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

PHASE III

MARCH 2002

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 third-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 September 22, 2001 to December 12, 2001.

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 third phase of the exploration project was prepared.

Results of the third-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.

March 2002

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ABSTRACT

Geological survey, drilling survey, and re-analysis of airborne magnetic survey results were carried out as the third year survey of the mineral exploration project in Region I. The results obtained are summarized as follows.

Geological Survey:

Magnetic susceptibility was measured for the entire area, and the relation between magnetic susceptibility and rock species and alteration was clarified.

The results of remanent magnetism measurement indicated that there are many airborne magnetic anomalies with reverse magnetic polarity in the survey area. Some of the low airborne magnetic anomalies, together with some of the high anomalies, possibly indicate blind intrusive igneous bodies or solidified magmas.

A total of 14 areas were surveyed with the purpose of verifying promising areas extracted from the results of airborne magnetic survey analysis, and also for geological reconnaissance. Two areas, namely Chusmisa and Camiña, were extracted as having high mineral potential. These two areas show geological features characteristic to porphyry copper type mineralization.

Phyllic or acidic alteration or mineralized zones were confirmed in 9 of the above 14 areas. These alteration zones or mineralized zones are in; periphery or vicinity of medium wavelength airborne magnetic anomalies, within or vicinity of intermediate magnetic intensity zones, and periphery or vicinity of short wavelength anomalies. However, the reverse is not true and magnetic anomalies do not necessarily mean existence of alteration zones, mineralized zones or shallow intrusive igneous bodies.

South of Chusmisa, Paleocene-Early Eocene (65-48Ma) porphyry copper belt and Late Eocene-Early Oligocene (43-31Ma) porphyry copper belt occur parallel with border extending almost in the N-S direction, to the north of Chusmisa, however, Paleocene-Early Eocene porphyry copper belt is developed and the Late Eocene-Early Oligocene belt is intersected by Neogene-Quaternary volcanic rocks. In the area between northeast of Chusmisa and Tignamar, there is a possibility of Late Eocene-Early Oligocene porphyry copper belt hidden below Neogene-Quaternary volcanic rocks, and possibly not existing.

Drilling:

Of the 12 holes drilled near airborne magmatic anomalies, 3 holes, MJC-1, MJC-11, MJC-12 reached pre-Oligocene units which are the porphyry copper host rock horizon. MJC-1 and MJC-11 are considered to have confirmed porphyry copper type mineralization and alteration zones, but the copper grade of the mineralized zones is low and the bonanza may exist near the 2 drill holes.

The 9 boles drilled elsewhere penetrated through Oligocene-Miocene conglomerate or younger units. MJC-10 in the area northeast of Camiña, confirmed the existence of pyrite mineralization and epithermal type mineralization and acidic alteration in Tertiary-Quaternary volcanic rocks.

The general trend of the magnetic susceptibility of the cuttings correspond well with the geology and alteration of the drill holes.

Re-analysis of the Airborne Magnetic Survey Results:

Frequency analysis of the airborne magnetic survey data revealed magnetic anomaly patterns characteristic to

porphyry copper mineralized zones. The genesis of this magnetic anomaly pattern is considered as follows. Medium wavelength magnetic anomaly was formed by batholithic complex body, which is a product of activity precursory to porphyry copper type mineralization. While short wavelength magnetic anomalies were formed by hypabyssal rocks including the ore deposits, and the intermediate magnetic intensity zones expresses the hydrothermal alteration zones associated with igneous intrusive activity.

During the process of delineating promising areas using these magnetic anomaly patterns, it is necessary to consider the following. Namely, similar magnetic anomaly patterns may appear in volcanic areas; intrusive igneous bodies may lose magnetism in large-scale alteration zones and may not be extracted as short wavelength magnetic anomalies; medium wavelength magnetic anomalies may not occur because of the interaction and mutual elimination by induction magnetism and remanent magnetism, and medium wavelength magnetic anomalies may be formed by topography and conglomerate formations.

Recommendation for the Future Survey:

Cooperative mineral exploration carried out in the Region I Area during the past three years resulted in the acquisition airborne magnetic data, geological and geochemical data, and other information which are very relevant for mineral exploration of the area. As this area is considered to be highly prospective regarding porphyry copper deposits, it is recommended that future prospecting be carried out fully utilizing these data.

It would be desirable to take note of the following points in the future work.

1. Survey Methods

In this area, thick young volcanic rocks cover the surface and it is difficult to detect the mineral deposits lying under these rocks. Airborne magnetic survey and gravity survey were implemented in order to clarify many of the problems concerning the geology of the area. The potential and problems of these methods are as follows.

(1) Airborne magnetic survey

CODELCO has shown that high macroscopic correlation exists between the major porphyry copper deposits of northern Chile and transverse magnetic anomalies. This fully applies to the major porphyry copper deposits in the central to southern parts of Region I. But transverse magnetic anomalies are not clear in the northern part, and thus in the present survey investigation was not limited to transverse magnetic anomalies, but all magnetic anomalies were analyzed and examined. Frequency analysis was adopted in order to consider the relation between porphyry copper deposits and magnetic anomalies in the level of individual anomalies. The existence of magnetic anomaly patterns each consisting of a set of medium wavelength magnetic anomaly, short wavelength magnetic anomalies, and intermediate magnetic intensity zones was discovered characteristic to known porphyry copper mineralized zones. Pattern analysis was carried out for these magnetic anomaly sets, and the results were applied to the survey area and promising zones for mineral prospecting were extracted on this basis.

Regarding the extracted promising zones, confirmation of alteration zones, mineralized zones, and of related igneous bodies will be the next step. Two-dimensional or 3-dimensional detailed modeling using airborne magnetic data is believed to be effective for determining the existence and scale of such igneous bodies. Modeling will not necessarily provide accurate information regarding the depth of these bodies and thus application of other methods (drilling, gravity, electromagnetic methods and others) is recommended.

(2) Gravity survey

The results of gravity survey carried out during the second year are believed to be effective for understanding the geologic structure such as the thickness of ignimbrite, but since the method is expensive in terms of areal coverage, it would be necessary to limit the area of survey. Also the usefulness of magnetic data will increase significantly by carrying out joint analysis with gravity data. In the future, if gravity survey - airborne or land - can be used to cover wide area economically, this would indeed be a very effective method to apply in this area.

2. Porphyry Copper Belts

Regarding the porphyry copper belt in Region I, its continuity north of Queen Elizabeth Prospect was not clear because of insufficient radiometric age data. The age determination carried out during the present survey clarified the metallogenic province of this area, and it is anticipated that the newly acquired data would contribute to the delineation of promising areas.

3. Promising Areas

It is recommended that the following survey be carried out in the future in order to clarify the geology and mineral deposits of the promising areas extracted by the present survey.

(1) Magnetic anomaly zones extracted by re-analysis of airborne magnetic survey.

Extract surface manifestations by satellite image analysis in the magnetic anomaly zones delineated by pattern analysis.

(2) Mineralized and altered zones extracted by geological survey

Carry out further detailed geological and other relevant surveys in the seven areas extracted by geological survey, namely Mocha-Soleda, La Planada, Queen Elizabeth, Tignamar, Diana, Chusmisa, and Camiña areas.

(3) Promising areas extracted by drilling survey

Carry out further drilling for blind buried porphyry copper mineralized zones inferred to occur in the Camarones area.

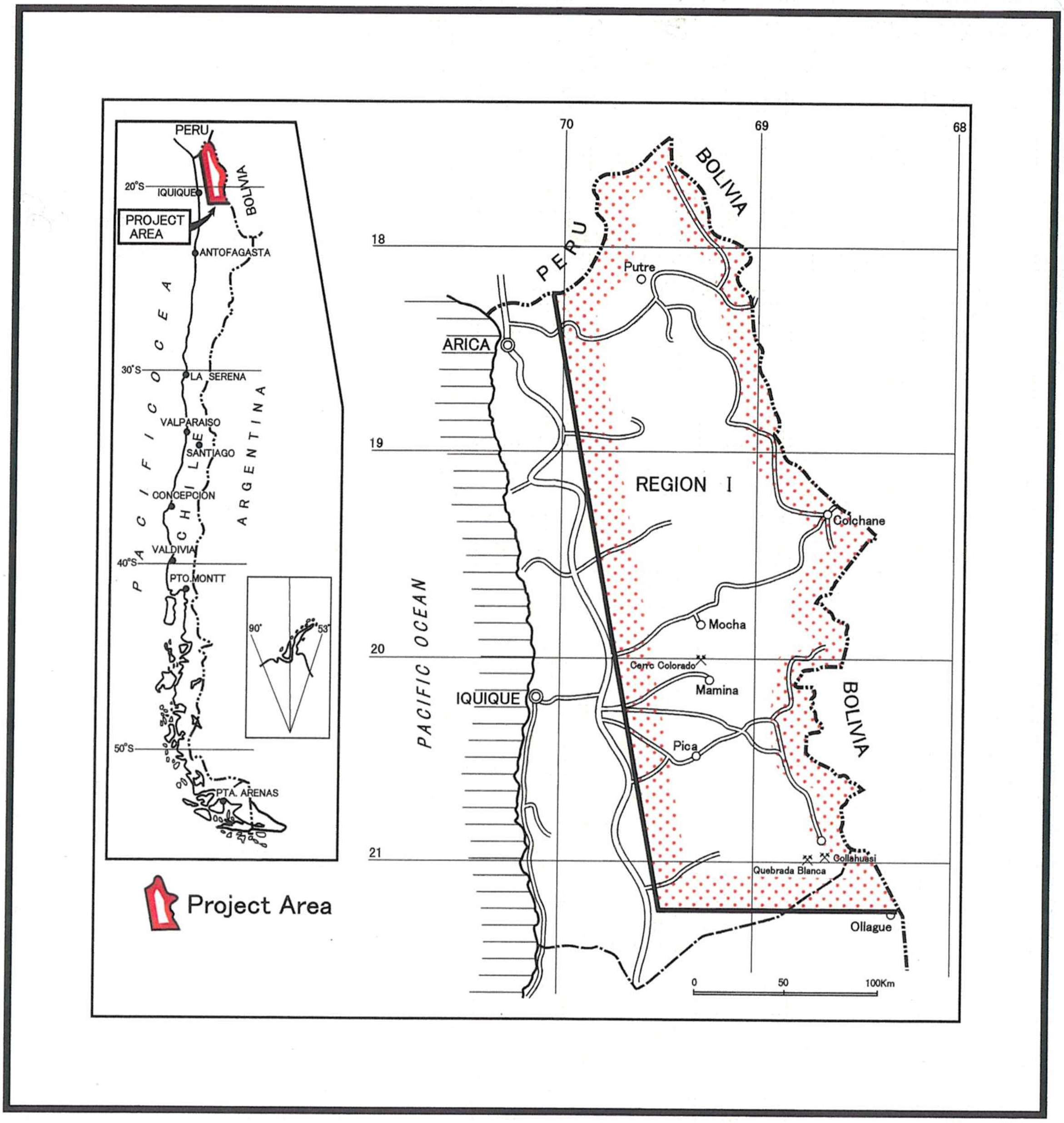

Fig. 1-1 Index Map of the Project Area

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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 third year of this project.

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

1-2-1 Conclusions of the Second phase

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. 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.

1-2-2 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.

1-3 Outline of the Third Phase Survey

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.

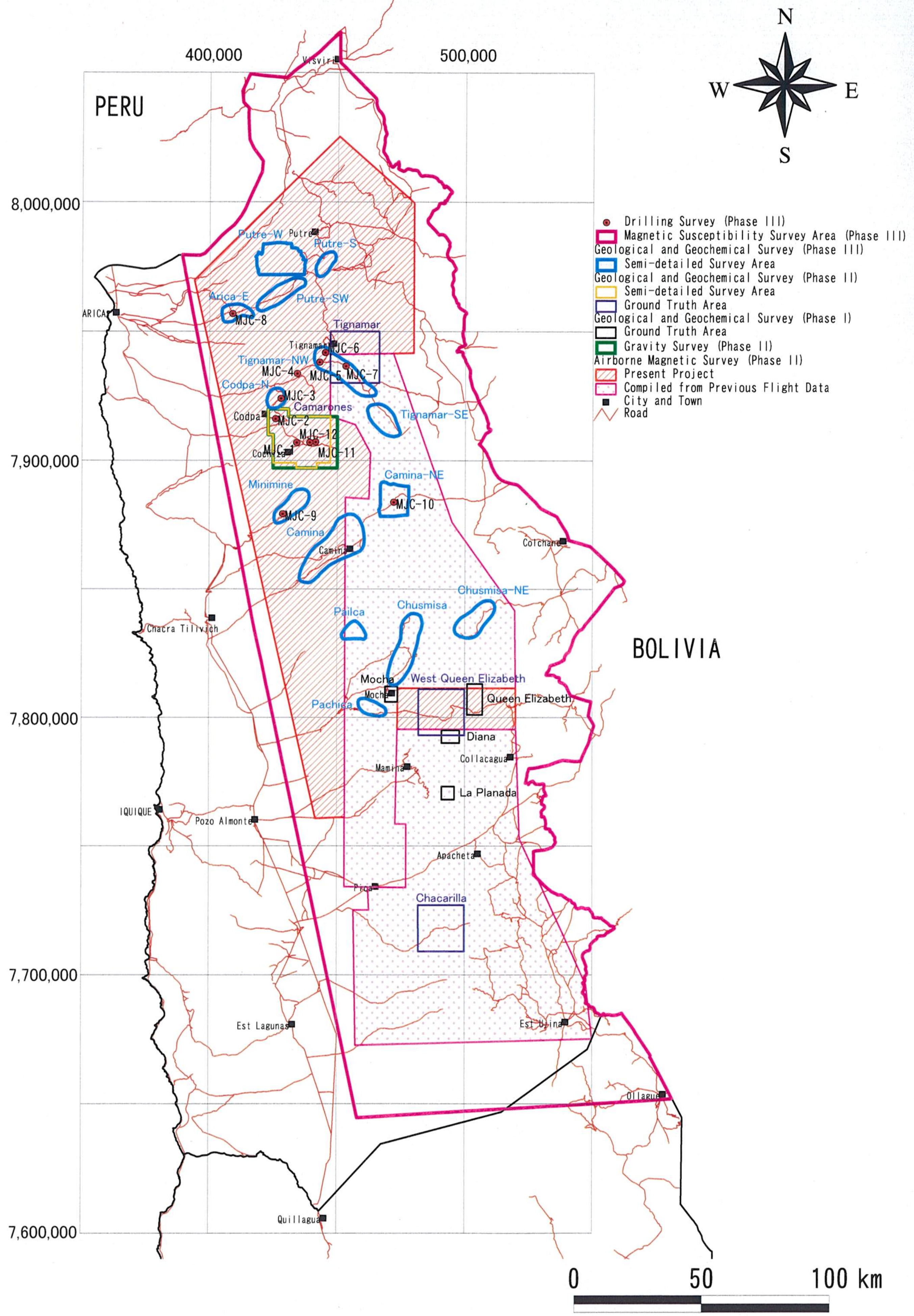

Fig. 1-2 Location Map of the Survey Area

The objective of the work carried out during the third 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 third year comprises; geological survey, drilling, and re-analysis of the airborne magnetic survey results. The total amount of work done is shown in Table 1-1.

Regarding the geological survey, magnetic data of the rocks distributed on the surface of the whole survey area were collected in order to provide references for re-interpretation of the airborne magnetic survey results. And also, the relation between porphyry copper mineralization, and airborne magnetic anomalies and geologic structure was examined in the anomalies extracted from the results of the airborne magnetic survey. Thus promising areas were extracted by integrated analysis of the results of various surveys carried out.

The anomalous zones extracted by airborne magnetic survey were drilled, and thus the geology and mineralization alteration were confirmed.

As for the re-analysis of the airborne magnetic survey results, the results of the geological survey and drilling carried out this year were used for the re-analysis of the airmag results, and the relation between the airmag anomalies, and geology and mineralization will be examined. Thus blind intrusive bodies related to porphyry copper mineralization were extracted.

1-4 Members of the Survey Team

(1) Field supervisor (Metal Mining Agency of Japan)

Tadashi Itoh
Hiroshi Shimotori
Masaomi Kurihara
Masato Ishii
Takeshi Harada

(2) Survey Team

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

Table 1-1 Amount of Work

Survey Method	Amount phase 3	
Geological Survey	Areal extent	
	Magnetic susceptibility measurement	873 points
	Reconnaissance survey	2,500 km^2
	Remanent Magnetization measurement	14 sites
	Length of traverse	
	Magnetic susceptibility measurement	1,750 km
	Reconnaissance survey	500 km
	Laboratory work	
	Thin sections	60 sections
	Polished sections	20 sections
	X-ray diffraction analysis	61 samples
	Ore assay (Au,Ag,Cu,Mo,Pb,Zn,S)	23 samples
	Geochemistry of rock (Au,Ag,As,Sb,Hg,Cu,Mo,Pb,Zn)	163 samples
	Fluid inclusion analysis	
	Homogenization temperature	12 samples
	Salinity	12 samples
	K-Ar age determination	
	Whole rock / Mineral	35 samples
Drilling	Number of drill holes	12 holes
	Total length drilled	5,326 m
	Laboratory work	
	Thin sections	26 sections
	X-ray diffraction analysis	26 samples
	Ore assay (Au,Ag,Cu,Mo,Pb,Zn,S)	144 samples
	Geochemistry of rock (Au,Ag,As,Sb,Hg,Cu,Mo,Pb,Zn)	282 samples
	Magnetic susceptibility measurement	265 points
Re-analysis of airborne magnetic survey	Areal extent	15,000 km^2

Masaaki Sugawara (Team leader, Geological and geochemical survey)
Susumu Takeda (Geological survey)
Koji Hamono (Geological survey)
Ken Obara (Geological survey)
Yuya Furukawa (Drilling)
Shigeo Moribayashi (Re-analysis of airborne magnetic survey results)

2) Chilean side (Corporacción Nacional del Cobre de Chile)
Carlos Huete L. (Project Manager, Chief geologist)
Raúl Venegas C. (Drilling and geological survey)

1-5 Duration

Geological survey: 27 September 2001 to 4 December 2001
Drilling: 27 September 2001 to 1 December 2001
Laboratory work and report preparation: 13 December 2001 to 28 February 2002

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	0.1

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 or Miocene intrusive rocks (plutonic rocks, hypabyssal rocks).

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

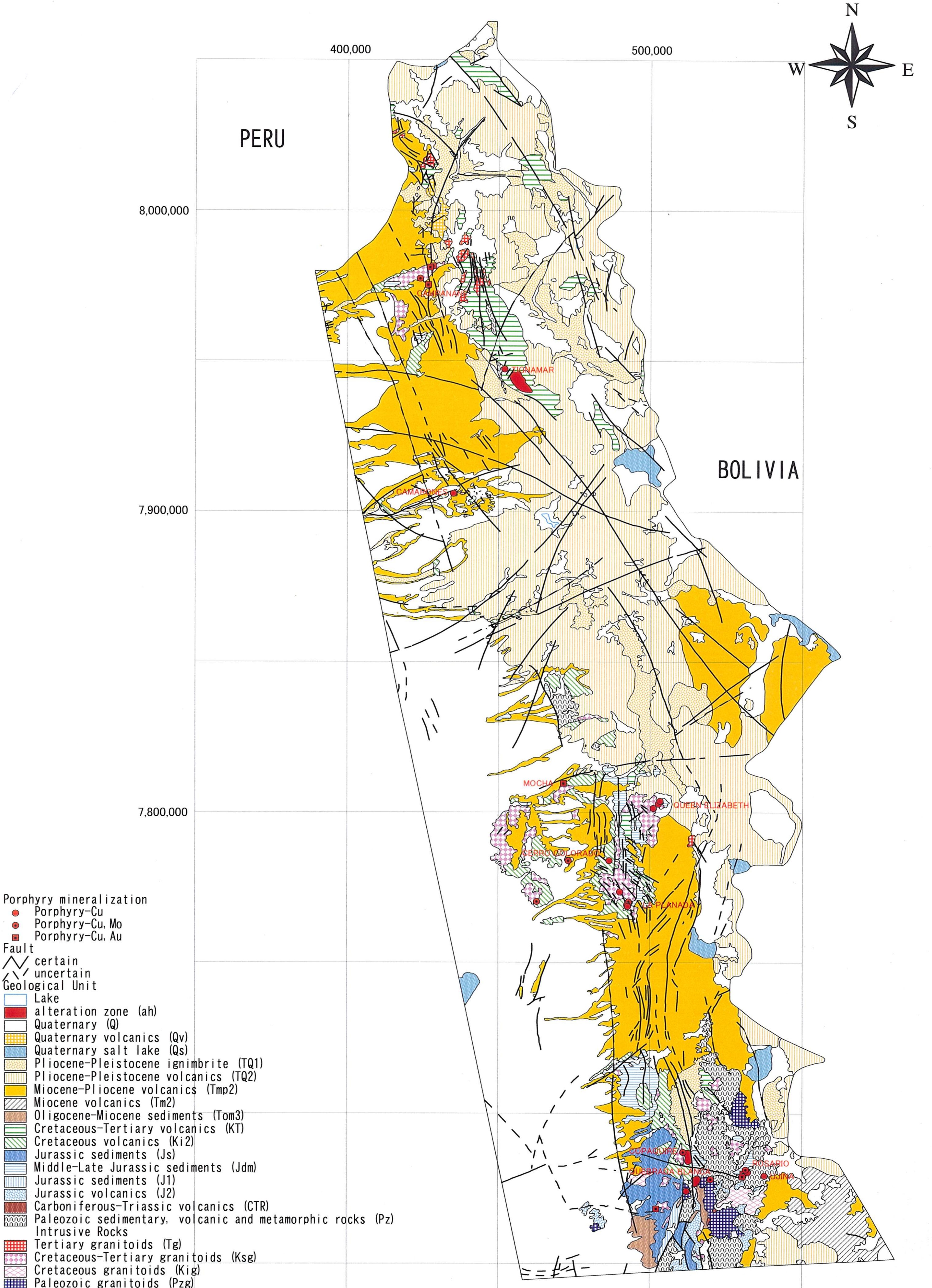

Fig. 1-3-1 Geological Map of the Project Area

Table 1-3-1 Stratigraphy of the Study Area

Period	Epoch	Formation (example)	Strata: Symbols: 1:1,000,000 Geologic Map	Strata: Symbols: 1:250,000 Geologic Map	Strata: Symbols: 1:50,000 Geologic Map*[1]	Strata: Symbols: Photogeologic Interpretation Map 1:250,000 TM	Strata: Symbols: Photogeologic Interpretation Map 1:50,000 GEOSCAN	Strata: Lithology	Intrusive Rocks: Symbols: 1:1,000,000 Geologic Map	Intrusive Rocks: Symbols: 1:250,000 Geologic Map	Intrusive Rocks: Symbols: 1:50,000 Geologic Map *[1]	Intrusive Rocks: Symbols: Photogeologic Interpretation Map 1:250,000 TM	Intrusive Rocks: Symbols: Photogeologic Interpretation Map 1:50,000 GEOSCAN		Intrusive Rocks: Lithology	Mineralization
QUATERNARY			Q, Qv	Qal, Qpd, Qcs, Qcp, Qip(i), Qip(s), Qvc	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$_1$	Qv, Qvr, TQc,Tsu, Tsh, TPv, Tpvi, TPiv	TQi(Qp)	TQ$_1$, Tvs$_2$	Ti$_4$, Ti$_{4w}$	Andesitic-basaltic flow, pyroclastic rock, Dacitic-rhyolitic 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					(d) dyke			
TERTIARY	Pliocene - Miocene	Altos de Picas	Tmp$_2$	Tt, Tig	TQt	Tvs, Ts$_1$	Tt, Ti$_1$, Ti$_2$, Ti$_3$	Rhyolitic - basaltic flow, pyroclastic rock, Ignimbrite, Intercalation of continental sediments								
	Miocene	Trapa - Trapa	Tm$_2$	Tpd		Tv$_1$		Rhyolitic -dacitic tuff, Andesitic - dacitic flow, pyroclastic rock	Tg	Kti, Tgd		Ti		Tg	Plutonic/Hypabysal rocks	Epithermal
	Miocene - Oligocene	San Pedro	Tom$_2$	Tmc (OLLAGÜE), Tc		Ts$_1$, Ts		Conglomerate, Breccia, Sandstone, Shale, Siltstone (continental facies)								
	Paleocene									Tgrd, Tdc, Tmc			(d) dyke	Tgd	Granodiorite, Diorite, Quartz diorite, porphyries	Porphyry Copper
EARLY TERTIARY - LATE CRETACEOUS		Las Chilcas	KT	Kiv, Kv(s)		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 (Granodiorite, Diorite, Quartz diorite, porphyries)	
EARLY CRETACEOUS		Bandurria, Lo Prado	Ki$_2$	Kv(m), Kce, Ka, Kc(i), Kv(i)	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$_1$s	Sandstone, Calcareous sandstone, Limestone, Marl, Shale, Conglomerate, Chert, Andesite								
JURASSIC			J$_1$	Jm, Jv(m)		Js$_1$										
		La Negra	J$_2$	JKv, Jv(i)		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					Plutonic/Hypabyssal rocks : Paleozoic	
PALEOZOIC		Aguada de la Perdiz	Pz	Pz(s), Pzc(s), Pzc(m), Pzc(I), Pzim, pC	-	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)		Pzg		Pg	(d) dyke	Pzg	Diorite, Granite, Granodiorite,	

*[1] : QUIPISCA, MAMIÑA (GEOSCAN AREA)

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

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 Chislluma)	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 Chislluma)	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	7981434	428160	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	Cu 5-30%	Porphyry-Cu,Au	8,12
23	Dos Hermanas	7977300	423900	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	Campanane	7975231	426572	Cu,Au,W	Chrysoc, Atac, Mal, Cup, Cc, Scheelite, Hem, Mt, Lim	Jasper, Qz, Kao, Ser	stockwork	N20W-N40E	85E-90	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	7975711	473041	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	7958275	417102	Cu	Chrysoc, Antl, Mal, Cc, Cerus, Angl, Py	Qz	vein	NS	50E			Ser	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	Capitana	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	469457	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	7806845	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	7804337	496482	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	7783799	473117	Cu,Mo	Cc, Brochantite, Chrysoc, Atac, Mal, Cup, Teno, Dioptase, Antl, 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
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

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

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
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	496236	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-ad. (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	7774655	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-ad, 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 Planada	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	7686337	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	7674166	512158	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
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	336	90	Wd: 1-3	Dac-po		-	-	Porphyry-Cu,Au	12,13

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

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
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)	7681321	531544	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)	7679299	537701	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	7673614	490544	Cu			vein						s		Vein and Irregular-Cu	12
143	Quebrada Blanca	7678106	520079	Cu,Mo	Lim, Py, Cp, Mo, Bn, Cu-oxi		stockwork			Altered zone: 7km^2, 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	7674592	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	492625	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	Olga, 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
172	Jamiralla	7981042	427199	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		Porphyry-Cu,Au	8,12
173	Camina	7867125	459305	Cu	Mal, Chrysoc	Qz	vein			-	Di-po			-	Vein and Irregular-Cu	
174	Poroma	7803463	482145	Cu		Cal	vein			Wd: 0.05	Vol. Bre.			-	Vein and Irregular-Cu	
175	Chusmisa	7831208	478252	Cu	Chrysoc, Antl, Cerus	Qz, Tou	vein	N40W	75-80NE	Wd: 2.5	Gd	Ser		-	Vein and Irregular-Cu	

Abbreviation (Table 1-3-2) (4)

<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)
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10. Skarmeta J. and Marinoic N. (1981)
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13. Vergana H, and Thomas A. (1984)

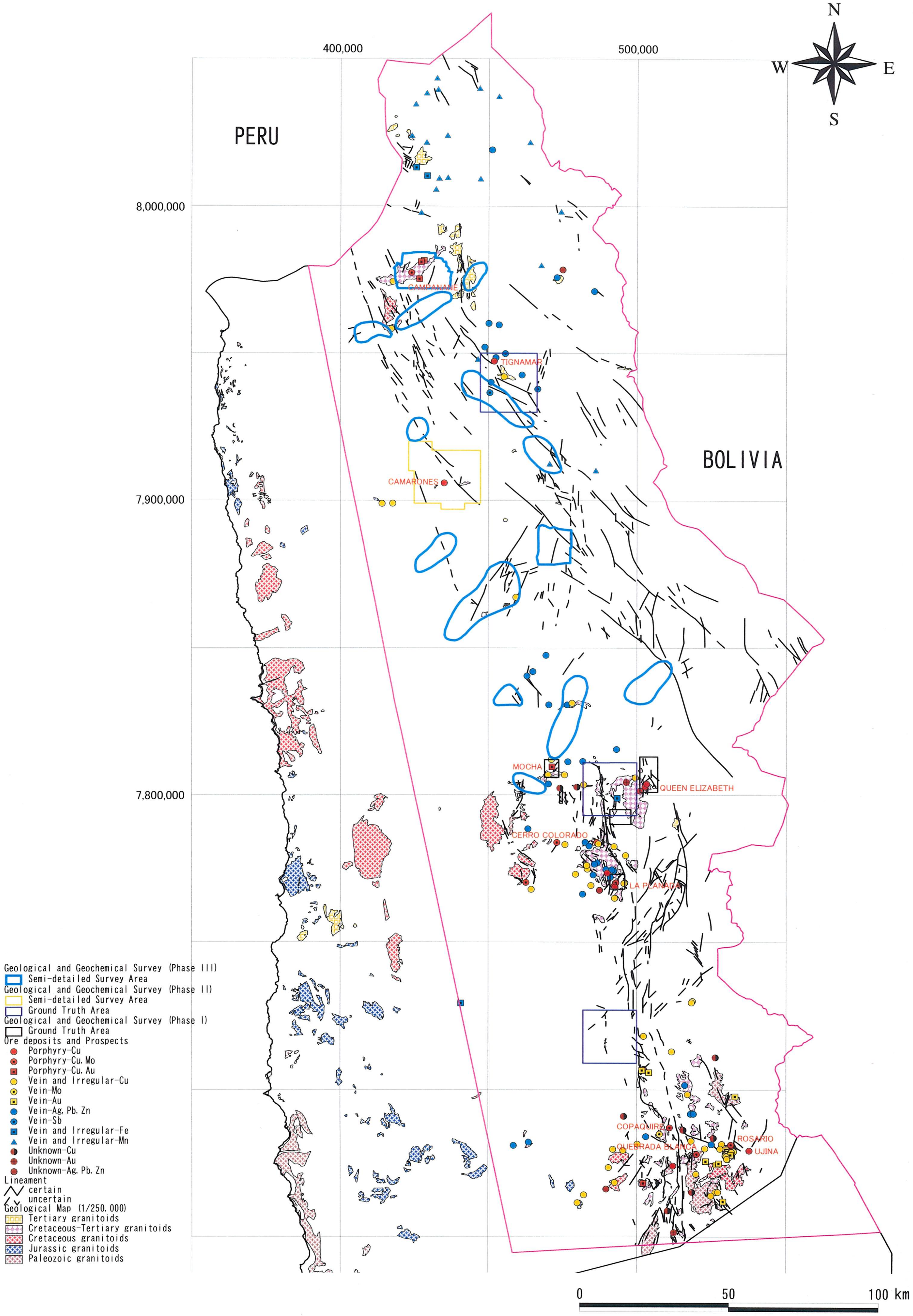

Fig. 1-3-2 Relationship among Granitoids, Ore deposits and Prospects in the Study Area

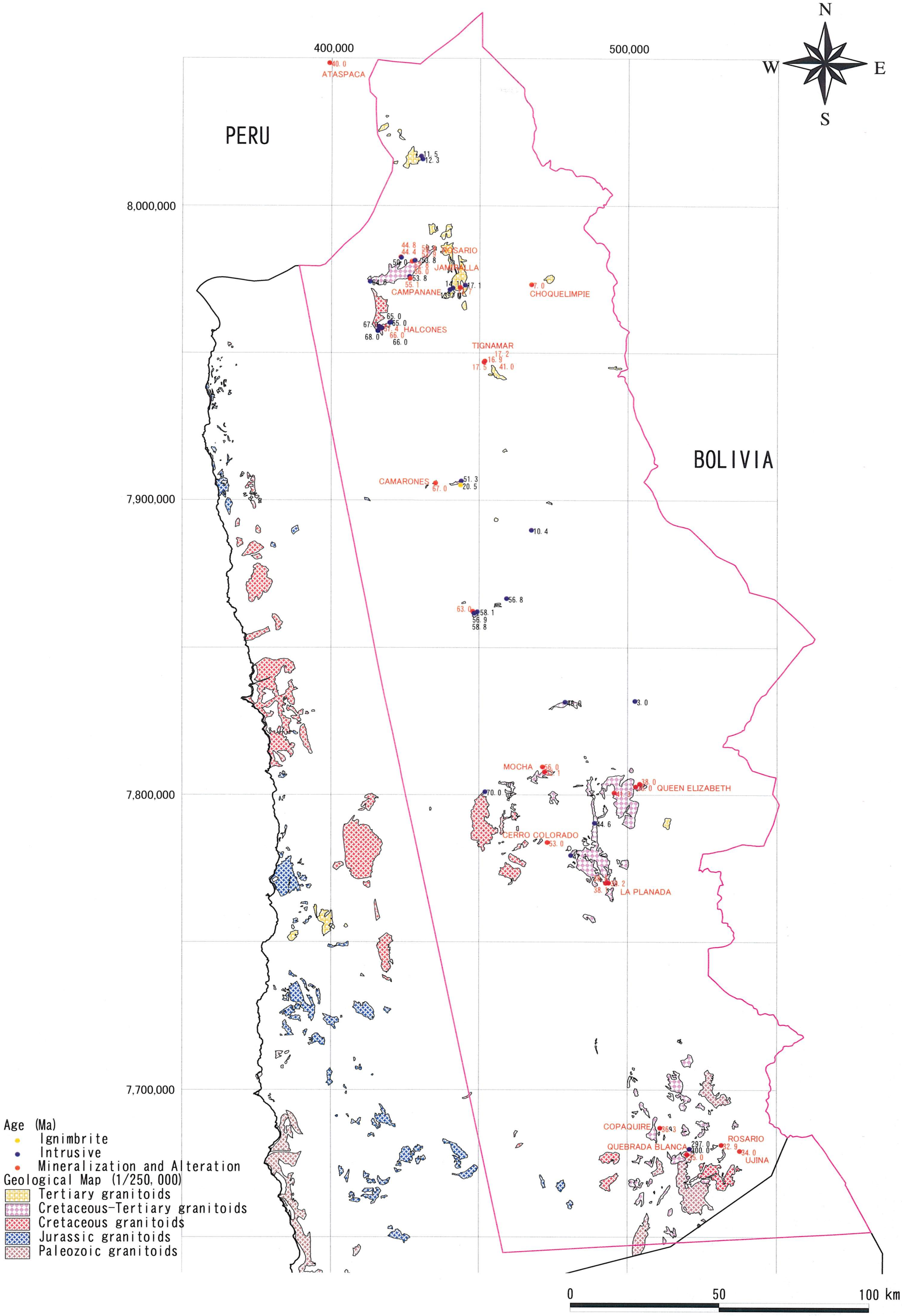

Fig. 1-3-3 Compiled Distribution Map of Radiometric Age in the Study Area

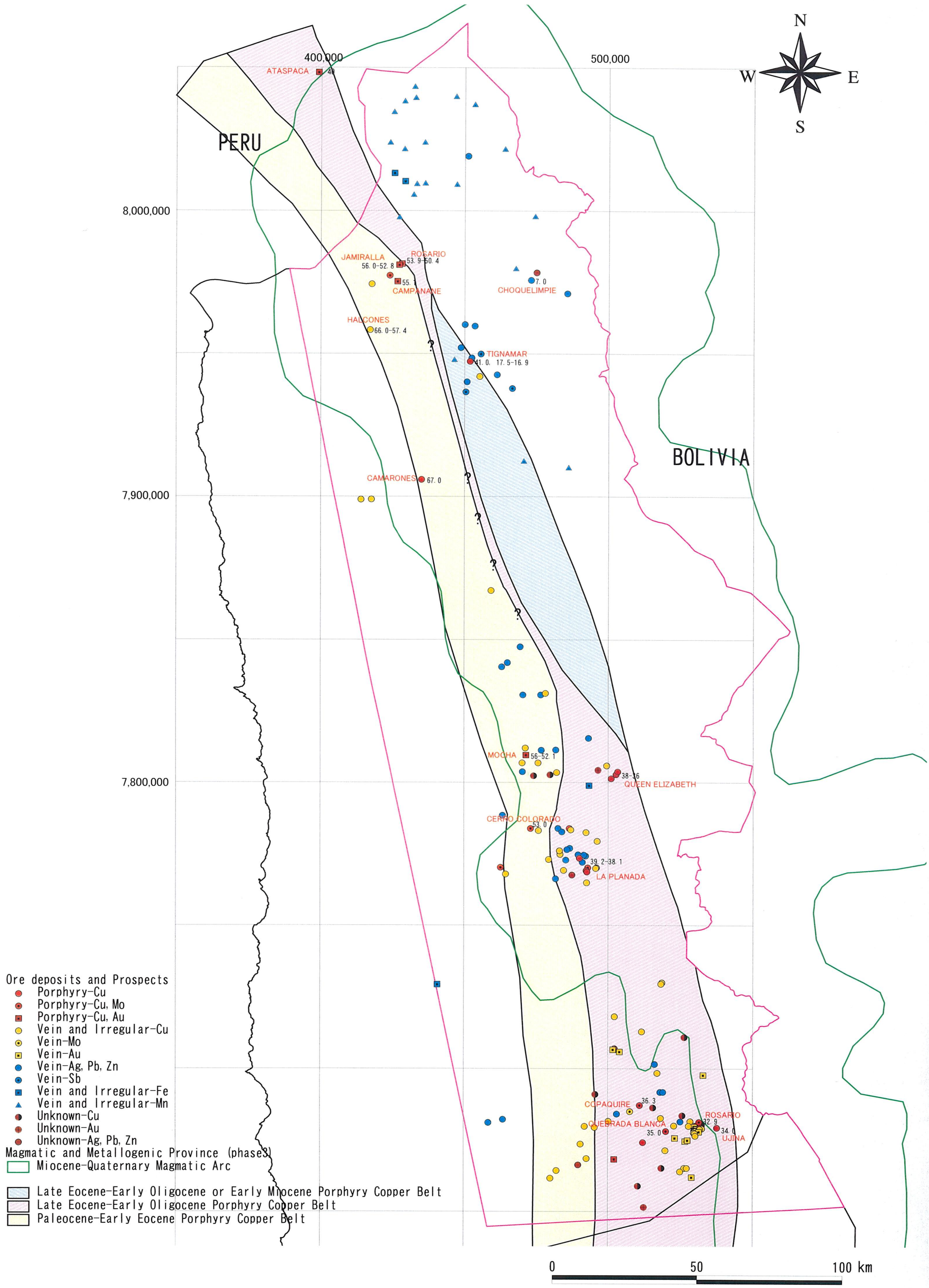

Fig. 1-3-4 Magmatic and Metallogenic Province in the Region I Area

CHAPTER 4 INTEGRATED ANALYSIS OF THE SURVEY RESULTS

4-1 Characteristics of Geologic Structure, Mineralization and Mineralization Control

The characteristics of the geology, alteration, and mineralization of the areas of reconnaissance survey during the third year are summarized in Table 1-4-1.

In the Chusmisa and Camiña areas, the following geologic features which are characteristic to the occurrence of porphyry copper type mineralization, were confirmed. Namely; the laterally extensive occurrence of phyllic alteration, the existence of porphyry or granitic rocks associated with mineralization, and the occurrence of intrusive igneous bodies with age (65~48 Ma) similar to the porphyry copper deposits in northern Chile~Peru. But quartz vein network and Cu, Mo rock geochemical anomalies were not observed. The pyrite dissemination zone in quartz porphyry in the western alteration zone of Camiña area is similar to the "pyrite shell" of the San Manuel – Kalamazoo model of Lowell & Guilbert (1970).

Porphyry-copper type mineralization was reconfirmed in the area to the west of Putre, but its occurrence was limited to the vicinity of phyllic alteration or near ore veins. Development of phyllic alteration is not confirmed in the lower horizons at nearby creeks, and it is possible that the deeper phase of the mineralization is exposed on the surface.

In eastern Arica area, copper veins were confirmed in granodiorite, but alteration was confined to zones adjacent to the veins, the homogenization temperature of fluid inclusions is low, indicating epithermal mineralization. The age of alteration lies within that of porphyry copper deposit genesis, and the veins are believed to have been formed following the porphyry copper mineralization.

The wide-spread phyllic alteration-pyritization around quartz porphyry bodies to the south of Putre is similar to the mineralization and alteration of porphyry-copper-type minimization, but the age of porphyry intrusion and alteration is Miocene which is different from that of the known porphyry copper deposits in northern Chile. The age of sericitization of quartz porphyry sampled from the vicinity of mineralized zone in Tignamar area is also Miocene. Eocene mineralization has been reported from the Tignamar area (Clark et. al., 1998), and mineralization may have occurred more than once in this area. The zone extending from the south of Putre to Tignamar area has been regarded as the porphyry copper belt of Late Eocene-Early Oligocene (43-31Ma), but igneous intrusive bodies and porphyry-copper-type

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
								Disappearance Temperature (average °C)	Salinity (NaCl average wt%)				Cu>84ppm		Cu>260ppm		Cu>581ppm		Mo>36ppm			
													Number	%	Number	%	Number	%	Number	%		
Pachica	Andesitic lava/volcaniclastics (K), Granodiorite (K), Diorite (K)	?	Chl, Epi, (Ser), (Ka), (Qz)	-	Py, (Hem), (Lim)	Bar, Cal, Qz	rare	-	-	50	7	14	2	14	1	7	0	0	0	0	0.805	Au-Zn-As-Hg
Chusmisa	Shale・Sandstone・Conglomerate・Basaltic-andesitic lava/volcaniclastics (K), Granodiorite・Diorite・Granite・Dacite (T)	Granite・Diorite (T)?	Ser, Tou, Qz, Bi, Chl, Epi	48±1.4 (Whole rock-primary)	Cu-oxi, Py, Hem	Qz, Tou, Epi	rare	-	-	35	4	30	3	10	0	0	0	0	0	0	0.582	Ag-Pb-Zn-As
Chusmisa Northeast	Ignimbrite (T, Q), Andesitic-basaltic lava・Dacite (T-Q)	?	Ka, Qz, Ser	-	py, Hem, Native S	Qz	small	-	-	20	8	21	0	0	0	0	0	0	1	5	1.595	As-Hg
Pailca	Ignimbrite (T), Conglomearte (T-Q)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Camiña (Western part)	Andesitic-basaltic lava/volcaniclastics・Sandstone・Shale (K), Granodiorite・Diorite・Qz-porphyry (T)	Qz-porphyry (T)	Ser, Qz, Chl, Epi	63±2, 56.9±2 (Whole rock-alteration)	Py	Ser	rare	-	-	30	5	27	0	0	0	0	0	0	0	0	0.474	-
Camiña (Eastern part)	Andesitic-basaltic lava/volcaniclastics (K), Diorite・Diorite porphyry (T)	Diorite porphyry (T)	Qz, Chl, Epi	58.8±2 (Whole rock-primary)	Cu-oxi	Qz	rare	-	-	4598	2	22	8	36	2	9	2	9	0	0	0.239	Cu-Zn-As
Camiña Northeast	Ignimbrite (T), Basaltic-andesitic lava (T-Q)	Andesite?	Serr, Ka, Qz	10.4±0.4 (Whole rock-primary)	Lim	-	none	-	-	20	5	2	0	0	0	0	0	0	0	0	1.243	As-Hg
Minimiñe	Conglomerate・Ignimbrite (T-Q)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Codpa North	Ignimbrite (T)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tignamar Northwest	Ignimbrite (T), Pumice tuff・Basaltic-andesitic lava (T-Q)	?	Ka, Qz	-	Lim	-	-	-	-	47	3	6	1	17	0	0	0	0	0	0	1.227	Pb-Zn-As
Tignamar Southeast	Ignimbrite (T), Pumice tuff・Basaltic-dacitic lava (T-Q)	?	Ka, Al, Qz	-	Lim	-	-	-	-	26	1	3	0	-	0	0	0	0	0	0	7.754	As
Putre South	Basaltic-rhyolitic lava (K), Granodiorite・Diorite・Diorite porohyry・Qz-porphyry (T), Ignimbrite・Basaltic-andesitic lava (T-Q)	Qz-porphyry・Diorite porphyry (T)	Ser, Qz, Chl, Epi	13.7±0.5, 14.1±0.6, 13.7±0.7 (Whole rock-primary), 17.1±0.5 (Bi-primary)	Py, Lim	Qz	none	-	-	44	3	16	2	13	0	0	0	0	0	0	0.961	Zn-As
Putre Southwest	Granodiorite・Diorite (K-T)	-	Chl	65±2 (Whole rock-primary)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arica East	Shale・Marble (J), Sandstone (K), Granodiorite (K-T)	Granodiorite (K-T)	Ser, Ka, Qz	66±2, 68±2 (Bi-primary), , 57.4±2.1, 66±2 (Whole rock-Alteration)	Cu-oxi, Cc, Py	Qz	small	143	-	2903	17	2	2	100	2	100	2	100	0	0	0.104	Au-Ag-Cu-Mo-Pb-Zn-As
Putre West	Sandstone (K), Granodiorite (T)	Granodiorite (T)	Qz, Ser, Kf, Tou	56±1.5, 52.8±1.4, 50.4±2, 44.4±2 (Ser-Alteration), 50±1.2 (Bi-Alteration), 55.1±1.9 (Whole rock-primary), 53.8±1.4 (Bi-primary)	Cu-oxi, Cp, Py	Qz, Tou	abundant	398-319	47.3-39.7	12417	10	15	11	73	8	53	8	53	0	0	0.082	Au-Ag-Cu-Pb-Zn

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 mineralization of this age are not observed to the north of Tignamar area.

Areas to the northeast of Chusmisa, northeast of Camiña, northwest of Tignamar and southeast of Tignamar belong to the Pre-Andes zone which lies to the east of the survey area, and Neogene-Quaternary igneous rocks are developed. Large-scale acidic alteration zones occur in this area and limonitization or pyrite mineralization (or volcanogenic sulfur deposits) are associated.

The intrusive age and alteration age of the intrusive bodies and mineralization age acquired by the present survey and those in existing data (K-Ar ages) have been compiled and are laid out in Figure 1-3-3. On the basis of this figure, the conventional metallogenic provinces have been revised (Fig. 1-3-4). The results show that the boundary of the Paleocene-Early Eocene (65-48Ma) porphyry copper belt and Late Eocene-Early Oligocene (43-31Ma) porphyry copper belt extends in almost N-S direction south of Chusmisa. North of Chusmisa to the west of Putre near the Peru border, there is only one data regarding the age of Late Eocene-Early Oligocene, and others show latest Cretaceous-Early Eocene, or post-Miocene age. To the north of Tignamar, uplifted zone consisting of Paleozoic and Cretaceous units occurs in NNW-SSE direction, and the age of the igneous bodies measured during the present survey in this zone all showed Miocene. Therefore, the possibility of the occurrence of Late Eocene-Early Oligocene intrusive bodies in this area is very small. To the north of Chusmisa, post-Miocene volcanic rocks occur distributed in the NW-SE direction on the eastern side. Thus the N-S trending Late Eocene-Early Oligocene porphyry copper belt is intersected by Neogene-Quaternary volcanic rocks. The area between the area to the northeast of Chusmisa and Tignamar, there is a possibility of Late Eocene-Early Oligocene porphyry copper belt hidden below Neogene-Quaternary volcanic rocks, and possibly not existing.

4-2 Airborne Magnetic Anomalies and Porphyry Copper Type Mineralization

Re-analysis of the results of airborne magnetic survey yielded the following results. Namely, the known porphyry copper mineralized zones have the following common pattern, they occur:

① In peripheries of medium wavelength anomaly zones.
② In intermediate magnetic intensity zones or the vicinity.
③ Is accompanied by short wavelength magnetic anomalies.

Also it was clarified that, of the alteration or mineralized zones confirmed by the present geological reconnaissance, the following has features which almost completely coincide with the above three conditions. They are, all phyllic or acidic alteration zones with the exception of that in the area to the west of Putre; and the mineralized zones at Chusmisa, northeast of Chusmisa, Camiña, northeast of Camiña, northwest of Tignamar, southeast of Tignamar, south of Putre, and east of Arica. Also the mineralized zones to the west of Putre has characteristics which agree with the above ②and ③, but medium wavelength magnetic anomaly zone does not exist.

Regarding medium wavelength magnetic anomaly zones related to known porphyry copper mineralization, almost all of them are associated with intrusive bodies within the zone or in the vicinity. The results of magnetic susceptibility measurements indicate that the intrusive rocks of the survey area have stronger values than volcanic rocks, and they are apt to result in higher airborne magnetic anomalies. About half of the medium wavelength magnetic anomalies related to known porphyry copper mineralization have high anomalies and the other half low anomalies. The low anomalies are interpreted to be related to intrusive igneous rocks with remanent magnetism with reverse polarity. The magnetic polarity of the intrusive rocks was measured at 10 localities and 4 of them had reverse magnetic polarity. These four localities agreed very well with the distribution of low airborne magnetic anomaly. Where remanent magnetic intensity with reverse polarity is equal to induction magnetism, magnetic anomaly may not occur in some cases because the remanent and induction magnetism eliminate each other. In the mineralized zone to the west of Putre, medium wavelength magnetic anomaly is lacking in spite of the wide distribution of intrusive bodies, the above could be the cause of this lack.

The scale of the medium wavelength magnetic anomalies approximates the scale of exposed batholithic complex plutonic bodies, and on the other hand, these are believed to approximate the scale of magma chamber directly below volcanoes (Takahashi, 1986). The fact that known porphyry copper mineralized zones occur at the peripheries of the medium wavelength anomaly zones, is believed to indicate that batholiths exist in subsurface zones and the mineralized zones occur in the peripheral part of these batholiths.

Intermediate airborne magnetic intensity zones have irregular shape, but there are differences of the pattern by areas. By dividing Region I into eastern, western and the central part, it is seen that the intermediate magnetic intensity zone in the western part with manto type deposits is relatively large with loop shape (Figs. 1-4-1, 1-4-2). While that in the central part consists of continuous relatively wide zone extending in the ENE-WSW~WNW-ESE and NNE-SSW~NNW-SSE directions, and in the younger volcanic rock area in the northeast the zones constitute aggregates of thin small loops.

In the central - southern part of the survey area, the zone of intermediate magnetic intensity continuous in the NNE-SSW~NNW-SSE direction coincides with the zone of developed lineaments. In this area, porphyry copper mineralized zones occur near the intersection of the N-S trending lineaments and E-W trending intermediate magnetic intensity zones. In the younger volcanic area in the northeast, the small-loop intermediate magnetic intensity zones coincide with the zone of lineament development. But at the northern end, lineaments are not developed in the intermediate magnetic intensity zones.

Many of the acidic to neutral alteration zones extracted from TM and GESCAN images occur in the intermediate magnetic intensity zones. These alteration zones also often occur near the periphery of short wavelength anomalies. Also in some cases, where alteration zones are developed widely, short wavelength magnetic anomalies do not occur. The results of magnetic susceptibility measurements indicate a clear correlation between the intensity of phyllic and acidic alteration and the decrease of magnetic susceptibility. This fact has been confirmed by drilling. Among the known porphyry copper mineralized zones, some are possibly not associated with short wavelength magnetic anomalies such as the vicinity of Cerro Colorado and Collahuasi, and if such anomalies are lacking, it is believed that the lack is caused by alteration zones similar to the above.

Cordillera-type porphyry copper deposits are believed to have been formed near the boundary of volcanic and plutonic rocks. Also around the time of mineralization, plural number of magma intrusion activities are recognized during the course of several million years. Considering such genetical environment of porphyry copper deposits together with the magnetic anomaly conditions mentioned above, it is believed that, basically, batholithic plutonic complex which is a product of precursor activity of porphyry copper mineralization is expressed as intermediate wavelength anomalies, the plutonic and hypabyssal bodies including ore deposits as short wavelength anomalies and the hydrothermal alteration zones associated with intrusive activities as intermediate magnetic intensity zones.

Also it is natural if we assume that Cordillera-type porphyry copper deposits were formed near the boundary of volcanic and plutonic bodies, magnetic anomaly pattern similar to the porphyry copper mineralized areas are recognized in the younger volcanic areas on the

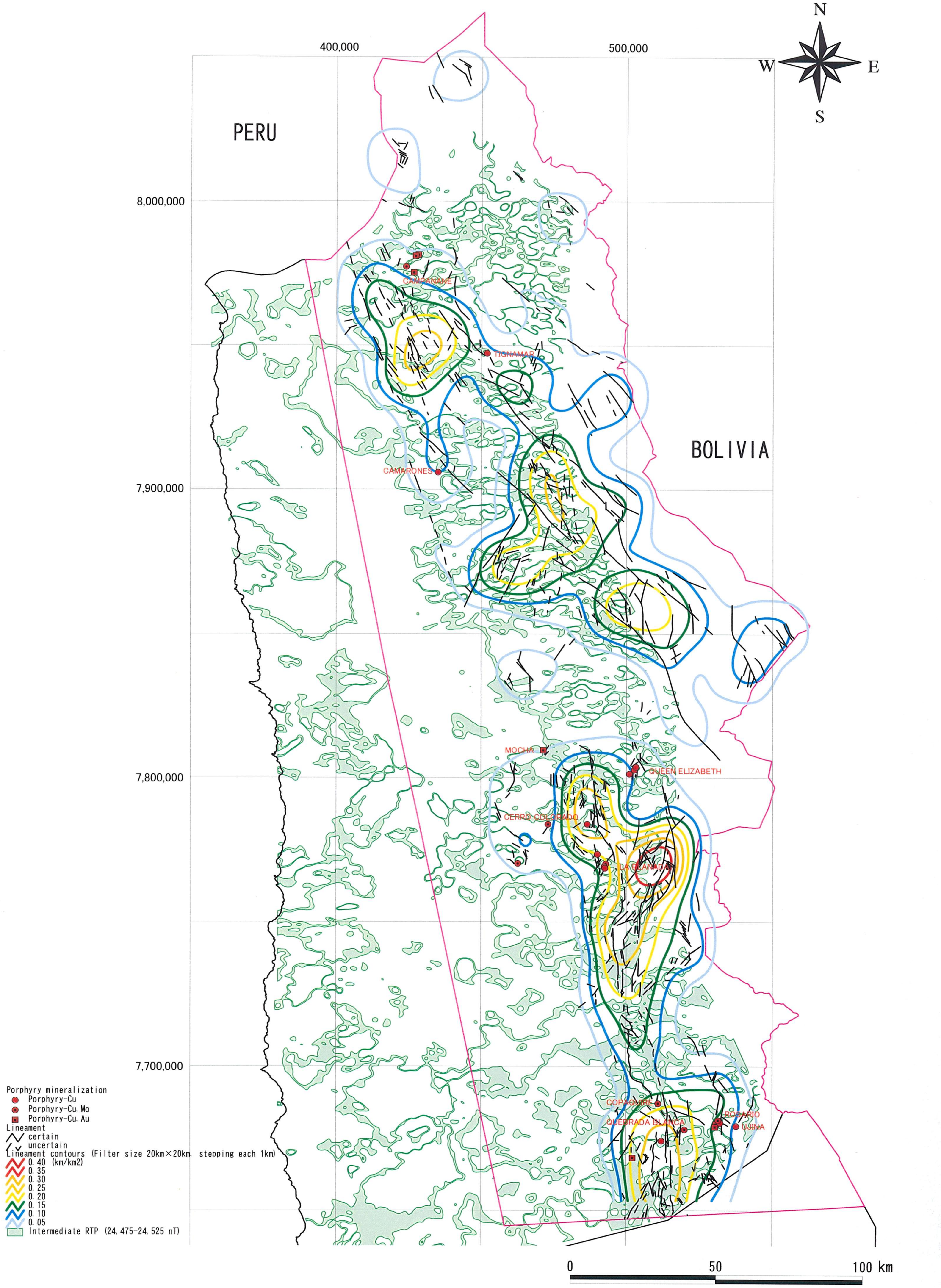

Fig. 1-4-1 Relationship Between Intermediate Magnetic Intensity Zones and Lineaments

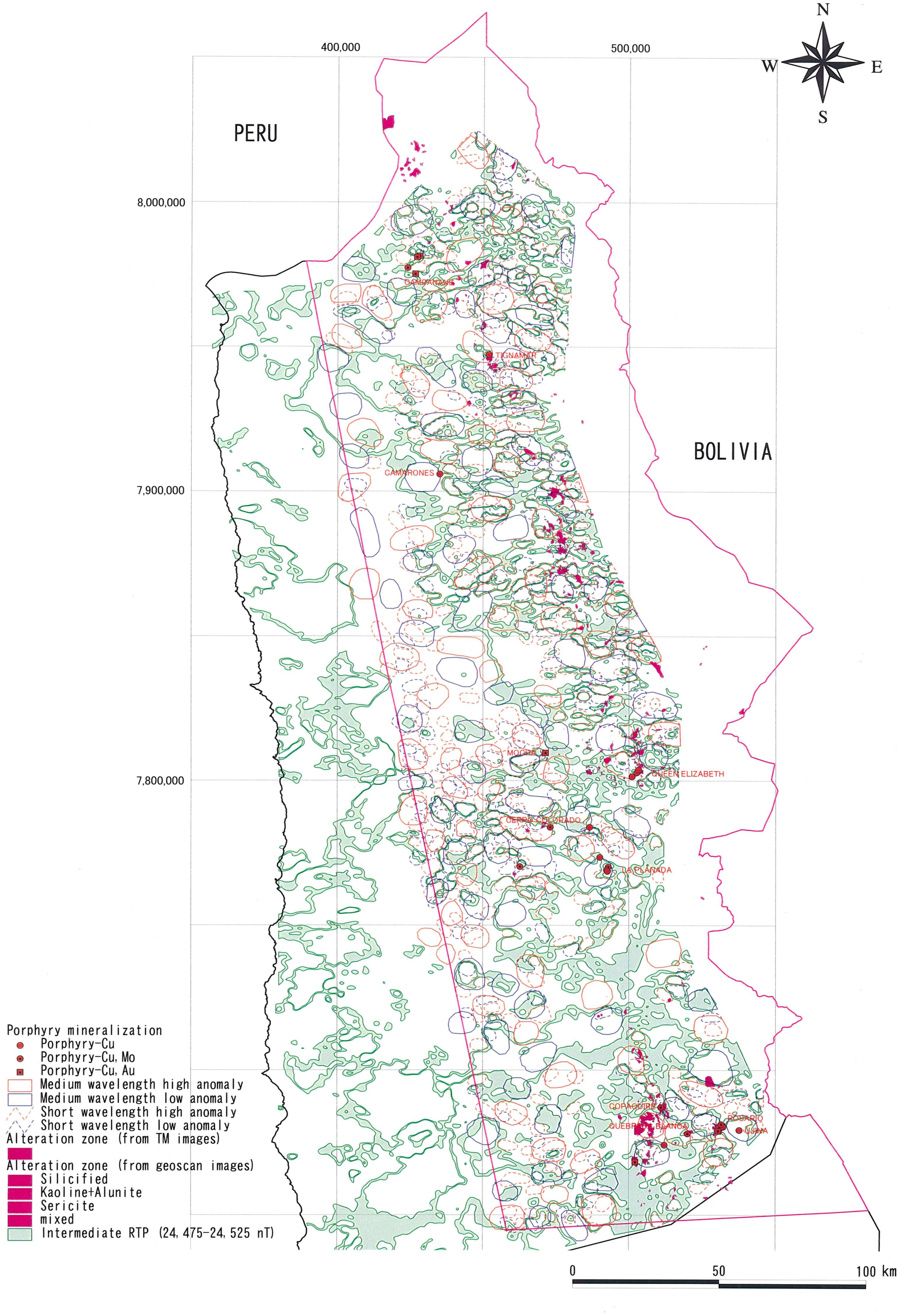

Fig. 1-4-2 Relationship Between Airborne Magnetic Anomalies and Alteration Zone

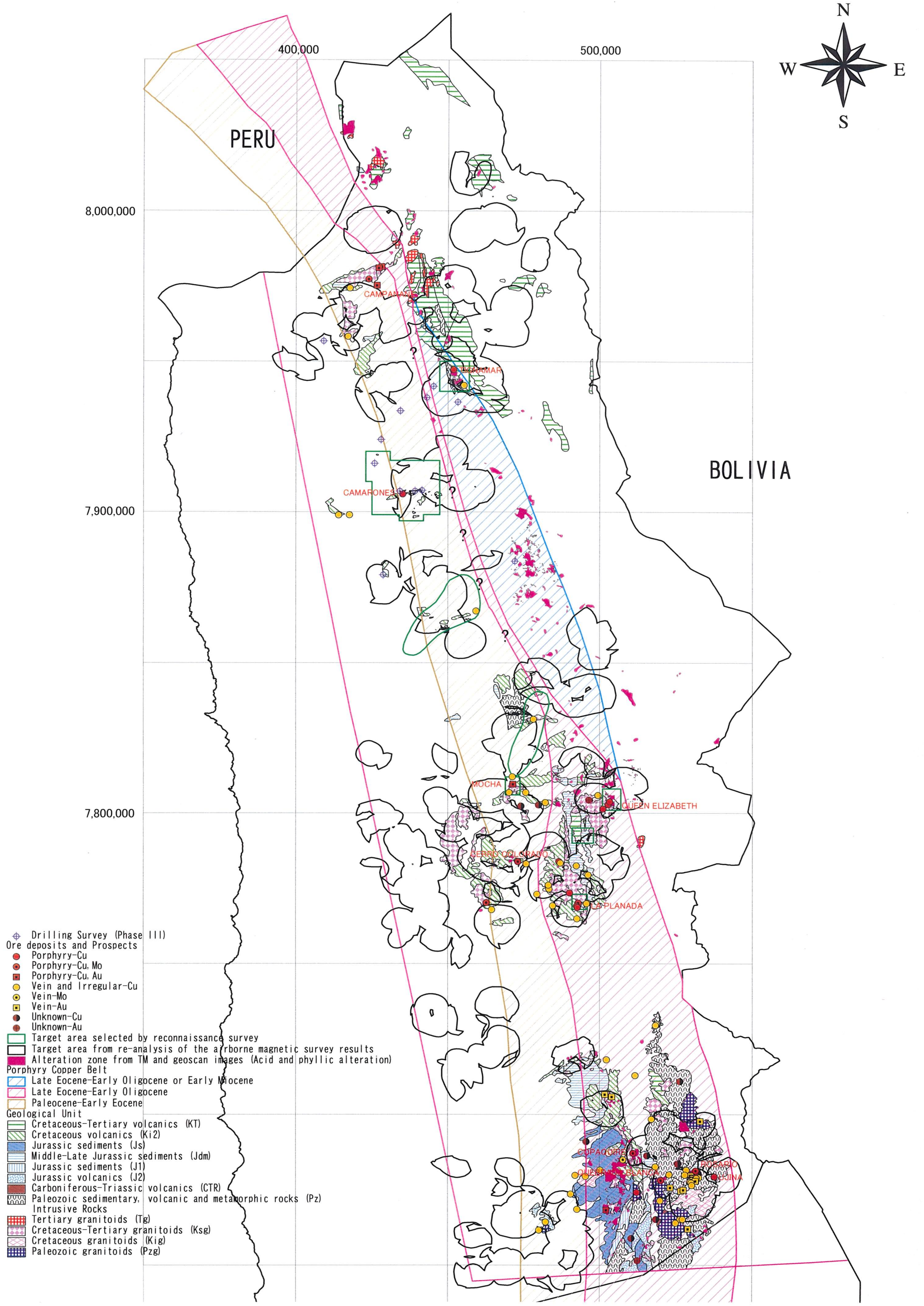

Fig. 1-4-3 Integrated Interpretation Map of the Region I Area