NO.

REPORT
ON
THE MINERAL EXPLORATION
IN THE ORURO-UYUNI AREA
OF
THE REPUBLIC OF BOLIVIA

(PHASE III)

March 2002

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

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PREFACE

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

The JICA and MMAJ sent a survey team headed by Mr. HASHIMOTO Morio to the Republic of Bolivia from July 31, 2001 to October 20, 2001.

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

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

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

March, 2002

Takao Kawakami
President
Japan International Cooperation Agency

Naohiro Tashiro
President
Metal Mining Agency of Japan

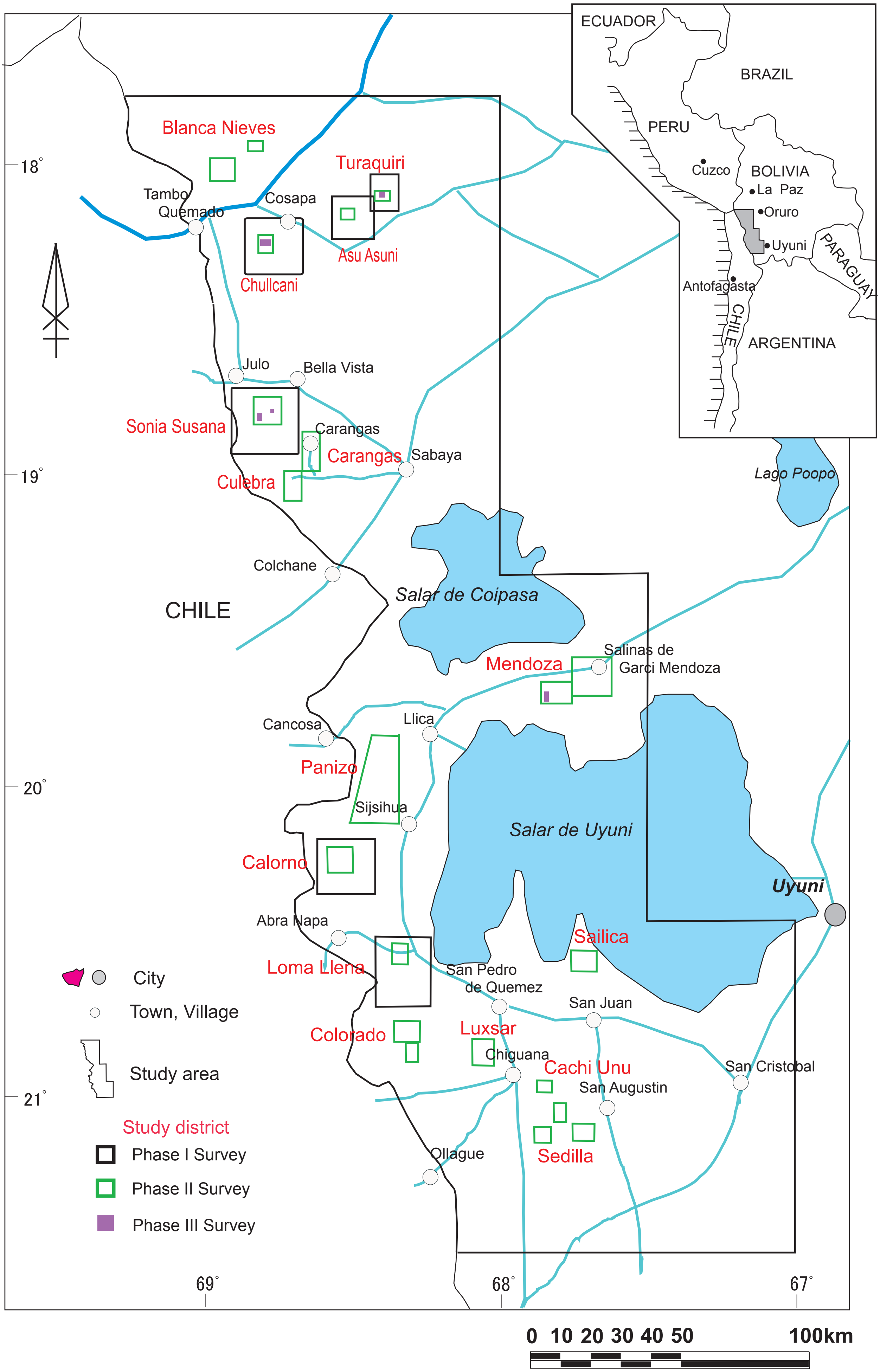

Fig. I-1 Location Map of the Survey Area

SUMMARY

This report sums up the survey in Phase III (FY 2001, the final FY of the survey) implemented in the Oruro-Uyuni region of the Republic of Bolivia, under the technical cooperation.

The survey findings, overall evaluation and exploration guidelines for Phase Ⅲ are summarized in the following paragraphs:

Survey Findings

(1) Detailed Geological Survey (Scale 1/5,000): Four Districts

In the Turaquiri District, many ore veins consisting mainly of manganese were confirmed northwest of the Main Turaquiri Vein. New gold mineralization was confirmed around intrusive rock.

In the Chullcani District, monzodiorite intruded in the center part of the Chullcani Volcano and zonation of alteration minerals was confirmed centering on this intrusive rock. The intrusive rock could be interpreted as the center of hydrothermal activities. Geochemical anomalies of gold were found both in and around the intrusive rock.

In the southern part of Jankho Kkollu Prospect (Sonia - Susana District), many lead and zinc bearing veins were confirmed around altered intrusive rock. Porphyry type mineralization was expected in the Santa Catalina Prospect (Sonia - Susana District), however, its positive showings were not confirmed in this survey.

Many lead and zinc bearing veins were confirmed in Iranuta of the Mendoza District. It is presumed that these ore veins were formed by mineralization related to the rhyolitic intrusive rock in the north. The geochemical anomaly of gold confirmed in Mt. Chorka is interpreted to be caused by hypabyssal rock inferred to lay under it.

(2) Drilling Survey: Chullcani District (Two Drill Holes, 600 m)

A dominant hydrothermal alteration zone was intersected. However, significant mineralization could not be confirmed.

Overall Evaluation

Silver, lead, zinc and copper ore deposits can be expected in the deeper parts of the manganese veins confirmed in the Turaquiri District. A gold addition can also be expected around the intrusive rock. However, such mineralization is interpreted as rather small in size.

Exposure of intrusive rock on the surface is confirmed in the Chullcani District.

Quartz-sericite alteration zone is distributed in the intrusive rock and areas around it, satisfying conditions for the precipitation of gold. A drilling result shows, however, that the geochemical anomaly of gold on the surface is not dominant underground. Possibilities that gold is deposited in the southeast area still remain, nevertheless, the gold mineralization may be weak in Chullcani District.

Silver, lead, zinc and copper bearing veins were confirmed in the Jankho Kkollu Prospect (Sonia - Susana District). However, possibilities of a large deposit are low. Positive showings of an expected porphyry copper type mineralization in the Santa Catalina Prospect could not be confirmed in this survey. Such mineralization would be located quite deep if it exists.

In the Mendoza District, both intrusive rock and epithermal gold-silver mineralization are expected in the deep parts of Mt. Chorka. High sulfidation gold and copper mineralization is expected in the northern slope and top of the mountain. However, the size of the mineralization may be small, because Mt. Chorka is interpreted as a single stratovolcano.

Recommendations for the Future

There are no strong reasons for further exploration can be suggested as the result of the project, although the survey revealed detailed information for the geology and mineralization of the area. However, the recommendations for further explorations are summarized as follows, for re-evaluating the potentiality of the Oruo - Uyuni Area and adjacent Western Andes Region.

(1) Recommendations for exploration of epithermal type mineralization

The analysis of remote sensing data is a useful tool for selecting a hydrothermal alteration zone from a wide area. The potential mineralized zone should be selected by geochemical investigations. Further detailed geological investigations should be mentioned from the following viewpoints.

i) Existence of ore bringers (domes and intrusive rocks).

ii) Existence of hydrothermal fluid (mineralized solution) paths (fractures, hydrothermal breccias and breccia pipes).

iii) Repetitive supply of hydrothermal fluids (overlap of igneous activities).

The analytical study should be mentioned for the following viewpoints.

a) Dissection degree of volcano: distribution of igneous rock age, homogenization temperature of fluid inclusions, geochemical anomalies and altered minerals, etc.)

b) Evaluation of the vertical position in mineralization: distribution of altered minerals, geochemical anomalies and gangue minerals.

Those districts with high potential that are narrowed down in this detailed geological survey should preferably conduct geophysical exploration and drilling exploration to reveal the geological structures and mineralization deep underground.

(2) Recommendations for exploration of porphyry type mineralization

The mineralized age of Chilean porphyry copper deposits have a tendency to become younger from west to east. It shows the potentiality of this type mineralization in the volcanic region of the Western Bolivian Andes. But at the younger volcanoes, the porphyry type mineralization would be located quite deep underground if it exists.

Therefore it is desirable for a detailed investigation of volcanic stratigraphy (especially in dating the age of volcanic rocks) of the Western Andes Region as basic information for the explorations. It also should be important information for the exploration of the epithermal type mineralization mentioned above.

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PART I GENERAL REMARKS

Chapter 1 Introduction

1.1 Background of Survey

To comply with the request of the Government of Bolivia, the subject mineral resources survey in the Oruro-Uyuni region of the Republic of Bolivia is undertaken by the Government of Japan, in conformity to the Scope of Work agreed by the two governments on December 10, 1999.

1.2 Conclusions and Recommendations of Phase II Survey

1-2-1 Conclusions of Phase II Survey

In Phase II, geological surveys and geochemical explorations of varying precision were conducted in a total of 16 districts covering the districts surveyed in Phase I and ten new districts. The chemical analysis for stream sediments samples collected by SERGEOMIN was conducted.

The survey in Phases I and II revealed that the hydrothermal alteration zones widespread in the Oruro-Uyuni region are likely to host epithermal ore deposits at depth. It is assumed an epithermal deposit rich in gold, silver, lead and zinc related with shallow volcanic rocks; an epithermal deposit of precious metals related with hypabyssal intrusive rocks; a high sulfidation type of gold, silver, copper ore deposit (quartz-alunite vein type); and a low sulfidation type (quartz-adularia vein type) are expected.

Impregnation of gold and cooper ore deposits of the porphyry type is also possible in deep parts of the districts with extensive erosion. Hydrothermal activity could be interpreted as intensive in districts where domes, intrusive rocks, hydrothermal breccia and breccia pipes are distributed. Possibilities of deposition of epithermal ore deposits in these districts were assessed to be high.

As for promising areas, the following districts could be identified from north to south: the Turaquiri, Chullcani, Sonia - Susana, Calorno, Mendoza (Co. Mokho and Co. Chorka Prospect), Panizo District (Panizo Prospect), Sailica District (Plasmar Mine) and Sedilla District (Eskapa Prospect).

1-2-2 Recommendations of Phase II Survey

It was proposed in the Phase II survey that detailed geological surveys and geophysical exploration would be conducted in districts, which had high possibilities of ore deposition in Phase Ⅲ to obtain more detailed information. It was also proposed that borehole drilling would be conducted in some of these districts to confirm a three-dimensional model (geological structure, distribution of alteration, resistivity structure, geochemical variations and other factors) to assist the identification of promising districts.

1-3 Outline of Phase Ⅲ Survey

1-3-1 Survey Area

The Oruro-Uyuni area is situated approximately between 150 km and 560 km south of La Paz, the capital city (Fig. I-1). The western half of the region is constituted by mountainous zones, altitude 4,000 m to 5,000 m, whereas the eastern half consists mainly of moderately inclined plateaus and saline lakes of altitudes up to 4,000 m above sea level.

The four districts of the phase III survey are located in the northern part of the Oruro-Uyuni area.

1-3-2 Survey Purpose

For effectively selecting a potential area for a mineral deposit in the short term, a geological survey to reveal the geological setting and occurrence of mineral deposits will be carried out in the Oruro-Uyuni region, Republic of Bolivia.

1-3-3 Survey Method

During the Phase Ⅲ survey, geological surveys were conducted in four promising districts, which identified by the Phases I and Ⅱ surveys (Turaquiri, Chullcani, Sonia - Susana and Mendoza Districts). A drilling survey was also conducted in the Chullcani District (See Table I-1-1). Sampling and laboratory tests were conducted (Table I-1-2).

Table I-1-1 Content of the Survey

Content	Items and Quantity
Geological Survey	Districts: Turaquiri, Chullcani, Sonia - Susana, Mendoza Scale of Survey: 1:5,000 Coverage Area: Total 12 km^2 Turaquiri District: 1.5 km^2 Chullcani District 6.0 km^2 Sonia - Susana District: 1.5 km^2 Mendoza District: 3.0 km^2 Length of geological survey route: Total 120 km
Drilling Survey	Location: Chullcani District Length of drilling: 600 m (300 m × 2) Inclination: 90° Road construction: 12 km

Tabele I-1-2 List of Laboratory Test

Content	Items and amount of Laboratory tests	
Geological surveys	1) Chemical Analysis (rock samples) (11 elements) 2) Chemical Analysis (ore samples) (11 elements) 3) Microscopic Observations of Thin Sections 4) Microscopic Observations of Polished Sections 5) X-ray Diffraction Analysis	500 10 20 10 70
Drilling Survey	1) Chemical Analysis (rock) (11 elements) 2) Microscopic Observations of Thin Sections 3) X-ray Diffraction Analysis	

11 Elements of chemical analysis:Au,Ag,Cu,Pb,Zn,As,Sb,Hg,Mo,Ba,Sn

1-3-4 Survey Team

The members of the Japanese survey team and their counterparts in Bolivia are as follows:

1) Survey Team

Japan		Bolivia Republic	
Name	Entity	Name	Entity
HASHIMOTO Morio (Head/General) (Chief Geologist)	MINDECO	Fernando Murillo Salazar (Coordinator) (Chief Geologist)	SERGEOMIN
TAKEBE Akimitsu (Geologist)	MINDECO	Yerco Santa Cruz Salvatierra (Geologist)	SERGEOMIN
HIBI Fukuji (Geologist)	MINDECO	Gribert Borja Navarro (Geologist)	SERGEOMIN
		Manuel Menacho Leon (Geologist)	SERGEOMIN
		Guido Quezada Cortez (Geologist)	SERGEOMIN

- Mitsui Mineral Development Engineering Co., Ltd.

2) Inspection

ITO Tadashi: MMAJ

SHIOKAWA Satoshi : MMAJ PERU

3) Seminar

SAKATA Tsuyoshi : MMAJ

KURIHARA Masaomi : MMAJ

HASHIMOTO Morio : MINDECO

1-3-5 Survey Period

Survey Period is shown in Table I-1-3

Table I-1-3 Period of the Survey

	2001						2002		
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan..	Feb.	Mar.
Preparation	30								
Field survey	31			20					
Laboratory work		15					15		
Reporting					1		31		
Seminar									5 ■

Chapter 2 Geographic Setting of Survey Area

2-1 Topography and Drainage System

The study area is located on two physiographic provinces, in the westernmost part of Bolivia, which are: first, the Altiplano or a flat plain at an elevation of about 3,700 m above the sea level with longitudinal and transversal elevations covering an area of about 100,000 km^2. The most prominent geographic feature of the extensive Puna - Altiplano plateau, which is after the Tibetan plateau that is the world highest and large plateau (700 x 200 km), is that it is covered by an extensive array of Neogene volcanic centers.

The second is a volcano chain that defines the natural border with Perú and Chile with altitudes of higher than 6,000 m.a.s.l. (Sajama, 6,542 m; Parinacota, 6,132 m; Payachatas, 5,982 m; Tunupa, 5,000 m.), It developed 620 km from north (Perú) to south (Argentina) running in the NW - SE direction.

The drainage of the area belongs to the central basins or lacustrine, which covers almost all the Altiplano and is formed by Lago Titicaca, Lago Poopó, Salar de Coipasa, Salar de Uyuni and Río Desaguadero.

Lago Poopó is located in the Oruro department (Prov. Poopó, Sancari and Abaroa) at 3,868 m. Its main rivers are Pazña, Challapata, Conde, Sevaruyo, and Kimpara.

The Lakajahuira River is the only drainage between Poopó and Salar de Coipasa, Ríos Lauca and Sabaya, and runs into Salar de Coipasa.

The main rivers to drain into Salar de Uyuni are Río Grande or Quetena in the south and Río Chica Chica in the east. Among them, almost all the rivers are very small and intermittent, having water only during the rainy season (December - March) making it difficult for transportation because of a lack of bridges.

2-2 Climate and Vegetation

Bolivia is in the south latitude (10° - 23°) so the climate should be tropical to subtropical however due to the altitude over 3,600 m in the study area, it is dry and cold. During nighttime, the temperature is almost always below zero.

The rainy season corresponds to summer (December to March) and the annual precipitation is about 400 mm (Table 1).

In some parts of the area due to the intensive cold, rain is converted to snow or ice. The maximum temperature of this season is about 22°C, and the minimum temperature is -5°C.

The dry season is in wintertime, and the maximum temperature rises to 18°C and the minimum is -22°C, even the temperature makes it the best time for fieldwork. In winter, winds are very strong from the west and temperature difference between day and night are 30°C making it very cold during night. The humidity varies between 0 and 22% (Table I-2)

Table Ⅰ-2 Temperature and Humidity in Oruro City

	Ene.	Feb.	Mar.	Abr.	May.	Jun.	Jul.	Ago.	Sep.	Oct.	Nov.	Dic.	Anual
Temp.Ambiente ℃	11.5	11.0	10.5	9.2	5.8	3.4	2.7	4.9	7.2	9.4	10.9	11.7	8.2
Temp. Maxima Media	18.3	18.5	17.8	17.9	16.3	14.3	14.1	16.5	17.6	18.7	19.6	19.5	17.40
Temp. Minima Media	4.7	3.5	3.2	0.5	-4.7	-7.4	-8.7	-6.6	-3.2	0.2	2.3	3.9	-1.0
Precipitation mm.	87.1	48.8	64.3	25.4	8.2	3.7	5.8	5.6	22.7	26.5	27	39.5	364.6
Humedad Relativa	61	53	59	54	52	44	43	41	42	41	43	45	48
Direction y vel. Nudos	E-7	E-6	E-6	S-5	S-3	S-2	NW-4	S-4	S-5	S-6	S-7	E-5	S-5

Station : Oruro, Province : Llocodo, Departament : Oruro

Period : 1995 – 1999 Latitud Sur : 17°58' , Longitud Oeste : 67°04' , Altitud : 3,702 m

To describe the vegetation of the area, it is necessary to divide the Altiplano in two sections:
-Altiplano Central. - (18° - 20° 30' Lat. S) is distinguished by its cold and dry climate. As a result, large sand covers the pampas, which grows intermittently thola (lepidophyllum quadrangulare), yareta (azorella sp) and paja brava (stipa ichu). Some places cultivate quinua, potato, barley and other typical tubers.

Around the slopes of the volcanic cones, there are small trees and bushes: Keñua, Kiswara and Thola.

-Altiplano Sur.- (20°30"- 22°51"Lat. S) is a dessert and sandy zone, where parihuanas or flamencos (phoenicopterus chilensis) live. Around the western edge of Salar de Uyuni (Llica - Salinas de Garci Mendoza) are developed big areas of quinua crops.

Chapter 3 General Geology

3-1 General Geology in the Surrounding Areas

Bolivia is roughly divided into five geotectonic provinces, which from west to east, are called the Cordillera Occidental, Altiplano, Cordillera Oriental, Sub-Andes - Beni-Chaco Plain and Brazilian Shield.

The survey area pertains to the Cordillera Occidental and the Altiplano. (Figs. I-3-1 and I-3-2)

Cordillera Occidental

The Cordillera Occidental is extensively covered by Tertiary to Recent volcanic rocks that effused along the N-S uplifting axis of the Mesozoic to Paleozoic basement rocks, where continental to netric sediments lie between the volcanic bodies.

The volcanic rocks that constitute the mountains are chiefly late Miocene to Pliocene andesite and rhyolite lava, while Quaternary dacite is also present in the vicinity of the mountaintops.

The large-scale and widespread volcanic activity, characteristic of the Cordillera Occidental, was brought about by the subduction of the Nazca Plate under the South American Continental Plate. Accompanying the volcanic activity, numerous stratovolcanoes were formed.

Altiplano

The Altiplano has the Proterozoic to Paleozoic basement extensively covered by formations of vast volcanic product and continental sediments of the Cretaceous to Recent age.

The continental sediments are composed of late Cretaceous continental molasse sediments (red bed) and Eocene to Oligocene foreland basin sediments (sandstone, and alternated beds of sandstone and mudstone).

Igneous activity took place in the Miocene to Pliocene time. Andesitic effusive activity continued during the Miocene time in the southern part whilst, in the northern part, effusive activity of rhyolitic pyroclastic rocks continued from the Miocene to Pliocene time, which caused a huge amount of continental volcanic product to be deposited.

A schematic geologic column of the survey area is exhibited in Fig. I-3-3.

Cordillera Oriental

The Cordillera Oriental is underlain by abyssal to terrigenous sediments of the Paleozoic age and marine to continental shelf carbonate rocks of the Mesozoic age.

These are composed of thick sedimentary rocks of the Paleozoic to Mesozoic age (miogeosyncline sediments) deposited on the Precambrian basement, where thrust faults with N-S axes and complicated fold structures were formed by the Caledonian (Ordovician), Hercynian

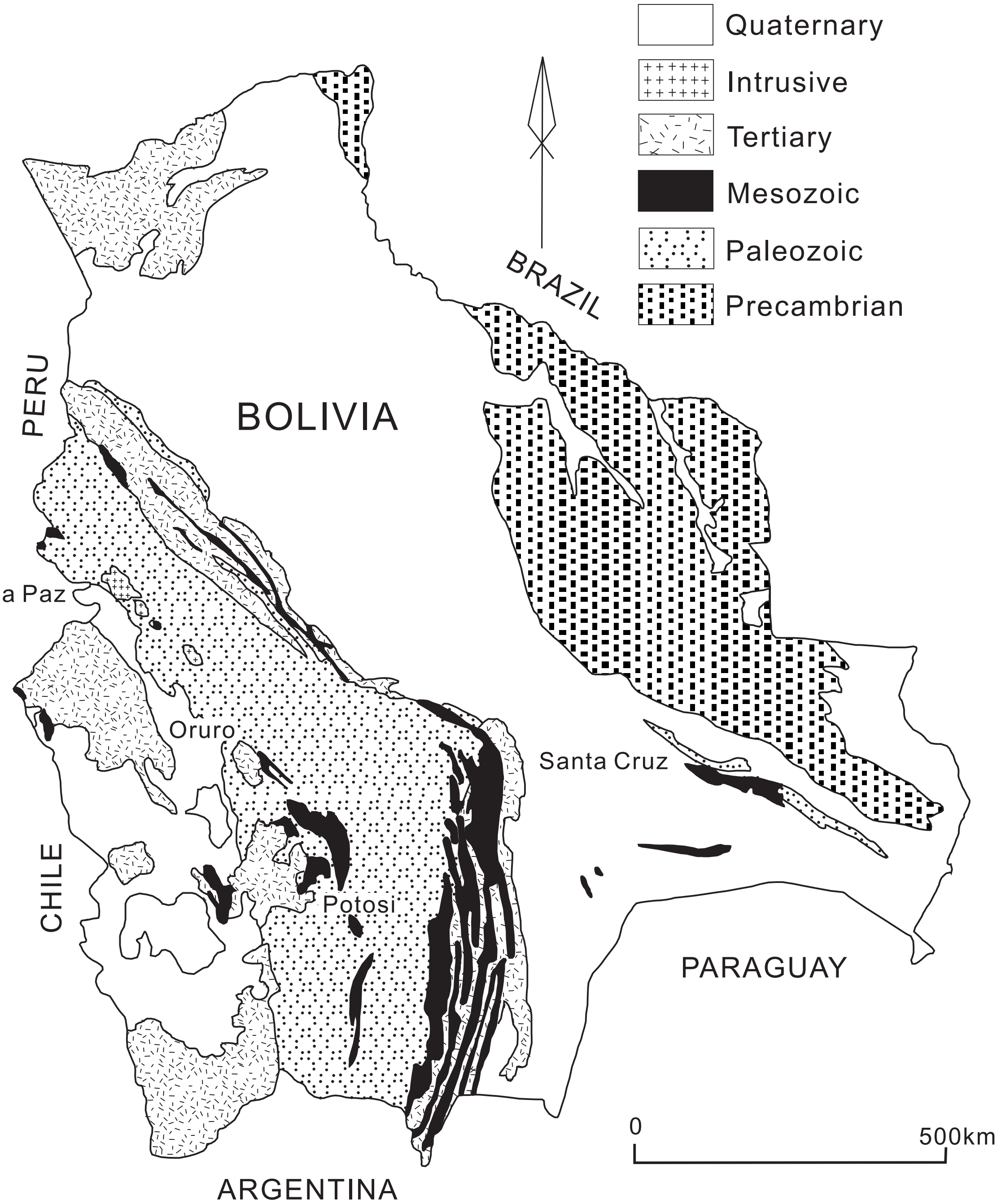
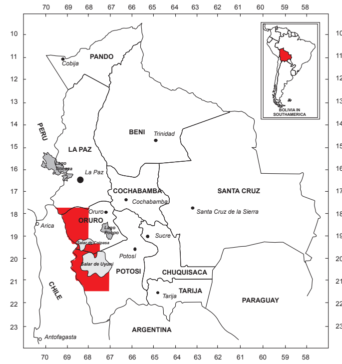


Fig.I-3-1 Geological Map of Bolivia



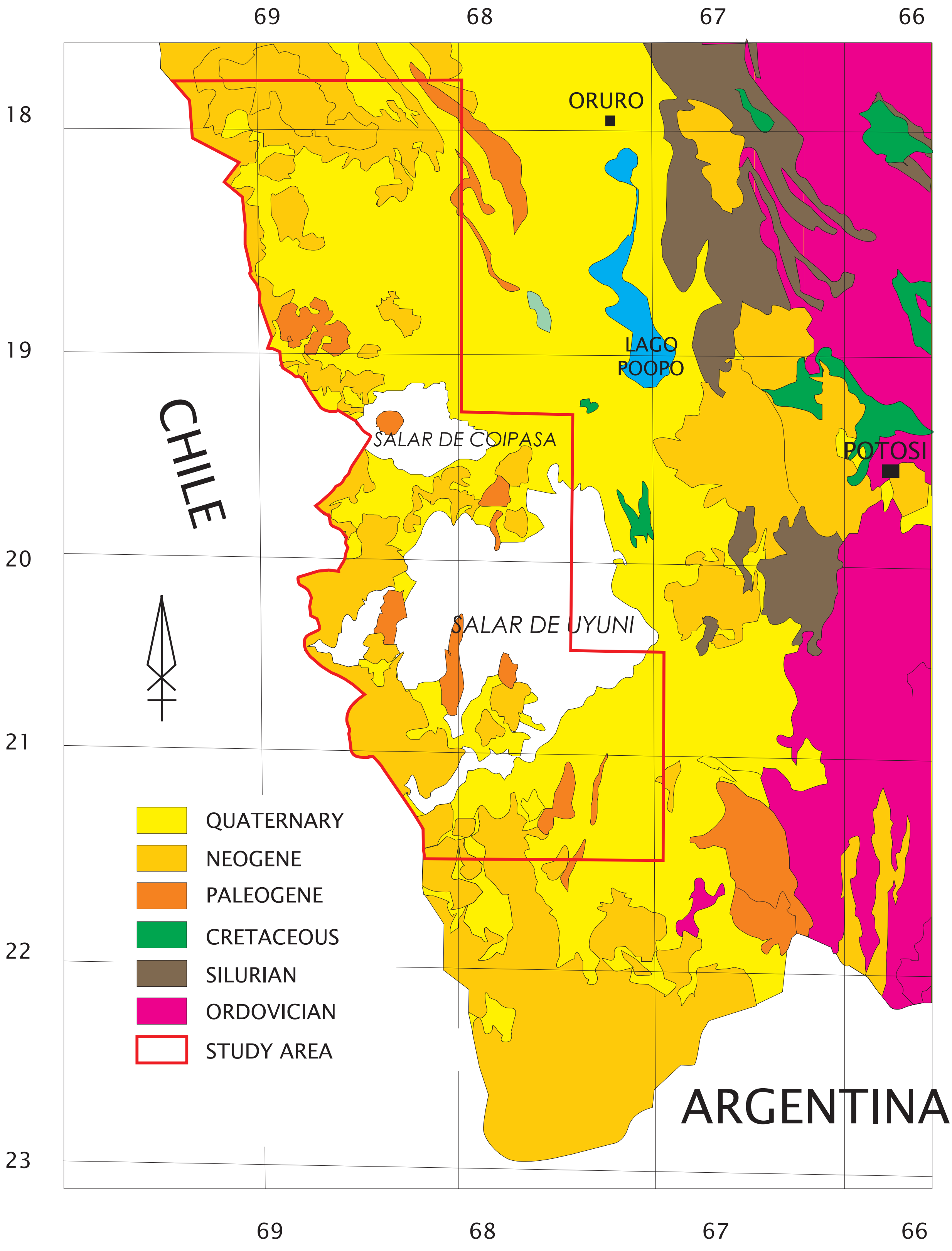


Fig. I-3-2 Schematic Geologic Map of the Area

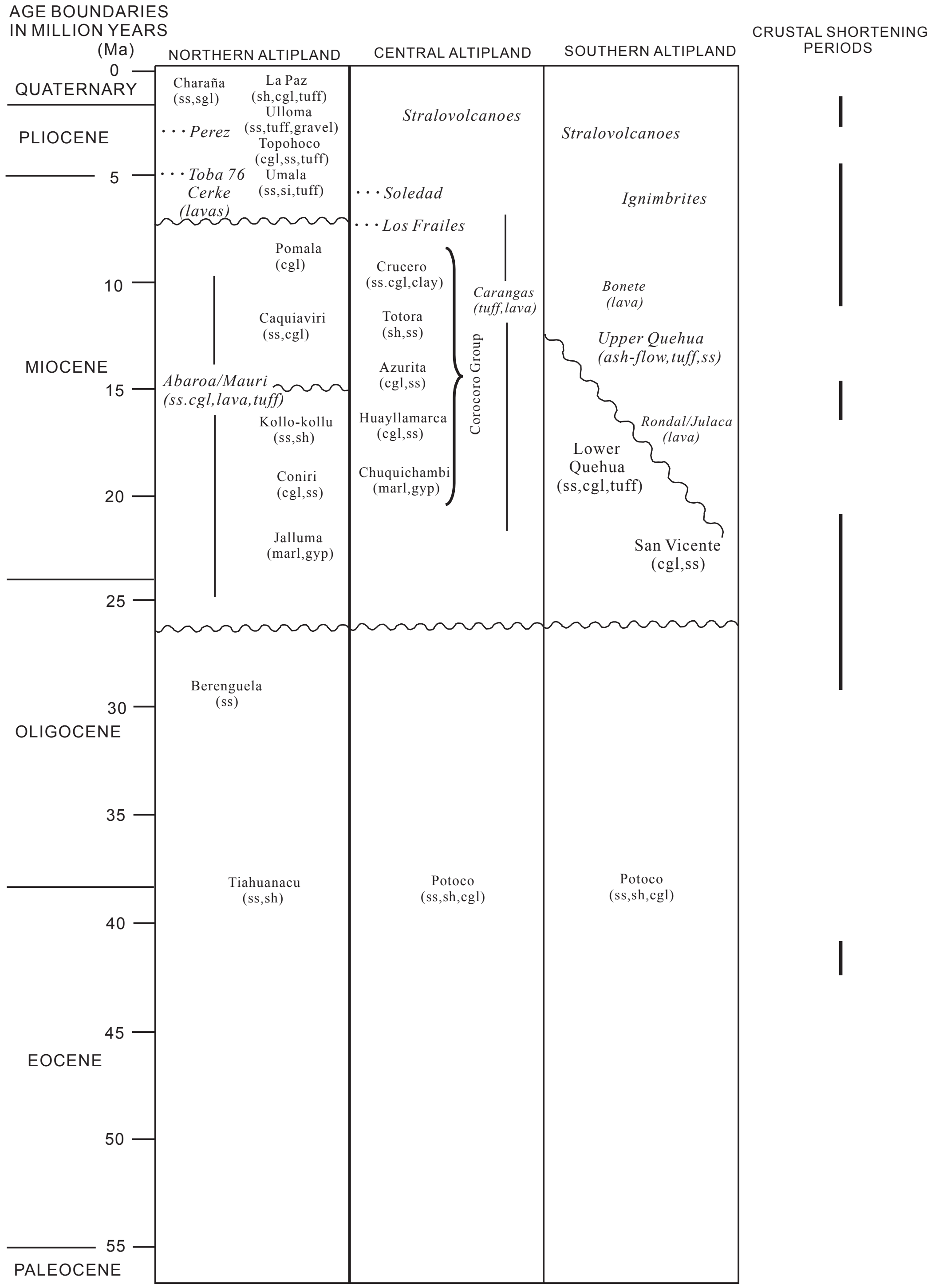


Fig.I-3-3 Schematic Geologic Column of the Survey Area

(Devonian to Triassic) and Andean (Cretaceous to Cenozoic) orogenic movements.

Simultaneously with the close of the Hercynian movement (Permian to Triassic), the subject region became a tension field where peralkaline volcanic activity and intrusion of granitic plutonic rocks occurred.

Afterwards, the plate subduction began, causing calc-alkaline volcanic activity, which lasted from the Jurassic to the Cenozoic time.

At the time of the Andean orogenic movement (Tertiary), the Cordillera Oriental was uplifted by the E-W compressive stress, causing to form the fold and thrust fault zones. At the western side of the Cordillera, the andesitic volcanic activity, ensuing intrusion of hypabyssal rocks and overthrust towards the Altiplano side took place.

Sub-Andes - Beni-Chaco Plain

The region consists of the folded mountains adjoining the eastern side of the Cordillera Oriental and the vast plain zones -- the Beni-Chaco Plain -- to the east.

The folded mountains are composed of Paleozoic and Neogene rocks. In the eastern plain zones, these formations are extensively underlain by Quaternary lake sediments and talus sediments.

Brazilian Shield

An extension of the Brazilian Shield stretches toward eastern Bolivia to form a tropical rain forest zone covering an area of 22,000 km^2.

The region is underlain by Proterozoic to Cretaceous rocks, mostly Proterozoic altered rocks such as gneiss, biotite schist and quartz schist.

These altered rocks underwent laterization in the Tertiary or later time, and are covered by Quaternary alluvium.

3-2 Characteristics of Mineralization in the Survey Area

Ore deposits of metallic minerals concentrate in the area that embraces the Cordillera Occidental, Altiplano and Cordillera Oriental, where copper mineralization accompanying alkali basalt, sedimentary copper mineralization accompanying late Tertiary red sandstone beds, so-called 'Bolivian type' polymetallic mineralization mainly of tin and silver, and epithermal mineralization mainly of gold and silver are known to be present.

In the Cordillera Occidental, small-scale epithermal gold-silver veins embedded in Miocene dacitic volcanic rocks are known to exist, a part of which is accompanied by sulfide minerals such as copper, lead, zinc and bismuth.

Also present in the area are hydrothermal alteration zones, mainly argillized and widespread in dacitic volcanic rocks. Silicification and pyrite dissemination are observed partly in the alteration zones. Under these hydrothermal alteration zones, the occurrence of porphyry-type gold-copper deposits is expected.

From the Cordillera Oriental to Altiplano, the Bolivian type polymetallic vein deposits are found, while copper deposits accompanied by alkali basalt and red sandstone are present from the north to south of the central Altiplano.

The Bolivian type polymetallic vein deposits, underlain by the upper Tertiary to Quaternary, have not yet been fully elucidated, but many of them are lead-zinc deposits with relatively low tin-tungsten contents and high copper contents. A variety of Bolivian type polymetallic vein deposits are known; they are roughly divided into those rich in silver and tin and those rich in silver, gold and copper.

Ore deposits rich in silver and tin are often seen in the Cordillera Oriental. These have mineralogically complex combinations of silver, tin, lead, zinc, tungsten, bismuth, gold, etc.

These typical ore deposits are found at such mines as Cerro Rico de Potosi, Pulacayo and Huanuni, which are classified into two types: one rich in silver sulfate minerals and the other in which the lower tin zones became exposed as a result of denudation of the upper silver zones.

Ore deposits rich in silver, gold and copper are seen in the Altiplano. The most typical deposit is the Kori Kollo mine currently under operation. The deposit has silver, gold and some copper, apparently resembling auri-argentiferous iron sulfide deposits, but it is classified into the polymetallic deposit as it contains lead, zinc, antimony, tin, etc.

The mines and ore showings existent in the survey area are shown in Fig. I-3-4 .

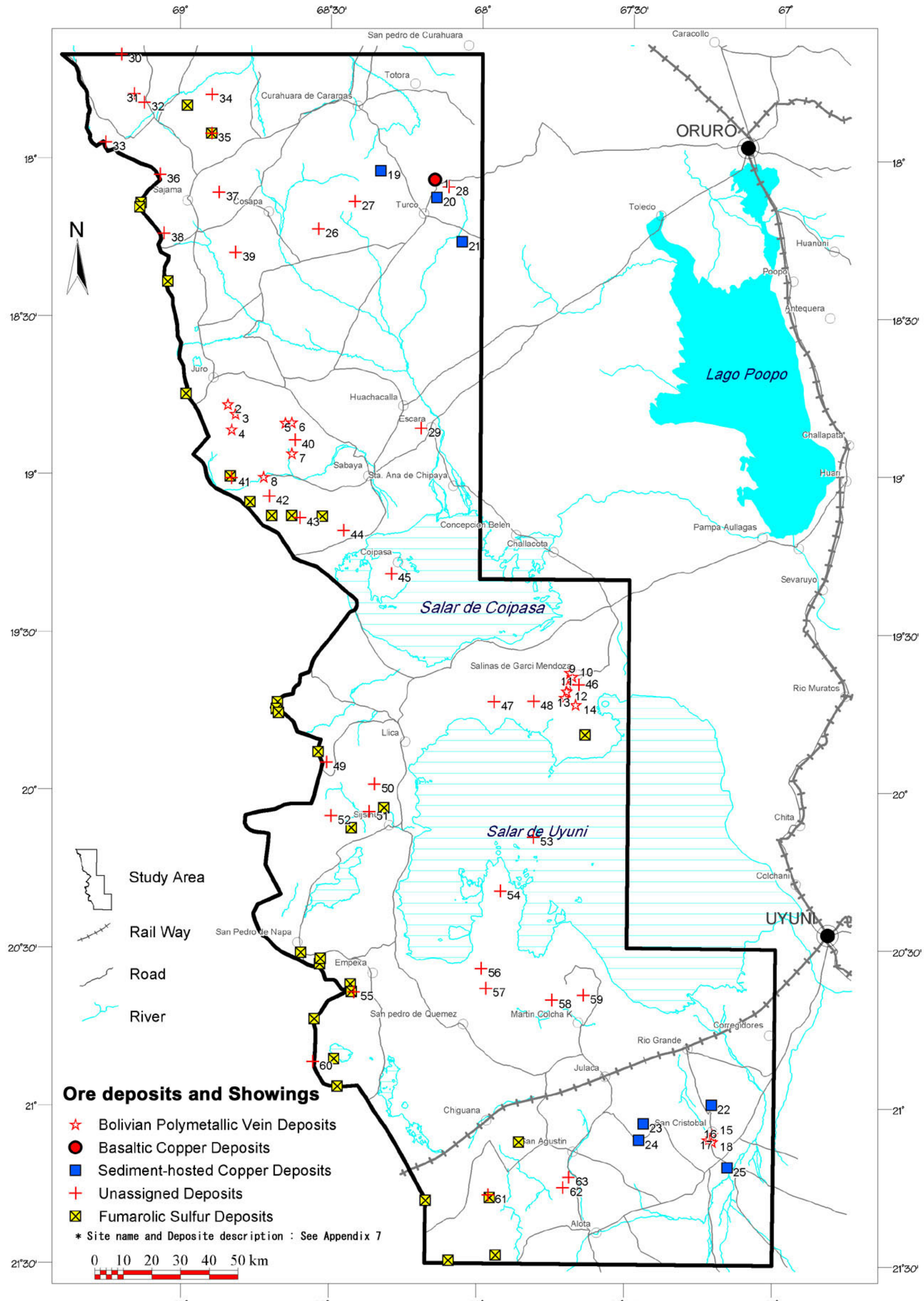


Fig. I-3-4 Ore Deposits and Showings in the Area

Chapter 4 Comprehensive Analysis

4-1 Relationship of Geology and Geologic Structure with Mineralization

4-1-1 Geology

The survey area is extensively covered by volcanic rocks centering around the Cordillera Occidental, except crystalline schist and gneiss exposed in the inliers southeast of the Chulcani district and continental sediments of Tertiary or a later age observed in some parts of the Altiplano.

The volcanic rocks generally form stratovolcanoes; alteration -- mainly argillization -- zones are widespread in the volcanic rocks. The known ore deposits are embedded in these alteration zones, presumably formed by the hydrothermal process.

4-1-2 Geological structure

Except the San Cristbal deposit (trending NE-SW) and Eskapa district (trending N-S), mineralization is observed in fractures with the E-W trend; the trends are E-W at Turaquiri, E-W (N70° W) at Carangas and E-W (N80° E ~ N75° W) at Salinas de Garci Mendoza. The fractures with the E-W trend might have fulfilled an essential function for mineralization.

4-1-3 Expected types of ore deposits

The following types of ore deposit are expected to be present in the survey area:

[1] Copper deposits accompanying alkali basalt
[2] Bedded copper deposits embedded in Paleogene red sedimentary rocks (The Corocoro-type)
[3] Epithermal deposits
[4] Bolivian type polymetallic vein deposits
[5] Porphyry-type copper-gold deposits

Of these types, veinlet-type and disseminated copper deposits accompanying late Oligocene alkali basalt and the Corocoro-type deposits are not large enough to be exploration targets.

Bolivian type polymetallic vein deposits have a general tendency that sulfide mineral veins in the lower part change into barite-quartz or barite-chalcedony veins in the upper part, which is considered attributable to porphyry-type mineralization shifting to epithermal mineralization.

Therefore, the presence of these veins may suggest emplacement of Bolivian type polymetallic vein deposits in the lower part and porphyry-type deposits in the deeper part.

The deposits are classified into following types although it is difficult.

I Bolivian type polymetallic deposits

(A) Ore deposits rich in silver-tin (mainly at Cordillera Oriental)
Mineral assemblage : silver-tin-lead-zinc-tungsten-bismuth-gold
Vein : sulfide vein
Example : Potosí deposit, Pulacayo deposit, Huanuni deposit

(B) Ore deposits rich in silver-gold-copper (mainly at Cordillera Oriental)
Mineral assemblage : silver-gold –small amount of copper (lead-zinc-antimony-tin)
Vein : sulfide vein
Example : Kori Kollo deposit

II Epithermal gold-silver-lead-zinc deposits related to shallow volcanic activity
Mineral assemblage : (gold)-silver- small amount of lead-zinc-tin
Vein : barite-quartz vein
Example : San Cristóbal deposit

III Epithermal precious metal deposits related to shallow hypabyssal intrusive activity
Mineral assemblage : gold-silver- lead- zinc- (copper)
Vein : alunite-kaolin-quartz vein, barite-quartz vein with neutral alteration zone
Example : Choquelimpie deposit, La Española deposit

IV High sulfidation type deposits (quartz-alunite vein type deposit)
Epithermal gold-silver-copper deposit
Mineral assemblage : (gold)-silver- copper (enargite)
Vein : alunite- barite- quartz vein
Example : Laurani deposit, Choquelimpie deposit, La Española deposit

V Low sulfidation type deposits (quartz-adularia vein type deposit)
Sericitized zone with adularia, carbonate minerals
Neutral argillic alteration zone
Vein : quartz-adularia vein
Example : peripheral part in the La Española mine

Figs. I-4-1 (1) and I-4-1 (2) indicate schematic models of hydrothermal ore deposits including the Bolivian type polymetallic vein deposits and porphyry copper-gold deposits accompanied by epithermal alteration, respectively.

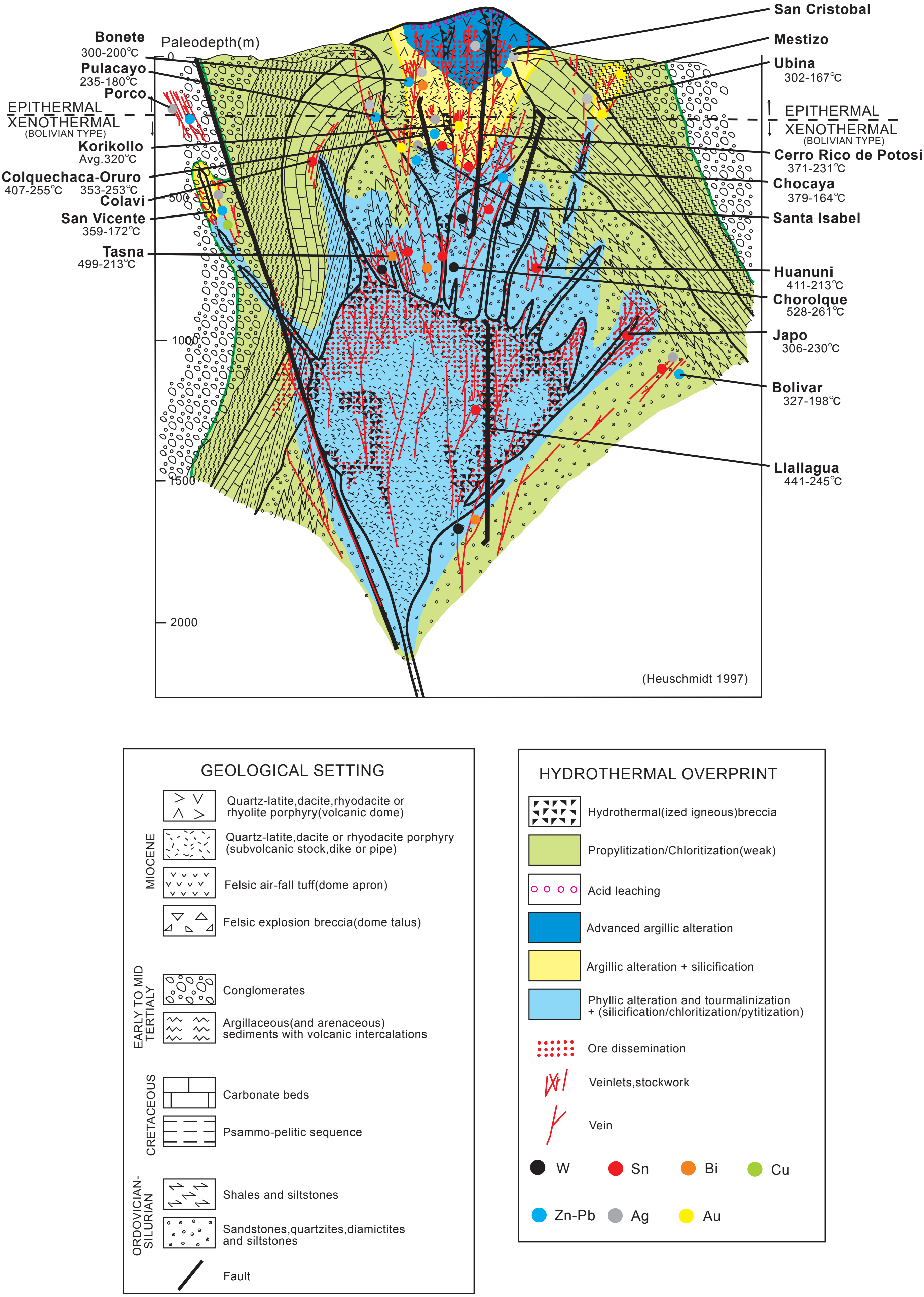


Fig. I-4-1(1) Idealized Model of Bolivia Type Deposit

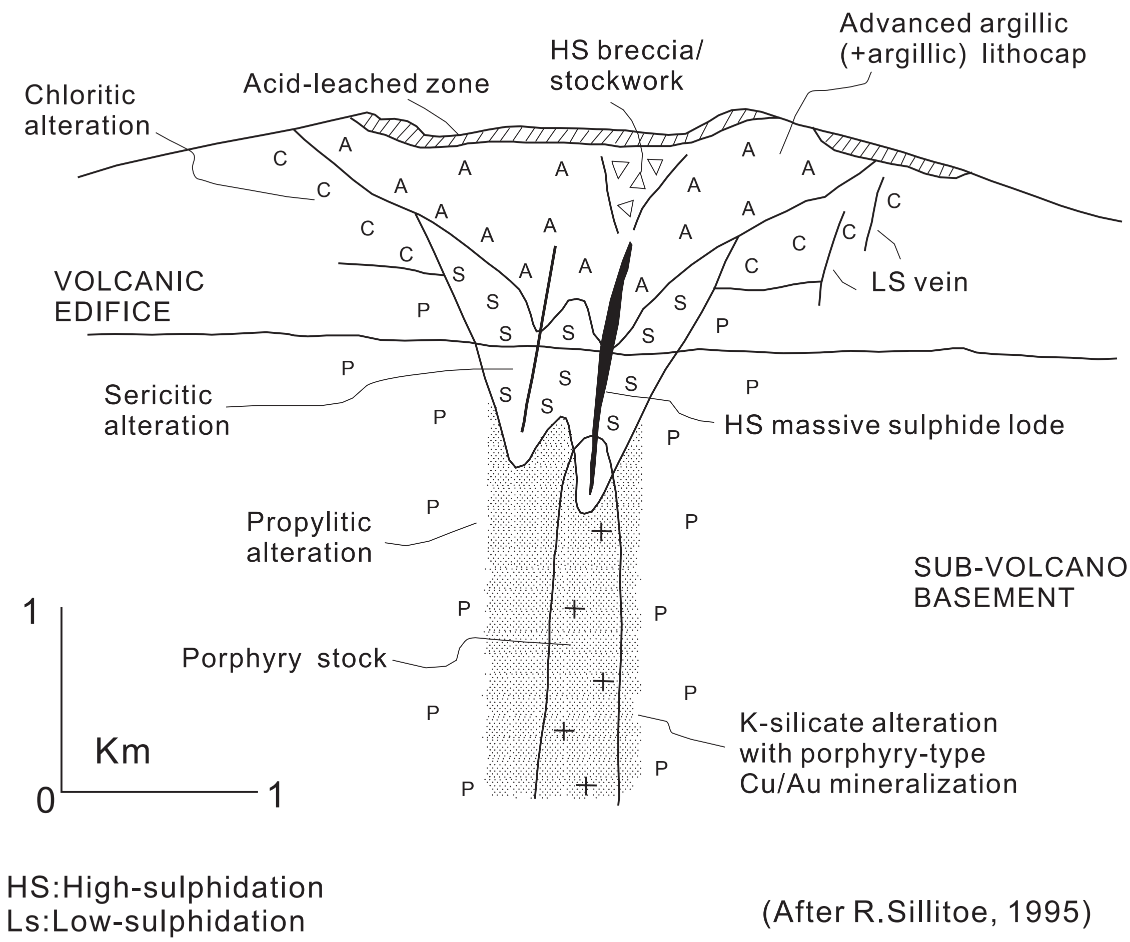


Fig.I-4-1(2) Idealized Lithocap and Underlying Porphyry Cu/Au Deposit

4-2 Survey Findings by District

4-2-1 **Turaquiri district** (Fig. I-4-2(1))

The Phase III survey revealed distributions of Middle to Upper Miocene sedimentary rocks, Miocene to Pliocene volcanic rocks and the presence of andesite intrusive rock.

The Turaquiri deposits are interpreted as epithermal barite-quartz type deposit. It is associated with base metals and precious metals, which occur along the east-west fractures formed by the development of the caldera system. Many ore veins are confirmed northwest of this ore deposit. Most of them, however, are less than 10 cm in vein width and mineralizations of network and dissemination types are not confirmed.

Variations in ore minerals are confirmed. Centering on the Turaquiri Vein, the veins change from lead and zinc veins to manganese dioxide veins in northwest and clayey veins farther outside. Showings of local gold anomalies are confirmed in this Phase.

4-2-2 **Chullcani district** (Fig. I-4-2(2))

Hydrothermal alterations distribute in andestic volcanic rocks (Middle Miocene to Pliocene) and Diorite in the Chullcani District.

The igneous activity of Chullcani Volcano started around 6.5 Ma. Wide hydrothermal alteration zones were formed through the intrusion of diorite and andesite and by hydrothermal activity caused by intrusions. It is interpreted that subsequent erosion denuded the center part of the volcanic body and that dome and mesa of basalt were formed from Late Pliocene to Pleistocene (See Fig. II-2-2 (4)).

Alteration minerals show a distribution of quartz-sericite in diorite and areas around it. Quartz zone surrounds quartz-sericite zone and cristobalite zone appears outside of the quartz zone. This suggests that intrusive rock of diorite is the center of hydrothermal activity.

The geochemical exploration in Phase III also shows a geochemical anomaly of gold in a diorite intrusive rock body and areas around it. Anomalous parts of lead, zinc and molybdenum are also distributed in the same area.

The MJB0-1 drill hole shows that hydrothermal alteration is dominant all over the cores, confirming the intense hydrothermal activity. Dissemination of pyrite and native sulfur are also detected. The assembly of alteration minerals suggests a temperature rise toward the deep part. A chemical analysis shows an anomaly of lead, arsenic and zinc in some parts. However, prominent mineralization is not confirmed.

The MJB0-2 drill hole shows a continuation of diorite in some parts sandwiching andesite. Silicified and argillized zones with fault zone intersect the diorite body. The assembly of alteration minerals suggests that the condition is sufficient for gold precipitation. However, the

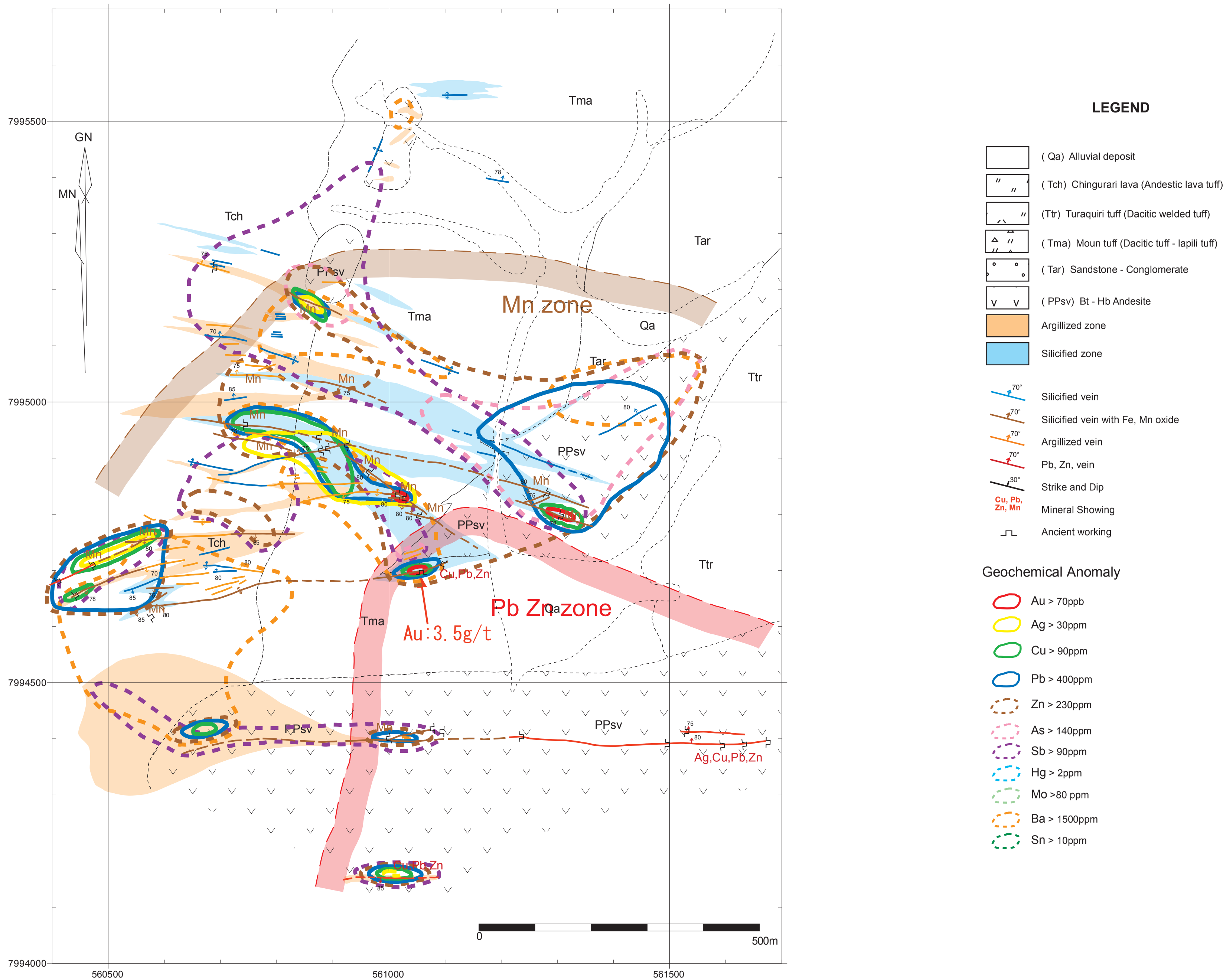


Fig. I-4-2(1) Integrated Interpretation Map of the Turaquiri District

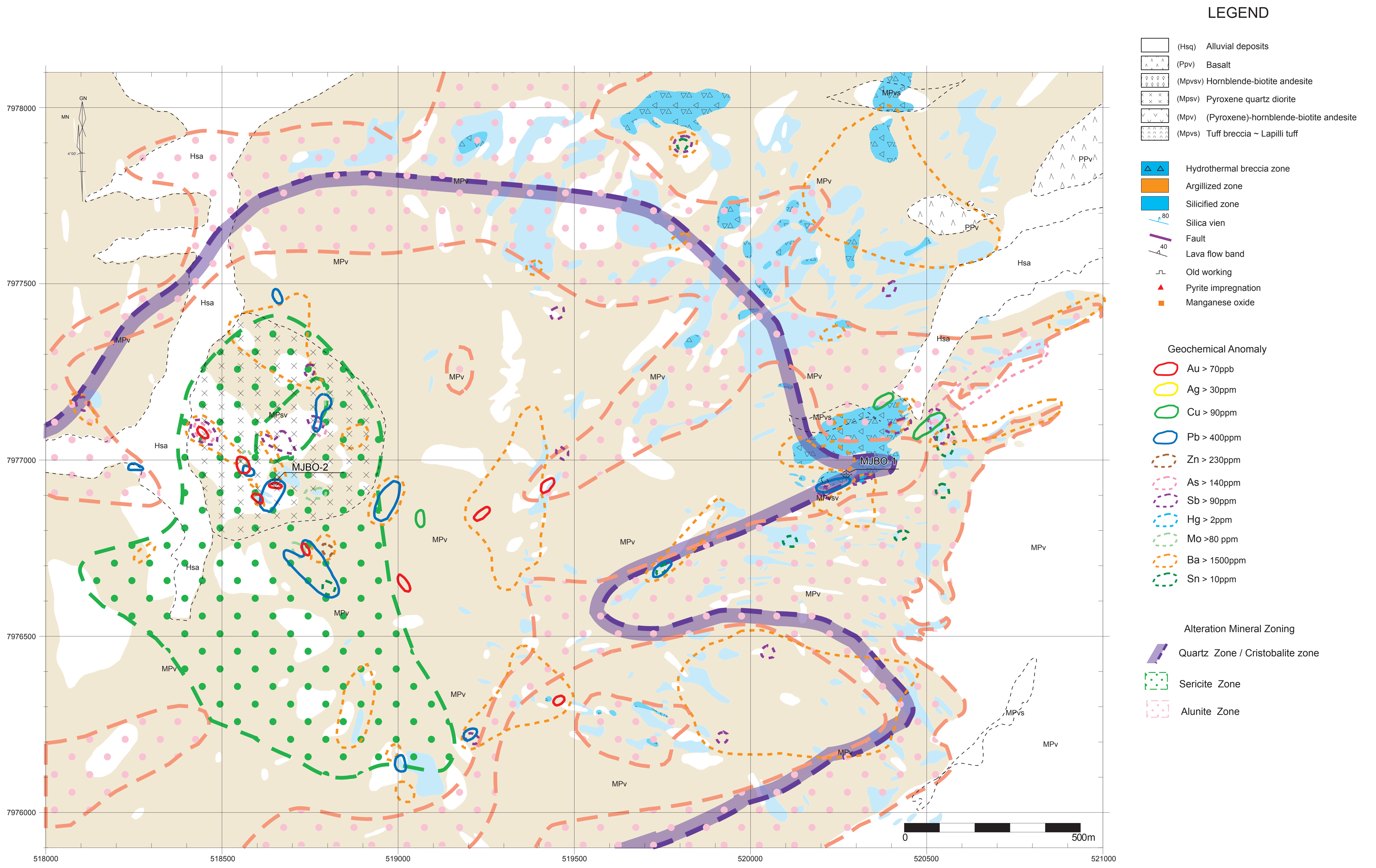


Fig. I-4-2(2) Integrated Interpretation Map of the Chullcani District chemical analysis show that gold mineralization is only slightly higher than that for the MJB0-1 drill hole and prominent gold mineralization are not confirmed. The steep structure of alteration is confirmed in both drill holes.

In the Chullcani District, epithermal mineralization related to shallow activity of intrusive rock and high sulfidation type epithermal mineralization in some parts are estimated.

4-2-3 Sonia - Susana district (Fig. I-4-2(3))

Volcanic rocks in the Jankho Kkollu Prospect are correlated to the Negrillos Formation (Upper Oligocene to Lower Miocene). The Phase III survey revealed that dacite intruded into a stratovolcano and the center part of the volcano is exposed due to erosion. It is possible that the volcano was formed later than the time when the Carangas Formation was formed in the Middle Miocene age, instead of the Upper Oligocene to Lower Miocene ages.

Many lead-zinc bearing barite-quartz veins are confirmed in areas south of the intrusive rock body. Limonite veins are confirmed north of the intrusive rock body. It is not clear whether their mineralization periods are the same or not, although there are mineral differences in the vein type.

Judging from the existence of neutral hydrothermal alteration and intrusive rock, the mineralization of this area is estimated to be an epithermal silver, lead, zinc and copper mineralization related to a hypabyssal intrusive activity in a shallow place. However, ore veins in the south part are discontinuous and small in size. The veins in the north part are also very small.

Geochemical anomaly of molybdenum shows that the porphyry type mineralization is expected for the Santa Catalina prospect. However, positive showings suggesting its existence are not confirmed in this survey.

4-2-4 Mendoza district (Figs. I-4-2(4))

Volcanic rocks consisting mainly of dark gray andesite lava and pyroclastic rocks dominate this area. All rocks have undergone hydrothermal alteration (argillization and silicification).

A large number of lead-zinc bearing veins are confirmed in propylitic rocks in the Iranuta section.

The mineralization in the Iranuta section does not contain tin and shows neutral alteration. This suggests that the mineralization corresponds to a epithermal type mineralization related to the activity of hypabyssal intrusive rocks in shallow depth. The average homogenization temperature of fluid inclusions is 258°C, suggesting that the mineralization in the Iranuta section is slightly below the epithermal ore deposits.

Based on the results of the geochemical analysis, the distribution of geochemical anomalies

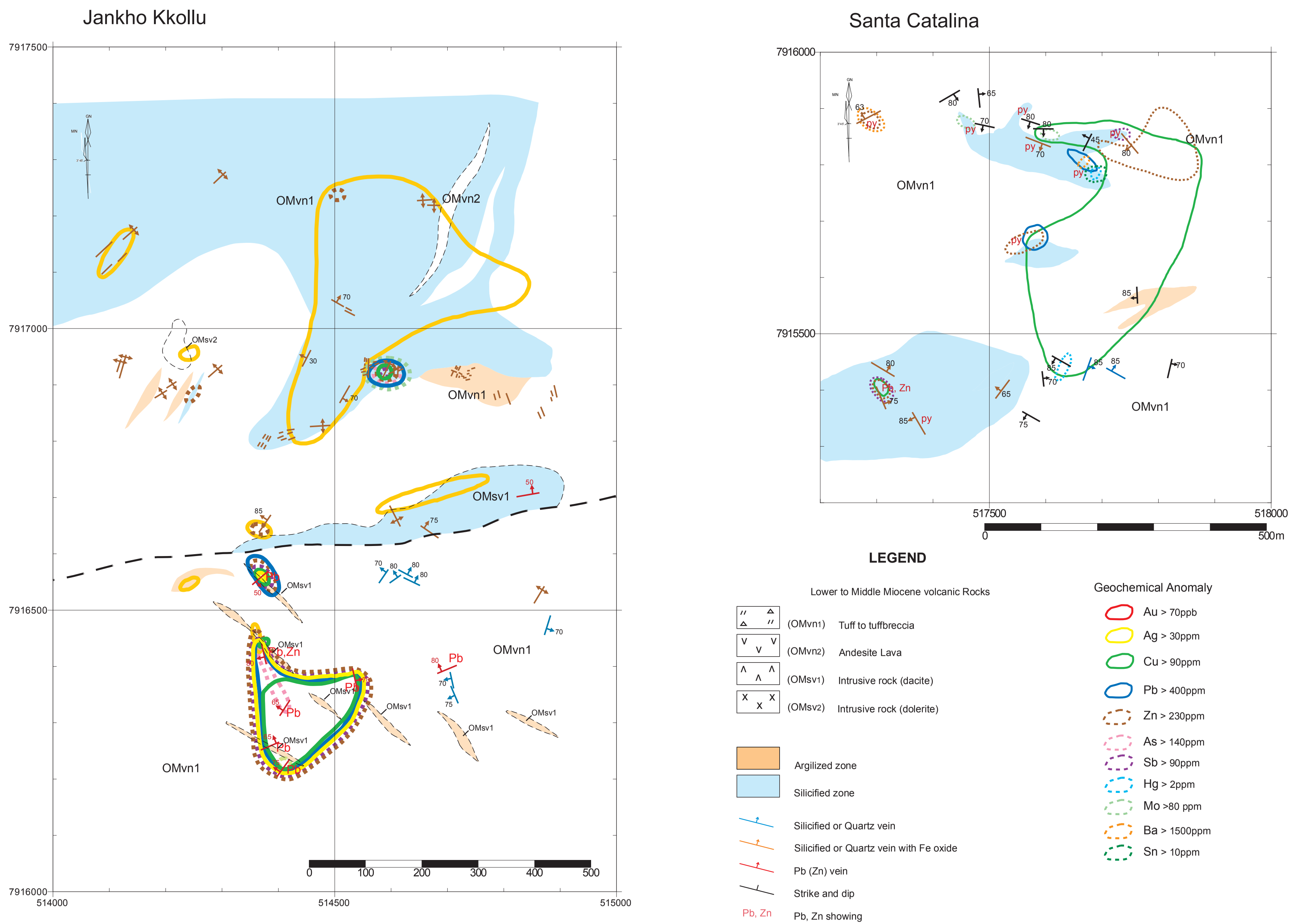


fig. I-4-2(3) Integrated Interpretation Map of the Sonia-Susana District

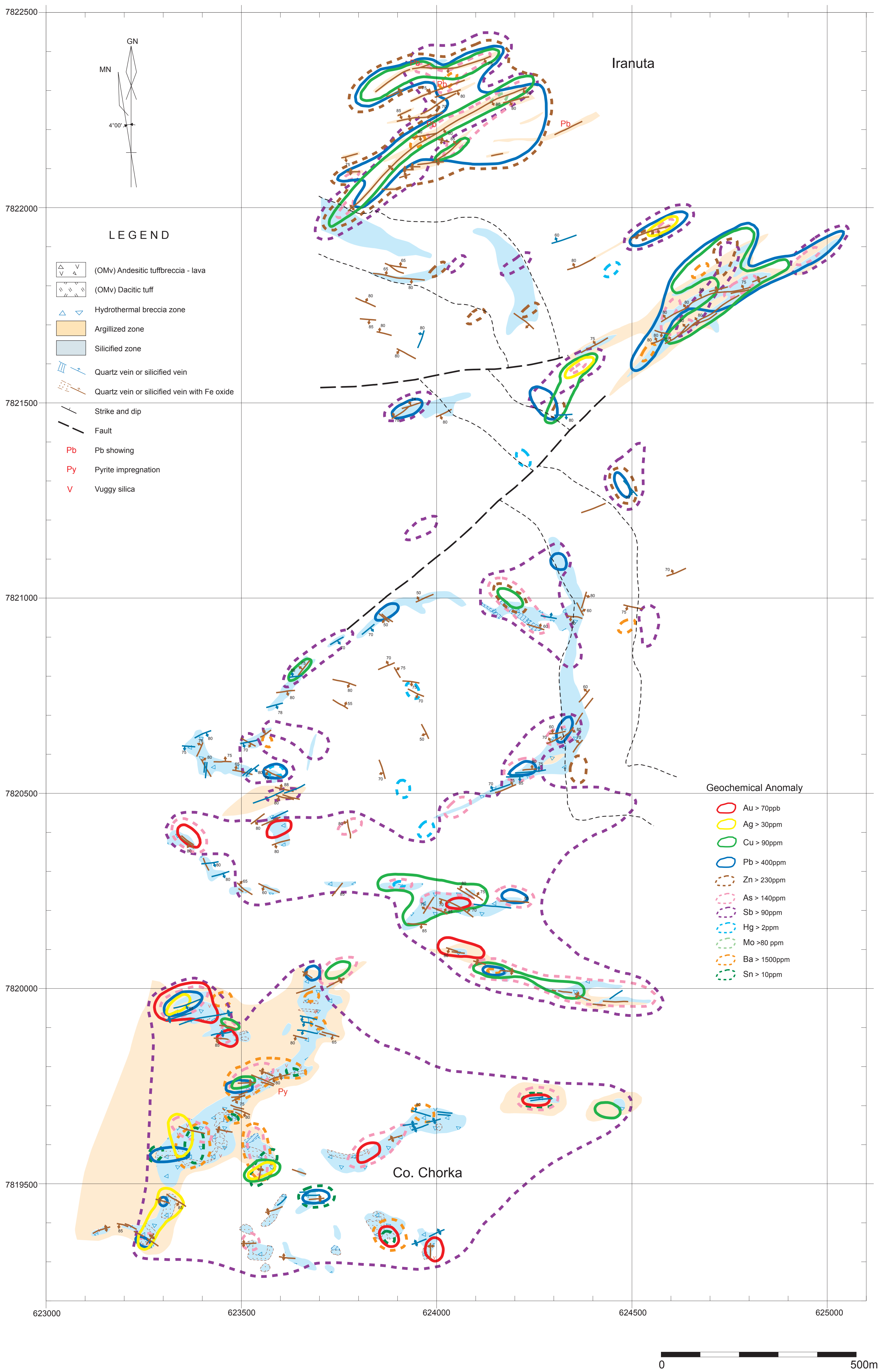


Fig. I-4-2(4) Integrated Interpretation Map of the Mendoza District and hydrothermal alteration minerals, the mineralization in the Iranuta section is believed to have been caused by rhyolite intrusive rocks in the north and that the mineralization is different from Co.Chorka.

The acidic alteration, confirmed on the upper north slope of Co. Chorka and is inferred to be caused by magma, overlaps with geochemical anomalies of gold, copper, arsenic, antimony and mercury. A high sulfidation type mineralization is expected there.

An existence of intrusive rock is estimated below places near the top of Co. Chorka because of dominant hydrothermal activity in the area. Possibilities for epithermal gold and silver ore deposits related to hypabyssal intrusive activity in shallow places are high. However the size of the mineralization may be small because Co. Chorka is interpreted as a single stratovolcano.

4-3 Potentialities of Ore Deposits

Summarizing the results of three years survey, the possibility of existing base metal bearing epithermal precious metal ore deposits beneath the widely spread hydrothermal alteration zones in the Cordillera Occidental is presumably high.

The existence of such ore deposits is expected where, 1) rock of ore bringer is located 2) passage of hydrothermal solution (mineralized fluid) is located 3) hydrothermal solution was repeatedly supplied, and the potentiality and location of ore deposits can be estimated from 4) the amount of erosion and 5) geochemical anomalies.

1) As regards to the ore bringer, a dome structure or intrusive rock has played a role of supplying the hydrothermal solution and heat. A number of intrusive rocks are observed in the district of Mendoza, Co. Kancha and Guadalupe mine.

2) As regards to the passage of hydrothermal solutions, the areas where fractures are well developed and the presence of hydrothermal breccia or breccia pipe is recognized are thought to be suitable. Since a number of known ore deposits occur in the east-west fractures (e.g. ore deposits of Salinas de Garci Mendoza, Todos Santos, Carangas and Turaquiri), the area where the east-west fractures are well developed is presumed.

3) As regards to the area where hydrothermal solution was repeatedly supplied, the area of volcanic complex seems to be more promising than the area of a single stratovolcano. In the area where old volcanic rocks (alteration) and young volcanic rocks (alteration) are co-existing, overprinting of mineralization can be expected. The size of the hydrothermal alteration zone is generally larger in the area where the hydrothermal solution was repeatedly supplied. Co. Kancha in the Mendoza district (dacite intrusions were 16.2 Ma and 8.0 Ma), and Sonia –Susana district (hydrothermal alteration was 17 Ma and 1.75 Ma)

are examples.

4) The amount of erosion is estimated from the data of age determination, homogenization temperatures of fluid inclusion, geochemical anomalies and alteration minerals. In case the erosion is well advanced and mineralization is weak on the surface, an intense mineralization is not expected deep underground, so that the potential of the area is thought to be low.

5) As regards to the geochemical anomaly, useful information is obtained at the La Deseada mine, where anomalies of lead, arsenic and antimony (locally gold and copper) are located in the upper part of the mineralization, and anomalies of gold, silver, copper, lead, zinc and antimony are located in the lower part of mineralization. Taking the above factors and vein character into consideration, the location of a mineralized zone can be presumed.

The potential area can be selected by comprehensive study of the above factors.

Chapter 5　Conclusions and Recommendations

5-1　Conclusions

The surveys in Phases I and　II　revealed that the hydrothermal alteration zones widespread in the Oruro-Uyuni region are likely to host epithermal ore deposits at depth.　It is assumed an epithermal deposit, rich in gold, silver, lead and zinc, related to shallow volcanic rocks; epithermal deposit of precious metals related to hypabyssal intrusive rocks (upper part of porphyry type deposit?); high sulfidation type of gold, silver copper ore deposit (quartz-alunite vein type); and low sulfidation type (quartz-adularia vein type) are expected.

Promising districts were identified.　In PhaseIII, four districts were selected from these promising districts and surveys were conducted. The results of the surveys in these districts are summarized below.

Turaquiri district

The Phase　III　survey revealed distributions of Middle to Upper Miocene sedimentary rocks and Miocene to Pliocene volcanic rocks and the presence of andesite intrusive rock. Although signs of local gold anomalies are just confirmed in areas around this intrusive rock., it seem to be small in size.

Many ore veins are confirmed northwest of the Turaquiri deposit. Most veins, however, are less than 10 cm in vein width and mineralizations of network and dissemination types are not confirmed.

Variations of ore minerals are confirmed.　Centering on the Turaquiri Vein, the veins change from lead and zinc veins to manganese dioxide veins in the northwest and clay veins farther outside.

The foregoing observation suggests that veins beneath the manganese dioxide veins in the northwestern part of the area surveyed in Phase　III　might change to silver-lead-zinc-copper bearing vein , but they are insufficient size for a bulk mining operation.

Chullcani district

The igneous activity of Chullcani Volcano started around 6.5 Ma.　Wide hydrothermal alteration zones were formed through the intrusions of diorite and andesite and hydrothermal activity caused by intrusions.　It is interpreted that subsequent erosion denuded the center part of the volcanic body and that a dome and mesa of basalt were formed from Late Pliocene to Pleistocene　(See Fig. II-2-2 (4)). Distribution of a quartz-sericite alteration zone shows that diorite intrusive rock is the center of hydrothermal activity.

Dominant hydrothermal alteration is confirmed throughout the MJBO-1 drill hole, it is inferred to be a local center of hydrothermal fluid activity. The assemblage of alteration minerals suggests that a temperature rising toward the deep part. A chemical analysis shows anomalies of lead, arsenic and zinc in some parts. However, prominent mineralization is not confirmed. Silicified - argillized zone associated fault zone intersects diorite in the MJBO-2 drill hole.

Geochemical analysis shows that gold mineralization is only slightly higher than that for the MJB0-1 drill hole and prominent gold mineralization are not confirmed. The steep structure of alteration is confirmed in both drill holes.

The facts that intrusive rock is exposed on the surface and the gold geochemical anomaly on the surface is not dominant in the drill holes suggest possibilities that gold mineralization was weak in general. However, because existing ore deposits are not necessarily embedded all over the intrusive rock and in domes as in the Todos Santos ore deposit surveyed in Phase II, and a quartz-sericite alteration zone stretches to the southeastern part and diorite may probably exist in the deep part, and hydrothermal breccia and breccia pipes are distributed in the adjacent southeastern part suggest intensive hydrothermal activity. Possibilities remain for epithermal gold ore deposition in the northeast part of the MJBO-2 drill hole related to an intrusive activity in shallow parts.

Sonia - Susana district

In Jankho Kkollu prospect in the Sonia-Susana district, the survey revealed that the dacite intruded into a single stratovolcano and the center part of the volcano was exposed due to erosion. It is possible that the volcano was formed later than the time when the Carangas Formation was formed in Middle Miocene, instead of Upper Oligocene to Lower Miocene.

Many lead-zinc bearing barite-quartz veins are confirmed in areas south of the intrusive rock body. The limonite veins are confirmed north of the intrusive rock body.

Judging from the existence of neutral hydrothermal alteration and intrusive rock, the mineralization of this area is estimated to be a epithermal type silver, lead, zinc and copper mineralization related to a hypabyssal intrusive activity in a shallow place. However, ore veins in the south part are discontinuous and small in size. The veins in the northern part are also very small. Therefore, ore deposits are not expected to be large.

The geochemical anomaly of molybdenum shows that the porphyry type mineralization is still expected for the Santa Catalina Prospect. However, positive showings suggesting its existence, are not confirmed in this survey.

Mendoza district

Volcanic rocks consisting mainly of dark gray andesite lava and pyroclastic rocks dominate this area. All rocks have undergone hydrothermal alteration (argillization and silicification). A large number of lead-zinc bearing veins are confirmed in propylitic rock in the Iranuta section.

Based on the results of the geochemical analysis, the distribution of geochemical anomalies and hydrothermal alteration minerals, the mineralization in the Iranuta section is believed to have been caused by rhyolite intrusive rocks in the north and that the mineralization is different from Co. Chorka. These ore veins are believed to expose relatively deep parts of the vein systems as epithermal ore deposits and large-scale ore deposits are not expected.

The acidic alteration, confirmed on the upper north slope of Co. Chorka and is inferred to be caused by magma, overlaps with geochemical anomalies of gold, copper, arsenic, antimony and mercury. A high sulfidation type mineralization is expected there.

An existence of intrusive rock is estimated below places near the top of Co. Chorka because of dominant hydrothermal activity in the area. Possibilities for epithermal gold and silver ore deposits related to hypabyssal intrusive activity in shallow places are high. However the size of the mineralization may be small because Co. Chorka is interpreted as a single stratovolcano.

5-2 Recommendations for the future

There are no strong reasons for further exploration can be suggested as the result of the project, although the survey revealed detailed information for the geology and mineralization of the area.

However, the recommendations for further explorations are summarized as follows, for in case of re-evaluating the potentiality of the Oruo - Uyuni Area and the adjacent Western Andes Region.

(1) Recommendations for exploration of epithermal type mineralization

The analysis of remote sensing data is a useful tool for selecting a hydrothermal alteration zone from a wide area. The potential mineralized zone should be selected by geochemical investigations. Further detailed geological investigations should be mentioned with the following viewpoints.

i) Existence of ore bringers (domes and intrusive rocks).
ii) Existence of hydrothermal fluid (mineralized solution) paths (fractures, hydrothermal breccias and breccia pipes).
iii) Repetitive supply of hydrothermal fluids (overlap of igneous activities).

The analytical study should be mentioned for the following viewpoints.

a) Dissection degree of volcano: distribution of igneous rock age, homogenization temperature of fluid inclusions, geochemical anomalies and alteration minerals, etc.

b) Evaluation of the vertical and lateral position in the mineralization system: distribution of alteration minerals, geochemical anomalies and mineral assemblage of veins.

Those districts with high potential that are narrowed down in this detailed geological survey should preferably conduct geophysical exploration and drilling exploration to reveal the geological structures and mineralization at deeper parts.

(2) Recommendations for exploration of porphyry type mineralization

Th mineralized age of Chilean porphyry copper deposits have a tendency to become younger from west to east. It shows the potentiality of this type mineralization in the volcanic region of the Western Bolivian Andes. But at the younger volcanoes, the porphyry type mineralization would be located quite deep underground if it exists.

Therefore it is desirable for a detailed investigation of volcanic stratigraphy (especially age dating of volcanic rocks) of the Western Andes Region as basic information for the explorations. It also should be important information for the exploration of the epithermal type mineralization mentioned above.