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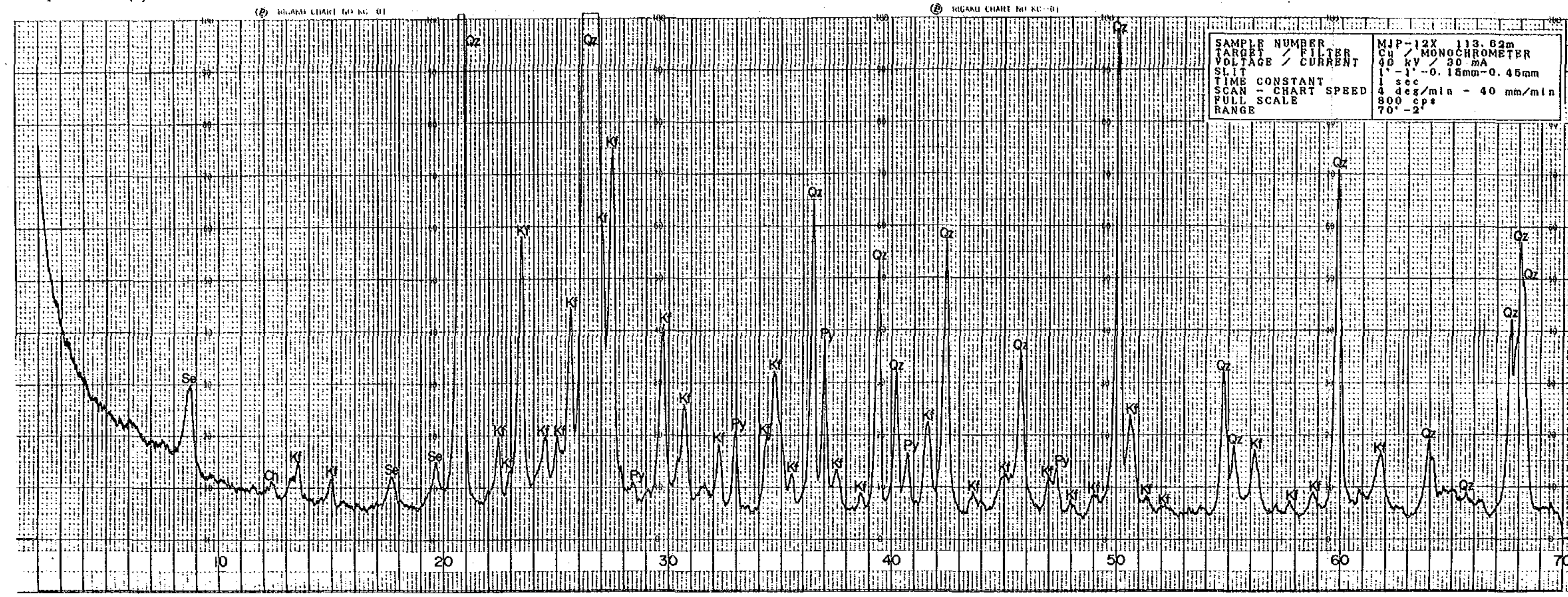

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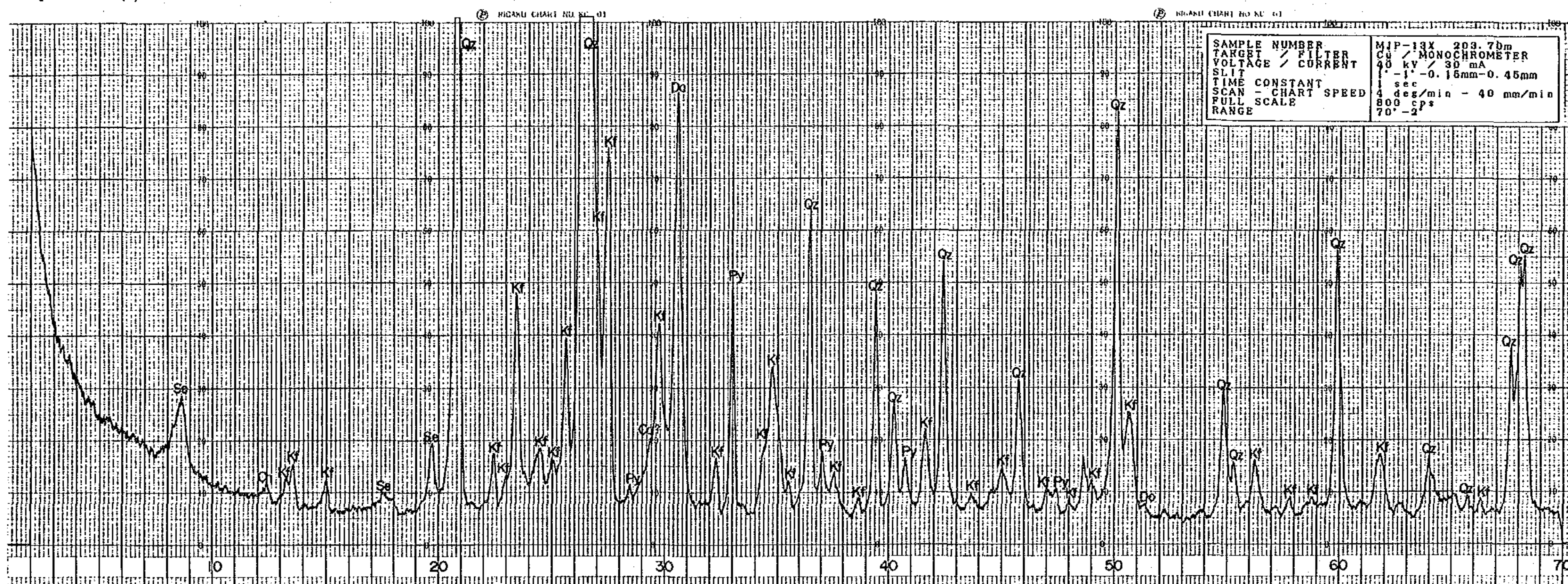

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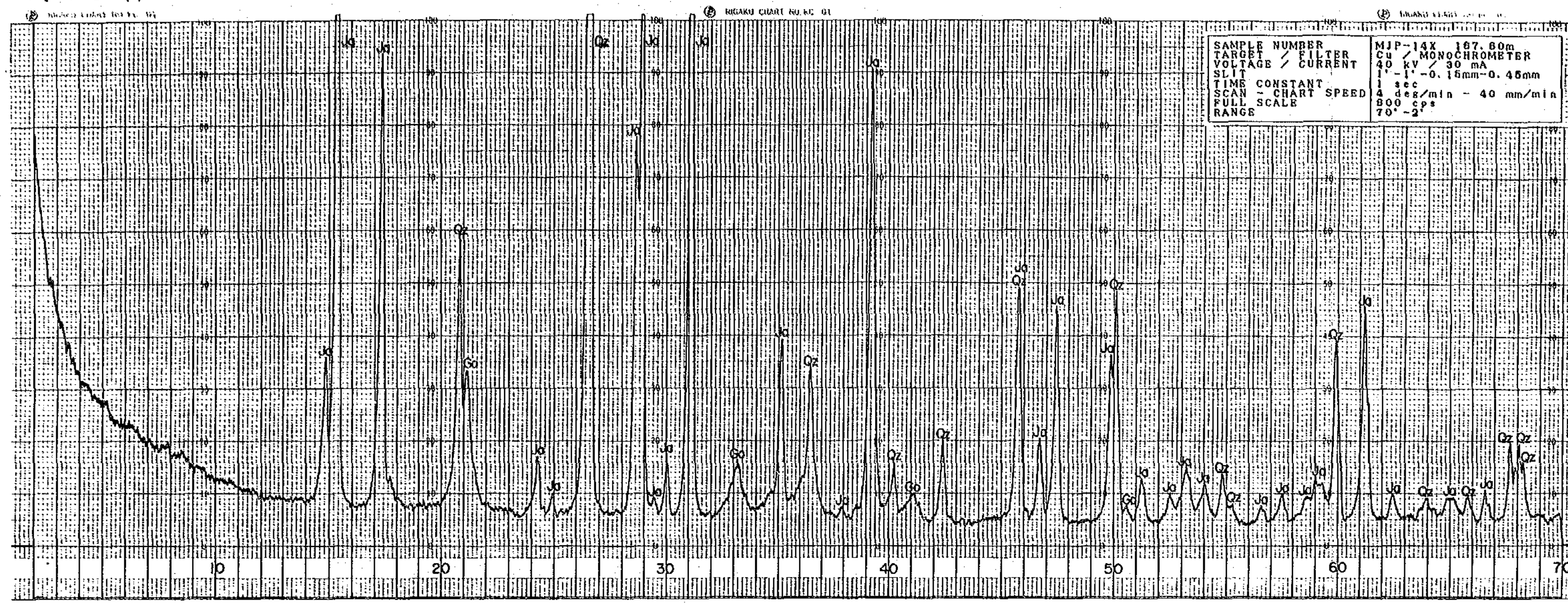

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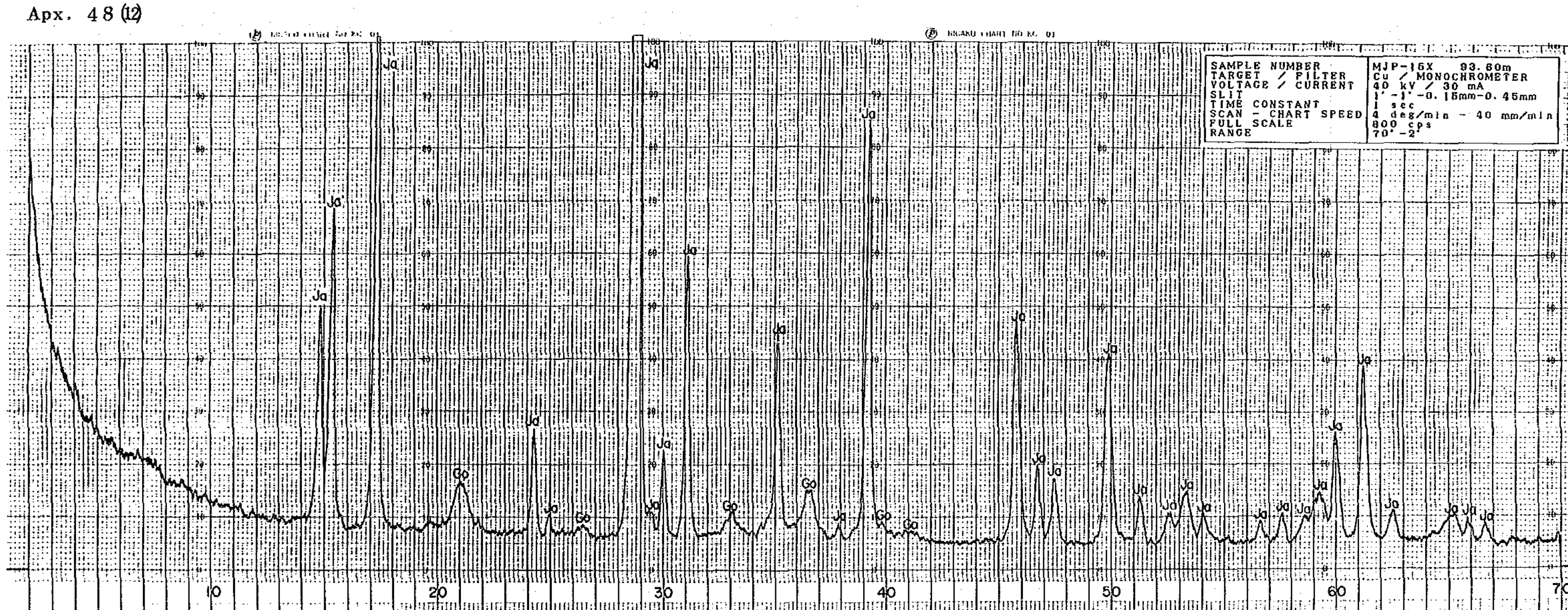

REPUBLIC OF PERU
REPORT ON MINERAL EXPLORATION
IN
COTAHUASI AREA

CONSOLIDATED REPORT

JANUARY 1988

JAPAN INTERNATIONAL COOPERATION AGENCY

METAL MINING AGENCY OF JAPAN

PREFACE

At the request of the Government of the Republic of Peru, the Japanese Government planned and carried out a geological survey concerning mineral exploration to examine the possibility of the existence of mineral resources in the Cotahuasi Area located in the southern part of Peru. The Japan International Cooperation Agency was entrusted with the execution of the general plan. The Japan International Cooperation Agency in turn entrusted the execution of this survey to the Metal Mining Agency of Japan since this survey was essentially a professional survey of geology and mineral resources.

The survey was conducted for three years from fiscal 1985 to 1987 and accomplished as schedule with the cooperation of the Peru Government, and particularly the Instituto Geologico Minero y Metalurgico (INGEMMET).

This report is the compilation of the results of the whole survey during these three years.

Lastly, we would like to express our heartfelt gratitude to the members concerned of the Government of the Republic of Peru, the Ministry of Foreign Affairs of Japan, and the Embassy of Japan in Peru, and to all those who extended their kind cooperation to us in executing above-mentioned survey.

January, 1988

Kensuke Yanagiya
President
Japan International Cooperation Agency

Junichiro Sato
President
Metal Mining Agency of Japan

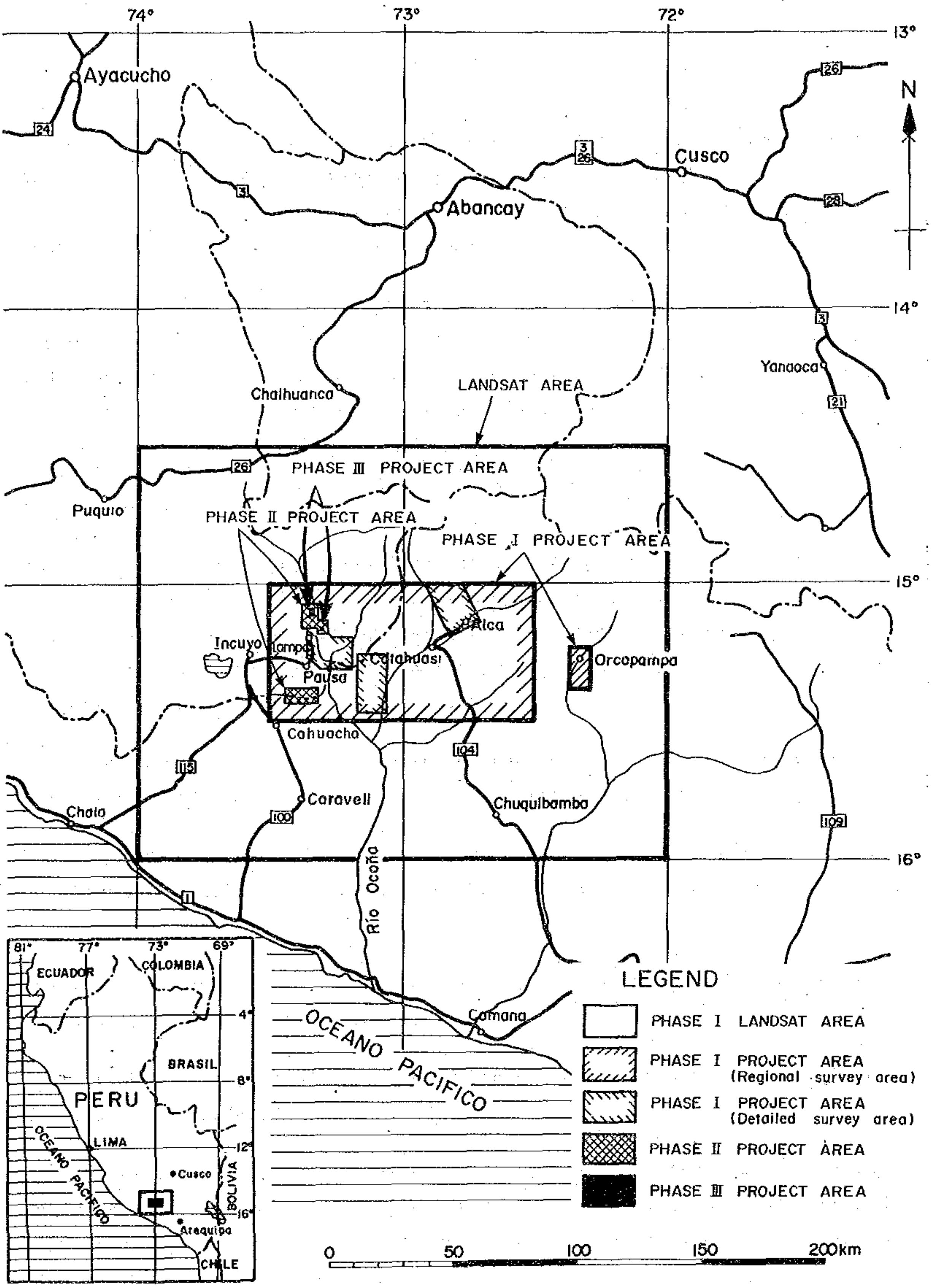

Fig. I – 1 Location Map of the Project Area

ABSTRACT

The Government of the Republic of Peru had requested Japanese Government for an assistance and co-operation in the mineral exploration of the Cotahuasi Area located in the southern Peru with an intention to activate exploitation of non-ferrous metal industries.

In response to the request, Japanese Government conducted a mineral exploration of the proposed area for the periods of 3 years from 1985 to 1987, by having entrusted the exploration work to the Japan International Cooperation Agency (JICA) and the Metal Mining Agency of Japan (MMAJ).

This report summarizes all the work carried out during the periods and the results of the work.

The 1st year's work comprises a geological interpretation of landsat imageries for an area of 30,000 km^2 including the proposed area, and a regional geological and geochemical (stream-sediment sampling) survey for an area of 6,000 km^2 followed by a follow-up geological prospecting for the selected 3 areas of 800 km^2 in total.

The above work resulted in having uncovered the regional geology in relation with mineral occurrences in the Cotahuasi area.

The area is distributed by the Jurassic and the Cretaceous systems mainly consisting of sedimentary rocks over the basement of Precambian granite and diorite.

The Tertiary and Quarternary systems mainly consisting of volcanic rocks unconformably overlie these rocks.

Batholiths or stocks of diorite and dikes of andesite intrude the rocks of Miocene age or older.

Mineralization and associated alteration are hosted by the rocks of Miocene age or older, and consist mainly of quartz veins, quartz vein networks and silicified or oxidized zone along fractures or fractures zones, associated with Au and Ag minerals in places.

The 1st year work outlined 4 promising target areas for mineralization, namely (1) Mina Pararapa, (2) Tanisca alteration zone, (3) Mina Luicho and (4) Pirca alteration zone. However, the 3 areas except the Pirca alteration zone were covered by private mining concessions and discarded for further exploration work.

By having re-examined the results of the 1st year's work, the Marcabamba (80 km^2) and the Pirca (90 km^2) areas were selected for the 2nd year targets. The Pirca area was divided into two sub areas, the eastern and the western Pirca.

Geological mapping and geochemical prospecting (soil sampling) were carried out in both the Marcabamba and the Pirca areas, and 10 holes of diamond core drilling with a total length of 1,000 m were put in the eastern Pirca sub-area.

In the Marcabamba area, a number of mineralization and alteration zones were found either in the Tertiary Tacaza Formation (Tc) or in the Cretaceous Hualhuani (Yu) and Murco (Mu) Formations. Of the zones, two zones, the Colpar and the Marcamalata, were of particular interest because of their association with geochemical anomalies of notable sizes and values.

In the Pirca area, geochemical anomalies were small in sizes and low in values of elements of interest, in spite of extensive alteration zones.

The drill holes in the eastern Pirca sub area failed to intersect sections of mineralization of any values though alteration was prominent.

Based on the results above described, the Colpar (5 km^2) and Marcamalata (2 km^2) of the Marcabamba area were selected for the 3rd year targets.

The 3rd year's work comprises detailed prospecting with an aid of trending and drilling of 5 holes, 3 250 m-hole for the Colpar and 2 200 m-holes for the Marcamalata.

In the course of the detailed prospecting a number of abandoned old workings and mineralized outcrops were located in the Colpar alteration zone and the geochemical anomaly adjacent to the south which had been outlined in the previous year. These old workings, without any record remained, had been unknown for years even by local residents.

The 3rd year work located two mineralized zones in the Colpar, the northern mineralized zone including 4 mineralized veins and the southern mineralized zone including 9 mineralized veins, both hosted by the Tacaza Formation (Tc).

These veins are mostly developed along NE-SW trending fractures or fractured zones, and consist of quartz veins, quartz vein networks and silicified zones. Major ore minerals are electrum, argentite, polybasite, pearceite, galena, sphalerite, chalcopyrite and pyrite. An identified alteration mineral assemblage is quartz-potash feldspar (aduralio)-sericite with or without chlorite.

A surface sample of the N3 vein in the northern mineralized zone indicated assay results of 5.70 g/t Au and 640 g/t Ag for a width of 1 m.

The holes MJP-11 and -12 intersected a number of quartz veins, quartz vein networks and silicified zones including the N1 and N2 veins with appreciable values of Au and Ag but were too short to reach the N3 and N4 veins.

The northern mineralized zone may continue to the northern silicified zone to the northeast and form a sizable unit of the mineralization-alteration zone with a length of about 1.5 km and a width of 0.3 km.

Surface samples of the S3 and the S7 veins in the southern mineralized zone indicated assay results of 21.50 g/t Au and 410 g/t Ag for a width of 0.15 m of the 3 vein and 20.10 g/t Au and 1200 g/t Ag for a width of 0.3 m of the S7 vein.

The hole MJP-13 intersected S3, S4 and S5 veins, a part of which indicated appreciable values in Au and Ag with subordinate Cu, Pb and Zn values.

The southern mineralized zone is possible to continue southwestwards under the scree cover to the Auebrada Querumahuaico alteration zone and may form a sizable unit of a mineralization-alteration zone with a length of about 0.9 km and a width of 0.2 km.

The mineralization in the Marcamalata is hosted by sedimentary rocks of the Hualhuani and Murco Formations of Cretaceous age and yieldes some Ag values with minor Au and other elements. The mineralized veins are discontinuous and limited in extensions in general.

The holes MJP-14 and -15 intersected a number of quartz veins and quartz vein networks but without any Au-Ag values of commercial interest.

The work failed to find any evidences suggesting potential for commercial mineralization.

In conclusion, the 3rd year work resulted in outlining the two mineralization-alteration zones in the Colpar.

However, no promising evidences were formed for the Marcamalata.

CONTENTS

PART II DETAILED REPORT

PART III CONCLUSION AND RECOMMENDATION

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PART I SUMMARY REPORT

PART 1 SUMMARY REPORT

CHAPTER 1 OUTLINE OF THE 3 YEAR PROJECT

1-1 Location

The project area is situated in the southern part of the Republic of Peru. The center of the area is about 200 km northwest of Arequipa, the second largest city in the country, at the latitue of about 15°15'S and the longitude of about 73°00'W (Fig. I-1).

1-2 Purposes

The project was intended to evaluate the potential of the area for possible commercial mineral occurrences by comprehending the geology in relation with mineralization and associated alteration.

1-3 Methods and Techniques

The applied methods and techniques are summarized in Table 1-1 and Fig. 1-2 in accordance with the progress of the 1st year's through the 3rd year's project. Fig. 1-3 provides the flows of the decision-makes and the actions taken based on the results of each year's work.

1-4 The Project Areas, the Quantities of the Work and Project Periods

The areas investigated and the quantities of the work are summarized in Table 1-1 and Fig. 1-1 for each year.

The time required for each year's programme is also summarized in Table 1-1.

1-5 Organization of the Survey Team

Organization of negotiating team and field survey team in phase I to III are summarized in Table I-2.

Table I-1 Project Summary

Year	Method	Area	Quantity	Field Work	Laboratory Work	Period
1st year	LANDSAT data analysis	Area covered by LANDSAT data analysis (Lat. 14°30'S - 16°00'S and Long. 72°00'W - 74°00'W)	30,000 km^2	Interpretation of geological structure		From 25th Sept. '85 to 28th Feb. '86
	Geological survey and geochemical exploration	Regional survey area (Lat. 15°00'S - 15°30'S and Long. 72°30'W - 73°30'W)	Area: 5,200 km^2 No. of geochemical samples: 1,309	Exploration density: 0.29 km/km^2 (1,439 km/5,200 km^2) Sampling density: 0.25/km^2 (1,309/5,200 km^2) Geochemical samples: Riverbed deposits	Microscopic observation of rocks and ores X-ray diffraction (powder method) analysis Chemical analysis of rocks (13 components) Chemical analysis of ores (Au, Ag, Cu, Pb and Zn)	
		Detailed survey area: Areas A, B and C	Total area of 3 areas (A, B and C): 800 km^2	Indicator element: Au, Ag, Cu, Pb, Zn and As Exploration density: 0.80 km/km^2 (600 km/800 km^2) Sampling density: 1.02/km^2 (815/800 km^2)		
		Orcopampa Mine and entire surrounding area	No. of geochemical samples: 50	Geochemical samples: Riverbed deposits Indicator element: Au, Ag, Cu, Pb, Zn and As		
			No. of samples for absolute age determination: 5	K - Ar method		
	Geological survey and geochemical exploration	Marcabamba Area	Area: 80 km^2 No. of geochemical samples: 620	Exploration density: 2.1 km/km^2 (164 km/80 km^2) Sampling density: 7.8/km^2 (620/80 km^2) Geochemical samples: Soil samples Indicator element: Au, Ag, Cu, Pb, Zn and As	Microscopic observation of rocks and ores X-ray diffraction (power method analysis)	From 11th Jul. '86 to 10th Feb. '87
2nd year		Pirca Area	Area: 90 km^2 No. of geochemical samples: 1,408	Exploration density: 2.9 km/km^2 (261 km/90km^2) Sampling density: 15.6/km^2 (1,408/90 km^2) Geochemical samples: Soil samples Indicator element: Au, Ag, Cu, Pb, Zn and As	Chemical analysis of rocks (13 components) Chemical analysis of ores (Au, Ag, Cu, Pb and Zn)	
	Drilling operation	Pirca Area	10 holes Total drilling length: 1,000 m	Drilling length 100 m x 10 holes (vertical drilling)		
3rd year	Geological survey (Detailed survey including trench survey)	Colpar Area	Area: 5.0 km^2 Trench survey: Total length 179.5 m	Exploration density: 5.2 km/km^2 (26.1 km/5.0 km^2)	Microscopic observation of rocks and ores X-ray diffraction analysis (powder method) Chemical analysis of ores (Au, Ag and partly Cu, Pb and Zn)	From 26th Jun., '87 to 30th Jan., '88
		Marcamalata Area	Area: 2.0 km^2 Trench survey: Total length 153 m	Exploration density: 8.1 km/km^2 (16.2 km/2.0 km^2)		
	Drilling operation	Colpar Area	3 holes Total drilling length: 750 m	Drilling length 250 m x 3 holes (-45° inclined drilling)		
		Marcamalata Area	2 holes Total drilling length: 400 m	Drilling length 200 m x 2 holes (-45° inclined drilling)		

Table I-2 Organization of Negotiating Team and Field Survey Team in Phase I-III

	Negotiating team						Field survey team					
	Japanese side			Peruvian side			Japanese side			Peruvian side		
1985	Makoto Ishida	leader	Metal Mining Agency of Japan	Juan Zegarra W.	leader	Instituto Geologico Minero y Metalurgico	Hiroshi Miyajima	leader	Sumiko Consultants Co., Ltd.	Cesar Vilca Neira	leader	Instituto Geologico Minero y Metalurgico
	Yoshikazu Taketomi		Ministry of International Trade and Industry; Agency of Natural Resources and Energy	Gregorio Flores N.		ditto	Kiyoharu Nakashima	member	ditto	Hector Zarate Olazagal	member	ditto
	Sumihiro Fure		Metal Mining Agency of Japan; Lima Office	Erick Soriano B.		ditto	Masatsugu Sakai	ditto	ditto	Walter Rodriguez Olaete	ditto	ditto
	Tadaaki Ezawa		Metal Mining Agency of Japan				Seiji Tsuchida	ditto	ditto	Carlos Jimenez Velasco	ditto	ditto
	Takashi Kamiki		ditto				Jiro Natori	ditto	ditto	Emilio Rojas Rivera	ditto	ditto
							Hisaaki Nagao	ditto	ditto			
1986	Makoto Ishida	leader	Metal Mining Agency of Japan	Juan Zegarra Wuest	leader	Instituto Geologico Minero y Metalurgico	Kiyoharu Nakashima	leader	Sumiko Consultants Co., Ltd.	Cesar Vilca Neira	leader	Instituto Geologico Minero y Metalurgico
	Sumihiro Fure		ditto (Lima Office)	Gregorio Flores Ñañes		ditto	Masayoshi Matsugi	member	ditto	Hector Zarate Olàzagal	member	ditto
	Takashi Kamiki		ditto	Cesar Vilca Neira		ditto	Jiro Natori	ditto	ditto	Emillio Rojas Rivera	ditto	ditto
				Walter Rodriquez Olarte		ditto	Akihiko Murase	ditto	ditto	Daniel Carpio T. and others	contractor	Geotec S.A.
				Emilio Rojas Rivera		ditto						
1987	Kazunori Kano	leader	Metal Mining Agency of Japan	Juan Zegarra Wuest	leader	Instituto Geologico Minero y Metalurgico	Kiyoharu Nakashima	leader	Sumiko Consultants Co., Ltd.	Cesar Vilca Neira	leader	Instituto Geologico Minero y Metalurgico
	Kenzo Hagio		ditto (Lima Office)	Gregorio Flores Ñañes		ditto	Atsumu Nonami	member	ditto	Hector Zarate Olazagal	member	ditto
	Yozo BABA		ditto	Cesar Vilca Neira		ditto	Akihiko Murase	ditto	ditto	Walter Rodriquez Olarte	ditto	ditto
	Naotaka Adachi		ditto	Hector Zarate Olazagal		ditto				Pedro Samame I. and others	contractor	Geotec S.A.

Fig. I-2 Flow Chart of Survey in Cotahuasi Area

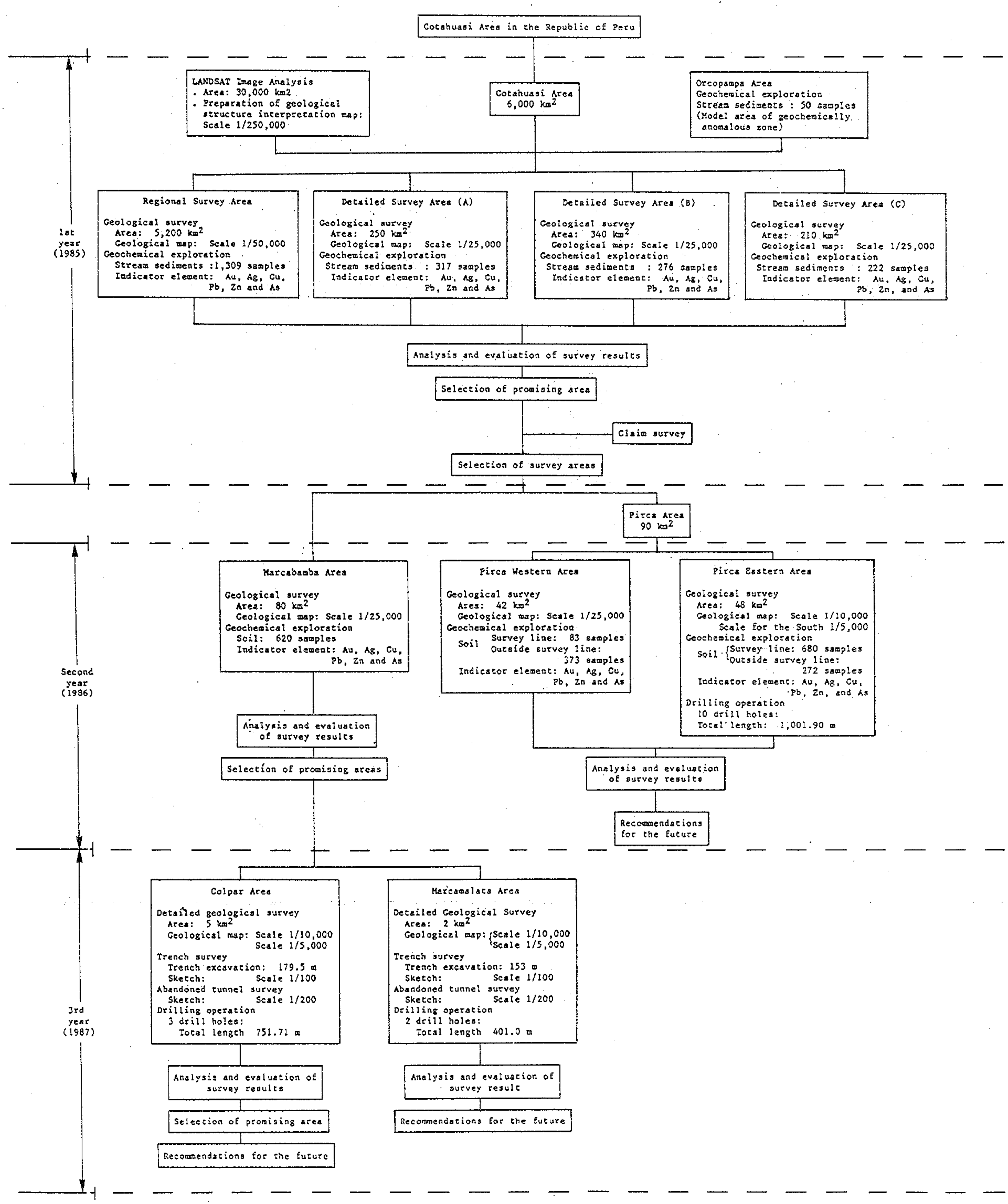
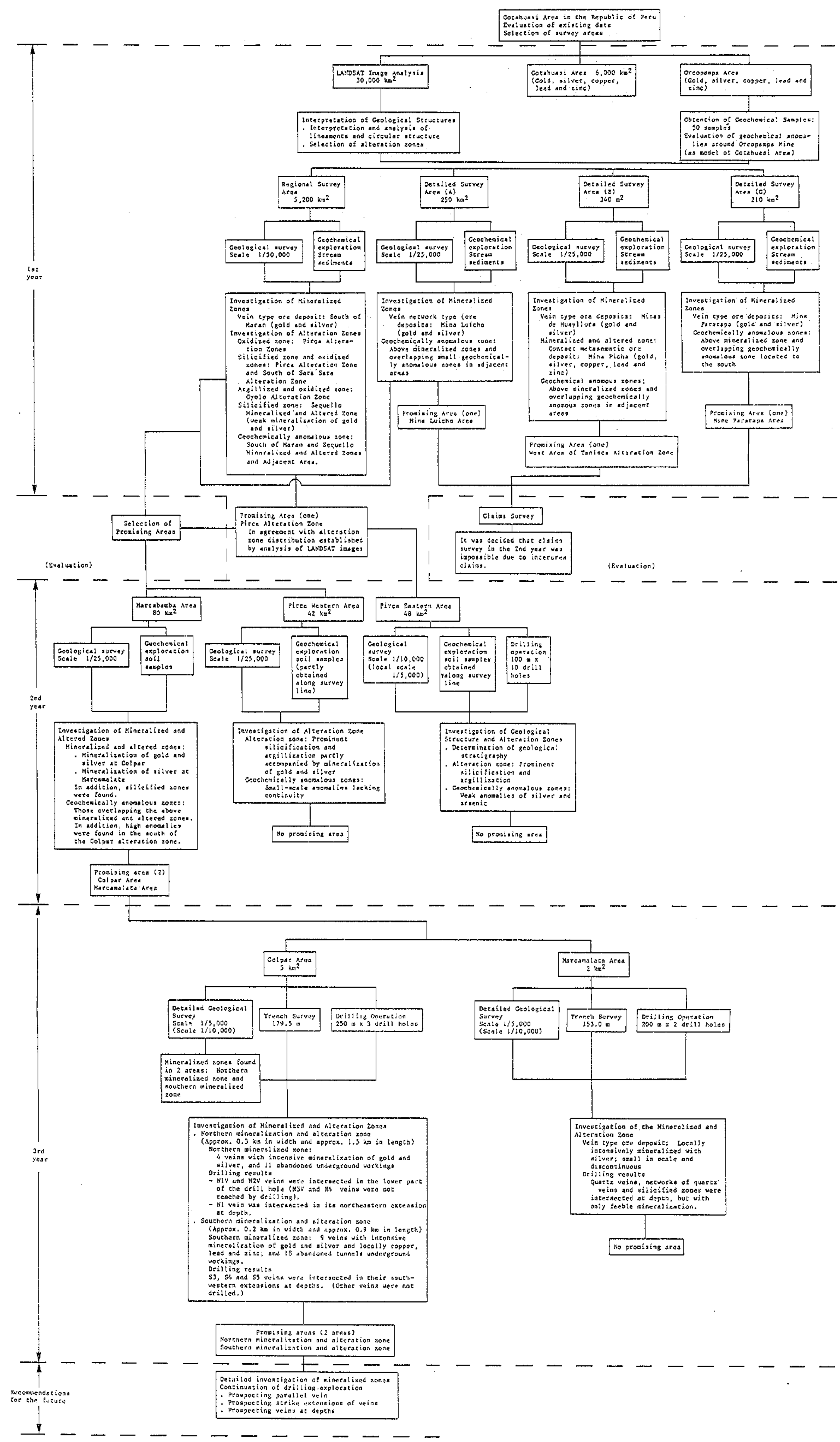


Fig. I-3 Flow Chart of Selection of Promising Ore Deposit Areas



CHAPTER 2 PREVIOUS WORK

2-1 Report of Previous Work

The reports of the previous work are listed in the appendices of this report.

Fornari, M and Vilca, C.N. (1977) describe the general geology of the Ayacucho-Arequipa region in their report on argentiferous mineral occurrences in the southern Peru.

Metallogenic maps covering the whole area of Peru have been prepared by Bellido, D. et al (1972) and published by the Minister of Energy and Mines of the Republic of Peru.

Local geology is described by Victor, P.G. for Pausa and Caraveli (1983) and by Carlos G.R. and David, D.M. for Coracora Pacapausa (1983).

Results of geochemical investigation of the Andes zone, southern Peru, are available in papers collected by Onuma, N. (1985).

The following explanation of the regional geology and the mineralization are summarized from the reports of the previous work above mentioned.

2-2 Regional Geology and Mineralization of the Ayacucho-Arequipa Region

(1) Geology

The region occupies a large of the southern Peru include the Cotahuasi area, the area for the 3 year programme, outlined by the latitudes of 14°00' and 16°30'S and the longitudes of 71°30' and 74°30'S (Fig. I-4).

The west Andes Range in this region forms a great plateau about 150 km wide with an average elevation of about 4,000 m. The platau is mildly relieved with occasional high peaks, the highest of which reaches 6,426 m above sea level.

The Andes Range, since the cessation of uplifting, have been subject to retrogressive erosion having initiated from the west coast facing the Pacific Ocean. However, most of the area have not been deeply disected as yet except the Cotahuasi area where many deep valleys with about 2,000 m elevation differences are well developed.

Signs of glaciation are observed at a number places on the pleau and thick morrains or glacial soils and cirques are well developed. The rocks distributed in this area comprise metamorphics of Precambrian era and sedimentaries and volcanics of Palacozoic, Cesozoic and Cenozoic eras.

The Precambrian metamorphics are distributed along the Oceanic coasts or along a few rivers at their bottoms, and consist mainly of gneisses or gneissic granites.

The Palaeozoic sedimentary rocks unconformably overly the Precambrian basement. This area emerged above sea level towards the end of the Carboniferous and, supplied clastics to surrounding sedimentary basins in the Permian.

These Permian sedimentary basins become sites for volcanisms and were deposited thick volcanic piles interbedded with marine sediments in Triassic age.

The area started emerging again in the Cretaceous. The tectonic of Cretaceous is characterized by an extensive Orogensis which formed the west Andes Range of the NW-SE trending folding mountains at the end of the Cretaceous. Granodioritic batholiths along the Oceanic coast intruded mostly during Cretaceous age.

Red beds, terrestrial clastic sediments, deposited in the late Cretaceous and the early Tertiary.

Oligocene to miocene volcanics and pyroclastics unconformably overly older rocks. At the base of the volcanics and pyroclastics, there are developed volcanic breccias containing agglomerates and tuffs.

The upper section consists mainly of andesitic volcanics with subordinate rhyolites and is co-related to the Tacaza formation.

The Tacaza formation changes its lithology laterally in the area of argentiferous mineral deposits. The western part, the Pugio zone, is dominated by pyroclastics and sediments interbedded with layers or lenses of shales, gypsum and carbonates. These lithological features indicate lagoonal natures of the sedimentary basins. These characteristic sediments is absent in the eastern part or developed only to a limited extent.

The Oligocene-Miocene pyroclastic are gently folded forming anticlines and synclines with bedding planes dipping upto 60 degrees.

Though individual tectonic elements are variable in their direction, the major folding belts trend in the NW-SE direction parallel to the Andean mountains. The trend may be a remnant of the major tectonic element of the late Cretaceous.

Ignimbrites of the Pliocene to Quarternary is widely distributed covering eroded surfaces.

The tuffs are not influenced by the folding structures observed in the Tacaza formation.

In addition, there are andesitic lavas, the activity for which initiated in early pliocene and have continued to the present time.

A number of strato volcanics in the southern Peru formed mostly in the Pleistocene. Andesitic lavas extruded from these volcans are extensively distributed to form lava plateous or fill valley bottoms.

(2) Mineralization

Known mineral occurrences in the Ayacucho-Arequipa region are shown in Fig. 1-4. Table I-3 presents particulars of major occurrences of these.

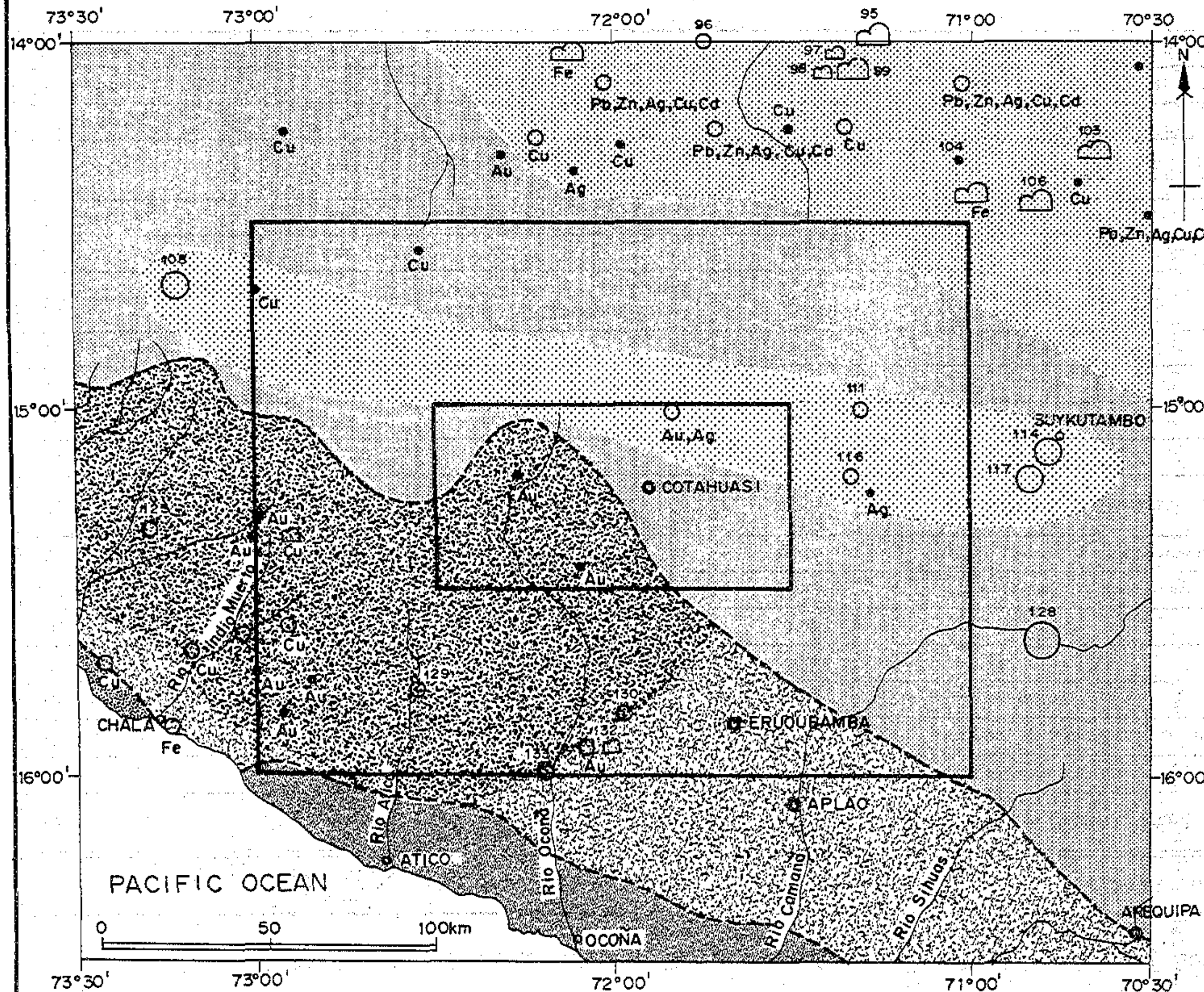
The matellogenic map of Peru divides the region into 4 metallogenic sub provinces, namely the highland polymetalic, the Oceanic Copper, the Oceanic Iron, and the Precambrian Metamorphic. The highland polimetalic sub province comprises the Andahuoylos-Yauri and the Puqino-Caylloma blocks. The northwestern part of the Oceanic Copper sub-province is named of the Nazca-Ocona block.

The Andahuaylos-Yauri subprovince, being located in the northeast of the region, is mainly distributed by Iron-Copper mineral occurrences of a pyrometasomatic type. The Puquio-Cailloma subprovince occupies the central part of the region including the Cotahuasi project area and is distributed by hydrothermal or pneumatritic Au and/or Ag mineral occurrences. Hydrothermal or pneumatlitic Cu and Au mineral occurrences are known in the Nazca-Oconia block occupying the south-western part.

All of the mineralization is believed to have been formed in the periods of late Cretaceous or Tertiary age.

The Cotahuasi project area, being located in the central part of the region, occupies parts of the Puquio-Caylloma subprovince in the northeast and of the Nazca-Ocona block in the southwest.

The Colpar which have been selected for a potential area for Au-Ag mineralization, belongs to the Nazca-Ocona Cu or Ag metallogenic area in the Oceanic Copper subprovince.



METALOGENIC PROVINCE

- Coastal Ferruginous Areas
- Pacific Cupriferous Sub-Province
  - Nazca - Ocoña Area
- Highland Polymetalic Sub-Province
  - Mineralization in Voicanic Rocks
    - Puquio - Caillomo Area
  - Mineralization in Sedimentary Rocks
    - Andahuaylas - Yauri Area
- Mineralization in Precambrian Metamorfics

TYPES OF MINERAL DEPOSITS

- Veins or Seams
- Mantles or Stratiform Bodies
- Irregular Bodies

DIMENSIONES

- Occurres Prospects
- Small Deposits
- Medium Deposits
- Big Deposits

PRINCIPAL MINES IN AYACUCHO - AREQUIPA REGION

95	Chalcobamba	Cu	Cont.
96	Yuringa	Cu	Hyd.
97	Charcas	Cu	Cont.
98	Sulfobamba	Cu	Cont.
99	Ferrobamba	Cu	Cont.
103	Livitaca	Fe	Cont.
104	Colquemarca	Au	Alluv.
106	Katanga	Cu	Hyd.
108	San Juan de Lucanas	Au, Ag, Pb, Zn	Hyd.
111	Arcata	Au, Ag	Hyd.
114	Suykutambo	Au, Ag	Hyd.
116	Orcopampa	Ag, Pb, Zn	Hyd.
117	Caillomo	Au, Ag, Cu, Pb	Hyd.
123	San Luis	Au	Hyd.
124	La Capitana	Au	Hyd.
128	Madrigal	Cu	Hyd.
129	Calpa	Au	Hyd.
130	Alpacay	Au	Hyd.
132	Andaray	Cu	Cont.
133	Posco	Au, Ag, Cu	Hyd.

Cont. : Contact Metasomatic Deposits
Hyd. : Hydrothermal or Pneumatolytic Deposits
Alluv. : Alluvial Deposits

- Cotahuasi Area
- Reconnaissance Mapping Area Using LANDSAT Images
- Ayacucho-Arequipa District

Fig. I-4
METALOGENIC MAP OF AYACUCHO-AREQUIPA REGION SOUTHEASTERN PERU

Table I −3 Principal Mineral Deposits of Ayacucho−Arequipa District Southeastern Peru

	PRINCIPAL MINERAL DEPOSITS	MINERAL ASSOCIATIONS	METALLOGENIC PROVINCES	METALLOGENIC EPOCH	TYPE OF MINERAL DEPOSITS	DIMENSIONES
95	Chalcobamba	Cu	HIGHLAND POLYMETALIC SUB−PROVINCE Andahualas−Yauri Area	Upper Cretaceous−Tertiary	Contact metasamatic, Irregular	Medium
96	Yuringa	Cu	ditto	ditto	Hydrothermal or Pneumatolytic, Vein or Seam	Small
97	Charcas	Cu	ditto	ditto	Contact metasamatic, Irregular	Small
98	Sulfobamba	Cu	ditto	ditto	ditto	Small
99	Ferrobamba	Cu	ditto	ditto	ditto	Medium
103	Livitaca	Fe	ditto	ditto	ditto	
104	Colquemarca	Au	ditto	ditto	Hydrothermal or Pneumatolytic, Mantle or Stratiform	Occurrences or Prospects
106	Katange	Cu	ditto	ditto	Hydrothermal or Pneumatolytic, Irregular	Medium
108	San Juan de Lucanas	Au, Ag, Pb, Zn	HIGHLAND POLYMETALIC SUB−PROVINCE Puquio−Caylloma Area	ditto	Hydrothermal or Pneumatolytic, Vein or Seam	Medium
111	Arcata	Au, Ag	ditto	ditto	ditto	Small
114	Suykutambo	Ag, Pb, Zn	ditto	ditto	ditto	Medium
116	Orcopampa	Au, Ag, Cu, Pb	ditto	ditto	ditto	Small
117	Cailloma	Au	ditto	ditto	ditto	Medium
123	San Luis	Au	PACIFIC CUPRIFEROUS SUB−PROVINCE Nazca−Ocona Area	ditto	ditto	Small
124	La Capitana	Cu	ditto	ditto	ditto	Small
128	Madrigal	Au	HIGHLAND POLYMETALIC SUB−PROVINCE	ditto	ditto	Big
129	Calpa	Au	PACIFIC CUPRIFEROUS SUB−PROVINCE Nazca−Ocona Area	ditto	ditto	Small
130	Alpacay		ditto	ditto	ditto	Small
132	Andaray	Cu	ditto	ditto	Contact metasamatic, Irregular	Small
133	Pasco	Au, Ag, Cu	ditto	ditto	Hydrothermal or Pneumatolytic, Vein or Seam	Small

CHAPTER 3 GENERAL GEOLOGY OF THE COTAHUASI AREA

3-1 Geology

The Precambrian basement complex comprises mainly gneiss and diorite and is located in the southern part of the area for the field work of the project. (The name Cotahuasi specifies the area for the field work)

The Jurassic system, unconformably overlying the Precambrian basement, consists of green or brown andesitic volcanics in the lower part with a development of foliated structures at its bottom and of grey - black limestone, dark - greenish grey shales and thick sandstones in the middle and the upper parts.

The Cretaceous system is composed of light grey - grey thick silicious sandstone in the lower part and of shales with subordinate sandstones and grey - dark grey limestones containing fossils.

Intensive faulting and folding structures are extensively developed in the Jurassic and the Cretaceous systems which are unconformably overlain by the tertiary system.

The lower part of the Tertiary system consists of sedimentary rocks mainly of sandstones and conglomerates and is overlain by andesitic or dacitic volcanics with highly variable facies, which are in turn overlain by rhyolitic pyroclastics.

Folding structures are locally developed in the sedimentary and andesitic volcanic rocks of the lower part.

The Quarternary system includes volcanoes such as Nevado Solimana, which exceed 5,000 m in elevations, and is composed of andesitic volconics of the lower most formation widely distributing over the Archiplano plateau, and of overlying glacial deposits with local development of andesites and basalts. Alluvials are developed along rivers, on gentle slopes or in basins such as the Archiplano basin, and consists generally of taffaceous materials.

Major intrusives are Cretaceous granitic batholiths or stocks belonging to the Coast batholith, and dioritic and andesitic stocks or dikes of Tertiary age.

The arrangement of the Cretaceous intrusive bodies generally trends WNW-ESE, parallel to the trend of the Coast batholith.

The arrangement of the Tertiary intrusive bodies are not well defined due to the Quarternary covers but there appear to be two directions NE-SW and NW-SE.

The rocks of the early Miocene or earlier (the Tacaza formation or lower) have been subject to folding and faulting which have formed a number of geological blocks.

No major folding or faulting is developed in the rocks of the late Miocene or later (the Alpabamba formation or upper)

Axes of anticlines and synclines run generally in the direction of NW-SE or WNW-ESE.

NW-SE trending faults are predominated in this area with subordinate occurrences of E-W, NE-SW or N-S trending faults.

3-2 Alteration and Mineralization

Alteration and mineralization are not well developed in the area distributed mainly by sedimentary rocks of Cretaceous age due to development of limestones and siliceous sandstones.

Alteration zones of sizable scales associated with reddish brown stains are often observed in the area distributed by volcanic rocks of Miocene age or earlier.

Alteration zones are located at Oyolo and Mina Lucho of the Area A, at Tanisca and Mina Picha of the Area B, and at Mina Pararapa of the Area C in the area for the detailed work of Phase I, as well as at Sara Sara, Pirca and Maran in the area for the regional work.

Of these alteration zone, the Tanisca zone is the most extensive continuing in the direction of N-S for approximately 10 km with widths ranging from 1 to 3 km. The alteration is argillization in the andesitic volcanics of the Tacaza formation, associated with weak silicification in part.

Oxide clay veins and quartz veins occur in the underlying silicious sandstones of the Yura formation and have been once meagrely prospected.

The Mina Pararapa alteration zone is formed along a NNW-SSE trending porphyritic andesite dike and in the surrounding andesitic volcanics of the Tacaza formation and shows brown colour and outcrops due to iron oxide stains.

A quartz vein with some Au-Ag values is located in association with alteration zone, and strikes N20°E dipping 80°NE.

The vein had been explored in underground until a recent year. Au values, variable from place to place, are averaged at 4.61 g/t for approximately 200 m along the strike, though occasionally as high as 40 g/t according to data at the Mine (Mina Pararapa).

The vein can be traced for approximately 1.3 km with variable widths ranging from 0.5 to 1.5 m. There are god potential for parallel veins nearby.

The alteration zone is approximately 1 km wide and 2.5 km long.

The Mina Luicho and the Maran alteration zones are also associated with Au-Ag mineralization but smaller in dimensions than those above described.

The Mina Picha alteration zone is located at the contact between limestones of the Cretaceous Arcurquia formation and a diorite stock, and contains skarn minerals in association massive Cu·Pb·Zn ores.

The mineralization is apparently of pyrometasomatic origin.

Other alteration zones than above described, showing brown colour due to oxide iron stains, are associated with only poor mineralization.

Major alteration zones identified by the landsat imagery analysis are located to the southeast of Nevado Cororupa, nearby Nasama and to the Northeast of Nevado Firura and appear to consist of white clay alteration.

CHAPTER 4 GENERAL REMARKS OF THE COTAHUASI AREA

4-1 Introductory Notes to the Republic of Peru.

The Republic of Peru is situated in the Pacific Ocean Side of the South American Continent and occupies an area of 1,285,215 km^2 extending from the Equator to the latitude 18°20'S.

The total population is estimated at approximately 19.2 millions (1984), of which natives (Indios) account for 47%, mestizos (mixed bloods between natives and white) for 40% and whites for 12%. The Country, together with Bolivia, is highly populated with the natives among the South American countries.

The capital of the Country is Lima

The official language is Spanish which is widely used all over the country. However, Quechua is also popular among the natives and Aimava is locally used in the part near the boarder to Bolivia.

The Country's gross national product amounted to approximately 18 billion dollars in U.S. (1984) or 789$ per capita.

The domestic production of primary energy totals 11,080,000 tons in crude oil equivalent, and exceeds the domestic consumption of 7,660,000 tons.

The Country, being abundant in mineral resources was ranked at the 2nd place in the world for the silver production (1,739 tons), at the 4th for the zinc (580,000 tons), at the 5th for the lead (210,000 tons), and at the 8th for the copper, according to the 1983 records. Petroleum and natural gas are also plentiful in the country.

According to the 1983 statistics, the Country's exports and imports amounted to 3,015 million and 2,680 million dollars in U.S. respectively, and the trade ballance was surplus by 327 million dollars in U.S.

The Nation's official external debt amounted to 11,484 million dollars in U.S.

The country exported zinc, silver and copper ores totalling US$330 millions to Japan, and in turn imported automobiles, steels, machinery and other processed materials totalling US$140 millions in 1985. This resulted in the Pere's trade surplus by US$190 millions.

Galloping inflation brought about a serious economic dislocation in Peru before 1984. After coming to power, the present Peruvian regime has implemented a series of measures aimed at the stabilization of the national economy, such as the fixing of the exchange rate of Soles against the US dollar and price control. The present bank exchange rate of Soles against the US dollar stands at 17,300 Soles to US$1.00 and the official rate at 14,000 Soles to US$1.00. The Peruvian Government has announced its intention to freeze the exchange rates and oil price until the end of the first six-month period of 1986.

4-2 Access to the Project Area

The survey areas are located in the southern part of the Republic of Peru.

The principal communities in the survey area which are served by a road passable in vehicles are Cotahuasi and Pausa, both located almost in the center of the area. The access road to the two communities starts in Arequipa, Peru's second largest city, but there is no roadway connecting the communities directly (Fig. I-5).

Cotahuasi can be reached by following the National Highway 1 from Arequipa to Tambillo and then taking Departmental Road 103 running northwestward and passing Pta Colorado, Aplao and Chuquibamba. The distance between Arequipa and Cotahuasi is about 410 km and can be covered in eight to ten hours by car. That section of the access road running from Arequipa to Pta Colorado (nearly 180 km) is paved, but the remaining section (about 230 km) leading to Cotahuasi is a gravel road.

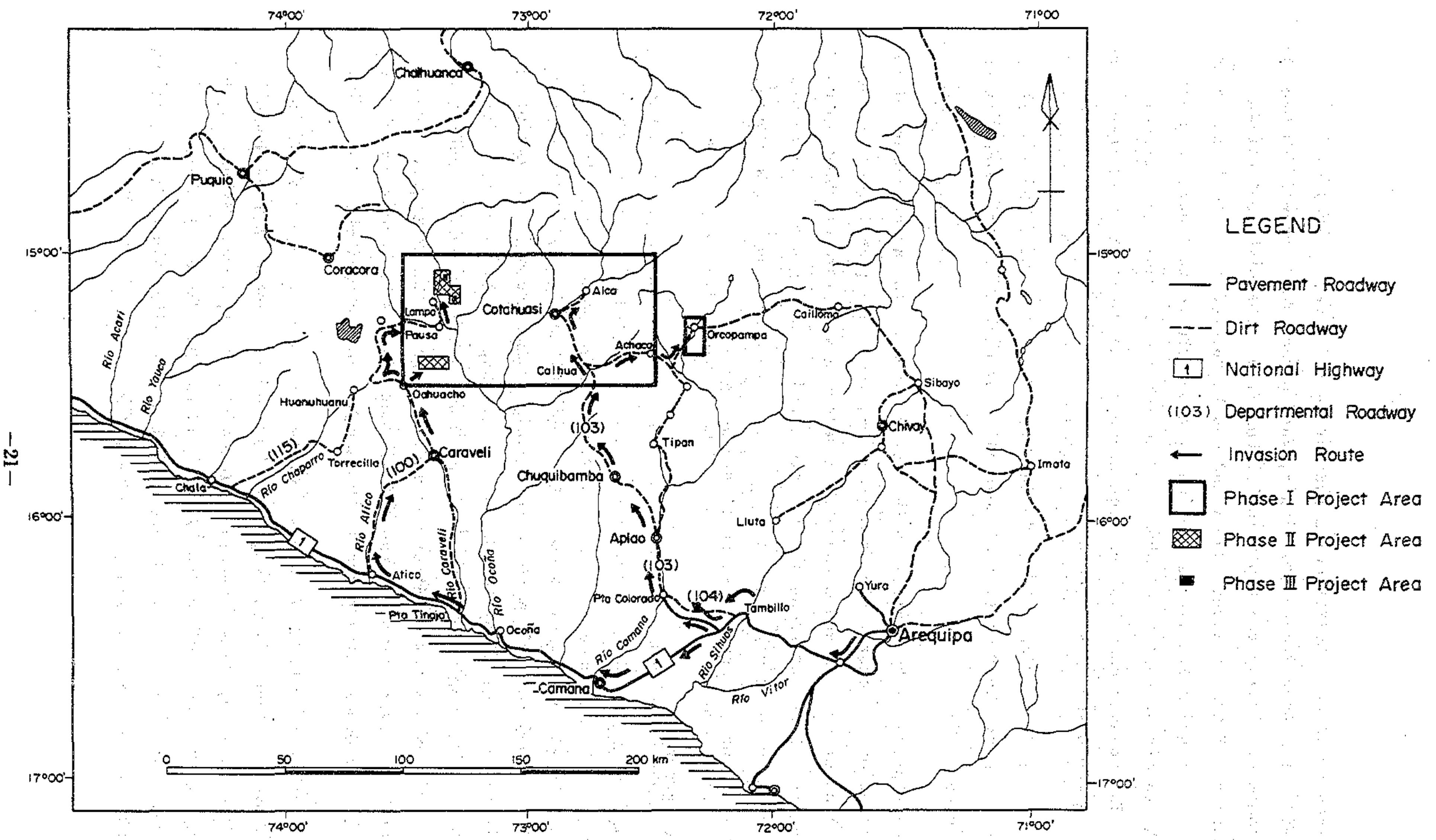


Fig. I－5 Accessibility Map to the Project Area

Pausa can be reached by following the national Highway 1 along the coastline from Arequipa to Pta Tinaja, then proceeding northward to Craveli and from there taking the Departmental Road 100. The distance between Arequipa and Pausa is about 490 km and can be covered in 10 to 12 hours by car. The Arequipa-Pta Tinaja section of about 280 km in length is paved and the remaining section of about 210 km leading to Pausa is a gravel road. The roadway condition between Arequipa and Pausa is worse than those of the Arequipa-Cotahuasi route.

Pausa can also be reached by following the National Highway 100 from Atica and then taking the Departmental Road 115 from Chala, but this route takes much longer time.

The roads passable by vehicle in the survey area, with the exception of the above-mentioned access roads from Arequipa, include a gravel road of about 20 km connecting Alca and Cotahuasi, a second gravel road of about 15 km running from Pausa to Lampa along a river and another gravel road running about 8 km to the south. There are no other roadways and horses provide the only means of transportation of men and goods.

4-3 Geography

(1) Topography

The survey area is located in the southwest of the Altiplano, a plateau 4,000 to 5,000 m above sea level, in the Andes. The Altiplano is deeply incised by two Grand Cannyon-shaped valleys of relative height ranging from 1,000 to 2,500 m which are believed to have been formed by dissection after the middle stage of the Tertiary. These are the rivers of Rio Maran and Rio Cotahuasi which meet together into the Rio Ocona which pours in the south into the Pacific.

Rising above the Altiplano are Quaternary volcanos 5,500 to 6,300 m above sea level which range from WNW to ESE. These include Nevado Sara Sara (5,505 m), Nevado Solimana (6,093 m), Nevado Firura (5,498 m) and Nevado Coropuna (6,377 m). In the ESE direction other Quatenary volcanos of comparable height including Nevado Anpato (6,288 m), stretch into outside the survey area.

The Altiplano generally consists of gently sloping hills and stretches of flatland among them. Marshlands or extensive grasslands called "pampa" and marshes or lagoons called "laguna" are formed in the basins.

The valleys shaped like the Grand Cannyon are mostly sloped at a greater angle than 40° and they often form precipitous (sloped at 60° to 70°) or nearly perpendicular cliffs. There are intermittent stretches of alluvial flatland of limited area along major rivers. The breast of the steep slopes are dotted with gently sloping flatlands of limited area.

(2) Climate and Vegetation

The region extending from the southwestern end of the survey area to the Pacific Coast belongs to the arid zone of the South American Pacific Coasts which is characterized by the desert type climate which permits of almost no vegetation. On the other hand, the Altiplano district including the survey area belongs to the semiarid climate and is generally called a zone of grass-covered cold highlands and basins.

In the survey area, the difference between the lowest and highest elevation is approximately 5,200 m, the lowest being the vicinity (1,150 m) of the southern bed of Rio Cotahuasi and Rio Maran and the highest being Nevado Coropuna (6,377 m). As a result, the climate and vegetation of the survey area vary widely with elevation.

In the areas along the Rio Cotahuasi and Rio Maran which are at a lower elevation than 2,300 m, the temperature is higher and papayas, bananas, grapes, pacays and other fruits are raised and a variety of trees and plants grow.

The areas lying between 2,300 and 3,500 m in height have a mild semiarid climate and maize, wheat, other cereals and broad beans are raised there, but fruits are almost non-existent. In the hill district several species of cactus and shrubs grow rather densely. Most of the communities, including Cotahuasi and Pausa where a base camp was set up, are concentrated in this mild semiarid climate zone.

The climate of the mountain district ranging in elevation between approximately 3,500 m and 5,000 m is a cool to cold semiarid climate. The midslopes of the mountains of up to about 4,000 m in height are dotted with a growth of several species of cactus and shrubs, but in the Altiplano district ranging in elevation from 4,000 to 5,000 m the growth of cactus and shrubs is very limited and a greater part of this district forms a desert except a wide variety of moss growing in the pampas and scatterings of low shrubs.

The mountains of 5,000 m or greater height are crowned with perpetual snow and in this mountain district the weather is extremely cold and no vegetation is found.

In the Altiplano district, rainfall is generally small and the dry season lasts from April to September and the wet season from October to March. In the survey area, the wet season sets in earlier in its eastern part and rainfall starts in October, but in the western part the wet season tends to begin half a month to a month later. During the wet season, snow falls in the mountains of 4,000 m or more in height and rain falls in the lower mountains.

CHAPTER 5 CONCLUSION AND RECOMMENDATION

5-1 Conclusion

The exclusive conclusions of the 3 year-project are summarized as follows.

(1) The basement of the project area consists of gneissic granites or diorites of Precambrian age.

The Jurassic and Cretaceous systems, mainly consisting of sedimentary rocks, unconformably overlies the Precambrian basement and ore unconformably underlain by volcanic rocks of the Tertiary and the Quarternary systems. Intrusions comprises granitic batholiths or stocks of Cretaceous age and andesitic and dioritic stocks or dikes of Tertiary age.

(2) Folding and NW-SE or NE-SW trending fault structures are well developed in the Jurassic and the Cretaceous systems as a result of the Andean Orogeny.

NW-SE or NE-SW trending faults are also observed in the Miocene volcanics, particulary the Tacaza formation (Tc).

These structural features are well expressed in the landsat imagery.

(3) Mineralization and alteration occur mainly in the Tacaza formation of Miocene age or lower formations.

Most of the known deposits in the project area are of Au-Ag vein type and consist of quartz veins, quartz vein networks, or silicified or oxidized fractures.

A pyrometasomatic deposit of a small scale has been located at the contact between a diorite stock and limestones of the Cretaceous Arcurquina formation.

(4) Alteration (silicification and argillization) zones of sizable seales were outlined in the Pirca area in the course of the 1st year's field work.

However, the 2nd year's geochemical investigation indicated that geochemical anomalies associated with the alteration zones were limited in their extensions and low in values of elements of interest.

The results of the 10 holes of drilling in the eastern Pirca area intersected intensive alteration zones but with only minor mineralization.

(5) Alteration and mineralization zones were outlined in the Tacaza formation (Tc) of Miocene age and in the Hualhuani (Yu) and the Murco (Mu) foramation of the Cretaceous age in the Marcabamba area.

Of a number of the alteration (silicification and argillization) and mineralization zones outlined in the course of the 2nd year's investigation, the Colpar and the Marcamalata alteration zones were associated with promising geochemical anomalies.

The 2nd year's work resulted in selection of two target areas, the Colpar (5 km^2) and the Marcamalata (2 km^2), including these alteration zones, for the 3rd year's programme.

(6) A number of abandoned old workings, which had been unknown, were located in the Colpar in the course of the 3rd year's work.

Two mineralized zones, the northern and the southern mineralized zones, were outline in the Miocene Tacaza formation (Tc) by the detailed prospecting with aids of trending.

These mineralized zones include mineralized veins, 4 major veins in the northern zone and 9 in the southern zone, in association with surrounding silicification and minor parallel veins.

All the vein except for two in the southern zone trend in the general direction of NE-SW, and comprise quartz veins, quartz vein network and silicified fracture zones.

Major ore minerals are electrum, argentite, polybasite, pearceite, galena, sphalerite and pyrite in association with alteration minerals of quartz, potash feldspar and sericite with or without chlorite.

(7) The N3 vein of the northern vein yielded a surface sample of the best assay results, 5,79 g/t Au and 640 g/t Ag for an 1 m width.

The drill holes, MJP11 and 12, interseated the N1 and N2 veins but were too short to reach the N3 and N4 veins. The mineralized intersections yielded appreciable values in Au and Ag, which would suggest the mineralized zone to be continuous for a substantial distances.

The northern silicified zone, located to the northeast of the northern mineralized zone, may continue to the northern mineralized zone. If the assumption is true, the incorporated alteration mineralization zone would form a sizeable area approximately 0.3 km wide and 1.5 km long.

(8) In the southern mineralized zone, the S3 and the S7 veins yielded surface samples of high assay values, 21.50 g/t Au and 410 g/t Ag for, a 0.15 m width and 20.10 g/t Au and 1,200 g/t Ag for a 0.3 m width respectively.

The drill hole, MJP-13, intersected the S3, the S4 and S5 veins and the quartz vein network of the S4 vein indicated assay values of 5.04 g/t Au, 45.0 g/t Ag, 0.79 % Cu, 1.37 % Pb and 1.30 % Zn. The mineralization contains appreciable values of Cu, Pb and Zn in addition to Au and Ag, and is considered to be promising.

The southern mineralized zone may continue to the Quebrad Quermahuaico alteration zone. If the assumption is true, the incorporated alteration mineralization zone would form a sizable area approximately 0.2 km wide and 0.9 km long.

(9) The mineralization-alteration in the Marcamalata occurs in the Cretaceous Hualhuani (Yu) and Murco (Mu) formation and is associated with a minor amount of Ag.

All the observed veins are limited in extentions and discontinuous.

The two holes, having been drilled beneath the surface mineralized veins, intersected a number of quartz veins and quartz vein networks but without mineralization of any values.

(10) In conclusion, the two mineralization-alteration zones, the northern (0.3 km wide and 1.5 km long) and the Southern (0.2 km wide and 0.9 km long), seem to be promising judging from the exclusive results of the 3 year work, and would be worthwhile for further exploration.

5-2 Recommendation

The fiscal year 1987, closing at the end of March, 1988, is the last year of the 3 year technical co-operation project in the Cotahuasi area by Japanese Government.

However, the 3 year work for the project have outlined two promising targets for potentially commercial mineralization in the Colpar, the northern mineralization-alteration zone (0.3 km wide and 1.5 km long), and the southern mineralization-alteration zones (0.2 km wide and 0.9 km long).

It would be recommended that these two zones in the Colpar be followed up by further detailed exploration including diamond core drilling.

Methods and purposes of the recommended work are summarized in the table below.

Method	Purposes
Detailed Prospecting	To clarify occurrences, extents, and grades of the mineralization on the surface by investigating further in detail mineralized outcrops and abandoned old workings of the mineralization-alteration zones.
Drilling	To define extents and grades of veins in strike sides and dip sides, and also to explore other veins parallel to the known ones.

PART II DETAILED REPORT

PART II DETAILED REPORT

CHAPTER 1 LANDSAT IMAGERY ANALYSIS

1-1 The Area for the Landsat Imagery Analysis

An area of 30,000 km^2 was selected for the Landsat Imagery Analysis, including the Cotahuasi Area. (Fig. I-1)

1-2 Result of the Analysis

The Landsat Imageries covering the above area were interpreted with an emphasis placed on comprehending regional features of the geological structure.

The results of the analysis are shown in the Interpretation map of the Landsat Imagery. (Fig. II-1)

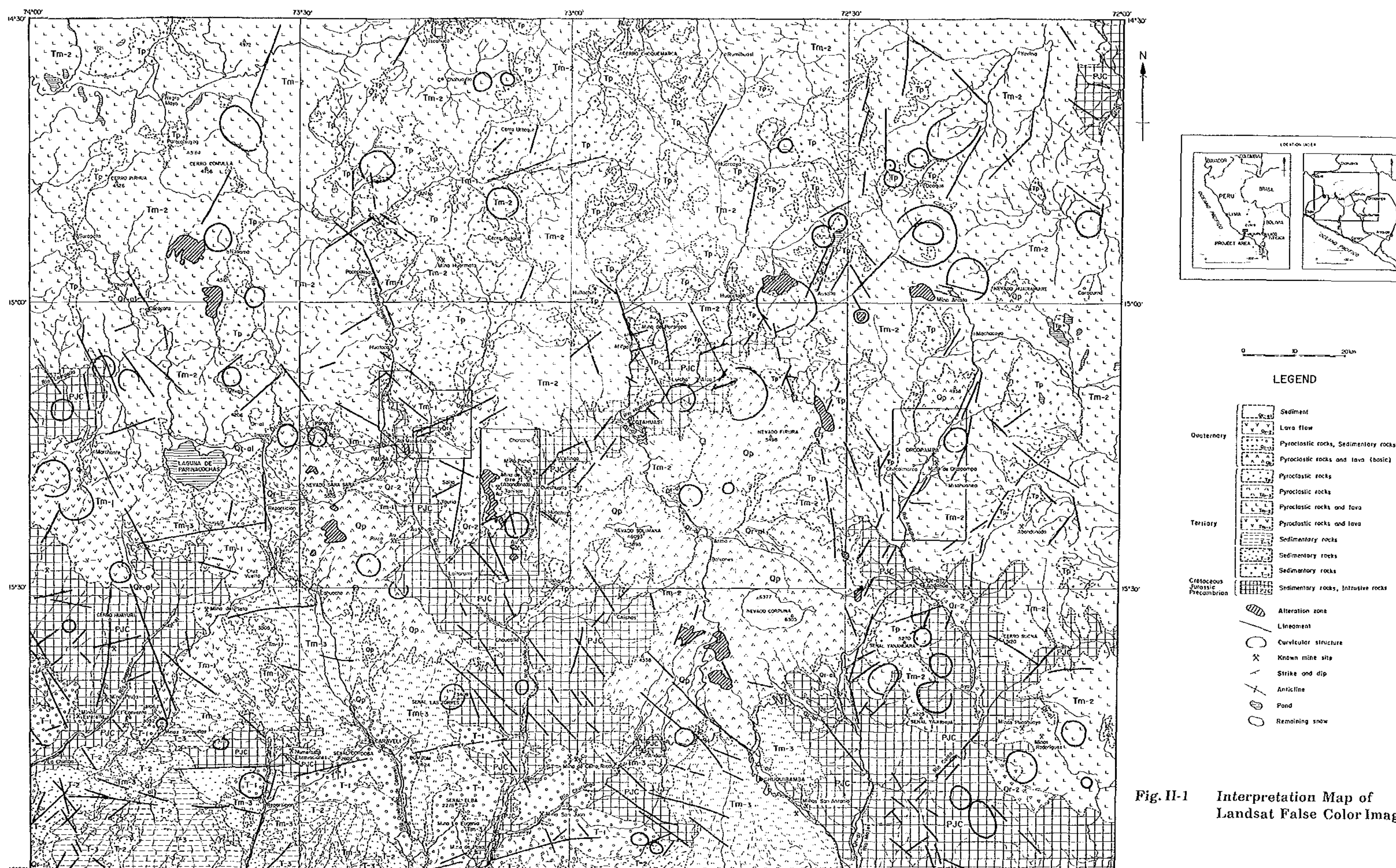


Fig. II-1 *Interpretation Map of Landsat False Color Images*

CHAPTER 2 GEOLOGICAL INVESTIGATION IN THE COTAHUASI AREA

2-1 Geology and Geological Structure (Fig. II-2)

The geology of the project area consists of Precambrian basement comprising gneissic granite osic and diorite, the thick Jurassic and Cretaceous systems composed of clastic and calcareous rocks, and widespread Tertiary and Quaternary systems composed mainly of volcanic rocks and intrusive rocks.

Intrusive rocks occur as batholiths of diorite and numerous stocks and dikes of diorite and andesite. These are partly accompanied by skarns and alteration zones.

The formations of Miocene or earlier are heavily folded in general and block faulted. However, neither prominent nor fault is observed in the formations later than Miocene.

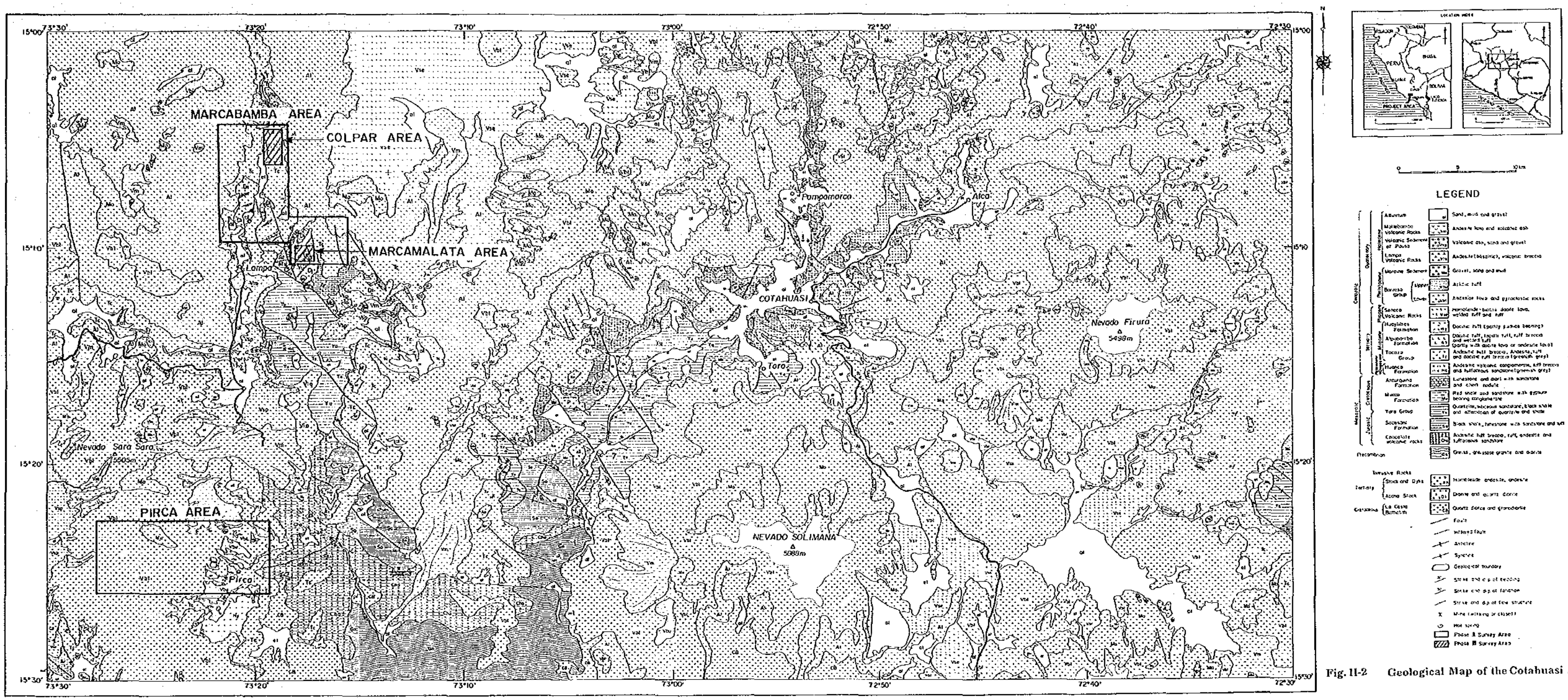
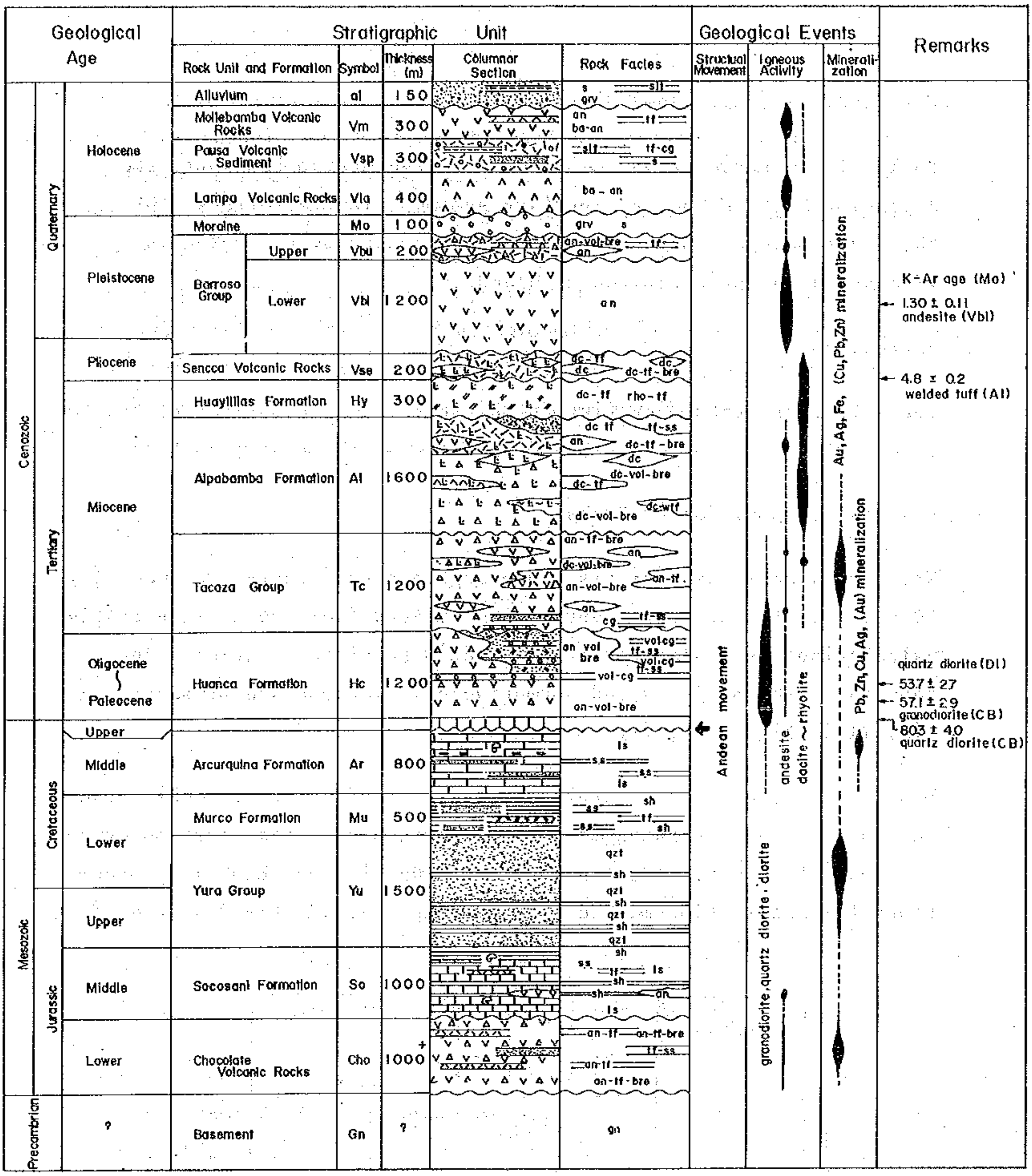


Fig. II-2 Geological Map of the Cotahuasi Area



Abbreviations

gn	gneiss, gneissose diorite	qzt	quartzite	ba-an	basaltic andesite lava
an-tf-bre	andesitic tuff breccia	vol-cg	volcanic conglomerate	tf-cg	tuffaceous conglomerate
an-tf	andesitic tuff	cg	conglomerate	slt	silt
tf-s.s.	tuffaceous sandstone	dc-vol-bre	dacitic volcanic breccia	grv	gravel
ls	limestone	an-tf-bre	andesitic tuff breccia		
an	andesite lava	dc-wtf	dacitic welded tuff		
sh	shale	dc-tf	dacitic tuff		
tf	tuff	dc	dacitic lava		
s.s.	sandstone	rho-tf	rhyolitic tuff		

Fig. II-3 Generalized Stratigraphic Column of the Cotahusai Area

(1) Stratigraphy (Fig. II-3)

Rocks of the survey area comprises the Precambrian Basement, the Jurassic, Cretaceous, and Tertiary systems, intrusive rocks through these Basement and systems, and the Quaternary System which is widespread in the Altiplano highlands.

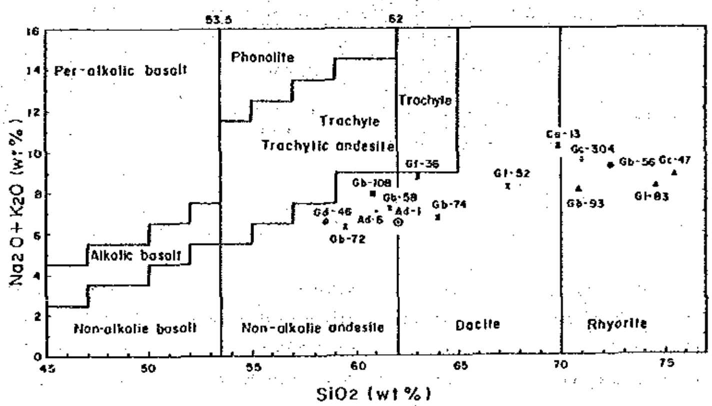
(2) Intrusives

The intrusive rocks occurring in the survey area comprise Coast batholith, (CB), Accha stock (Di) and andesite stocks and dikes (An).

(3) Chemical Composition of Rocks

Whole rock chemical analysis (covering 13 constituents) was made for 20 rock samples collected during the present field work and normative calculations were also performed under CIPW classification. The results of the analysis and normative calculations are presented in Fig. II-4, Fig. II-5, Fig. II-6.

Described below are the results of analysis of volcanic rocks found in the Survey area according to a simple method of classification of the type of volcanic rocks on the basis of the Sio_2 and $Na_2O + K_2O$ contents (classification method of Middlemost, E.A.K. (1972)) (Fig. II-4).



⊙: Tc , ▲: Al, ●: Vse, x: Vbl, +: Vbu, ·: Vla , ■: Vm (Simbols of Giological Unit)

Using the Volcanic Rocks Classification Diagram of E.A.K. Midlemost

Fig. II-4 SiO_2 - (Na_2O + K_2O) Variation Diagram of Valcanic Rocks

Fig. II-5 illustrates the relationship between K_2O and MgO based on the results of the chemical analysis of rocks (13 constituents). The diagram of Fig. II-5 shows that the MgO content tends to decrease with an increase of K_2O, but the rhyolitic rocks of the Alpabamba Formation (Al) have a lower MgO content than other rocks and a correlation between the MgO content and K_2O content cannot be established.
A sample (Gb-56) from the Senca Formation (Vse) is a rhyolitic rock and exhibits a facies similar to that of the rhyolitic rocks of the Alpabamba Forma-tion, but it shows a higher MgO content than the rhyolitic rock of the Alpabamba Formation.

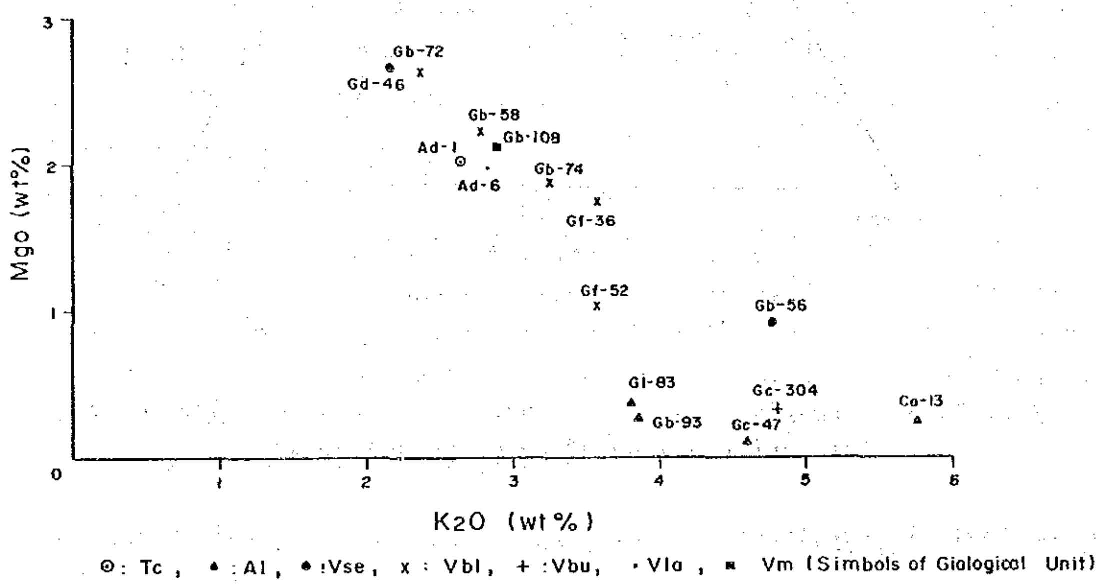


Fig. II-5 K20 - MgO Variation Diagram of Valcanic Rocks

With respect to intrusive rocks, whole rock chemical analysis was made for two samples of the Coast batholith (CB) and two samples of the Accha stock. All these samples are granitic in composition and a triangular diagram of quartz - (albite + anorthite) -orthoclass was prepared on the basis of the classification of Bateman et al., (1963) selected from among the various classifications of felsic igneous rocks (Fig. II-6).

The four samples can be classified as granodiorites. The Coast batholith in the south of the survey area tends to contain a slightly larger quantity of orthoclase.

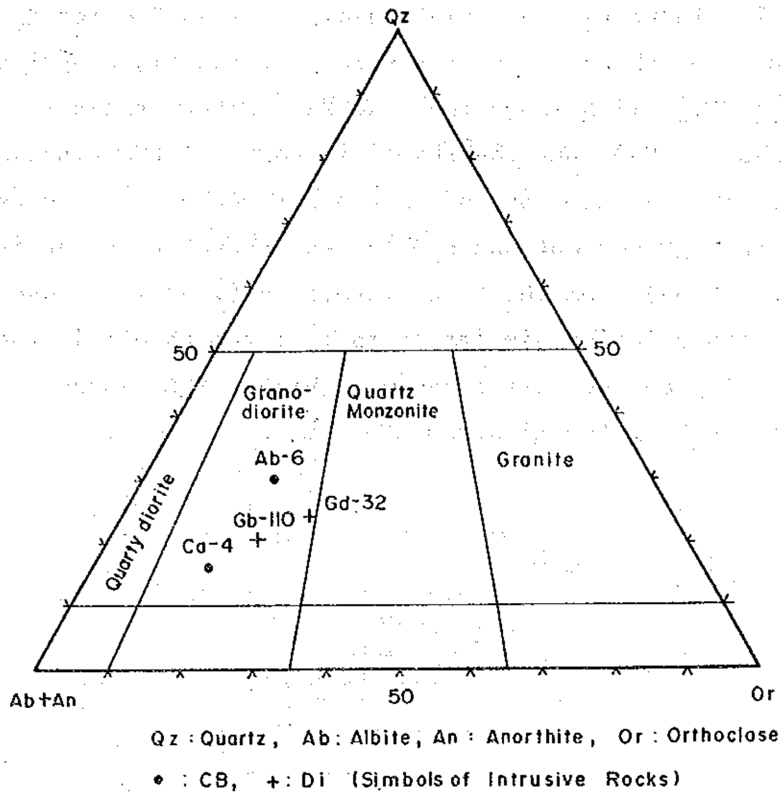


Fig. II-6 Normative Quartz - Orthoclass - (Albite + Anorthite) Triangular Digram of Some Igneous Rocks

(4) Geological Structures

The geological structure of the Survey Area is highly characterized by the remarkable folds and faults formed in the Jurassic and Cretaceous rocks by the orogeny of the Andes. In the Tertiary formations strata show a gentle dip locally and small faults are observable. Judging from their scale, the strata in the Tertiary System do not seem to have undergone the effects of a vehement tectonic movement (Fig. II-2).

The folds found in the Jurassic and Cretaceous rocks include a large-scale syncline having a N70° W axis in the Socosani Formation occurring in the south of Mt. Tanisca, an E-W syncline found in the

Yura Group west of the village of Velinga on the Cotahuasi River, NW-SE anticline and syncline, N-S anticlines and NE-SW anticlines in that part of the Arcurquina Formation extending from Lancacolla west of the village of Cotahuasi to Taurisma to the northeast.

The folds observed in the Tertiary rocks include small-scale anticlines and synclines with a NNW-SSE axis found in the Tacaza Group west of the village of Carcana in the north of detailed survey area B. No other folds are found in the strata formed after Cretaceous age.

Faults are developed in the formation of the middle Miocene or earlier. The major faults trend, generally in the NW-SE direction including a NW-SE trending fault passes by the village of Saima in the south of the detailed survey area A, an E-W fault in the valley of Palmadeas to the southeast, an NW-SE fault extending from a point east of Lamapa via the south of San Jose de Ushua to the vicinity of Mt. Tanisca and an NW-SE fault running along a valley south of Mina Picha. These faults have throws estimated to be over 1,000 m. Substantially parallel to these large-scale faults are other faults, such as those running across the northeast of Bitama, Mina Luicho and Puca Puca, all found in the west of the survey area, and those passing the valley of Ccolapa and the Chuquibamba River.

NNW-SSE faults are found to the west of Colta, to the east of Pomacocha and in the valley of Anirca northeast of Mina de Huayllura. NE-SW faults are located in a valley east of Quechualla on the Cotahuasi River, east of the village of Cotahuasi, near Puica in the northeast of the survey area and around Sumana east of Puica. All these NNW-SSE and NE-SW faults are on a relatively small scale and some of these have cut the Alpabamba Formation. The NW-SE and NE-SW orientations of fold axes and faults are regionally in substantially consistent with the NW-SE and NE-SW lineaments and the directions of arrangement of circular structures extracted from LANDSAT images. This presumably reflects the basement structure of the survey area.

2-2 Mineralization and Alteration

The mineralization and alteration in the Cotahuasi area as follows.

The alteration zones and mineralized zones in the project area are shown in Fig. II-7. These zones are distributed mainly in the Jurassic and Cretaceous rocks and in the Tacaza Group of the Tertiary. Major among them are a) Mina Pararapa, b) Minas de Huayllura (East of Tanisca), c) West of Tanisca, d) Mina Luicho, e) Mina Picha, f) South of Maran, g) Oyolo and h) Pirca.

The alteration zone can be grouped according to the type of alteration into 1) white alteration with silicification, 2) brown alteration with silicification and argillization and 3) brown alteration contaminated with ferrous oxide.

Mineralization includes vein type mineralization of quartz veins bearing gold and silver; mineralization of gold and silver found in the zones of contamination with ferrous oxide along fracture zones and joints; contact metasomatic mineralization of gold, silver, copper, lead, zinc and magnetite occurring in skarns found in the area of contact between intrusive rocks and limestones; and pyritization of desimination type observable in and around intrusive rock bodies.

The mineralized zones with confirmed outcrops of gold-silver bearing quartz veins include a) Mina Pararapa, Copacahuana Mine in the Minas de Huayllura b) and f) the south of Maran. In Mina Luicho the mineralized zone is locally accompanied by quartz veinlets which lack continuity.

Table II-1 show the scale, host rock, and characteristics of alteration and mineralization of each zone.

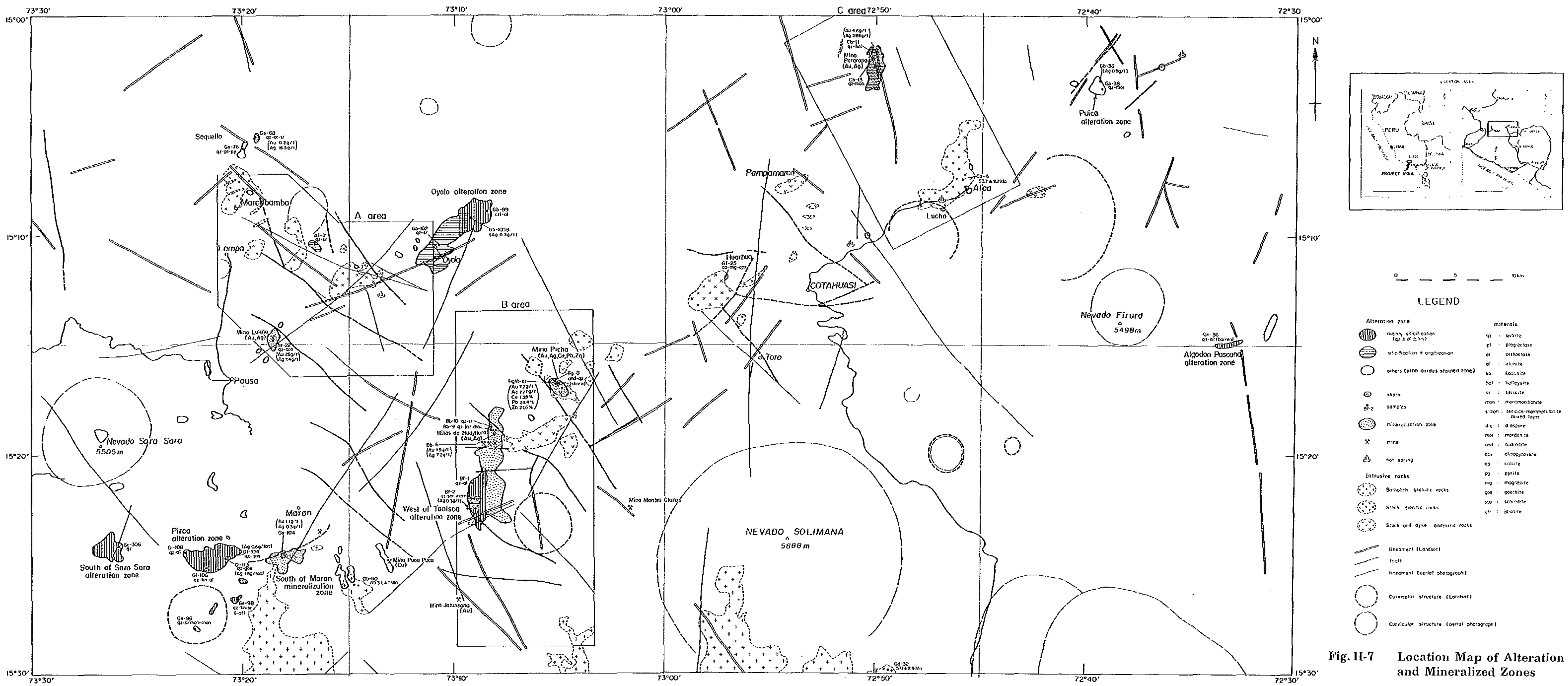


Fig. II-7 Location Map of Alteration and Mineralized Zones

Table II-1 List of Alteration and Mineralization Zones (Main)

Name	Location	Scale	Host rock	Alteration	Mineralization
Mina Pararapa	Approx. 20 km North-northeast of Cotahuasi	1 km × 2.5 km	Andesite dikes (An) and Andesitic volcanic rocks (Tacaza Group)	•Brown altered zone contaminated by ferrous oxide •Hydrothermal alteration consisting primarily of silicification (quartz + halloysite, cb-11 quartz + montmorillonite cb-13) •The andesite dikes are chloritized and contaminated by pyrites.	•Mineralization of gold and silber in N20°W and 80°NE gold-silver bearing quartz veins •Quartz vein being prospected by tunnels is 0.5 to 1.5 m wide and 1.3 km long. •According to the mine data, the grade of gold ore is Au, max. 40 g/ton and average 4.6 g/ton. •The average grades of gold and silver ores contained in quartz dikes of 80 cm in width are Au 4.6 g/ton and Ag 288 g/ton.
Minas de Huayllura (east of Tonisca)	Approx. 30 km west-southwest of Cotahuasi	1∼2 km × 10 km	Quartzite (Yura Group)	•Brown altered zone contaminated by ferrous oxide •Hydrothermal alteration accompanied by quartz veinlets (quartz + sericite Bb-10 quartz + diaspare + sericite + jarosite Bb-9)	•Mineralization exists in oxidized zones occurring along fracture zones and joints and in gold-silver bearing quartz veins •Abandoned small-scale adits are found at several locations •Analysis of the quartz veins of Mine Copacahuana shows the grades of Au and Ag are 4.6 g/ton and 288 g/ton.
West of Tonisca	Approx. 33 km west-southwest of Cotahuasi and approx. 23 km east-southeast of Pausa	1.5 km × 4 km	Andesitic volcanic rocks (Tocaza Group)	•Essentially hydrothermal alteration of quartz + alunite and quartz + sericite + montmorillonite •Relationship between both types of alteration is not clear.	•Conspicuous mineralization not observable. •Analysis of altered rocks containing clay minerals revealed the content of Au 0.06 g/ton and Ag 0.31 g/ton.
Mina Luicho	Approx 5 km northeast of Pausa	1 km × 2 km	Quartzite (Yura Group)	•Silicification around quartz veinlets and contamination with ferrous oxide. (quartz + scorodite (Ae-22)	•Gold-silver bearing quartz veinlets and contamination with ferrous oxide observable. Orientation of the veinlets is not clear. •A dozen or so small-scale stopes are scattered. •Spot samples from the stopes showed Au 26.0 g/ton, Ag 114.1 g/ton and Au 9.7 g/ton, Ag 30.2 g/ton.
Pirca	Approx. 15 km south of Pirca	2 km × 5 km	Andesite and pyroclastic rocks (Tacaza Group and lower part of Barroso Group)	•Mostly hydrothermal alteration of quartz + alunite.	•Contaminated with goethite near Pirca. •Vein-type mineralization not observable. •Analysis of samples from the zone contaminoted with goethite showed the grade of Ag 0.6 to 1.6 g/ton.
South of Maran	Approx. 15 km south-southeast of Pausa	1.5 km × 3.5 km	Andesitic tuff to tuff breccia (Chocolate Formation)	•Silicification around quartz veinlets, veinlike silicification and contamination with ferroces oxide.	•Gold-silver bearing quartz veins about 10 cm wide and contamination with limonite around fracture zones are observable as several locations. •Analysis of samples from Pyrite quartz veins (5 to 10 cm wide) showed the grades of Au 1.1 g/ton and Ag 0.3 g/ton. •There are many abandoned old adits. In downstream areas river sediments are washed for gold.
Oyolo	Approx. 20 to 25 km northeast of Pausa	2 km × 8 km	Dacitic pyroclastic rocks (Tacaza Formation to Alpabamba Formation)	•Hydrothermal alteration (primarily argillization). In the northeast Cristobalite + alunite and in the southwest quartz + sericite	•Locally accompanied by contamination with ferrous oxide (grade: Ag 0.3 g/ton) •Conspicuous mineralization not observable.
Mina Picha	Approx. 22 km west-southwest of Cotahuasi	Small ore bodies scattered in area of approx. 1 km × 2 km	Limestone (Arcurquina Formation) and diorite (stock)	Skarn type metamorphism (garnet (andradite) - calcite-quartz)	•Skarn type •Mineralization of Cu, Pb, Zn, Ag and Au. •Ore bodies are small lens-shaped bodies. •Analysis of mineral ores consisting mainly of galena and sphalerite showed the following grades: Au 7.7 g/ton, Ag 770 g/ton, Cu 1.38%, Pb 23.4%, Zn 21.6%

2-3 Geochemical Prospecting

Geochemical prospecting in the area was conducted with the purpose of detecting geochemical anomalies caused by mineralization and of obtaining basic data for mineral exploration in the next phase of the project.

In the prospecting, stream sediments were collected and six elements, gold (Au), silver (Ag), arsenic (As), copper (Cu), lead (Pb) and zinc (Zn) were analyzed as indicators of mineralization. The results are shown in Fig. II-8 and Table II-2.

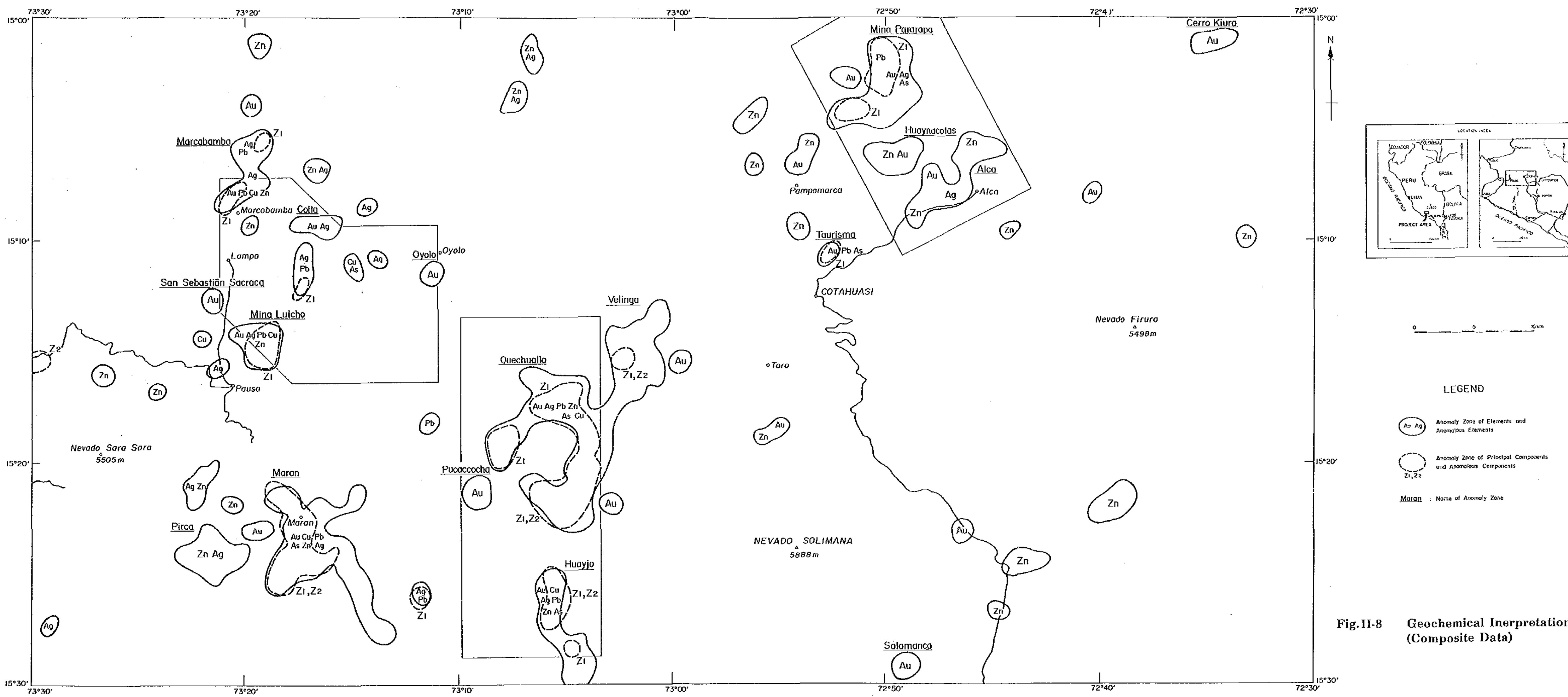


Fig. II-8 Geochemical Inerpretation Map (Composite Data)

Table II-2 List of Geochemical Anomaly Zones

	Anomalous zone	Location	Scale	Indicator element						Remarks
				Au	Ag	As	Cu	Pb	Zn	
			(km × km)							
	- Cotahuashi Area -									
1	Mina Pararapa	Approx. 20 km NNW of Cotahuashi	8 × 9	++	++	+		-		Au>Ag
2	Quechualla	Along Cotahuashi River in the Center of the Survey Area	11 × 14							
	Picha	Northern part of Anomalous zone		++	++	+	-	+	-	Ag>Au
	Quechualla	Along Cotahuashi River		++	++	-		+	-	Au>Ag
	Abandonada	South of Quechualla		+	+	-	+	-	++	
	Tanisea	Western part of Anomalous zone		++	+			+		
3	Huayjo	Approx. 10 km south of Quechualla	2 × 10	++	+	-	++	+	-	
4	Maran	Approx. 10 km south-east of Pausa		++	-	+	++	+	-	Cu>Au
5	Mina Luicho	Approx. 4 km north-east of Pausa	4 × 4	++	++		++	+	-	Au>Ag,Cu
6	Marcabamba	Marcabamba in the north-east of the survey area	3 × 6	+	++		-	-	+	
7	Velinga	Approx. 15 km west-southwest of Cotahuashi	4 × 7	+		+	-		-	Au>As
8	Alca	Approx. 15 km northeast of Cotahuashi	4 × 10	+	+				-	
9	Huaynacotas	Approx. 6 km northwest of Alca	3 × 5	+					++	
10	Colta	Approx. 15 km north-northeast of Colta	3 × 6	+	+			-		Ag>Au
11	Pirca	Approx. 13 km south of Pausa	4 × 4		-				+	
12	Taurisma	Approx. 3 km north of Cotahuashi	1.5 × 2	-	-			-		
13	Cerro Kiura	Northeastern margine of the Survey Area	1.5 × 4	+						
14	Pausaccocha	Approx. 10 km west of Quechualla	2.5 × 2.5	+						
15	Oyolo	Approx. 20 km northeast of Pausa	1.5 × 2	+						
16	San Sebastian Sacraca	Approx. 7 km north of Pausa	1.5 × 2	+						
17	Salamanca	Approx. 10 km southeast of Nevada Sollman	1.5 × 2	+						
	- Orcopampa Area -									
18	Orcopampa	Central part of the Orcopampa Area	10 × 6	(++)	(++)			-	+	
19	Orcopampa North	Approx. 5 km northeast of Orcopampa	4 × 6	(++)	(++)					

Promising geochemical anomalies are located at Mina Pararapa, Quechualla, Maran, Huayjo, Mina Luicho and Marcabamba. Other anomalies in a single element or multiple elements are located at Cerro Kiura, Hucaccocha (a part of the western alteration zone in Tanisca), Alca and Colta.

2-4 Summary of the Results of the 1st Year's Work

A total of 15 mineralization and alteration zones were identified in the Cotahuasi Area.

The major mineralization and alteration zones are summarized in Table II-3.

Table II-3 Principal Mineralization Zones (Cotahuasi Area)

No.	Name of Mineralized or Alteration Zone	Size of Mineralized or Alteration Zone	Host Rock	Alteration	Mineralization
(1)	Minas Pararapa	1 km x 2.5 km	Andesite (An) dikes and andesitic volcanic rocks (Tc)	Hydrothermal alteration, primarily silicification; browning of ferrous oxide	Gold-silver bearing quartz veins, 0.5 - 1.5 m wide, 1.3 km long
(2)	Mina de Huayllura (East of Tonisca)	1 - 2 km x 10 km	Sandstone (Yu)	Browning by ferrous oxide; hydrothermal alteration with fine quartz vein	Oxidized zones along fracture zones and joints; fine quartz vein with gold and silver
(3)	West of Tonisca	1.5 km x 4 km	Andesitic volcanic rock (Tc)	Hydrothermal alteration accompanied by argillization and silicification	Noticeable mineralization not observed
(4)	Mina Luicho	1 km x 2 km	Sandstone (Yu)	Silicification around fine quartz veins; browning by ferrous oxide	Gold-silver bearing fine quartz veins and browning of ferrous oxide
(5)	Mina Picha	1 km x 2 km	Limestone (Ar)	Skarn zones formed by intrusion of diorite; mainly garnet skarns	Composed of small-scale lense and massive ores, galena black jack and chalcopyrite and bearing gold and silver
(6)	South of Maran	1.5 km x 3.5 km	Andesitic tuff breccia and tuff (Cho)	Silicification around fine quartz veins and browning by ferrous oxide	Gold-silver bearing fine quartz veins and gold-bearing brown contaminated zone by ferrous oxide along fracture zones
(7)	Oyolo	2 km x 8 km	Andesitic to dacitic pyroclastic rock (Tc - Al)	Hydrothermal alteration, primarily argillization; browning by ferrous oxide	Noticeable mineralization not observed
(8)	Pirca	2 km x 5 km	Andesitic volcanic rock (Tc)	Hydrothermal alteration with silicification	Contaminated zone by ferrous oxide

Among the mineralization and alteration zones tabulated here, the largest unit deposit is the gold-silver bearing quartz vein occurring in the mineralized zone of Mina Pararapa. This vein is 0.5 to 1.5 m wide and 1.3 km long. According to the unpublished data of the mine, the highest grade of gold is 40 g/ton and the average grade 4.6 g/ton. According to the results of the present survey, the average grade for 0.8 m of vein width is 4.6 g/ton for gold and 288.0 g/ton for silver.

Analysis of local samples collected from contaminated part by brown ferrous oxides occurring along fissures in the mineralized zones of Mina Luicho, though on a small scale, shows a grade of 26.0 g/ton for gold and 114.1 g/ton for silver.

Massive ores collected from the stockpile of the Mina Richa show a grade of 7.7 g/ton for gold, 777 g/ton for silver, 23.4% for lead, 21.6% for zinc and 1.38% for copper. Such high-grade ores cannot be found in the other mineralized zones surveyed.

Table II-4 Principal Geochemical Anomaly Zones (Cotahuasi Area)

No.	Name of Geochemically Anomalous Zone	Anomaly in Univariate Statistical Analysis (Plural Elements)	Existance of Anomaly in Principal Component Analysis		Size of Anomalous Zone	Area
			1st Principal Component	2nd Principal Component		
1	Mina Pararapa	Au, Ag, (As), (Pb)	Yes	No	7 km x 4 km	28 km^2
2	Quechualla (Tanisca)	Au, Ag, Pb (Zn)(As) (Cu)	Yes	No	13 km x 10 km	130 km^2
3	Huayjo	Au, Cu, Ag (Pb), (Zn)(As)	Yes	Yes	10 km x 2 km	20 km^2
4	Marcabamba	Au, Ag, Pb (Cu)(Zn)	Yes	No	7 km x 3 km	21 km^2
5	Mina Luicho	Au, Ag, Pb (Cu)(Zn)	Yes	No	4 km x 3 km	12 km^2
6	Maran	Au, Cu, Pb, (As), (Zn)(Ag)	Yes	Yes	9 km x 4 km	36 km^2
*	Orcopampa	Zn, Pb, (Au)(Ag)	Yes	No	6 km x 5 km	30 km^2
*	North of Orcopampa	Au, Ag	Yes	No	5 km x 4 km	20 km^2

Mineralized/Alteration zones, such as Mina Pararapa composed mainly of gold bearing quartz veins, Minas de Huayllura (east of Tanisca) composed of gold bearing fine quartz veins and oxidized zones, Mina Luicho and southern Maran, substantially overlap geochemically anomalous zones consisting mainly of Au and Ag. Mina Picha displaying contact metasomatic mineralization overlap geochemically anomalous zones of Au, Ag, Pb, (Zn) and (As) in a conspicuous manner.

Interesting alteration zones which are close to known mineralized zones and which overlap weak geochemically anomalous zones include the alteration zone in the west Tanisca overlapping an anomalous zone of Au and the alteration zone of Pirca overlapping anomalous zones of Zn and Ag.

Of the geochemically anomalous zones, those of Vellinga along the Cotahuasi River and of northern Huayjo reflect brown altered zones of ferrous oxide bearing small-scale gold deposits. The anomalous zones, including those of Alca in the northeast of the survey area, Quepacc and southern Huayjo in the south, and Marcabamba in the northwest, overlap intrusive bodies of diorite and reflect a weak pyritization caused by the intrusion.

The following tabulation gives the suggested survey areas and methods of survey for the second and succeeding survey years which are based on the results of the first-year survey.

Table II-5 Recommendation for Follor-up Survey (Cotahuasi Area)

Area	Method of Survey
1. Mina Pararapa	Detailed geological survey Geochemical exploration Geophysical prospecting Diamong Drilling
2. West of Tanisca Alteration Zone	Detailed geological survey Geochemical exploration Geophysical prospecting
3. Mina Luicho	Detailed geological survey Geochemical exploration
4. Pirca Alteration Zone	Detailed geological survey Geochemical exploration Geophysical prospecting

However, it is necessary to examine the circumstances of the establishment of mining concessions in the selection of survey areas for the second and succeeding years.

CHAPTER 3 PIRCA AREA

3-1 Geology and Geological Structures

The Pirca Area in the southwest part of the first year's survey area, extends westwards from the Pirca village approximately 15 km south of the Pausa, and covers on area of 90 km^2 (Fig. I-1). This area was divided into two subareas, the Pirca Eastern Area (48 km^2) and the Pirca Western Area (42 km^2), with an intention to carry out surveys more in details in the eastern area than in the western area.

The geology of the both areas are shown in Fig. II-9 and II-10.

The stratigraphic sequences of the area are composed in stratigraphically ascending order of the Jurassic Chocolate volcanics at the bottom, the Tertiary Tacaza Formation (Tc), the Quaternary system comprising the Pirca sediments (PS), the Upper and Lower Barroso Formations (Vbu, Vbl), Moraine (Mo) of the Pleistocene and the Pausa volcanic sediments (Vsp) and alluvium (al) of the Holocene. There are also distributed by minor hornblende andesite dikes.

No prominent tectonic element has been recognized in the Pirca Area.

In the Pirca Eastern Area, the Tacaza Formation appears to have been deformed subject to the Andean Orogeny (at the waning stage of the orogeny?). The beddings of the formation strike in the direction of E-W and dip 10° to 15° to N.

Faults have been recognized at three localities, one trending NW-SE along the Paccha creek in the vicinity of Millo, another trending NE-SW on the slope to the northeast of Millo and the third also trending NE-SW on the slope approximately 1 km southeast of Millo. Magnitudes of dislocation by these faults appear to be small, possibility within ranges of several tens of meters.

No Notable structural features has been recognized in the Pirca Western Area.

3-2 Mineralization and Alteration

A number of alteration zones of variable sizes have been observed in the Pirca Area (Fig. II-11, II-12).

However, the mineralization of this area is generally weak and no mineralized zone has ever been exploited though several localities have been explored by means of trenching.

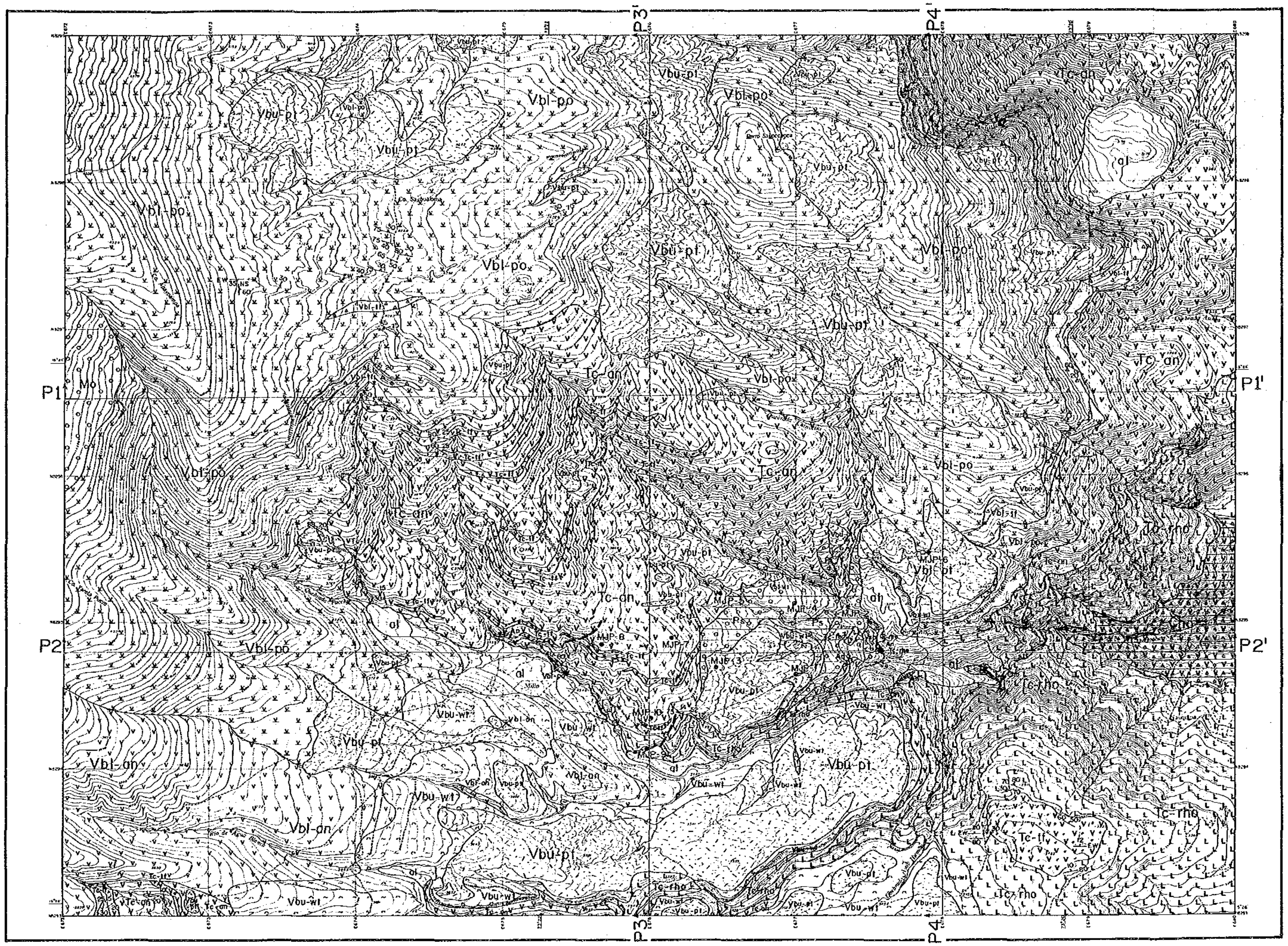
Most of the alteration zones are located in areas distributed by the andesitic lavas (Tc-an) and the andesite tuffs (Tc-an) of the Tacaza Formation (Tc), and a few in areas distributed by the rhyolitic tuffs (Tc-rho) of the same formation.

No primary alteration or mineralization has been recognized in the Quaternary system, though fragments of altered or silicified rocks are contained in the Pirca sediments, the lowermost formation of the Quaternary.

Distributions, sizes and modes of occurrences of the major alteration and mineralization zones are summarized in Table II-6. Seven major alteration zones, PE-1 through PE-7 are recognized in the Pirca Eastern Area, and three, PW-1 through PW-3, in the Pirca Western Area.

The zones PW-1 and PW-3 in the Pirca Western Area include the Au-Ag mineralization associated with the alteration dominated by silicification and the accompanying quartz veinlets.

No or very little evidences of the Au-Ag mineralization have been recognized in the Pirca Eastern Area. There is none at all in respect to the Cu-Pb-Zn mineralization. Pyritization is the only megascopically identified mineralization in the Pirca Eastern Area (Table II-7).



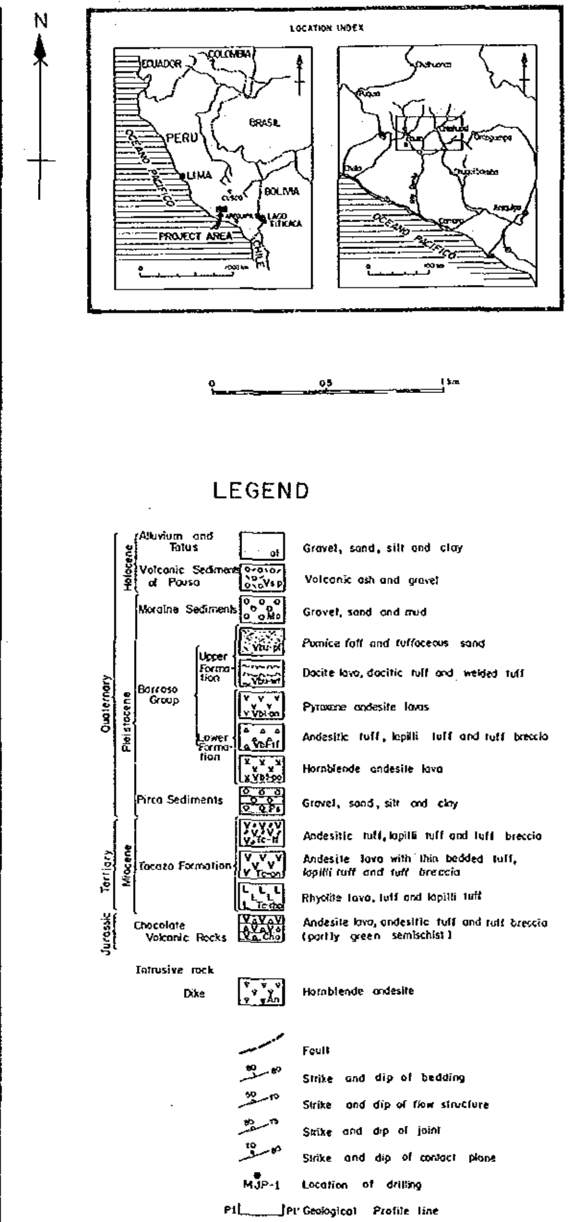


Fig. II-9 Geological Map of the Pirca Eastern Area