REPORT
ON
THE COOPERATIVE MINERAL EXPLORATION
IN
THE REGION I AREA
THE REPUBLIC OF CHILE

PHASE II

FEBRUARY 2001

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

PREFACE

In response to the request of the Government of the Republic of Chile, the Japanese Government decided to conduct a Mineral Exploration Project consisting of analysis of existing data, analysis of satellite images, geological survey, geochemical survey, geophysical surveys, drilling exploration and other relevant work in the Region I area to clarify the potential of mineral resources, and entrusted the survey to Japan International Cooperation Agency (JICA). The JICA entrusted the survey to Metal Mining Agency of Japan (MMAJ), because contents of the survey belongs to a very specialized field of mineral exploration. The survey conducted during this fiscal year is the second-phase of a three-phase project to be completed in 2001, MMAJ sent a survey team headed by Mr. Masaaki SUGAWARA to the Republic of Chile from October 10, 2000 to December 28, 2000.

The field survey was completed on schedule with the cooperation of the Government of Republic of Chile and Corporación Nacional del Cobre de Chile (CODELCO). The team exchanged views with the officials of CODELCO. After the team returned to Japan, further studies were made and a report on the second phase of the exploration project was prepared.

Results of the second-phase survey are summarized in this report which constitutes a part of the final report.

We wish to express our deep appreciation to the persons concerned of the Government of the Republic of Chile, the Ministry of Foreign Affairs, the Ministry of Economy, Trade and Industry, the Embassy of Japan in Chile and the authorities concerned for the close cooperation extended to the team.

February 2001

Kunihiko SAITO
President
Japan International Cooperation Agency

Naohiro TASHIRO
President
Metal Mining Agency of Japan

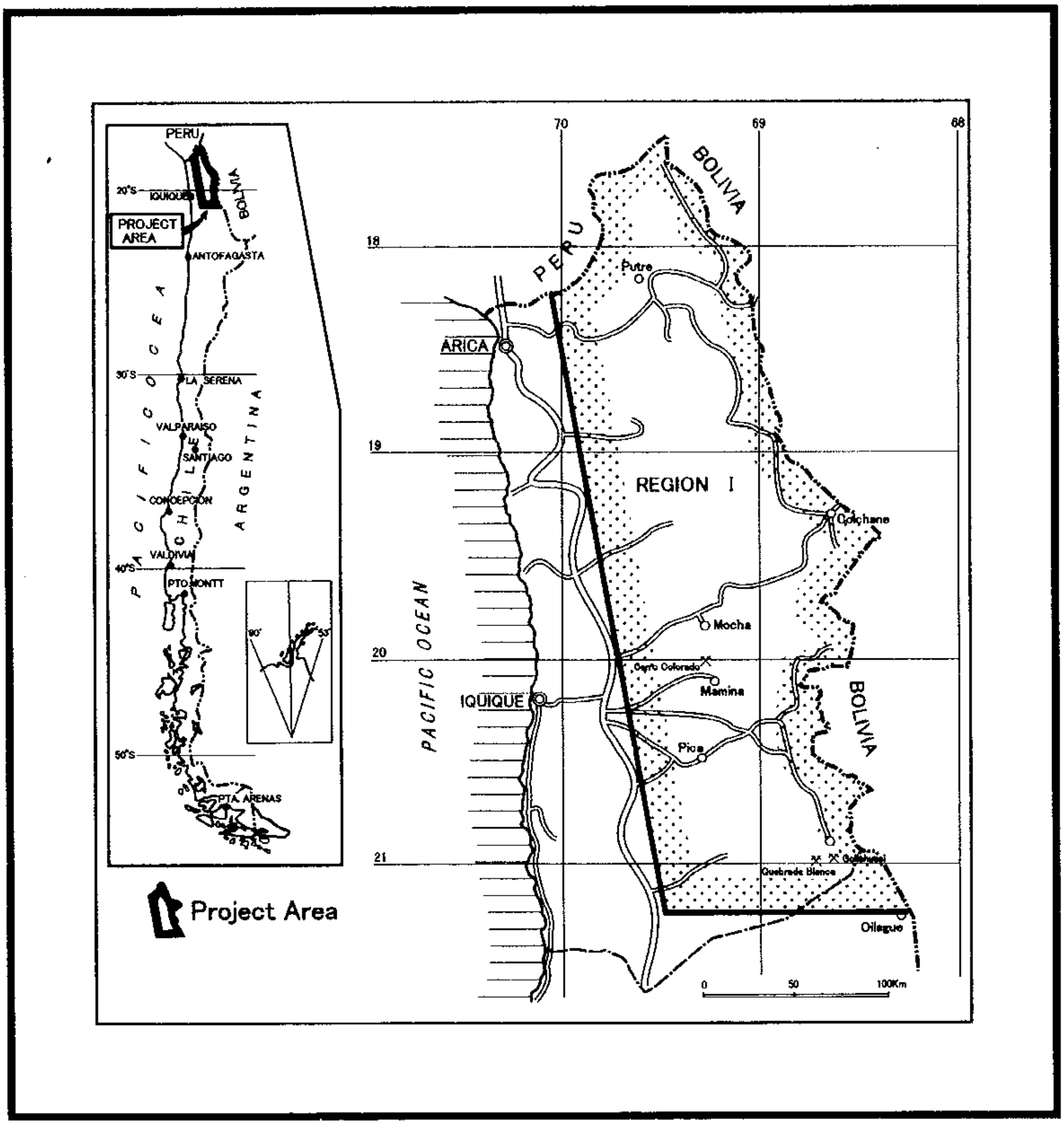

Fig. 1-1 Index Map of the Project Area

SUMMARY

Geological survey · geochemical survey, gravity survey, and airborne magnetic survey were carried out as the second-year survey of Region I (Fig. 1-1). The results are summarized as follows.

Geological · geochemical survey

A total of eight localities were surveyed during the first and second year for ground truth and reconnaissance surveys. These surveys were carried out in high mineral potential localities extracted by analysis of existing data, satellite image analysis, and other relevant work carried out during the first year. The following six localities were confirmed as possessing characteristic features of porphyry copper-type mineralization; namely Mocha-Soledad district, La Planada district, Queen Elizabeth district, Tignamar district, Camarones district and Diana district. Of these districts, those judged to be most highly potential from the Cu-Mo mineralization intensity are the Queen Elizabeth and La Planada districts.

In the Mocha-Soledad district, there is a possibility of porphyry copper deposit occurrence at eastern Mocha and between eastern Mocha and Soledad aside from the deposits confirmed in the Mocha district.

In the Tignamar district, there are negative factors regarding the further development of porphyry-type mineralized zone in spite of the existence of further room for exploration in the northern side of the northern part of the district. In the southern side of the northern part, there are wide occurrences of altered zones which could not be surveyed this year and there are rooms for further exploratory work.

In the Camarones district, a regional hydrothermal alteration zone was confirmed between the Quebrada Camarones and the southernmost part of the survey area. This regional alteration zone is believed to have been formed by a series of hydrothermal activities from porphyry copper-type activity to epithermal type. The buried location of the center of this activity, namely the porphyry copper zone has been inferred from various studies. The known copper mineralization in quartz porphyry host rock could possibly be a peripheral phase of this porphyry copper mineralization.

In the Diana district, the alteration zone is similar to the Au-rich mineralization · alteration zone formed above porphyry copper deposits. Thus there is a possibility of porphyry copper deposit occurrence in subsurface zones.

Localities other than those mentioned above are either poor in porphyry copper-type indications or weak in mineralization and the porphyry copper potential is low.

Gravity survey

Gravity anomalies were confirmed in the Camarones district. High gravity anomalies indicate localities where the basement complex occurs either exposed on the surface or in shallow subsurface zones. In other words, these are localities where the ignimbrite cover is

lacking or thin. Whereas low gravity anomalies occur in localities with deep basement and thick ignimbrite cover. The thickness of the ignimbrite was estimated from the results of 3-dimensional 2-layer modeling.

From the distribution of gravity and magnetic anomalies, occurrences of intrusive bodies with large subsurface extension are inferred in the Camarones district, namely at the northwestern margin, southern part, and along the Quebrada Camarones in the central part. Parts of the intrusive bodies are exposed on the surface, and the thickness of the volcanic rocks overlying the intrusive bodies is estimated by gravity anomaly analysis to be less than 200~300m, and these localities are considered for future exploration.

Airborne magnetic survey

Subsurface geologic structure of the whole survey area was clarified by magnetic analysis. And areas with possibilities of porphyry copper deposit occurrence were extracted by examination of regional geologic structure, local and regional magnetic characteristics, and the distribution of known mineralized zones.

The following work was recommended for the third-year survey.

(1) Carry out ground truth survey of promising areas extracted by integrated analysis of the results of airborne magnetic survey and the results of various surveys already carried out. This ground truth survey will verify the results of the airborne magnetic survey and will enable the extraction of areas for detailed survey.

(2) Carry out gravity survey and other relevant work of areas where concealed mineralized zone is anticipated. These areas are within the promising areas mentioned above (1). These work will verify the results of the airborne magnetic survey and will enable the extraction of areas for detailed survey.

(3) Examine the feasibility of drilling surveys for blind porphyry copper deposits inferred to exist in the Camarones district.

(4) Examine the necessity of detailed geological survey, geochemical survey, and gravity survey of areas where Corporacción Nacional del Cobre de Chile (CODELCO) holds concession. These are within the high porphyry copper potential localities (Mocha-Soledad, La Planada, Queen Elizabeth, Tignamar, and Diana) delineated by the ground truth survey of the first and second year.

CONTENTS

CONTENTS

PART II DETAILED DISCUSSIONS

FIGURES

TABLES

APPENDICES

PLATE

PART I OVERVIEW

PART I OVERVIEW

CHAPTER 1 INTRODUCTION

1-1 Background and Objectives

In response to the request by the Government of the Republic of Chile to conduct mineral exploration, the Japanese Government dispatched a mission to discuss the details of the project in December 1999. And as a result of the consultations with Corporacción Nacional del Cobre de Chile (CODELCO), an agreement was reached for cooperative exploration of the Region I area (Fig. 1-1) and the "Scope of Work (SW)" was signed by the representative of both Governments. The objective of this project is to assess the mineral potential of the area through analysis of existing data, analysis of satellite images, geological survey, geochemical exploration, geophysical exploration, and drilling during the three year period of fiscal 1999 to 2001.

This is the second year of this project.

1-2 Conclusions of the First Phase and Recommendations for the Second Phase

1-2-1 Conclusions of the first phase

Analysis of existing data including GEOSCAN image analysis, satellite image analysis, and geological survey and geochemical survey were carried out in Region I during the first year survey and the following conclusions were reached.

(1) Many alteration zones were extracted in Paleogene and older formations and the vicinity and in Miocene-Quaternary volcanic rocks by TM image analysis. These alteration zones are aligned in the NW-SE~NNW-SSE direction in the northern part, and in the N-S~NNW-SSE direction in the central to the southern parts of the survey area. The above directions of alteration zone alignment are harmonious with the prominent direction of the lineaments developed in the alteration zones.

(2) Analysis of images of visible near infrared ~ short-wave infrared region, short-wave infrared region, and thermal infrared region was carried out and the following results were obtained. Detailed geologic structure was clarified; alteration zones consisting of sericite, kaolin, alunite, and silica were extracted at Tignamar, Palca, Queen Elizabeth, Cerro Colorado, Copaquiri, and Collahuasi areas; and sericitized zone was extracted at the Mocha area.

(3) Mineralization of the known deposits and mineral prospects of the survey area was classified from the analysis of existing data on geology and ore deposits. And porphyry copper-type mineralized zones and possibly closely related prospects (Mo veins, irregular Cu, Cu veins, unknown-shaped Cu, Au veins, unknown-shaped Au) were selected.

(4) Many mineral prospects closely related to porphyry copper-type mineralized zones are distributed in Paleocene-early Eocene porphyry copper belt in the northern part, and in Paleocene-early Eocene and late Eocene-early Oligocene porphyry copper belts in the central to southern parts of the survey area. Epithermal mineralized zones related to Miocene-Quaternary igneous activity occur in the northern to central parts of the area and some of it is believed to overlap with the porphyry copper mineralized zones.

(5) Porphyry copper mineralized zones and possibly closely related prospects occur in and near Cretaceous-Tertiary intrusive bodies (plutonic and hypabyssal rocks).

(6) Porphyry copper mineralized zones occur; in the northern and central parts in Cretaceous-Tertiary intrusive bodies or in Cretaceous volcanic rocks, and in the southern part in Paleozoic sedimentary and volcanic rocks, Cretaceous volcanic rocks, Paleozoic granitic rocks, or in Cretaceous-Tertiary intrusive bodies.

(7) Faults on geological maps and fractures expressed as lineaments extracted from TM images are fractures which are generally closely related to the occurrence of ore deposits and prospects. The direction of the lineaments near the deposits and prospects is diverse. The porphyry copper mineralized zones occur either in the peripheries of the zones where lineaments are developed (Cerro Colorado, Collahuassi, etc.,) or near the center of lineament concentration (Quebrada Blanca, Copaquire, etc.).

(8) In the central and southern parts many mineral prospects including porphyry copper mineralized zones occur in the alteration zones or vicinity, while in the northern part many of them occur in localities where alteration zones have not been extracted.

(9) Hydrothermal activities related to mineralization are effective within a range of 4km from the alteration zones, ore deposits, and prospects. The hydrothermal zones of this area are generally elongated in the NNW-SSE direction, but activities elongated in the E-W direction intersecting the major NNW-SSE direction are inferred in the northern,

central, and southern parts. The known porphyry copper mineralized zones occur within this E-W hydrothermal system. The hydrothermal zones coincide with lineament concentration in the central and southern parts, but the correlation between the two is relatively poor in the northern part, with better coincidence with the distribution of Miocene-Quaternary volcanoes.

(10) The following localities were selected as promising for porphyry copper occurrence.

① Porphyry copper-type mineral prospects and within 4km.

② Mineral prospects possibly related to porphyry copper mineralization in Oligocene and older formations (Mo veins, irregular Cu, Cu veins, unknown-shaped Cu, Au veins, unknown-shaped Au) and alteration zones (acidic alteration zones and sericitized zones extracted by GEOSCAN image analysis and alteration zones extracted by TM image analysis), and within 4km of the above.

1-2-2 Recommendations for the second year

(1) It is recommended that verification survey be carried out in localities selected as promising for porphyry copper occurrence and were not surveyed during the first year.

(2) Geomagnetic anomalies at right angles to the axis of Central Andes are probably closely related to porphyry copper-type mineralized zones. The existing airborne geomagnetic maps are not sufficiently precise for extracting promising zones. Therefore, it is recommended that high precision airborne geomagnetic survey be carried out and the details of the above trans-Central Andes geomagnetic anomalies be clarified. This will result in more focused targeting of the promising localities and in selection of promising localities for blind buried deposits in areas where alteration zones were not detected because of coverage by younger formations.

(3) It is recommended that gravity survey be carried out in localities extracted as promising for porphyry copper occurrence by the above high precision airborne geomagnetic survey so that the thickness of the formations overlying mineralized zones can be inferred.

(4) It is recommended that geological reconnaissance be carried out in localities considered to be promising from the results of image analysis and high precision airborne geomagnetic survey.

1-3 Outline of the Second Phase Survey

Table 1-1 Amount of Work

Survey Method	Amount			
	phase 1		phase 2	
Analysis of Geoscan Images	Areal extent	2,550 km^2		
Analysis of Satellite Images Landsat TM and Existing Data	Areal extent	34,000 km^2		
Airborne magnetic survey			Survey area: Areal extent Length of survey line	 15,000 km^2 31,100 km
Geological Survey and Geochemical Prospecting	Areal extent	600 km^2	Areal extent Ground truth survey Semi-detailed survey	 600 km^2 454 km^2
	Length of traverse	100 km	Length of traverse Ground truth survey Semi-detailed survey	 150 km 225 km
	Laboratory work Thin sections Polished sections X-ray diffraction analysis Ore assay (Au,Ag,Cu,Mo,Pb,Zn,S) Geochemistry of rock (Au,Ag,As,Sb,Hg,Cu,Mo,Pb,Zn) Fluid inclusion analysis Homogenization temperature Salinity K-Ar age determination Whole rock / Mineral	 30 sections 21 sections 50 samples 21 samples 137 samples 6 samples 5 samples 5 samples	Laboratory work Thin sections Polished sections X-ray diffraction analysis Ore assay (Au,Ag,Cu,Mo,Pb,Zn,S) Geochemistry of rock (Au,Ag,As,Sb,Hg,Cu,Mo,Pb,Zn) Fluid inclusion analysis Homogenization temperature Salinity K-Ar age determination Whole rock / Mineral	 50 sections 40 sections 102 samples 44 samples 354 samples 11 samples 10 samples 3 samples
Gravity survey			Areal extent Number of Station	538 km^2 349

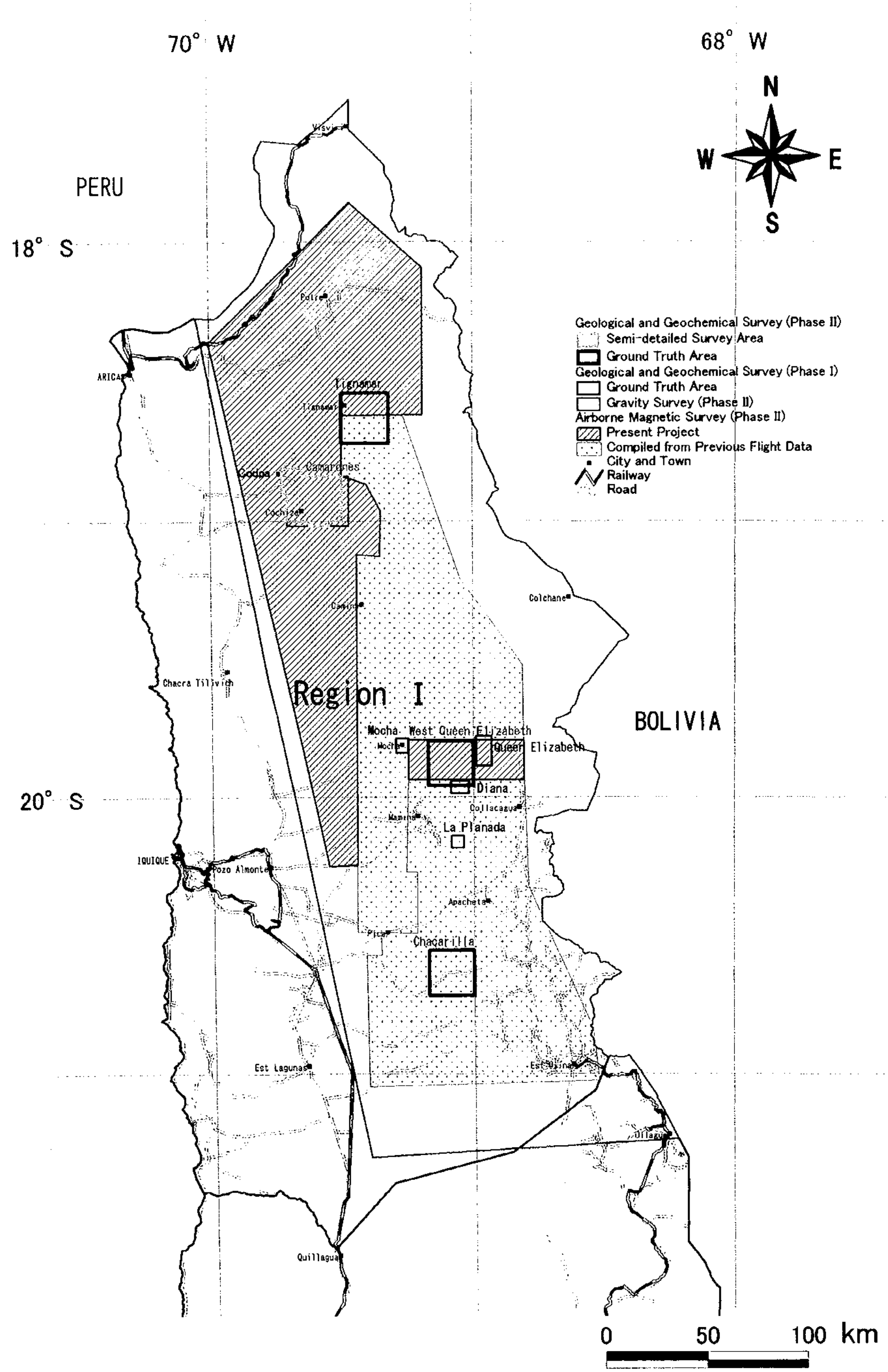

Fig. 1-2 Location Map of the Survey Area

The survey area is located in the northern part of Chile (Fig. 1-1). Also the areas surveyed by various methods are laid out in Figure 1-2.

The objective of the work carried out during the second year is to select the promising areas in the Region I area of the Republic of Chile, and to pursue technology transfer to the Chile counterpart organization.

The work carried out during the second year comprises; airborne magnetic survey, gravity survey, geological survey, and geochemical prospecting. The total amount of work done is shown in Table 1-1.

Regarding airborne magnetic survey, the regional geomagnetic structure of Region I was clarified, and the relation among mineralization, geologic structure and geomagnetic structure was discussed. Thus the results of this survey contributed to the delineation of promising areas for porphyry copper deposit occurrences.

The subsurface structures related to mineralization of the promising district of the survey area, particularly basement topography and thickness of volcanic rocks which cover the basement were clarified through gravimetric studies.

As for geological survey and geochemical prospecting, ground truth and semi-detailed survey to verify geologic structure, mineralization and alteration were carried out in some parts of the promising areas selected from analysis of GEOSCAN images, analysis of satellite images and analysis of existing data. Thus synthesizing the results of analysis of images, analysis of existing data, airborne magnetic survey, gravity survey, and geologic and geochemical survey was carried out to select the promising areas.

1-4 Members of the Survey Team

(1) Field supervisor

Tadashi Itoh (Director of Technical Cooperation Division, Mineral Resource Survey Department, MMAJ)

Takeshi Harada (Technical Cooperation Division, Mineral Resource Survey Department, MMAJ)

Takashi Kamiki (Representative of Santiago Office, MMAJ)

(2) Survey Team

1) Japanese side (Nikko Exploration & Development Co., Ltd.)

Masaaki Sugawara (Team leader, Geological and geochemical survey)

Masao Yoshizawa (Airborne magnetic survey)

Susumu Takeda (Geological and geochemical survey)

Masahiro Suzuki (Geological and geochemical survey)

Shigeo Moribayashi (Gravity survey)

Saburo Tachikawa (Gravity survey)

Tadanori Iwasaki (Gravity survey)

2) Chilean side (CODELCO)

Enrique A. Tidy (Coordinator)

Gerardo Behn R. (Airborne magnetic survey, Gravity survey)

David Pacci L. (Geological and geochemical survey)

Karsten Berg H. (Geological and geochemical survey)

1-5 Duration

Field supervising: 15 November 2000 to 16 November 2000 (by Kamiki),
3 December 2000 to 11 December 2000 (by Itoh, Harada and Kamiki)

Geological and geochemical survey: 10 October 2000 to 9 December 2000

Gravity survey: 23 October 2000 to 9 December 2000

Airborne magnetic survey: : 11 October 2000 to 9 December 2000

Laboratory work and report preparation: 12 December 2000 to 28 February 2001

CHAPTER 2 GEOGRAPHY OF THE SURVEY AREA

2-1 Location and Access

The survey area is located in the eastern part of Region I with about 400km in the N-S direction and about 100km in the E-W. The area is 34,000 km^2 bounded by the following meridians and latitudes (Fig. 1).

	Lat. S	Long. W		Lat. S	Long. W
①	18° 16′	70° 02′	②	17° 30′	69° 28′
③	21° 15′	69° 28′	④	21° 15′	68° 12′

The area is bordered on the north by Peru, and on the east by Bolivia.

Major cities in the vicinity are Arica and Iquique. The population is about 170 thousand in the former, and about 150 thousand in the latter.

It is three-hour flight from the Santiago international airport to Iquique, and also four hours to Arica.

There is a Pan-American highway along the west boundary of the survey area. There are several roads from the highway to the east, and those are mostly unpaved. A road system is not developed in the area, and the access to inland areas is difficult, particularly to the eastern part. Iquique or Arica to the eastern part is more than several hours by car.

2-2 Topography and Drainage

The northern and central parts of Chile comprise three parallel geologic zones; the Andes to the east, the Coastal Range to the west and the Central Valley between the two mountain ranges. The western part of the survey area belongs to the Central Valley to the Pre-Andes zone with gentle relief of relatively low elevation (1,000-3,000m). The eastern part of the survey area belongs to the Pre-Andes zone to the Andes Range with steep relief of high elevation (3,000-5,000m).

The drainage of the area flows from the east to the west, and a flood rarely rises. In the Central Valley water flows under the surface, and the drainage becomes extinct.

2-3 Climate and Vegetation

The survey area belongs to the desert climatic zone and also to the alpine climatic zone, and is constantly exposed to strong winds. The relatively cold season is June to September and relatively mild warm season is January to March. During December to March thunderstorms occur often. At Arica, the average annual temperature is 18.7℃, and during December to March the maximum temperature is 28℃ and minimum temperature is 16.8℃. The monthly mean temperature and precipitation during the 30 years between 1961 and 1990 observed at Arica are shown in Table 1-2.

The vegetation of the area is very scarce owing to paucity of precipitation.

Table 1-2 Monthly Mean Temperature and Precipitation Observed at Arica (1961～1990)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature (℃)	22.1	22.1	21.4	19.4	17.7	16.5	15.7	15.6	16.3	17.5	18.9	20.7	18.7
Precipitation (mm)	0.1	0.2	0.0	0.0	0.0	0.2	0.3	0.1	0.1	0.0	0.1	0.0	1.1

CHAPTER 3 OUTLINE OF GEOLOGY AND MINERALIZATION OF THE SURVEY AREA

A geological map of the survey area is shown in Figure 1-3-1, and the stratigraphy in Table 1-3-1.

The geology of the survey area is comprised of Paleozoic, Carboniferous~Triassic System, Jurassic System, Cretaceous System, Upper Cretaceous~Paleogene System, Paleogene System, Neogene System and Quaternary System.

Pre-Tertiary system is intermittently distributed in the northern part (north of about 18° 48′ S), central part (between about 19° 27′ S～20° 16′ S) and southern part (south of about 20° 29′ S) of the survey area.

Southern Pre-tertiary system consists of Paleozoic sedimentary rocks · volcanic rocks · metamorphic rocks, Carboniferous~Triassic volcanic rocks, Jurassic volcanic rocks · sedimentary rocks, Cretaceous volcanic rocks, Cretaceous~Paleogene volcanic rocks and Paleozoic plutonic rocks, and is intruded by Cretaceous~Paleogene intrusive rocks (plutonic rocks, hypabyssal rocks).

Pre-tertiary system of the central part consists of Paleozoic sedimentary rocks, Jurassic sedimentary rocks, Cretaceous volcanic rocks, Cretaceous~Paleogene volcanic rocks, and is intruded by Cretaceous~Paleogene intrusive rocks (plutonic rocks, hypabyssal rocks).

Northern Pre-tertiary system consists of Paleozoic metamorphic rocks, Jurassic sedimentary rocks, Cretaceous volcanic rocks and Cretaceous~Paleogene volcanic rocks, and is intruded by Cretaceous~Paleogene intrusive rocks (plutonic rocks, hypabyssal rocks).

Tertiary System consists of Oligocene~Miocene sedimentary rocks distributed in the

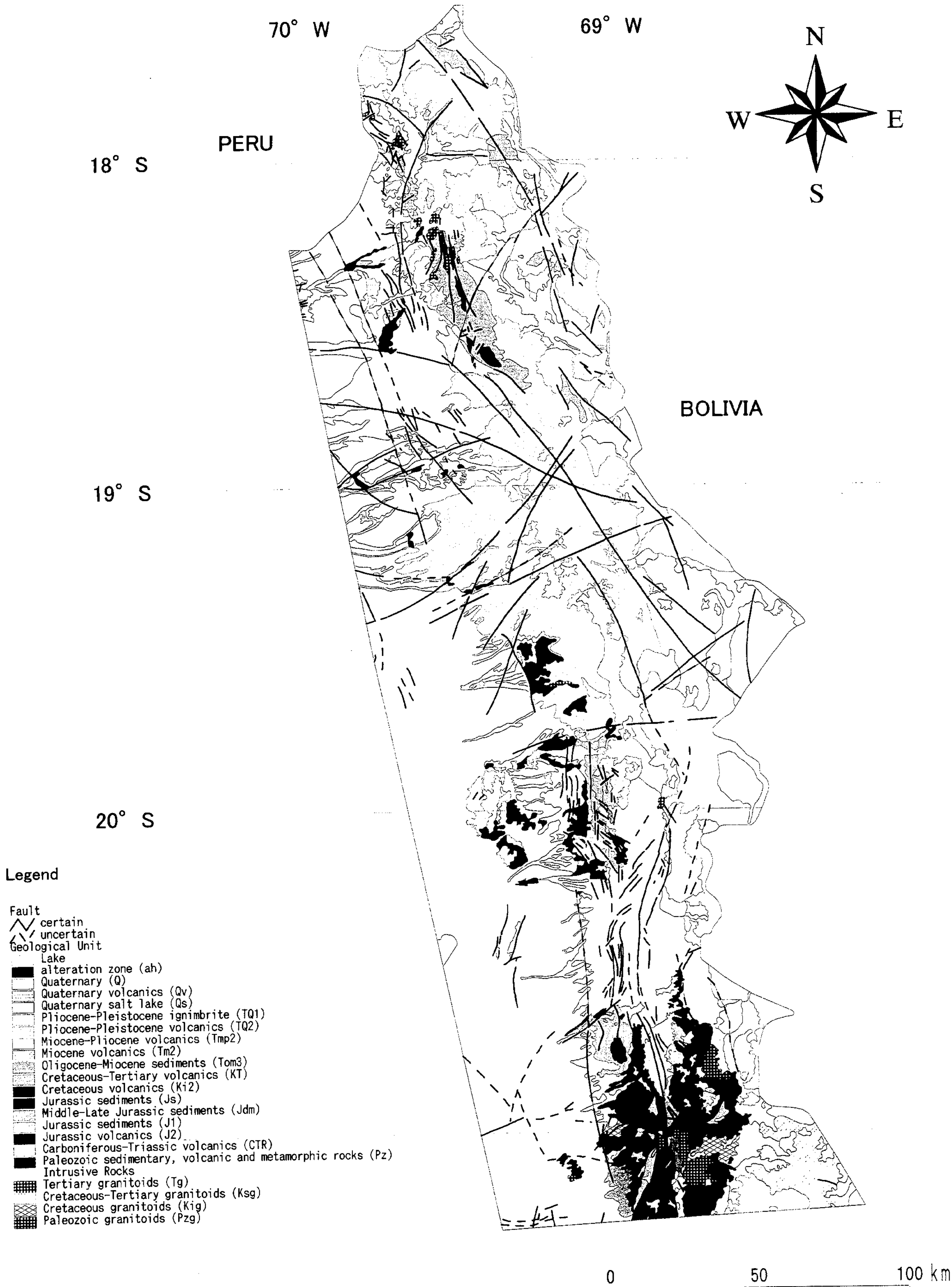

Fig. 1-3-1 Geological Map of the Study Area

Table 1-3-1 Stratigraphy of the Study Area

Period	Epoch	Formation (example)	Strata						Intrusive Rocks							Mineralization
			Symbols					Lithology	Symbols						Lithology	
			1:1,000,000 Geologic Map	1:250,000 Geologic Map*1	1:50,000 Geologic Map*2	Photogeologic Interpretation Map 1:250,000 TM	Photogeologic Interpretation Map 1:50,000 GEOSCAN		1:1,000,000 Geologic Map	1:250,000 Geologic Map *1	1:50,000 Geologic Map *2	Photogeologic Interpretation Map 1:250,000 TM	Photogeologic Interpretation Map 1:50,000 GEOSCAN			
QUATERNARY			Q, Qv	Qal, Qpd, Qcs, Qip(i), Qip(s)	Qp	Qd, Qa, Qd_1, Qa1, Ts2, Ts3	Qal ,Qtl, Qd, Qs	Fluvial, Lacustrine, Glacial, Aeolian, Alluvial, Colluvial, Mudflow, Talus								
QUATERNARY · TERTIARY	Pleistocene · Pliocene	Huaylas	TQ_1	Tsu, Tsh, TPv, Tpvi, TPiv	TQi(Qp)	TQ_1, Tvs_2	Ti_4, Ti_{4w}	Dacitic ignimbrite, Tuff, Intercalation of continental sediments								
		Cola de Zorro	TQ_2	TMv, TMvi		Tv_1, Tv_2, Tv_3	Tv, Tvc, Tvb_2, Tvb_1, Tva	Andesitic · basaltic flow, pyroclastic rock				Ti	(d) dyke			
TERTIARY	Pliocene · Miocene	Altos de Picas	Tmp_2	Tt	TQt	Tvs, Ts_1	Tt, Ti_1, Ti_2 Ti_3	Rhyolitic · basaltic flow, pyroclastic rock, Ignimbrite, Intercalation of continental sediments	Tg	KTi						Epithermal
	Miocene	Trapa · Trapa	Tm_2	Tpd		Tv_1		Rhyolitic ·dacitic tuff, Andesitic · dacitic flow, pyroclastic rock						Tg	Plutonic/Hypabysal rocks	
	Miocene · Oligocene	San Pedro	Tom_2	Tmc (OLLAGÜ E)		Ts_1, Ts		Conglomerate, Breccia, Sandstone, Shale, Siltstone (continental facies)								
	Paleocene									Tgrd, Tdc, Tmc			(d) dyke	Tgd	Quartz diorite	Porphyry Copper
EARLY TERTIARY · LATE CRETACEOUS		Las Chilcas	KT	Kiv		K, Kv	K_2	Andesitic · rhyolitic flow, pyroclastic rock, Dacitic · rhyolitic ignimbrite, Intercalation of shale/limestone/sandstone/ conglomerate (continental)	Ksg	KTpgr, Ksg, Kgd	Kg	Kg		Kg /Kp	Plutonic/Hypabyssal rocks	
EARLY CRETACEOUS		Bandurria, Lo Prado	Ki_2	Kce, Ka	Kce, KTpb	Kv	K_1	Andesitic · rhyolitic / trachytic flow, pyroclastic rock, Ignimbrite, Intercalation of sediments	Kig							
LATE JURASSIC		Rio Damas	Js	Jsc, Jqc		Js_2	Js_2 /Jkv	Conglomerate, Sandstone, Shale, Limestone, Andesitic flow, breccia (continental:Js_2) /Basalt lava, doleritic dikes, trachyte with tuffs and chert (Late Jurassic to Early Cretaceous ; Jkv)								
LATE · MIDDLE JURASSIC	Malm · Dogger	El Profeta	Jdm	Jqm		Jv, Js_1, Js_2	Js_1 /Js_1s	Sandstone, Calcareous sandstone, Limestone, Marl, Shale, Conglomerate, Chert								
JURASSIC			J_1	Jm		Js_1										
		La Negra	J_2	JKv		Jv	Jv	Andesitic flow/tuff, Rhyolitic/dacitic/trachytic flow, Dacitic tuff with intercalation of sediments								
JURASSIC · TRIASSIC									TR·jg						Triassic · Jurassic, Granitoid	
TRIASSIC · CARBONIFEROUS		Porfido cuarcifera	CTR	-	-	-	-	Tuff, Breccia flow and mainly rhyolitic to dacitic ignimbrites intercalated with pyroclastics and hypabyssal rocks	Pzg	Pg, Pzgrd, Pzgr, Pzsg			(d) dyke		Plutonic/Hypabyssal rocks : Paleozoic	
PALEOZOIC		Aguada de la Perdiz	Pz	Pzc(s), Pzc(m), Pzc(l), Pzim	-	P	Pz Pzv	Southern part : Micaceous schist, Metacherts, Serpentinite (metamorphosed) (Permian) Central part : Quartzitic/feldspathic sandstone, Shale, Conglomerate, Chert, Limestone (Silurian· Ordovician) Northern part : Micaceous schist, Amphibole gneiss, Sedimentary and volcanic rocks, (mylonitization in part)				Pg		Pzg	Diorite, Granite, Granodiorite,	

*1 : COLLACAGUE, OLLAGÜE, QUILLAGUE (GEOSCAN AREA)
*2 : QUIPISCA, MAMIÑA (GEOSCAN AREA)

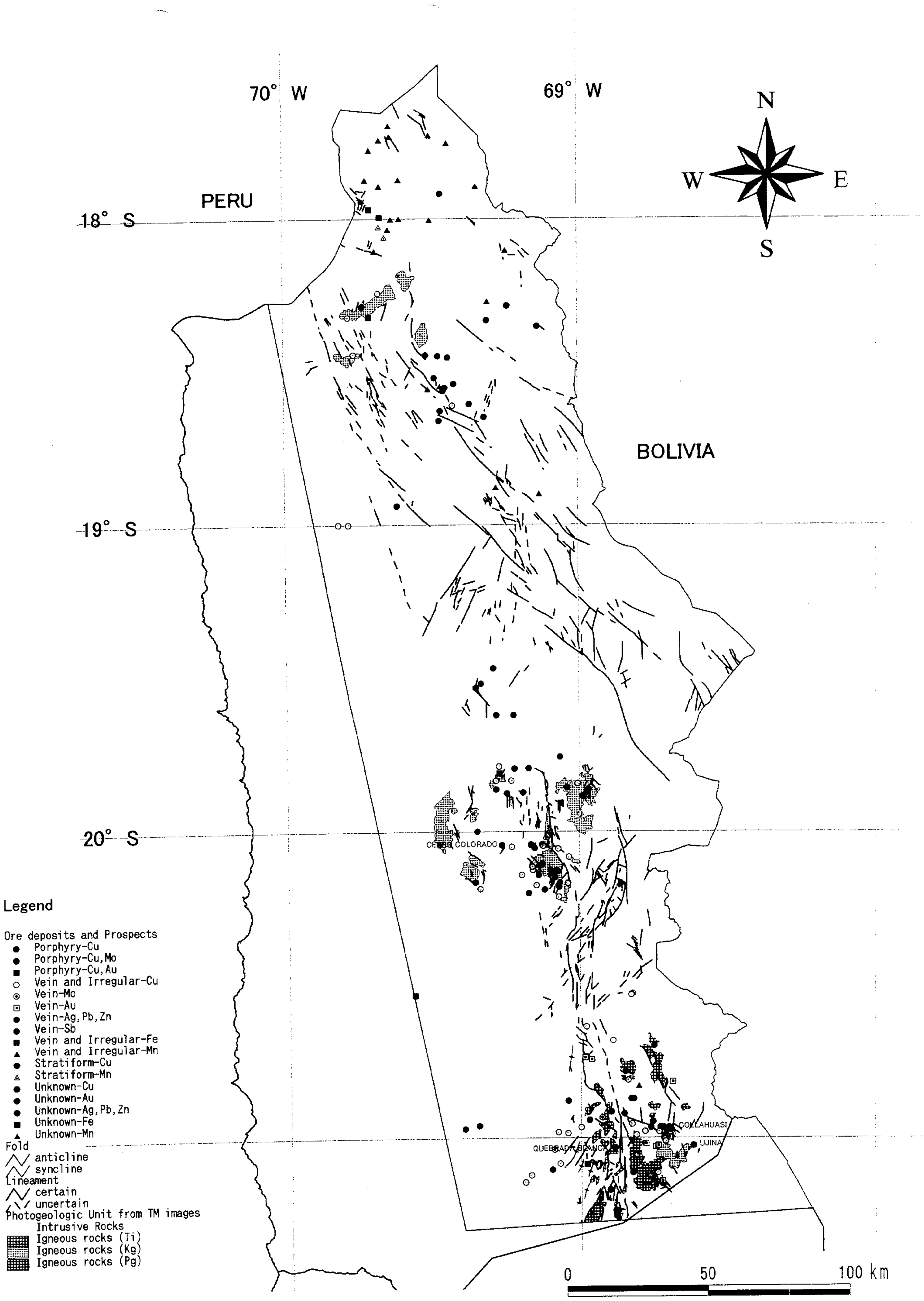

Fig. 1-3-2 Relationship among Granitoids from TM images, Ore Deposits and Prospects in the Study Area

Table 1-3-2 List of Ore Deposits and Prospects in the Study Area

No.	Name	Location UTM N	Location UTM E	Type of Ore	Ore Mineral	Gangue Mineral	Form of Ore Deposit	Direction of Strike / Structure	Dip	Dimension Length × Width (m)	Wall Rock	Alteration	Ore Reserve (Million t / category)	Ore Grade	Type of Mineralization	Source of Data
1	Laguna Blanca	8043420	432447	Mn			irregular, pocket						s		Vein and Irregular-Mn	12
2	Sicuni, Quiullere	8039549	432778	Mn			irregular, pocket						s		Vein and Irregular-Mn	12
3	Culco(Bofadales de Chiallluma)	8038318	428965	Mn			irregular, pocket						s		Vein and Irregular-Mn	12
4	Ancara	8034543	425268	Mn			irregular, pocket						s		Vein and Irregular-Mn	12
5	Carbunabe	8039923	446879	Mn			irregular, pocket						s		Vein and Irregular-Mn	12
6	Culco(Bofadales de Chiallluma)	8037173	453353	Mn			vein						s		Vein and Irregular-Mn	12
7	Kilometro 154	8023916	423931	Mn			irregular, pocket						s		Vein and Irregular-Mn	12
8	Abundancia	8021611	428919	Mn			irregular, pocket						s		Vein and Irregular-Mn	12
9	Ancolacani	8023959	436009	Mn			vein						s		Vein and Irregular-Mn	12
10	Locura	8019023	451066	Ag,Pb,Zn			vein						s		Vein-Ag,Pb,Zn	12
11	Ancopujo	8021595	463877	Mn			irregular, pocket						s		Vein and Irregular-Mn	12
12	San sebastian	8013079	425455	Fe			vein						s		Vein and Irregular-Fe	12
13	San sebastian	8010216	429172	Fe	Hem	Vitric materials	irregular, pocket	–	–	diameter: 300	Oxaya F. (tuff, lava)	?	s	Fe 52%	Vein and Irregular-Fe	8,12
14	Navidad	8009455	433198	Mn	Pyrolusite, Psilomelane	–	stringer, irregular, pocket	–	0	Thickness: 2-5, dia. 400	Huaylas F.	–	s	Mn 46%	Vein and Irregular-Mn	8,12
15	Este de Mina Navidad, Navidad Este	8009686	436161	Mn			irregular, pocket						s		Vein and Irregular-Mn	12
16	Pascual	8009276	447173	Mn			irregular, pocket						s		Vein and Irregular-Mn	12
17	Huachipato	8006674	428867	Mn	Pyrolusite, Psilomelane	silica	manto, irregular, pocket	–	–	5000 × 500, thickness 0.5	Huaylas F. (tuff)	–	s	Mn 17%, SiO2 45%	Stratiform-Mn	8,12
18	San Alberto	8005690	432152	Mn			irregular, pocket						s		Vein and Irregular-Mn	12
19	Rosario	8002919	430891	Mn			stratiform						s		Stratiform-Mn	12
20	Kilometro 130	7997816	427206	Mn			irregular, pocket						s		Vein and Irregular-Mn	12
21	Monica	7998156	474395	Mn			irregular, pocket						s		Vein and Irregular-Mn	12
22	Rosario,Jamiralla	7982773	428531	Cu,Au	Chrysoc, Atac, Cc, Cup, Mal, Chalcanthite, Native Cu-Au	Tou, Qz	vein	0, 90		wd:<1/ 50×5	Gd	Ser, Kao, Lim, Qz, Tou	s	Rosario: Cu 5-30%	Vein and Irregular-Cu	8,12
23	Dos Hermanas	7977993	422735	Cu,Mo	Py, Cp, Mo, Bn	Qz, Adul, Bio	stockwork	340, 40, 85	90	–	Gd, Di-po	Chl, Ser, Clay, (Sil)	s	–	Porphyry-Cu,Mo	8,12
24	Evall	7974320	417677	Cu			irregular, pocket						s		Vein and Irregular-Cu	12
25	Camparani	7974350	425075	Cu,Au,W	Chrysoc, Atac, Mal, Cup, Cc, Scheelite, Hem, Mt, Lim	Jasper, Qz, Kao, Ser	stockwork	15	85E	100 × (0.1-0.5)	Tou,Breccia	Kao, Ser, Tou	s	–	Porphyry-Cu,Au	8,12
26	Choquelimpie	7979891	467760	Mn			irregular, pocket						s		Vein and Irregular-Mn	12
27	Choquelimpie	7978352	474950	Ag,Pb,Zn(Au)			stockwork						s		Unknown-Ag,Pb,Zn	12
28	Choquelimpie	7973252	467560	Au,Ag,Pb,Zn,(Cu)	Arg, Py, Cp, Sp, Gn, Realgar	Qz, Ba, Cal	vein, hydrothermal breccias: high sulfidation	–	–	length: 140-710	Lupica F. (lava, breccia, conglo.), Di-po	Py	s	Au 29.4g/t, Ag 730g/t	Vein-Ag,Pb,Zn	8,9,12
29	Churiguaya	7971061	485631	Cu	Native Cu, Cup, Chrysoc	–	irregular, pocket	–	–	15 × 3	Andesitic lava	Hydrothermally altered	s	–	Vein-Ag,Pb,Zn	8,12
30	Lucita, Halcones	7960608	419637	Cu			vein						s		Vein and Irregular-Cu	12
31	El Milagro	7960478	445616	Cu			stratiform						s		Stratiform-Cu	12
32	Patino	7960158	450052	Ag,Pb,Zn,Cu			vein						s		Vein-Ag,Pb,Zn	12
33	Campanani	7952077	448701	Ag,Pb,Zn			vein						s		Vein-Ag,Pb,Zn	12
34	Capitana	7948984	450715	Mn			no record								Unknown-Mn	12
35	Churicala	7947977	446391	Mn			irregular, pocket						s		Vein and Irregular-Mn	12
36	San Lorenzo	7959614	453539	Pb,Zn,Ag,Cu	Py, Cp, Sp, Tet, Gn	Qz, Ba	vein	0	–	150 × 0.5	Lupica F. (Ad, conglo.), Di, Qz-po	Kao, Py, Lim	s	Pb 33%, Zn 17%, Ag 500g/t	Vein-Ag,Pb,Zn	8,12
37	Santa Rosa	7948504	452475	Ag,Pb,Zn	Py, Cp, Gn, Sp, Cerus, Angl	Qz, Clay	vein	280	90	140 × 1	Lupica F. (volcanics), Di-po	Hydrothermally altered	s	2 samples from gallery: Pb 8-13%, Ag 320g/t, Au 1g/t	Vein-Ag,Pb,Zn	8,12
38	Tignamar	7947289	451872	Cu	Py, Cp, Cc, Cu-oxi	Qz, Tou, Ser	stockwork, blanket				Gd, Gd-po, Qz-po	Qz, Tou, Bi, Ser, Chl, Epi, Ka			Porphyry Cu	
39	Apalacheta	7949882	455673	Ag,Sb			vein						s		Vein-Sb	12
40	Churicala Norte, Churicala Sur	7942025	455269	Cu,Ag			vein						s		Vein and Irregular-Cu	12
41	Chulpa, Trinidad	7942591	461282	Ag,Pb,Zn			vein						s		Vein-Ag,Pb,Zn	12
42	Capitena	7940133	450843	Pb,Zn,Ag,Cu,Sn,Bi	Py, Apy, Gn, Sp,	Clay, Qz	vein, lens	350-10	60-80W	wd: 15	Lupica F. (volcanics), Di	Hydrothermally altered	s	–	Vein-Ag,Pb,Zn	8,12
43	Ociel	7936591	450431	Ag,Sb	Py, Stib, Apy	Qz, Clay	vein	40	90	wd: 0.5	Lupica F. (volcanics)	?	s	–	Vein-Sb	8,12
44	Ociel	7937844	466565	Sb			vein						s		Vein-Sb	12
45	Taruguire	7912512	470613	Mn			irregular, pocket						s		Vein and Irregular-Mn	12
46	Surire	7910206	486203	Mn			irregular, pocket						s		Vein and Irregular-Mn	12
47	Camarones	7905880	435120	Cu	Py, Cp, Cc, Cu-oxi, meta-alunogen	Qz, Ser, Chl, Tou, Kf, Bi	diss, stockwork			180+	Qz-po, And	Qz, Ser, Chl, Tou			Porphyry-Cu	
48	Taltepe	7898947	414005	Cu			vein						s		Vein and Irregular-Cu	12
49	Sta. Ana	7898963	417584	Cu			vein						s		Vein and Irregular-Cu	12
50	El Sapte	7847446	489457	Ag,Pb,Zn			vein						s		Vein-Ag,Pb,Zn	12
51	Sapte	7841905	465060	Ag,Pb,Zn			vein						s		Vein-Ag,Pb,Zn	12
52	San Pedro	7840463	463069	Ag,Pb,Zn			vein						s		Vein-Ag,Pb,Zn	12
53	Quebrada Guacesina	7830628	470430	Ag,Pb,Zn			vein						s		Vein-Ag,Pb,Zn	12
54	Guacesina	7830637	476616	Ag,Pb,Zn			vein						s		Vein-Ag,Pb,Zn	12
55	Paguanta	7815491	493190	Ag,Pb,Cu			vein						s		Vein-Ag,Pb,Zn	12
56	Limacsina	7811388	481879	Ag			vein						s		Vein-Ag,Pb,Zn	12
57	Sta. Rita, San Antonio	7811272	476851	Ag,Pb,Zn			vein						s		Vein-Ag,Pb,Zn	12
58	Beatriz, Chile, Independencia, Chipamani(ex-San Antonio), Pascuala	7812053	471303	Cu,Au			vein						s		Vein and Irregular-Cu	12
59	Maria Ines, Pascuala (Mocha)	7809543	471489	Cu,Au			vein, stockwork						60	Cu 0.4%	Porphyry-Cu, Au	12
60	San Juan de Mocha	7808845	470195	Cu,Au			vein						s		Vein and Irregular-Cu	12
61	San Enrique, Llulla, Nueva Victoria, Tres Marias, Tres Puntas	7806844	475705	Cu (Au,Ag)			vein						s		Vein and Irregular-Cu	12
62	Subercagua	7803737	470265	Ag,Pb,Zn			vein						s		Vein-Ag,Pb,Zn	12
63	Sta. Fe	7802305	474141	Cu			no record								Unknown-Cu	12
64	Sta.Fe, Colpa	7802644	479899	Cu			no record								Unknown-Cu	12
65	Mosquito de Oro	7804426	495498	Au			no record								Unknown-Au	12
66	Chana, Sta. Rosa	7805865	499476	Au,Cu			vein						s		Vein and Irregular-Cu	12
67	Ollarapu	7798892	493406	Fe			vein						s		Vein and Irregular-Fe	12
68	Queen Elizabeth, Rosa, Cucho	7802777	502766	Cu			vein, stockwork						s		Porphyry-Cu	12
69	Violeta	7788453	463386	Ag,Pb			vein						s		Vein-Ag,Pb,Zn	12
70	Cerro Colorado	7783600	472286	Cu,Mo	Cc, Brochantite, Chrysoc, Atac, Mal, Cup, Teno, Dioptase, Anti, Chalcan, Turq, Cov, Py, Mo, Hem, Lim, Mt, Chromian spinel	Qz, Tou, Gyp, Alb, Or, Ser, Kao, Pyroph, Alu, Mont, Jar, Alunogen	stockwork	ENE-WSW	–	>(1000 × 800)	Andesitic tuff, Qz-po, Dac/Trachy-po, Breccia, Ad	Sil, Ser, Py, (Alu), Tou, Prop	204	Cu 1.02%	Porphyry-Cu,Mo	1,5,6,12
71	Amilca	7783104	475862	Cu,Au	Py, Hem, Cu-oxi, Au	–	vein	330	60E	–	Ad, Congl (Cerro Empexa F.)	?	s	–	Vein and Irregular-Cu	11,12
72	San Marcos	7783855	482657	Cu,Ag,Pb	Gn, Sp, Cp, (Cup, Cc, Mal)	Ba, Qz	vein / manto	320-30	25NE-20NW	wd: 1	Ss, Brec (Cerro Empexa F.)	Propilitic	s	Cu 2.9%, Pb 2%, Ag 190g/t	Vein-Ag,Pb,Zn	11,12

Table 1-3-2 List of Ore Deposits and Prospects in the Study Area

No.	Name	Location UTM N	Location UTM E	Type of Ore	Ore Mineral	Gangue Mineral	Form of Ore Deposit	Direction of Strike / Structure	Dip	Dimension Length × Width (m)	Wall Rock	Alteration	Ore Reserve (Million t / category)	Ore Grade	Type of Mineralization	Source of Data
73	Flor del Desierto	7783848	486599	Cu,Ag,Pb,Zn	Py, Cp, Hem, Cu-oxi	-	stockwork (porphyry Cu)	-	-	-	Rhyo-stock, Ad(Cret)	Ser, Kao, Prop	s	-	Porphyry-Cu	11,12
74	Lallinca	7783369	487091	Cu	Cc, Cup, Chrysoc, Mal	Qz, Tou	vein	340	60E	(80-100)×(1-1.5)	Ad (Cerro Empexa F.)	Chl, Epi	-	-	Vein and Irregular-Cu	11,12
75	San Andres	7782619	484000	Ag,Pb,Zn	Py, Apy, Cp, Sp, Gn	Qz	vein	0	75W	100×1	Gd	Chl, Kao	s	-	Vein-Ag,Pb,Zn	11,12
76	Gualchagua	7782416	492364	Cu	Cup, Chrysoc, Cu-oxi	-	vein	60	90	-	Chacarilla F. (Jur)	?	s	-	Vein and Irregular-Cu	11,12
77	Columtucsa	7779416	498236	Cu	Cc, Py, Chrysoc	Tou	irregular vein	NW	-	-	Gd	Kao	-	-	Vein and Irregular-Cu	11,12
78	Sagasca, Molibdeno Cerro Colorado	7770192	462693	Cu,Mo	Chrysoc	-	stockwork, dissemination : exotic	-	-	Thickness: 10-30	Conglomerate (Altos de Pica F.)	-	>10	Cu 2.5%	Porphyry-Cu,Mo	6,12
79	Sagasca	7767871	464475	Cu			irregular, pocket						s		Vein and Irregular-Cu	12
80	Mina Pila	7772025	491127	Zn,Pb,Sb,As,Cu	Sp, Gn, Py, Stib, Apy, Cp	Qz, Ba, Cal	vein	340	45NE	300×(1-2)	Meta-sd. (Mesoz)	Chl, Epi, Kao,	Probable: 0.01	Au 2.9g/t, Ag 550g/t, Pb 3.3%	Vein-Ag,Pb,Zn	11,12
81	Mollaca, Rio Tinto S	7772986	479410	Cu,Ag			vein						s		Vein and Irregular-Cu	12
82	Yabricoya	7774217	492227	Zn,Pb,Cu,Sb,Ag	Sp, Gn, Py, Cp, Stib, Arg?	Qz, Ba	vein	300	80NE	wd: 0.5	Gd-po, Di	Kao	s	gallery 380m: Ag 310g/t, Pb 3%	Vein-Ag,Pb,Zn	11,12
83	Rio Tinto	7774761	483380	Cu	Cc, Teno, Chrysoc, Hem	Qz, Tou	vein	65	70SE	250×(0.6-1)	Gd	Kao	s	U/G: Cu 12.8%, Ag 50g/t, Au 0.4g/t	Vein and Irregular-Cu	12
84	Rio Tinto Norte	7776014	483168	Cu	Cp, Bn, Py, Chrysoc, Teno	Tou	vein	70	35N	(50-60)×0.5	Gd	Chl, Kao	s	-	Vein and Irregular-Cu	12
85	Luisa	7776910	486755	Pb,Cu,Zn	Gn, Tet, Sp, Py, Angl, Chrysoc	Tou, Qz, Ba	vein	330-335	20-25NE	100×(0.5-1)	Gd-Adam	Tou, Sil, Kao	0.004	U/G Probable: Au 3.4g/t, Ag 870g/t, Pb 8.3%	Vein-Ag,Pb,Zn	11,12
86	Luisa de Canulpa	7776423	485783	Ag,Au,Pb,Zn			vein						s		Vein-Ag,Pb,Zn	12
87	Zoila Rosa	7774855	489652	Cu,Ag,Pb,Zn,Au	Gn, Py	Cal	vein	330	30NE	20×0.7	Ad, Gd	?	s	gallery 20m & incline 30m: Au 8-1.6g/t, Ag 92-630g/t, Pb 1.6-3.5%	Vein-Ag,Pb,Zn	11,12
88	Aguada, San Felix, Rosario, Fortuna	7774545	491638	Cu,Ag,Pb,Zn			vein						s		Vein-Ag,Pb,Zn	12
89	Tigre-San Carlos	7773463	490112	Cu	Cc, Cup, Native Cu, Chrysoc, Teno, Cp	Tou	breccia pipe	-	-	-	Meta-sd, Gd	Tou	s	-	Porphyry-Cu	11,12
90	Labranza	7770113	495967	Cu	Py, Cp	-	vein	90	40S	wd: 0.5	Gd, Rhyo-po	Kao	>0.01	dump: Au 5-10g/t, Ag 60g/t, Cu 3.5%	Vein and Irregular-Cu	11,12
91	Santiago	7769899	495716	Cu			vein						s		Vein and Irregular-Cu	12
92	La Planeda	7770086	492991	Cu,Au,Mo	Mo, Py, Cp, Cc, Cov, Cup, Chrysoc, Hem	Tou, Qz	breccia pipe, porphyry copper	-	-	-	Rhyodac-po	Ser(marginal), kao(central)	m	Cu 20%	Porphyry-Cu,Mo	11,12
93	Infiernillo	7769188	484605	Cu	Cc, Hem, Chrysoc,	Qz	irregular vein	NW	90	-	Ad, congl.	Epi	-	-	Vein and Irregular-Cu	11,12
94	Hundida	7769089	492444	Cu	Chrysoc, Mal, Cc, Cup	Tou, Qz	dissemination, irregular, breccia	NNW	-	140×?	Rhyodac-po	fresh	-	-	Porphyry-Cu	11,12
95	Arauco	7768622	492700	Cu	Cup, Cc, Chrysoc, Mal	Tou, Qz	breccia pipe	-	-	-	Rhyodac-po	Tou, Chl	-	gallery 10m: Cu 14.8%, Au 1.5g/t, Ag 13g/t	Porphyry-Cu	11,12
96	Sofia	7767535	487512	Ag (Au,Pb,Zn)	Chrysoc	Qz	? (oxide Cu)	-	-	-	Congl, Ad	?	s	pit & adit 70m: Cu 5-6%	Unknown-AgPbZn	11,12
97	Jauja	7772794	485348	Ag,Au,Pb,Zn,As,Cu	Py, Apy, Sp, Cp, Bn, Tet, Gn	Qz, Cal	vein	290-315	60-75SW	250×(0.5-1.5)	Di	Kao	0.01	U/G: Au 5.4g/t, Ag 476g/t, Pb 7%, Zn 15%	Vein-Ag,Pb,Zn	11,12
98	Rio Tinto S, Jauja	7766238	481821	Cu,Ag,Au,Pb,Zn			vein						s		Vein-Ag,Pb,Zn	11,12
99	Sitilca	7764884	492559	Cu,Au	Py, Cp, hem, Chrysoc	Qz	vein	0	50W	150×0.2	Sedim. & volcanics (Cret)	?	s	Adits: Cu 5%, Au 20g/t	Vein and Irregular-Cu	11,12
100	Carmela	7729293	440784	Fe			vein						s		Vein and Irregular-Fe	12
101	Vicuna de Punta Malla, Punta Malla II	7729939	518662	Ag,Cu	Gn, Cu-oxi, Hem, Lim	Qz	vein	10	60N	200×0.5	Ss, Rhy dyke		s	Cu 5.7%, Ag 105g/t	Vein and Irregular-Cu	12,13
102	Punta Malla	7729497	518349	Ag,Cu	Mal, Azur, Hem	-	vein	300	76N	10×0.8	Ad		s	-	Vein and Irregular-Cu	13
103	Empexa (Alona)	7718107	502292	Cu	Cu-oxi, Hem	Qz	vein	0	30E	100×0.4	Ad		s	Cu 4%	Vein and Irregular-Cu	12,13
104	Caballuno	7712902	511665	Cu	Cp, Cc, Cu-oxi, Py, Hem	Qz	vein	0	70E	120×1	Ad(Paleoz), Gd(Tert)	Prop, Clay	s	Oxi. Ore: Cu 5%	Vein and Irregular-Cu	12,13
105	Longacho	7710893	526347	Cu	Chrysoc, Mal, Lim, Hem	-	-	90	70S	wd: 0.5-1	Gd		-	-	Unknown-Cu	13
106	San Antonio	7706930	502291	Ag	Mn-oxi, Lim	Qz	-	320	30N	wd: 1	Ad		-	Ag 1762g/t	Unknown-Ag,Pb,Zn	13
107	Rosario,(Cerro Campana)	7705823	504060	Au	Au, Lim, Hem	Qz	vein	70	48N	-	Gd, Dac-po: Tert	Clay, Sil	s	-	Vein-Au	12,13
108	Carmen	7706598	501770	Au	Au, Lim	Qz	vein	310	60N	50×0.3	Ad		s	Au 2.5g/t	Vein-Au	13
109	San Miguel	7701499	516132	Au,Ag,Cu,Pb,Zn	Gn, Cp, Bn, Cu-oxi	-	vein	90	80S	70×1	Gd		s	Pb 2.25%, Au 2g/t	Vein-Ag,Pb,Zn	12,13
110	Pasaca	7698399	517066	Au,Ag,Cu	Ag, Au, Cu-oxi	-	vein	80	80S	100×?	Gd		s	Ag 87g/t	Vein and Irregular-Cu	12,13
111	Pastillas	7697712	532986	Au	Au	Qz	vein	0	80E	800×3	Gr		s	-	Vein-Au	12,13
112	Vicuna	7696292	520810	Mn	Mn-oxi., Lim	Ba	-	320	60N	wd: 1	Dac		-	-	Unknown-Mn	13
113	Majala	7690992	495631	Cu			no record								Unknown-Cu	12
114	Copaquire, (Establecimiento Copaquire, Quebrada Huiquintipa), Sulfatos	7687116	511023	Mo,Cu	Chalcanthite, Atac, Au, (Cp, Py)	-	stockwork	0	-	Altered zone: 2500×600	Gd, Gd/Monz-po, Altered qz(dac)-po : E.Tert	Center: Qz-Ser, Bio, Periphery: Py, Sil, Epi	m	Copaquire: 27million t -Mo 0.077%, Sulfatos: Cu 0.5-1.6%, Mo 95g/t	Porphyry-Cu,Mo	12,13
115	Condor	7688337	515598	Cu	Cu-oxi	Qz	-	15	90	-	Ad		-	Cu 2-3%	Unknown-Cu	13
116	Flor de Tarapaca (Alta)	7691758	518100	Ag,Pb,Cu	Gn, Cu-oxi, Ag, Hem	Ba	vein	65	85S	150×0.5	Ad		s	Pb 4.9%, Ag 493g/t	Vein-Ag,Pb,Zn	12,13
117	Flor de Tarapaca Baja	7691757	519036	Pb,Cu,Ag	Gn, Cp, Arg, Cerus, Cu-oxi, Py	Qz	vein	75	80N	1×1	Ad		s	-	Vein-Ag,Pb,Zn	13
118	Malta	7685015	507694	Mo	Mo, Cp, Cu-oxi, Py	Gyp	vein	315	55S	300×1.5	Gd		s	Mo 0.3%	Vein-Mo	12,13
119	Colcol	7684131	503119	Ag,Pb,Zn,Cu	Gn, Sp, Arg, Cu-oxi, Lim	Qz	vein	90	55S	100×0.5	Red ss		s	Pb 30%, Ag 300g/t	Vein-Ag,Pb,Zn	12,13
120	Hunquintipa	7681456	525053	Ag,Pb	Gn	Ba	vein	75	43NW	50×0.3	Ad		-	Ag 75g/t	Vein-Ag,Pb,Zn	13
121	Hunquintipa	7682682	518298	Cu			irregular, pocket: exotic				Gravel		s		Vein and Irregular-Cu	12
122	Huiquintipa	7683558	525680	Cu			no record						8	Cu 1.43%	Unknown-Cu	4,12
123	Lolon	7681091	458522	Ag,Au,Pb			vein						s		Vein-Ag,Pb,Zn	12
124	Challacollo	7682210	463614	Ag			vein						s		Vein-Ag,Pb,Zn	12
125	San Guillermo de Catigna, Catigna	7679813	491996	Cu			vein						s		Vein and Irregular-Cu	12
126	Las Porfiadas	7679482	495426	Cu			vein						s		Vein and Irregular-Cu	12
127	Yamincha	7681586	500208	Cu, Mn	Cu-oxi		vein	30	65S	-	Red ss, Ad dyke		s	-	Vein and Irregular-Cu	12,13
128	Abundancia, Aurora, Carmen, Quebrada Blanca	7678696	519852	Cu			vein						s		Vein and Irregular-Cu	12
129	Aurora	7680021	522868	Cu			vein						s		Vein and Irregular-Cu	12
130	Tarapaca	7680008	530768	Cu, Au?	Chrysoc, Au?, Specu, Lim	Qz	vein/stockwork	340	90	60×4.5	Ad, Dac-po		-	-	Porphyry-Cu,Au	12,13

Table 1-3-2 List of Ore Deposits and Prospects in the Study Area

No.	Name	Location UTM N	Location UTM E	Type of Ore	Ore Mineral	Gangue Mineral	Form of Ore Deposit	Direction of Strike / Structure	Dip	Dimension Length × Width (m)	Wall Rock	Alteration	Ore Reserve (Million t / category)	Ore Grade	Type of Mineralization	Source of Data
131	Don Manuel	7679677	529936	Au, Mn	Au, Mn-oxi, Lim	Qz	vein/stockwork	0-342	90	470 × 1.5	Ad		-	-	Vein-Au	12,13
132	Esperanza	7679012	530455	Cu, Au	Chrysoc, Atac, Turq, Chenev, Au		vein/stockwork	338	90	Wd: 1-3	Dac-po		-	-	Porphyry-Cu,Au	12,13
133	Forasteras	7678791	530246	Au,Cu	Au, Mal, Chrysoc, Chenev, Lim	Qz	vein	312	70S	Wd: 1-4	Dac-po		-	-	Vein and Irregular-Cu	12,13
134	Anita	7678349	530038	Au, Ag	Au, Specu, Lim	Qz	vein	20	63N	800 × 2	Dac-po		Possible: 1	Au 7.6g/t, Ag 100g/t	Vein-Au	12,13
135	Rosario (Collahuasi),	7681445	531395	Cu,Mo	Cp, Cc, Mo, Chrysoc, Mal, Py, Lim	Qz	vein/stockwork	NW-SE	-	Altered zone: 2500 × 1000	Dac-po(Olig)	Ser, Prop, (U/G: Mt, Bio, Kf, Chl	Rosario, supergene enriched ore:50	Cu 1.5%	Porphyry-Cu,Mo	3,4,9,12,13
					Alongside but higher than porph. Cu: En							Alongside but higher than Por. Cu: (Qz-Alu)	Rosario, primary ore: 710	Cu 0.93%		
136	Ujina (Collahuasi)	7675008	540008	Cu			stockwork						supergene enriched ore:>100	Cu 2%	Porphyry-Cu	3,4
													Ujina, primary ore: 1266	Cu 0.78%		
137	Venus	7680891	532121	Cu	Cp, Cc, Bn, Chrysoc, Mal, Py, Lim	Qz	vein/stockwork?	-	-	-	Dac-po, Ad				Porphyry-Cu	12,13
138	Ponderosa	7680448	532225	Cu	Cp, Bn, Tet, Cc, Chrysoc, Mal, Py, Lim	Qz	stockwork?	320	70S	wd: 13	Dac-po		Possible: 0.5	Cu 8%, Ag 60g/t, Au 1g/t	Porphyry-Cu	12,13
139	San Carlos	7680226	532432	Cu	Cp, Bn, Cc, Chrysoc, Turq, Py, Lim	Qz		300	73S	wd: 9	Altered po		-	Cu 18.7%	Unknown-Cu	12,13
140	Jilguero	7679008	532534	Cu	Chrysoc, Mal, Lim	Qz	vein?	330	90	wd: 1.5	Gd-po		-	-	Vein and Irregular-Cu	12,13
141	Tinque	7678788	531806	Cu	Chrysoc, Mal, Lim	-	vein?	-	-	-	Dac-po		-	-	Vein and Irregular-Cu	12,13
142	Las Granadas	7673814	490544	Cu			vein						s		Vein and Irregular-Cu	12
143	Quebrada Blanca	7674166	512158	Cu,Mo	Lim, Py, Cp, Mo, Bn, Cu-oxi		stockwork			Altered zone: 7km², Mineralized zone (E-W): 2000 × 1000m Leaced zone: 80-100m, Sec. Enriched zone: 30-100m	Qz-Monz(Olig), Dac/Rhyo-po	Prop, Clay, Qz-Ser, Sil, Bio, (Kf), Tou	supergene enriched ore: 90	Cu 1.3%,	Porphyry-Cu,Mo	2,3,7,12
													primary ore: 400	Cu 0.5%, Au 0.1g/t, Ag 1-2g/t, Mo 0.015%		
144	Yareta, Yaretita	7675704	523174	Ag,Au,Mn			vein						s		Vein-Au	12
145	Jovita	7681561	528484	Cu	Cc, Bn, Cov, Chrysoc, Mal	-	vein	NW	90	-	Altered po		s	-	Vein and Irregular-Cu	12,13
146	Ingenio	7681450	529108	Fe	Py, Lim	Qz	-	NW	90	-	Altered po		-	-	Unknown-Fe	12,13
147	Trinidad	7674582	526706	Ag,Mn	Mn-oxi., Lim	Qz	vein	280	90S	100 × 0.5	Gd		s	Mn 15.3%, Ag 806g/t, Au 2.37g/t	Vein-Au	12,13
148	Moctezuma, (Borracha)	7674922	527538	Ag, Au,Cu,Mn	Psilomelane, Pyrolusite		vein	350	80S	300 × 2	Dac-po, Ad		>2	Mn 10%, Ag 250g/t, Au 2g/t	Vein-Au	12,13
149	San Nicolas	7679902	527962	Cu, Mn, Au	Chrysoc, Atac, Mn-oxi, Lim	Qz	vein	300	90	600 × 5	Dac		-	-	Vein and Irregular-Cu	12,13
150	Anita	7664311	482242	Cu,Au			vein						s		Vein and Irregular-Cu	12
151	Sud-America	7678349	529830	Cu	Chrysoc, Mal, Turq, Chenev, Au, Lim, Mn-oxi	Qz	vein	10	80W	400 × 1	Dac-po		-	-	Vein and Irregular-Cu	12,13
152	Pergolesi	7678238	530038	Cu	Cp, Cc, Chrysoc, Mal, Au, Py, Lim	Qz	vein	30	70N	wd: 5	Ad, Tuff		-	-	Vein and Irregular-Cu	12,13
153	Delirio	7678127	530349	Cu, Au	Cp, Cc, Chrysoc, Mal, Au, Py, Lim	Qz	vein	0	90	wd: 4	Ad, Dac-po		-	-	Vein and Irregular-Cu	12,13
154	Los Caciques	7677904	531492	Au	Au, Lim, Mn-oxi	Qz	vein	339	90	wd: 1	Dac		-	-	Vein-Au	12,13
155	Japonesa	7677575	529725	Cu	Cp, Cov, Enar, Chrysoc, Chenev, Py, Lim	Qz	vein	NW	90	wd: 0.3	Dac, Ad		-	-	Vein and Irregular-Cu	12,13
156	La Borracha	7677353	530036	Cu	Chrysoc, Atac, Lim	Qz	vein	350	40E	wd: 1	Ad		-	-	Vein and Irregular-Cu	12,13
157	Dulcinea	7676467	530242	Cu	Chrysoc, Mal, Lim	Qz	vein	320	75N	wd: 1	Rhy-po		-	-	Vein and Irregular-Cu	12,13
158	Quilahuena	7661652	480064	Cu,AU	Chrysoc, Au, Lim	Qz	vein	32	69E	40 × 2	Cret (contact of Gd)	-	Probable: 0.002, Possible: 0.006	?	Vein and Irregular-Cu	10,12
159	Pirula	7666309	489718	Ag,Pb			no record								Unknown-Ag,Pb,Zn	12
160	Capona, (Quebrada de Mani)	7668524	482625	Au,Ag,Cu	Gn, Py, Lim, Chalcanthite	Gyp	vein	100	80N	200 × (0.1-0.7)	Jur, Tert	-	Probable: 0.002	Ag 15-1000g/t, Pb 1-36%	Vein and Irregular-Cu	10,12
161	Olqa, Lorena, Caniqueta	7668305	502181	Cu,Au			stockwork						s		Porphyry-Cu,Au	12
162	Julia	7665195	518486	Cu			no record								Unknown-Cu	12
163	Tres Marias, (La Peruana)	7665185	526379	Cu	Cu-oxi	-	vein	45	90	wd: 1-2	Gd		s	-	Vein and Irregular-Cu	12
164	Gales	7665183	527210	Cu	Cu-oxi	-	vein	305	90	wd: 1	Rhy-po		s	-	Vein and Irregular-Cu	12
165	La Esperanza	7663970	524923	Cu	Cu-oxi	-	vein	-	-	4 × 1	Gd		s	-	Vein and Irregular-Cu	12
166	Conacona	7661971	528970	Au			vein						s		Vein-Au	12
167	Macata	7658894	510381	Cu			no record								Unknown-Cu	12
168	Chocal	7651477	512452	Au			no record								Unknown-Au	12
169	Jovita	7671392	519844	Cu		-	vein			-			s	-	Vein and Irregular-Cu	12
170	Santa Rosa (Queen Elizabeth)	7801352	501079	Cu			vein, stockwork						s		Porphyry-Cu	12
171	Cucho (Queen Elizabeth)	7803746	503302	Cu			vein, stockwork						s		Porphyry-Cu	12

Abbreviation (Table 1-3-2)

<Ore Mineral>

Angl	Anglesite
Antl	Antlerite
Apy	Arsenopyrite
Arg	Argentite
Atac	Atacamite
Azur	Azurite
Bn	Bornite
Cc	Chalcocite
Cerus	Cerussite
Chalcan	Chalcanthite
Chenev	Chenevixite
Chrysoc	Chrysocolla
Cov	Covelline
Cp	Chalcopyrite
Cup	Cuprite
Enar	Enargite
Gn	Galena
Hem	Hematite
Lim	Limonite
Mal	Malachite
Mo	Molybdenite
Mt	Magnetite
Oxi	Oxide
Py	Pyrite
Sp	Sphalerite
Specu	Specularite
Stib	Stibnite
Teno	Tenorite
Tet	Tetrahedrite
Turq	Turquiose

<Gangue Mineral>

Adul	Adularia
Alb	Albite
Alu	Alunite
Ba	Barite
Bio	Biotite
Cal	Calcite
Gyp	Gypsum
Jar	Jarosite
Kao	Kaolinite
Mont	Montmorillonite
Or	Orthoclase
Pyroph	Pyrophyllite
Qz	Quartz
Ser	Sericite
Tou	Tourmaline

<Wall Rock>

Ad	Andesite
Adam	Adamellite
Congl	Conglomerate
Dac	Dacite
Di	Diorite
Gd	Granodiorite
Monz	Monzonite
Po	porphyry
Rhyo	Rhyolite
Rhyodac	Rhyodacite
Sedim	Sedimentary
Ss	Sandstone
Trachy	Trachytic
Tert	Tertiary
Olig	Oligocene
Mesoz	Mesozoic
Cret	Cretaceous
Jur	Jurassic
Paleoz	Paleozoic

<Alteration>

Chl	Chlorite
Epi	Epidote
Kao	Kaoline
Kf	K-feldspar
Lim	Limonite
Mt	Magnetite
Prop	Propyritization
Py	Pyrite
Qz	Quartz
Ser	Sericite
Sil	Silicification
Tou	Tourmaline
u/g	Underground

<Type of Mineralization>

Ir	Irregular, pocket
Por	Porphyry
St	Stratiform
Unk	Unknown
Ve	Vein

<Category of Ore Reserve>

Metal (ore grade)	s	m	
Cu *1	<10,000	10,000–	10,000
Au *1	<2	2–	200
Ag *1	<60	60–	6,000
Mn(48%) *2	<100,000	100,000–	10,000,000
Fe(60%) *2	<500,000	500,000–	50,000,000
Pb *1	<25,000	25,000–	2,500,000
Zn *1	<20,000	20,000–	2,000,000

*1 fine metal (t)
*2 ore reserve (t)

<Source of Data>

1 Canadian Minilng Journal (2000)
2 Mineral Yearbook (1997)
3 Mining Magazine (1992)
4 Mining Magazine (1999)
5 MMAJ (1978)
6 Olivier C. (1968)
7 Ramirez C. and Huete C. (1981)
8 Salas R., Kast R., Montecinos F. and Salas I. (1966)
9 Sillitoe R. (1991)
10 Skarmeta J. and Marinoic N. (1981)
11 Thomas A. (1967)
12 Ulriksen C. (1990)
13 Vergana H, and Thomas A. (1984)

southern part of the survey area, Miocene volcanic product in the southeasternmost part and Miocene~Pliocene volcanic product in the northern and central~southern part. The latter has ignimbrite, and is distributed in areas with relatively gentle relief around the Paleozoic~Mesozoic area.

In the eastern part of the survey area, Pliocene~Pleistocene volcanic products are distributed throughout the zone north of the central part, along the Bolivia border etc.

Quaternary sand and gravel are distributed widely in the western part of the survey area.

There is a N-S trending zone with development of faults south of the central part of the survey area. This fault group consists of continuous faults of N-S system and those of NE-SW system derived from the former faults. The faults of N-S system include the West Fault which is estimated to be controlling the distribution of the porphyry copper deposits. On the other hand large faults of NNW-SSE~NW-SE system are predominant in the northern part. NNW-SSE~N-S trending faults developed in the north may be located in the northern extension of the N-S fault group of the central part.

Many prospects of base metals Cu, Pb, Zn, etc., and precious metals Au, Ag occur in Paleozoic~Mesozoic areas and its periphery, and large scale deposits and prospects of porphyry copper type exist in those prospects (Fig. 1-3-2, Table 1-3-2). Prominent mineralization of porphyry copper type are as follows;

Southern part : Collahuasi-Ujina deposits, Quebrada Blanca deposit, Olga prospect, Copaquire prospect
Central part : Cerro Colorado deposit, Mocha prospect, Queen Elizabeth prospect, La Planada prospect
Northern part : Tignamar prospect

Regarding the above of porphyry copper-type mineralization, Cerro Colorado deposit and Mocha prospect are considered to be the product of Paleogene to Early Eocene mineralization, and are correlated to the porphyry copper zone in Peru. Others are considered to have formed by mineralization between late Eocene and early Oligocene.

CHAPTER 4 INTEGRATED ANALYSIS OF THE SURVEY RESULTS

4・1 Geologic Structure, Mineralization Characteristics, and Mineralization Control

The geology, alteration, and the characteristics of mineralization are summarized in Table 1-4-1.

The characteristic modes of occurrence of porphyry copper mineralization are as follows. ① The existence of porphyry or granitic rocks accompanied by stockwork・dissemination type mineralization, ② the existence of potassic or phyllic alteration, ③ existence of Au, Ag, Cu, Mo, As rock geochemical anomalies, ④ existence of relatively high-temperature and high salinity mineralizing solution, ⑤ low Pb/Cu ratio.

Such geologic conditions are found in Mocha and La Planada districts. And porphyry copper deposits have already been discovered in the Mocha district. Thus the geology of the Mocha district is a model for evaluating the porphyry copper potential of other districts.

Regarding the above ① to ⑤ geologic conditions, although there are a few unclear points, relatively good agreement is found in the mineralized zones of southern part of the Queen Elizabeth district and the west mineralized zone of the Camarones district.

The mineralization age of both southern Queen Elizabeth district and La Planada district is middle to late Eocene (39~38Ma) and coincides with that of the northern Chile (43~31Ma).

In the west mineralized zone of the Camarones, the occurrence of 10m-thick secondary enrichment zone is confirmed by drilling. The inferred age of alteration of quartz porphyry, 67±2Ma, corresponds to the oldest mineralization age (65~50Ma: Clarke et al., 1990) of porphyry copper zone in Peru. As this zone is located at the westernmost part of the above mineralized zones, this is believed to be a reasonable figure.

The characteristics of the chemical compositions of the geochemical anomalies and the alteration of the mineralized zones in the Quebrada Camarones and the southernmost part of the survey area are as follows. Those in localities of large-scale granitic intrusion show porphyry copper-type anomalies and those in the vicinity are of hydrothermal type. But the salinity of the quartz fluid inclusions is all very low and the homogenization temperature decreases from the central mineralized zone of the Quebrada Camarones outward. These alteration associated with mineralization was caused by hydrothermal activity related to magmatic intrusion around the west~central mineralized zone of the Quebrada Camarones which occurred following the igneous activity of the quartz porphyry that formed the porphyry copper-type mineralization of the west mineralized zone of the Quebrada Camarones. It is believed that the igneous activity of the quartz porphyry of this zone occurred under lithostatic pressure while the following magmatic activity occurred under increasing static water pressure and thus porphyry copper deposits were not formed and epithermal activity became dominant.

The Pb/Cu ratio of the Camarones west mineralized zone is slightly higher than that of the typical porphyry copper mineralization. It is known that Pb/Cu ratio declines toward the center of porphyry copper mineralization (Atkinson Einaudi 1975, JICA·MMAJ 1999). Thus this Camarones west mineralized zone could correspond to the periphery of porphyry copper mineralization.

The Camarones northwest mineralized zone includes porphyry copper-type alteration and quartz veins, but copper minerals are not found and the salinity of the quartz vein fluid inclusions is very low. Also in the vicinity of this mineralized zone, Neogene ignimbrite and quartz veins are developed ion the Quaternary formations. The relation between these epithermal mineralization and porphyry copper mineralization is not clear.

The northern Tignamar district show porphyry copper-type mineralization and alteration and secondary enrichment zone is said to have been confirmed by shaft. The results of the present survey indicate that porphyry copper-type mineralization and epithermal-type mineralization are overlapping in this district. The evidences are; the low salinity of the fluid inclusions, constitution of the geochemical anomalies, and the existence of Ag-Pb-Zn veins at relatively short distances. Such overlapping could results in enrichment of the mineral deposits, but if the transition from porphyry copper-type mineralization to epithermal activity is early, rich porphyry copper deposits are probably not formed. The low grade of Cu and Mo on the surface may indicate the possibility of the latter case.

In the Soledad district, porphyry bodies with age similar to that of the porphyry of the Mocha district occur in the central part of an annular structure. Porphyry copper-type mineralization and alteration occur in these bodies and thus there is a possibility of mineralized zones in the intruded plug, but the scale of the phyllic alteration is small and the vicinity is propylitized zone.

Table 1-4-1 Characteristics of Geology, Alteration and Mineralization at the Survey Areas

Area	Wall Rock (Age)	Ore Bringer	Alteration Minerals	K-Ar Age (Ma) of Primary Rock / Alteration	Ore Minerals	Gangue Minerals	Development of Quartz Vein	Fluid Inclusion		Cu content (average ppm)	Mo content (average ppm)	Total number of samples	Anomalous Samples								Pb/Cu	Elements of Strong Geochemical Anomaly	Dominant Principal Component with High Score
								Disappearance Temperature (average °C)	Salinity (NaCl average wt%)				Cu>84ppm Number	Cu>84ppm %	Cu>260ppm Number	Cu>260ppm %	Cu>581ppm Number	Cu>581ppm %	Mo>36ppm Number	Mo>36ppm %			
Moche	Dacite (K), Qz-porphyry (T), Meta-volcanics (K), Andesite (K), Rhyodacite (K), Quartz diorite (K)	Qz-porphyry (T),	Qz, Tou, Ser, Smec, Chl, (Epi), Cal, Kao, Gyp, Jar,	56	Cp, ((Py)), Cov, At, Cry, Goe	Si, Tou, Kf, Ser, Chl, Ana, (Zir), (Mon), (Apa)	abundant	332-339	40.5-42.3	3327	21	8	7	88	7	88	7	88	3	38	0.051	Au-Cu	-
Soledad	Andesite (K), Meta-andesite (K), Granodiorite porphyry (T), Qz-porphyry (T), Rhyodacite (K), Quartz diorite (K)	Granodiorite porphyry (T), Qz-porphyry (T),	Qz, Tou, Ser, Smec, (Chl), (Epi), (Amp), Ka, (Jar),	52.1±2.0 (Bi-alteration)	Py, Cp, (Gal), (Po), (CuZn), (Goe)	Si, Tou, Chl, (Tit), Ana, (Zir), (Mon), (Apa), (Opx), (Cpx), (Cal), (Epi)	small	-	-	166	7	20	9	45	2	10	1	5	0	0	0.185	Cu-Zn-As	-
Northern Queen Elizabeth	Andesite (K), Dacite (K)	-	Qz, Ser, Smec, Al, Ka	-	Py, Lim, Hem	Qz	small	-	-	15	10	31	0	0	0	0	0	0	1	3	8.086	As-Hg	-
Central Queen Elizabeth	Meta-siltstone (K)	-	Qz, Ser, Smec, Tou	-	-	Qz, Tou	none	-	-	75	7	15	2	13	1	7	0	0	1	7	9.703	Au-Ag-Pb-Zn-As-Hg	-
Southern Queen Elizabeth	Andesite (K), Dacite (K), Granodiorite (K), Granodiorite porphyry (T), Qz-porphyry (T), Rhyodacite porphyry (T),	Granodiorite porphyry (T),	Qz, Tou, Bi, Ser, Smec, Chl, (Epi), (Cal), Ka, (Alu), (Gyp), (Jar)	38.0±1.4 (Bi-alteration)	Py, Cp, Cry, Mal, Gal, Hem, Goe	Si, Kf, Ser, Ana, (Zir), (Mon), (Apa), (Cal), (Jar)	abundant	424	-	10703	70	17	14	82	14	82	11	65	6	35	0.195	Cu-Mo	-
Diana	Siltstone (J), Quartzite (J), Meta-chert (J), Meta-basalt (J), Andesite (K), Granodiorite porphyry (K/T), Dacite porphyry (K/T), Granite (K/T), Qz-porphyry? (K/T)	Granodiorite porphyry (K/T), Qz-porphyry? (K/T)	Qz, Ser, Chl, (Epi), Ka, (Jar)	-	Py, (Cp), (Hm), Goe	Qz, Ser, Ba	small	-	-	105	14	44	16	36	3	7	1	2	4	9	0.379	Au-Cu-As	-
La Planada	Meta-dacite (K), Meta-porphyry (K), Meta-volcanics (K), Granodiorite (K), Diorite (T), Granodiorite porphyry (T), Qz-porphyry (T)	Diorite (T), Granodiorite porphyry (T), Qz-porphyry (T)	Qz, Tou, Kf, Bi, Chl?, Ser, Kao, Trem, Ep	38.1±0.9, 38.6±1.3, 39.2±1.7, (Bi-alteration)	Py, Cp, Mo, (Bo), (Cov), (Pyr), Cry, (Ang), Cer, (Hem)	Si, Tou, Chl, (Kf), (Bio), (Ser), (Tit), (Ana), (Zir), (Mon), (Apa), (Cpx), (Cal)	abundant	328-334	40.4-40.5	9607	182	23	23	100	17	74	15	65	20	87	0.061	Cu-Mo-As	-
Eastern Chacarilla	Sandstone (J), Shale (J), Diorite (K/T), Porphyry (K/T)	Diorite (K/T), Porphyry (K/T)	Qz, Ser, Chl, Cal, (Ka)	-	Py, Mal, Lim	Qz, Ser, Chl, Apa	small	-	-	27	6	17	1	6	0	0	0	0	0	0	0.578	Zn-As	-
Western Chacarilla	Shale (J), Quartzite (J), Granodiorite porphyry (K/T)	Granodiorite porphyry (K/T)	Qz, Ser, Chl	-	Py, Cp, Cu-Zn	Qz, Chl, (Side), (Ba), (Gyp)	none	-	-	23	6	13	1	8	0	0	0	0	0	0	0.175	none	-
Northern Part of West Queen Elizabeth	Shale (K), Andesite (K), Diorite (K/T), Granite porphyry (K/T)	?	Qz, Ser, Chl, Epi, Smec, Ka, Pyroph	-	Py, ((Sp))	Qz, Kf, (Chl), (Bi)	rare	-	-	21	7	29	1	3	0	0	0	0	0	0	0.517	none	-
Southeastern Part of West Queen Elizabeth	Shale (J), Volcaniclastics (K), Granodiorite (K/T), Porphyry (K/T)	Granodiorite (T)	Qz, Ser, Chl, (Epi), (Ka)	41.3±1.0 (Bi-primary rock)	Py, Cp, Mal, Cu-oxi, Mt, Lim	Qz, Kf, (Ser), (Chl)	small	-	-	2687	8	15	3	20	2	13	2	13	0	0	1.319	Au-Cu-Zn-As	-
Central Part of West Queen Elizabeth	Andesitic volcaniclastics (K), Porphyry? (K/T)	?	Qz, (Bi), Ser, Epi, Ka, (Jar)	-	Py, ((Gal))	Pl, Cpx	none	-	-	20	5	8	0	0	0	0	0	0	0	0	0.253	none	-
Western Part of West Queen Elizabeth	Andesite? (K), Granite porphyry (K/T)	?	Qz, Ser, (Chl), (Ka)	-	-	-	none	-	-	13	3	8	0	0	0	0	0	0	0	0	0.527	none	-
Northern Tignamar	Andesitic volcaniclastics (K), Granodiorite (K/T), Granodiorite porphyry (K/T), Quartz porphyry (K/T)	Granodiorite (K/T), Granodiorite porphyry (K/T), Quartz porphyry (K/T)	Qz, Tou, Bi, Ser, Chl, Epi, (Ka),	-	Py, Cp, Cc, Cu-oxi	Qz, Tou, (Ser)	abundant	291	0.40	72	3	14	4	29	0	0	0	0	0	0	0.367	Zn-As-Hg	-
Southern Tignamar	Andesite (T-Q), Dacite (T-Q), Volcaniclastics (T-Q), Porphyry (T-Q)	?	Qz, Ser, Alu, Ka, Jar Smec	-	Py, Lim, Hem	Qz, (Cal)	small	-	-	20	3	26	0	0	0	0	0	0	0	0	3.467	Pb-Zn-As-Hg	-
Western Q. Camarones	Andesitic lava/volcaniclastics (K), Quartz porphyry (K)	Quartz porphyry (K)	Qz, Ser, Chl, Tou	67±2, (Whole rock-alteration)	Cc, Cp, Meta-alunogen, Cu-oxi, Py, Lim	Qz, Ser, Chl, Tou, Kf, Bi	abundant	-	-	Int. 1165	5	43	27	63	16	37	8	19	0	0	0.567	Cu-Mo-As	1, 4, 5, 6
										K 317	9	34	19	56	7	21	4	12	1	3	1.28		
Central Q. Camarones	Andesitic lava/volcaniclastics (K), Rhyolitic volcaniclastics (K-T), Quartz diorite (K), Quartz diorite breccia pipe (K), Quartz porphyry breccia pipe (K), Diorite (T), Diorite porphyry (T),	Quartz porphyry breccia pipe (K) ? or Diorite porphyry (T) ? or ?	Ser, Qz, Kf, Bi	-	Cu-oxi, Py, Lim	Qz, Gyp	small	362	0.6	Int. 45	6	17	3	18	0	0	0	0	0	0	0.775	Cu-Mo-As	1, 4, 6
										K, KT 694	22	11	3	27	1	9	1	9	1	9	1.66		
Eastern Q. Camarones	Andesitic lava/volcaniclastics (K), Rhyolitic volcaniclastics (K-T), Diorite (T)	Diorite (T) ?	Ser, Qz, Amp	-	Cu-oxi, Py, Lim	Qz, Kf, Chl, Ba	small	282	0.6	95	7	10	2	20	2	20	0	0	0	0	1.104	Au-Hg	5, 6
Southern Q. Camarones	Rhyolitic volcaniclastics (K-T)	?	Ser, Qz	-	Py, Lim, Hem	Qz	small	275～237	0.5	28	7	50	3	6	0	0	0	0	0	0	4.294	Pb-Mo-As-Hg	2, 4, 5
Southernmost Camarones	Rhyolitic volcaniclastics (K-T), Quartz diorite (K), Quartz diorite breccia pipe (K), Diorite porphyry (T),	Diorite porphyry (T) ?	Chl, Ser, Tou, Kf, Bi	51.3±1.7 * (Whole rock-primary)	Cu-oxi, Py, Hem, Lim	Qz, Kf, Bi	small	299～225	0.5～0.7	81	8	27	8	30	1	4	0	0	1	4	1.907	Cu-Mo-As-Hg	1, 2, 4, 5
Northwesternmost Camarones	Andesitic lava/volcaniclastics (K), Rhyolitic volcaniclastics (K-T), Quartz diorite (K)	Quartz diorite (K) ?	Qz, Epi, Ser, Amp, Bi, Kf	-	Lim, Hem	Qz, Epi, Bi, Tou, Kf	abundant	323	0.6	61	5	21	6	29	0	0	0	0	0	0	0.418	none	5, 6

Abbr. Py=pyrite, Hm=hematite, Lim=limonite, Mt=magnetite, Cp=chalcopyrite, Gal=galena, At=atakamite, Mal=Malacite, Goe=goethite, Cov=covellite, Cry=chrysocolla, Cu-oxi=Cu oxide, Po=pyrrhotite, CuZN=hydrous CuZn mineral, Cc=chalcocite, Sp=sphalerite, Kf=K-feldspar, Ser=sericite or muscovite, Bi=biotite, Ba=barite, Side=siderite, Chl=chlorite or clay minerals, Epi=epidote, Qz=Quartz, Si=SiO_2 minerals, Cal=calcite, Jar=jarosite, Pyroph=pyrophyllite, Alu=alunite, Ka=kaolin, Gyp=gupsum, Smec=smectite, Tou=tourmaline, Amp=Amphibole, Trem=tremolite, Cpx=clinopyroxene, Opx=orthopyroxene, Pl=plagioclase, Ana=anatase, Apa=apatite, Tit=titanite, Zir=zircon, Mon=monazite, J=Jurassic, K=Cretaceous, T=Tertiary, KT=Cretaceous-Tertiary, I=Intrusive *: Age of Diorite porphyry at eastern Quebrada Camarones

Alteration of the northern and central Queen Elizabeth districts is acid alteration dominant and acidic-phyllic dominant types respectively. The mineralization is weak, and the Pb/Cu ratio and the element constitution of the geochemical anomalies indicate epithermal mineralization.

The alteration in the Diana district is acid-phyllic-propylitic alteration and the relatively small Pb/Cu ratio and the constitution of the geochemical anomalies suggest porphyry copper-type mineralization. This district is said to lack Upper Jurassic~lower Pliocene formations, and this is a relatively long absence compared to other areas where Upper Cretaceous~Miocene or lower Paleogene to Oligocene formations are lacking.

In the Chacarilla district, mineralization and alteration with the possibility of porphyry copper deposits occur, but the Cu and Mo grades are low, and such mineralization is considered to be of small scale.

In the West Queen Elizabeth district, acidic-intermediate-propylitic alteration zones occur in the northern, central, and western parts, but the degree of mineralization is very weak. The Pb/Cu ratio indicate that the activity in the former two parts could be epithermal mineralization.

In the southeastern part of the West Queen Elizabeth district, magnetite-containing copper mineralization occur controlled by fractures at the border of granodioritic bodies and they are considered to be formed by hypothermal activity. The age of granodiorite is middle Eocene (41Ma) and it overlaps the age of the major porphyry copper deposits in northern Chile. But quartz stockwork veinlets are not developed and the Pb/Cu ratio of this mineralized zone is higher than that of the typical porphyry copper deposits. Thus the depth of the formation of these deposits could be deeper than porphyry copper deposits.

In the southern Tignamar district, the alteration is acidic dominant, and the Pb/Cu ratio and the constitution of the geochemical anomalies indicate epithermal-type mineralization, but the degree of mineralization is weak.

The distribution of many faults, subsurface intrusive bodies, and caldera structures extracted by airborne magnetic survey is harmonious with that of known mineralized zones and regional geologic structure (AP-17, AP-18).

4・2 Mineral Potential

In the Mocha district, porphyry copper deposits were discovered by drilling and a reserve of 60 million tons of Cu 0.4% ore has been already delineated. Porphyry copper-type mineralization and alteration occurs in the eastern part of this district and its Cu content is high and the existence of ore deposits is highly possible. Also at the Soledad district on the southern side of this eastern altered zone, there is a possibility of mineralized zones in the intruded plug, but he surface alteration is of a small scale. It is seen from the above that regarding mineral potential of this district, possibility of porphyry copper deposits under the alteration zone in east Mocha district and between the above alteration zone and the Soledad district is anticipated. The topography of this zone is rugged, but it is relatively close to the existing road.

Southern part of the Queen Elizabeth district and the La Planada district are extremely promising for locating porphyry copper deposits from geologic conditions, mineralization and alteration. The topography of the southern Queen Elizabeth district is relatively gentle and is close to existing road and is easy to explore. The topography of the La Planada is relatively rugged, but a road passes through the area and the access is relatively easy.

The mineralization and alteration of the Diana district is similar to the Au-rich mineralization and alteration formed above the porphyry copper mineralization, and thus there is a possibility of blind deposits beneath the surface. Although there are no access roads, the topography is relatively gentle and the area is relatively easy to explore.

In the northern Tignamar district, the occurrence of porphyry copper-type mineralization is confirmed in the northern part. The extent of the mineralized zone is not clear, but there are possibilities of the occurrence of dominant propylitization and epithermal mineralization. Thus the existence of negative factors for large-scale porphyry copper mineralization cannot be denied. Drilling was carried out in parts of the southern part of the district and it is clarified that the alteration zones extend southward. Therefore, there are rooms for exploration in the southern alteration zones, but the topography is rugged and the access is not easy.

Localities of ground truth other than those mentioned above are either poor in porphyry copper-type indications or weak in mineralization and the porphyry copper potential is low.

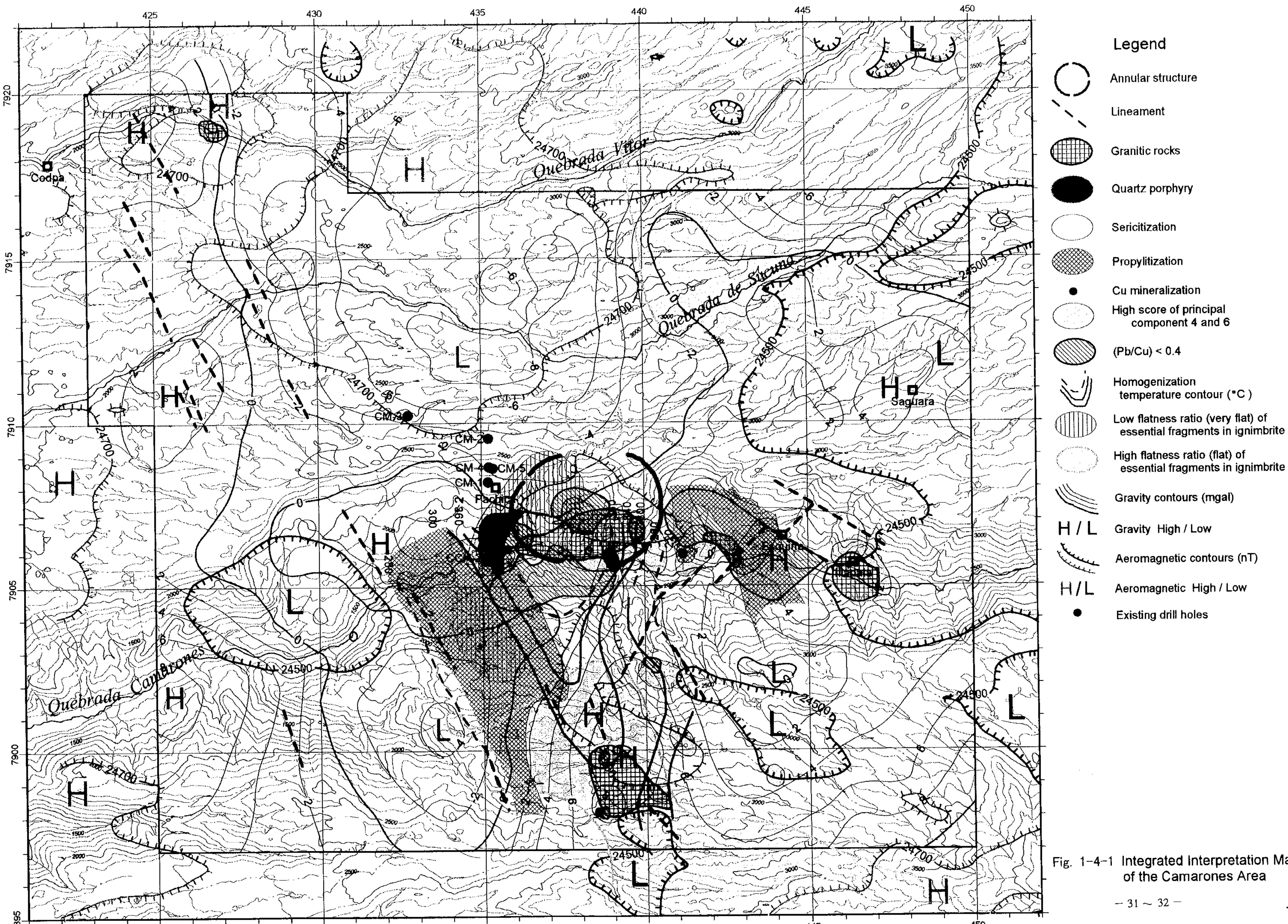

Fig. 1-4-1 Integrated Interpretation Map of the Camarones Area

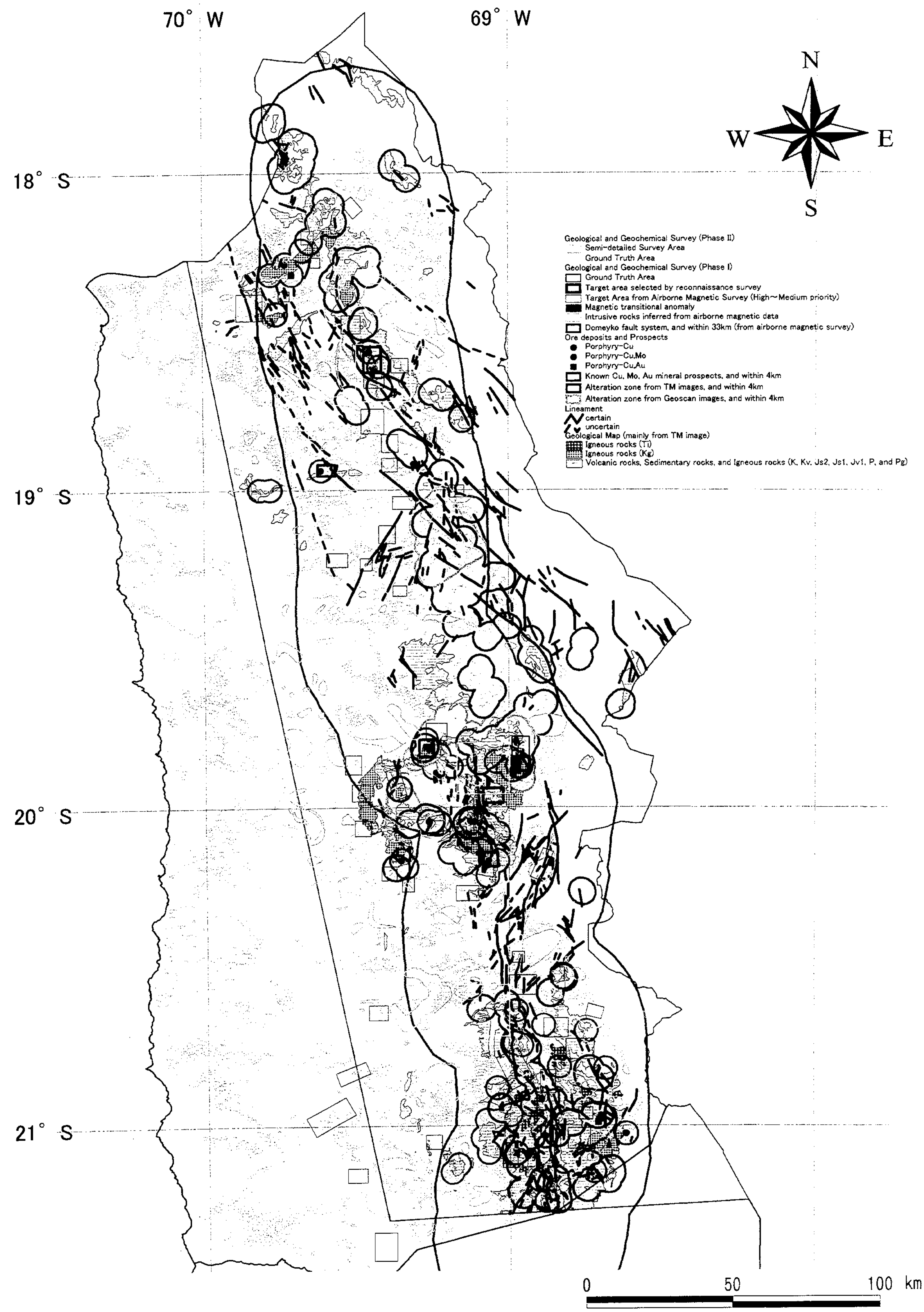

Fig. 1-4-2 Integrated Interpretation Map of the Region I Area

The results of the survey in the Camarones are summarized in Figure 1-4-1. The results of new interpretation of a 1/50,000 TM image are also included. Also low Pb/Cu parts from the Pb/Cu contour map (appended; anomaly grades processed by contour map software Surfer 7.0, but the sampling locations are not evenly distributed and may affect the accuracy). This contour map was prepared by using the geochemical survey and ore assay results of the southern part of this district.

In the Quebrada Camarones~southernmost part of the survey area, sericitized · pyritized zones, an annular structure, high magnetic anomalies, large-scale intrusions occur around the west mineralized zone (southern Pachica) ~ central mineralized zone. Also high-temperature hydrothermal activity inferred from fluid inclusion data, high score of the fourth and sixth principal components which indicate porphyry copper-type mineralization from geochemical data, band low Pb/Cu parts of rocks are distributed here. The annular structure indicates upward pressure by buried plug intrusion. The high magnetic anomalies indicate intrusion of igneous rocks in subsurface zones. The high-temperature hydrothermal solution indicates the center of hydrothermal activity related to igneous intrusion. The low Pb/Cu ratio indicate center of porphyry copper mineralization. All of the above phenomena occur in a saddle of high gravity anomaly, and this fact indicates low density of the quartz porphyry or altered rocks in comparison to the unaltered rocks in the vicinity. Thus center of porphyry copper deposit is anticipated to occur between the west and the central mineralized zones, and the copper mineralization of the quartz porphyry of the west mineralized zone is believed to be the periphery of the above mineralization. The results of drilling carried out in a locality to the north~northwest of the west mineralized zone are not clear, but it does not coincide with the promising zones inferred from the present survey. The bottom of the ignimbrite of the zone between the west and the central mineralized zones is inferred to be shallower relative to other areas from the flatness of the essential fragments contained in the welded tuff and the gravimetric three-dimensional analysis. This is a favorable factor for exploration. The locality is on a steep slope of the northern bank of the Quebrada Camarones and these factors cause difficulties concerning mineral exploration.

The mineral showings and fluid inclusion data of northwestern Camarones indicate that this mineralized zone is possibly the peripheral phase of porphyry copper mineralization. This mineralized zone coincides with high magnetic anomaly and another high magnetic anomaly occurs on the northern side. The possibility of these high magnetic anomalies indicating buried igneous intrusive bodies is believed to be high. And the possibility of these igneous bodies being accompanied by porphyry copper mineralized zones is also considered, but it is difficult to actually delineate exploration targets.

Airborne magnetic survey was carried out for the whole survey area (Region I) and regional geologic structure, and local and regional magnetic characteristics were clarified. Comprehensive examination of these data together with the occurrence of known mineralized zones enabled the extraction of localities promising for occurrence of porphyry copper mineralized zones, epithermal mineralized zones containing Au and Ag, and related volcanic domes (Fig. 1-4-2).

CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS

5 - 1 Conclusions

The following results were obtained from the geological · geochemical survey, gravity survey, and airborne magnetic survey carried out during the second year of the project in the Region I.

Geological survey · geochemical survey

Ground truth and reconnaissance surveys were carried out during the first and second year at four localities each year, a total of eight localities. These localities were extracted as promising for locating mineral deposit by analyses of existing data, satellite images, and other relevant information. These surveys confirmed that the localities with geologic characteristics of porphyry copper mineralization and mineral potential are; Mocha-Soledad district, La Planada district, Queen Elizabeth district, Tignamar district, Camarones district, and Diana district (Fig. 1-4-2). Drilling in parts of the Mocha-Soledad, Tignamar, and Camarones district discovered porphyry copper-type secondary enrichment zones. Of these districts, most potential localities, from the intensity of Cu-Mo mineralization, are concluded to be the Queen Elizabeth and La Planada districts.

In the Mocha-Soledad district, there is a possibility of porphyry copper deposit occurrence at northeastern Mocha and between eastern Mocha and Soledad aside from the deposits confirmed in the Mocha district.

In the Tignamar district, there are alteration zones at two locations, namely in the northern and southern parts. The occurrence of porphyry-type mineralization has already been confirmed on the northern side of the northern part of the district. And although there are room for further exploration outside the drilled zones, there are negative factors regarding the further development of porphyry-type-mineralized zone such as propylitic alteration and the possibility of dominant epithermal-type mineralization. In the southern side of the northern part, there are wide occurrences of altered zones, which could not be surveyed this year, and there are rooms for further exploratory work, but the topography is rugged and the access is difficult.

In the Camarones district, a regional hydrothermal alteration zone was confirmed between the Quebrada Camarones and the southernmost part of the survey area. This regional alteration zone is believed to have been formed by a series of hydrothermal activity from porphyry copper-type to epithermal-type activity. The location of the center of this activity, namely the porphyry copper zone, was inferred from the study of annular structure, distribution of intrusive bodies, fluid inclusion data, geochemical anomalies, high magnetic anomalies, gravity anomalies, and other relevant data. The known copper mineralization in quartz porphyry host rock could possibly be a peripheral phase of this porphyry copper mineralization.

In the Diana district, the alteration zone is similar to the Au-rich mineralization · alteration zone formed above porphyry copper deposits. Thus there is a possibility of porphyry copper deposit occurrence in subsurface zones.

Localities other than those mentioned above are either poor in porphyry copper-type indications or weak in mineralization and the porphyry copper potential is low.

<u>Gravity survey</u>

High gravity anomaly occurs in the following localities; extensive area from the eastern to southeastern and southern part of the Camarones district, western margin of the survey area, and from middle stream of Quebrada Camarones to the west of Pachica. On the other hand, low gravity anomaly occurs in; wide area from the middle stream of Quebrada Vitor to the middle stream of Quebrada Sucuna in the northern part of the survey area, southern bank of the Quebrada Camarones in the southwest, and upstream Quebrada Sucuna in the northeastern margin.

The drainage zone of the Quebrada Camarones is in high gravity zone with the exception of a part of the southwest. The low gravity anomaly zone at the middle stream of Quebrada

Vitor to Quebrada Sucuna has relatively high gravity at its eastern, southern, and western border and has a clear outline.

Basement complex in the Camarones district is closely related to high gravity anomaly. This is evidenced by the high density, 2.50~2.80g/cm^3, of the rock samples. The high gravity anomalies indicate either surface exposure of the basement complex or its occurrence in shallow subsurface zones, namely either the lack or thin ignimbrite cover. On the other hand, the low gravity anomalies indicate deep basement complex and thick overlying ignimbrite. Three-dimensional two-layer modeling results show that the thickness of the ignimbrite cover is more than 500m at the extensive zone from the middle stream of Quebrada Sucuna to middle to upstream of Quebrada Vitor, and a belt on the southern bank of the upstream to middle reaches of Quebrada Camarones. It is estimated that the thickness would attain more than 1,000m in the high elevation zone in the northern to northeastern part and in the southeastern part of the survey area.

Extensive subsurface occurrence of intrusive bodies is inferred form the distribution of the high gravity anomalies and magnetic anomalies at; southern part of the survey area, near Esquiña in the central part, and east of Pachica. Parts of the intrusive bodies are exposed on the surface, and the overlying volcanic rocks are estimated to be less than 200~300m thick. These zones should be considered for future exploration. Results of analysis indicate that the basement complex occurs in shallow subsurface zones at; near Saguara in the east, downstream zone of the Quebrada Sucuna in the west, and downstream zone of the Quebrada Camarones. Notable magnetic anomalies, however, were not detected in these localities.

Airborne magnetic survey

Subsurface geologic structure of the whole survey area was clarified by magnetic analysis, and the northern continuity of the fault system related to mineralization was confirmed. An example would be the Domeyko Fault.

The structure of the subsurface intrusive bodies and calderas were inferred from magnetic data and these are harmonious with the known mineralized zones and regional geologic structure.

Areas with possibility of the occurrence of porphyry copper mineralization or Au/Ag-bearing epithermal mineralized zones/volcanic domes were extracted from the examination of regional geologic structure from magnetic analysis, local and regional magnetic characteristics, and the distribution of the known mineralized zones (Fig. 1-4-2).

5・2 Recommendations for the third year

1. Extract promising areas by comprehensive examination of ; the results of the airborne magnetic survey and the results of various surveys already carried out. And carry out ground truth survey of the extracted promising areas. This ground truth survey will verify the results of the airborne magnetic survey and will enable the extraction of areas for detailed survey.

2. Carry out gravity survey and other relevant work of areas where concealed mineralized zone is anticipated. These areas are within the promising areas mentioned above (1). These work will verify the results of the airborne magnetic survey and will enable the extraction of areas for detailed survey.

3. Examine the feasibility of drilling for subsurface porphyry copper deposits inferred to occur in the Camarones district.

4. Examine the necessity of detailed geological survey, geochemical survey, and gravity survey of areas where Corporacción Nacional del Cobre de Chile (CODELCO) holds concession. These are within the high porphyry copper potential localities (Mocha-Soledad, La Planada, Queen Elizabeth, Tignamar, and Diana) delineated by the ground truth survey of the first and second year.