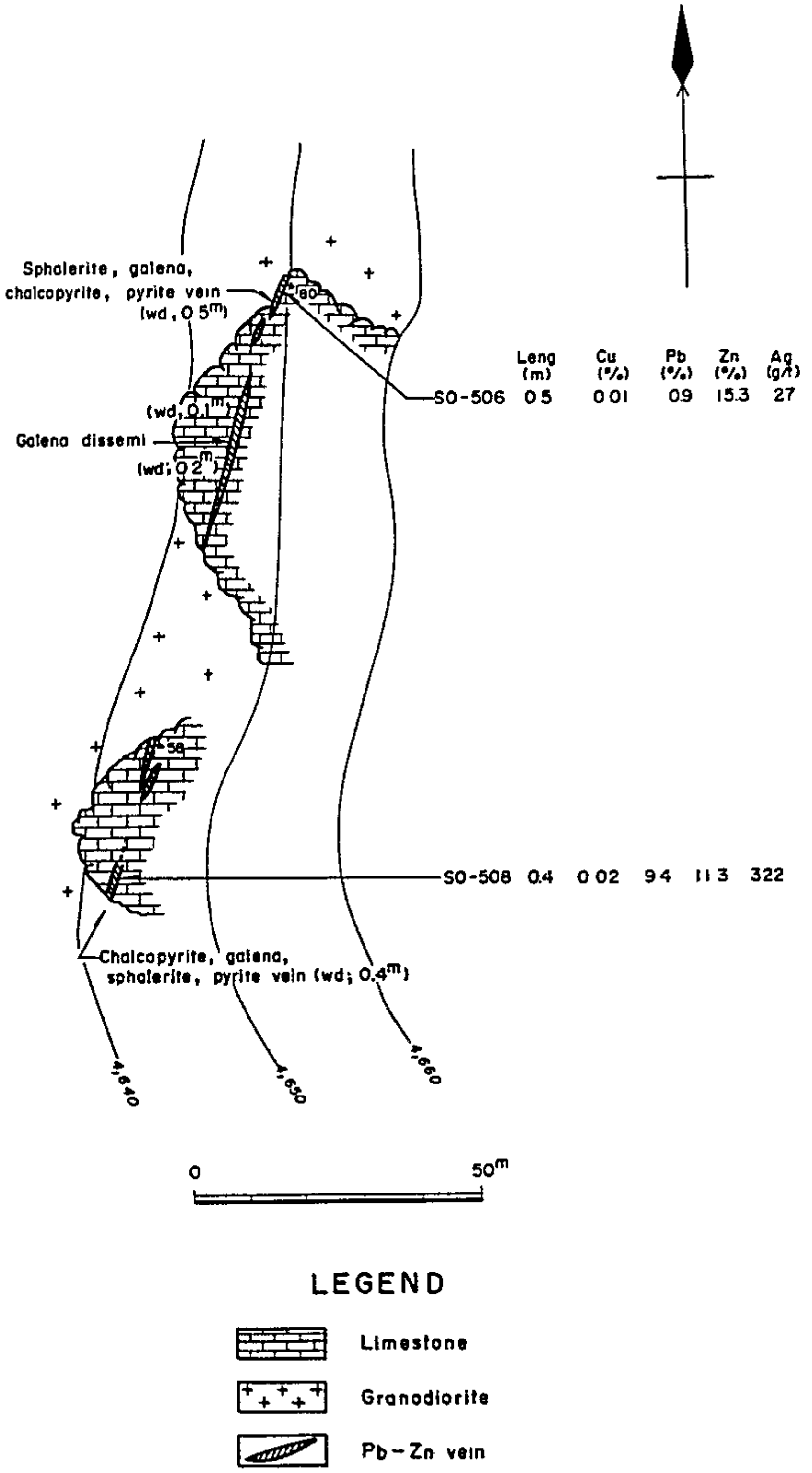
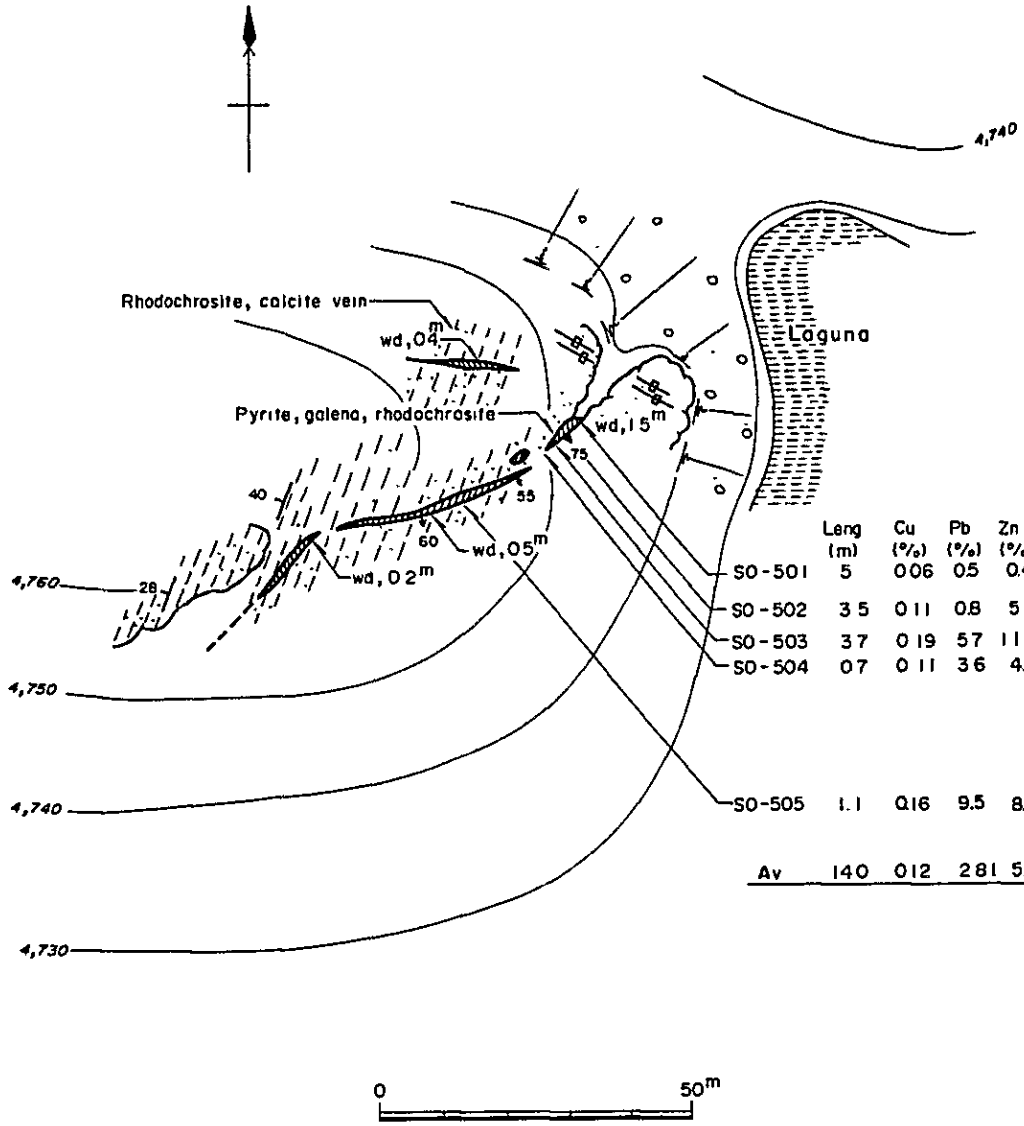


Fig. I-10. Geological Sketch of Mineral Indications in the B Area
(1) Pirihuya



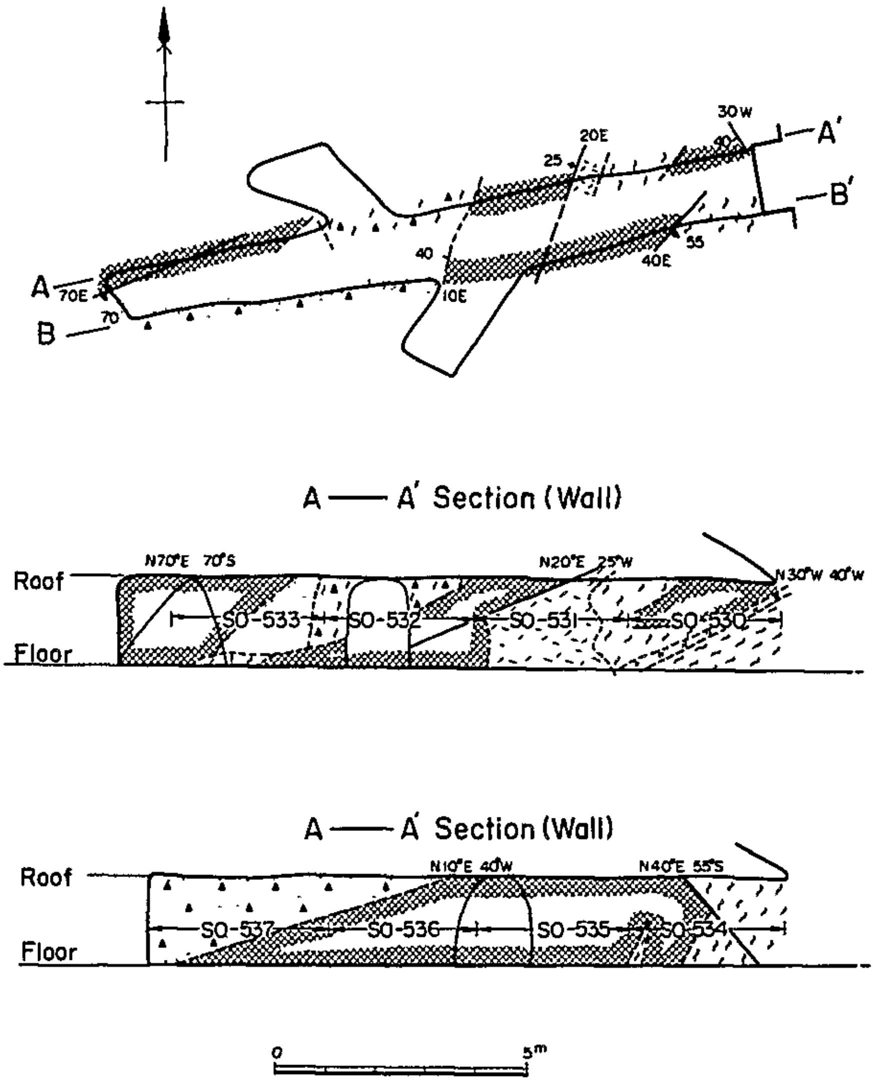
	Leng (m)	Cu (%)	Pb (%)	Zn (%)	Ag (g/t)
SO-501	5	006	05	0.4	55
SO-502	3 5	0 11	0.8	5 4	65
SO-503	3 7	0 19	5 7	11 9	93
SO-504	0 7	0 11	3 6	4.0	69
SO-505	1.1	0.16	9.5	8.6	117
Av	140	012	281	551	73

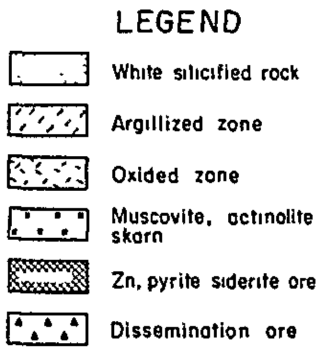
LEGEND

Alternation of sandstone & shale

Cu, Pb, Zn vein

Fig. I-10. Geological Sketch of Mineral Indications in the B Area
(2) Yanacocha





Sample No.	Leng (m)	Cu (%)	Pb (%)	Zn (%)	Ag (g/t)
SO-530	3	0.20	tr	3 8	7
SO-531	3	1 22	tr	7 2	55
SO-532	3	0.21	tr	13.9	147
SO-533	3	0.21	tr	1 1	1 4
SO-534	3	0 21	0 1	7 1	2 1
SO-535	3	0.17	0.1	8.9	3 1
SO-536	3	0.47	0.2	11 1	103
SO-537	3.5	0.24	0.2	22.9	175
Av	24.5	0.36	0.08	9.77	7 1

Fig. I-10. Geological Sketch of Mineral Indications in the B Area (3) Chalgoac

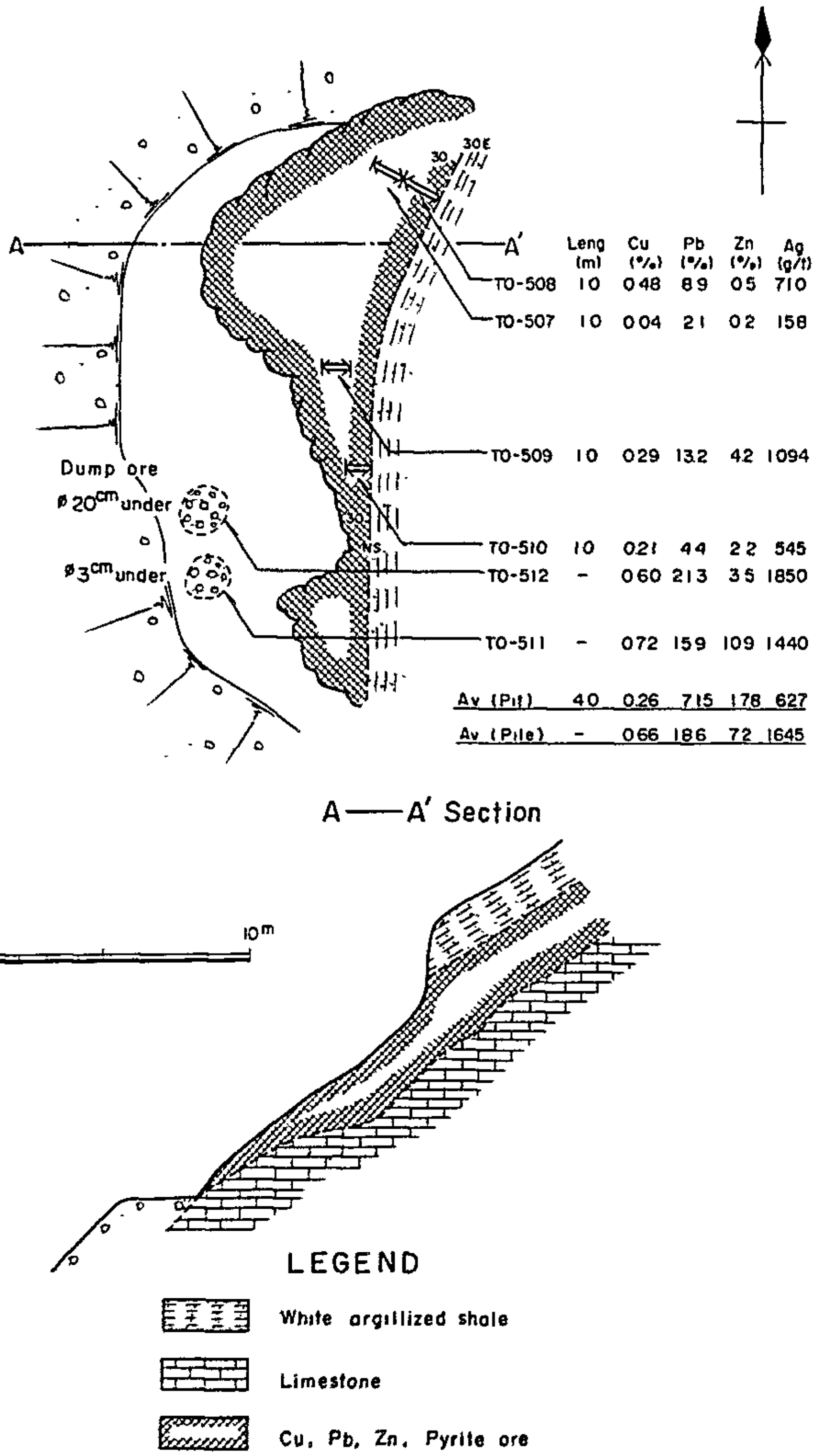


Fig I-10. Geological Sketch of Mineral Indications in the B Area
(4) Uchcumachay

Fig. I-11 Summary of X-ray Diffraction Test

Sample No. \ Mineral	Galena	Sphalerite	Chalcopyrite	Cerussite	Smithsonite	Hemimorphite	Hydrozincite	Pyrite	Pyrrhotite	Magnetite	Ilvaite	Goethite	Lepidocrosite	Hedenbergite	Garnet	Epidote	Tremolite	Chlorite	Sericite	Antigorite	Phlogopite	Muscovite	Quartz	Calcite	Dolomite	Siderite	Plagioclase	Rutile	Anatase	Alunite	Laumontite
NO-629																							⊚				◎				◎
NO-656		⊚						○										○		○				o	○						
NO-657		o			○			⊚											△				△		⊚						
NO-658						○	○											⊚				○									
NO-661																							⊚							◎	
NO-662		○																⊚					⊚								
SO-504	◎	◎						o											△				⊚								
SO-511	○		◎					◎							○		o	○					⊚	o	o						
TO-509	⊚	◎		△				◎															◎	o							
IC-701												o	o										⊚								
IC-706																							⊚					o	o		
IC-802		⊚			⊚													○					⊚								
IC-806		⊚	o							○								○					⊚			○					
TP-302		△									○								△				○			◎					
TP-305								o		◎								◎	o							◎					
TP-307		o						o	○	o								○	o				○			◎					
CQ-301	○	○						○						○	o								△								
CQ-356	○	◎														○		◎	△				○								
CQ-372		o														o		o					⊚	⊚							
CQ-391										⊚					○			o													

⊚ Very abundant　　o Rare

◎ Abundant　　△ Very rare

○ Common

Fig. I-12 Summary of Microscopic Observation of the Thin Section

Sample No. \ Mineral	Quartz Qz	Plagioclase Pl	K-feldspar Kf	Muscovite Ms	Biotite Bi	Hornblende Hb	Actinolite Act	Clinopyroxene Cpx	Orthopyroxene Opx	Garnet Gar	Epidote EP	Chlorite Chl	Sericite Ser	Calcite Cal	Carbonates Car	Barite Br	Clay minerals Cla.	Sphene Sph	Zircon Zr	Apatite Ap	Opaque minerals Opq	Sphalerite Sp	Others
NO-613	○	◎									△						o		△				o
NO-624	○	○										o	o		○					△	o		
NO-625	o	◎				o		○			△	o			○				△	△	o		
NO-630	◎	o									o					○			△				
NO-633	○	◎	o								o	o	o						△		△		
NO-643	o									◎	o	o		○					△			o	
NO-647	○	○				o		o				○					o		△		△		○
NO-652	○	◎	○			△													△		△		
SO-514	○	○						△			o	△							△	△			
SO-518	◎	◎										△	o		o					△	△		
SO-523	○	◎	o		○							o						△		△	△		
SO-529	o			△									○						△		△		o
TO-513	○	◎	o								o	o	△		o		o				o		
IC-706	◎												△								△		
IC-901	◎												◎										
IC-902	◎												○		△		o		△		△		
CQ-332	o									○		o		◎							o		
CQ-353	o							◎				o			○								
CQ-386	○									○		o			◎							△	
TP-304	o						◎					○			○						o		

◎ ..... Abundant

○ ..... Common

o ..... A little

△ ..... Rare

Fig. I-13 Summary of Microscopic Observation of the Polished Section

Sample No. \ Minerals	Magnetite	Hematite	Pyrite	Marcasite	Pyrrhotite	Arsenopyrite	Hydro-oxides	Sphalerite	Smithsonite	Galena	Cerussite	Chalcopyrite	Chalcocite	Covellite	Tetrahedrite	Bi-Pb-S minerals	Argentite	Molybdenite
	Mt	Hm	Py	Mar	Po	Asp	Hyd	Sp	Smi	Gl	Cer	Cp	Cc	Cv	Tet	Bi-Pb	Arg	Mo
NO-643			○					◎		○		o						
TO-506			○					◎		○		o	△	△				
IC-705		◎					o	○				◎	o		o	o	△	
IC-802	△	△	○					◎	○	△		o						
IC-806	o	o						◎				o				o		△
CQ-306			◎					○		○		o						
CQ-356			◎			△		◎	△	○	o	o	△	△				
CQ-372			o					◎		○		△						
TP-307	◎		○		○							o						
TP-312	o		o	△	○			◎										

◎ ..... Abundant

○ ..... Common

o ..... A little

△ ..... Rare

Table I-4 Assay Results of Rock-forming Elements

No.	Field No.	Location	Rock Type (Formation)	Ca (%)	Mn (%)	Fe (%)	Mg (%)	Ba (%)	Sr (%)	SiO_2 (%)	Co (%)
1	NO-606	G-4	Sk (Ph)	21.8	10.8	1.93	0.66	<0.001	0.012	24.18	0.002
2	NO-616	G-4	Ls (Jm)	26.0	0.04	2.08	1.32	0.006	0.012	18.21	<0.001
3	NO-617	G-4	Ls (Ph)	35.7	0.08	1.11	1.26	<0.001	<0.001	1.97	<0.001
4	NO-620	G-4	Ls (Ph)	33.5	<0.01	0.36	0.32	0.004	0.053	5.63	<0.001
5	NO-621	G-4	Ls (Ph)	36.6	0.02	0.40	0.31	<0.001	<0.001	1.93	<0.001
6	NO-654	G-4	Ls (Cl)	34.2	0.02	1.16	0.50	0.002	0.013	4.84	<0.001
7	NO-655	G-4	Ls (Ph)	32.3	0.00	0.36	0.44	0.008	0.020	12.11	<0.001
8	CB-04-055	IC-3	Ml (St)	8.22	0.20	3.66	7.52	0.001	<0.001	40.22	<0.001
9	CB-04-119	IC-3	Sh (St)	0.17	0.00	0.77	0.54	0.042	0.021	75.10	<0.001
10	CB-07-052	IC-4	Sk (St)	4.46	0.14	11.4	13.2	<0.001	<0.001	29.95	<0.001

Geological Unit

Jm ... Jumasha formation
Cl ... Chulec formation
Ph ... Pariahuanca formation
St ... Santa formation

Abbreviation

Ls ... Limestone
Ml ... Marl
Sh ... Shale
Sk ... Skarn

CB-07-055
07 — DDH No.
055 — Depth (m)
Drilled core

Chapter 4 Synthetic Discussion on the Iscay Cruz Mineralized Zone

4-1 Geologic Structure and Mineralization

Mineralization in this area occur in calcareous rocks of the Santa formation. This formation constitutes wing of folded sedimentary rocks. Because of tight folding, however, the dip here is nearly vertical and partly overturned. The thickness varies from 40 m to 80 m.

Throughout prominent mineralized zones in the Limpe area, Cunsha Punta area and Chupa ore deposit, the host formation is overturned, and the lower unit of the Chimu formation, which is arenaceous sandstone of the Farrat formation in the case of Chupa deposit, is distributed in the apparent hanging wall side. Chemically inert sandstone seems to have acted as shattered rock against chemically reactive limestone of the host horizon where the ore minerals are concentrated.

In the Iscay Cruz area, shear faults and fractures are densely developed in ENE-WSW direction which is diagonal to the folding axis. Mineralization of the Chupa ore deposit is strongly controlled by the diagonal fracture system. These fractures are considered to be important as channel way of the ore solution and also as the place of precipitation of the ore minerals. The fractures as well as NNW-SSE faults may effect extension of mineralized zone.

4-2 Igneous Activity and Mineralization

Dacite porphyry intrudes as stock at about 1 km west of the Cumbre de Iscay Cruz. This stock is only weakly altered and skarnization in the surrounding limestone is also faint. Thus the intrusion may not be related to the mineralization. Andesitic porphyry dike is recognized in this area, which is later than the mineralization.

In the Oyon and Chimu formations to the east of Cumbre de Cunsha Punta, present are more than ten dikes of acidic compositions. These dikes themselves and the intruded wall rocks are both intensely altered hydrothermally, and the original minerals are converted to quartz, sericite and pyrophyllite. Pyrite and limonite are disseminated in the altered rocks. Distinct brecciation is seen at margin of these dikes, and breccia dike or vein is formed in some places. These dikes are distributed, though sporadically, in the entire Iscay Cruz area along the anticlinal axis, and in the Cumbre de Limpe area, they intrude into the Santa formation. The strong alteration as well as spatial relationship of the dikes with mineralized zones suggests that the acidic dikes are most closely related igneous activity to the mineralization in the surveyed area. Because of the intense alteration, the original composition of the dikes is hardly identified. Yet they are assumed originally a quartz prophyry, for the remaining phenocrysts of quartz and feldspars.

5-3 Wall Rock Alteration

Host rocks of the known mineralized zones are limestone of the Santa formation which intercalates tuffaceous siltstone and shale. The limestone in this area appears to be clayey, as compared with limestones in the other areas. It is not clear, however, whether this character is due to the original impure nature or due to later alteration such as silicification, dolomitization and sideritization.

To the north of Cumbre de Cunsha Punta, skarn occurs with disseminated chalcopyrite and sphalerite. In the massive sulfide orebody recognized to the north of Cumbre de Limpe, a large amount of pyrite and pyrrhotite replace limestone. Horse stone in the orebody and the surrounding wall rocks are distinctly silicified, sericitized, sideritized and dolomitized.

In the vicinity of Cumbre de Iscay Cruz, silicified siderite is seen widely and is disseminated with galena and sphalerite. The surrounding rocks of shale and marlstone are pyrite disseminated. Brecciation of the host rocks is distinct in the high grade part. Prominent alterations related to the mineralization are sideritization and silicification. Chemically, iron, manganese and silica are added. This addition is considered due to hydrothermal alteration.

Fig. I-14 is a graph showing variation of major components of unaltered limestone of the Santa formation in the Iscay Cruz area, and dolostone and siderite bed occurring around the orebodies, which may indicate migration of these components during hydrothermal alteration. This figure reveals that the limestone is composed of highly pure $CaCO_3$ but in the dolostone about 50 percent of calcium has been leached out and replaced by magnesium, iron and manganese. In the siderite bed, calcium has been completely leached out and replaced by iron and manganese; silicon has been also added.

4-4 Zonal Distribution of Ore and Gangue Minerals

The mineralization tends to occur along the Santa formation for about 12 km in length, and concentration of the ore minerals is sporadic within this horizon. However, an overall view indicats a regional zonation of the ore minerals. In the place like north of Cumbre de Cunsha Punta which is very close to the center of acidic igneous activities, present are skarn deposits containing chalcopyrite, sphalerite, magnetite, pyrite and pyrrhotite.

To the north and south flanks of this mineralized zone, i.e., around Cumbre de Limpe and to the south of Cumbre de Cunsha Punta, massive sulfide orebody is formed. Galena and sphalerite are disseminated in the massive pyrite and pyrrhotite orebody. In the outermost zone like the vicinity of

Cumbre de Iscay Cruz and Antapampa area, only galena and sphalerite are disseminated in manganiferous siderite mass. This lateral variation on type of mineralization and on kind of ore minerals is considered to have resulted in a series of mineralized solution brought up from the acidic igneous center just mentioned above.

Fig. I-15 is a ternary diagram of copper, lead and zinc of mineralized outcrop whose assay values on the channel sampling are given in Fig. I-6. Since abundance of copper and lead is relatively low to that of zinc, copper and lead are multiplied by the factors of 100 and 10, respectively. The figure indicates that the Cu-Pb-Zn ratio differs depending upon locality of the outcrop; thus showing a regional zonation. The Iscay Cruz area constitutes Pb-Zn-rich, outer zone; the Limpe area is Cu-Pb-Zn intermediate zone; and the Antapampa area and the Chupa ore deposit appear to be a transitional zone of the two zones mentioned above, and finally the Cunsha Punta area including Tinyag is characterized by high copper, inner zone. This zonation of the ore metals may be attributed to evolution of the ore solution and different physicochemical conditions that occurred in the Santa formation during formation to these minerals.

4-5 Discussion on the Geophysical Results

(1) IP prospecting covering all the Iscay Cruz area reveals a clear contrast in the northern and southern areas, which is separated at Lag. Quellaycocha. The northern area is shown by low FE and high AR properties which are not promising a large-scale pyrite orebody. This interpretation was proved to be valid by DDH-1 and DDH-2 drillings.

(2) High FE and low AR anomalies are located in the Limpe area and further to the south. The anomalies are particularly distinct in the Limpe area, which is nearly the center of the mineralized zone. The anomalies were

interpreted to imply concealed lead-zinc-pyrite orebodies, and the interpretation was tested to be true by DDH-3 and three other drill holes.

(3) The next ranked, high FE and low AR anomaly is seen in the southernmost, Antapampa area. The anomaly is mainly concealed and plunges southward. DDH-11 and DDH-12 confirmed that anomaly was caused by copper-bearing hematite-pyrite orebody occurring in siderite bed.

(4) The third class, high FE anomaly is observed in the Cunsha Punta area, Tinyag skarn outcrop area and the area around Lags. Tinyag. Among them, the Cunsha Punta anomaly is concealed, possibly due to the measurement lines set up at distant from the orebody. FE anomaly around the Tinyag skarn outcrop is rather weak. This may be due to the fact that the skarn contains only a little pyrite but is rich in magnetite and sphalerite, in addition to unproper distance between the measurement lines and the orebody. High FE anomaly around Lags. Tinyag may possibly caused by limonite deposited at margin of lake. Besides, low AR zone and the highest and the widest MF (metal factor) anomaly were obtained in the area from Lags. Tinyag to Cunsha Punta pass.

(5) As stated above, IP prospecting provided very useful information on exploration of base metals in the surveyed area.

4-6 Discussion on the Drilling Results

Twelve drill holes were made from the last year to this year. Nearly all drilling, except DDH-8, detected orebody and mineralized zones. Fig. I-16 illustrates copper-lead-zinc ratio of the main orebodies discovered by the drilling. Here, copper and lead are multiplied by 50 and 10, respectively.

According to this figure, the ores from DDH-1, 2 and 3 located in the north are relatively rich in lead which constitute the outer zone, and zinc-rich ores from the Limpe area represent the intermediate zone.

It is reasonable that skarn ores of DDH-7 is plotted in copper-zinc-rich field which demonstrates the inner zone. However, the ores of DDH-12 are also plotted in the same field. These ores imply also a center of the mineralization. Thus minor centers of the mineralization might have existed in the deep south, besides the main center.

4-7 Occurrence of Outcrop and Mineralization

It was confirmed by drilling that high-grade lead-zinc pyrite ore-bodies concealed widely in the Limpe area. In spite of the intense mineralization, pyrite mineralization in the outcrop is weak and small in scale. The surface manifestation is shown by hematite dissemination in silicified rocks, black gossan oxidized from manganiferous siderite and weak dissemination of galena and sphalerite in dolostone. The hematite and black gossan, which are exposed widely on the surface, cannot be considered as oxidized products of the hidden pyrite orebody. Thus these outcrop materials are different primarily from the orebody, and may be an upper manifestation of low temperature mineralization and alteration of the hidden lead-zinc pyrite mineralization.

4-8 Consideration on the Genesis

The skarn deposit is tentatively considered as contact metasomatic deposit of post-magmatic and limestone replacement deposit is product of a hydrothermal stage mineralization. The siderite-hosted deposit may have been formed at much lower temperature stage. Coexistence of the variety of mineralization is characteristic in this surveyed area, and is in accord with the Cordilleran type of ore deposits by Petersen (1965).

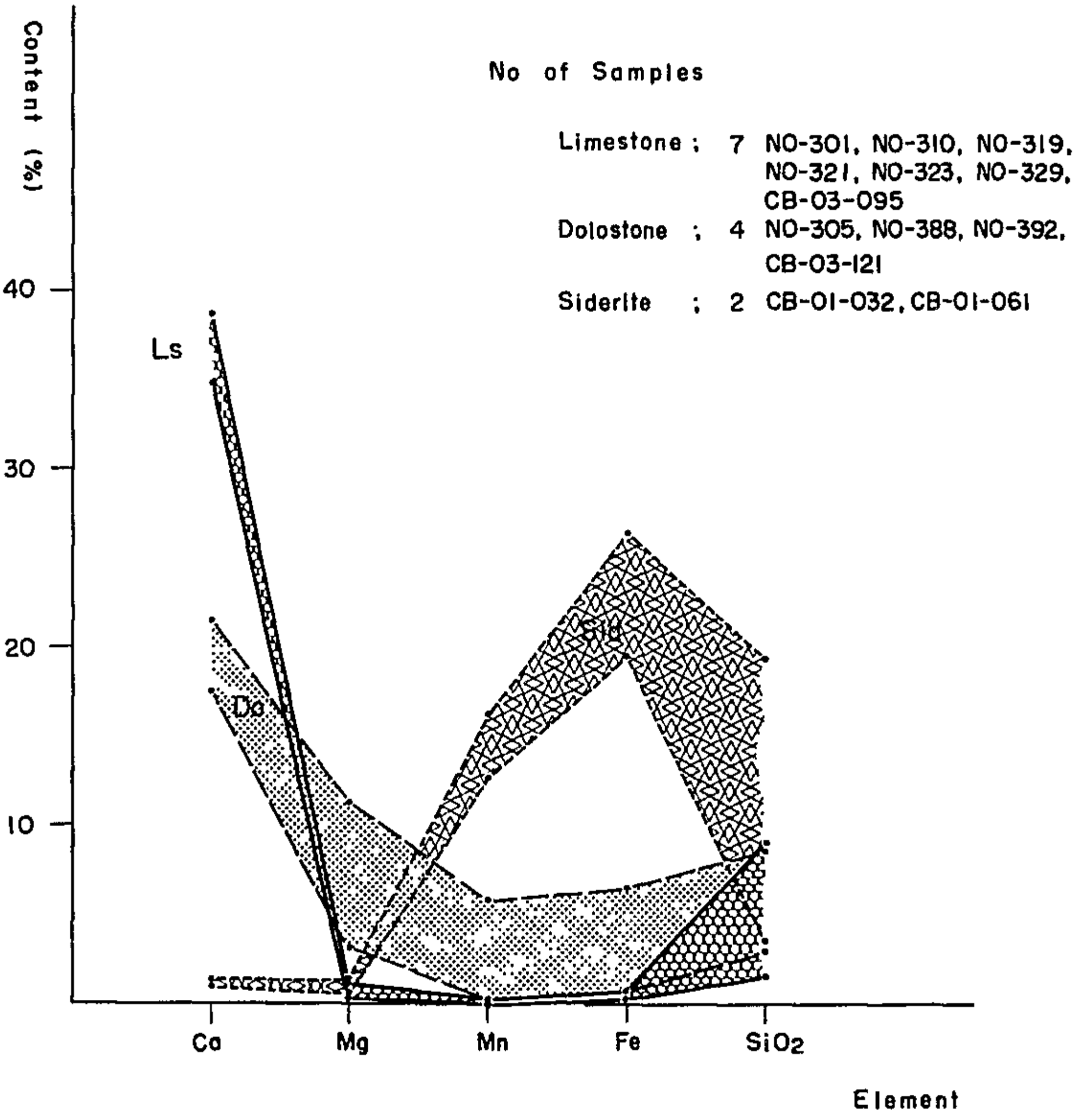


Fig. I – 14 Variation Diagram for Chemical Components of the Carbonate Rocks of the Santa Formation in the Iscay Cruz Area

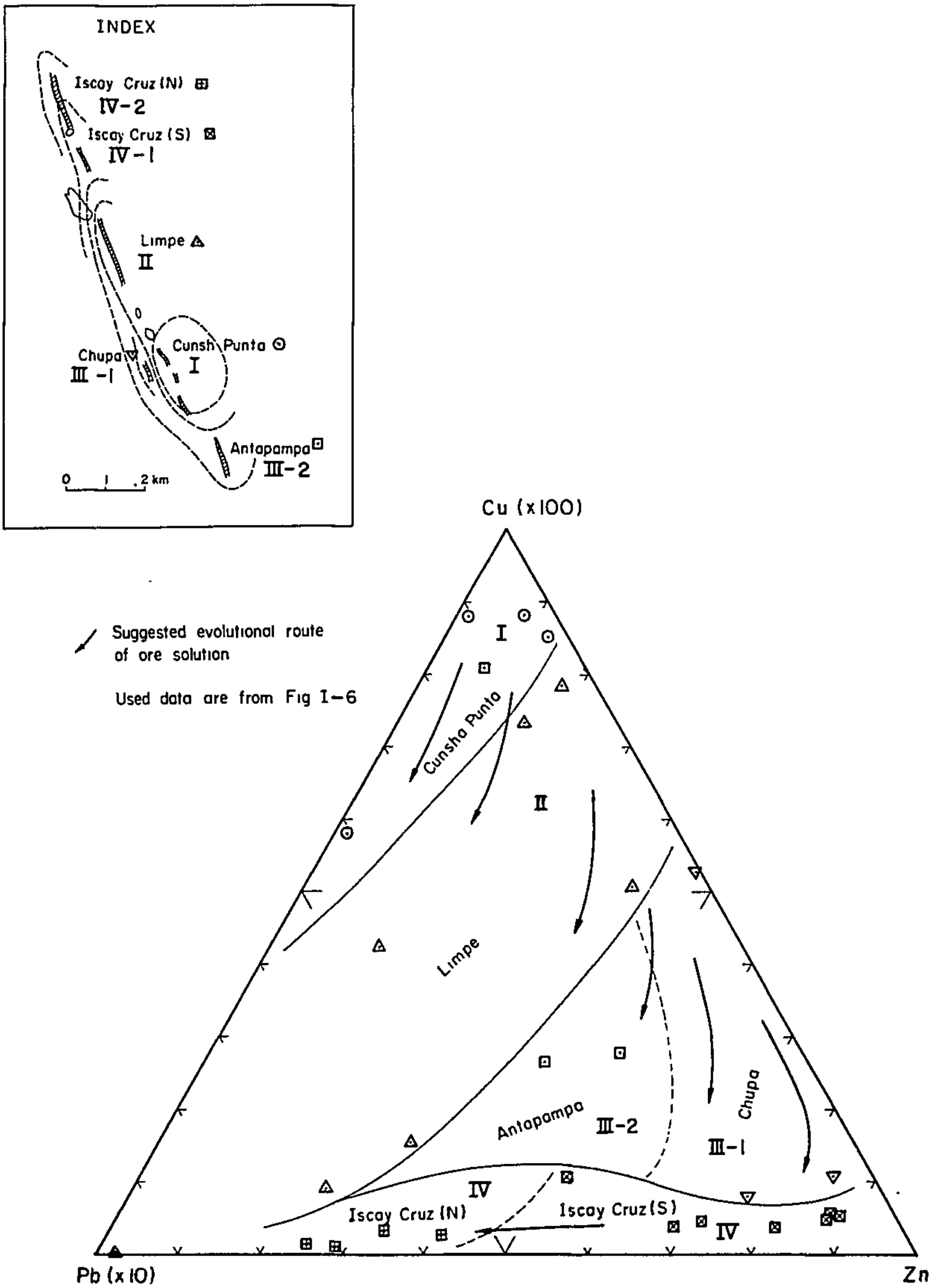


Fig. I-15. Triangular Diagram for Cu-Pb-Zn Ratio in the Iscay Cruz Area

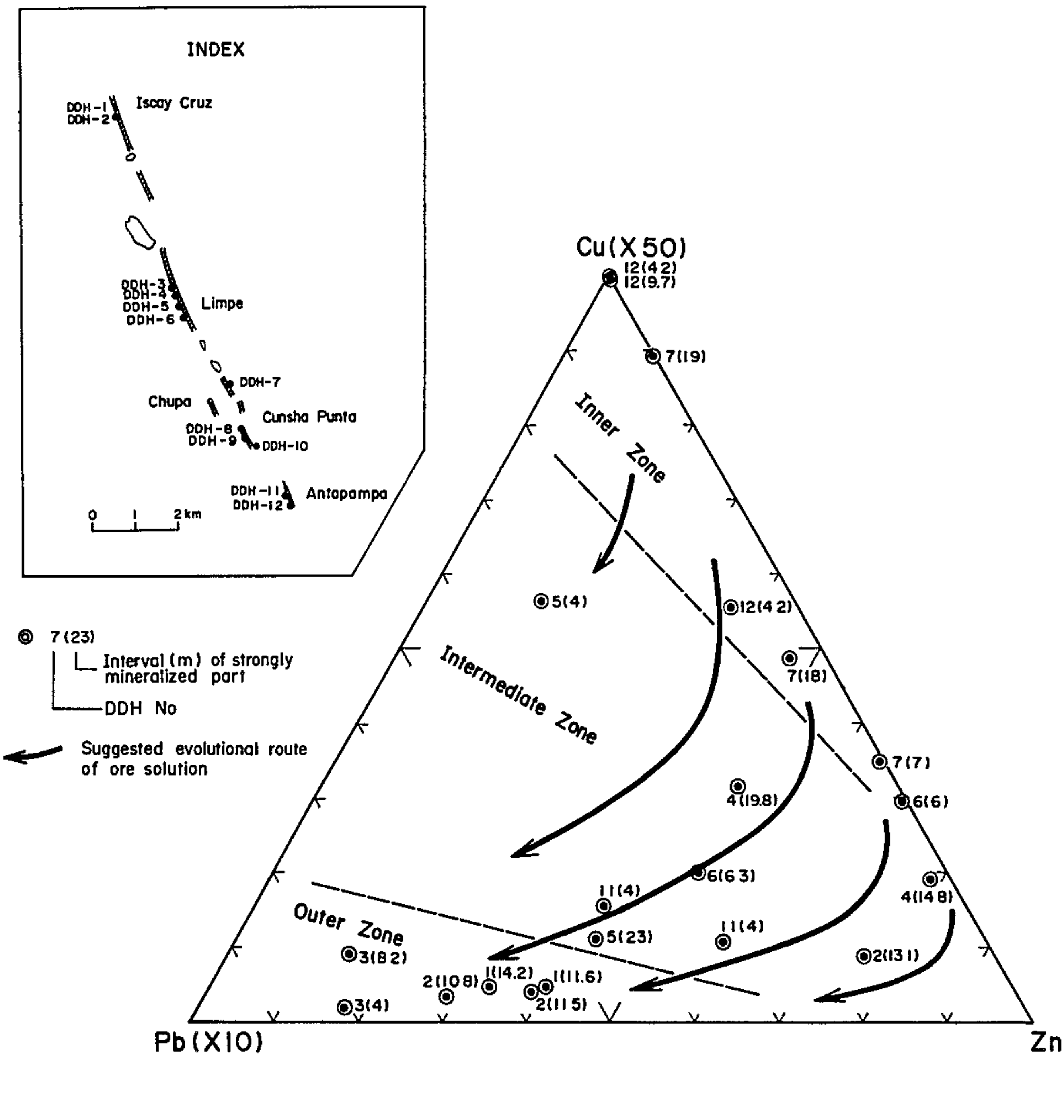


Fig. I - 16. Triangular Diagram for Cu-Pb-Zn Ratio in the Drilled Core

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PARTICULARS

PART Ⅱ

GEOPHYSICAL PROSPECTING

PART II

GEOPHYSICAL PROSPECTING

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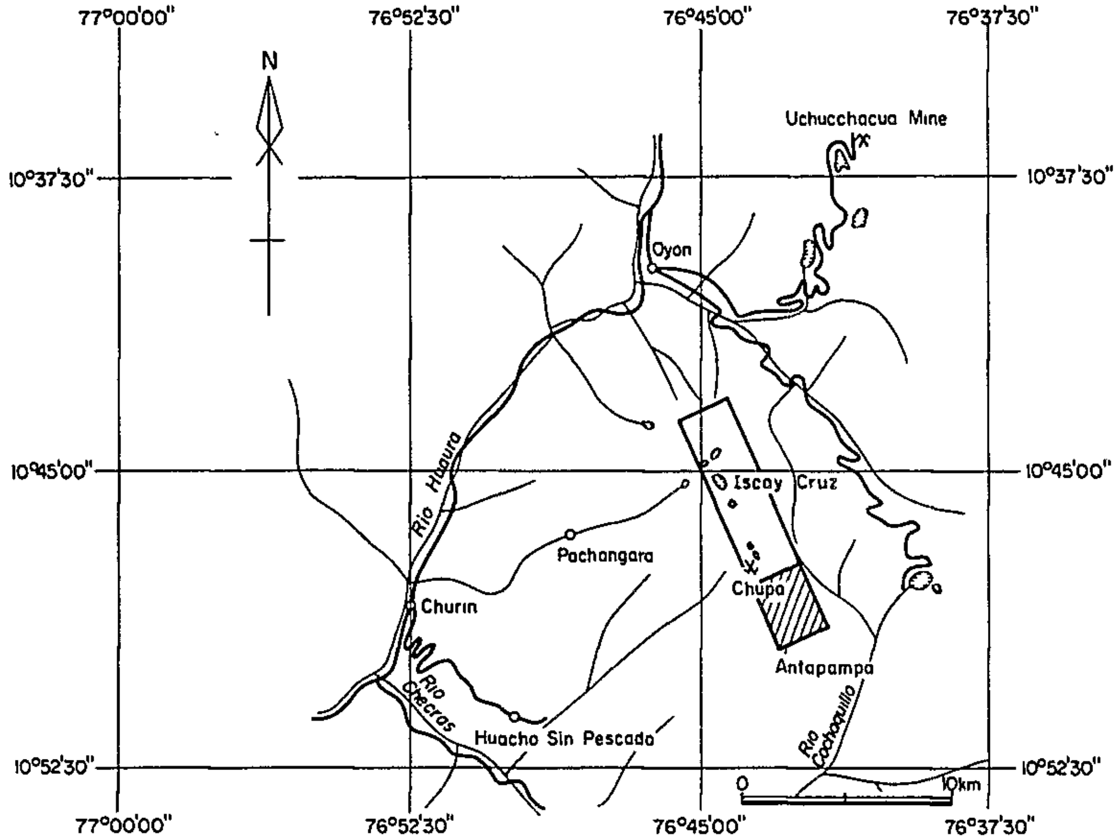


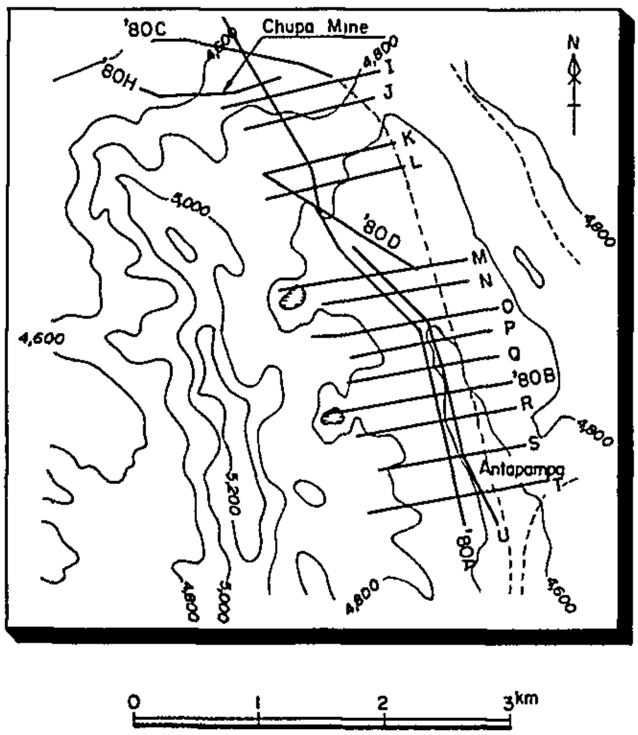


Fig.II-1 Location map of the surveyed area

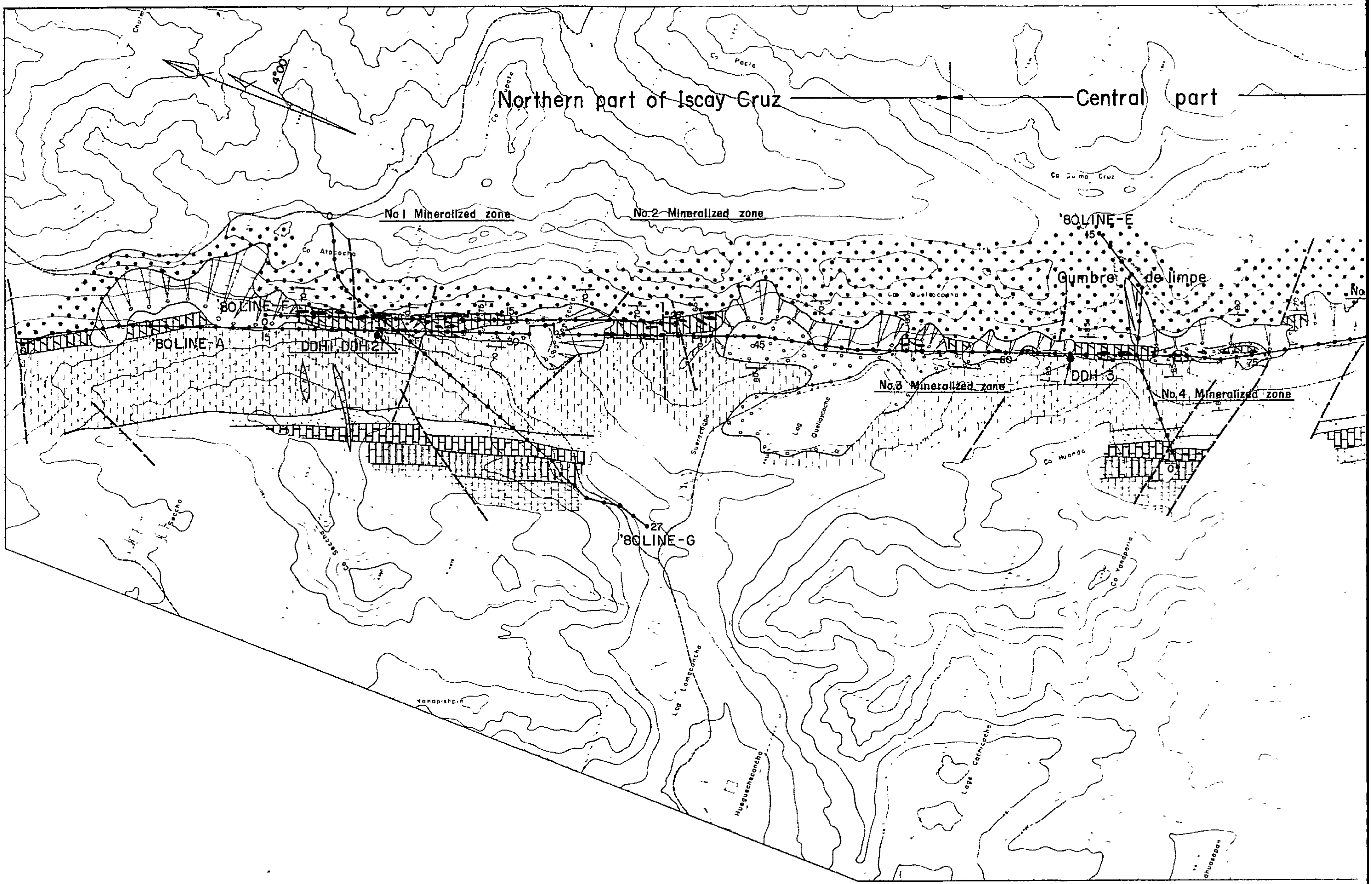
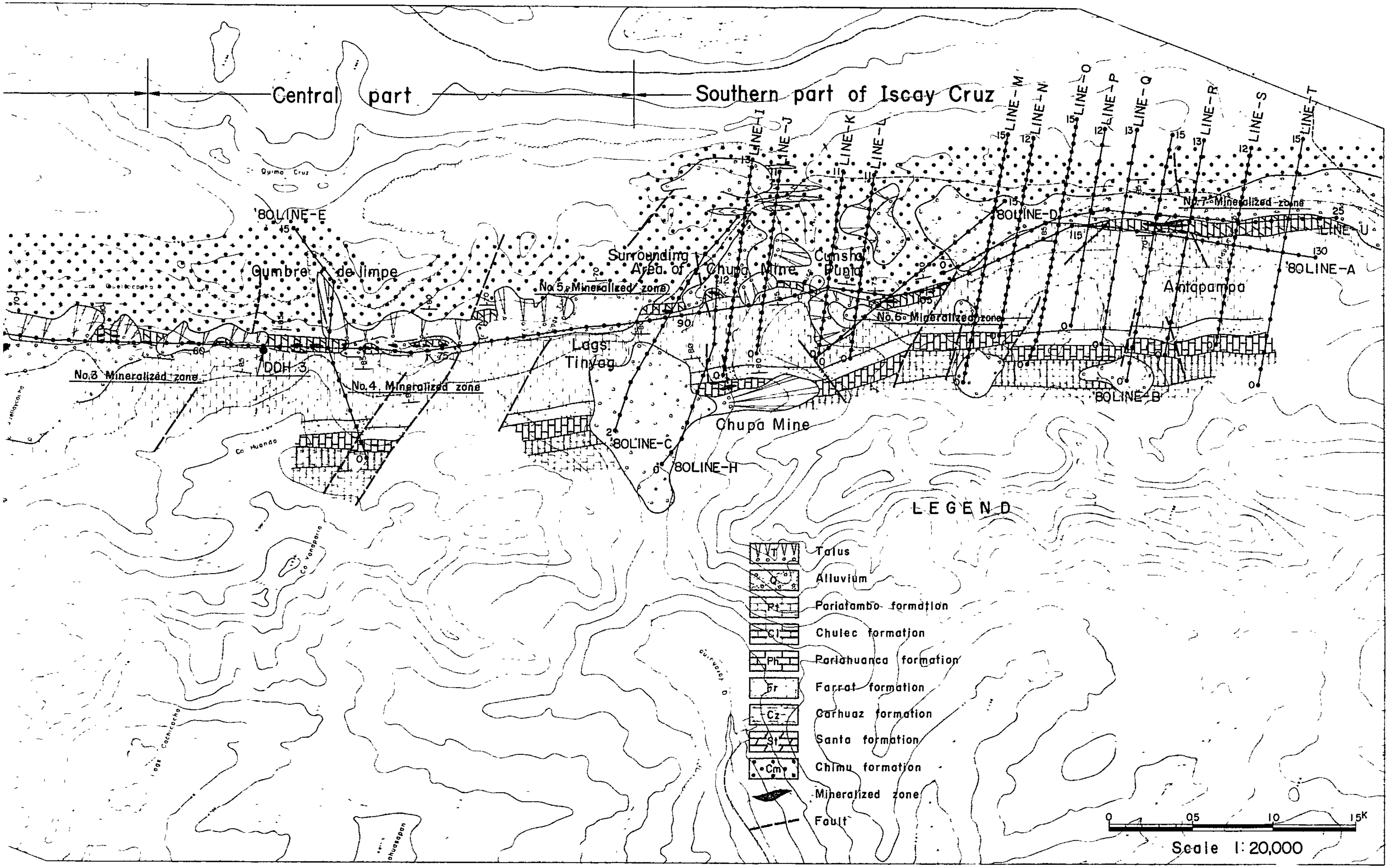


Fig.II-2 Explanatory map of the surveyed area



planatory map of the surveyed area