REPORT
ON
REGIONAL SURVEY
FOR
MINERAL RESOURCES
IN
THE SOUTHERN ANDES AREA
THE ARGENTINE REPUBLIC

FINAL REPORT

MARCH 2001

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

PREFACE

In responding to the request of the Government of the Argentine Republic, the Government of Japan decided to conduct a regional survey for mineral resources in the Southern Andes area, Argentine republic, and entrusted the survey works to the Japan International Cooperation Agency (JICA). JICA, considering the technical nature of geology and mineral resources, entrusted the survey works to the Metal Mining Agency of Japan (MMAJ).

JICA and MMAJ agreed on the Scope of Work (S/W) with the Subsecretaria de Mineria, Secretaria de Industria, Comercio y Mineria, Ministerio de Economia y Obras y Servicios Publicos of the Government of the Argentine Republic after discussing the survey program, on December 2, 1999.

The survey works was commenced by two years schedule from 1999, and the survey in 2000 is the final stage. MMAJ dispatched a survey team consisting of six members to the Argentine from November 13 to December 23, 2000. The survey works in the Argentine was carried out successfully with close cooperation of the Argentine government authorities.

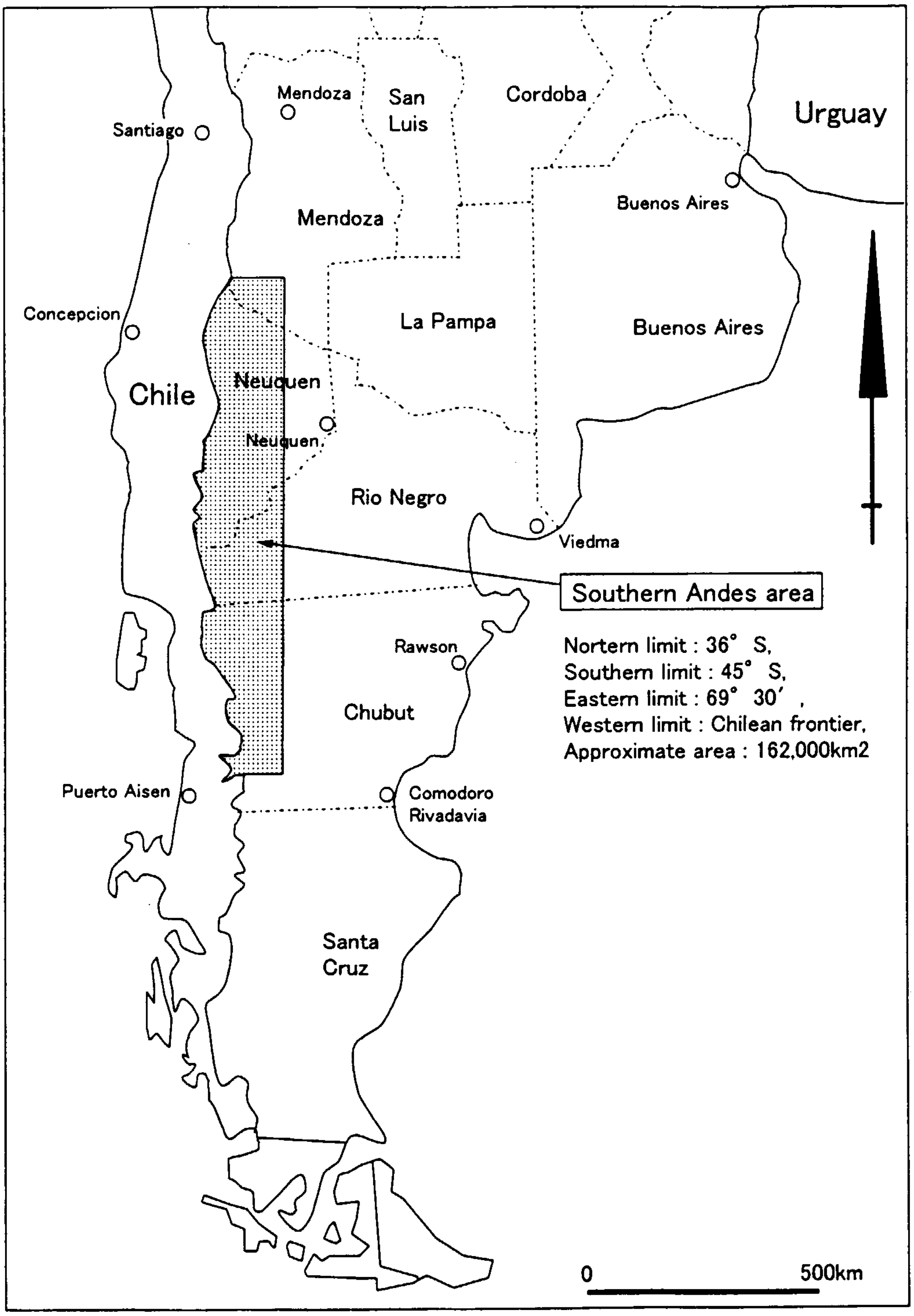
This report is the final report that summarizes the results of the survey works carried out in two years.

We would like to express our sincere appreciation to the officials concerned of the Argentine government, and we also grateful to the officials concerned of the Ministry of Foreign Affairs of Japan, the Ministry of Economy, Trade and Industry of Japan, and the Japanese Embassy in Argentine for their helpful supports to conduct the survey works.

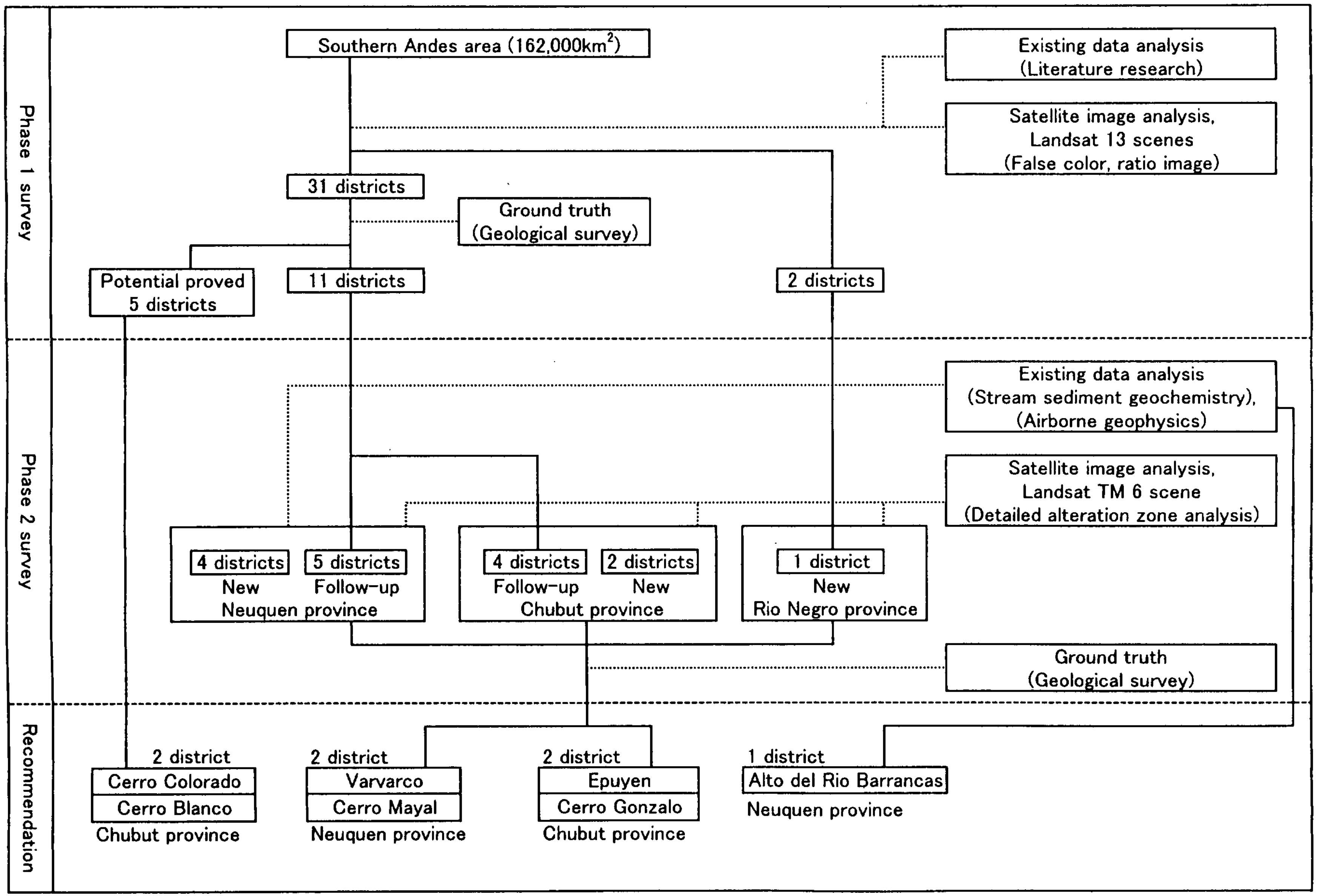
March, 2001

Kunihiko Saito
President
Japan International Cooperation Agency

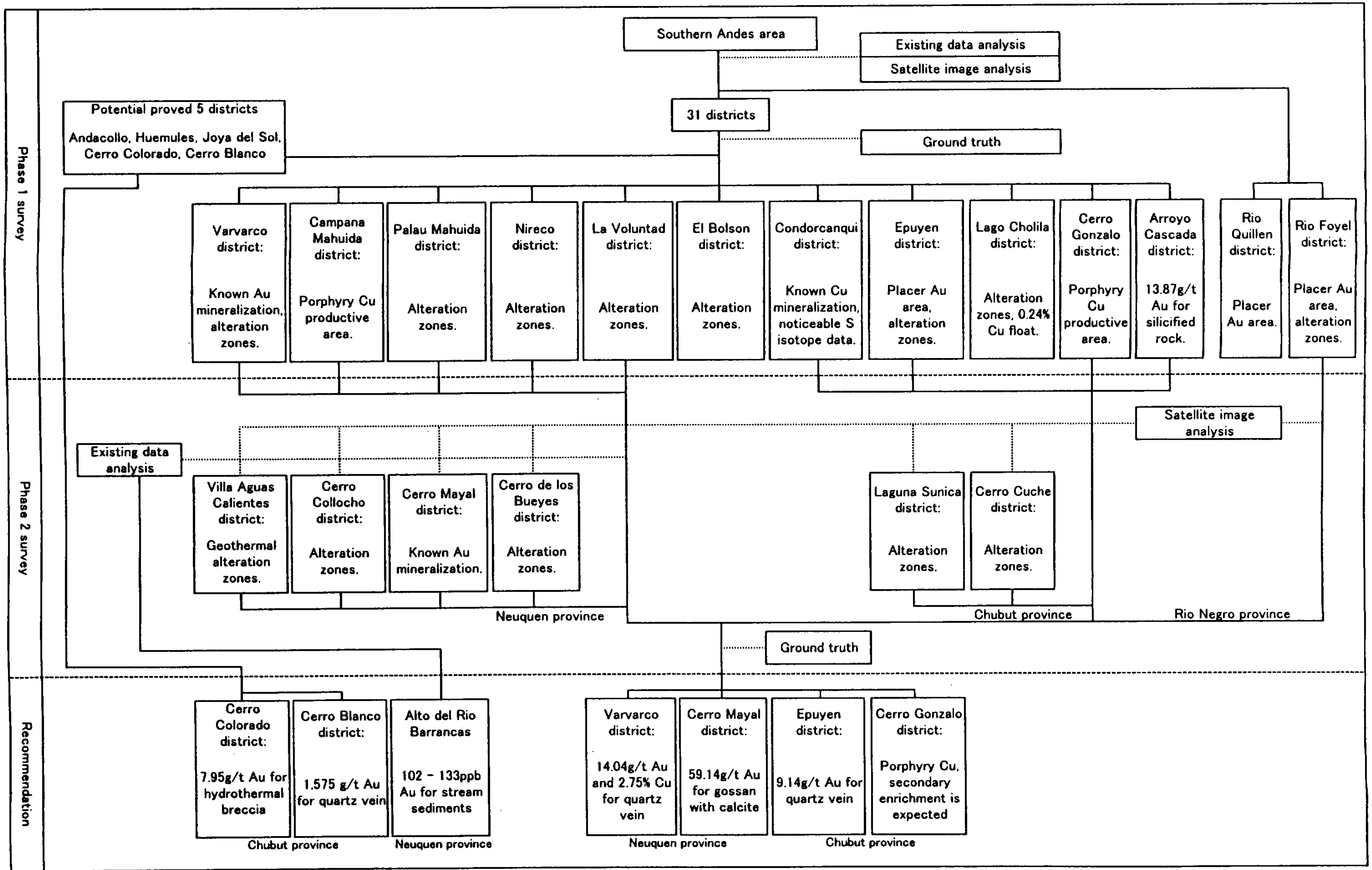
Naohiro Tashiro
President
Metal Mining Agency of Japan



Location map of the Southern Andes area, the Argentine Republic.



Flow chart of sequence of the survey.



Flow chart on process of the selection of promising districts.

SUMMARY

The southern Andes area is located in the southwestern part of the Argentine Republic, and the area covers 162,000km^2 with northern and southern limits of 36° and 45° south latitude respectively, eastern limit of 69° 30′ and western limits along the border with Chile. The purpose of this survey is evaluation for the potential of non-ferrous metallic mineral resources within a period of two years, and selection of promising districts, and also provision of information for the further exploration. In the course of the survey, the existing data analysis, satellite image analysis on LANDSAT TM and ground truth survey were conducted.

As a result of the literature research of the existing data analysis, gold vein, auriferous polymetallic vein, high sulfidation gold, porphyry copper are thought to be important mineralization types as exploration targets. Meanwhile, as a result of the existing data analysis for stream sediments geochemistry, anomalous gold values are obtained in Alto del Rio Barrancas district.

As a result of the satellite image analysis, alteration zones near the lineaments are thought to be important, because fractures are necessary as conduits for hydrothermal mineralization.

As a result of the ground truth survey, high potential of the Andacollo, Huemules, Joya del Sol, Cerro Colorado and Cerro Blanco districts were proved in Phase-1 survey. In Andacollo district, auriferous polymetallic vein deposit is being exploited. In Huemules and Joya del Sol districts, feasibility study is being executed for auriferous polymetallic vein deposit and auriferous quartz vein deposit respectively. In Cerro Colorado and Cerro Blanco districts, promising mineralization were discovered for high sulfidation gold deposit and auriferous polymetallic vein deposit respectively, but these have not been surveyed in detail. In Phase 2 survey, Varvarco, Cerro Mayal, Epuyen and Cerro Gonzalo districts are selected as promising districts. In Varvarco district, 14.04g/t Au, 524g/t Ag, 2.75% Cu and 2.69% Pb were obtained for quartz vein with chalcopyrite and malachite. In Cerro Mayal district, 59.14g/t Au and 3.4g/t Ag were obtained for gossan with calcite veinlets. In Epuyen district, 9.14g/t Au and 12.4g/t Ag were obtained for quartz vein. In Cerro Gonzalo district, secondary enrichment is expected under limonitic zone at Arroyo Luque.

Consequently, further exploration of detailed geological, geochemical, geophysical and drilling surveys are recommended for the Varvarco, Cerro Mayal, Epuyen, Cerro Gonzalo, Cerro Colorado and Cerro Blanco districts based on the ground truth survey results. Meanwhile, geological survey and geochemical survey by medium of rock and soil are recommended for Alto del Rio Barrancas district based on the existing data analysis for stream sediments geochemistry.

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PART I : GENERAL DISCUSSIONS

Chapter 1 Introduction

1-1 Circumstances of the survey

For mining in the Argentine Republic, while petroleum, natural gas and limestone had been developed until 1991, large-scale development of nonferrous metal resources had not been carried out. In 1992, the policy to promote investment from foreign countries in the mining field was started, and laws related to mining (such as the Mining Investment Act and the Mining Reconstruction Act) were amended in 1993. As a result, exploration and development by overseas companies became active, reaching a peak in 1997 when about 80 companies carried out mining operations. Since then exploration and development activities have been on the decline partly because prices of copper and gold have remained low, though substantial exploration activity has been continuing.

Basic surveys for cooperation in resource development in the Argentine Republic were launched by the Japan International Cooperation Agency (JICA) and Metal Mining Agency of Japan (MMAJ) in Japanese fiscal year 1977. Their surveys had been conducted in the following 7 areas from that time to fiscal year 1998 (Fig. I-1-1).

Northern area (surveys for resource development)	Fiscal 1977 - 1980
Famatina area (surveys for regional development planning)	Fiscal 1980
Patagonia area (surveys for resource development)	Fiscal 1981 - 1983
Alto de la Blenda area (surveys for resource development)	Fiscal 1986 - 1989
Falajon Negro area (surveys for regional development planning)	Fiscal 1990 – 1991
Western area (surveys for resource development)	Fiscal 1992 - 1994
Eastern Andes area (mineral resource surveys over a wide area)	Fiscal 1997- 1998

Under such conditions, Subsecretaria de Mineria, Secretaria de Industria, Comercio y Mineria of the Argentine Republic highly appreciated the surveys for cooperation in resource development carried out in the preceding fiscal years, and on November 30, 1998 (by Official Letter No. 350) they asked Japan for basic surveys in the Southern Andes area, where potential of copper, gold, etc. was expected. The Argentine side wants to utilize the results of these surveys as basic data to promote exploration and development of the area through introduction of foreign currencies.

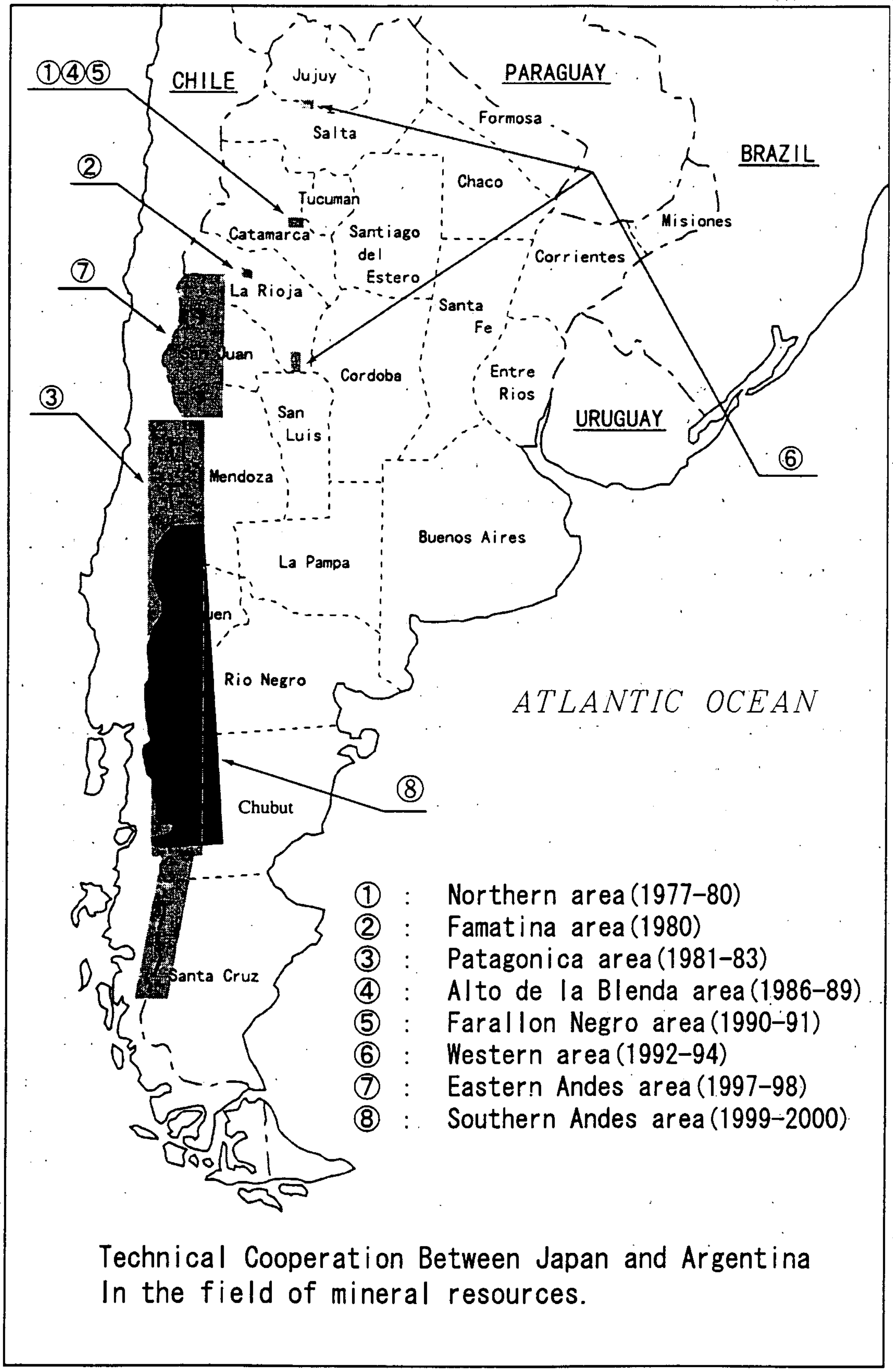


Figure I-1-1 Location map of the past projects

1-2 Outline of the survey

1-2-1 Objectives of the survey

The objective of the surveys is to efficiently extract highly potential areas for ore deposits from a vast area of the Southern Andes. This will be conducted by carrying out analysis of existing data, analysis of satellite images, and the ground truth survey (field survey) and then by comprehensively analyzing the obtained results. This fiscal year is the second year of the two-year plan.

1-2-2 Survey area

The survey area is located in the southwest of the Argentine Republic. It has an area of approximately 162,000 km^2, extending in the North-South direction from Lat. 36° 00' S at the north end to Lat. 45° 00' S at the south end, and in the east-west direction from the border line between Argentina and the Republic of Chile at the west end to Long. 69° 30' W at the east end. The survey area stretches over Mendoza, Neuquen, Rio Negro and Chubut Provinces (Fig. I-1-2). Geographically the area is roughly divided into the mountainous zone in the western side and the lowland zone in the eastern side.

1-2-3 Survey methods

1) Existing data analysis

a) Phase-1

Data, figures and maps are listed up which were obtained from geological surveys and mineral resource investigations conducted in this area so far by Servicio Geologico Minero Argentino (SEGEMAR) belonging to Subsecretaria de Mineria and Mining Direction (Direccion de Mineria) of Provincial Governments. Then mineral occurrences that are considered to be important are selected.

b) Phase-2

Geochemical analysis is conducted for stream sediment samples which SEGEMAR has collected in Neuquen Province etc., and the result is analyzed and interpreted.

Airborne geophysical data (magnetics and radiometrics) which SEGEMAR has acquired in Neuqeuen Province is analyzed and interpreted.

2) Satellite image analysis

a) Phase-1

False color synthetic image and color ratio image are drawn up from LANDSAT TM data. These images of entire area are geologically interpreted together with the existing data. Geological structures related to genesis of ore deposit, such as lineament and circular structure, are grasped, and alteration zones are extracted, in order to contribute to selecting areas highly potential for ore deposits.

b) Phase-2

For areas which include promising districts extracted by Phase I survey, subdivision of alteration zones was tried using LANDSAT TM data.

3) Ground truth survey

a) Phase-1

Based on the results of analysis of the existing data and satellite images, geological surveys (ground truth) are conducted in order to investigate local geology, alteration zones, mineral occurrences, etc. In addition, collected rock and ore samples are used for laboratory analysis, and the result is employed for comprehensive analysis together with the result of ground truth.

b) Phase-2

Follow up survey is conducted in promising districts which were selected after considering the result of Phase I survey. Also the ground truth is performed in districts which are required for the survey based on the analysis of the existing data and satellite image. The results including the laboratory analysis are comprehensively analyzed and estimated.

1-2-4 Survey team

1) Existing data analysis and ground truth survey

a) Japanese side

Ken Nakayama:	Japan Mining Engineering Center for International Cooperation (JMEC)
Ikuhiro Hayashi:	JMEC
Hajime Hishida:	JMEC
Haruhisa Morozumi:	JMEC
Takayoshi Murakami:	JMEC
Ryuta Okubo:	JMEC

b) Argentine side

Mario Alberto Zubia:	Servicio Geologico Minero Argentino (SEGEMAR) Comodoro Rivadavia-Chubut
Juan Carlos Zanettini:	SEGEMAR, Mendoza
Rafael Alberto Gonzalez:	SEGEMAR, General Roca-Rio Negro
Roberto L.M. Viera:	SEGEMAR, Comodoro Rivadavia-Chubut
Marcelo J. Marquez:	SEGEMAR, Comodoro Rivadavia-Chubut

2) Satellite images analysis (conducted in Japan)

Yoneharu Matano (analysis and reports):	JMEC
Masataka Ochi (production of images, analysis, and reports):	JMEC
Hiroshi Kanbara (data processing and production of images):	JMEC

Masataka Ochi executed the remote sensing seminar in Argentine (Phase-2).

3) Interpretation and report making (conducted in Japan)

Ken Nakayama:	Japan Mining Engineering Center for International Cooperation (JMEC)
Ikuhiro Hayashi:	JMEC
Hajime Hishida:	JMEC
Haruhisa Morozumi:	JMEC
Takayoshi Murakami:	JMEC
Ryuta Okubo:	JMEC

1-2-5 Period and amount of the survey

1) Existing data analysis and ground truth survey

a) Phase-1

From January 12 (Wed.), 2000 to February 21 (Mon.), 2000

Table I-1-1 Record of the phase-1 ground truth survey.

Item	Performance
Visiting sites	31 districts
Obtained samples of rocks and ores	314 pieces

b) Phase-2

From November 13 (Mon.), 2000 to December 23 (Sat.), 2000

Table I-1-2 Record of the phase-2 ground truth survey.

Item	Performance
Visiting sites	16 districts
Obtained samples of rocks, ores and pan concentrated sediments	265 pieces

2) Satellite image analysis

a) Phase-1

From December 22 (Wed.), 1999 to March 17 (Fri.), 2000

Data processing, mosaic image preparation and interpretation of LANDSAT TM data

b) Phase-2

From September 11 (Mon.), 2000 to October 31 (Fri.), 2000

Detailed analysis (subdivision of alteration zones) of LANDSAT TM data

c) Remote sensing seminar

From June 7 (Wed), 2000 to Jun 21 (Wed), 2000

3) Presentation of the survey results

From March 5 (Mon), 2001 to March 10 (Sat), 2001

4) Laboratory works, interpretation and report making

a) Phase-1

From February 22 (Tue.), 2000 to March 23 (Thu.), 2000

Table I-1-3 Amount of the laboratory works of phase-1 survey.

Item	Number of samples
Thin section observation	29
Polished thin section observation	16
Powdery X-ray diffraction	71
Bulk chemical analysis for geochemical survey (28 elements)	128
Bulk chemical analysis including PGM elements for Geochemical survey (31 elements)	5
Bulk chemical analysis for petrochemical study (48 elements)	13
Ore grade assay (23 elements)	24
Fluid inclusion study (Homogenization temperature and Salinity)	13
$\delta^{18}O$ composition measurement	9
$\delta^{34}S$ composition measurement	7
K-Ar radiometric dating	3

b) Phase-2

From December 25 (Mon.), 2000 to March 23 (Thu.), 2001

Table I-1-4 Amount of the laboratory works of phase-2 survey.

Item	Number of samples
Thin section observation	28
Polished thin section observation	12
Powdery X-ray diffraction	123
Bulk chemical analysis for geochemical survey (28 elements)	139
Bulk chemical analysis for petrochemical study (48 elements)	5
Ore grade assay (23 elements)	16
Bulk chemical analysis for pan samples (22 elements)	12
Fluid inclusion study (Homogenization temperature and Salinity)	6
$\delta^{18}O$ composition measurement	2
$\delta^{34}S$ composition measurement	4
K-Ar radiometric dating	5

Chapter 2 Geography of the survey area

2-1 Location and accessibility

The survey area is in the north of a district called Patagonian Andes located in the southwest of the Argentine Republic. It is an expanse with an area of 162,000 km^2 stretching long and narrow from north to south, with its northern end limited by Lat. 36°00' S, the southern end limited by Lat. 45°00' S, the western end limited by the border with Chile, and the eastern end limited by Long. 69°30' W (Fig. I-1-2). The area covers the three Provinces of Neuquen, Rio Negro and Chubut (and geographically small part of the southern tip of Mendoza Province). Major cities and towns of the survey area from north to south includes Chos Malal, Zapala, San Martin de los Andes (of Neuquen Province), San Carlos de Bariloche, El Bolson (of Rio Negro Province), Esquel, Tecka and Alto Rio Sengual (of Chubut Province).

For access to the survey area regular flights are generally used from Buenos Aires to Neuquen, the central city of Neuquen Province (four to five 2-hour flights per day), to San Carlos de Bariloche, the tourist city of Rio Negro Province (four to five 2-hour-and-20-minute flights per day) or to Comodoro Rivadavia, the central city of Chubut Province (six to seven 2-hour-and-15-minute flights per day). From these local cities to the survey area, travelling by car on trunk roads is a common means of access. Although Esquel of Chubut Province has an airfield, no regular flights are in service now.

Most of main roads in the survey area are paved and well maintained. Among them, National Road No. 40 runs from north to south through practically the entire survey area, connecting Chos Malal, Zapala, Esquel and Alto Rio Senguer. National Road No. 237 connects Neuquen and San Carlos de Bariloche, and is partly used for travel between Zapala and San Carlos de Bariloche. National Road No. 258 connects San Carlos de Bariloche and Leleque located to the south, and is used for travelling between San Carlos de Bariloche and Esquel. Besides national roads, provincial roads are also well developed for traffic to connect major cities and towns. Although paved provincial roads are not as many as national roads, they are also well maintained for high-speed driving.

Distance between major cities and towns, and time required for travelling there are as follows;

General Roca - Zapala:	234 km, 3 hours.
Zapala - Chos Malal:	211 km, 3 hours.
Zapala - San Carlos de Bariloche:	363 km, 5 hours.
San Carlos de Bariloche - El Bolson :	132 km, 2 hours 30 minutes.
El Bolson - Esquel:	165 km, 2 hours.

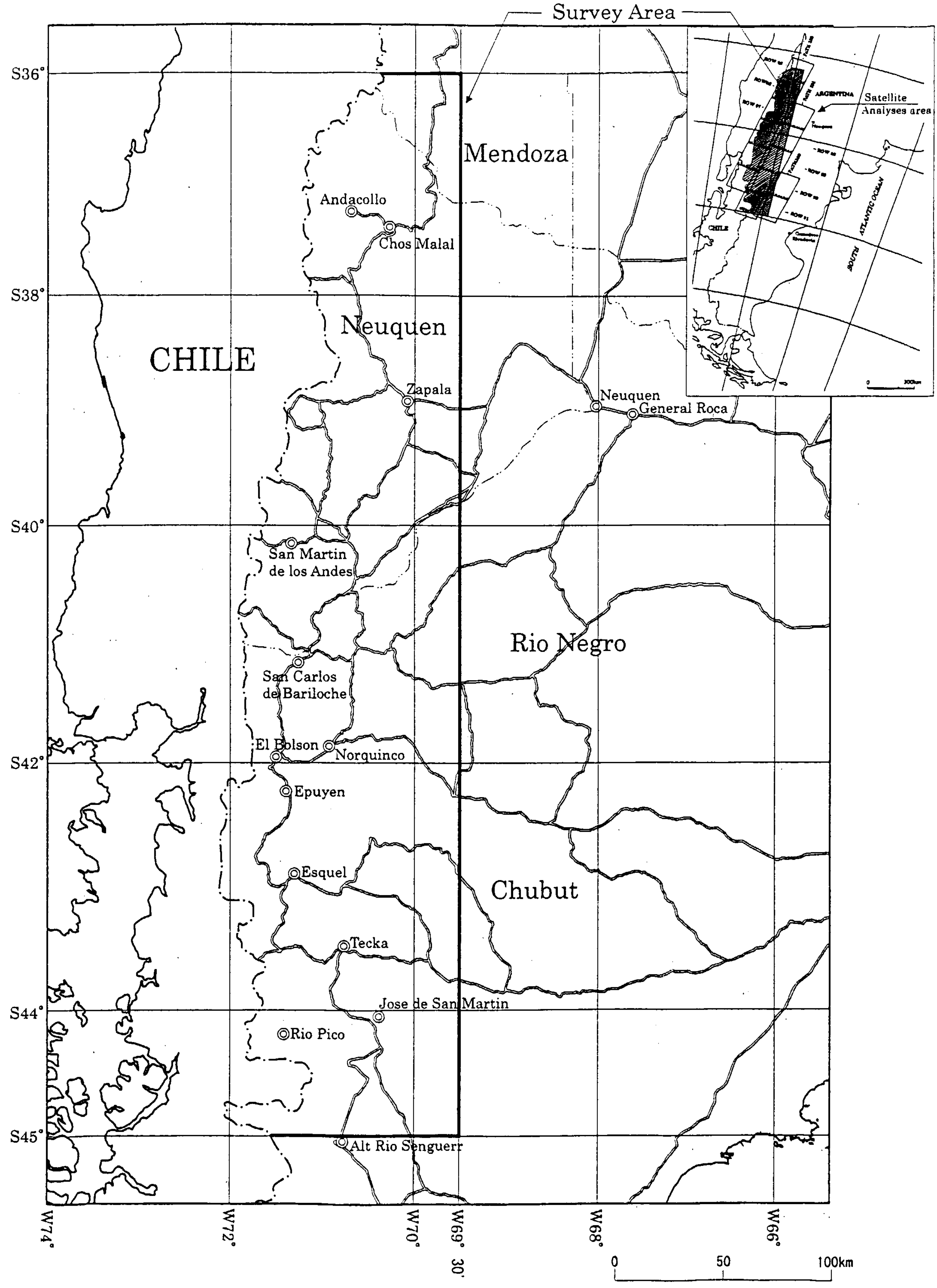


Figure I-1-2 Geographic map of the survey area

Esquel - Alto Rio Senguerr: 351 km, 4 hours.
Alto Rio Senguerr - Comodoro Rivadavia: 354 km, 4 hours.

Access to mineral occurrences or alteration zones is mostly in a bad condition. Passing through streams, travelling on snow roads in winter and muddy roads in summer necessitate the use of four-wheel drive vehicles. When exploring deep into mountains, it is desirable to use two four-wheel drive vehicles or the combination of one four-wheel drive vehicle and one truck for transportation. For access to mountain areas where no roads are available, horses were employed in phase-2 survey.

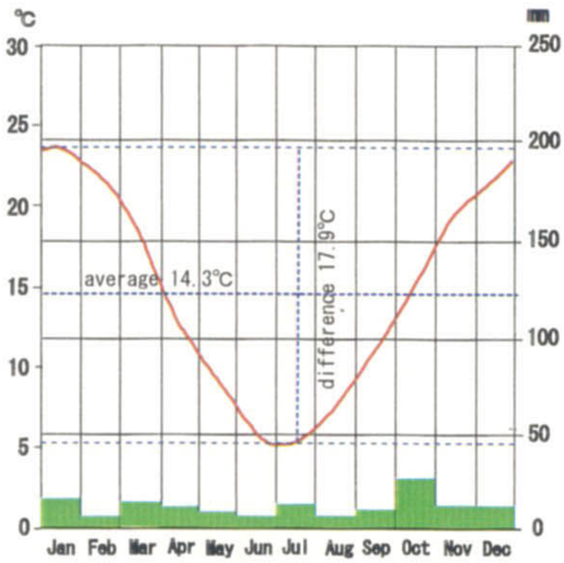
Gas stations operate in every major city and town from early in the morning until evening, so there is no problem of fueling. The fuel price as of November 2000 is US$0.479/l for normal gasoline, US$0.649/l for super gasoline, US$0.719/l for ultra gasoline, and US$0.394/l for gas oil at Esquel, Chubut Province.

2-2 Topography and drainage

The topography of the survey area changes its feature from west to east into three zones; i.e., the mountain zone at an elevation of 1,500 to 2,000 m near the Chilean border in the west, the hilly zone at an elevation of about 1,000 m in the central area, and the plains in the east. Expanses of high plateaus characteristic of the Andes to the north of the survey area are not observed. The elevation gradually becomes lower, and the width of mountains (Cordillera) becomes narrower toward the south until it averages less than 100 km. The mountains of highest elevation are Mt. Volcan Domuyo (4,709 m: Neuquen Province) and Mt. Volcan Lanin (3,776 m), which are located on the border between Argentina and Chile, and make part of the divide of the Pacific and the Atlantic Oceans. The rest of the mountains, however, for the most part are obstructed everywhere by rivers running westward or eastward and do not function as the continental divide. A majority of volcanic activity centers are present on the western side of the mountains, i.e., on the Chilean side.

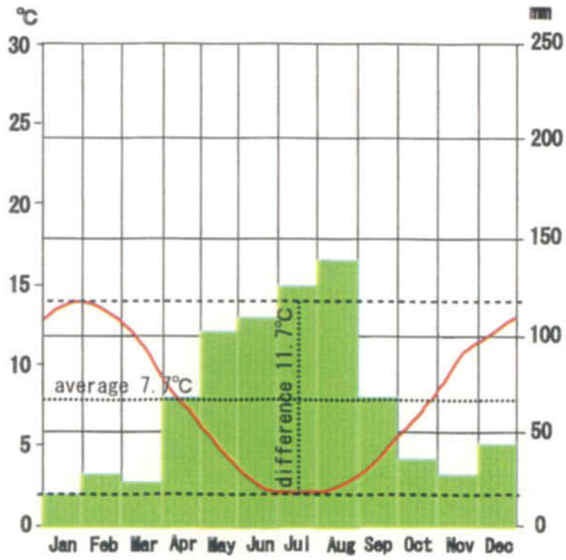
In the western mountain area, rivers trending to the E-W or NW-SE are prominent, and the flow of these rivers is interrupted in the south of Lat. 39° S to build up lakes. Especially, San Carlos de Bariloche and its surroundings have so many lakes that the area is named Lake District and designated as a national park. The lakes are very deep at high elevation and some of them, such as Lake Nauel Huapi, have glacial topography similar to fjords.

These rivers run toward the east for a while and then flow into the N-S trending rivers (Rio Alumine, Rio Agrio, A Picum Leufu, Rio Colon, etc.). In the plains, numerous branch rivers from various directions run into these rivers, change the flow to the northwest or to the northeast according to the topography of low land, and on the whole flow toward the east.



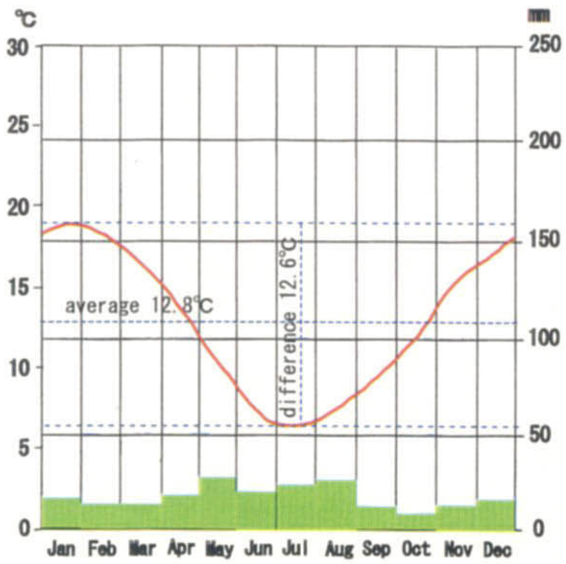
Latitude: 38° 57′ S
Longitude: 68° 08′ W
Altitude: 270 m
Total precipitation: 139mm
Major wind: West, East & Southeast
Average velocity: 13 km/h

(a) Climate at Neuquen, Neuquen Province



Latitude: 41° 09′ S
Longitude: 71° 10′ W
Altitude: 836 m
Total precipitation: 782 mm
Major wind: West
Average velocity: 24 km/h

(b) Climate at San Carlos de Bariloche, Rio Negro Province



Latitude: 45° 47′ S
Longitude: 67° 30′ W
Altitude: 61 m
Total precipitation: 187 mm
Major wind: West, Northwest & Southwest
Average velocity: 32 km/h

(c) Climate at Comodoro Rivadavia, Chubut Province

Fig. I-2-1 Data of climate of the survey area

2-3 Climate

The climate of Patagonian Andes is strongly affected by the Pacific Ocean extending to the west and south of the South American Continent and exposed to the strong wind spiraling around the Antarctic. In Argentina, mountains trending from north to south serve as a barrier to this westerly wind but, at the same time, they bring abundant rainfall and snowfall. The westerly wind, after rainfall, brings a dry climate to the area on the eastern side. Due to strong oceanic influence, unforeseeable climate changes frequently occur. In spring and early summer, it is not uncommon to see good weather suddenly change to bad one, accompanied by strong rain and storm from the Pacific. In such a case, snowfall can occur except in low land even in the middle of summer.

In general, the climate becomes harsher toward the south. This is reflected by the vegetation limit (upper limit) of alpine plants and also by the drop of accumulated snow level in the summertime. For example, alpine plants can be seen at an elevation above 2,000 m in the north of Neuquen Province, but lichen can grow at an elevation above 400 m in Cape Horn in the south. In the north, perpetual snow can be seen only at an elevation above 2,400 m but that elevation drops to 450 m in islands around the Antarctic at the Chilean southern tip.

Storms are caused by low pressure in the steppe area in Argentina. This low pressure grows as air is heated in the summertime and a humid air block is drawn in from the Pacific Ocean. In general, winds escalate as they advance to the south and might, in some cases, cause danger in high places where there are no mountains to stand in their way. Westerly winds become the strongest between November and January, and continue until the end of April. In wintertime there is little wind and the calm season continues for a long time.

Of Patagonian Andes, the north is generally more stable than the south and has a long and hot summers without much of a breeze. In the area from Lake District to Aisen, the weather may break after a humid and uncomfortably warm breeze blows from the north. In the mountain area, thunder showers frequently occur in a hot summer.

2-4 Vegetation

The vegetation in Southern Cordillera is divided into three zones from west to east; the humid lowland, the colder and dry mountain zone and the semi-dry steppe zone, reflecting the climate change. Towards the south, the climate becomes harsher with the temperate rainforests and deciduous forests occupying lower elevations.

The evergreen temperate rainforests comprise plural kinds of evergreen trees and cover the entire area in the west of Cordillera. Of the three zones, this zone is wide and the most thickly grown area and has all the important plant species in it. The north of Patagonian Andes and Lake District are rich in temperate rainforest species that grow at an elevation below 1, 400 m.

Deciduous forests grow in semi-alpine to alpine areas and occupy the vegetation line ranging from an elevation of 600 m to Lake District. Conditions suitable for deciduous forests are not only little rainfall but also good draining and a harsh winter season.

The steppe zone hems the eastern side of Cordillera with low vegetation on the whole. This zone, also called pampa, is distributed with slow-growing, hardy bushes. Concentrations of low trees are seen on riverside.

Chapter 3 General geology, ore deposits and mining activities

3-1 General geology

3-1-1 General geology of Argentine

Concerning the geology of the survey area, reference was made mainly to the 1/2,500,000-scale all-Argentina geological map issued by SEGEMAR in 1997 and the 1/1,000,000-scale MAPA de Recursos Minerales del Area Fronteriza Argentina-Chilena entre los 34° y 56°S (Zanettini et al., 1999) issued by SEGEMAR in cooperation with SERNAGEOMIN of Chile in 1999. For the geotectonic evolution, reference was made to the CD-ROM version of the Metallogenic Map of Argentina (Zappettini, 1998) issued by SEGEMAR in 1998. In addition to the above, relatively rich data are available for every province, including the 1/400,000-scale Geologia y Metalogenesis del Orogeno Andino Cenral (Mendéz et al., 1995) covering the area extending from lat. 32° to 40°S (Appendix-1).

An entire geological tarranes map of the South American continent by Zappettini (1998) is shown in Fig. I-3-1. The Argentine territory is considered to be formed by tecto-stratigraphic, allochthonous terranes that were initially separate (e.g., Ramos, 1996). The accretion of these geological terranes and the simultaneous progress of geological phenomena are characterized by extensive tectonic movements due to subduction of ophiolitic rocks, deformation, metamorphism, and the creation of wide tectonic corridors with the development of shear zones. The post-accretional evolution consists of the development of intra-cratonic basins with marine and continental deposits, the creation of intracontinental rifts and the post-collisional and extensional magmatism. It is also characterized by a persistent magmatic arc activities related to the Pacific-plate subduction.

Geologically, the Argentine territory can be roughly divided into five terranes: the Rio de

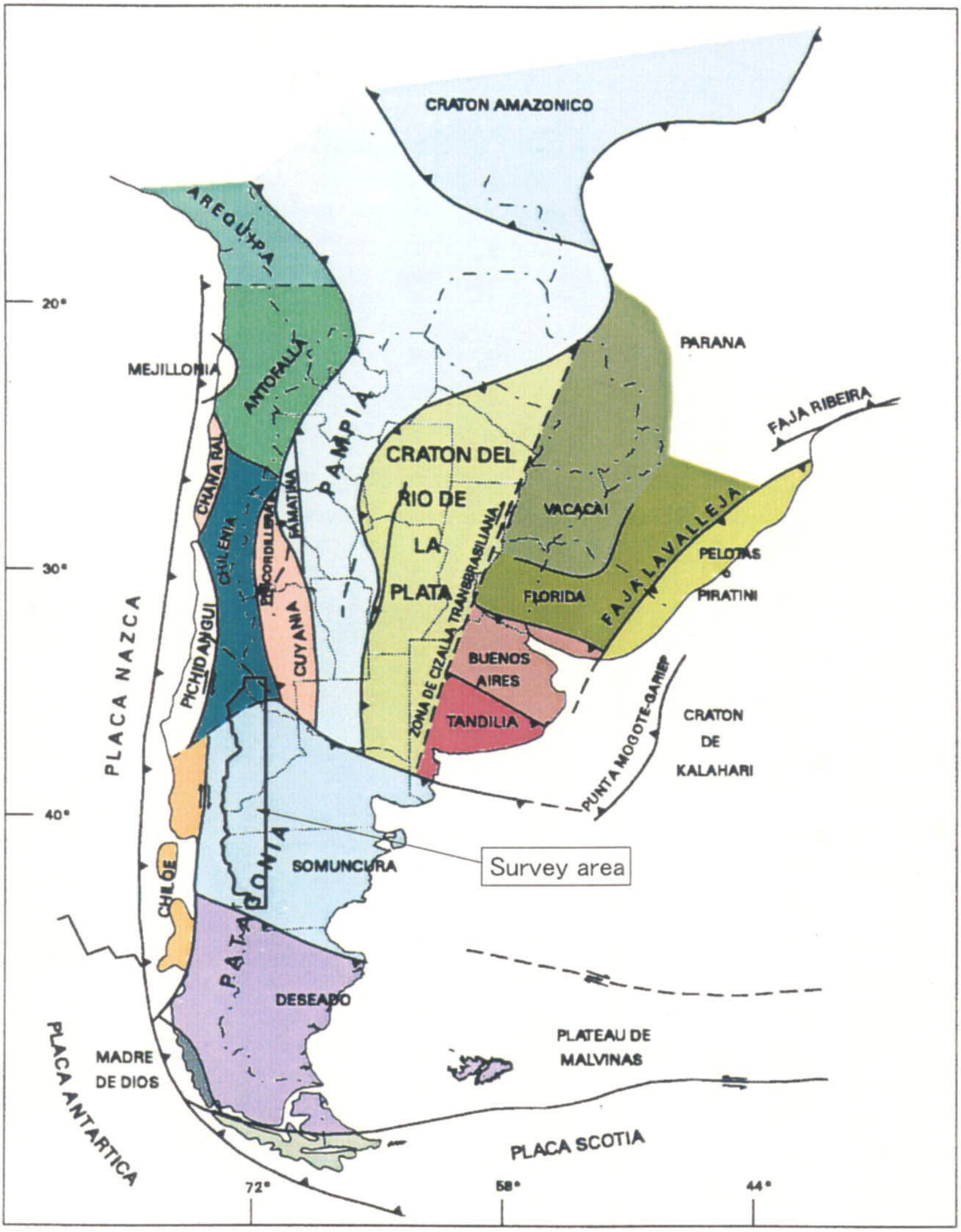
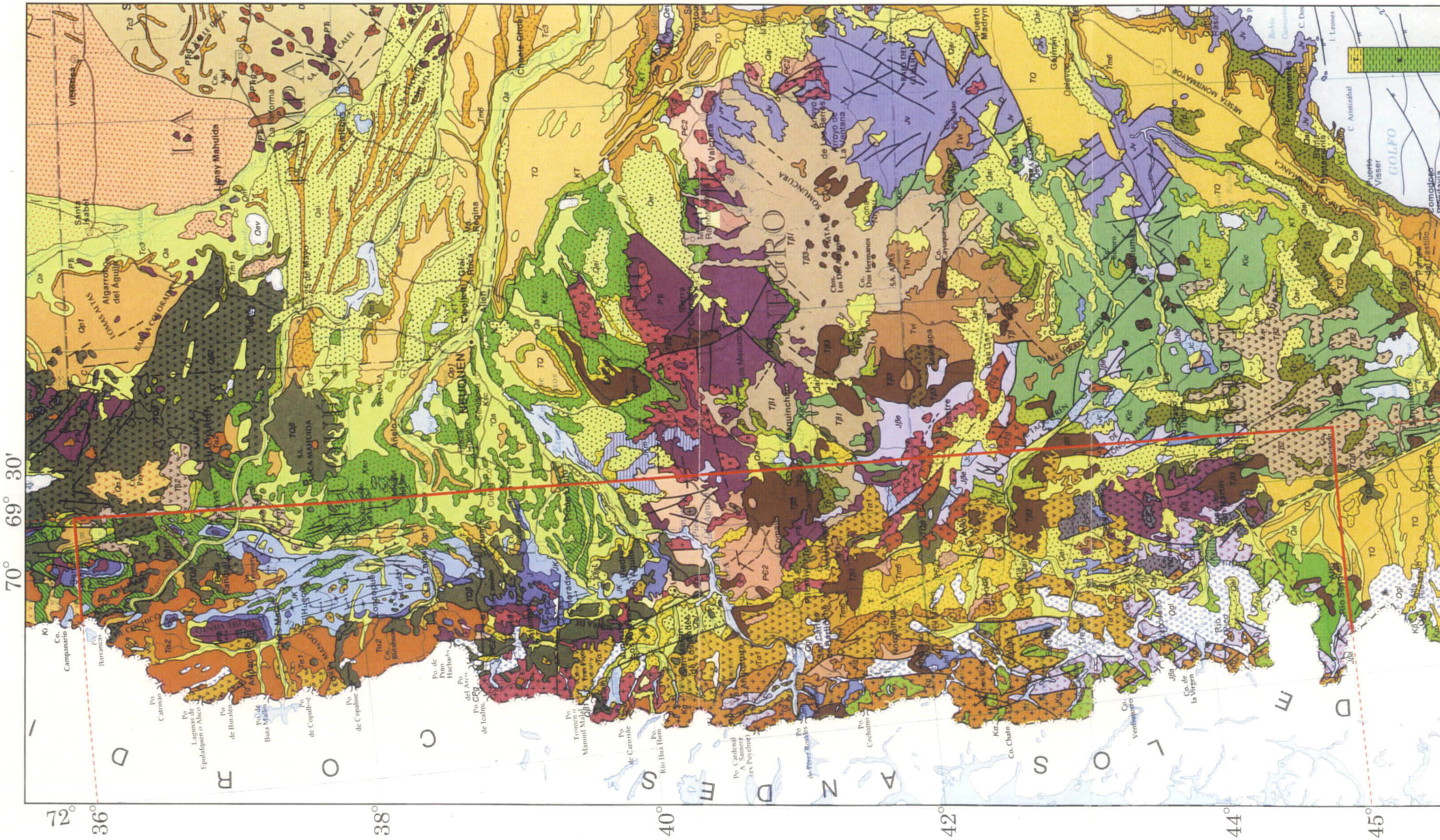


Fig. I-3-1 Accretionary terranes of the southern region of South America (SEGEMAR, 1998; after Ramos, 1988; Kraemer et al., 1995; Ramos, 1996; Bahlburg y Herve, 1997).



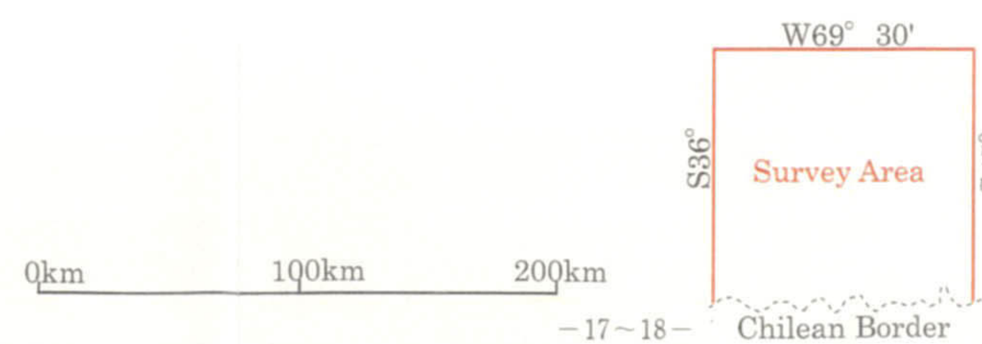
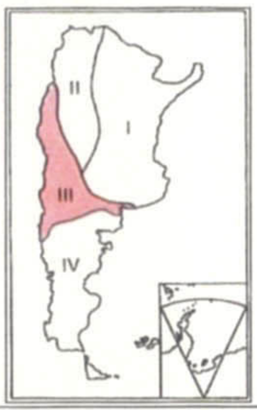
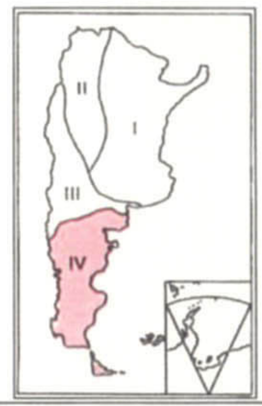


Fig.I-3-2 Geological Map of the survey area





Geologic time scale	Precordillera, Cordillera Frontal, Cordillera Principal, Cuenca Neuquina	Andes Patagónico-Fueguinos, Patagonia Extra Andina (Macizo Nord-Patagónico, Cuenca San Jorge, Macizo del Deseado, Cuenca Austral, Malvinas).
Cenozoic – Quaternary – Holocene	Qev evaporitic deposits; Qe arenitic eolian deposits; Qa alluvial & colluvial deposits; basalt & pyroclastic sed. (Puentelitense & Tromenlitense)	Qa alluvial & colluvial deposits; Qm massive deposits of denudation; Qev evaporitic deposits; Qe arenitic eolian deposits; Qtu peat deposits; Qm coastal deposits
Cenozoic – Quaternary – Pleistocene	Qa1 acidic & intermediate volcanic rocks, pyroclastic sed. (F. Tilhué and eq.); Qp1 alluvial deposits; basic volcanic rocks (Chapualitenses); Qal alluvial deposits; Qgl glacial & gracifluvial deposits; TQB basic volcanic rocks pyroclastic sed. (Coyocholitense, F.Maipo, & eq.)	Qal alluvial deposits; Qgl glacial deposits; TQ conglomerate (Patagonian gravels); TQB basalt (Fs.Cráter, Mojón & eq.)
Cenozoic – Neogene	Tn3 epiclastic continental sed. (Fs. Co. Azul, El Sauzal & eq.); Tn2 epiclastic continental sed. (Gr.Pontón Grande, Fs. Aisol, Tristeza & eq.); Tn2 acidic & intermediate volcanic rocks, epi- & pyroclastic sed. (Fs. Farallones, Doña Ana, Cajón Negro, Huincán & eq.); T pyro- & epiclastic continental sed. (Fs.Chichinales, Collón Curá & eq.); Tg granitoids (Fs. Vaca Laufquen, Leonardo, Las Peñas & eq.); TB basic volucanic rocks	Tm epiclastic continental & marine sed. (Fs. Río Negro, Río Mayo & eq.); T epi- & pyroclastic continental sed. (Fs.Collón Curá, Santa Cruz & eq.); Tg granite (Fitz Roy granite); TB basalt (Fs. Chenque Niyeu, Strobel, Lago Buenos Aires, El Mirador & eq.); acidic volcanic rocks (Piré Mahuida complex); Tvi basic & intermediate volcanic & intrusive rocks (F.Quiñelaf); TB2 indifferentiated basalt
Cenozoic – Paleogene	Ta1 intermediate & basic volcanic rocks epi- & pyroclastic sed. (F.Auca Pan, Serie Andesítica & eq.); Tc1 epi- & pyroclastic continental sed., evaporite (F.Divisadero Largo & eq.); Tm1 epi- & pyroclastic marine & continental sed. (F.Vaca, Mahuida)	Tmc epiclastic continental & marine sed. (F.Ñorquinco & eq.); Tm3 epiclastic marine sed. (F.Patagonia & eq.); TB1 basalt (Fs. Somuncurá, Posadas & eq.); basic volcanic rocks (Fs.El Buitre, Co.Cortado, El Canquel & eq.); epiclastic marine & continental sed. (Fs.Río Turbio, San Julián, Río Leona & eq.); Ta1 acidic, intermediate & basic volcanic rocks (F.Ventana & eq.); Tc epi- & pyroclastic continental sed. (Fs.Sarmiento, Río Chico & eq.)
Mesozoic – Cretaceous	KT epiclastic continental & marine sed., gypsum, limestone (Gr. Malargüe & eq.); KTv intermediate volcanic rocks; Kuc epiclastic continental sed. (Gr. Neuquén y eq.); K indifferentiated epiclastic continental & marine sed., limestone, dolostone, gypsum, intermediate volcanic rocks; Kg acidic plutonic rocks (F. Los Machis); Kl epiclastic continental & marine sed., limestone, dolostone, evaporite (Gr. Rayoso & eq.); JK epiclastic & chemical marine & continental sed. (Gr. Mendoza & eq.)	KT epiclastic marine & continental sed. (Fs.Roca, Salamanca, Coli Toro & eq.); KB basalt (F.Tres.Picos Prieto & eq.); Kuc epiclastic continental sed. (Gr. Neuquén & eq.); Km epiclastic marine sed. (Fs.Mata Amarilla, Piedra Clavada & eq.); acidic volcanic rocks (F. La Cautiva); Kg granitoids of Andean batholith; Klc epiclastic continental sed. (Gr.Chubut, F.Baqueró & eq.); Kv intermediate volcanic rocks (F. Divisadero); Mz gabbro, basaltic dykes (F.Tecka & eq.). Ophiolite of Georgias Islands; JKm epiclastic & chemical continental & marine sed. (Gr. Fortín Nogueira & eq.); Klm epiclastic & chemical marine sed. (Fs.Springhill, Río Mayer & eq.)
Mesozoic – Jurassic	Jfa intermediate & acidic volcanic rocks (F.Montes de Oca & eq.); J epiclastic marine sed., limestone, gypsum (Grs.Cuyo, Lotena & eq.); Jmc indifferentiated epiclastic marine & continental sed., limestone, gypsum	Jc epiclastic & chemical continental sed. (F.Cañadón Asfalto & eq.); intermediate & basic volcanic rocks a) Andinas (F.Lago La Plata & eq.) b) Extra andinas (Fs.Bajo Pobre, Lonco Trapial & eq.); Jg granitoids (Gr. Leleque & eq.); Jpc pyro- & epiclastic continental sed. (F.Roca Blanca & eq.); Jv acidic volcanic rocks (Gr.Bahía Laura, Fs.Lemaire, Marifil, El Quemado & eq.); Jm epiclastic marine sed., limestone (Fs.Piltriquitrón, Osta Arena & eq.); granitoids (F.La Leona); TrJv acidic volcanic rocks
Mesozoic – Triassic	Tr epi- & pyroclastic continental sed. (Gr.Uspallata, Fs.Paso Flores, Lapa & eq.)	Tr epi- & pyroclastic continental sed. (Fs.El Tranquilo Paso Flores, Lapa & eq.)
Paleozoic – Permian	PTr acidic & intermediate volcanic rocks, epiclastic continental sed. (Gr. Choiyoi, Lihuel Calel & eq.); PTrg indifferentiated granitoid of Cordillera Frontal & Sur de La Pampa; P epiclastic continental sed. (Fs. Carapacha, Patquia & eq.)	PTr epiclastic continental sed. (F.Estrecho San Carlos); PTr acidic & intermediate volcanic rocks (Gr.Choiyoi & eq.); P epiclastic continental sed. (F.La Golondrina); PCg granitoids (F.Lipetrén & eq.)
Paleozoic – Carboniferous	CP epiclastic & chemical continental & marine sed., intermediate volcanic rocks (Gr. Paganzo, F.Agua Negra & eq.); CPg granodiorite, granite, tonalite, rhyolite dyke (Colangüil batholith, F. Huechulaufquen & eq.); C pyro- & epiclastic continental & marine sed. (Gr.Andacollo, F.Agua Escondida & eq.); Cg granodiorite, granite, tonalite (F.Tabaquito, Cochiguas unit & eq.); DC epiclastic continental sed. (F. Punilla & eq.)	CP epiclastic continental & marine sed. (Grs.Tepuel, Isla Soledad & eq.)
Paleozoic – Devonian	SD epiclastic marine sed. (Grs.Tucunuco, Ciénaga del Medio, Gualilán, Villavicencio & eq.)	D epiclastic marine & continental sed. (Gr.Gran Malvina, Fs.Bahía de La Lancha & eq.); Db low grade metamorphic rocks (Fs.Río Lácteo & Lapataia)
Paleozoic – Silurian		S epiclastic marine sed. (F.Sierra Grande)
Paleozoic – Ordovician	Om epiclastic marine sed., limestone (Fs.Yerba Loca, Gualcamayo, San Juan & eq.); COg granite, diorite, gabbro (Nihuil complex, Curacó granite)	Pzg granitoids (Fs.Mamil Choique, Pailemán, Sobral & eq.)
Paleozoic – Cambrian	C marine sed., limestone, dolostone (Grs.Marquesádo, Matagusanos & eq.)	
Proterozoic – upper / middle / lower	PC2 high & low grades metamorphic rocks, mafic & ultramafic rocks (F.Colohuincul & eq.)	PC2 low to high grade metamorphic rocks and associated granitoids (Fs.Cushamen, El Jagüelito & eq.)

Abbreviations
- Compl.: Complex
- F.: Formation
- Fs.: Formations
- G.: Group
- Grs.: Groups
- eq.: Equivalents
- Sed.: Sedimentary rocks

Fig. I-3-3 Legend for the geological map of the survey area

Table I-3-1 Simplified stratigraphy of the survey area.

Period	Epoch	Neuquen Province: Stratigraphy	Neuquen Province: Intrusive	Rio Negro - Chubut Provinces: Stratigraphy	Rio Negro - Chubut Provinces: Intrusive	
Quaternary	Holocene	Depositós aluviales y coluviaes (Qa : alluvium and colluvium)		Depositós aluviales y coluviaes (Qa : alluvium and colluvium)		
	Pleistocene	Depositós glaciarios y glacifluviales (Qgl : glacial and gracifluvial deposits)		Depositós glaciarios y glacifluviales (Qgl : glacial and gracifluvial deposits)		
		Campos basálticos de Zapala (TQ β : basic volcanic rocks)				
Tertiary	Neogene	Fm. Cajón Negro (T α 2 : acidic, intermediate volcanic rocks)	Granitoides (Tg : granitoids)	Fm. Collón Curá (T : continental sedimentary rocks)		
	Paleogene	Serie Andesitica, Fm. Auca Pan (T α 1 : intermediate, basic volcanic rocks)		Fm. Ñorquinco (Tm4 : continental and marine sedimentary rocks)		
				Fm. Ventana (T α 1 : acidic, intermediate, basic volcanic rocks)		
Mesozoic	Cretaceous	Grupo Neuquén (Ksc : continental sedimentary rocks)	Plutonitas ácidas (Kg : granitoids)	Fm. Tres Picos Prieto (K β : basalt)	Granitoides del Batolito Andino (Kg : granitoids)	Gabros (Mz : Gabbro)
				Fm. Divisadero (K α : intermediate volcanic rocks)		
		Grupo Rayoso (Ki : marine and continental sedimentary rocks with limestone, dolomote, evaporite)		Fm. Apeleg (Kim : marine sedimentary rocks)		
	Jurassic	Grupo Mendoza (JK : marine and continental sedimentary rocks)	Granitoides (Jg : granitoids)	Fm. Lago la Plata (J β a : basic, intermediate volcanic rocks)	Granitoides (Jg : granitoids)	
		Grupo Cuyo (J : marine sedimentary rocks with limestone and gypsum)		Fm. Piltriquitron (Jm : marine sedimentary rocks with limestone, acidic to intermediate volcanic rocks)		
	Triassic	Grupo Choiyoi (PTR : acidic, intermediate volcanic rocks with continental sedimentary rocks)		Grupo Choiyoi (PTR : acidic, intermediate volcanic rocks)		
Paleozoic	Permian		Granitoides (CPg : Granitoids)		Granitoides (PCg : Granitoids)	
	Carboniferous	Grupo Andacollo (C : marine and continental sedimentary rocks)		Grupo Tepuel (CP : marine and continental sedimentary rocks)		
	Devonian					
	Silurian					
	Ordovician					
	Cambrian				Granitoides (PZg : Granitoids)	
Proterozoic		Fm. Colohuincul (PC2 : low to high grade metamorphics, mafic and ultramafic rocks)		Fm. Cushamen (PC2 : low to high grade metamorphics and associated granitoids)		

Marks of geological unit, such as "Kg", are common to Figure I-3-2, I-3-3 except PTR and PC2.
PTR and PC2 correspond to PTR and PC2 of figure I-3-2, I-3-3 respectively.

la Plata Craton, Pampia, Cuyania, Chilenia and Patagonia.

The Rio de la Plata Craton is composed of a number of small geological terranes, which were collided during 2,300 to 1,900 Ma. And these were consolidated and amalgamated by the Transamazonic orogeny in the Lower Proterozoic.

The Pampia terrane consists of basically marble basement with schists and gneiss, which are the metamorphic equivalents of a sequence deposited in a stable margin about 900 to 1000 Ma. In the Upper Proterozoic about 750 Ma, it collided and accreted against the Rio de la Plata Craton.

The Cuyania terrane, also called Cuyania-Precordillera, was formed by high- and low-grade metamorphoric rocks, which were metamorphosed between 900 and 1100 Ma, and early Paleozoic sedimentary rocks. It contains an area with a suture zone indicating accretion of the Cuyania and Precordillera terranes during the Proterozoic. The Cuyania and Pampia terranes were accreted about the end of Ordovician which is indicated by the magmatic arc previous to the suture.

The nature of the Chilenia basement is masked by igneous and metamorphic rocks of the Upper Paleozoic and remains unclarified. It includes a basement with evidence of deformation and metaphorism between 500 and 415 Ma, covered by Silurian sediments. It accreted against Cuyania in the Upper Devonian. The suture is marked by numerous ophiolite fragments. The plutonics and the partly andesitic volcanics represent the magmatic arc previous to the suture.

Patagonia is formed by two terranes: the Somuncura and Deseado, which could have collided in the Lower Paleozoic Famitinian Orogeny. It was preceded by a magmatic arc related to the subduction of the Deseado massif. Patagonia was entirety joined to the rest of the Argentine territory during the Upper Paleozoic, and it was the last large accreted fragment. The Permian plutonism of the Somuncura group would correspond to the magmatic arc previous to the suture. The location of the suture in the western sector is obliterated by the post-accretional magmatism as well as by the sequences and arc rocks from the Mesozoic and Cenozoic eras. Its position is controversial, and it could be positioned in a NE-SW direction, which would agree with the distribution of Permian igneous activity, or it could continue in a NW-SE direction, consistent with the Maipo magnetic anomaly.

3-1-2 General geological of the survey area

The geological map by SEGEMAR (1997) is shown in Fig. I-3-2 and its legend in Fig. I-3-3. Table I-3-1, which is a summary of Fig. I-3-3, provides the simplified stratigraphy of the area corresponding to that actually surveyed. The geological outline of this area is given below on the basis of these findings and the geological descriptions by Zanettini et al. (1999):

1) Proterozoic (PC2)

In the survey area, the Proterozoic exposes in a small scale to the south of Paso de Pino Hachado of Neuquen province, in the proximity of San Carlos de Bariloche of Rio Negro province, and in Chshamen of Chubut province. Forming the basement of the survey area, these comprise low- and high-grade metamorphoric rocks such as phyllite, schist and gneiss, and intruded by granite to granodiorite. They underwent complex metamorphism and have quartz and pegmatite veins. The result of a Rb-Sr radiometric dating of the sample taken near Huechlafquen Lake of Neuquen province, revealed 714 ±10 Ma (Parica, 1986). They are called the Colohuincul formation in Neuquen province and the Chshamen formation in Chubut province.

2) Cambrian to Ordovician (PZg)

In the survey area, the granitoids of Cambrian to Ordovician are distributed in the east of Chshamen of Chubut province, and its northwestern distribution extends to the territory of Rio Negro province.

3) Carboniferous (C, CP)

In the survey area, the Carboniferous is distributed in Andacollo of Neuquen province, and Tecka to Jose de San Martin of Chubut province. They consist of the marine and continental conglomerates, shales, sandstones and a small amount of limestone, containing fossils. In Andacollo, these rocks are intercaleted with andesitic tuff layers. The total thickness is as large as about 2,000 m. In Neuquen province, it is named the Andacollo group (C), overlain by the Permian unconformably. In Chubut State, it is named the Tepuel group (CP), overlain by the Jurassic unconformably.

4) Permian to Triassic (CPg,PCg, PTR)

In the survey area, the distribution of the Permian to Triassic extends to the proximity of Andacollo and to the west of Zapala of Neuquen province, and to the east of Ñorquinco of Rio Negro province. It is comprised of granitoids intruding in early Permian and the volcanic rocks of the upper Permian to Triassic closely associated with these granitoids. The granitoids (CPg, PCg) of tonalite to granite revealed 278 ± 10 Ma and 264 ± 8 Ma (Caminos et al., 1979, 1982). The volcanics are named the Choiyoi group (PTR), composed of andesitic to rhyolitic lavas and pyroclastic rocks. Fossils of continental plants were discovered from the basal conglomerate and sandstone. The thickness of the Choiyoi group reaches 550 to 1,800 m. Radiometric dating revealed 252 ±14 Ma and 232 ±10 Ma (Caminos et al., 1979, 1982). These granitoids and volcanics were probably produced by the plate subduction from the

Pacific Ocean side.

5) Jurassic terrane (J, Jm, J β a, Jg, Mz)

In the survey area, the Jurassic is distributed intermittently between Andacollo and Zapala and to the south of Zapala of Neuquen province, and also intermittently distributed between Epuyen and Lago Fontana of Chubut province. These comprise sedimentary rocks, volcanic rocks and plutonic rocks. The plutonic rocks consist of granitoids and gabbro.

The sedimentary rocks comprise clastic sedimentary rocks, limestone and evaporite, and include basic volcanics among them. Part of them gradually shifts to a continental sediments, representing the sediments of a stage in which an oceanic basin is transformed into land in the age of island arc regression. According to the faunal contents, it is known that these rocks belong to the Pliensbachian to Kimmeridgian ages (Emparan et al., 1992, etc.). They are called the Cuyo group (J) in Neuquen province and the Piltriquitron, Osta Arena formations (Jm) in Chubut province.

The distribution of volcanic rocks is extensive in the south of lat. 40°S and further continues to Cape Horn, outside of the survey area, along the Andes cordillera. Theses comprise rhyolite containing ignimbrite, dacite, andesitic and basaltic lavas, and pyroclastic rocks. In the survey area of Chubut province, andesitic and basaltic rocks are dominant. It is named Lago la Plata formation (J β a). The rocks form a part of the most extensive acidic volcanic terrane in the world, genetically linked to the extensional processes that led to the break-up of the Gondwana continent.

The distribution of granitoids (Jg) in this area is small in scale and found in Varvarco of Neuquen province, and in the proximity of Leleque of Chubut province. The age of the latter rocks was determined at 195 Ma (Gordon and Ort, 1993). They are composed of tonalite, granodiorite and granite, which are calc-alkali granite having a normal K_2O content and aluminous character.

Gabbro (Mz) is distributed over the Sierra de Tepuel to the southeast of Tecka of Chubut province. These rocks are composed of banded gabbro rocks (Page, 1984) and gave thermal metamorphism to the Carboniferous sedimentary rocks (CP). Outside the survey area, ophiolite sequence is distributed between lat. 50° and 55°S on the Chilean side. It is considered as belonging to the Upper Jurassic to Lower Cretaceous, because it is contained in the Jurassic sedimentary rocks and overlain by the Cretaceous sedimentary rocks; U-Pb radiometric dating gave results of 140 to 137 Ma (Stern et al., 1992). It is also estimated that the gabbro rocks in the survey area belong to the same period.

6) Upper Jurassic to Cretaceous terranes (JK, Ki, Ksc, Kim, K α, K β, Kg)

In the survey area, the Cretaceous is distributed from Mendoza province to the southwest of Zapala of Neuquen province. In Rio Negro and Chubut provinces, it is distributed along the Chilean border to the west of the survey area. It comprises sedimentary, volcanic and granitic rocks.

Sedimentary rocks area divided into the lower group belonging to the late Jurassic Tithonian age to early Cretaceous Albian age, and the upper group belonging to the Late Cretaceous Cenomanian to Campanian ages. In Neuquen province, the lower group is further divided into the Mendoza group (JK) and the Rayoso group (Ki) in ascending order. In Chubut province, the lower group is named the Apeleg formation (Kim). Although different in property by their respective sedimentary basins, these comprise shale, calcareous rocks and a small amount of sandstone. In the Aptian and Albian ages, evaporite and a small amount of continental shale were deposited. The average thickness is about 4,500 m. In Neuquen province, the upper group is named the Neuquen group (Ksc), which comprises sandstones, shale and a small amount of continental conglomerates. The thickness of the group reaches 1,600 m.

Volcanic rocks are mainly distributed in Chubut province, comprising the Divisadero formation (K α) consisting of andesitic volcanics and the Tres Picos Prieto formation (K β) consisting of basaltic volcanics. The Tres Picos Prieto formation is intercalated with sedimentary rocks and is considered a product of late Cretaceous volcanism (Page, 1980).

Granite rocks (Kg) are extensively distributed along the Chilean border in Rio Negro and Chubut provinces. Radiometric dating of the rocks showed a value of around 100 Ma (e.g., Ramos, 1983). They are calc-alkali monzogranite closely associated with the plate subduction along the active margin of the continent. Also, in relation to the Campana Mahuida porphyry Cu deposit in Neuquen province, the distribution of andesite porphyry of 74 Ma is known (Sillitoe, 1977).

7) Paleogene (T α 1, Tm4, Tg)

In the survey area, the Paleogene is distributed in the northwest of Neuquen province, and intermittently from San Martin de los Andes in the southwest of Neuquen proince to Tecka of Chubut province, via San Carlos de Bariloche of Río Negro province. It comprises volcanic rocks and granitoids.

The volcanic rocks (T α 1) are named the Serie Andesítica in the northwest, and the Auca Pan formation in the southwest of the Neuquen province. And the Ventana formation in Río Negro and Chubut provinces. The Serie Andesítica mainly comprises andesite lavas and the pyroclastic rocks. It includes continental sediments which vertebrata fossils are found. The thickness of the Auca Pan and Ventana formations is as large as more than 1,000 m, showing vertical and horizontal rock facies variations. In the west, andesitic rocks are dominant accompanied by basaltic rocks while rhyolitic rocks are dominant in the east. These are calc-alkali rocks of medium-K to high-K.

Sedimentary rocks are distributed from south of the San Carlos de Bariloche in the Chubut province to north of Esquel in the Chubut province intermittently. These are called the Ñorquinco formation (Tm4) composed of continental and marine sediments, such as epiclastic conglomerate and sandstone.

For the granite rocks (Tg), radiometric dating gave the results of 50 to 7 Ma (e.g., Pesce, 1981; Llambías and Rapela, 1989). The granitic rocks of the Paleogene distribute in the form of small bodies in Andacollo and Cerro Caicayen in the northwest of Neuquen province. The granitic rocks of the Neogene will be mentioned later.

8) Neogene (T α 2, T, TQ β , Tg)

In the survey area, the Neogene is extensively distributed in the northwest of Neuquen province. It is also distributed from the southwest of Neuquen province to the west of San Carlos de Bariloche of Río Negro province, from Ñorquinco of Río Negro province to the east of Leleque of Chubut province. These comprise volcanic rocks, sedimentary rocks and granitic rocks.

Volcanic rocks are the Cajón Negro formation (T α 2) distributed from the northwest end of Neuquen province to the mountains in the west of Zapala, and the Campos Basálticos de Zapala (TQ β) distributed around of Zapala. These are calc-alkali rocks accompanying island arc orogeny. The Cajón Negro formation erupted around 2 Ma. It mainly comprises andesitic to basaltic lavas and agglomerates and accompanies a small amount of acidic lavas and ignimbrites. They form the eroded stratovolcanos. The volcanic activity of the Campos Basálticos de Zapala continued to the Pleistocene, and around the Lago Laguna Blanca in the southwest of Zapala, it continued to the Holocene. It is mainly composed of basaltic lavas and accompanied by pyroxene andesite and dacite.

Sedimentary rocks distribute in the range from Ñorquinco of Río Negro province, to the east of Leleque of Chubut province. These are named the Collón Curá formation (T). Its basement consists of thick conglomerates and changes to shale and sandstone. It mainly comprises continental sediments but has some local marine sediments, producing many plant fossils as well as mammal fossils.

Concerning the granitic rocks (Tg), radiometric dating gave the result of 15 Ma and 7 Ma (e.g., Munizaga et al., 1985). These are mainly distributed in the Chilean side beyond the border, and in the survey area, only a part is distributed in a small scale in the northwest of Neuquen province and along the Chilean border in the area bordering Neuquen and Río Negro provinces.

9) Quaternary (TQβ, Qgl, Qa)

Concerning the Quaternary in the survey area, basaltic rocks (TQβ) have been already mentioned, which started activity in the Neogene. The Quaternary mainly comprises the glacial sediments (Qgl) of the Pleistocene and the alluvium and colluvium (Qa) of the Holocene. The glacial sediments are distributed filling depressions in mountain regions along the border with Chile while the alluvium and colluvium are distributed in the low land along rivers and the flat land to the east of the survey area.

3-2 General information of ore deposits

The distribution of major known deposits in the survey area and its surroundings is shown in Fig. I-3-4 and Table I-3-2. The area covers Mendoza, La Pampa, Neuquen, Río Negro and Chubut provinces. According to the geological terranes of Fig. I-3-1, the known deposits in Neuquen, Río Negro and Chubut provinces belong to the Patagonia terrane. Based on the Zappetini (1998), the mineralization of the Patagonia terrane is summarized below in chronological order.

1) Pampian and pre-Pampian events

These events were the diastrophism when Pampia collided with the Río de la Plata craton (Fig. I-3-1) or preceding diastrophism to the collision, and corresponds to the Proterozoic to late Cambrian.

In Patagonia terrane, during the deposition of the turbidite sequence which form the bedrock of the Somuncura massif (Fig. I-3-1), secondary basins developed with syn-sedimentary faults, which controlled the emplacement of sedimentary exhalative Pb-Zn-Ag deposits (Gonzalito mine, Río Negro). Limestone and dolomite beds are intercalated in this sequence, and they are being exploited.

2) Famatina events

These events were the diastrophism when Cuyania and Chilenia were accreted to Pampia and when Somuncura collided against Deseado (Fig. I-3-1). It corresponds to the late Cambrian to Carboniferous.

At this time, in the east of Patagonia terrane, a passive margin sequence was deposited during the Silurian and Devonian. It was accompanied by the sedimentary Fe deposits (Sierra Grande, Río Negro).

3) Gondowana events

These events were the diastrophism when Patagonia terrane collided with rest of the

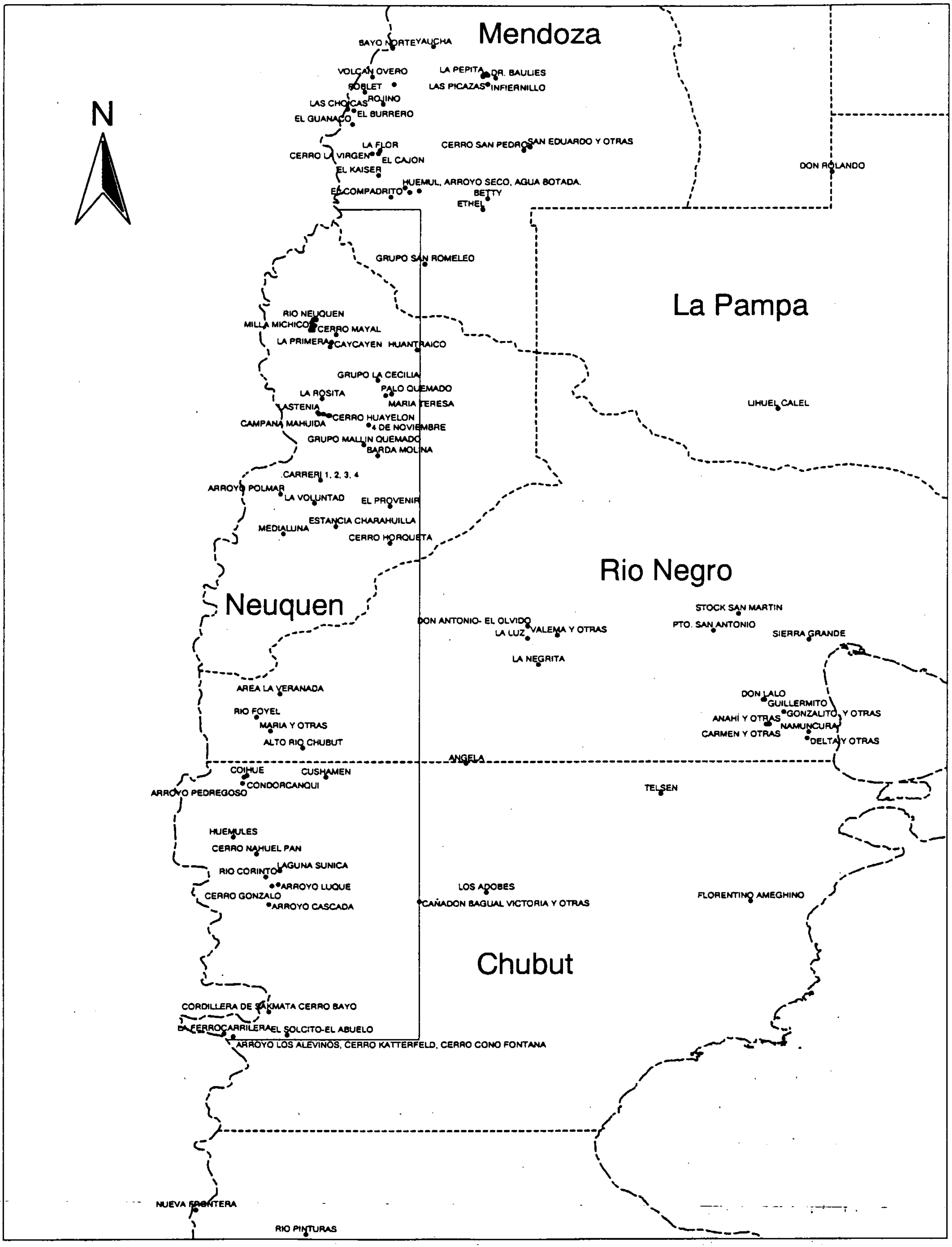


Fig. I-3-4 Distribution of major known mineral occurrences in the Provinces of Mendoza, Neuquen, La Pampa, Rio Negro and Chubut where almost of them belong to the Patagonia tarrane of Fig. I-3-1, after Zappettini (1998).

Table I-3-2 Major known mineral occurrences shown in Fig. I-3-4.

PROVINCE	NAME	MAJOR ELEMENT	MINOR ELEMENT	MODEL	LON (D)	LON (M)	LAT (D)	LAT (M)
MENDOZA	LA FLOR	Pb,Ag,Zn	Cu	Epithermal	69	56	35	22
	CERRO LA VIRGEN	Cu	Ag,Zn	Metasomatism	70	1	35	34
	EL CAJON	Pb,Zn,Ag	Au	Epithermal	69	57	35	24
	EL KAISER	Fe		Metasomatism	69	57	35	38
	HUEMUL, ARROYO SECO, AGUA BOTADA	U	Cu	Sedimentary	69	40	35	46
	CERRO MIRANO, ROSA	U	Cu	Sedimentary	69	31	35	48
	CASA DE PIEDRA	U,Cu		Sedimentary	69	37	35	49
	EL COMPADRITO	Ba		Sedimentary	69	49	35	52
	BETTY	Mn		Epithermal	68	47	35	53
	ETHEL	Mn	F	Epithermal	68	50	36	0
	GRUPO SAN ROMELEO	Cu		Sedimentary	69	27	36	35
LA PAMPA	LIHUEL CALEL	Co,Mo,Cu		Porphyry	65	40	38	10
NEUQUEN	ERIKA -SOFIA Y OTRAS, ANDACOLLO	Au	Pb,Zn	Epithermal	70	37	37	11
	RIO NEUQUEN	Au		Placer	70	39	37	11
	LOS MAITENES-EL SALVAJE	Au		Porphyry	70	40	37	13
	EL PORVENIR	Pb,Zn,Au,Cu,Ag		Epithermal	70	38	37	15
	MILLA MICHICO	Au	Pb,Zn,Ag	Epithermal	70	40	37	16
	GRUPO CURA MALLIN	Cu	Pb,Zn	Epithermal	70	41	37	18
	CURA MALLIN	Ba		Exhaletive sulfides	70	39	37	18
	CERRO MAYAL	Au		Epithermal	70	24	37	21
	CAYCAYEN	Cu	Fe	Porphyry, Metasomatism	70	27	37	26
	LA PRIMERA	U	Cu	Sedimentary	70	28	37	29
	HUANTRAICO	Fe		Association of subaerial volcanism	69	32	37	31
	GRUPO LA CECILIA	Sr	Ba	Sedimentary	69	57	37	51
	PALO QUEMADO	U,V	Cu	Sedimentary	69	48	38	0
	MARIA TERESA	U,V	Cu	Sedimentary	69	52	38	1
	LA ROSITA	Ba		Sedimentary	70	33	38	3
	LASTENIA	Pb,Ag,Zn		Epithermal	70	36	38	12
	CAMPANA MAHUIDA	Cu	Au	Porphyry	70	32	38	13
	AMELIA, BELEN , TERESA	Pb,Ag,Zn	Ba	Epithermal	70	35	38	13
	AGUSTINA Y OTRAS	Pb,Ag,Zn		Epithermal	70	29	38	14
	CERRO HUAYELON	Pb,Ag,Zn	Cu	Epithermal	70	28	38	14
	4 DE NOVIEMBRE	Ba		Sedimentary	70	3	38	20
	GRUPO MALLIN QUEMADO	Ba		Sedimentary	70	6	38	33
	BARDA MOLINA	Cu		Sedimentary	69	57	38	40
	CARRERI 1, 2, 3, 4	Pb,Ag,Zn	Cu	Vein and Breccia (Various genesis)	70	34	38	56
	ARROYO POLMAR	Au		Placer	71	0	39	5
	LA VOLUNTAD	Cu	Mo	Porphyry	70	38	39	11
	EL PROVENIR	Cu		Sedimentary	69	49	39	13
	ESTANCIA CHARAHUILLA	Cu,Ag	U	Sedimentary	70	24	39	26
	MEDIALUNA	Au		Placer	70	58	39	31
	CERRO HORQUETA	Cu		Sedimentary	69	49	39	37
RIO NEGRO	STOCK SAN MARTIN	W		Vein associated with granitoid	66	5	40	23
	DON ANTONIO- EL OLVIDO	Mn		Epithermal	68	21	40	31
	PTO. SAN ANTONIO	F		Vein and Breccia (Various genesis)	66	21	40	34
	VALEMA Y OTRAS	F		Vein and Breccia (Various genesis)	68	2	40	37
	LA LUZ	Pb,Ag,Zn		Epithermal	68	21	40	39
	SIERRA GRANDE	Fe		Sedimentary	65	20	40	40
	LA NEGRITA	Mn		Epithermal	68	14	40	56
	AREA LA VERANADA	Au	Cu,Pb,Zn	Epithermal	71	0	41	15
	GUILLERMITO	W	Mn	Vein associated with granitoid	65	48	41	19
	DON LALO	Mn		Epithermal	65	49	41	19
	GONZALITO Y OTRAS	Pb,V,Ag,Zn	Cu,Fe,As	Exhaletive sulfides	65	36	41	27
	RIO FOYEL	Au		Placer	71	15	41	30
	ANAHI Y OTRAS	F		Vein and Breccia (Various genesis)	65	45	41	35
	CARMEN Y OTRAS	F		Vein and Breccia (Various genesis)	65	47	41	35
	NAMUNCURA	Fe		Sedimentary	65	20	41	40
	DELTA Y OTRAS	F		Vein and Breccia (Various genesis)	65	21	41	44
	ALTO RIO CHUBUT	Au		Placer	70	45	41	50
CHUBUT	MARIA Y OTRAS	Pb,Ag,Zn,Cu		Epithermal	71	6	41	39
	ANGELA	Pb,Zn	Ag,Au	Epithermal	69	0	42	0
	COIHUE	Cu,Au	Pb,Zn	Porphyry	71	21	42	8
	CUSHAMEN	Mo		Vein associated with granitoid	70	30	42	9
	CONDORCANQUI	Cu	Au	Association of subaerial volcanism	71	23	42	9
	ARROYO PEDREGOSO	Au		Placer	71	24	42	13
	TELSEN	Au		Epithermal	66	55	42	20
	HUEMULES	Au		Epithermal	71	30	42	48
	CERRO NAHUEL PAN	Au		Epithermal	71	15	42	59
	LAGUNA SUNICA	Au	Cu	Epithermal	71	0	43	10
	RIO CORINTO	Au		Placer	71	9	43	14
	ARROYO LUQUE	Cu	Mo	Porphyry	71	1	43	19
	CERRO GONZALO	Mo,Cu,Ag,Au		Vein and Breccia (Various genesis)	71	5	43	20
	LOS ADOBES	U	Cu	Sedimentary	68	47	43	24
	FLORENTINO AMEGHINO	Mn		Epithermal	65	57	43	30
	CAÑADON BAGUAL VICTORIA Y OTRAS	Pb,Ag,Zn	Au,Bi	Epithermal	69	30	43	30
	ARROYO CASCADA	Au,Ag		Epithermal	71	7	43	32
	CORDILLERA DE SAKMATA CERRO BAYO	Au	Pb,Zn	Epithermal	71	7	44	42
	LA FERROCARRILERA	Pb,Zn	Cu,Au,Ag	Epithermal	71	36	44	56
	EL SOLCITO-EL ABUELO	Fe	Mn	Metasomatism	70	55	44	57
	ARROYO LOS ALEVINOS, CERRO KATTERFELD, CERRO CONO FONTANA	Au	Cu,Pb,Zn,Ag	Epithermal	71	30	44	58

Gondowana continent, and corresponds with the late Carboniferous to early Jurassic.

The magmatic arc in Somuncura massif preceded the collision of Patagonia with the Gondowana continent, followed by a large lava plateau and post-collisional ignimbrites associated with Permian granitoids. This volcanism was accompanied by W vein mineralization (San Martín, Río Negro), fluorite veins (Valema; San Antonio; Carmen, Río Negro), Mn deposits (Don Antonio, Río Negro), and hydrothermal kaolin deposits.

4) Mesozoic events

These events were the diastrophism that an important extensional regime developed a significant basin in the periphery of the cratonic nucleus and the Gondowana continent was dismantled by the opening of the Atlantic Ocean. It corresponds to the Jurassic and the Cretaceous.

The volcanic activity related to the rifting which originated with opening of the Atlantic Ocean generated epithermal gold deposits which is controlled by shear zones. Outside the area of Fig. I-3-4, the Cerro Vanguardia Au deposit was formed in Santa Cruz province. In the Cretaceous, on the other hand, a magmatic arc was formed by the Pacific subduction which generated the porphyry Cu deposits (Campana Mahuida, Neuquén; Cerro Coihue, Chubut).

In the Jurassic, intracratonic basins were formed around the periphery of cratonic nucleus from the south of San Juan province to the south of Neuquen province, accompanied by sedimentary deposits. There are sedimentary Cu deposits (El Provenir, Neuquén), barite deposits (Mallín Quemdo, Neuquén), celestite and gypsum.

The retro-arc basins formed during the Jurassic to Cretaceous have marine and continental stratabound deposits of celestite-barite (Noviembre; Grupo La Cecilia, Neuquén), halite, limestone and phosphorite.

The sequences filling the thermal subsidence basins, which emerge after magmatism contain deposits of stratabound U deposits (Los Adobes, Chubut).

5) Andean events

These events were the diastrophism of the Andean orogeny over the Paleogene, Neogene, and Quaternary.

a) Paleogene

The Paleogene is represented by volcanic arc activities, which reached their climax in Chile to generate numerous porphyry Cu deposits. The volcanic arc extends southward to Chubut province via Mendoza and Neuquen provinces. The volcanic activities generated porphyry Cu deposits also in Patagonia terrane (Cerro Caicayan, Neuquén). And gold-rich polymetallic deposit (Huemlas, Chubut) and manto-type Cu deposit (Condorcanqui, Chubut) relative to andesitic lava were generated. At the latitudes of these deposits, it is suggested that paleo-Benioff zone was flattened during the Oligocene to Miocene.

b) Neogene

The Neogene epoch includes the evolution and migration of a magmatic arc emplaced in the axis of the Andean cordillera. The range of the magmatism extended eastward up to 700 km from the oceanic trench. Major ore deposits, including the Bajo de la Alumbrera porphyry Cu deposit of Catamarca provnce in the northwest region of Argentine, were generated by the magmatic activities.

Between lat. 36° and 41°S, the volcanic arc migrated to the west in the beginning of the Miocene, and developed toward east retro arc magmatism represented by the Auca Mhuida volcano of Neuquén province. Related to the eastern magmatism are veins of magmatic Fe (Huantraico, Neuquén), epithermal Mn deposits (Ethel, Mendoza) and fumarolic sulfur deposits. In the west region, related to the magmatism are gold-rich polymetallic deposits (Andacollo, Neuquén) and prophyry Au deposits (Los Maitenes-El Salvaje, Neuquén).

The sediments related to retro-arc basins are accompanied by clay, sedimentary bentonite and lagoon diatomite.

To the south of lat. 41°S, magmatism was restructured. The volcanism characterized by a high angle inclination of the Benioff zone and low velocity of convergence, and isoleted volcanos like Tronador. This is a intraplate alkaline volcanism related to extension regime and has no known ore deposits.

The passive margin basins have economically interesting deposits of limestone, gypsum, bentonite, sedimentary kaolin and alunite.

c) Quaternary

The Quaternary sedimentary basins in dry climate have concentrations of sodium chloride and local concentrations of sulfate. In mountain regions, a variety of heavy minerals are found in high concentration due to erosion. Alluvial Au deposits are distributed extensively in linkage with the type of a variety of primary gold ore deposits (e.g., Río Neuquén, Neuquén).

3-3 Recent mining activities

1) Exploration activities

The exploration activities in Neuquen province were started in 1941 by the Dirección General de Fabricaciones Militares (DGFM) with organized activity extensively carried out as Plan Cordillerano between 1963 and 1969. From 1968 to 1969 during this period, as Plan Cordillerano Centro, drilling campaign was executed in promising sites then selected by these exploration activities (Mendéz et al., 1995).

Also in Rio Negro and Chubut States, the first exploration was done by DGFM (e.g., Pages, 1951). Later, an extensive investigation by Plan Patagonia Comahue of the Servicio Minero Nacional (current; Subsecretaria de Mineria) was executed from 1972. Following the results, an exploration activity based on a UN revolving fund was carried out between 1977 and 1982, and the final report was submitted in 1983.

These fundamental investigations have so far identified numerous mineral occurrences. The distribution of all the known deposits in the survey area is shown in Fig. I-3-5. Table I-3-3 summarizes the major deposits of these. Outline of main mining activities are described here from north to south.

The mining properties of Andacollo gold mine in Neuquen province are owned by the Corporación Minera del Neuquén Sociedad del Estado Provincial (CORMINE S.E.P.), and the operation was started from January 1999 by Mineral Andacollo Gold S. A., a Canadian and Chilean joint venture, under the contract with CORMINE S.E.P. However, the operation was being suspended as of November 2000 by the 10 million dollar fund lack. During the operation, quartz veins containing gold and base metals were exploited underground to produce gold by the cyanide process on site. The minimum capacity of the plant is 200 t/d. The announced minable ore reserves are 199,916 tons of 7.77 g/t Au for the Erica vein and 79,836 tons of 14.72 g/t Au for the Sofia vein. According to a company source, the production capacity of gold was 50,000 oz/y.

The Campana Mahuida in Neuquen province is porphyry Cu deposit and was drilled by the DGFM and Falconbridge with 45 holes totaling 4,043 m. As the result, 4,637,782.3 tons of 0.73% Cu for oxides and 22,890,977 tons of 0.6% Cu for sulfides were calculated by cut-off 0.3% Cu. At present, there are no exploration activities going on. The mine property is owned by the CORMINE S.E.P.

Drilling exploration is now active in the area of Joya del Sol gold deposits in Chubut province. The mine property is owned by Minera el Desquite S. A., whose capital is 60% held by a British company, Brancote Holdings Plc., and 40% by an Argentine company, MBP. The former is actually engaged in the exploratory operation. The exploration target is low-sulfidation epithermal auriferous quartz veins. According to Sunshine Mining, which

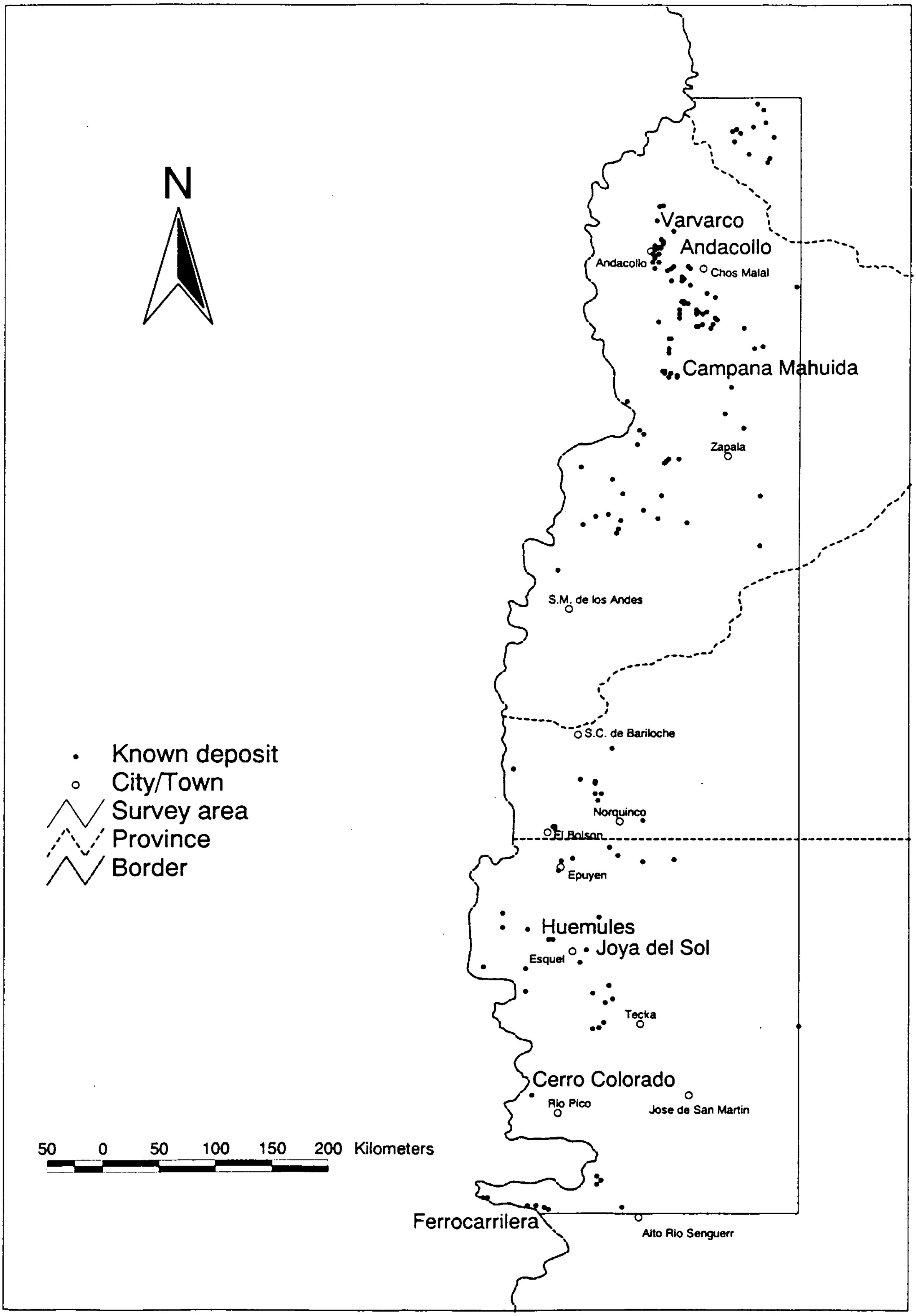


Fig. I-3-5 Distribution of all known mineral occurrences in the survey area.

Table I-3-3 Data of major deposits of the survey area.

Type	Name	Province	Metal	Type	Host rock	Data	Property	Note
1	Erica	Neuquen	Au,Pb,Zn	Polymetal vein	Tuff (C)	199,916t, 7.77g/t Au	Minera Andacollo Gold S.A./CORMINE S.E.P.	These veins were exploited as the Andcollo gold mine from January 1999 to mid-2000 (50,000 oz/y Au). Currently the production has been suspended for financial reason.
1	Sofia	Neuquen	Au,Pb,Zn	Polymetal vein	Tuff (C)	79,836t, 14.72g/t Au		
2	Joya del Sol	Chubut	Au,Ag	Low sulfidation quartz vein	Andesitic and dacitic volcanics (J β a)	2,128,400 oz Au, 8.08g/t Au., 3,985,000 oz Ag, 15.1g/t Ag	Minera el Desquite S.A.	PhaseI, II & III drilling programme have been completed.
3	Campana Mahuida	Neuquen	Cu,Au,Mo	Porphyry Cu (Chacocite blanket)	Sandstone (Jk), Andesite (Kg)	4,637,782.3t, 0.73% Cu oxide and 22,890,977t, 0.6% Cu, (Cut off 0.3% Cu)	CORMINE S.E.P.	Outline of orebody was unveiled by drilling survey. Secondary enrichment zone is not thick.
3	Huemules	Chubut	Au,Ag,Pb	Polymetal vein	Andesitic volcanics (J β a)	Total 2,975,000t (750,000t contains 9g/t Au)	Minera el Desquite S.A.	Ore reserves were calculated by drilling survey of UNRF. Currently Minera el Desquite owns the property because it is adjacent to their Joya del Sol property.
3	La Ferrocarrilera	Chubut	Pb,Zn,Ag	Polymetal vein	Andesitic volcanics (J β a)	708,630t, 1.63% Pb, 4.49% Zn, 0.61% Cu, 0.1g/t Au, 14g/t Ag	Gropo Minero Aconcagua S.A.	Previously it was explored by drilling and underground survey in 1940's. Lower extension of the veins is not expected.
4	Cerro Colorado	Chubut	Au	High sulfidation epithermal breccia	Andesite (J β a), Granitoids (Kg)	7.95g/t Au, 66 samples of 2,200km2	Billiton Argentina B.V.	Billiton Argentina B.V. retains the property. Drilling survey was ceased in 1998 after the withdrawal of Newcrest Argentina S.A. who was the partner of J/V.

Type1= mine in operation (but operation is now stopped), Type2=drilling survey is being conducted, Type3= exploration was ceased, but reserve calculation was done, Type4= exploration was ceased, but noticeable ore grades were reported.

gave up the exploration, the reserves are estimated at 209,000 oz for gold and 1,410,000 oz for silver with an average grade of 5.8 g/t Au and 39.5 g/t Ag, respectively. Minera el Desquite S.A. acquired the option right from Sunshine Mining in October 1998 and has been conducting systematic drilling exploration since 1999. Drilling surveys of No. 1 to 3 phase were conducted in 1999, first half of 2000 and second half of 2000, respectively. Measured and indicated ore reserves including the proximal properties are as follows.

	Ounces/Gold	Ounces/Silver
Esquel Gold Project PAH	2,128,400 (8.08g/tAu)	3,985,000 (15.1g/tAg)
La Joya del Sol	209,000 (5.8g/tAu)	1,413,000 (39.5g/tAg)
Huemules	114,300	Not Available
Total Resources	2,451,700	5,398,000

(90% is measured and indicated category, http://www.brancote.com/)

Minera el Desquite S.A. acquired the properties (10.018 Has) adjacent to their Esquel properties from Minera Andes S.A.

The Huemules in Chubut province is auriferous polymetallic vein deposits. The drilling survey conducted under the above-mentioned UN-revolving fund project estimates that the reserve of 2,975,000 tons. Of this reserve, the ore with grade averaging higher than 9g/t Au is re-estimated to be 750,000 tons (Viera and Hughes, 1999). Minera el Desquite S.A now owns the Huemules mine property because it is located about 20 km to the west of the earlier-mentioned Joya del Sol deposits. Even if the single reserve of Huemules deposits may not be economically feasible for development, it is certain that the combined development with the Joya del Sol deposits will make it economically feasible.

The Cerro Colorado in Chubut province is high-sulfidation Au deposit with hydrothermal breccias where value of 7.95 g/t Au is obtained in the surface alteration zone. Billiton Argentina B.V. participated in the joint venture with Newcrest Minera Argentina S.A. and started a drilling survey in 1998. Billiton, however, stopped the survey because Newcrest decided to withdraw from the operation. The mine property is still owned by Billiton.

The Ferrocarrilera in Chubut province is polymetallic vein deposits of Pb, Zn and Ag. Drilling exploration and a underground survey were conducted in the 1940s. The place was also taken up as one of the UN-revolving fund projects. Based on the result of these exploration surveys, the ore reserve was calculated by SEGEMAR in 1985 and determined to be 708,630 tons of 1.63% Pb, 4.49% Zn, 0.61% Cu, 0.1g/t Au and 14g/t Ag, respectively (Zubia, 1985). The exploration is now stopped as the ore condition in the lower extension is not encouraging. The mine property is owned by the association of small-mine owners.

2) Public mining corporation

The Neuquen province government established a public mining corporation, CORMINE S.E.P.(Corporación Minera del Neuquén, Sociedad del Estado Provincia) in 1975. The CORMINE S.E.P. owns mining properties and promotes exploration activities within the province through the option contracts with private companies. Its function and authority, however, were sharply reduced in midyear 2000 under the recent mining policy of the central government, i.e., easing of control and promotion of induction of foreign funds. The number of personnel was cut from 60 in 1995 to 18 in November 2000. Most of the mining properties possessed by CORMINE have been opened to the private sector except for three main properties, Andaccolo, campana Mahuida and La Voluntad.

Meanwhile, the Chubut province government established the Petrominera Chubut S.E. which mainly runs the petrol mining activities. Although the company owns the mining properties of metallic minerals, the exploration for them is not promoted.

3) PASMA Project

In order to create a comprehensive investment environment by the Argentine government, the PASMA project (Proyecto de Apoyo Minero Argentino) is now in progress with the support of the World Bank. The objectives of this project is to format as a database, open and share through the Internet various kinds of information possessed by the central government, and respective province governments, including mining property information and fundamental geological information.

As a part of the PASMA project, the program of geophysical and mineral resources mapping has been implemented, and the metallogenic map published by SEGEMAR in 1997 was digitized in 1998 (Zappettini ed., 1998). In addition, airborne geophysical survey is being carried out over the range including the survey area.

4) Proyect Minero Rio Negro

Under the agreement between the Rio Negro province government and SEGEMAR, information systematization by GIS (Geographic Information System) is being executed on geology, mineral deposits, geophysical data, geochemical data and industrial raw materials. The fruits were published in the form of CD-ROM in 1998.

5) Chile-Argentine mining treaty

A treaty regarding mineral resources around the border between Chile and Argentina was signed by the presidents of both countries in December 1997, for the purpose of improvement of the environment to promote mineral resources development around the border. Parliamentary approval in both countries, however, was suspended because of a certain issue regarding the southern border. To solve this bottleneck, a new border treaty was signed and approved by the parliaments of both nations in June 1999, and ratified by the presidents of both nations in August 1999. Consequently, the mining treaty was tabled for parliamentary approval, approved by both National Congresses in August 2000, and finally became effective in February 2001. Argentina's main advantage from this treaty is that mining products around the national border can be shipped from ports on the Pacific side, while Chile's main advantage is that the abundant water resources and land inclining gently on the Argentina side can be used. In addition, it is advantageous for both countries that foreign funds can be induced to ore deposits that have not been developed around the border. Projects preceding the approval of this treaty are the El Pachon Project (Cu, 50% by San Jose, 50% by Cambior; in the place adjoining Los Pelambres on the Chilean side) and the Pascua (Chile)- Lama (Argentina) Project (Au, Barrick Gold). The Pascua-Lama Project has been put off indefinitely because the price of gold remains low, although development was planned to be start in December 2000.

Construction work on a road crossing the national border connecting from San Pedro de Atacama in the Region II of Chile, via Paso de Jama, to Salta in Argentine was started in December 2000. This border-crossing road is expected to become an important international trunk line from Argentina and Paraguay to the Mejilones complex port in the northern part of Antofagasta in the Region II of Chile, on the Pacific side. Moreover, it is expected that the progress of improvement of infrastructure beyond the border, such as laying of two gas pipe lines between Salta and Mejillones and linking of electric power between Salta and Antofagasta, will promote development of mining in both countries.

6) Governmental organization reforms

The administration shift to new president of De la Rúa in December 1999 resulted in organization reforms of the central government. The mining related organization chart is currently as follows, after secondary reforms.

[Former Government]

Ministerio de Economia y Obras y Servicio Publicos
|
Secretaria de Industria, Comercio y Mineria
|
Subsecretaria de Mineria
|
SEGEMAR — Direccion Nacionl de Mineria

[Current Government]

Ministerio de Economia
|
Secretaria de Energia y Mineria
|
Subsecretaria de Energia y Mineria
|
Coordinador de Mineria
|
SEGEMAR — Direccion Nacional de Mineria

7) Mining related Web site

The Web site of Ministerio de Economia and SEGEMAR were recently Up-loaded. Followings are the those addresses.

Ministerio de Economia : http://cdi.mecon.gov.ar/
http://www.mecon.gov.ar/
http://infoleg.mecon.gov.ar/
SEGEMAR : http://segemar.gov.ar/

Chapter 4 Synthetic interpretation on survey results

4-1 Existing data analysis

In the existing data analysis, a literature research was done regarding data owned by SEGEMAR, provincial governments and private companies in the Phase-1. In the Phase-2, analysis was done on airborne geophysical exploration data acquired in the Neuquen province, which is owned by SEGEMAR. In addition, 9,242 stream sediments samples, which were taken in the Neuquen province by SEGEMAR in past, were re-analyzed for 48 elements, and the chemical analysis results were interpreted.

In the literature research of the existing data analysis, known deposits in the survey area are classified into vein deposits, porphyry copper deposits, high sulfidation gold deposits, placer gold deposits, sedimentary ore deposits and others. Vein deposits are subdivided into auriferous polymetallic vein deposits and non-auriferous polymetallic vein deposits. Important among these deposits as the subject of the exploration is gold and auriferous polymetallic vein deposits, high sulfidation gold deposits and porphyry copper deposits. Representative ore deposit for auriferous quartz vein is Joya del Sol, auriferous polymetallic vein is Andacollo, high sulfidation gold is Cerro Colorado and porphyry copper is Campana Mahuida.

These ore deposits were formed in connection with hydrothermal activities, and magmatic activities played an important role as the heat source. Therefore, in order to interpret the promising district regarding mineralization, it is important to understand the distribution of magmatic arcs related to mineralization.

Furthermore, in the Alto del Rio Barrancas district, geochemical anomalies of 102 to 133ppb Au is sporadically but widely recognized from the interpretation result for stream sediments geochemical exploration data in the existing data analysis. As there are no known ore deposits, the existence of new ore deposits is expected in this district.

4-2 Satellite image analysis

In the Phase-1, interpretations of geology and lineament were done for the false color images, and hydrothermal alteration zones were extracted from ratio composite images. In the Phase-2, detailed extraction of alteration zones was done in the unit of a pixel, which forms an image, by means of pattern matching of pseudo-reflectance between observed satellite image data and idealized alteration models. Although the accuracy of extraction of alteration zones was better in the Phase-2 due to nature of the analyzing method, there was not a wide difference for extraction of alteration zones between in the Phase-1 and Phase-2. As a result of the ground truth, it was confirmed that the extraction of alteration zones through the Phase-1 to Phase-2 was almost appropriate.

4-3 Ground truth

In the ground truth, survey districts were selected based on the results of the existing data analysis and the satellite image analysis. In the Phase-1, 31 districts were surveyed where the known mineralization and alteration zones are distributed. In the Phase-2, total 16 districts were surveyed. Among them, 9 districts were selected for follow-up survey based on the results of the Phase-1, and 7 districts were newly selected.

As a result of the Phase-1 survey, high potential was recognized for five districts of Andacollo, Huemules, Joya del Sol, Cerro Colorado and Cerro Blanco, and decided not to include these in the Phase-2 survey.

In the Andacollo district, auriferous polymetallic vein deposit is already being exploited by Minera Andacollo Gold S.A. Concerning the auriferous polymetallic vein deposit in the Huemules district and the auriferous quartz vein deposit in the Joya del Sol district, Minera el Desquete S.A. is conducting a feasibility study, and the total volume of gold reached 2,451,700 oz according to information on the Internet. Concerning the high sulfidation gold deposit in the Cerro Colorado district and the auriferous polymetallic vein deposit in the Cerro Blanco district, Billiton Argentina B.V. is now ceasing the exploration. However, 7.95 g/t Au was reported for the hydrothermal braccia on ground surface of the Cerro Colorado district, and 1.575 g/t Au was confirmed for quartz veins in the Cerro Blanco district in this survey.

As a result of the Phase-2 survey, four districts of Varvarco, Cerro Mayal, Epuyen and Cerro Gonzalo are considered to be promising.

Varvarco ore deposit in the Varvarco district actually comprises the Mina Santos ore deposit and Mina Santos West ore deposit, and the host rock is granodiorite. At the old mine of Mina Santos ore deposit, network quartz veins with pyrite dissemination of about 50 cm in the maximum width are observed, and quartz veins with chalcopyrite and malachite revealed the analysis results of 14.04g/t Au, 524g/t Ag, 2.75% Cu and 2.69% Pb. Quartz veins with pyrite dissemination at the Mina Santos West ore deposit revealed analysis results of 15.27g/t Au and 37g/t Ag. In the Cerro Mayal district, there is distribution of andesite porphyry which has altered to white and intrudes into sedimentary rocks of the lower Cretaceous, and limonitized calcite veinlets is distributed in fracture zones. This channel sample revealed analysis results of 59.14 g/t Au and 3.4 g/t Ag. In the Epuyen district, quartz veins of about 20 cm in width are hosted in quartz porphyry intruding into the Cretaceous granite batholith and revealed analysis results of 9.14g/t Au and 12.4g/t Ag. This is described for the first time as a result of this survey, and we have named it the Rio Blanco ore deposit. Several other limonitic outcrops in the vicinity are seen from a distance. The Cerro Gonzalo district consists of Sectors 1 to 6, and Sector 1 is called Arroyo Luque. In Arroyo Luque, hypogene porphyry copper deposit is exposed at the level of the streams and revealed the content of 1295 to 1655ppm Cu. Oxidized leaching zone locally containing malachite is formed on the upper part of hills, and the existence of a secondary enrichment zone is expected beneath the hills. Sector 6 in Cerro Gonzalo is located on the topographically highest area, and alteration zones indicate conditions of supergene oxidized leaching. Therefore, the existence of a secondary enrichment zone is also expected in the lower part.

Although Condorcanqui copper deposit was not judged to be promising, important geological information was obtained from this survey. The dissemination ore deposit of chalcopyrite, malachite and so on, whose host rock is andesite lava and pyroclastic rocks, have been considered up to now as ore deposits of the manto-type, whose host rock is Ventana formation of Paleogene. However, it is considered from this survey results that the host rock of ore deposits is Piltriquitron formation of Jurassic, and it is metasomatic copper deposit related to dacite dykes that derived from granitoids of the very end of the Jurassic to the early Cretaceous.

4-4 Control factors of mineralization

Important deposits as the subject of the exploration is gold and auriferous polymetallic vein deposits, high sulfidation gold deposits and porphyry copper deposits. These ore deposits were formed in connection with hydrothermal activities, and magmatic activities played an important role as the heat source. Therefore, in order to interpret the promising district regarding mineralization, it is important to understand the distribution of magmatic arcs related to mineralization. As a result of examination on the age of granitic rocks and volcanic rocks, both of which have a possible relationship with mineralization, that were obtained by the K-Ar radiometric dating (Table II-4-1, Fig. II-4-1), in the Neuquen province which is the northern part of the survey area, there is a high possibility that the formation of Compana Mahuida porphyry copper deposit and Andacollo, Varvarco and Cerro del Diablo vein deposits is limited to the period between the late Cretaceous and the Paleocene. This period was before the Eocene, when intensive volcanic eruptions started due to Andean orogenic movement, and it is suggested that intrusive rocks without volcanic eruption brought about mineralization. In the Chubut province which is the southern part of survey area, there is a high possibility that Cerro Gonzalo porphyry copper deposit and Cerro Colorado high sulfidation gold deposit were formed in the late Cretaceous. Joya del Sol gold vein deposit has a high possibility that it was formed in the period between the middle and late Cretaceous. However, it also has a possibility of paleogene because the Ventana formation of Paleogene has received hydrothermal alteration in proximal Laguna Sunica. The late Cretaceous is considered to be important as the time when the age of formation of gold vein deposits, high sulfidation gold deposits and porphyry copper deposits was overlapping. This late Cretaceous is the period when the volcanic eruption was not active, and it is therefore suggested that intrusive rocks without volcanic eruption brought about mineralization similarly to Neuquen province. This is considered to mean that formation of promising ore deposits is difficult in the case that volcanic eruption is active because volatile components contained in magma are discharged, as pointed out by Sillitoe (1980).

Consequently, promising districts are selected as places where the distribution of the Cretaceous and Paleogene magmatic arcs harmonizes with the distribution of gold and auriferous polymetallic vein deposits, high sulfidation gold deposits, porphyry copper deposits and placer gold deposits (Fig. II-4-2).

In the satellite image analysis, various lineaments were interpreted in addition to the geological interpretation. The lineaments in the direction of N-S, NE-SW and NW-SE are dominant on the whole. This is considered to reflect that lineaments are in the compressive stress field in the direction of E-W due to subduction of the plate from the Pacific side. However, as there were various tectonic movements before Andean orogenic movement, in addition, various lineaments were also generated by the vertical movements of blocks. Therefore, systematic analysis for directions of lineaments is considered to be difficult to extract the promising districts. Moreover, any lineaments just corresponding to fractures hosting the vein ore deposits were not interpreted.

On the other hand, hydrothermal alteration zones were extracted in a total of 244 places, but not all of them are related to mineralization. But the existence of hydrothermal activities and fractures that were conduits of the hydrothermal water is indispensable for mineralization. Because of this, it is considered that alteration zones existing on or near lineaments are important from the viewpoint of hydrothermal alteration zones along fractures. As a result of selection for the alteration zones located within 2 km from each lineament, promising district are selected as places where the objective alteration zones are distributed harmoniously with gold and auriferous polymetallic vein deposits, porphyry copper deposits and placer gold deposits (Fig. II-4-3).

4-5 Selection of promising districts

The result of overlapping of promising districts selected by the existing data analysis, the satellite image analysis and the ground truth is shown in Fig. II-4-5. Nine districts selected from the ground truth conform well to both or either of the promising districts selected from the existing data analysis and/or satellite image analysis, except for the Epuyen district. As to the Epuyen district, there is overlapping with only a part of the promising districts selected from the existing data analysis. This is because, for the promising district selected from the existing data analysis, consideration was not given to the existence of Rio Blanco gold vein deposits in the Epuyen district, which is described here for the first time.

Among five districts of Andacollo, Huemules, Joya del Sol, Cerro Colorado and Cerro Blanco that the high potential were proved in the Phase-1 ground truth, it is considered regarding three districts of Andacollo, Huemules and Joya del Sol, exploration is sufficient because calculation of ore reserves has been already performed. As to two districts of Cerro Colorado and Cerro Blanco, although promising mineralizations have been known, calculation of ore reserves has not been performed yet. Therefore, exploration such as a drilling survey should be conducted.

Regarding four districts of Varvarco, Cerro Mayal, Epuyen and Cerro Gonzalo that have been selected in the Phase-2 ground truth, outcomes from further exploration hereafter are expected.

As an interpretation result of the stream sediments geochemistry in the existing data analysis, the Alto del Rio Barrancas district which is accompanied by geochemical anomalies of 102 to 133ppb Au has been selected although these are sporadically. In this district, the existence of new gold deposits is expected.

The range extending from south to north including the Varvarco and Andacollo districts is a promising district in satellite image analysis. Because the Butalon Norte district located between the two districts (Fig. II-3-1-1) is not, however, selected as a promising district in the ground truth, promising places in Varvarco and Andacollo districts are limited to each scope. The range including the Joya del Sol district and the northern area of it is also a promising district in satellite image analysis. But as Minera el Desquite S.A. has already acquired northern mining properties such as Leleque, it is considered that exploration has been sufficiently carried out.

Consequently, based on the ground truth results, six districts of Varvarco, Cerro Mayal, Epuyen, Cerro Gonzalo, Cerro Colorado and Cerro Blanco are recommended as promising districts. In addition, based on the stream sediments geochemistry in the existing data analysis, the Alto del Rio Barrancas district is recommended as a promising district.

Chapter 5 Conclusions and proposals

5-1 Conclusions

In this survey, existing data analysis, satellite image analysis and a ground truth were carried out over two fiscal years of Phase-1 and Phase-2.

In the existing data analysis, a literature research was done regarding data owned by SEGEMAR, provincial governments and private companies in the Phase-1. In the Phase-2, analysis was done on airborne geophysical exploration data acquired in the Neuquen province, which is owned by SEGEMAR. In addition, 9,242 stream sediments samples, which were taken in the Neuquen province by SEGEMAR in past, were re-analyzed for 48 elements, and the chemical analysis results were interpreted.

In the satellite image analysis, the false color images of 13 scenes were made and geological interpretation was done for them, and alteration zones of total 244 places were extracted by making of ratio composite images. In the phase-2, detailed extraction of alteration zones was done for 6 scenes including promising district, and the alteration zones were divided into neutral alteration and acid alteration.

In the ground truth, survey districts were selected based on the results of the existing data analysis and the satellite image analysis. In the Phase-1, 31 districts were surveyed where the known mineralization and alteration zones are distributed. In the Phase-2, total 16 districts were surveyed. Among them, 9 districts were selected for follow-up survey based on the results of the Phase-1, and 7 districts were newly selected. Interpretation for above-mentioned survey results is as follows.

Interpretation on results of the existing data analysis is shown in Fig. II-4-2. In the literature research of the existing data analysis, known deposits in the survey area are classified into vein deposits, porphyry copper deposits, high sulfidation gold deposits, placer gold deposits, sedimentary ore deposits and others. Important among these deposits as the subject of the exploration is gold and auriferous polymetallic vein deposits, high sulfidation gold deposits and porphyry copper deposits. These ore deposits were formed in connection with hydrothermal activities, and magmatic activities played an important role as the heat source. Therefore, in order to interpret the promising district regarding mineralization, it is important to understand the distribution of magmatic arcs related to mineralization. As a result of examination on the age of granitic rocks and volcanic rocks, both of which have a possible relationship with mineralization, that were obtained by the K-Ar radiometric dating (Table II-4-1, Fig. II-4-1), in the Neuquen province which is the northern part of the survey area, there is a high possibility that the formation of Compana Mahuida porphyry copper deposit and Andacollo, Varvarco and Cerro del Diablo vein deposits is limited to the period between the late Cretaceous and the Paleocene. This period was before the Eocene, when intensive volcanic eruptions started due to Andean orogenic movement, and it is suggested that intrusive rocks without volcanic eruption brought about mineralization. In the Chubut province which is the southern part of survey area, there is a high possibility that Cerro Gonzalo porphyry copper deposit and Cerro Colorado high sulfidation gold deposit were formed in the late Cretaceous. Joya del Sol gold vein deposit has a high possibility that it was formed in the period between the middle and late Cretaceous. However, it also has a possibility of paleogene because the Ventana formation of Paleogene has received hydrothermal alteration in proximal Laguna Sunica. The late Cretaceous is considered to be important as the time when the age of formation of gold vein deposits, high sulfidation gold deposits and porphyry copper deposits was overlapping. This late Cretaceous is the period when the volcanic eruption was not active, and it is therefore suggested that intrusive rocks without volcanic eruption brought about mineralization similarly to Neuquen province. This is considered to mean that formation of promising ore deposits is difficult in the case that volcanic eruption is active because volatile components contained in magma are discharged, as pointed out by Sillitoe (1980).

Consequently, promising districts are selected as places where the distribution of the Cretaceous and Paleogene magmatic arcs harmonizes with the distribution of gold and auriferous polymetallic vein deposits, high sulfidation gold deposits, porphyry copper deposits and placer gold deposits.

Furthermore, as a result of interpretation on the stream sediments geochemistry, anomalies of 102 to 133ppb Au are recognized sporadically but widely in the Alto del Rio Barrancas district. As there are no known ore deposits, the existence of new ore deposits is expected in this district.

Interpretation on results of the satellite image analysis is shown in Fig. II-4-3. In the satellite image analysis, various lineaments were interpreted in addition to the geological interpretation. The lineaments in the direction of N-S, NE-SW and NW-SE are dominant on the whole. This is considered to reflect that lineaments are in the compressive stress field in the direction of E-W due to subduction of the plate from the Pacific side. However, as there were various tectonic movements before Andean orogenic movement, in addition, various lineaments were also generated by the vertical movements of blocks. Therefore, systematic analysis for directions of lineaments is considered to be difficult to extract the promising districts. Moreover, any lineaments just corresponding to fractures hosting the vein ore deposits were not interpreted.

On the other hand, hydrothermal alteration zones were extracted in a total of 244 places, but not all of them are related to mineralization. But the existence of hydrothermal activities and fractures that were conduits of the hydrothermal water is indispensable for mineralization. Because of this, it is considered that alteration zones existing on or near lineaments are important from the viewpoint of hydrothermal alteration zones along fractures. As a result of selection for the alteration zones located within 2 km from each lineament, promising district are selected as places where the objective alteration zones are distributed harmoniously with gold and auriferous polymetallic vein deposits, porphyry copper deposits and placer gold deposits.

Interpretation on results of ground truth is shown in Fig. II-4-4. As a result of Phase-1 ground truth, high potential was recognized for five districts of Andacollo, Huemules, Joya del Sol, Cerro Colorado and Cerro Blanco, and decided not to include these in the Phase-2 survey. In the Andacollo district, auriferous polymetallic vein deposit is already being exploited by Minera Andacollo Gold S.A. Concerning the auriferous polymetallic vein deposit in the Huemules district and the auriferous quartz vein deposit in the Joya del Sol district, Minera el Desquete S.A. is conducting a feasibility study, and the total volume of gold reached 2,451,700 oz according to information on the Internet. Concerning the high sulfidation gold deposit in the Cerro Colorado district and the auriferous polymetallic vein deposit in the Cerro Blanco district, Billiton Argentina B.V. is now ceasing the exploration. However, 7.95 g/t Au was reported for the hydrothermal braccia on ground surface of the Cerro Colorado district, and 1.575 g/t Au was confirmed for quartz veins in the Cerro Blanco district in this survey.

The Phase-2 survey was conducted for nine follow-up districts of Varvarco, Campana Mahuida, Palau Mahuida, Nireco, La Voluntad, Condorcanqui, Epuyen, Cerro Gonzalo and Arroyo Cascada, and seven new districts of Villa Aguas Calientes, Carro Collocho, Cerro Mayal, Cerro de los Bueyes, Rio Foyel, Laguna Sunica and Cerro Cuche. As a result for these, four districts of Varvarco, Cerro Mayal, Epuyen and Cerro Gonzalo are considered to be promising.

Varvarco ore deposit in the Varvarco district actually comprises the Mina Santos ore deposit and Mina Santos West ore deposit, and the host rock is granodiorite. The quartz veins with chalcopyrite and malachite from Mina Santos ore deposit revealed the analysis results of 14.04g/t Au, 524g/t Ag, 2.75% Cu and 2.69% Pb. The quartz veins with pyrite dissemination from Mina Santos West ore deposit revealed analysis results of 15.27g/t Au and 37g/t Ag. In the Cerro Mayal district, there is distribution of andesite porphyry which has altered to white and intrudes into sedimentary rocks of the lower Cretaceous. The limonitized calcite veinlets in fracture zones revealed analysis results of 59.14g/t Au and 3.4g/t Ag. In the Epuyen district, quartz veins of about 20 cm in width are hosted in quartz porphyry intruding into the Cretaceous granite batholith and revealed analysis results of 9.14g/t Au and 12.4g/t Ag. This is described for the first time as a result of this survey, and we have named it the Rio Blanco ore deposit. The Cerro Gonzalo district consists of Sectors 1 to 6, and Sector 1 is called Arroyo Luque. In Arroyo Luque, hypogene porphyry copper deposit is exposed at the level of the streams and revealed the content of 1295 to 1655ppm Cu. Oxidized leaching zone locally containing malachite is formed on the upper part of hills, and the existence of a secondary enrichment zone is expected beneath the hills. Sector 6 in Cerro Gonzalo is located on the topographically highest area, and alteration zones indicate conditions of supergene oxidized leaching. Therefore, the existence of a secondary enrichment zone is also expected in the lower part.

Although Condorcanqui copper deposit was not judged to be promising, important geological information was obtained from this survey. The dissemination ore deposit of chalcopyrite, malachite and so on, whose host rock is andesite lava and pyroclastic rocks, have been considered up to now as ore deposits of the manto-type, whose host rock is Ventana formation of Paleogene. However, it is considered from this survey results that the host rock of ore deposits is Piltriquitron formation of Jurassic, and it is metasomatic copper deposit related to dacite dykes that derived from granitoids of the very end of the Jurassic to the early Cretaceous.

The result of overlapping of promising districts selected by the existing data analysis, the satellite image analysis and the ground truth is shown in Fig. II-4-5. Nine districts selected from the ground truth conform well to both or either of the promising districts selected from the existing data analysis and/or satellite image analysis, except for the Epuyen district. As to the Epuyen district, there is overlapping with only a part of the promising districts selected from the existing data analysis. This is because, for the promising district selected from the existing data analysis, consideration was not given to the existence of Rio Blanco gold vein deposits in the Epuyen district, which is described here for the first time.

Among five districts of Andacollo, Huemules, Joya del Sol, Cerro Colorado and Cerro Blanco that the high potential were proved in the Phase-1 ground truth, it is considered regarding three districts of Andacollo, Huemules and Joya del Sol, exploration is sufficient because calculation of ore reserves has been already performed. As to two districts of Cerro Colorado and Cerro Blanco, although promising mineralizations have been known, calculation of ore reserves has not been performed yet. Therefore, exploration such as a drilling survey should be conducted.

Regarding four districts of Varvarco, Cerro Mayal, Epuyen and Cerro Gonzalo that have been selected in the Phase-2 ground truth, outcomes from further exploration hereafter are expected.

As an interpretation result of the stream sediments geochemistry in the existing data analysis, the Alto del Rio Barrancas district which is accompanied by geochemical anomalies of 102 to 133ppb Au has been selected although these are sporadically. In this district, the existence of new gold deposits is expected.

The range extending from south to north including the Varvarco and Andacollo districts is a promising district in satellite image analysis. Because the Butalon Norte district located between the two districts (Fig. II-3-1-1) is not, however, selected as a promising district in the ground truth, promising places in Varvarco and Andacollo districts are limited to each scope. The range including the Joya del Sol district and the northern area of it is also a promising district in satellite image analysis. But as Minera el Desquite S.A. has already acquired northern mining properties such as Leleque, it is considered that exploration has been sufficiently carried out.

Consequently, based on the ground truth results, six districts of Varvarco, Cerro Mayal, Epuyen, Cerro Gonzalo, Cerro Colorado and Cerro Blanco are recommended as promising districts. In addition, based on the stream sediments geochemistry in the existing data analysis, the Alto del Rio Barrancas district is recommended as a promising district.

5-2 Proposals for Phase-2 survey

Six districts of Varvarco, Cerro Mayal, Epuyen, Cerro Gonzalo, Cerro Colorado and Cerro Blanco are selected as promising districts based on the results of the ground truth. Besides, Alto del Rio Barrancas district is selected as promising district based on the interpretation on the stream sediments geochemistry in the existing data analysis (Fig. III-1, Table III-1).

Varvarco ore deposit in the Varvarco district actually comprises the Mina Santos ore deposit and Mina Santos West ore deposit, and the host rock is granodiorite. At the old mine of Mina Santos ore deposit, network quartz veins with pyrite dissemination of about 50 cm in the maximum width were observed. The quartz veins with chalcopyrite and malachite from Mina Santos ore deposit revealed the analysis results of 14.04g/t Au, 524g/t Ag, 2.75% Cu and 2.69% Pb. The quartz veins with pyrite dissemination from Mina Santos West ore deposit revealed analysis results of 15.27g/t Au and 37g/t Ag. It is recommended that drilling survey should be planned to unveil the scale of veins after execution of detailed geological survey, geochemical survey and geophysical survey.

In the Cerro Mayal district, there is distribution of andesite porphyry which has altered to white and intrudes into sedimentary rocks of the lower Cretaceous. The limonitized calcite veinlets in fracture zones revealed analysis results of 59.14g/t Au and 3.4g/t Ag. It is recommended to plan drilling survey to unveil the underground conditions of mineralization after careful tracing of limonitic calcite zone by detailed geological survey, geochemical survey and geophysical survey.

In the Epuyen district, quartz veins of about 20 cm in width are hosted in quartz porphyry intruding into the Cretaceous granite batholith and revealed analysis results of 9.14g/t Au and 12.4g/t Ag. This is described for the first time as a result of this survey, and we have named it the Rio Blanco ore deposit. Several other limonitic outcrops were seen from a distance. It is recommended to understand the scale and nature of mineralization more accurately by conducting of systematic geological survey and geochemical survey. Moreover, the Lago Cholila district is located next to the Epuyen district on the west side, and the chemical analysis result of 2490ppm Cu was obtained from float sample in the river running down from alteration zones in the Phase-1. Although it was planned to conduct the follow-up survey in the Phase-2, the survey was not carried out because permission for entry was not obtained from the landowner. Therefore, places requiring exploration in the Epuyen district have the possibility of expansion to the western part.

The Cerro Gonzalo district consists of Sectors 1 to 6, and Sector 1 is called Arroyo Luque. In Arroyo Luque, hypogene porphyry copper deposit is exposed at the level of the streams and revealed the content of 1295 to 1655ppm Cu. Oxidized leaching zone locally containing malachite is formed on the upper part of hills, and the existence of a secondary enrichment zone is expected beneath the hills. Although it is apprehended that a high grade has not been realized even by secondary enrichment because the grade of primary minerization is low, it is desired to confirm underground conditions by drilling survey. To conduct the drilling survey, additional IP method geophysical survey is recommended prior to drilling survey because the previous IP method geophysical survey did not cover the whole mineralized zone. Meanwhile, Sector 6 in Cerro Gonzalo is located on the topographically highest area, and alteration zones indicate conditions of supergene oxidized leaching. The existence of a secondary enrichment zone is also expected in underground. Therefore, it is also recommended to conduct IP method geophysical survey in order to judge the possibility of the existence of secondary enrichment.

In the Cerro Colorado district, the mineralization of 7.95g/t Au was reported for hydrothermal breccia on ground surface where the Jurassic andesite is distributed. From now on, further continuation of the drilling survey is recommended to unveil the ore reserve and the average grade.

In the Cerro Blanco district, quartz porphyry intrudes into the Cretaceous sedimentary rocks. The chemical analysis result of 1.575g/t Au was obtained for the quartz vein hosted in the sedimentary rocks in this survey. The trench survey has been already done for the mineralized area. From now on, drilling survey is recommended after conduction of the geophysical survey, etc.

In the Alto del Rio Barrancas district, geochemical anomalies of 102 to 133ppb Au by means of stream sediments were recognized although they are sporadically. In this district, although magmatic arcs of the Paleogene to the Neogene are distributed and alteration zones were extracted from the satellite image analysis, no known ore deposits exist. Accordingly, the existence of new gold deposits is expected. It is desired to conduct general geological survey and geochemical survey by means of rock and soil samples. In the execution of these surveys, it is recommended to re-interpret the satellite images on scale of 1 to 100,000 or similar scale in detail though it was done on scale of 1 to 250,000 in this survey.

PART II : DETAILED DISCUSSIONS

Chapter 1 Existing data analysis

1-1 Organizations owning existing data

The almost existing data for the survey area was collected in the project finding survey in 1999 (1998 fiscal year) and the Phase-1 of this survey in 2000 (1999 fiscal yaer). In the Phase2 survey in 2000, the additional data and the newly published data were collected.

The organizations from which the data was collected are SEGEMAR, Mining Direction (Direccion de Mineria) of provincial governments, CORMINE S.E.P. Besides these, in the Phase-1, data was also collected from the private companies of Minera Andacollo Gold S.A., and Minera el Desquite S.A. which are conducting the exploitation and exploration activities.

In SEGEMAR, data was collected from its head office in Buenos Aires, the General Roca branch in Rio Negro province, and the Comodoro Rivadavia branch in Chubut province. The General Roca branch covers Neuquen, Rio Negro and La Pampa provinces. The Comodoro Rivadavia branch covers Chubut, Santa Cruz and Tierra de Fuego provinces.

Among the Mining Direction of provincial governments, the Neuquen province has office in Zapala City. The Rio Negro province has branch office within SEGEMAR's General Roca branch. The Chubut province has branch office in Esquel City.

CORMINE S.E.P. is a public mining corporation established by Neuquen provincial government. Its head office is located in Zapala City. Its function and authority were sharply reduced in midyear 2000 under the recent mining policy of the central government.

1-2 Literature research

The list of existing data collected from the above-mentioned organizations is shown in Appendix-1. Data of known deposits are mainly based on Zappettini ed. (1998) and Zanettini et al (1999). The list of the known deposits in the area is shown in Table II-1-1. The distribution of the known deposits is shown in Fig. I-3-4 and Fig. I-3-5.

Fig. II-1-1 is a compiled map based on the existing data. It classifies the known deposits by type and shows the distribution of the magmatic arcs of each period. The distribution of the magmatic arcs has been arranged from the GIS data-set by Zappettini ed. (1998). Fig. II-1-1 also shows the distribution of hydrothermal alteration zones extracted by the satellite image analysis of the Phase-1.

The known deposits are divided into five types of gold and auriferous base metals deposits, placer gold deposits, non-auriferous base metals deposits, sedimentary deposits and other deposits. The sedimentary deposits are deposits of copper, uranium, barite, celestite, etc. that are hosted in the sedimentary rocks of Jurassic to Cretaceous. The other deposits

Table II-1-1 Data of all known mineral occurrences of the survey area.

No.	Name	Lat(D)	Lat(M)	Lon(D)	Lon(M)	Metal	Form	Strike	Dip	Host rock	Data	Reference
1	Mallin de los Caballos	36	3	69	51	Cu,Ag,Au	stratiform	N40E	32NW	Ksc		Plan Cordillerano C., 1969
2	Grupo Liu Cullín	36	6	69	48	Cu	stratiform	N20E		Ksc		Plan Cordillerano C., 1969
3	Sin Nombre	36	12	69	47	Cu	stratiform	N20E	3NW	Ksc		Zanettini, 1995
4	Sin Nombre	36	14	69	53	Cu	stratiform	N45W		Ksc		Zanettini, 1995
5	El Mayán	36	15	70	1	Fe	vein	N90E	90	Ksc		Mendez et al., 1995
6	Sin Nombre	36	16	70	3	Fe	vein	N	90	Ta1		Mendez et al., 1995
7	Piedra Parada	36	17	69	59	Fe	vein	N90E	90	Ksc		Mendez et al., 1995
8	Juan Carlos	36	19	69	43	Pb,Zn	vein	N25W	90	Ta2		La Rocque, 1964
9	Amelia	36	21	70	2	Fe	vein	N	90	Ta2		La Rocque, 1964
10	Pedro Pablo	36	27	69	55	Fe	vein	N	90	Ta1		La Rocque, 1964
11	César	36	29	69	45	Cu	stratiform	N20E	80NW	Ksc		Plan Cordillerano C., 1969
12	Arroyo Caimucó	36	31	69	46	Cu	stratiform	N20E	80NW	Ksc		Plan Cordillerano C., 1969
13	Varvarco	36	52	70	37	Au,Cu	vein	N30E	30NW	PTR	2.04% Cu, 0.11% Pb, 0.21% Zn, 16.97g/t Au, 302.25g/t Ag, average of 6 samples from vein and fracture zone	Zanettini y Deza, 1989; CORMINE, 1996
14	Sin Nombre	36	53	70	38	Cu	vein	N45W	90	PTR		Zanettini y Deza, 1989
15	Butalón Norte	36	59	70	39	Au	stockwork			PTR	0.05g/t Au, 0.51g/t Ag, average of 176 rock samples	Zanettini y Lopez, 1988; CORMINE, 1996
16	Aquihuecó	37	4	70	31	Cu	vein	N30W	40SW	PTR		Plan Cordillerano C., 1969
17	La Premia	37	8	70	37	Au	vein	N	90	C		Zollner, 1949
18	Sorpresa	37	9	70	36	Au	vein	N	90	C		Llambia y Maivicini, 1978
19	Erica	37	10	70	36	Au	vein	N75E	90	C	199,916t, 7.77g/t Au	Angelelli, 1984; CORMINE, 1998
20	Arroyo Huaraco	37	11	70	40	Au	placer			Qa		Zollner y Amos, 1973
21	Gpo. San Cayetano	37	12	70	37	Au	vein	N70E	90	C, Ta1		Angelli, 1984
22	Sofia	37	12	70	38	Au,Pb,Zn	vein	N70E	90	C	79,836t, 14.72g/t Au	Angelli, 1984; CORMINE, 1998
23	Los Maitenes	37	13	70	40	Cu,Au	stockwork			Kg	0.4g/t Au, 55m depth drilling	Plan Cordillerano C., 1969; CORMINE, 1996
24	Gripo Duranzo	37	13	70	40	Au	placer			Qa		Zollner y Amos, 1973
25	Helena	37	15	70	38	Pb,Zn,Au,Ag	vein	N70E	70SE	PTR		Zollner y Amos, 1973
26	Arroyo Colo	37	15	70	41	Au	placer			Qa		Zollner y Amos, 1973
27	Gpo. Milla Michicó	37	16	70	40	Au,Pb,Zn,Ag	vein	N68	72NW	PTR		Angelelli, 1984
28	Gpo. Arroyo Nuevo	37	17	70	40	Au	placer			Qa		Zollner y Amos, 1973
29	Sin Nombre	37	19	70	38	Au	vein	N	90	J, JK		Mendez et al., 1995
30	Gpo. Cura-Mallin	37	19	70	41	Cu,Pb,Zn	vein	N45W	70NE	Ta2		Barrionuevo y Nie, 1955
31	Cerro Mayal	37	21	70	24	Au,Fe	vein	N60E	85NW	Ta1	0.10% Cu, 0.11g/t Au, 0.87g/t Ag, average of 23 rock samples	Zollner y Amos, 1973; CORMINE, 1996
32	Arroyo Butalón	37	21	70	31	Cu	vein	N45W	70SW	J, JK		Mendez et al., 1995
33	Arroyo Mayal	37	22	70	23	Au	placer			Qa		Zollner y Amos, 1973
34	General Paz	37	22	70	32	Pb	vein	N	85NW	J, JK		Angelelli, 1984
35	Sin Nombre	37	22	70	40	Au	vein	N45W	90	J, JK		Mendez et al., 1995
36	Atahualpa	37	23	70	34	Pb	vein	N25E	80NW	J, JK		Angelelli, 1984
37	Cerro Caicayen	37	26	70	27	Cu,Fe	stockwork			J, JK	porphyry Cu, 0.64% Cu, 0.06g/t Au, 0.78g/t Ag, average of 98 rock samples	Zappettini, 1998; CORMINE, 1996
38	Don Oscar	37	27	70	26	Fe	irregular vein	N	90	J, JK		Elizade, 1961
39	Tres Chorros	37	27	70	27	Cu	vein	N5E	90	J, JK		Barrionuevo y Nie, 1955
40	Mallin Quemado	37	28	70	27	U,Cu	stratiform	N25E		Ki		Angelli, 1950
41	La Chupapay	37	28	70	32	U	stratiform	N20E		Ki		La Rocque, 1964
42	Sin Nombre	37	30	70	23	Cu	vein	N	90	J, JK		Mendez et al., 1995
43	Huantraico	37	31	69	32	Fe	stratiform			Tb2		Zappettini, 1998
44	Naunauco	37	34	70	15	Cu	vein	N75E	90	Ki		Elizade y Gonzalez L.., 1958
45	Sin Nombre	37	36	70	11	Fe	vein	N	90	Ki		Mendez et al., 1995
46	Cerro del Diablo	37	38	70	26	Pb,Zn	vein	N50E	90	Ki		Angelelli, 1950
47	Cerro del Diablo	37	38	70	27	Cu	vein	N15E	80NW	Ki, Ta1		Angelelli, 1950
48	Pichi Huemul	37	39	70	24	Fe,Cu,Pb	vein	N65E	45SE	Ki		Llambia y Maivicini, 1978
49	Aurelia	37	39	70	26	Cu	vein	N15E	80NW	Ki, Ta1		Angelelli, 1950
50	Augusta	37	42	70	20	Fe,Mn,Cu	vein	N	N50E	Ki, Ta1		Angelelli, 1984
51	Mallín Largo	37	42	70	28	Fe	vein	N70E	50SE	Ki		Angelelli, 1984
52	Sin Nombre	37	43	70	15	Fe	irregular vein	N	90	Ki, Ta1		Mendez et al., 1995
53	Sin Nombre	37	43	70	19	Fe	irregular vein	N	90	Ki		Mendez et al., 1995
54	Cerro Negro	37	43	70	20	Fe,Pb,Zn,Cu	vein	N40E	70NW	Ki, Ta1		Mendez et al., 1995
55	Adnana	37	44	70	17	Fe,Mn	irregular vein	N	90	Ki, Ta1		Angelelli, 1984
56	Sin Nombre	37	44	70	20	Pb	vein	N	90	Ta1		Mendez et al., 1995
57	Bajada de la Greda	37	44	70	28	Fe,Mn	vein	N50W	90	Ki, Ta1		Mendez et al., 1995
58	Adnana 1	37	46	70	11	Fe,Mn	irregular vein	N	90	Ki, Ta1		Angelelli, 1984
59	Sin Nombre	37	46	70	28	Fe	irregular vein	N	90	Ki, Ta1		Mendez et al., 1995
60	Agua del Toro	37	47	70	10	Fe	vein	N	90	Ki		La Rocque, 1964

Table II-1-1 Data of all known mineral occurrences of the survey area.

61	La Y	37	48	70	38	Pb,Zn,Ag	vein	N40E	75SE	Ki		Plan Cordillerano C., 1969
62	La Rosa	37	49	70	12	Fe	vein	N	90	Ki		La Rocque, 1964
63	Africana	37	49	70	17	Fe,Mn	irregular vein	N90E	90	Ki, Ta1		Elizalde, 1961
64	Santa Lucida	37	50	70	19	Fe,Mn	irregular vein	N90E	90	Ki, Ta1		Elizalde, 1961
65	Santa Olga	37	50	70	20	Fe	vein	N	90	Ki		Angelelli, 1984
66	Grupo la Cecilia	37	51	69	57	Sr,Ba	stratiform			J, JK	evaporite, 50t, 90% $SrSO_4$	Zappettini, 1998
67	Santa Laura	37	51	70	13	Mn	vein	N40E	90	Ki, Ta1		Elizalde, 1961
68	Don Agustin	37	56	70	32	Pb	vein	N80E	90	J, JK		La Rocque, 1964
69	Pino Andino Norte	37	56	70	33	Cu,Au	stockwork			J, JK		Zanettini, 1995
70	Palo Quemado	38	0	69	48	U,V,Cu	disseminatio n			Ksc		Zappettini, 1998
71	Maria Teresa	38	1	69	52	U,V,Cu	disseminatio n			Ksc		Zappettini, 1998
72	Pino Andino Sur	38	1	70	33	Au	stockwork			J, JK, Ta1	porphyry Cu, 0.3% Cu, 0.14g/t Au, 6-30m depths of drill core	Zanettini, 1995; CORMINE, 1998
73	La Rosita	38	3	70	33	Ba	stratiform			J, JK, Ta1		Zappettini, 1998
74	Gpo.Cacque	38	12	70	35	Pb,Ag,Mn	vein	N75W	75SW	J, J K, Kg		Angelelli, 1984
75	Lastenia	38	12	70	36	Pb Ag Zn	vein			J, J K, Kg		Zappettini, 1998
76	Campana Mahuida	38	13	70	32	Cu,Au,Mo	stockwork			J, J K, Kg	porphyry Cu, 4,637,782.3t, 0.73% oxide Cu; 22,890,977t, 0.6% sulfides Cu	Zanettini, 1976; Mendez et al., 1995
77	Amelia, Belen, Teresa	38	13	70	35	Pb,Ag,Zn,B a	vein			J, J K, Kg		Zappettini, 1998
78	Agustina y Otras	38	14	70	29	Pb Ag Zn	vein			Ki, Ta1		Zappettini, 1998
79	Grupo Huayelon	38	15	70	29	Pb,Ag,Zn,C u	vein	N77E	90	Ki, Ta2		Angelelli, 1984
80	Candelaria	38	15	70	33	Fe	stratiform	N15W	10NE	J, JK		Angelelli, 1984
81	4 de Noviembre	38	20	70	3	Ba	stratiform			J, JK		Zappettini, 1998
82	Caferino Namuncurá	38	27	70	53	Pb,Ag	irregular			Ta2		Zanettini, 1995
83	Grupo Mallin Quemado	38	33	70	6	Ba	stratiform			J, JK		Zappettini, 1998
84	Barada Molina	38	40	69	57	Cu	disseminatio n			J, JK		Zappettini, 1998
85	Litrán	38	41	70	47	Fe	vein	N	90	PTR		La Rocque, 1964
86	Arroyo Manzano	38	43	70	45	Cu,Zn,Fe	stockwork			PC2, CPg		Plan Cordillerano C., 1969
87	Mallin Chileno	38	48	70	48	Fe	vein	N35E	90	PC2		Elizalde, 1961
88	Cerro Carren	38	55	70	28	Fe,Mn	vein	N37W	90	J, JK		Elizalde, 1961
89	Carren	38	55	70	33	Pb,Ag,Cu,F e	vein	N50E	90	J, JK		Angelelli, 1984
90	Carreri 1,2,3,4	38	56	70	34	Pb,Ag,Zn,C u	vein			CPg		Zappettini, 1998
91	Carren TG	38	57	70	35	Pb,Ag,Zn,C u	vein	N35W	90	CPg		Angelelli, 1984
92	Sin Nombre	38	59	71	15	Au	vein	N50E	90	CPg		Mendez et al., 1995
93	Arroyo Polmar	39	5	71	0	Au	placer			Qgl		La Rocque, 1964
94	La Voluntad	39	13	70	36	Cu,Ag,Mo	stockwork			CPg	porphyry Cu, 0.10% Cu, 0.005% Mo, 0.04g/t Au, average of 538 rock samples	Angelelli, 1984; CORMINE, 1998
95	Sin Nombre	39	12	70	55	Cu,Co,Ni	vein	N20W	55NE	CPg		Mendez et al., 1995
96	El Provenir	39	13	69	49	Cu	disseminatio n			J, JK		Zappettini, 1998
97	Catatun	39	20	70	45	Pb,Zn	vein	N30E	90	J , JK		Naviones Unidas, 1970
98	Sin Nombre	39	22	71	2	Au	placer			Qgl		La Rocque, 1964
99	Rio Quillén	39	23	71	8	Au	placer			Qgl		La Rocque, 1964
100	1° de Mayo	39	24	70	38	Pb,Zn	vein	N45W	72NE	PC2		Angelelli, 1984
101	Sin Nombre	39	25	70	56	Au	placer			Qa		La Rocque, 1964
102	Estancia Charahuilla	39	26	70	24	Cu,Ag,U	disseminatio n			J, JK		Zappettini, 1998
103	Cerro Caballadas	39	27	71	14	Pb,Zn,Cu	vein	N70W	80NE	CPg		Naviones Unidas, 1970
104	Sin Nombre	39	29	70	57	Au	placer			Qa		La Rocque, 1964
105	Medialuna	39	31	70	58	Au	placer			Qa		La Rocque, 1964
106	Cerro Horqueta	39	37	69	49	Cu	disseminatio n			Ki		Zappettini, 1998
107	Arroyo Metrecó	39	49	71	26	Pb	vein	N50E	90	CPg		Mendez et al., 1995
108	Area la Veranada	41	15	71	0	Au,Cu,Pb,Z n	vein			Ta1		Zappettini, 1998
109	Cerro Alcorta	41	25	71	47	Au,Ag,Cu	vein			JBa	0.47% Cu, 0.01% Pb, 88g/t Au, 407g/t Ag, 20m width quartz vein and veinlets	Giacosa, 1986
110	Rio Foyel	41	30	71	15	Au	placer			Ta1	5,000,000m^3, 175 to 200mg/m^3 Au	Zappettini, 1998; Mining Secretry, 1993
111	Innominada 3	41	31	71	8	Cu,Au	vein	N25W	90	Ta1		Dir. Min. Rio Negro, 1996
112	Cullin Mahuida	41	32	71	8	Au	vein	N	90	Ta1		Dir. Min. Rio Negro, 1996
113	Cóndor Huasi	41	37	71	5	Pb	vein	N10E	90	Ta1		Dir. Min. Rio Negro, 1996
114	Nina Petre	41	37	71	8	Pb,Zn,Cu	vein	N45W	55	Ta1		Dir. Min. Rio Negro, 1996
115	Maria	41	39	71	6	Pb,Zn,Cu	vein	N5E	74NW	Ta1	2% Cu, 12% Pb, 13% Zn, 3g/t Au, 45g/t Ag, vein 250m×1.6m	Dir. Min. Rio Negro, 1996; Mining Secretry, 1993
116	Alto Rio Chubut	41	50	70	45	Au	placer			T	10,000,000m^3, 175 to 500mg/m^3 Au	Zappettini, 1998; Mining Secretry, 1993
117	Quillén Curá	41	53	71	27	Pb,Cu	vein	N26E	90	T		Dir. Min. Rio Negro, 1996
118	Ñaley Cullin	41	53	71	28	Pb	vein	N52E	90	T		Dir. Min. Rio Negro, 1996
119	La Esmeralda	41	53	71	28	Pb,Cu	vein	N7W	90	T		Dir. Min. Rio Negro, 1996
120	Nahuel Pan	41	54	71	27	Pb,Cu,Fe	vein	N5E	90	T		Dir. Min. Rio Negro, 1996
121	Indio	42	3	71	1	C	manto	N17E	40SE	Ta1		Berrello, 1956

Table II-1-1 Data of all known mineral occurrences of the survey area.

122	Roja	42	7	70	57	Au	placer			Qa		Marquez et al., 1994
123	Cerro Coihue	42	8	71	21	Cu,Au	irregular vein	N15E	90	Kg		Genini, 1987
124	Cushamen	42	9	70	30	Mo	irregular vein	N85W	90	TQb, PC2		Butron, 1995
125	Condorcanqui	42	9	71	23	Cu,Au	irregular vein	N30W	90	Ta1		Ametrano et al., 1979
126	Mata	42	10	70	45	Au	placer			Qa		Marquez et al., 1994
127	Arroyo Pedregoso	42	13	71	24	Au	placer			Qa		Marquez et al., 1994
128	Cerro Colorado	42	35	71	52	Cu	stockwork			Ta1		Sepulveda y Viera, 1978
129	Lepá	42	37	71	6	C	manto	N25W	23SW	Ta1		Borrello, 1956
130	Cerro Techado Blanco	42	42	71	52	Ag	irregular vein	N40W	80SW	Kg		Marquez, 1980
131	Cerro Riscoso	42	43	71	40	Cu,Pb	irregular			Kg		Herrero y Pansi, 1981
132	Huemules	42	48	71	28	Au,Ag,Pb	vein	N35W	90	JBa	750,000t, 9g/t Au	Viera et al., 1988; Viera and Hughes, 1999
133	Mallin del Bronce	42	48	71	30	Au,Ag	irregular			JBa		Viera et al., 1988
134	Joya del Sol	42	53	71	12	Au,Ag	vein	N15W	90	JBa	2,128,400 oz Au, 8.08g/t Au., 3,985,000 oz Ag, 15.1g/t Ag	Brancote Holdings PLC (1999)
135	Cerro Nahuel Pan	42	59	71	15	Au	stockwork			CP, Ka	0.1% Cu, 6.1% Pb, 0.19% Zn	Naciones Unidas, 1983; Mining Secretry, 1993
136	Cerro Poncho Blanco	43	1	72	1	Cu	vein	N20E	90	JBa		Marquez, 1980
137	Cordón Situación	43	2	71	41	Cu,Pb	stockwork			Ka		Marquez et al., 1987
138	Laguna Sunica	43	10	71	0	Au,Cu	vein			Ta1		Zappettini, 1998
139	Los Pozones	43	13	71	41	Cu,Au	vein	N	90	JBa		Marquez y Butron, 1987
140	Rio Corintos	43	14	71	9	Au	placer			Qa		Angelelli, 1984
141	Arroyo Luque	43	19	71	1	Cu,Mo	stockwork			Kg		Marquez, 1988
142	Cerro Gonzalo	43	20	71	3	Mo,Ag	breccia			Kg	670,000t, 0.05% Cu, 0.048% Mo, 5g/t Au, 92g/t Ag	Marquez, 1988; Mining Secretry, 1993
143	Cañadon Bagual Victoria	43	30	69	30	Pb,Ag,Zn	vein			JBe		Zappettini, 1998
144	Princess	43	31	71	4	Au	stockwork			JBa		Marquez et al., 1994
145	Arroyo Cascada	43	32	71	7	Au	vein	N55W	25SW	JBa		Genini, 1989
146	Cerro Cuche	43	34	71	9	Mo,Au	stockwork			Kg, JBa		Pezzuchi y Takigawa, 1983
147	Cerro Riñon y Colorados	44	3	71	38	Au	stockwork			JBa, Kg	high sulfidation breccia pipe, 7.95g/t Au, 66 samples of 2,200km^2	Parisi, 1981; SEGEMAR, 1997; Perez and Sureda, 1999
148	Cerro Bayo	44	42	71	7	Ag	vein	N25W	75SW	Kim		Ramos, 1981
149	Cordillera Sakmata	44	44	71	5	Ag,Pb	vein	N30W	70SW	Kim		Ramos, 1981
150	Doña Isabel	44	46	71	7	Pb	vein	N20W	90	Kim		Ramos, 1981
151	La Fronteriza	44	52	71	59	Pb	vein	N35W	90	JBa		Dir.Gral.Min.Geol.Chubut, 1987
152	Lago Fontana	44	52	72	1	Cu	stockwork			Kg		Ramos, 1981
153	La Ferrocarrilera	44	56	71	36	Pb,Ag	vein	N35E	60SW	Jba	708,630t, 1.63% Pb, 4.49% Zn, 0.61% Cu, 0.1g/t Au, 14g/t Ag	Ramos, 1981; Secretaria de Mineria, 1985
154	Arroyo Canogas	44	56	71	40	Au,Pb	irregular vein	N25E	90	Kim		Marquez y Parisi, 1995
155	El Solcito-El Abuelo	44	57	70	55	Fe,Cu	vein	N70W	90	JBa		Medina y Maisterrena, 1981
156	Cerro Blanco	44	57	71	32	Pb,Ag	vein	N10W	85SW	JBa		Marquez y Parisi, 1995
157	Arroyo los Alevinos, Cerro Katterfeld, Cerro Cono	44	58	71	30	Au,Ag,Cu,Pb,Zn	vein			JBa		Zappettini, 1998

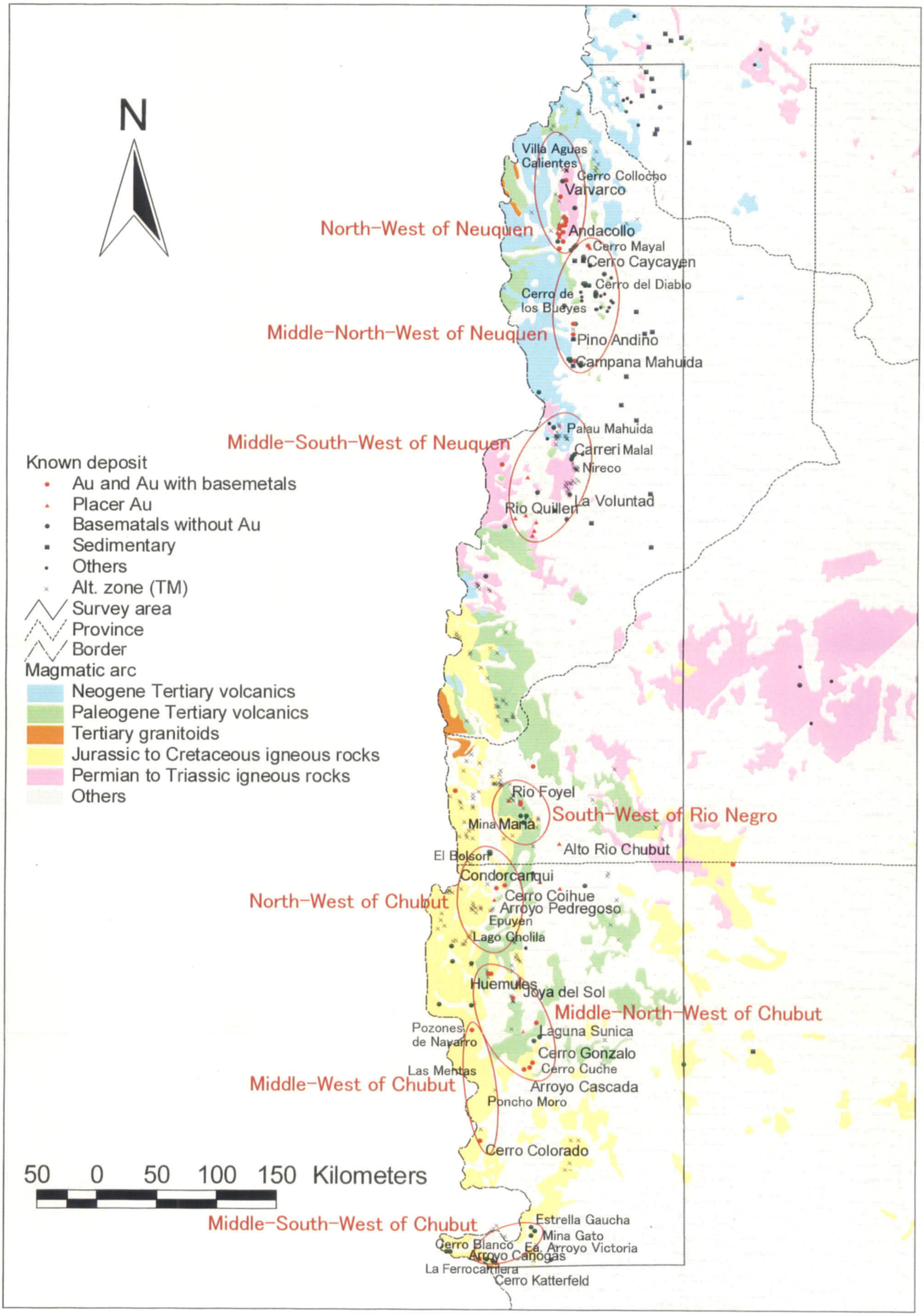


Fig. II-1-2-1 Compilatory result of the existing data analysis.

are deposits of iron, manganese and graphite. Fluorite deposits in Rio Negro province are also shown in Fig. II-1-2-1 although it is outside of the survey area.

The relations between the igneous activities and the mineralization of each period have already been explained (See I-3-2). The magmatic arcs of Permian to Triassic in Fig. II-1-2-1 were formed when the Patagonia terrane (Fig. I-3-1) collided with the Gondowana continent. The magmatic arcs of Jurassic to Cretaceous comprise two types; one of them was formed when the Atlantic Ocean opened and the Gondowana continent broke up in Jurassic, and another was formed in Cretaceous by the plate subduction from the Pacific Ocean side. The magmatic arcs of Tertiary were formed when the Andean orogeny was maximized by the plate subduction from the Pacific Ocean side. The magmatic arcs of the Tertiary are subdivided into Paleogene volcanic rocks, Neogene volcanic rocks and Tertiary granitoids.

Among the known mineralization in the area, gold and auriferous base metals vein deposits and porphyry copper deposits are important. Representative auriferous quartz vein deposit, auriferous base metals vein deposit and porphyry copper deposit are Joya del Sol deposit, Andacollo deposit and Campana Mahuida deposit respectively. The following is the results of the consideration through the existing data analysis based on Fig. II-1-2-1, in the categories of eight regions.

1) Northwestern region of Neuquen province

(Villa Aguas Calients district/Varvarco district/Cerro Collocho district /Andacollo district)

In the region from the Villa Aguas Calientes district to the Andacollo district in the northwestern part of Neuquen Province, igneous rocks are distributed which form magmatic arcs of the Permian to the Triassic, those of the Paleogene and those of the Neogene. Magmatic arcs of the Permian to the Triassic are composed mainly of acid to intermediate volcanic rocks of the Choiyoi group. On the western side of the Choiyoi group, there is distribution of intermediate to basic volcanic rocks and pyroclastic rocks of the Paleogene. In the border area between them, many mineral occurrences of auriferous base metals are distributed. A representative one is the Andacollo ore deposit (mine), which produced gold by cyanide process from 1999 to 2000. There is distribution of intrusive rocks such as Tertiary dacite porphyry near Andacollo ore deposit (CORMINE, 1998a). It is considered that mineralization occurred in and after the Paleogene. A lot of hydrothermal alteration zones were extracted from satellite image analysis in the areas where magmatic arcs of the Paleogene to the Neogene are distributed. It is expected that auriferous base metals veins of Andacollo type also exist in these areas.

2) Middle northwestern region of Neuquen province

(Cerro Mayal district/Cerro Caicayen district/Cerro del Diablo district/Cerro de los Bueyes district/Campana Mahuida district)

In the region from the Cerro Mayal district to the Campana Mahuida district in the middle northwestern part of Neuquen Province, sedimentary rocks of the Jurassic to the Cretaceous are widely distributed. The granitic rocks of the end of the Cretaceous to the Tertiary, intruding into these sedimentary rocks, are sporadically distributed although they are not shown in Fig. II-1-1 because of their small scale. In these areas where intrusive rocks are distributed, there is distribution of auriferous and non-auriferous base metals deposits. Campana Mahuida and Pino Andino are mineral occurrences of porphyry copper deposits, while Cerro Mayal, Cerro Caicayen, Cerro del Diablo and Cerro de los Bueyes are mineral occurrences of polymetallic vein deposits.

In Campana Mahida, a model area of porphyry copper deposits, many explorations have been carried out. According to Mendez et al. (1995), the ore reserves are as follows: oxides ore, 4,637,782 tons with 0.73% Cu; and sulfides ore, 22,890,977 tons with 0.6% Cu (cut off 0.3%). As to secondary biotite of andesite porphyry, which is considered to be related to mineralization of Campana Mahuida, the age of 74.2±1.4 Ma was obtained by the K-Ar method (Sillitoe, 1997). Because this corresponds to the upper Cretaceous, it is considered that this is the precedence of Andean events (See 1-3-2) and is associated with plate subduction from the Pacific side. It has been judged from previous explorations that these mineral occurrences are of the small scale and low grade (Mendez et al. 1995; CORMINE, 1996; CORMINE, 1998b). Exploration activities are not currently carried out.

3) Middle southwestern region of Neuquen province

(Palau Mahuida district/Carreri Malal district/Nireco district/La Voluntad district/Rio Quillen district)

In the region from the Palau Mahuida district to the Rio Quillen district in the southwestern part of Neuquen province, there is distribution of magmatic arcs of the Permian to the Triassic, those of the Paleogene and those of the Neogene. Known mineral occurrences include Carreri Malal, La Voluntad and Rio Quillen. Carreri Malal is mineral occurrence of polymetallic vein deposit, La Voluntad is that of porphyry copper deposit, and Rio Quillen is that of placer gold. Both Carrei Malal and La Voluntad are hosted in the plutonic complex of the Permian to the Triassic that intrudes into volcanic rocks of Choiyoi group of the Permian to the Triassic. Sillitoe (1976) and JICA/MMAJ (1984) reported 281±4 Ma (Permian) and 225±11 Ma (Triassic), respectively, as the K-Ar age of tonalite of this plutonic complex. As to La Voluntad, although many explorations have been executed and drilling surveys have also been carried out, secondary enrichment zones have not been intersected and no promising mineralization have been discovered. Because a lot of hydrothermal alteration zones were extracted from satellite image analysis in these areas, it is desirable that field surveys should be executed to investigate the conditions of mineralization and alteration.

4) Southwestern region of Rio Negro province
(Rio Foyel district/Mina Maria district)

In the region from the Rio Foyel district to the Mina Maria district in the southwestern part of Rio Negro province, magmatic arcs of the Jurassic to the Cretaceous and those of the Paleogene are distributed. Rio Foyel and Mina Maria are located in the area where volcanic rocks of the Ventana formation composing magmatic arcs of the Paleogene are distributed. Rio Foyel is a mineral occurrence of placer gold. Mina Maria is a mineral occurrence of base metals vein deposits with lead and zinc as the main, and it has an old adit for mining in the past. It is considered that these mineral occurrences were formed by mineralization in and after the Paleogene. Gold deposits as a source of placer gold and base metals deposits of the Maria type are expected to exist in these areas.

5) Northwestern region of Chubut province
(El Bolson district/Cerro Coihue district/Condorcanqui district/Epuyen district/Lago Cholila district)

In the northwestern region of Chubut province, magmatic arcs of the Jurassic to Cretaceous and those of the Paleogene are distributed. In the area where granitic rocks composing a magmatic arc of the Jurassic to the Cretaceous are distributed, Condoreanqui mineral occurrence is located and is considered to be of the manto type, and Cerro Coihue mineral occurrence is also located and is regarded as a porphyry copper deposit (Zappettini, ed. 1998). In both mineral occurrences, several explorations were executed. Although drilling survey (22 holes, total 626m) was carried out in Condoreanqui mineral occurrence, no good results that stimulate continuation of explorations have been obtained. It is considered that these mineralization were formed in and after the Jurassic because the hydrothermal alteration zones from satellite image analysis are concordant with the areas where magmatic arcs of the Jurassic to the Cretaceous are distributed.

Arroyo Pedregoso in the Epuyen district is a mineral occurrence of placer gold, and hydrothermal alteration zones were extracted from satellite image analysis in upstream areas of the El Bolson, Epuyen and Lago Cholila districts. Therefore, gold ore deposits that are source of placer gold are expected.

6) Middle northwestern region of Chubut Province

(Huemules district/Joya del Sol district/Laguna Sunica district/Cerro Gonzalo district/Arroyo Cascada district/Cerro Cuche district)

In the northwestern region of Chubut province, many mineral occurrences of gold and auriferous base metals are known. These are concordant with the distribution of magmatic arcs of the Jurassic to the Cretaceous and those of the Paleogene. Hydrothermal alteration zones were extracted from satellite image analysis in both distribution areas. It is suggested that these mineralization were formed in and after the Jurassic or the Paleogene. The Joya del Sol is a mineral occurrence of epithermal gold deposit, while Huemules, Laguna Sunica and Corro Cuche are mineral occurrences of auriferous base metals vein deposits. Current exploration activities in Joya del Sol and Huemules are as mentioned above (See I-3-3). On the other hand, in the Cerro Gonzalo mineral occurrence which is considered to be porphyry copper deposit and Arroyo cascade mineral occurrence known as gold ore deposit, although geophysical and drilling surveys were executed in the past, no exploration activities are carried out at present in either mineral occurrence. In order to clarify the potential of these mineral occurrences, it is desirable to conduct the field survey.

7) Middle western region of Chubut province

(Pozones de Navaro district/Las Mantas district/Poncho Moro district/Cerro Colorado district)

In the middle western region of Chubut province, magmatic arcs of the Jurassic to the Cretaceous are distributed along the national border with Chile. Hydrothermal alteration zones were extracted from satellite image analysis in the areas with these magmatic arcs distribution. Cerro Colorado and Cerro Riñon, both of which are gold mineral occurrences, and Los Pozones, which is a mineral occurrence of auriferous base metals, are known in these areas. The outlines of exploration activities in Cerro Colorado is as mentioned above (See I-3-3). Although Cerro Colorado and Cerro Riñon are included in the model areas because of their high sulfidation gold mineralization, mining properties of major private company have been already established, and it was concluded in the phase-1 survey that other mineral occurrences have no necessity for continuation of the survey. Therefore, these mineral occurrences were excluded from the phase-2 survey.

8) Middle southwestern region of Chubut province.

(Estrella Gaucha district/Mina Gato district/Estancia Arroyo Victoria district/Ferrocarrilera district/Cerro Blanco district)

In the middle southwestern region of Chubut province, there are distribution of sedimentary rocks of the Jurassic to the Cretaceous and magmatic arcs of the Jurassic to the Cretaceous. As the main mineral occurrences, Cerro Bayo, Cordillera de Sakmata, Cerro Katterfeld, Ferrocarrilera and Cerro Branco, all of which are auriferous base metals, are located in areas where magmatic arcs of the Jurassic to the Cretaceous are distributed. In these mineral occurrences, it is considered that these mineralization were formed in and after the Jurassic. The outline of exploration activities in Ferrocarrilera is as mentioned above (See I-3-3). In the Estrella Gaucha and Mina Gato districts, old kaolin exploitation pits exist. In the Cerro Blanco district, mining properties of major private company have been already established, and it was concluded in the phase-1 survey that other mineral occurrences have no necessity of continuation of the survey. Therefore, these mineral occurrences are excluded from the Phase-2 survey.

1-3 Airborne geophysical survey

1-3-1 Summary of airborne geophysical survey and specification

SEGEMAR has been acquiring airborne geophysical data (magnetics and radiometrics) over the country in recent years. The airborne geophysical data which was interpreted in this project is one of those which SEGEMAR has acquired. The airborne geophysical survey was flown over one portion of Neuquen Province by SIAL Geosciences Inc., a Canadian geophysical contractor, three times in 1999, that is from March 8 to June 7, from August 9 to 24, and from November 25 to December 5. The location of the survey area is shown in Figure II-1-3-1. N-S traverse of the area is between Lat. 37° 45' S and Lat. 39° 30' S, and E-W traverse is between Long. 70° 25' W and the border with Chile (northern part) or Long. 71° 00' W (southern part). Total area is ca. 10,000 km^2. An operations report was presented to SEGEMAR in April, 2000 (SIAL Geosciences Inc., 2000). Survey specification is summarized below:

Table II-1-3-1 Specification on the airborne geophysical survey, Neuquen Province

Survey type	Aeromagnetic, radiometric, digital terrain
Aircraft type	Piper PA-31T, Cheeyenne II
Total line kms	12,100 km
Flight-line direction	North-South
Flight-line spacing	1,000 meters
Tie-line direction	East-West
Tie-line spacing	7,500 m
Mean flight height	150 m

The following dataset was used for the interpretation.

1) Airborne geophysical data

a) Aeromagnetic data

Aeromagnetic data was acquired by SCINTREX CS-2 Cesium Vapor sensor with sampling rate of ten readings per second. Flight-line direction is North-South and spacing is 1,000 m, and tie-line direction is East-West and spacing is 7,500 m. After long wavelength diurnal and IGRF corrections were removed, the final leveling of the total magnetic field was done by intersection analysis using both flight-line and tie-line data.

Reduction to the pole calculation was applied to the total magnetic field. The magnetic value were then reduced to a regular 200 m X-Y grid, using GEOSOFT MONTAJ random gridding (minimum curvature) software. Color images of both Total Magnetic Intensity (TMI) (Fig.

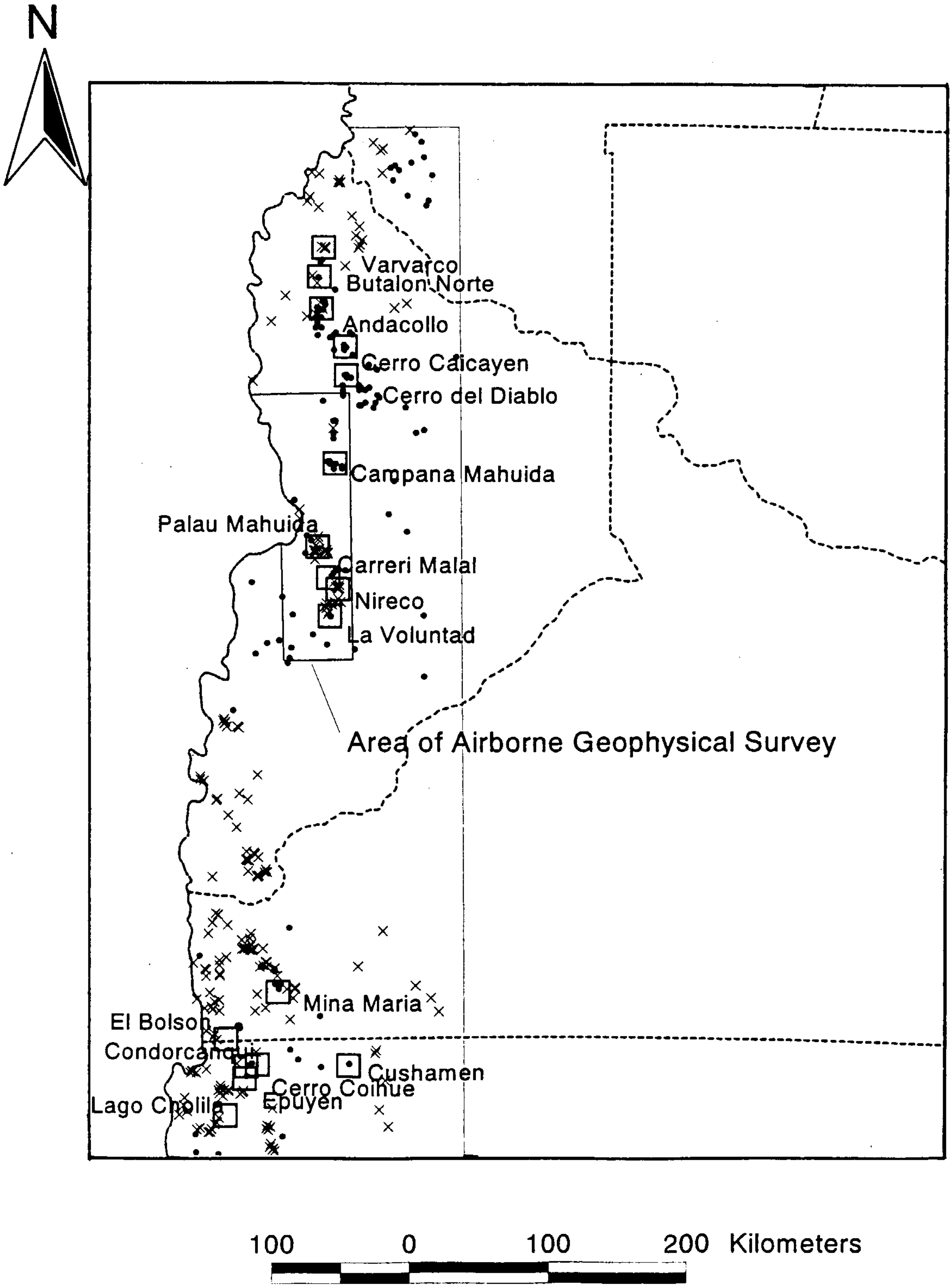


Fig. II-1-3-1 Location of the airborne geophysical survey

II-1-3-2) and Total Magnetic Intensity Reduced to the Pole (TMI-RTP) (Fig. II-1-3-3) were used for the interpretation.

b) Airborne radiometric data

Airborne radiometric data was acquired by the acquisition system consisting of a dual pack 256 channels gamma-ray spectrometer and detector. The raw data was processed to reduce raw counts/second into equivalent concentrations of potassium, thorium and uranium. For the interpretation a color image of potassium was used (Fig. II-1-3-4).

c) Digital terrain model

Digital terrain model (DTM) is computed using the GPS height information and radar altimeter data from the aircraft, providing resolution of approximately 2 to 5 m. The digital terrain data provides high resolution topographic information and is very effective in showing subtle hights and lows in the landscapes, as well as positions of faults. For the interpretation a color image of digital terrain model was used (Fig. II-1-3-5).

2) LANDSAT TM data

False color image (BGR = 14 7), ratio image (BGR = 3/1, 4/5, 5/7), and interpretation map of the LANDSAT TM data (Fig. II-1-3-6) were used for the interpretation.

3) Geological data

1:500,000 scale color geological map of the Neuquen Province published by SEGEMAR was used for the interpretation.

1-3-2 Interpretation result

1) Regional geology and mineral deposits

In the survey area of airborne geophysics there are formations from the Proterozoic to Quaternary. The following descriptions are cited from the report of Phase I survey by JMEC (JICA/MMAJ, 2000).

The Proterozoic exposes in a small scale to the south of Paso de Pino Hachado of the Neuquen province. Forming the basement of the survey area, these comprise low- and high-grade metamorphic rocks such as phyllite, schist and gneiss, and intruded by granite to granodiorite. The result of a Rb-Sr radiometric dating of the sample taken near the Huechulafquen Lake revealed 714±10 Ma (Parica, 1986).

The Permian to Triassic extends to the west of Zapala. It consists of granitoids intruding into the early Permian and the volcanics of the Upper Permian to Triassic closely associated

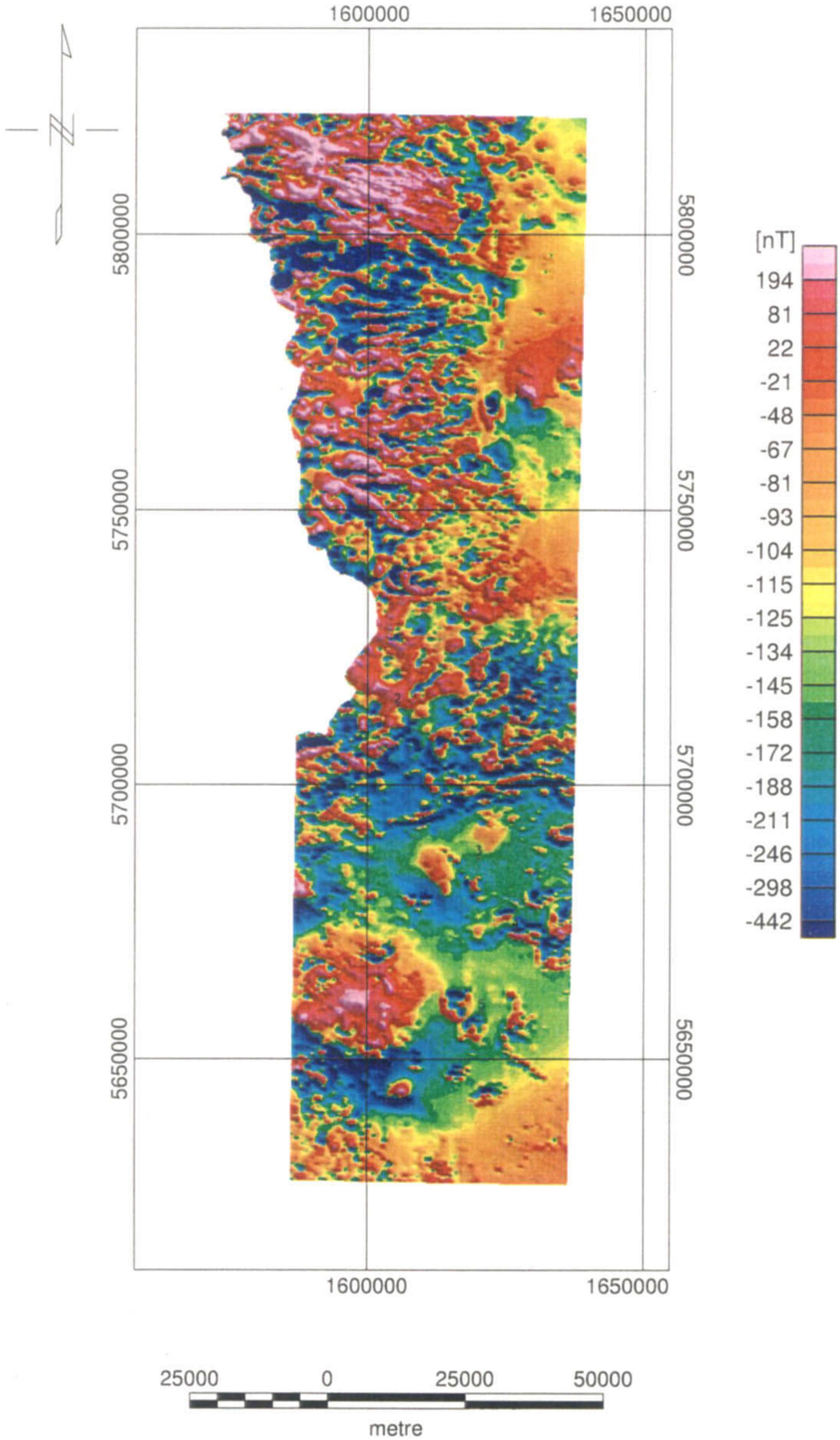


Fig. II-1-3-2 Total Magnetic Intensity image

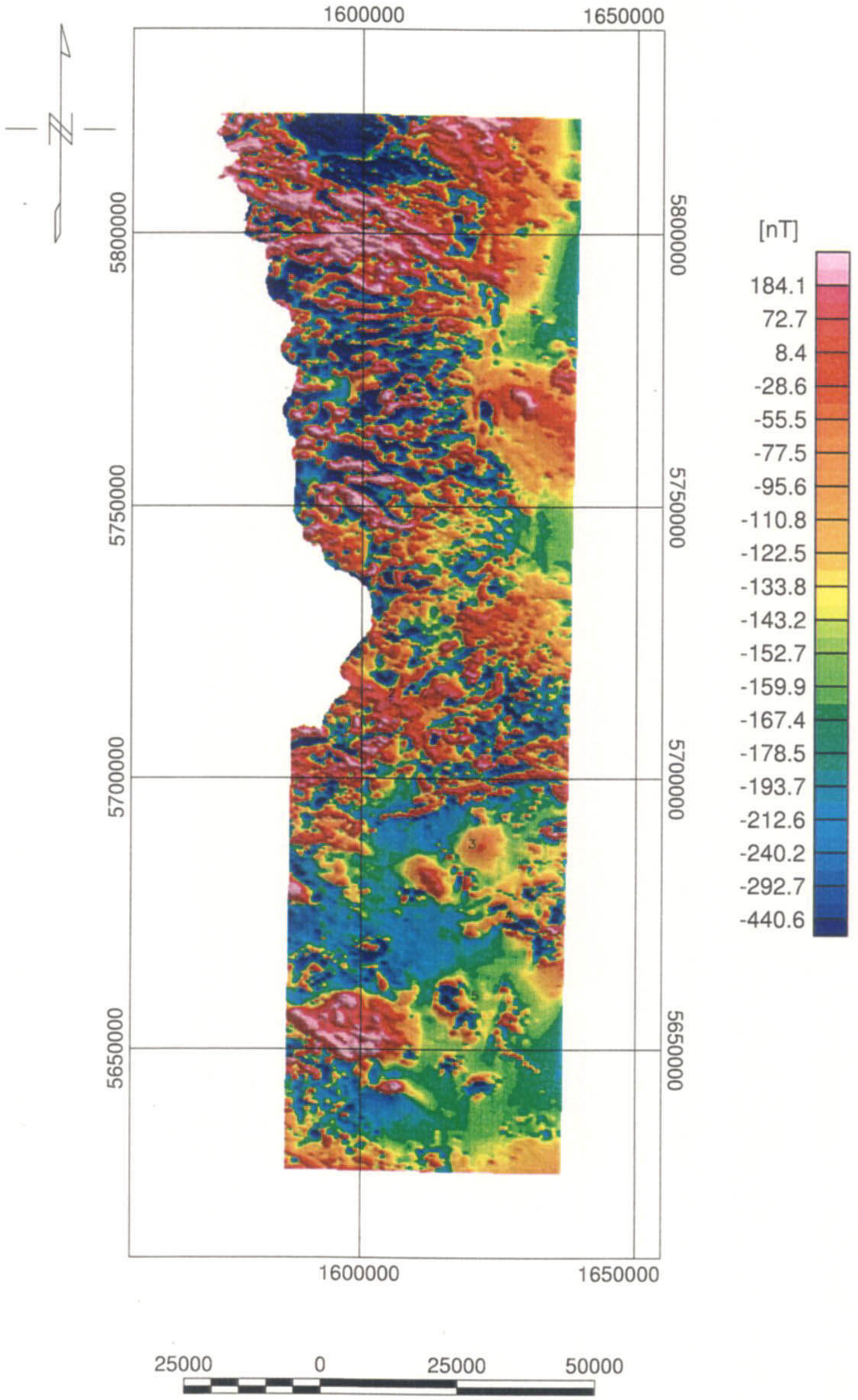


Fig. II-1-3-3 Total Magnetic Intensity (Reduced to the Pole) image

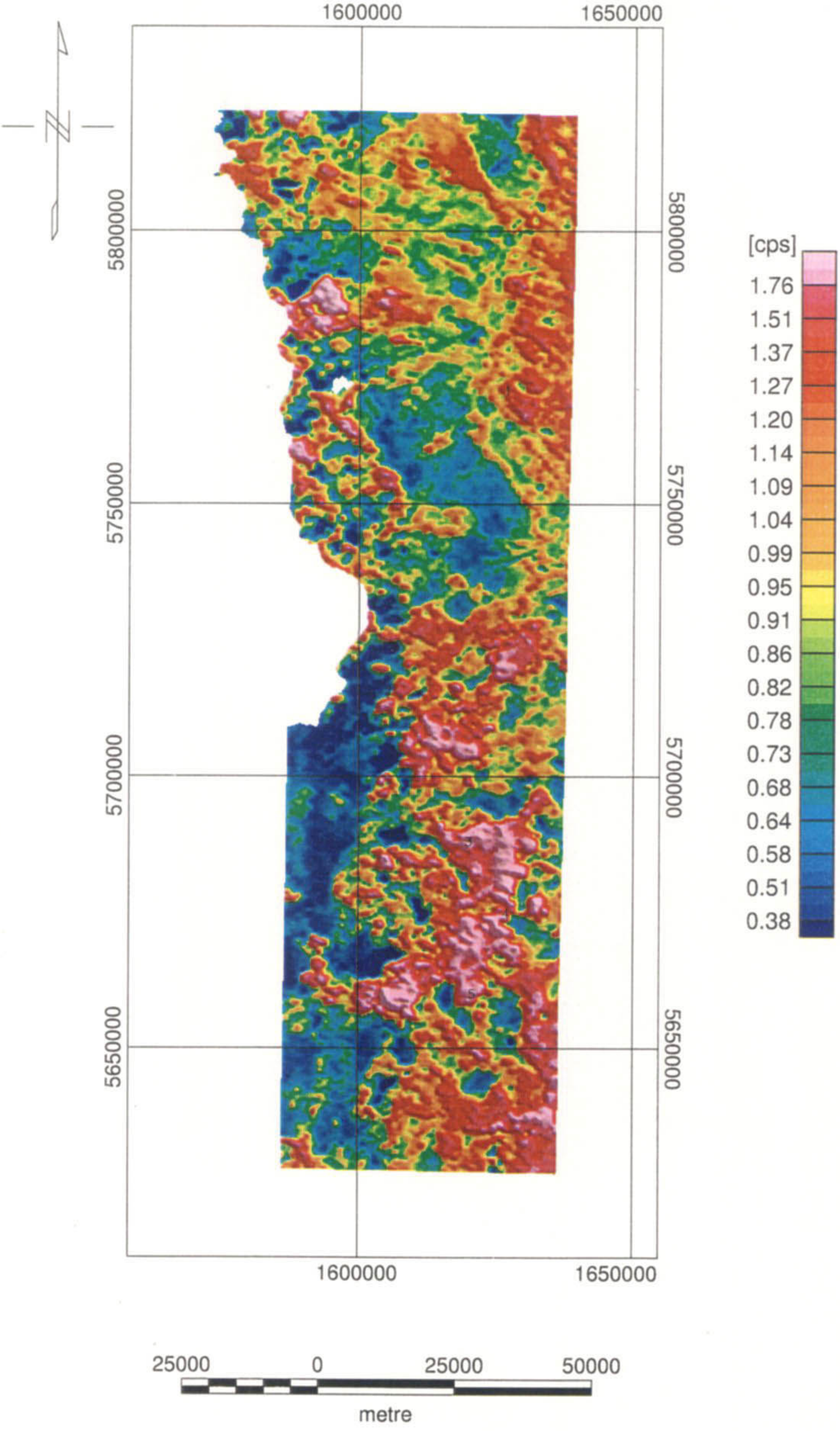


Fig. II-1-3-4 Radiometric image (K)

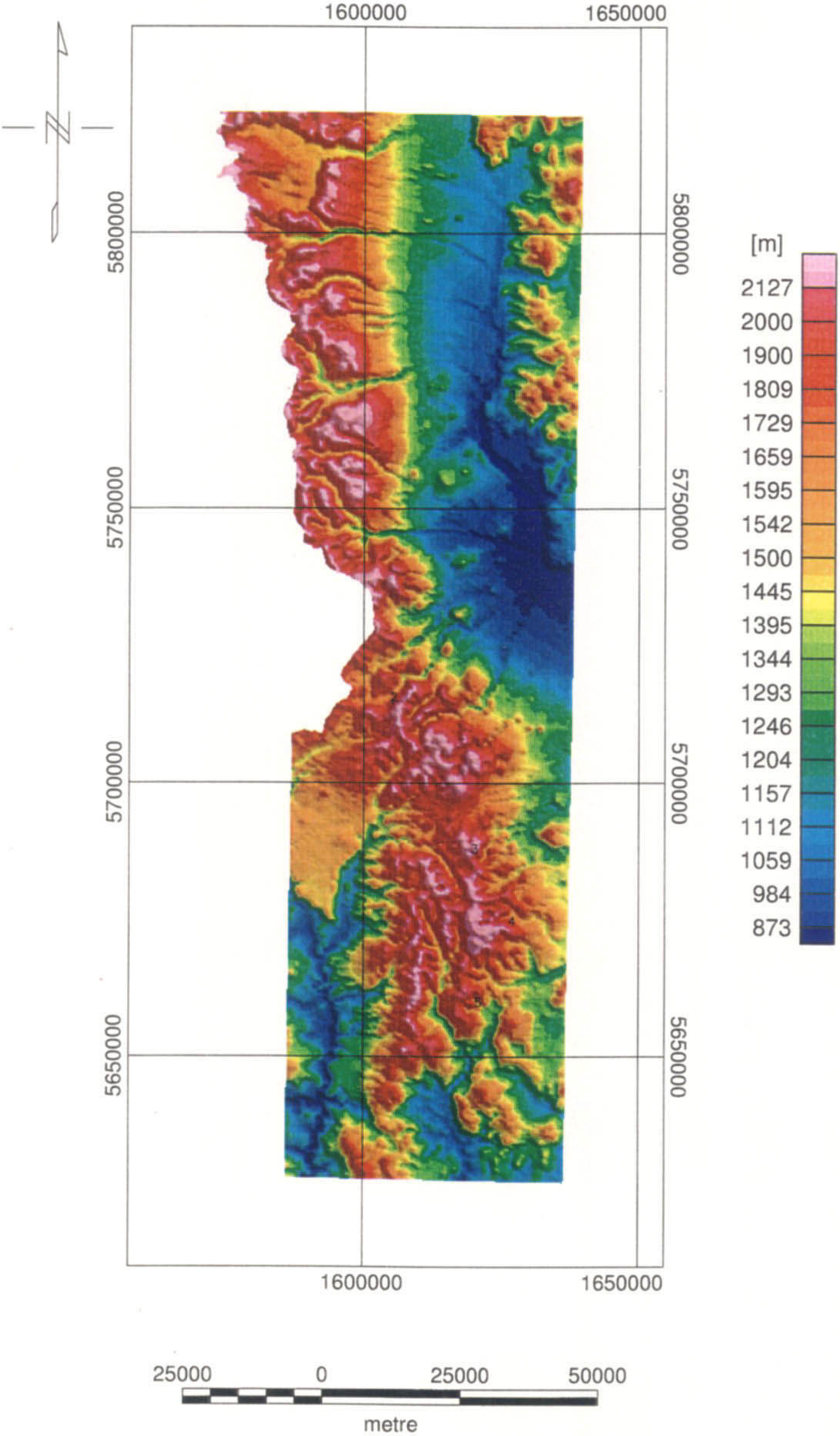


Fig. II-1-3-5 Digital Terrain Model image

with the granitoids. The volcanics are named the Choiyoi group (PTR), composing andesitic to rhyolitic lave and pyroclastic rocks. These granitoids and volcanics were probably generated by the plate subduction from the Pacific Ocean side.

The Jurassic occurs intermittently between Andacollo and Zapala and to the south of Zapala. These comprise sedimentary rocks, volcanic rocks and plutonic rocks. The sedimentary rocks comprise clastic rock, limestone and evaporite, and include basic volcanics among them. They are called the Cuyo group (J) in the Neuquen province.

The Cretaceous occurs from the Mendoza province to the southwest of Zapala. It comprises sedimentary, volcanic and granitic rocks. Sedimentary rocks are divided into the lower group belonging to the late Jurassic Tithonian age to early Cretaceous Albian age, and the upper group belonging to the Late Cretaceous Cenomanian to Campanian ages. In the Neuquen province, the lower group is further divided into the Mendoza group (JK) and the Rayoso group (Ki) in ascending order. The average thickness is about 4,500 m. The upper group is named the Neuquen group (Ksc), which comprises sandstones, shale and a small amount of continental conglomerates. The thickness of the group reaches 1,600 m.

The Paleogene is distributed in the northwest of the Neuquen province. It comprises volcanic rocks and granitoids. The volcanic rocks are named the Serie Andesitica in the northwest. The Serie Andesitica mainly comprises andesite lavas and the pyroclastic rocks. The granitic rocks of the Paleogene occurs in the form of small bodies in Andacollo and Cerro Caicayen in the northwest of the Neuquen province.

The Neogene is extensively distributed in the northwest of the Neuquen province. It consists of volcanic, sedimentary and granitic rocks. Volcanic rocks are the Cajon Negro formation distributed from the northwest end of the Neuquen province to the mountains in the west of Zapala, and the Campos Basalticos de Zapala distributed around Zapala.
The Cajon Negro formation erupted around 2 Ma. It mainly coomprises andesitic to basaltic lavas and agglomerates and accompanies a small amount of acidic lavas and ignimbrites. The volcanic activity of the Campos Basalticos de Zapala continued to the Pleistocene, and around the Lago Laguna Blanca in the southwest of Zapala, it continued to the Holocene. It is mainly composed of basaltic lavas and accompanied by pyroxene andesite and dacite.

The Quaternary mainly comprises the glacial sediments of the Pleistocene and the alluvium and colluvium of the Holocene. Activity of basaltic rocks which started in the Neogene continued to the Quaternary.

There have been several events of generating ore and mineral deposits in the area of the airborne geophysics, and it includes 5 districts of the ground truth of Phase I survey.

a) Campana Mahuida district

Campana Mahuida district is located about 100 km to the north-northwest of Zapala

City. In this district there are Campana Mahuida porphyry Cu deposits and polymetallic vein deposits of Grupo Cacque, Lastenia, Amelia, Belen, Teres, Agsutina y Otras, Grupo Huayelon and Candelaria. The latter deposits occur in such a way as to surround the former deposits.

This district is situated in the Neuquen back-arc basin consisting of the Jurassic shallow sea sedimentary rock. It is intruded by diorite, granodiorite, tonalite and andesite porphyry. As to andesite porphyry related to mineralization, 74.2 ± 1.4 Ma was reported by K-Ar radiometric dating for secondary biotite (Sillitoe, 1976).

Campana Mahuida deposit is located about 5 km south-southwest of Cerro Tres Puntos. It is hosted in the sedimentary rock and phyllic alteration zone of 2 km in diameter and surrounding prophylitic alteration of 10 km in diameter are observed. According to one of the drill cores oxidized leaching zone below the surface to ca. 50 m depth, secondary enrichment zone of chalcocite from 50 to 58 m depth, and primary sulfides zone of pyrite and chalcopyrite from 58 m to 84 m depth are observed in the sedimentary rock which overlies the andesite porphyry.

Several galena-barite veins are located about 5 km west of Campana Mahuida deposit. They are hosted in the sedimentary rock and hydrothermal alteration is not recognized.

b) Palau Mahuida district

Paul Mahuida district is located about 75 km to the NWW of Zapala City. The basement of this district is Proterozoic metamorphic rocks, Permian granitic rocks and Permian to Triassic volcanic rocks of the Choiyoi group. Neogene Tertiary andesite unconformably overlies them. Arroyo Manzano deposit of copper and zinc dissemination is known in Permian granitic rocks in the northwestern part of this district.

c) Carreri Malal district

Carreri Malal district is located about 50 km to the west of Zapala City. Geology consists of Chachil plutonic complex and volcanic rocks of the Choiyoi group of Permian to Triassic, Cuyo group of Jurassic sedimentary rocks and Cajon Negro formation of Neogene andesitic rocks.

Carreri Malal vein deposits are hosted along the contact zone between granitic batholith of Chachil plutonic complex and Choiyoi group of Triassic. The veins strike NW-SE and dip vertical. Silicified breccia dykes of 10 cm to 1.5 m width intruded into granite in three places, and it has relation with the mineralization of lead, zinc, copper and silver. Alteration of granite is weak. Chloritization of mafic minerals and argillization of plagioclase were only confirmed.

d) Nireco district

Nireco district is located about 47 km to the west-southwest of Zapala City. In the western side, there is distribution of Permian granite and Permian to Triassic volcanic rocks of the Choiyoi group. In the eastern side, Cuyo group of Jurassic sedimentary rocks occurs. They are unconformably overlain by Campos Basalticos de Zapala of Pliocene to Pleistocene basalt that forms lava plateaus.

Though no ore and mineral deposits have been recognized in this district, there are many alteration zones identified by the Landsat TM image analysis.

e) La Voluntad district

La Voluntad district is located about 60 km to the southwest of Zapala City and 25 km to the south of Carreri Malal district. Therefore geology is similar to that of Carreri Malal district. The host rock of La Voluntad deposit is granodiorite and tonalite, etc. Porphyritic granodiorite was intruded by granular granodiorite, porphyritic tonalite, microdiorite and rhyolite in old order.

Granodiorite and tonalite of La Voluntad plutonic complex are well affected by hydrothermal alteration, and also surrounding rocks are weakly altered.

2) Basis for the interpretation

a) Aeromagnetics

The aeromagnetic data maps the proportion of magnetic minerals (predominantly magnetite, ilmenite and pyrrhotite) in all rocks below the aircraft sensor. This can generally be considered to be the total amount of magnetite, as magnetite is the most common magnetic mineral. The amount of magnetite is dependent on primary and secondary processes.

Primary processes controlling the distribution of magnetite are:

- total iron (Fe) content in the rock (i.e. bulk chemistry of the magma)
- temperature and oxygen fugacity of the cooling environment. Cooling under the abundant oxygen environment allows magnetite to crystallize from titaniferous phases, thus will produce more magnetite and hence the rock will acquire a higher magnetic susceptibility.

Volcanics will have different magnetic susceptibilities due to the variations in chemistry of the magma and differences in geomorphological environments that can influence the rate of cooling. Hence rocks from different episodes of volcanic activity that appear to be lithologically similar may have variations in their magmatic source and cooling conditions that would result in the rocks having a different magnetic signature.

Secondary processes influencing magnetic susceptibility of rocks include metamorphism, metasomatism/alteration and deformation. All these processes can either increase or decrease the amount of magnetite.

Faults and fractures can be interpreted from the aeromagnetic data either through linear magnetic features, or by the truncation or termination of magnetic flows. Intrusive bodies and zones of alteration may be also a distinctive magnetic signature. Subcircular magnetic highs or lows may also reflect intrusive material or alteration along pre-existing faults, fractures or other zones of weakness.

b) Airborne radiometrics

The airborne radiometric data records the natural radiometric decay of the exposed rocks as well as in-situ and transported weathering products. The data are presented as total count data, as well as individual potassium, thorium and uranium channels. Zones of hydrothermal alteration (for example, potassic alteration) are expected to have a radiometric response. Drainage systems in the area are also evident in the radiometric data due to the buildup of transported soils and clays.

c) Digital terrain model

The digital terrain data provides topographic information and is very effective in showing subtle highs and lows in the landscapes, as well as positions of faults. The digital terrain model is computed using the GPS height information and radar altimeter data from the aircraft, providing resolution of approximately 2 to 5 m.

3) Overview of the interpretation

The interpretation map (Figure II-1-3-7) is largely interpretation map of the aeromagnetic data. It was often difficult to directly correlate the geological mapping with the magnetic data. Initially the following features were extracted from the aeromagnetic data:

- Linear magnetic units which often correlate to discrete volcanic flows that have either been mapped. Suggested flow directions are given.
- Discrete subcircular magnetic highs and lows believed to reflect intrusive plugs.
- Broader areas of increased magnetic response may be caused from an intrusive body at depth.
- Broader areas of demagnetization which may represent extensive areas of magnetite-destruction alteration.
- Faults and fractures: These are recognized either by a linear magnetic trend, or by

termination or truncation of magnetic units. More regional linear features which are evident in the total field displays of the aeromagnetic data were often difficult to position accurately from the detailed aeromagnetic and Landsat data. These probably reflect extensive underlying faults that have a regional control on volcanic activity and deformation.

Although in some areas the magnetic data correlate well with the published geological map, it is difficult to get an overall consistency. In many areas the information obtained from the aeromagnetic data considerably differs from the radiometric and Landsat TM data and the mapped geology, as these datasets depict the surface geology while the aeromagnetic data is mapping any magnetic body below the aircraft.

The surveyed area is roughly divided into the following three zones (Zone I, Zone II and Zone III) from the aeromagnetic data:

Zone I: central to western part of the northern half of the area, is mainly dominated by E-W elongated magnetic highs and lows which represents the Neogene to Quaternary volcanic lavas.

Zone II: eastern part of the northern half of the area, is characterized by intermediate quiet magnetic signature which represents the Jurassic to Cretaceous sedimentary rocks. Extensive magnetic highs represent granitic batholith, and relatively small circular features of magnetic highs and lows within this zone represent intrusive plugs into the sedimentary rocks.

Zone III: the southern part of the area, is dominated by low and flat magnetic signatures with isolated large bodies of magnetic highs. Magnetic signatures of this zone do not well correlate with the geological map and are difficult to interpret.

4) Interpretation for structure, lithology, alteration and mineralization

a) Structures of the survey area

Magnetic structure of N-S trend is observed between Zone I and Zone II. It is represented by not only one linear trend but also some parallel trends. One of them is a boundary between busy looking magnetic signature and quiet magnetic signature. Others are aligned small magnetic highs and lows, that is intrusive plugs.
There is also E-W or WWS-EEN magnetic boundary between Zone I and Zone III. This is a boundary between high to low magnetic signature and quiet magnetic signature. The structure within each zone is reviewed as follows:

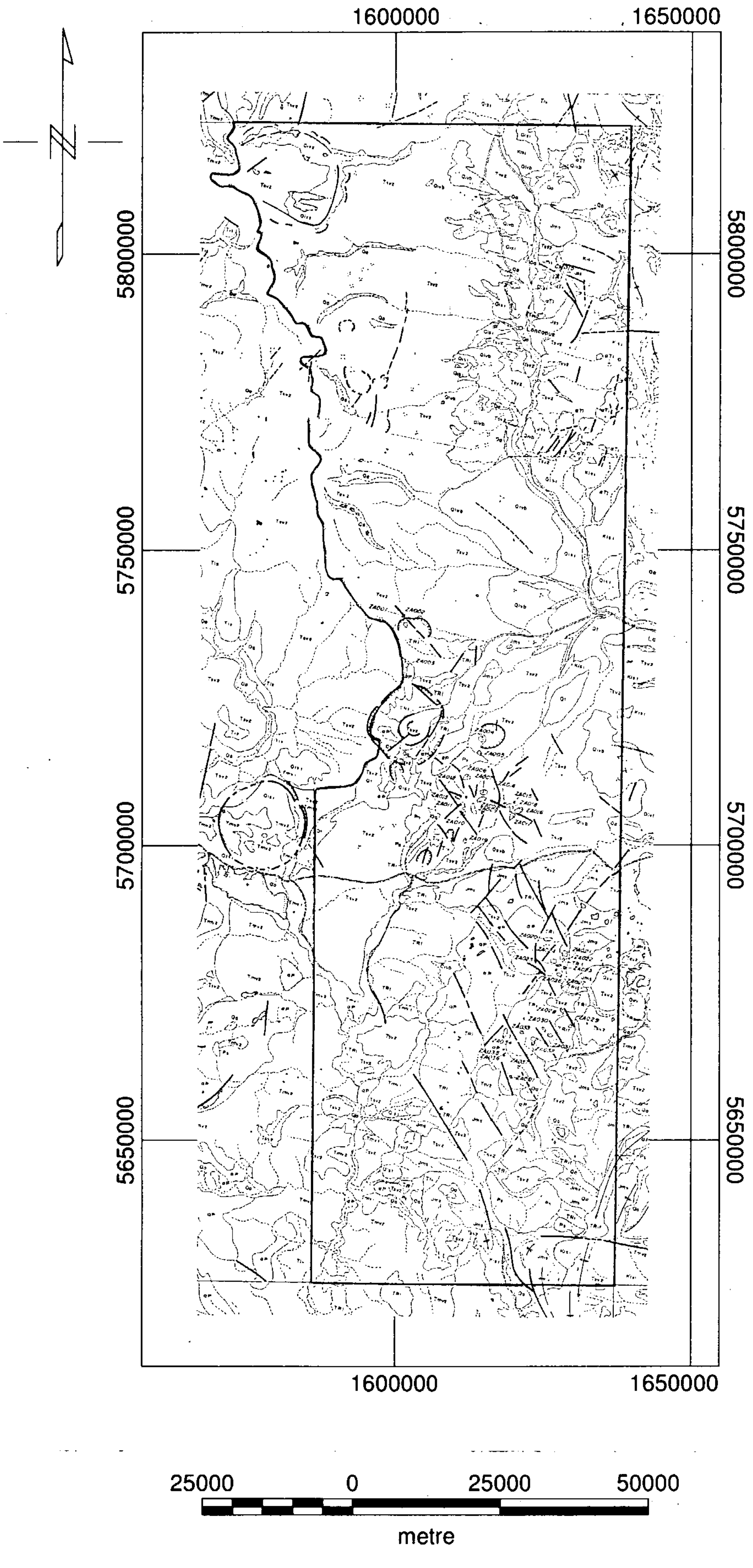


Fig. II-1-3-6 Interpretation map of the LANDSAT TM data analysis

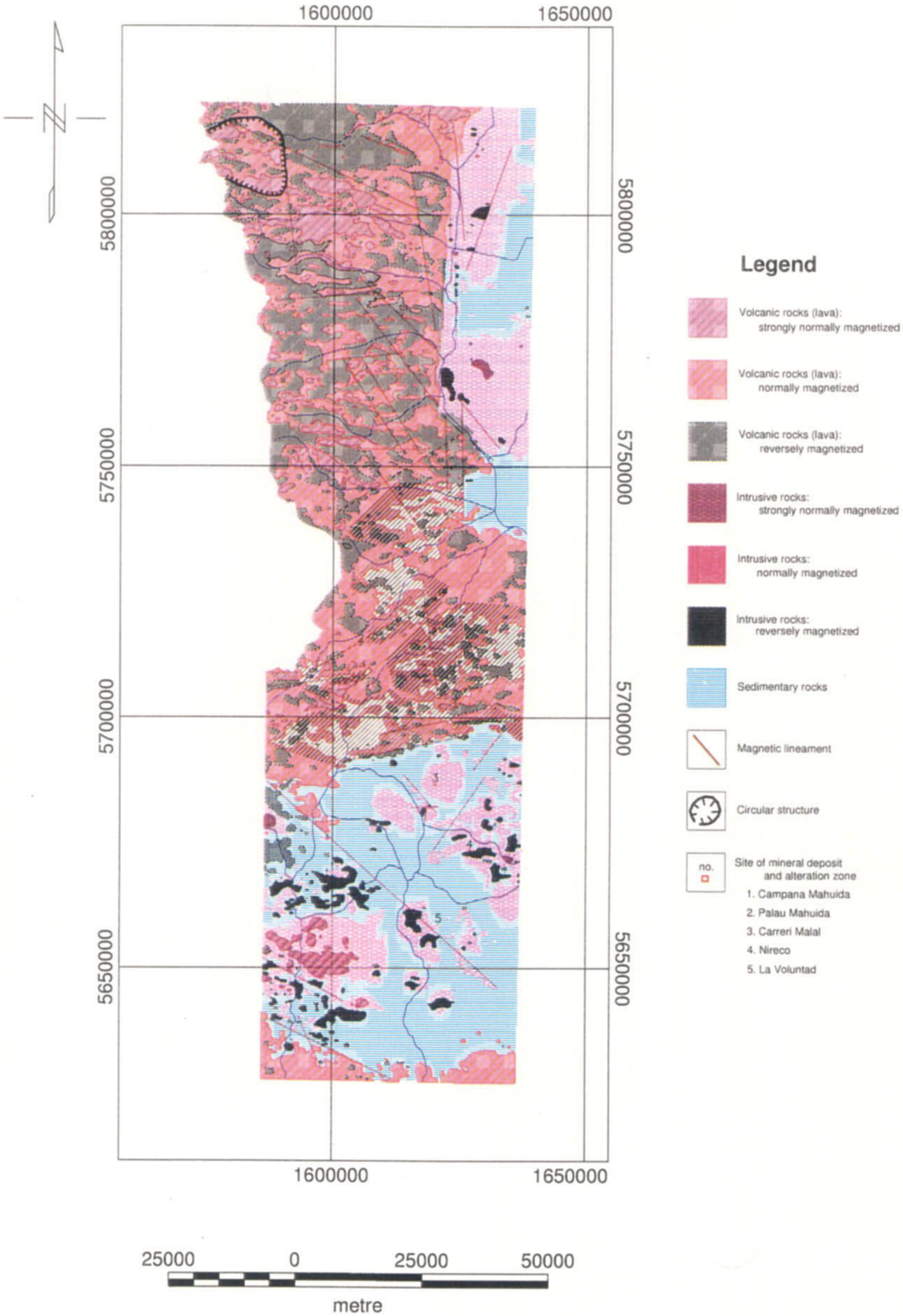


Fig. II-1-3-7 Interpretation Map of the airborne geophysics

Zone I: NWW-SEE to E-W trend of magnetic signature, which is enhanced by the contrast of extreme magnetic highs and lows, is prominent especially in the northern part. This trend is considered to represent the direction of volcanic lava flow. Also NW-SE trend is observed which cuts the E-W trend in the northern part.

Zone II: There is also N-S corridors of relatively small magnetic circular features just east of the boundary between Zone I and Zone II. In the north, linear contour of magnetics with N-S trend suggests that a large magnetic body beneath the sedimentary rock is getting shallower toward west. In the south, a large magnetic body beneath the sedimentary rock has NW-SE trends, some of which is extension of the trend from Zone I.

Zone III: There are several circular magnetic bodies in this zone. Some of the bodies and their boundaries have NW-SE or NE-SW trend.

b) Lithology of the survey area

From magnetic and radiometric data we can distinguish lithology of the survey area as follows:

Zone I: Coexistence of NWW-SEE or E-W elongated extreme magnetic highs and lows are identified to be volcanic lava flows that are normally and reversely magnetized respectively. DTM (Digital Terrain Model) data, in which main rivers flow eastward and others flow toward south-east, is concordant with the trend of the volcanic flow. High potassium count in this zone accounts for acidic volcanics like dacite or rhyollite which is dominant in the south, and low potassium count shows occurrence of basalt or andesite

Zone II: Large magnetic quiet (flat) areas with intermediate value represents sedimentary rocks. Large magnetic highs are observed in two areas (northern end and center). These are interpreted to be intrusions. Presence of only magnetic highs implies that not remanent but induced magnetism is predominant, and that plutonic batholith may be situated beneath the sedimentary rock. One exception is a concentric magnetic low and high to the west of Campana Mahuida, which is reversely magnetized inside and normally magnetized outside. Along the boundary with Zone I, there are aligned small magnetic plugs which are also thought to be intrusions. This N-S magnetic corridor continues up to 50 km, and may be related to the local tectonics.

Zone III: There is a considerable difference between interpreted geology from the magnetic data and existing geological map in this zone. Large magnetic quiet (flat) areas with intermediate value indicate the dominance of sedimentary rocks. Both long wavelength magnetic highs and circular features of magnetic high/low plugs are also observed. Long wavelength magnetic highs suggests the plutonic intrusions. Circular features of magnetic high/low plugs suggest multiple intrusions of volcanics to the shallow level.

c) Alteration and mineralization of the survey area

Relationship between magnetic signatures and mineralization or alteration zones of in 5 districts of the ground truth is summarized as follows:

(1) Campana Mahuida district

Campana Mahuida deposit is located on the southern shoulder of extremely high magnetic anomaly which is eminent from the surrounding magnetic highs. It is considered to be intrusive rocks whose longer diameter is about 5 km. Though phillic alteration in ca. 2 km diameter and propyritic alteration in ca. 10 km diameter were observed on the surface, a flat magnetic signature which characterizes alteration zone has not been extracted from this dataset.

(2) Palau Mahuida district

Arroyo Manzano mineral occurrence is located on the top of small body of the magnetic high. From the surrounding magnetic features it is interpreted to be hosted in the volcanic lava. This corresponds to the geological observation of wide distribution of Neogene andesite. It is difficult to get the relationship between the mineralization and magnetic signature from this dataset.

(3) Carreri Malal district

Carreri Malal deposit is situated on the shoulder of magnetic body in 10 km diameter of intermediate value but definite higher than the surroundings. This weakly magnetic body is interpreted to be granitic intrusion and may be related to the mineralization.

(4) Nireco district

Nireco district is located at the sharp boundary between magnetic high and low. This magnetic signature represents the intrusive rock. Hydrothermal activity may be related to the intrusion.

(5) La Voluntad district

La Voluntad district is located in an outer rim of couples of magnetic high and low. This magnetic signature is considered to be the volcanic intrusive and may be related to the mineralization.

5) Comparison with the LANDSAT TM satellite image

During Phase I of this project (Japanese Fiscal 1999), photo-geological interpretation of LANDSAT TM image was conducted in order to comprehensively understand geology, ore deposits and mineral occurrences of the survey area (JICA/MMAJ, 2000). The studied area is elongated in N-S direction along the border with Chile from Lat. 35° S to Lat. 45° S covering 250,000 km^2. 1:250,000 scale false color synthetic image (BGR = 145) and ratio image (BGR = 3/1, 4/5, 5/7) of 13 scenes were produced and undertaken for the study. Interpretation was executed on geological unit classification, extraction of alteration zone, extraction of lineament, folding structures and circular features with the existing geological data. Two scenes, that is the Chos Malal area and the Zapala area of LANDSAT TM image, cover the area of airborne geophysics. The following description is a result of comparing the interpretation of remote sensing data with that of airborne geophysical data.

a) Lineament

Zone I: From the LANDSAT TM image a concentration of lineaments in NE-SW and NW-SE trends is interpreted in the southern part of Zone I. Though there are trends of NNE-SSW and NEE-SWW in the magnetic data, no correlation with lineaments of remote sensing data is observed.

Zone II: From the LANDSAT TM image some small lineaments (NW-SE or NE-SW) are interpreted in an area where Tertiary igneous rocks are intruded into the upper Jurassic to lower Cretaceous sedimentary rock. In the magnetic data we cannot observe the trend of lineaments interpreted from the remote sensing data.

Zone III: In a relatively large portion of the LANDSAT TM image there are several systematic lineaments trending toward NW-SE and intermediate to long lineaments (NE-SW trend) cutting them. In the magnetic data we can observe magnetic trends toward NE-SW and NW-SE, but they are a few and do not have systematic feature.

b) Circular structure

Zone I: Some circular structures are interpreted from the LANDSAT TM image especially in areas where Tertiary and Triassic volcanics occur. One of them located in the northwestern corner of the area is also observed in the magnetic data. Others are difficult to extract from the magnetic data, because in the TMI-RTP map (Figure II-1-3-3) a lot of circular features are observed over areas of volcanic rocks.

Zone II: No circular structure is interpreted from the LANDSAT TM image.

Zone III: No circular structure is interpreted from the LANDSAT TM image.

c) Folding structure

No folding structure is interpreted from the LANDSAT TM image.

d) Alteration zone

In Zone I, II and III several alteration zones are extracted from the LANDSAT TM image. Because these sizes are around 1 to 2 km in diameter, there is no corresponding signatures in both magnetic (TMI-RTP) and radiometric (K-count) data which were acquired with 1 km line-spacing.

1-3-3 Concluding comments

Airborne magnetic and radiometric data were acquired over an area of ca. 10,000 km^2 in the western part of the Neuquen Province with 1 km line-spacing oriented in north-south.

Interpreted geology of the area is divided into three zones. Zone I, northwestern part of the area, is dominated by the volcanic lava flow which is charcterized by E-W elongated magnetic highs and lows. Zone II, northeastern part of the area, is dominated by the sedimentary rock with quiet magnetic signature into which large batholith and small stocks of granitic rocks intruded. Zone III, in the southern part of the area, consists of sedimentary rocks, granitic rocks and volcanic intrusions. Magnetic lineaments and circular structures are extracted in each zone. Radiometric potassium data helps to distinguish occurrences of basic volcanics from acidic volcanics and to locate the sedimentary rock especially in Zone II.

5 districts of the ground truth of Phase I survey are located in the survey area. Ore and mineral deposits and alteration zones of 4 districts are located to above or close to the volcanic intrusion or granitic intrusion. Hydrothermal alteration zone itself is not detected by magnetic signature in every district. It may be due to the 1 km line- spacing of the survey specification. Radiometric potassium data does not detect the K-alteration anomaly mainly due to the survey specification.

Though some of the trend of lineaments which were interpreted from the LANDSAT TM image correspond to magnetic lineaments, most of them do not exactly coincide with magnetic lineaments. It is mainly due to difference in physical property which satellite image data and aeromagnetic data deal with. Differences in depth of penetration by both methods as well as in resolution (LANDSAT TM image: 30 m pixel, TMI image: 200 m grid) are also related to the discrepancy. One circular structure at the northwestern corner of the survey area is interpreted from both LANDSAT TM image and aeromagnetic data.

The recommendation for the further exploration of ore deposits is as follows:

(1) TMI-RTP map delineate the shape of intrusion which may be related to the mineralization. It will support to select sites for the ground truth.

(2) Airborne magnetic and radiometric data with tight flight spacing (200 m line-spacing) will delineate alteration zones as either magnetic or radiometric signature. Follow-up airborne geophysical survey is required.

1-4 Stream sediments geochemistry

1-4-1 Circumstances

Under the Plan Cordillerano Project executed in the 1960s, a regional survey was conducted in the area along the Andean cordillera for the mineral resources. At that time, taken samples of stream sediments were analyzed only for copper, lead and zinc. However, chemical analysis for gold, silver and molybdenum in addition to path-finder elements of arsenic, antimony and mercury were not executed. Moreover, accuracy of the chemical analysis then was not sufficient. Therefore, SEGEMAR kept the remaining samples to analyze for other elements again in the future. Among them, number of samples related to the survey area is about 9,000 which were taken in the Neuquen province. All of the remained samples had been treated as under 80 mesh. The weight of stored sample is about 20 to 30g per each, although some of them is about 3 to 5g per each. Besides that, the soil and rock samples taken in the Chubut province by previous project was being stored in SEGEMAR, and the chemical analysis for them was also executed in this survey.

Recently, with the acquisition and improvement of basic information on mineral resources by the World Bank and cooperation in geochemical analysis by the Canadian Government as momentum, re-examination of coverage of national land by geochemical exploration, which is basic information for evaluation of mineral resources, was started. It was then determined that the goverment would execute geochemical explorations and re-analyze samples in stock according to the plan. The areas to be covered by this survey include the areas covered by the above-mentioned plan. Chemical analysis of the remaining samples stored by SEGEMAR was requested to the Japanese side. In the regional survey of the Eastern Andes area by JICA/MMAJ in 1997 to 1998, chemical analysis was also executed through a similar request. Because the all remaining samples will be used for this analysis as a final occasion, in accordance with basic program of above-mentioned geochemical exploration plan, the chemical analysis was executed for 48 elements including precious metals and rare earth elements by the package of Canadian laboratory.

This survey will contribute greatly to the Argentine government, which is now promoting mining policies actively, and could be the basic data for mineral resource exploration being made by Japanese side. Therefore, the request for the chemical analysis was accepted.

However, some samples were impossible to analyze because of the weight shortage, and also same samples do not have the coordinate data. Therefore, number of final samples available for data analysis was total 9,060 for stream sediments samples taken in the Neuquen province and total 782 for soil and rock samples taken in the Chubut province.

1-4-2 Samples

The samples of stream sediments were taken in the Neuquen province as shown in Fig. II-1-4-1. The number of samples in the areas of topographical maps on scale of 1/250,000 is as follows.

Table II-1-4-1 Number of samples for Neuquen Province

1/250,000 map	Quantity of samples
LAS CUEVAS	524
BARRANCAS	911
ANDACOLLO	1629
CHOS MALAL	917
PASO PINO HACHADO	1387
ZAPALA	369
JUNIN DE LOS ANDES	2000
PICUN LEUFU	367
SAN MARTIN DE LOS ANDES	957
Unknown	181
Total	9242

The total number of samples, which is available for geochemical data, is 9,060 except the inadequate samples to analyze because of weight shortage and the samples without coordinate.

The soil and rock samples were taken in the Chubut province as shown in Fig. II-1-4-2. The number of samples in each district is as follows.

Table II-1-4-2 Number of samples for Chubut Province

District		Quantity of samples
Arroyo Luque and Cerro Gonzalo	(soil)	387
	(rock)	135
Arroyo El Rapido	(soil)	86
	(rock)	86
Arroyo de los Alevinos	(rock)	25
Katterfeld	(rock)	46
Arroyo Canogas	(rock)	17
Total		782

The coordinate of the sampling sites is unknown.

1-4-3 Chemical analysis methods

In responding to the request of the Argentine side, the INAA method (28 elements) and the ICP-AES method (20 elements) were applied for the chemical analysis, because quick and cheap analysis is available for base metals, precious metals and rare earth elements even if the weight of samples is small.

Moreover, in responding to the request of the Argentine side, the chemical analysis was executed in XRAL Laboratories, a Division of SGS Canada Inc. in Canada same as the case of the Eastern Andes project.

Table II-1-4-3 List of elements and detection limits
(upper : INAA Method, lower : ICP-AES Method)

Element	D.L.	Element	D.L.	Element	D.L.
As	0.5ppm	Au	2ppb	Ba	50ppm
Br	0.5ppm	Ce	3ppm	Co	1ppm
Cr	5ppm	Cs	1ppm	Eat	0.2ppm
Fe	0.01%	Hf	1ppm	Hg	1ppm
Ir	5ppb	La	0.05ppm	Lu	0.05ppm
Na	100ppm	Nd	5ppm	Rb	5ppm
Sb	0.1ppm	Sc	0.1ppm	Se	3ppm
Sm	0.1ppm	Ta	0.5ppm	Tb	0.5ppm
Th	0.2ppm	U	0.5ppm	W	1ppm
Yb	0.2ppm				
Ag	0.2ppm	Al	0.01%	Be	1ppm
Bi	5ppm	Ca	0.01%	Cd	0.5ppm
Cu	0.5ppm	K	0.01%	Mg	0.01%
Mn	1ppm	Mo	1ppm	Ni	1ppm
P	0.001%	Pb	2ppm	Sn	10ppm
Sr	0.5ppm	Ti	0.01%	V	2ppm
Y	0.5ppm	Zn	0.5ppm		

The threshold values were determined based on the accumulation frequency distribution of the logarithm probability (Lepeltier, 1969; Sinclair, 1974, 1976). However, some arrangements were done according to the deviation of accumulation frequency and easiness to see the graphs.

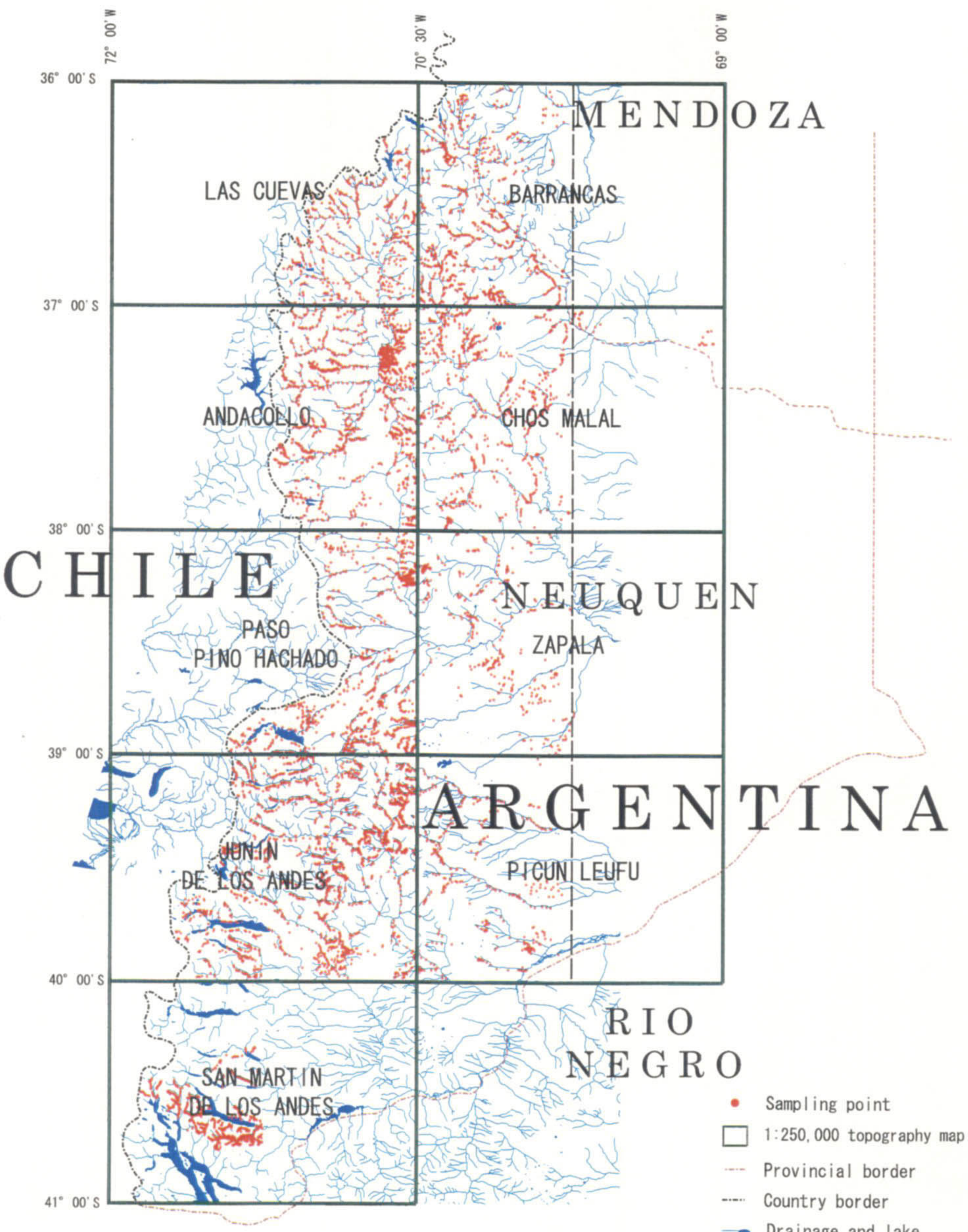
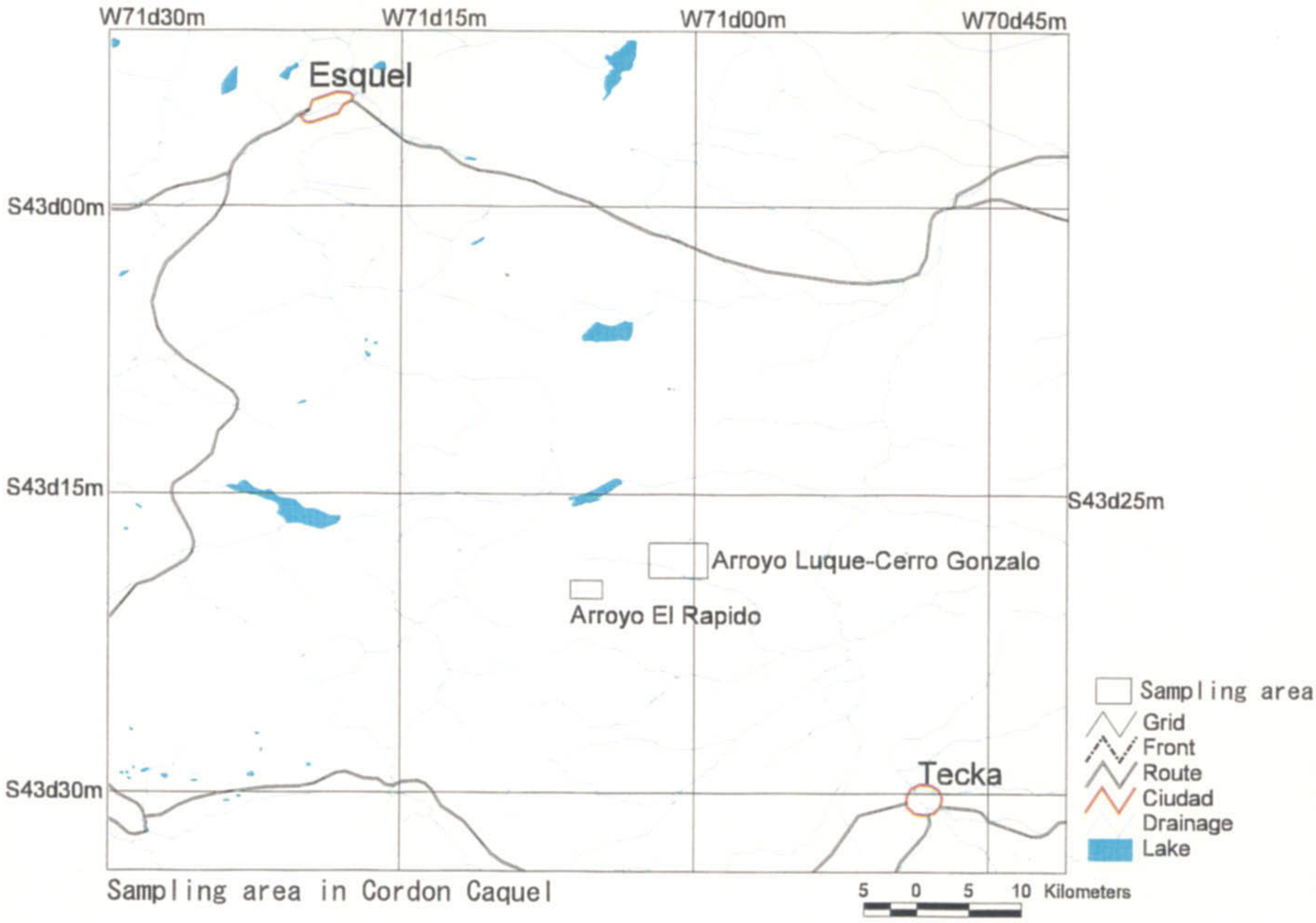
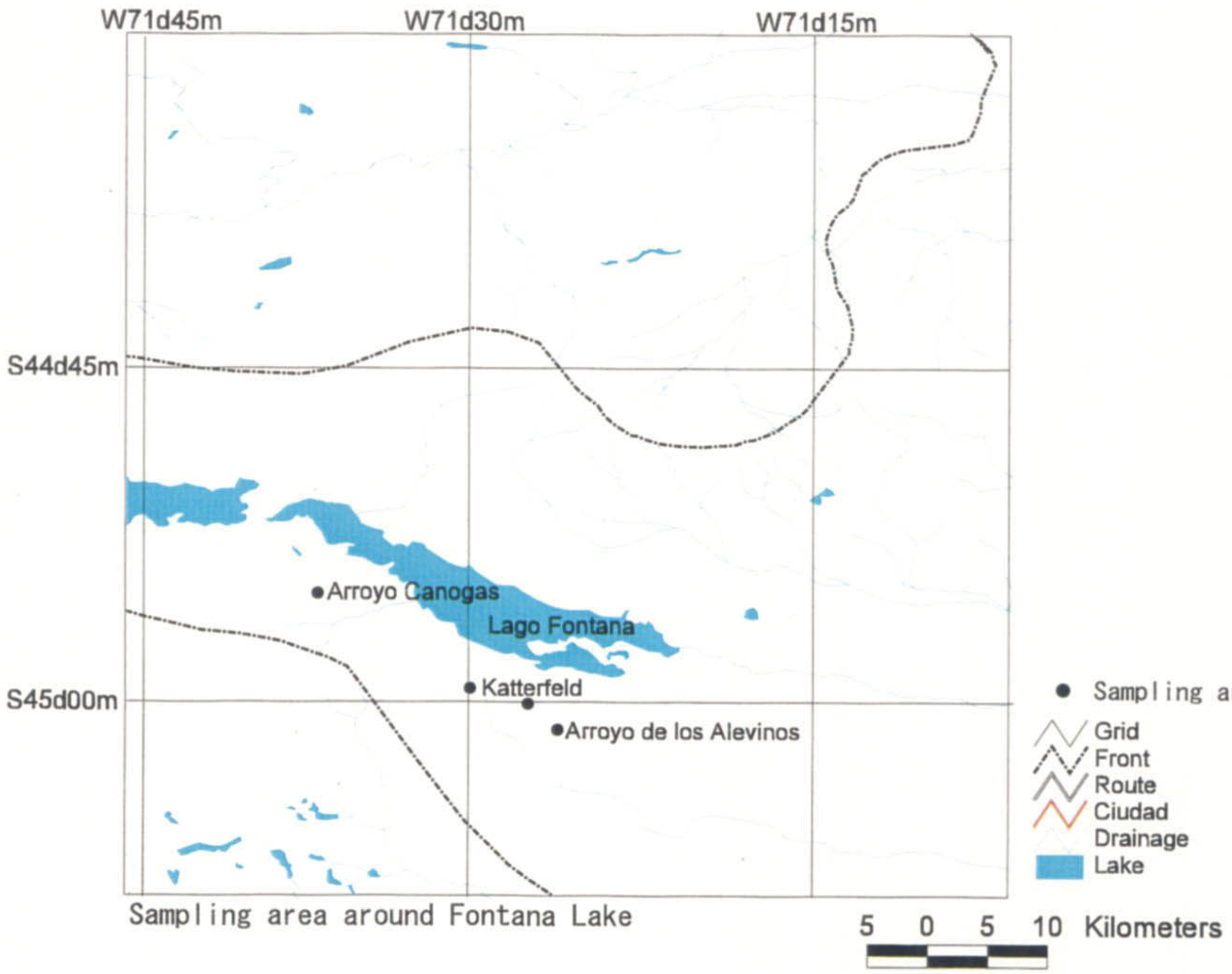


Fig. II-1-4-1 Sampling area of stream sediments for Plan Cordillerano Project in Neuquen Province, Argentine Republic



Sampling area in Cordon Caquel



Sampling area around Fontana Lake

Fig. II-1-4-2 Sampling areas of soil and rocks in Chubut Province, Argentine Republic

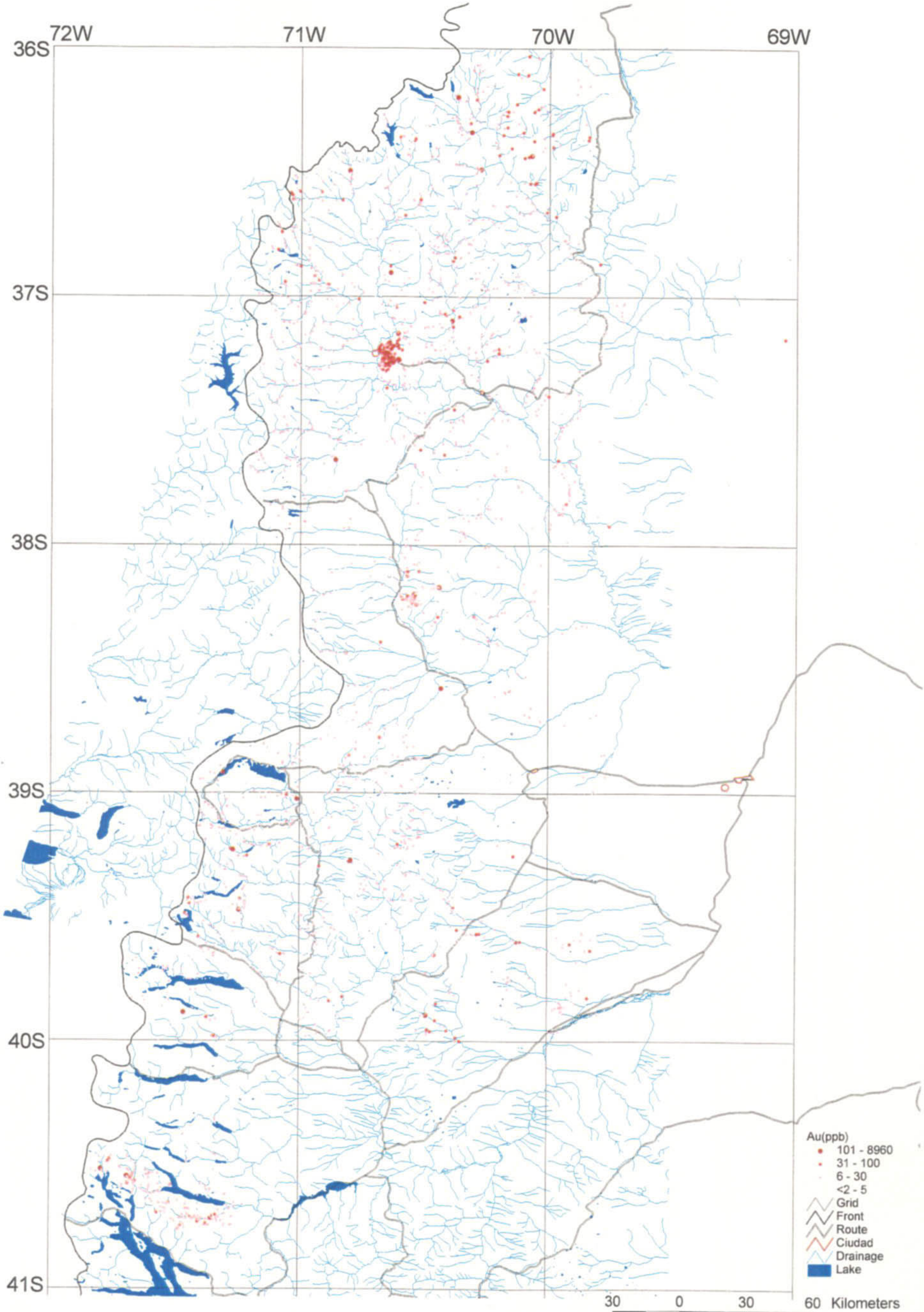


Fig. II-1-4-3 Distribution of Au(ppb) content in stream sediments, Plan Cordillerano Project

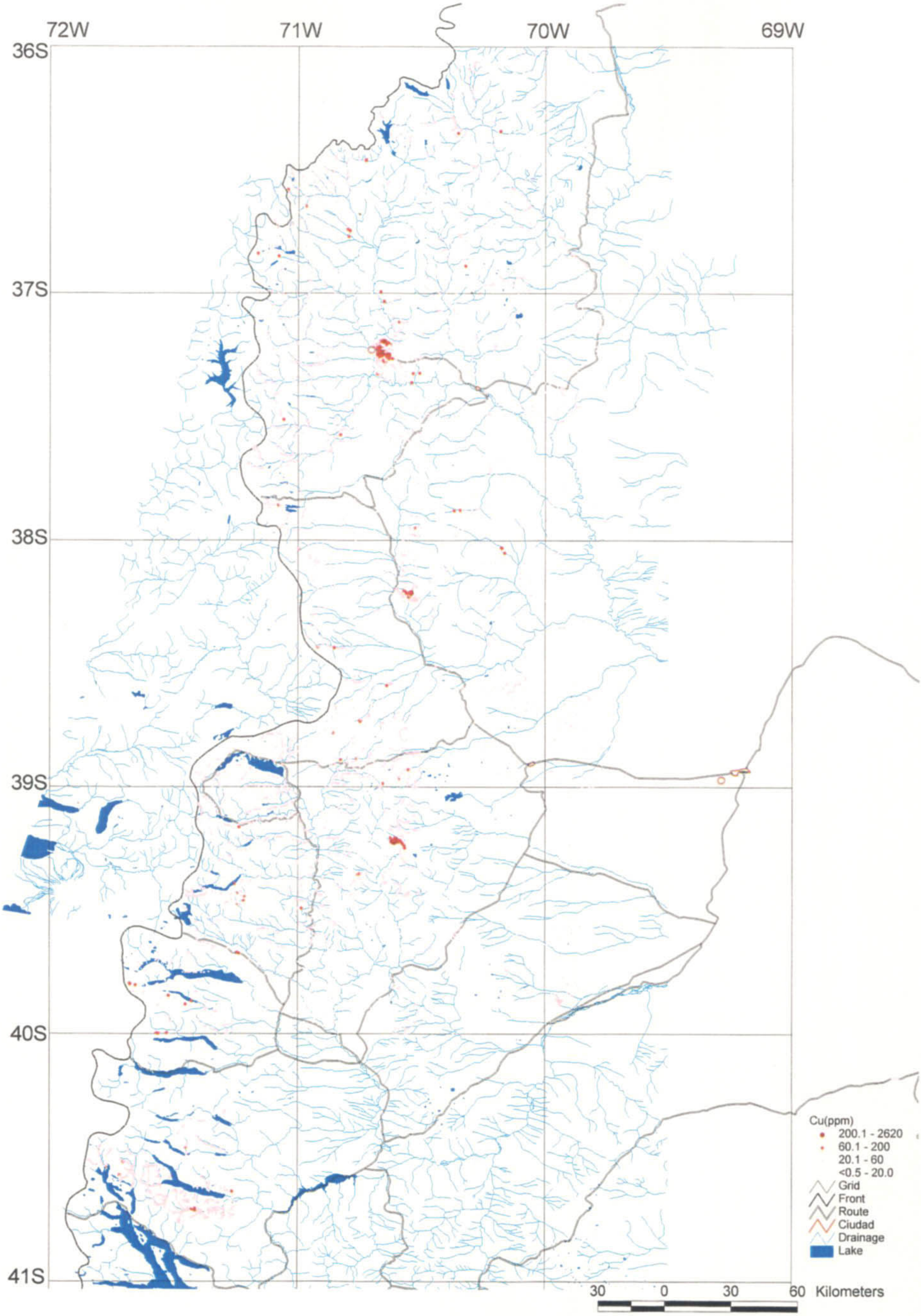


Fig. II-1-4-4 Distribution of Cu(ppm) content in stream sediments, Plan Cordillerano Project

1-4-4 Interpretation

The chemical analysis results are stored in CD-ROM as the Arc View files together with information on coordinates. As to the results for the Neuquen province, outputs for gold and copper contents are shown in Fig. II-1-4-3 and Fig. II-1-4-4. In both figures, concentrated anomalies of gold and copper around lat. 37° 15' S and 38° 15' S are corresponding to Andacollo and Campana Mahuida deposits, respectively. While concentrated anomalies of copper around 39° 15' in Fig. II-1-4-4 is corresponding to the LaVoluntad deposit. Except these mineral occurrences, scattered gold anomalies are recognized in the area from north of the Andacollo deposit to around Laguna Varvarco Campos in north. Moreover, gold anomalies of 102 to 133ppb Au are also recognized in the area from upstream of Rio Barrancas in the east of Laguna Varvarco Campos to Mendoza province. In this area, although detailed exploration has not ever conducted, many alteration zones were extracted in this survey, therefore new exploration activities are expected. Based on the distributions of andesite and andesitic pyroclastic rocks of Paleogene, and andsite, rhyolitic tuff and ignimbrite of Miocene to Pliocene in the area, the gold mineralization like the Andacollo deposit is expected because the gold mineralization of Andacollo is thought to be formed by igneous activities of Tertiary.

Concerning the soil and rock samples of the Chubut province, contents distribution maps were not made because of the lack of coordinate information. However, some chemical analysis results of high content gold and silver were obtained.

1,410ppb Au and 739ppb Au were obtained for rock samples of Arroyo el Rapido. 542ppb Au was obtained for soil samples of Arroyo Luque - Cerro Gonzalo. 86.8ppm Ag was obtained for rock sample of the Arroyo de los Alevinos. In Katterfeld, besides maximum 1,210ppb Au, 11 samples revealed >100ppb Au and 6 samples revealed >100ppm Ag for rock samples with arsenic anomalies. In Arroyo Canogas, besides maximum 880ppb Au, 7 samples revealed >100ppb Au for rock samples with arsenic anomalies. These soil and rock samples are thought to be taken near the known mineral occurrences, however they don't have the accurate coordinate information except these were taken in 100m grid intervals. Therefore, these results only have the nature of reference.