REPORT ON
THE INVESTIGATION OF MINERAL POTENTIAL IN
THE LONQUIMAY AREA AND REGIONS LOS LAGOS PHASE II FEBRUARY 1991
AND AYSEN, THE REPUBLIC OF CHILE
AYSEN AREA

JAPAN INTERNA
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REPORT

ON

THE INVESTIGATION OF MINERAL RESOURCES

IN

THE LONGTAN AREA AND REGIONS ADJACENT

AND ALSO, THE REPORT OF CHUNG-

AN AREA

PART II

FEBRUARY 1970

BY AN INTERNATIONAL COOPERATION AGENCY

METAL MINING AGENCY OF JAPAN

REPORT

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THE INVESTIGATION OF MINERAL POTENTIAL

IN

THE LONQUIMAY AREA AND REGIONS LOS LAGOS AND AYSEN, THE REPUBLIC OF CHILE

AYSEN AREA

PHASE II

FEBRUARY 1991

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

PREFACE

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

This is the second phase survey. The JICA and MMAJ sent a survey team headed by Mr. Yuya Furukawa to the Republic of Chile from 25 September to 13 December, 1990.

The team exchanged views with the officials concerned of the Government of the Republic of Chile and conducted a field survey in the Aysen area. After the team returned to Japan, further studies were made and the present report is the result.

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

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

February, 1991

Kensuke Yanagiya

Kensuke YANAGIYA
President,
Japan International Cooperation Agency

Gen-ichi FUKUHARA
President,
Metal Mining Agency of Japan

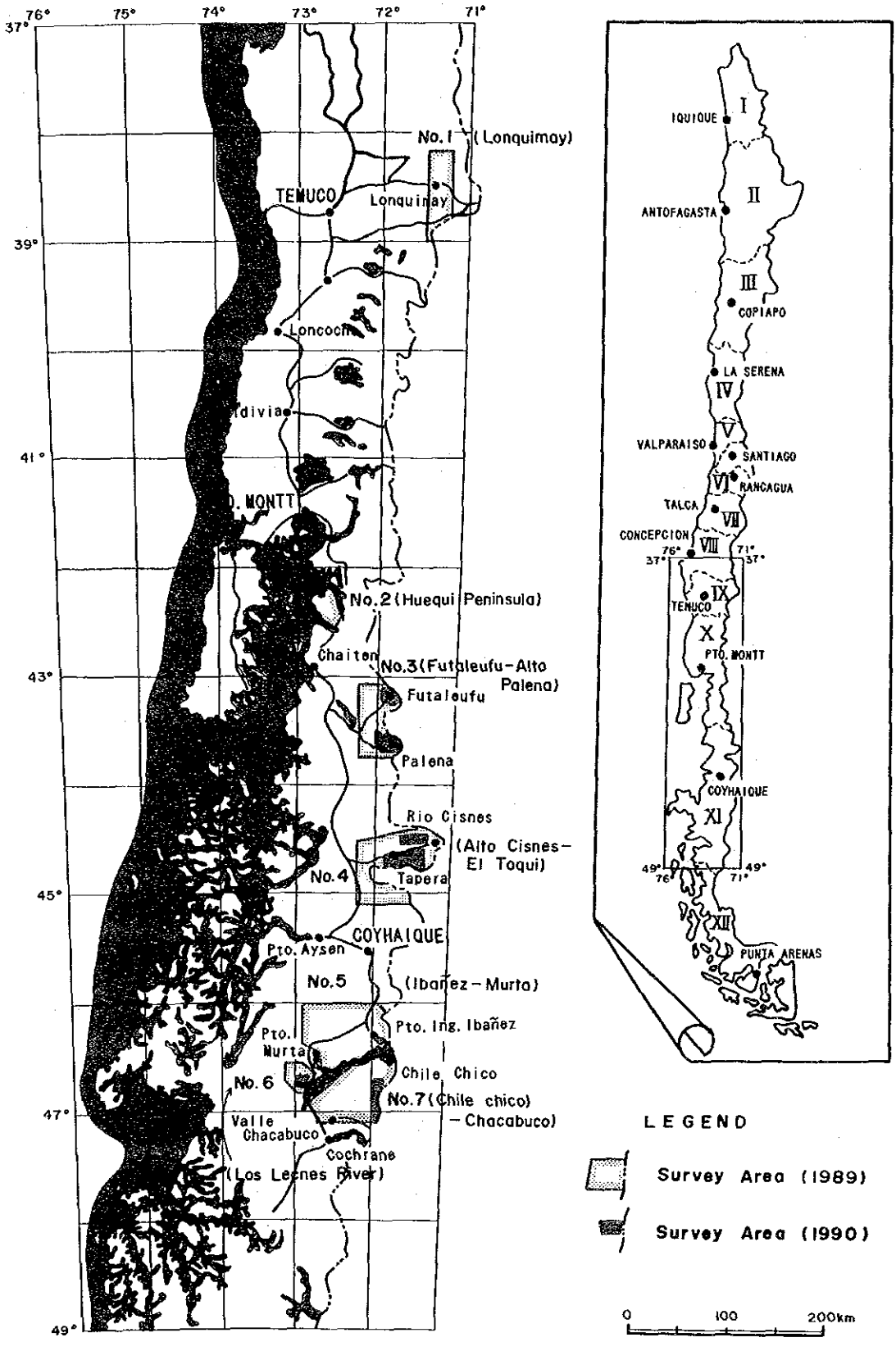

Fig.1-1 Index Map of Survey area

SUMMARY

This is the second phase of the cooperative joint exploration project in the Aysen Region. On the basis of the conclusion of the Phase I, emphasis of this phase was placed on the epithermal gold-silver mineralization and lead-zinc replacement mineralization represented by the Laguna Verde Deposit and El Toqui Deposit respectively.

For the exploration of the gold-silver deposits, the following work was planned, that is, tracing the geochemical anomalies of gold and silver detected during the first phase and extraction of the hydrothermal alteration zones by satellite images. The work of tracing previous anomalies were employed for the Futaleufu sub-area, and the satellite image analysis was employed for the eastern half of the area to the south of the Futaleufu-Alto Palena area.

For the lead-zinc exploration, Alto Palena sub-area and Alto Cisnes-El Toqui area were selected. Prior to the field work, photogeological interpretation of aerial photographs was carried out.

A. Results of the Phase II

(1) Satellite image analysis

This work was completed with false color composite images of TM bands 4-5-7 of Landsat 5. The alteration zone developed in the Laguna Verde Deposit was used as the standard for determination. Total of 170 alteration zones were extracted.

About 80% of the extracted zones are concentrated around the Lake General Carrera. Among them, the surface survey was carried out for sixteen alteration zones arranged in the N-S direction to the south of the Lake.

The localities and shapes of the alteration zones slightly differ from the observation on the surface. But for practical purposes, about 90% of localities by TM images largely coincided with the identification on surface. A total of 21 alteration zones are recognized in the area by surface field survey. Gold mineralization with maximum grade of 6.7ppm Au was found in three zones. One of these three zones also carries 1.1% Pb.

TM image analysis extracted other alteration zones (locality numbers 5-4 to 5-13) located 65km north of the Laguna Verde Deposit. They are large and

lie on the N-S tectonic line which is considered to control the arrangement of mineralized zones and alteration zones. Considering this and the results in the south mentioned above, gold mineralization of the Laguna Verde Deposit type is anticipated.

(2) Photogeological interpretation of aerial photographs

This method is most effective for the study of tectonic features, particularly lineaments. They correspond well to the observation in the field. As to photogeological rock unit classification, many of the granitic rocks with tabular joints were confused with volcanic rocks. Topographical modification caused by glaciation at times prevented the correct interpretation of rock units.

(3) Geological survey and geochemical exploration

i. Futaleufu-Alto Palena area (Futaleufu sub-area)

It is revealed by this survey that the geology of this area consists of Upper Jurassic Ibañez Formation of andesitic volcanic products and of Upper Cretaceous Granitic intrusive rocks. There are many indications of gold and copper mineralization in andesite of Ibañez Formation. These mineralization is believed to be caused by contact metamorphism related to the intrusion of granitic rocks. However, all of the showings are of low grade and small in size. Although several anomalies of gold, lead, zinc and arsenic were detected, they occur sporadically and do not indicate occurrence of sizable concentration.

Those results lead to a conclusion that the prospectivity is small in this area and that it does not warrant further exploration.

ii. Futaleufu-Alto Palena area (Alto Palena sub-area)

Shale and andesitic volcanic rocks of Coyhaique Formation host several vein and disseminated mineralization caused by contact metasomatism related to the intrusion of granitic rocks. Although bonanzas are expected locally, they are not continuous and the mineralized zones are small. On the other hand, several dense distribution of geochemical anomalies of lead, zinc and arsenic are detected on andesitic volcanic rocks of Coyhaique Formation and the rock of Divisadero Formation at the eastern periphery of granitic intrusion. Although this geochemical feature might suggest the presence of led-zinc vein type mineralization, the possibility of large deposits of El Toqui type, calcareous rock replacement lead-zinc occurring in these geochemically anomalous zones because of lack of calcareous rock.

It is concluded that the necessity for further exploration work is small.

Ⅲ. Alto Cisnes-El Toqui area

The geology of this area is composed mainly of Late Jurassic Ibañez Formation and Late Cretaceous granitic intrusion. Broad hydrothermal alteration zones accompanied with limonite-quartz stockworks are found developed at the periphery of granitic intrusion. Major alteration is silicification.

Ore assay on these alteration zones produced low grade results. However, geochemical anomalies of gold, lead and zinc occur in the outskirts of the alteration zones. The mineralization of Laguna Verde type is expected for this area from the similarities of the mineralization and alteration.

Ⅳ. Los Leones River area

The geology of this area consists of the Paleozoic metamorphic rocks, mainly muscovite schist and greenschist, and the intermediate to felsic intrusive rocks. Only faint copper-silver mineralization is developed in relation to the igneous activity of these intrusive rocks. Although gold, lead and zinc geochemical anomalies were detected in the periphery of the intrusive bodies, these anomalies are of extremely low level and do not suggest the existence of significant mineralization. Therefore it is concluded that the necessity for further exploration work is small.

Ⅴ. Chile Chico-Chacabuco area

As mentioned, TM image analysis extracted 16 alteration zones and the surface survey found 21 alteration zones. These 21 zones are divided locality-wise into nine alteration groups, Groups A to I.

Alteration Group C is ranked first for the prospectivity of gold mineralization. This was concluded from an ore assay of 6.7ppm Au and 1.1% Pb on one sample, overlapping geochemical anomalies of gold, silver, lead, zinc and arsenic, and the size of this alteration zone. Alteration Groups D and I also carry geochemical anomalies of gold, silver, lead and arsenic. Rather intensive silicification and dense stockwork of limonite are observed. Considering these features of Groups D and I, they are assessed to be very important for gold exploration, second after Group C.

Other alteration zones are concluded to be less prospective from the results of ore assay and geochemistry, their small extension and low degrees of alteration.

B. Recommendations for the Phase Ⅱ Exploration

The following work is recommended for the next stage based on the results of this survey.

(1) Geological and geochemical survey for the alteration zones 5-4 to 5-13 extracted by TM image analysis completed this year.

(2) Detailed geological and geochemical survey for the alteration zones A, B and C of Alto Cisnes-El Toqui Area.

(3) Detailed geological and geochemical survey for the alteration groups C and D of Chile Chico-Chacabuco area.

(4) Application of geophysical exploration using SIP technique for the important alteration zones selected by the work listed above.

Other than these areas, the zone between Ibañez River and Avellanos River in Ibañes-Murta area still remain untouched as recommended by the report of the first phase.

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PART I
OVERVIEW

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OVERVIEW

CHAPTER 1. INTRODUCTION

1.1. Background and Objective

This is the second phase of "The Investigation of Mineral Potential in the Lonquimay area and Regions Los Lagos and Aysen, Republic of Chile". This project started in the fiscal year 1989 and it aims to clarify the mineral potential and delineate the promising areas for mineral exploration.

The region has been left undeveloped so far due to the restrictions caused by geographic and climatic conditions, despite being noted for its underground resources. Whereas in recent years, the development of road system led to the active exploration in the region during the past decade, and the successful results such as the discovery of the Laguna Verde deposit.

Seven areas were selected for preliminary investigation prior to the commencement of this project as shown in Figure I-1-1. The aim of the first phase survey was to understand the regional features of geology and mineralization. That work consisted of the satellite imagery analysis (17 scenes of Landsat MSS Imagery) over the whole region, the existing data compilation and the field survey of representative mineral prospects. Also preliminary panning and stream sediment geochemical survey were carried out for acquiring the geochemical characteristics of the survey areas.

The conclusions and recommendations of the first phase survey are mentioned below. In this report, numbers are assigned to each area for simplifying the notation of the area locations as follows:-

The Lonquimay area: Area No.1
The Huequi peninsula area: Area No.2
The Futaleufu-Alto Palena area: Area No.3
The Alto Cisnes-El Toqui area: Area No.4
The Ibañez-Murta area: Area No.5
The Leones River area: Area No.6
The Chile Chico-Chacabuco area: Area No.7

1.2. Conclusions and Recommendations of the First Phase Survey

1.2.1. Conclusions of the first phase survey

The Lonquimay Area (Area No.1)

Mineralization of this area is characterized by gold and copper. Two types of gold mineralization are recognized in this area, namely vein or stockwork and placer gold. The former occurs in intrusive rocks or Cretaceous rocks. Some veins locally contain several grams per tonne to some tens of grams per tonne of gold, but their sizes are very small. The latter placer deposit accumulated in glacier sediments of the Bio Bio River. This deposit is very small and is being mined on a small scale. The possibility of further exploration increasing the ore reserves of those types of deposits is small.

Gold and silver stream sediment geochemical anomalies were found to occur relatively densely in the area between the Maravilla Mountain and the Bio Bio River.

The Huequi Peninsula Area (Area No.2)

The survey identified the existence of ultramafic rocks intruded by granitoids at the base of the Comau mountain situated in the northern part of the peninsula. Distribution and size were not determined. Gold anomalies were found by stream sediment geochemistry in the western part of the area.

The Futaleufu-Alto Palena Area (Area No.3)

This area lies on the eastern margin of the Patasgonia Batholith, and is overlain by Jurassic volcanic rocks and calcareous rocks of marine origin (Ibañez Formation, Coyhaique Formation and Divisadero Formation) which are closely related to the mineralization of the Aysen region. Furthermore, gold and silver geochemical anomalies were obtained in the northwest of Futaleufu and in the vicinity of Palena, dense distribution of lead anomalies were found. These geologic settings and the results of geochemical survey suggest that this area warrants detailed exploration for gold, silver, lead and zinc in future stages of the project.

The Alto Cisnes-El Toqui Area (Area No.4)

This area lies at the eastern margin of the Patagonia Batholith and eastern part of the area is broadly overlain by Mesozoic units. The large lead-zinc replacement deposits such as El Toqui and Cerro Estatuas occur in the calcareous beds of the Coyhaique Formation in this area. The gold vein deposits, such as the Katterfeld, occur in the Ibañez Formation. In the Katterfeld deposit, parallel veins are distributed with about ten meters

intervals and the mineralized zone is one kilometer wide. This zone is associated with gossaneous hydrothermal alteration zone which is several kilometers wide. Alteration assemblage is characterized by sericitization-silicification-kaolinitization.

Those deposits are notable in both scale and ore grade so that they would be targeted for future exploration.

The Ibañez-Murta Area (Area No.5)

Paleozoic metamorphic rocks and Mesozoic strata are widely distributed in this area. Although more than 70 mines and prospects are distributed in the area, many of them are small.

Sufficient exploration work has not been conducted in the area between the Avellanos River and the Ibañez River due to access problem. This area is underlain by Paleozoic unit and Mesozoic units, and intruded by many granitic stocks. This geology of the area is believed to be favorable for mineralization. In addition, a gold prospect occurs in the lower reaches of the Avellanos River (Prospect Rio Avellanos Ⅱ). These lead to the expectation that lead-zinc deposits of the El Toqui type or gold deposits of Katterfeld type may exist to be discovered.

No geochemical anomalies were obtained throughout the area No 5.

The Leones River Area (Area No.6)

Geology of this area is composed of the Patagonia Batholith on the western part and Paleozoic unit on the eastern part. Gold and arsenic geochemical anomalies were obtained densely in the basins of the Leones River and the Cañar River. No interesting deposit was recognized.

The Chile Chico-Chacabuco Area (Area No.7)

Geology of this area consists of Paleozoic metamorphic rocks, Mesozoic strata, Cenozoic strata, and stocks and dikes derived from the Patagonia Batholith. About 20 mineralized zones are known. Among them, Laguna Verde Gold Deposit and La Poza Lead Deposit are considered important.

Laguna Verde Deposit consists of epithermal veins which may be classified as hot spring type. Numerous quartz veins occur in Ibañez Formation. This deposit is associated with broad hydrothermal alteration zone with consisting of silicification and kaolinitization.

La Poza Deposit is possibly of sub-marine volcanogenetic origin. It is expected to have potential for the discovery of further ore.

Gold, silver and arsenic anomalies occur concentrated along the Aviles River and its tributaries in the south of this area. Hydrothermal alteration zones associated with ferruginous alteration was found in upstream area of these anomalies. Therefore, this anomalous zone is worth noting.

1.2.2. Recommendations of the first phase survey

The following points were recommended by the First Phase Survey.

(1) Extraction of the alteration zones is recommended. For that, Landsat TM imagery is believed to be useful. Material recommended is Landsat TM images covering the zone between the eastern edge of the Patagonia Batholith and the Argentina-Chile border in the Areas No.3 to No.7 . This work would be followed by the geological survey of the extracted alteration zones.

(2) In the Areas No.3 and No.4, photogeology and ground survey verifying the presence of mineralization in the Mesozoic area are recommended. The field work should include geochemical survey for acquiring the indications of mineralization.

(3) Geological and geochemical surveys to pursue the gold-silver anomalies found in the northern part of the Area No.3 are recommended.

(4) Geological and geochemical surveys to pursue the gold-silver anomalies found in the Area No.6 are recommended.

(5) Detailed geological survey on La Poza and La Paulina Deposits located in the Area No.7 are recommended.

1.3. Outline of the Work in Phase Ⅱ

1.3.1 Survey areas

Three types of work were selected and employed as follows:-

(1) Landsat TM image analysis

This work was carried out over the area enclosed by the following coordinates.

Northen Limit: 43°00′S
Southern Limit: 47°26′S
Eastern Limit: Chile-Argentina border
Western Limit: 73°26′W

The images (nine sub-scenes) cover the area from the Futaleufu area to the Chile Chico-Chacabuco area.

(2) Photogeological interpretation of aerial photographs

This work covered the southern part of the Futaleufu-Alto Palena (the Alto Palena sub-area) and the Alto Cisnes-El Toqui areas. Details are shown in section 2.2.

(3) Geological survey and geochemical survey

The work was carried out in the following four areas (Fig.1-1-1).

i. The Futaleufu-Alto Palena area

This area is divided into two sub-areas:

* Futaleufu sub-area
* Alto Palena sub-area

ii. Alto Cisnes-El Toqui area

iii. The Leones River area

iv. The Chile Chico-Chacabuco area

The coordinates enclosing these areas are listed in the following Table.

	Futaleufu Sub-area	Alto Palena Sub-area	Alto Cisnes-El Toqui Area
North Limit	43°06′S	43°30′S	44°25′S
South Limit	43°13′S	43°38′S	Chile-Argentina border
East Limit	71°50′W	Chile-Argentina border	71°22′W
West Limit	72°00′W	72°03′W	71°49′W

	Leones River Area	Chile Chico-Chacabuco Area
North Limit	46°42′S	46°40′S
South Limit	46°49′S	47°10′S
East Limit	72°47′W	Chile-Argentina border
West Limit	73°10′W	72°08′W

1.3.2. Objective of phase Ⅱ survey

(1) Satellite image analysis

In order to effectively explore for the hot spring type gold-silver deposits represented by the Laguna Verde Deposit, this analysis was employed to detect the alteration zones which accompany the Laguna Verde type deposit. The Landsat TM images were used for the analysis.

(2) Photogeological interpretation of the aerial photographs

In order to conduct field survey efficiently, this interpretation was carried out for understanding the general geologic setting and geologic structure of the survey areas prior to the geological survey. Particular emphasis was placed upon tracing the ore-hosting horizon (Coyhaique Formation) of lead-zinc replacement deposits such as El Toqui and Cerro Estatuas Deposits. This work was expected to delineate the important areas for the geological and geochemical surveys.

(3) Geological and geochemical surveys

i. Futaleufu and Los Leones River sub-areas

The survey was carried out in order to define the gold-silver mineralization which were detected by the reconnaissance survey of the First Phase.

ii. Alto Cisnes-El Toqui area

The work was planed to pursue ore-hosting horizon of El Toqui Deposit. Five traverse lines were selected on the basis of the results of the photogeological work. The southern part of the area was excluded from the survey because many exploration and mining concessions are marked out.

iii. Chile Chico-Chacabuco area

The satellite image analysis revealed the linear arrangement of the alteration zones in the north-south direction in the southern extension of the Laguna Verde deposit. The aim of the field work in the area is to identify these alteration zones.

Although a survey of La Poza and La Paulina Deposits located in this area was recommended on the basis of the First Phase survey, this was suspended due to the acquisition of shares of the concession by a foreign company.

1.3.3. Survey methods

(1) Satellite image analysis

Geologic units, geologic structures were analyzed and alteration zones were extracted from the false color images at scale 1:250,000 which were prepared from the CCT (Computer Compatible Tape) data obtained by the Landsat TM (Thematic Mapper). The bands 4-5-7 composite images were selected as this combination is believed most suitable for the alteration zone extraction. The alteration zones developed in the Laguna Verde Deposit was used as the standard for determination. The results of the analysis are compiled on the topographic map at scale 1:250,000.

The details of the results are mentioned in Chapter 1 of Part Ⅱ of this report.

(2) Photogeological interpretation of aerial photographs

Black and white aerial photographs were used for the analysis. The scale used was 1:68,000. The analysis was done by stereoscopic images and geological units were classified and geologic structures were read. The geology and geologic structure recognized in El Toqui and Cerro Estatuas mining area were used as reference. The photogeological map at the scale of 1:100,000 was compiled after the interpretation. The photographs were re-interpreted and modified after incorporating the geological data obtained in the field. Details are referred to the Chapter 2 of Part Ⅱ of this report.

(3) Geological survey and geochemical exploration

i. Methods employed

a. Futaleufu-Alto Palena Area and The Leones River Area

The 1:50,000 scale topographic maps were enlarged to 1:25,000 scale and were used in the field. The data were compiled in geological maps at the scale of 1:50,000.

Gold-silver concentration is expected in the Futaleufu sub-area and the Leones River area and the pan concentrate geochemistry was employed for these two areas. On the other hand, the stream sediment geochemistry was carried out in the Alto Palena area where the lead-zinc mineralization is expected. The mesh fraction of the stream sediment samples collected is -30 mesh.

b. Alto Cisnes-El Toqui area

Five traverse lines were selected in the zone where the Coyhaique Formation was identified to occur widely from the photogeological

interpretation. Care was taken to set the traverses at right angles to the general trend of the geologic structure. Route maps were made on topographic maps at the scale of 1:25,000 enlarged from 1:50,000 maps and the data were compiled into the "route geological map" which express the geology along the traverse lines. It was expected that not many outcrops would be distributed in the survey area, and geochemical samples were also collected simultaneously from river-beds in order to avoid missing any indication of mineralization. For this purpose, stream sediment geochemistry was employed because the lead-zinc mineralization was targeted in the area.

c. Chile Chico-Chacabuco area

Topographic maps at the scale of 1:50,000 were used for the work to identify the alteration zones. In the field, the alteration features were observed in detail and assay samples were taken to check the presence and the type of mineralization. As to the localities in which the landforms are too steep for access, float samples and pan concentrate geochemical samples were taken in the lower reaches of the streams which dissect the alteration zones upstream.

ii. Volume of work carried out

The length of traverses and numbers of samples analyzed are listed in Table I-1.

1.3.4. Organization of the survey team

The geological staff who participated in this project are as follows.

Japanese staff

NAME	ROLE
Tetsuo Suzuki (MMAJ[1])	Planning and coordinating
Yuya Furukawa (NED[2])	Chief geologist of the project Satellite imagery, photogeological interpretation, geological survey and geochemical exploration
Hideya Kikuchi(〃)	Geological survey and geochemical exploration
Susumu Takeda (〃)	Satellite imagery and photogeological interpretation
Takashi Yoshie(〃)	Photogeological interpretation, geological survey and geochemical exploration
Kenji Sato (〃)	Geological survey and geochemical exploration

Table I-1 Numbers of Samples Provided for Assaying and Laboratorical Works

AREA	Pan Concentrate (Au, Ag, Cu, Pb, Zn, Mo, As)	Stream Sediment (Au, Ag, Cu, Pb, Zn, As) Phase II	Stream Sediment (Au, Ag, Cu, Pb, Zn, As) Phase I	Ore Assay (Au, Ag, Cu, Pb, Zn,)	Whole rock Analysis	Thin Section	Polished Section	X - Ray diffraction	Dating (K-Ar)
Futaleufu-Alto Palena Area Sub-Area Futaleufu	131	-	-	23	8	23	8	6	2
Sub-Area Alto Palena	-	104	-	4	4	16	3	2	1
Los Leones River Area	216	-	-	18	1	19	5	6	2
Chile Chico-Chacabuco Area	57	-	-	51	-	2	4	34	-
Alto Cisnes-El Toqui Area	-	107	-	8	2	14	-	5	-
Re-analysed samples of phase I	-	-	273	-	-	-	-	-	-
T O T A L	404	211	273	104	15	76	20	53	5

※ Stream sediment samples taken at the work of the Phase I were re-analyzed by the Chemex Labs. Canada as well as them listed above.
※※ Pan concentrated geochemical samples taken in this area were assayed for same elements as them for the Ore Assaying.

Chilean staff

NAME	ROLE
Carlos Portigliati (SERNAGEOMIN[3])	Chief geologist Geological survey and geochemical exploration
Sonia Vogel (〃)	Geological survey and geochemical exploration

1) Metal Mining Agency of Japan
2) Nikko Exploration & Development Co., Ltd.
3) Servicio Nacional de Geologia y Mineria, Chile

1.3.5. Duration of work

The duration of the work are as listed below.

Satellite imagery analysis: 25 August - 20 September 1990

Photogeological interpretation of aerial photographs: 25 August - 20 September 1990

Geological survey and geochemical exploration: 25 September - 13 December 1990

Report preparation: 14 December 1990 - 25 February 1991

CHAPTER 2. GEOGRAPHY

2.1. Location and Access

2.1.1. Futaleufu-Alto Palena area

This area is located in the southeastern part of the X Region. Large towns in the area are Futaleufu and Palena near the Chile-Argentina border. Populations of the both townships are approximately 2,000. The access to the both towns from Santiago are as follows:-

Santiago —(by air, 1,600km)→ Coyhaique —(on road, 430km)→ Futaleufu and Palena

Commercial regular flights operating with small aircrafts are also available between Chaiten and the both towns. Futaleufu is located in the northern part of the area and Palena in the southern part. Direct distance between the two towns is about 70km. The road from Coyhaique is very winding, steeply undulating and only 5% paved. It takes about 10 hours by car.

2.1.2. Alto Cisnes-El Toqui area

This area lies in the northern part of the XI Region and is separated by the Lake Fontana belonging to Argentina. The northern half (the Alto Cisnes area) and the southern half (El Toqui area) are located about 100km and 60km north of Coyhaique respectively. The Austral main road runs longitudinally at the western edge of the area and the roads branching from the Austral main road lie across the area to Argentina via Alto Cisnes and El Toqui.

2.1.3. Los Leones River area

This area is on about 320km south-southwest from Coyhaique. The area is a remote area and the major town is only Puerto Guadal of about 500 or 600 habitants. About six hours are needed to reach the town on road from Coyhaique through the Austral main road. A small aerodrome is available near the town and small aircrafts for charter are available in Coyhaique. Car-road in this area is only the Austral main road, but horse-roads are well developed.

2.1.4. Chile Chico-Chacabuco area

This area is located near the Chile-Argentina border in the central part of the XI Region. The largest town is Chile Chico of about 2,000 habitants. To reach the city, ship ride on the Lake General Carrera is necessary. It is about 5 hour trip from Coyhaique to Chile Chico by vehicle and ship. On the other hand, a road connecting from Puerto Guadal and Chile Chico is under construction. Also regular air services with small aircraft are available

between Chile Chico and Coyhaique. There are only two roads accessible by car: They are the 60km long road connecting Chile Chico and the Lake Jeinimeni and the road crossing the southern part of the area in the east-west direction through Argentina. The horse road network is also poor and the access to the area is very difficult.

2.2. Topography and Drainage systems

2.2.1. Futaleufu-Alto Palena area

This area lies in the mountainous belt along the Andes Mountains near the Chile-Argentina border and its topography is characterized by the glacial landforms; the U-shaped valleys, glacial lakes and cirque are developed all over the area. The valleys are wide ranging between 100m and 1,000m and smooth cliffs stand on the both sides of the valleys. The drainage is generally linear due to the effect of glaciation and it does not reflect the physical characteristics of rock units. Therefore, the photogeological interpretation is more difficult than in other terrains. The summits of mountains range from 1,000m to 2,500m in altitude and their ridges show jagged crests with narrow width in many cases.

2.2.2. Alto Cisnes-El Toqui area

The western part of the area is characterized by glacier topography, but in the eastern part broad plain is formed behind the Andes Range. The valleys in the east are narrow and the ridges are flat. Altitude is between 1,000m and 2,000m decreasing from the west eastward. The typical drainage system is dendric converging from the east to the west.

2.2.3. Los Leones River area

Typical glacier landforms are developed in this area. Glaciers still remain in the western part of the area and occasionally flow into lakes and rivers. A large glacier zone is developed westward from the area to the Pacific Ocean. The mountain ridges are 1,000m to 2,500m in altitude increasing westward.

The major rivers such as the Leones River flow in the east-west direction. Whereas the tributaries of these rivers flow dominantly in the north-south direction and many of them are short.

2.2.4. Chile Chico-Chacabuco area

Typical glacier landforms are developed in this area as well. The valleys are broad U-shaped valleys and the mountain ridges are very rugged and many

water falls are formed. The access to the summits is often difficult due to rugged topography. The ridges show narrow jagged crest. There are many beautiful glacial lakes allover this area. Altitudes of many mountains are in the range of 2,000m.

The dominant trend of the rivers is north-south with parallel drainage pattern.

CHAPTER 3. GENERAL GEOLOGY OF THE AYSEN REGION

The Region lies in the southern part of the Andes Orogenic Belt formed along the western margin of sub-stable landmass, west of the Guapore Craton.

The Region is underlain by Paleozoic metamorphic basement which is overlain by Jurassic, Cretaceous, Tertiary and Quaternary Systems, and granitic rocks (Patagonia Batholith) intruded during the time from Jurassic to Tertiary. Distribution of the basement rocks in the north of lat 47°S are confined mainly to the western side of the area and they consist of greenschist, phyllite, quartz schist, mica schist, metasandstone, marl and calcareous schist. Metamorphic rocks other than greenchist are considered to be metasediments. Those rocks are very deformed. Sedimentary rocks are reported to be of Devonian to Carboniferous time by Skarmeta et al.,(1984).

Jurassic System is distributed to the east of the Patagonia Batholith elongated in the N-S direction. Rocks of Jurassic System consist mainly of volcanic rocks and pyroclastic rocks ranging from intermediate to acidic in composition. Skarmeta et al.,(1984) reported that sedimentary rocks in this system are of Dogger to Malm Series.

Cretaceous System also occurs to the east of the Patagonia Batholith. Lower Cretaceous consists mainly of sedimentary rocks of marine origin, intermediate to acidic lavas and pyroclastic rocks in ascending order. The Upper Cretaceous consists mainly of volcanic rocks and continental sediments.

Tertiary System lies on both sides of the Patagonia Batholith. Rocks of Tertiary units are sedimentary rocks of marine origin, continental sediments and volcanic rocks.

Extensive andesitic and basaltic volcanism took place during the end of Tertiary to early Quaternary mainly in the area of the Patagonia Batholith. A

part of that volcanism is still active at present.

Mesozoic to Cenozoic batholith (Andes Batholith) intruded along the western coast throughout the South America from Cape Horn to Colombia. A part of the Batholith located south of lat 39°S are called the Patagonia Batholith which is distributed in the investigated area. Stock-shaped granitic intrusions which probably have the same genetic origin as the Batholith intrude into the Mesozoic rocks particularly in the eastern marginal zone of the Batholith. Period of intrusion is estimated to be Middle Jurassic to Oligocene based on dating studies. Many rock types, granite to dunite are recognized in the batholith and chemical composition vary from basic on the west to acidic on the east (Skarmeta et al.,1984).

The Paleozoic basement rocks are deformed extensively and contains tholeiitic metabasite. It is assumed from these that the basement is a mélange formed in the subduction zone (Skarmeta et al.,1984). The extensive volcanism caused by subduction was active during the Mesozoic in the western margin of the continent (Skarmeta et al.,1984). This activity is assumed to have begun in middle or late Jurassic period. This igneous activity continued to the Cenozoic period and is partly still active at present.

Regional geologic structure is characterized by the N-S system for both fracture systems and fold structures. This direction is consistent for all sequences from Paleozoic to Recent. Fold structures in Paleozoic sequence show composite folds accompanied by drag folds and their axes trend in the N-S direction. Fold structures developed in Mesozoic rock are very gentle folds. Fold structures are not recognized in Cenozoic rocks. That is, the structural movements of Paleozoic and Mesozoic time are characterized by lateral movement, while those of Cenozoic are vertical movement.

CHAPTER 4. EVALUATION OF THE SURVEY AREAS ON THE PHASE Ⅱ

4.1. General Features of Tectonics and Mineralization

4.1.1. Futaleufu-Alto Palena area

In the Futaleufu Sub-area, alteration zones and indications of vein type and dissemination mineralizations are developed. The vein system is dominated by N-S system.

Whereas the disseminated mineralizations occur in the rocks strongly affected by epidotization and chloritization at periphery of granitic

intrusion.

Similar types of mineralizations are developed in Alto Palena sub-area as well. Major lineaments belong to either N60°W system or N45°E systems and vein systems are equally classified into the both systems, but no selectively directional trend is recognized. Whereas pyrite mineralization is found occurring along joints of granitic rocks. Disseminated mineralization tends to occur at peripheries of the granitic rocks as well as in Futaleufu sub-area.

4.1.2. Alto Cisnes-El Toqui area

Mineralizations known in this area are gold-copper and molybdenum vein type mineralizations and ferrugineous alteration zones accompanied with quartz stockwork. Gold-copper vein and alteration zones are developed near the contact with small dikes of porphyritic rocks distributed at peripheral part of the batholith of granitic rocks.

Directions of lineaments are dominated by N70°E. Elongations of porphyritic rocks and alteration zones tend to be controlled by that direction with exceptions like the Santa Teresa gold-copper vein deposit striking N50°W.

Molybdenum veins are clearly controlled by joint structure of the granite batholith.

4.1.3. Los Leones River area

Mineralization in this area is outlined as follows:-

ⅰ. In the margin of the diorite stock; quartz-pyrite-(chalcopyrite-hematite) stockworks.

ⅱ. In granitoids; quartz-pyrite vein.

ⅲ. In periphery of felsite and andesite dikes; quartz-pyrite stockworks and disseminations occasionally carrying silver-copper.

As shown, the mineralization takes characteristic features according to the local geologic setting.

4.1.4. Chile Chico-Chacabuco area

Major fault and fold systems trend in the N-S direction in this area. The

Alteration Groups are also arranged in the N-S direction, and the elongation direction of each group is largely N-S as well. Therefore, those alteration groups are believed to have been affected by a structural control in the N-S direction.

4.2. Relationship between Geochemical Anomalies and Mineralization

4.2.1. Futaleufu-Alto Palena area

Metals characterized Futaleufu sub-area are grouped into Au-Mo and Ag-Cu-Pb-As on the basis of the correlation in geochemistry. Spatial relationship of a pair Au-Mo to geology is considered to agree with distribution of the granitoid batholith. Thus it is presumed that occurrence of Au-Mo mineralization is confined to the inside of the batholith. On the other hand, anomalies of Ag-Cu-Pb-As are distributed mainly in the intruded rocks at periphery of batholith.

Geochemical characteristics in Alto Palena sub-area are represented by Cu-Pb-Zn anomalies, resembling that in Futaleufu sub-area. These anomalies are distributed at periphery of the granitoids batholith, which these distribution pattern suggests the intimate relationship of mineralization to the batholith.

4.2.2. Alto Cisnes-El Toqui area

Spatially the anomalies and mineralization agree well. But, interaction between ore metals and the species of the anomalous elements remains to be examined further, because sufficient data are not obtained yet.

4.2.3. Los Leones River area

Geology of this area consists of the Paleozoic metamorphic rocks, mainly muscovite schist and greenschist, and the intermediate to felsic intrusive rocks. Only faint copper-silver mineralization is developed in relation to the igneous activity of these intrusive rocks. Although gold, lead and zinc geochemical anomalies were detected in the periphery of the intrusive bodies, these anomalies are extremely low level and do not suggest the existence of significant mineralization. Therefore it is concluded that necessity for further exploration work is small.

4.2.4. Chile Chico-Chacabuco area

Although the work in this area is still in the early stages to discuss about mineralization, clear relationship between geochemical anomalies and mineralization is found in the Alteration groups C and D. Especially gold and lead geochemical anomalies are in good spatial accordance to the distribution

of the alteration zones.

4.3. Mineral Potential

4.3.1. Alteration zones in the north of the Lake General Carrera

Arrangement of mineralization and alteration zones developed on the western slope of the Andes Mountains seem to be controlled by N-S structure, i.e., the Laguna Verde Deposit and similar alteration zones are alined on a N-S line. Alteration zones extracted from TM images, numbers 5-4 to 5-13, lie on the northern extension of this N-S zone. Furthermore, these alteration zones are large and occur relatively close to each other. The TM image analysis obtained successful results in delineating the promising gold mineralization as mentioned below. From these, it is concluded that the above alteration zones are prospective for locating large epithermal gold mineralization.

4.3.2. Futaleufu-Alto Palena area (Futaleufu sub-area)

Extensive geological and geochemical surveys were carried out during the second phase, and also exploration activities were had been conducted in this area in the past. Despite this, mineralization found in this area is small veins and disseminations of chalcopyrite and pyrite. No prospect was significant enough to warrant advanced exploration such as geophysical survey or drilling. The geochemical survey of this phase ended in very disappointing result, i.e. numbers of anomalies are very small occurring only sporadically. As to the fissure systems, their development is very poor, and also it is noted that there is no distribution of calcareous rocks favorable for the mineralization of the replacement deposits such as El Toqui Deposit. Mineral potential of this area is believed to be low.

4.3.3. Futaleufu-Alto Palena area (Alto Palena sub-area)

Mineralization found in this area is vein type only. High grade ore of silver, copper, lead and zinc is partly recognized, but the veins are generally not continuous and thin. Also limestone does not occur and El Toqui type replacement can not expected. Geochemical anomalies are few and sporadically distributed.

This leads to a conclusion that the mineral potential in this area is very small.

4.3.4. Alto Cisnes-El Toqui area

This area hosts the Santa Teresa high grade gold-copper vein deposit.

Other than this, large silicification zones accompanied with limonite-quartz stockwork and geochemical anomalies of gold, lead and zinc densely occur in the area. Acidic igneous activity is extensive and porphyritic rocks crop out in several places. Those features indicate that this area is prospective.

4.3.5. Los Leones River area

Only faint copper-silver mineralization is developed in relation to the igneous activity of these intrusive rocks. Although gold, lead and zinc geochemical anomalies were detected in the periphery of the intrusive bodies, these anomalies are extremely low level and do not suggest the existence of significant mineralization. Therefore it is concluded that necessity for further exploration work is small.

4.3.6. Chile Chico-Chacabuco area

Nine Alteration Groups, i.e., Groups A to I, are recognized at the same locality as extracted by TM image analysis. Significant indications and geochemical anomalies of gold, lead and zinc are defined in the groups C and D. Those two groups are rather intensively silicified and ferruginous zones extend broadly. Those features indicate that this area is prospective for gold-lead-zinc mineralization.

CHAPTER 5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

5.1.1. Satellite image analysis

This work was done with composite images of bands 4-5-7 of the TM data of Landsat 5. Total of 170 alteration zones were extracted. Of those sixteen zones to the south of the Laguna Verde Deposit were selected for the surface survey to verify.

The localities and shapes of the alteration zones extracted from the images differ slightly from the observation on the surface. But for practical purposes, about 90% of the localities by TM images largely coincide with the identification on surface. Total of 21 alteration zones are recognized in the area. Gold mineralization with maximum grade of 6.7ppm Au was found in three zones. One of these three zones also carries 1.1% Pb.

There are other alteration zones (locality numbers 5-4 to 5-13) extracted from TM images. They grouped at 65km north of the Laguna Verde Deposit. They are large and lie on the N-S tectonic line which is considered to control the arrangement of mineralized zones and alteration zones. Considering this and the results in the south mentioned above, the existence of gold deposits of the Laguna Verde type is expected in this area.

5.1.2. Photogeological interpretation of aerial photographs

Photogeological interpretation and surface verification survey were conducted for Alto Palena sub-area and Alto Cisnes-El Toqui area. Tectonic features, especially lineaments of the photographs agree well with those observed in the field. As to photogeological rock units classification, many of the granitic rocks with tabular joints were confused with volcanic rocks. Topographical modification caused by glaciation sometimes prevented the correct interpretation of rock units. However, this photogeological work was very effective with regard to acquiring outline of general geologic settings, it was especially superior to the field survey for tracing faults.

5.1.3. Geological survey and geochemical exploration

(1) Futaleufu-Alto Palena area (Futaleufu sub-area)

It is revealed by this survey that the geology of this area consists of Upper Jurassic Ibañez Formation of andesitic volcanic products and Upper Cretaceous Granitic rocks intrusion. Many indications of gold and copper mineralizations are found in the andesite of Ibañez Formation. These mineralization is believed to be caused by contact metasomatism related to the intrusion of granitic rocks. However, all of the indications are of low grade and small. Also the distribution of geochemical anomalies is sporadic, although several anomalies of Au, Pb, Zn and As are detected.

Those results lead to the conclusion that the prospectivity is small and the area does not warrant further exploration.

(2) Futaleufu-Alto Palena area (Alto Palena sub-area)

Shale and andesitic volcanic rocks of Coyhaique Formation host several vein and disseminated mineralization caused by contact metasomatism due to the intrusion of the granitic rocks. The mineralized zones are very small, although bonanzas are expected locally. On the other hand, dense distribution of geochemical anomalies of lead, zinc and arsenic is detected at several localities on the andesitic volcanic rocks of Coyhaique Formation and the rocks of Divisadero Formation at the eastern periphery of granitic intrusives.

Although this geochemical feature might suggest the presence of led-zinc vein type mineralization, large deposits of El Toqui type, calcareous rock replacement lead-zinc deposit, is not expected to occur in those geochemically anomalous zones because no calcareous rock crops out.

Further exploration work is concluded to be not feasible here.

(3) Alto Cisnes-El Toqui area

Geology of this area is composed mainly of Late Jurassic Ibañez Formation and Late Cretaceous granitic intrusion. Broad hydrothermal alteration zones accompanied by limonite-quartz stockworks are developed at the periphery of the granitic intrusive bodies. Major alteration type is silicification.

Ore assays on those alteration zones show low grade content. However, geochemical anomalies of gold, lead and zinc overlap with the alteration zones. The mineralization of Laguna Verde type is expected for this area from the similarities of mineralization and alteration.

(4) Los Leones River area

Geology of this area consists of the Paleozoic metamorphic rocks, mainly muscovite schist and greenschist, and the intermediate to felsic intrusive rocks. Only faint copper-silver mineralization is developed in relation to the igneous activity of these intrusive rocks. Although gold, lead and zinc geochemical anomalies were detected in the periphery of the intrusive bodies, these anomalies are extremely low level and do not suggest the existence of significant mineralization. Therefore it is concluded that necessity for further exploration work is small.

(5) Chile Chico-Chacabuco area

As mentioned, TM image analysis extracted 16 alteration zones and the surface survey located 21 zones. These 21 zones are grouped locality-wise into nine alteration groups, Group A to Zone I.

Alteration Group C is ranked first for the prospectivity of gold mineralization concluded from an ore assay of 6.7ppm Au and 1.1% Pb on one sample, overlapping geochemical anomalies of gold, silver, lead, zinc and arsenic, and the size of this alteration group. Alteration Groups D and I are also overlapped by geochemical anomalies of gold, silver, lead and arsenic. Rather intensive silicification and dense stockwork of limonite are observed. Considering those features of groups D and I, they are assessed to be very

important for gold exploration, second after the group C. Whereas detailed survey might be nearly impossible due to its topographical obstructs.

Other alteration groups are concluded to be less prospective from the results of ore assay and geochemistry, their small extension and low degrees of alteration.

5.2. Recommendations for the Phase Ⅱ Exploration

The following works are recommended for the next stage based on the results of this survey.

(1) Geological and geochemical survey for the alteration zones 5-4 to 5-13 extracted by TM image analysis completed this year.

(2) Detailed geological and geochemical survey for the alteration zones A, B and C of Alto Cisnes-El Toqui area.

(3) Detailed geological and geochemical survey for the alteration zones C and D of Chile Chico-Chacabuco area.

(4) Application of geophysical exploration using SIP technique for the important alteration zone selected by the works listed above.

Other than these areas, the zone between Ibañez River and Avellanos River in Ibañez-Murta area is remained to be untouched as recommended by the report of the first phase.

PART II
DETAILED DISCUSSIONS

PART Ⅱ
DETAILED DISCUSSIONS

CHAPTER 1. SATELLITE IMAGE ANALYSIS

1.1. Area Coverage

The area covered by this work is shown in Figure Ⅱ-1-1. This analysis does not cover the Lonquimay nor the Huequi Peninsula areas that were included in the survey of Phase Ⅰ.

1.2. Data Used

The images used are four CCT (Computer Compatible Tape) scenes which were acquired by Thematic Mapper (TM) on Landsat 5. For the work, care was taken to select the clearest images without cloud cover and snow to the extent.

Those data were obtained through EOSAT (Earth Observation Satellite Company). Images used are listed in Table Ⅱ-1-1.

Table Ⅱ-1-1 List of TM Images Used

PATH	ROW	DATE	CLOUD COVER,%	SCENE ID	SCENE CENTRE POINT	
					LATITUDE	LONGITUDE
231	91	Jan.27,1985	20	Y5036413545X0	44°37′S	71°10′W
231	92	ditto	10	Y5033213551X0	46°02′S	71°41′W
231	93	ditto	20	Y5033213554X0	47°27′S	72°13′W
232	90	Jan.24,1987	20	Y5105913501X0	43°10′S	72°16′W

Landsat 5 was launched on 18 March, 1984 and is on a sun synchronous orbit at a height of approximately 700km above the earth surface. Its cycle is 16 days (Figure Ⅱ-1-2). This satellite carries also Multispectral Scanner (MSS).

TM data, compared to those of MSS, have higher resolution, larger numbers of the bands and wider range of wavelength for observation. For example, the normal resolution is 80m for MSS, while that for TM is 30m. Therefore, greater detail can be read from TM Images than from MSS.

General characteristics of the electromagnetic waves covered by TM device are summarized in Table Ⅱ-1-2.

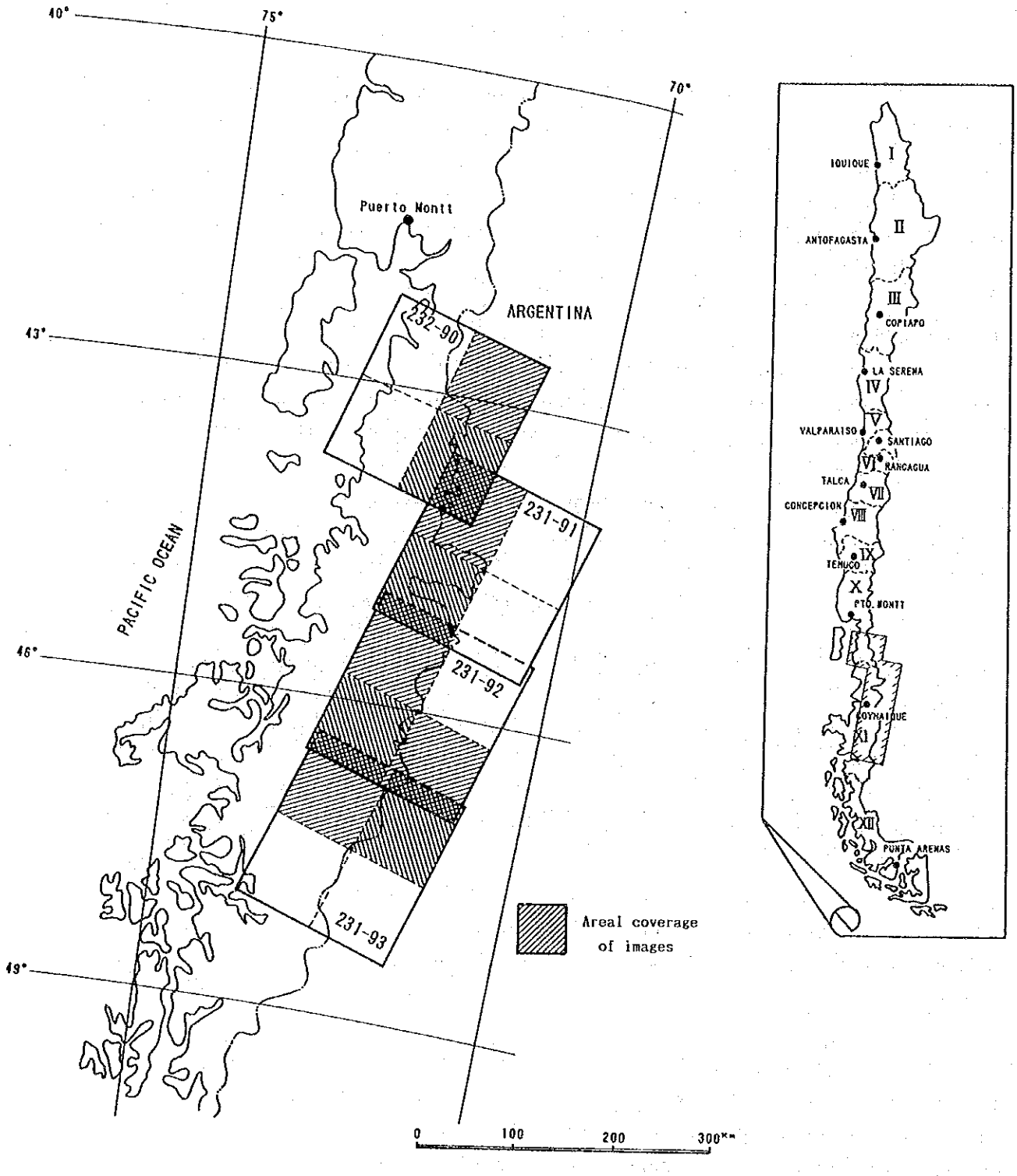
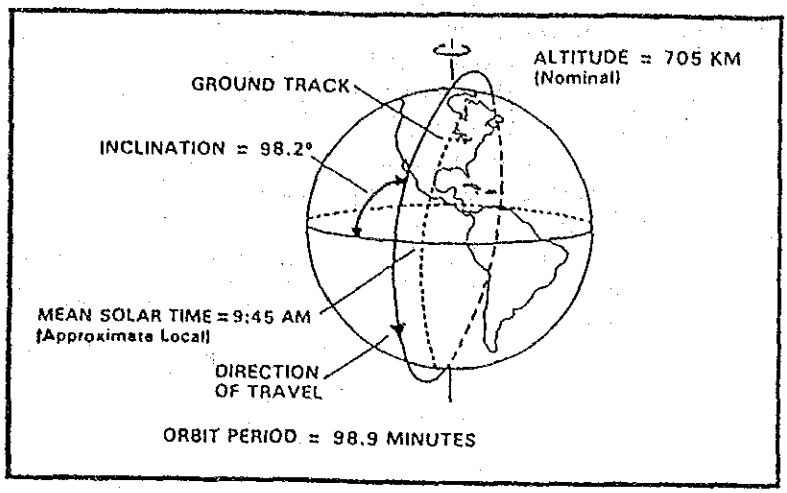


Figure II-1-1 Landsat Images Coverage Map



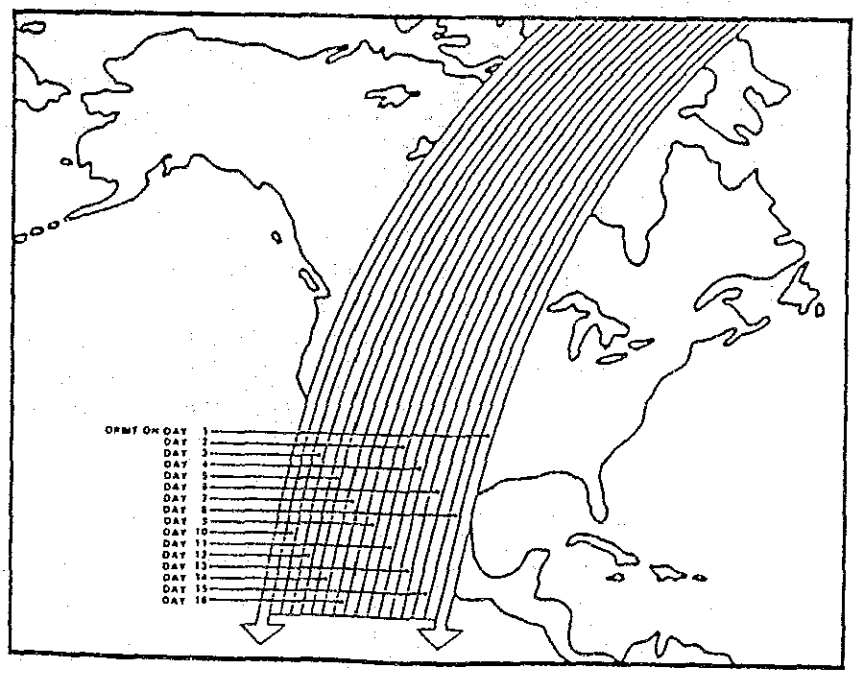


Figure II-1-2 Orbit and Ground Coverage Pattern of Landsat 5

Table Ⅱ-1-2 General Characteristics of Electromagnetic Waves Covered by TM

BAND	WAVELENGTH	CHARACTERISTICS	MAJOR APPLICATION	REMARKS
TM 1	0.45-0.52μm	* Applicable for distinction of coastal and marine zones, and recognition of deciduous tree and conifer. *Susceptible to atmospheric scattering due to short wavelength.	*Study of atmosphere *Ocean environment research	Equivalent to blue-green in visible range
TM 2 and TM 3	0.52-0.60μm 0.63-0.69μm	Good distinction of water and land.	*Vegetation classification and evaluation of plant activity.	TM2 is visible green and TM3 visible red, TM2 coverage overlaps over MSS band4 (0.5-0.6μm), TM3is MSS band5 (0.6-0.7μm)
TM 4	0.76-0.90μm	*High reflectance from plants *Effective for quantitative survey of plants *Radiance from sea and land clearly different	*Topographic classification. *Land use classification(soil, vegetation and geology)	Near infrared range
TM 5	1.15-1.75μm	*Possible for estimation of water content of plants and soil	*Estimation of water content on earth surface *Classification of vegetation	Cloud appear white and snow dark as compared with TM4.
TM 7	2.08-2.35μm	*Effective for distinction of hydrothermal alteration zone		Vegetation and water expressed black, rock and grass expressed white.
TM 6	10.4-12.5μm	*Higher temperature on surface represented by radiance on images, responding to radiared heat from earth surface	*Geothermal distribution *Thermal nature of rocks and soils *Natural environment characteristics	Far (thermal) infrared zone. Instantaneous view range is 120m, four times wider than other bands

In producing false colour images, three bands were selected from seven bands and red, green and blue colours were assigned. Combination of three bands were referred to the characteristics of each band, expected information and the results of the previous research are mentioned below.

Images listed on Table Ⅱ-1-1, are images of full-scenes. These full-scene images also cover Argentina and a part of the western edge which is not in the survey area. Considering that, the full scenes were divided into four

subscenes and nine subscenes which cover the survey area were used for the analysis.

1.3. Band Selection

For producing false colour images, three bands were selected from seven bands as mentioned above. However, the band 6 has a very different range of wavelength and spatial resolution, and therefore this band is excluded from the band combinations. At the selection of three bands from total of six bands, numbers of all combination are up to ${}_6C_3=20$.

Prior to the analysis, some experimental work was carried out examining the techniques for extracting the mineralized alteration zones established through the joint research work of MMAJ-ERSDAC (Earth Resources Satellite Data Analysis Centre) which has been studied since 1982. Some combinations suited for the alteration zones identified by the survey of the first phase were tested.

During the course of the above studies, extraction of alteration zones was attempted for the Antofagasta area, Chile in 1987. This study concluded that the bands 4-5-7 composite image is most useful for the extraction of alteration zone, interpretation of geologic structure and classification of rock unit of that area. Particularly, the alteration zones extracted from the images corresponded to those identified by the surface survey of the Cooperative Exploration Project in 1985.

As a result, this analysis employed the band conbination of 4-5-7 assigning colours to bands as follows; blue for band 4, green for band 5 and red for band 7. An example of false colour image is shown in Figures Ⅱ-1-3 to Ⅱ-1-5.

The characteristic colours are expressed on the false color images by cloud, snow, vegetation and alteration zone. Their histograms of the radiance are shown in Figures Ⅱ-1-6 and Ⅱ-1-7.

1.4. Analytical Methods

Extraction of alteration zones in the seconf phase was carried out with the composite images of bands 4-5-7 mentioned above. This analysis involves rock unit classification and interpretation of lineaments and fold structures paying attention on photogeological characteristics such as tone and texture, and topographical features such as drainage patterns, drainage density, rock

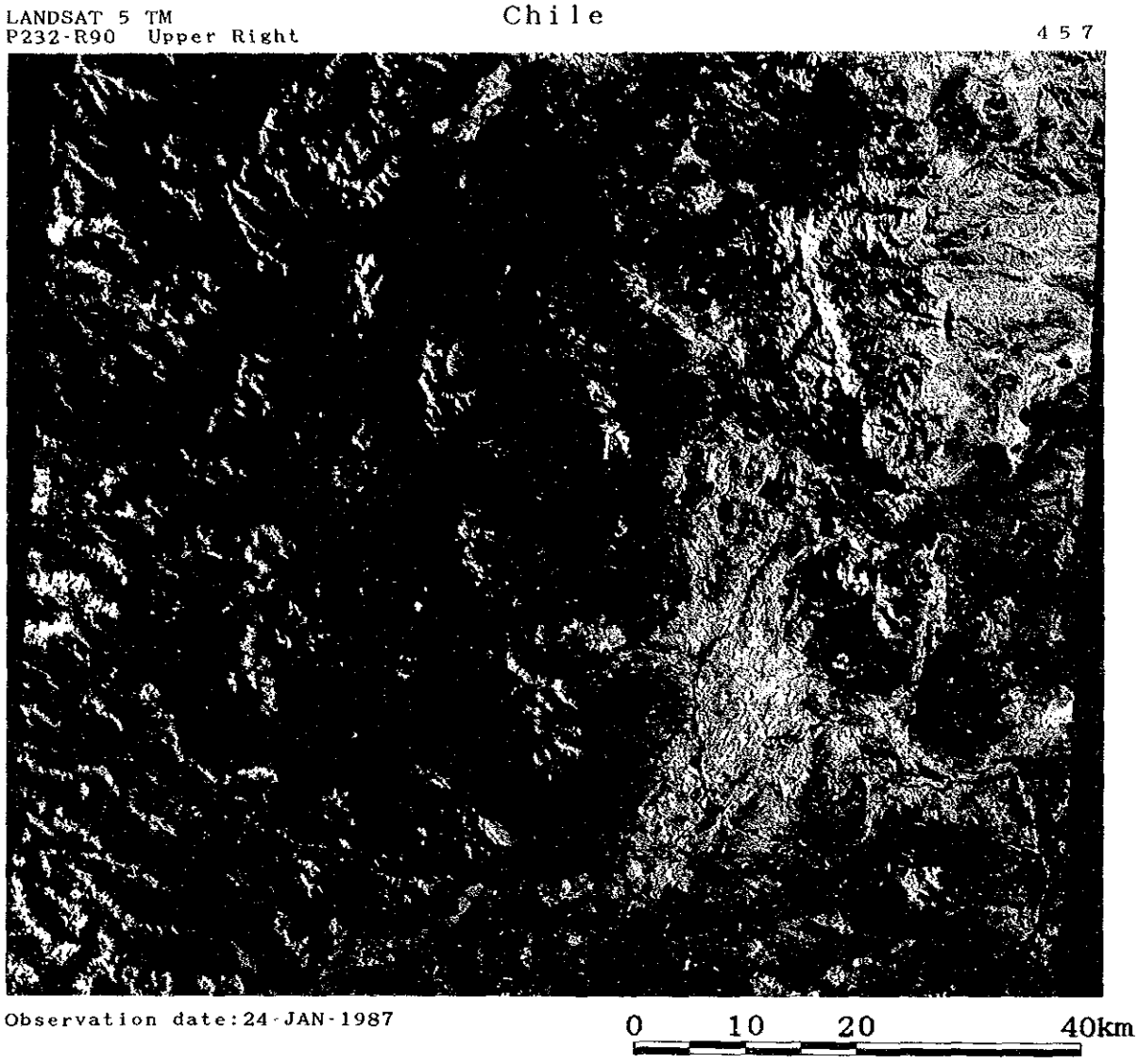


Figure II-1-3 False Color Image covering around the Futaleufu.

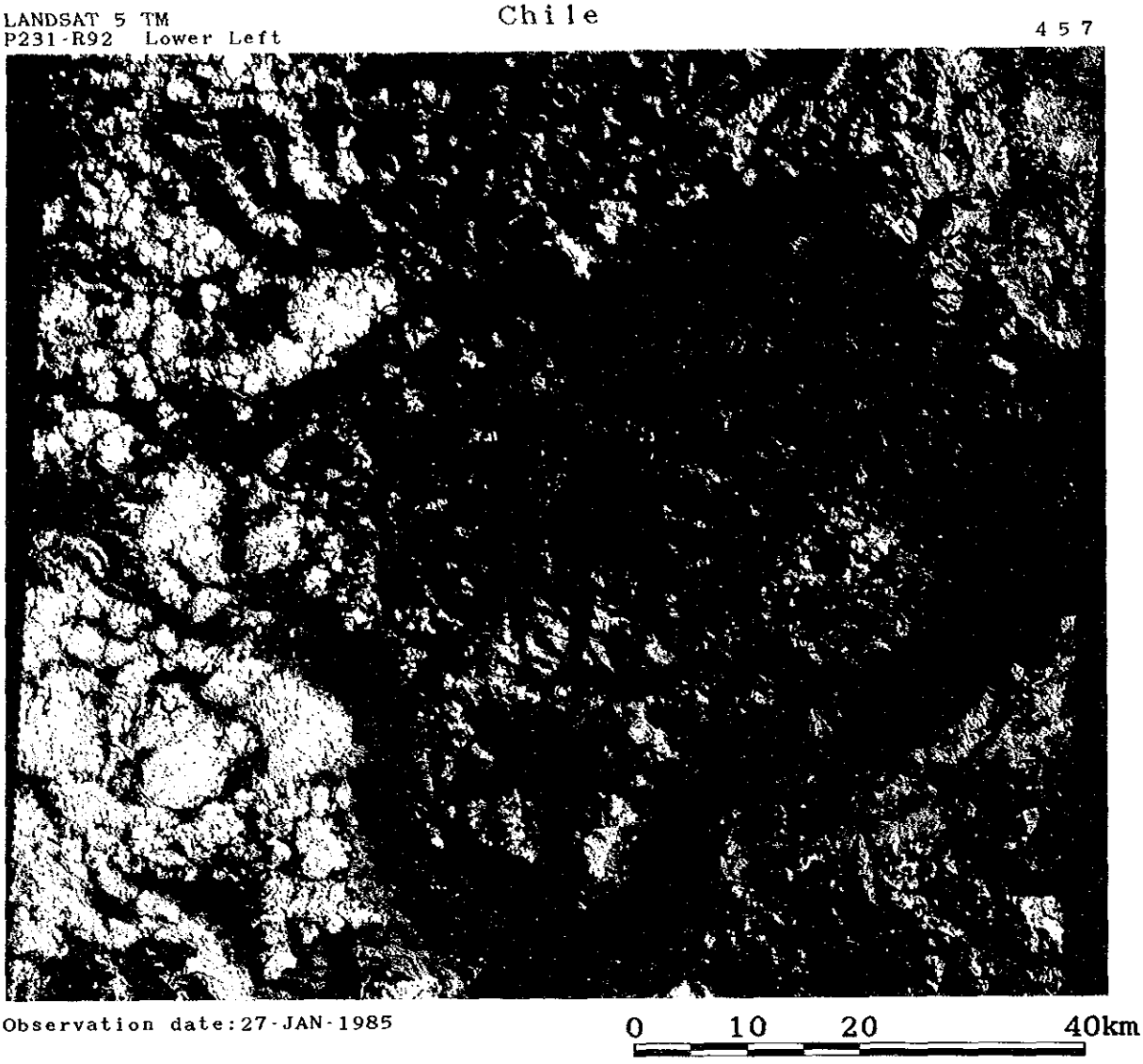


Figure II-1-4, False Color Image covering the North of the Lake General Carrera

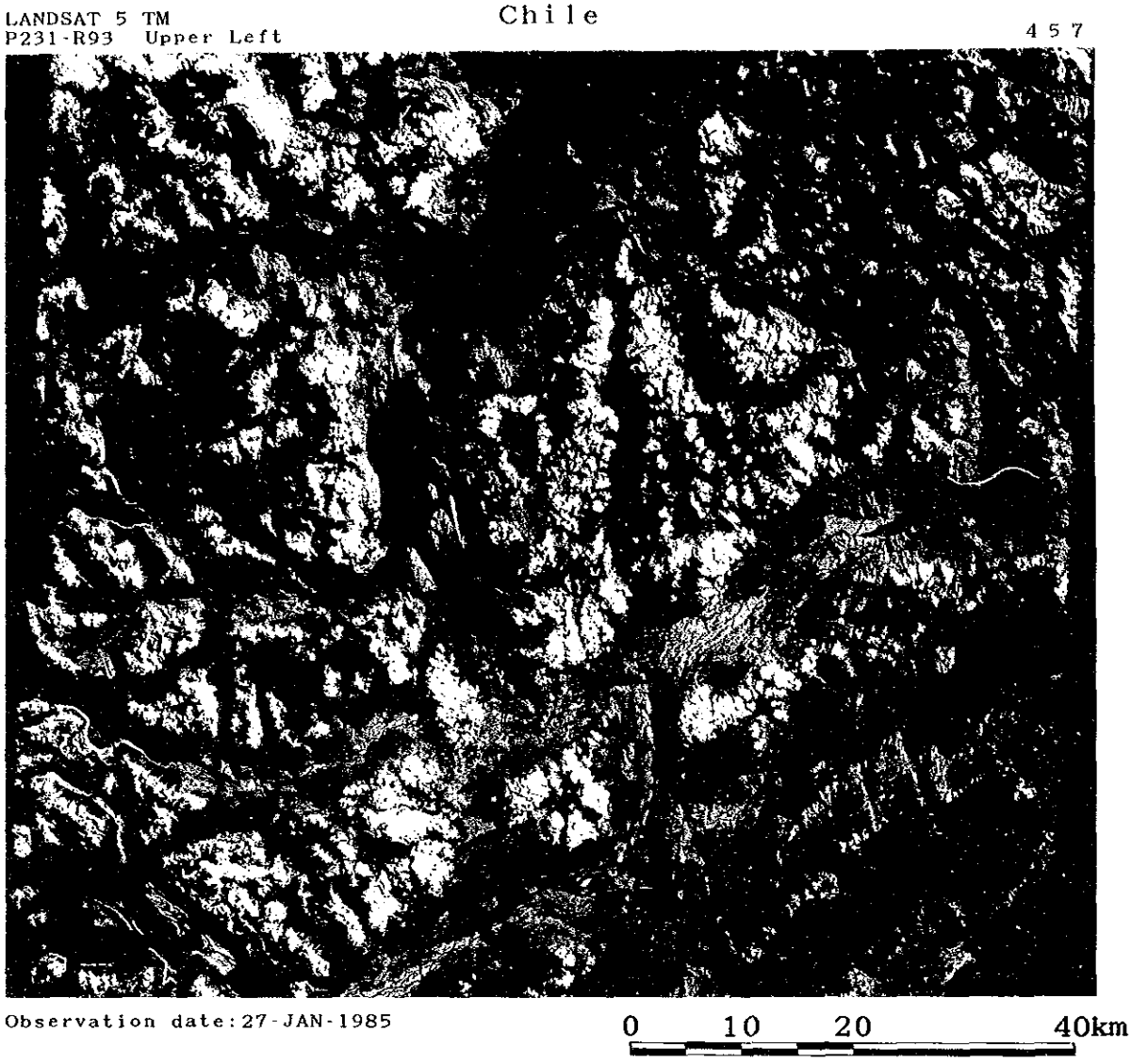


Figure II-1-5 False Color Image covering the South of the Lake General Carrera

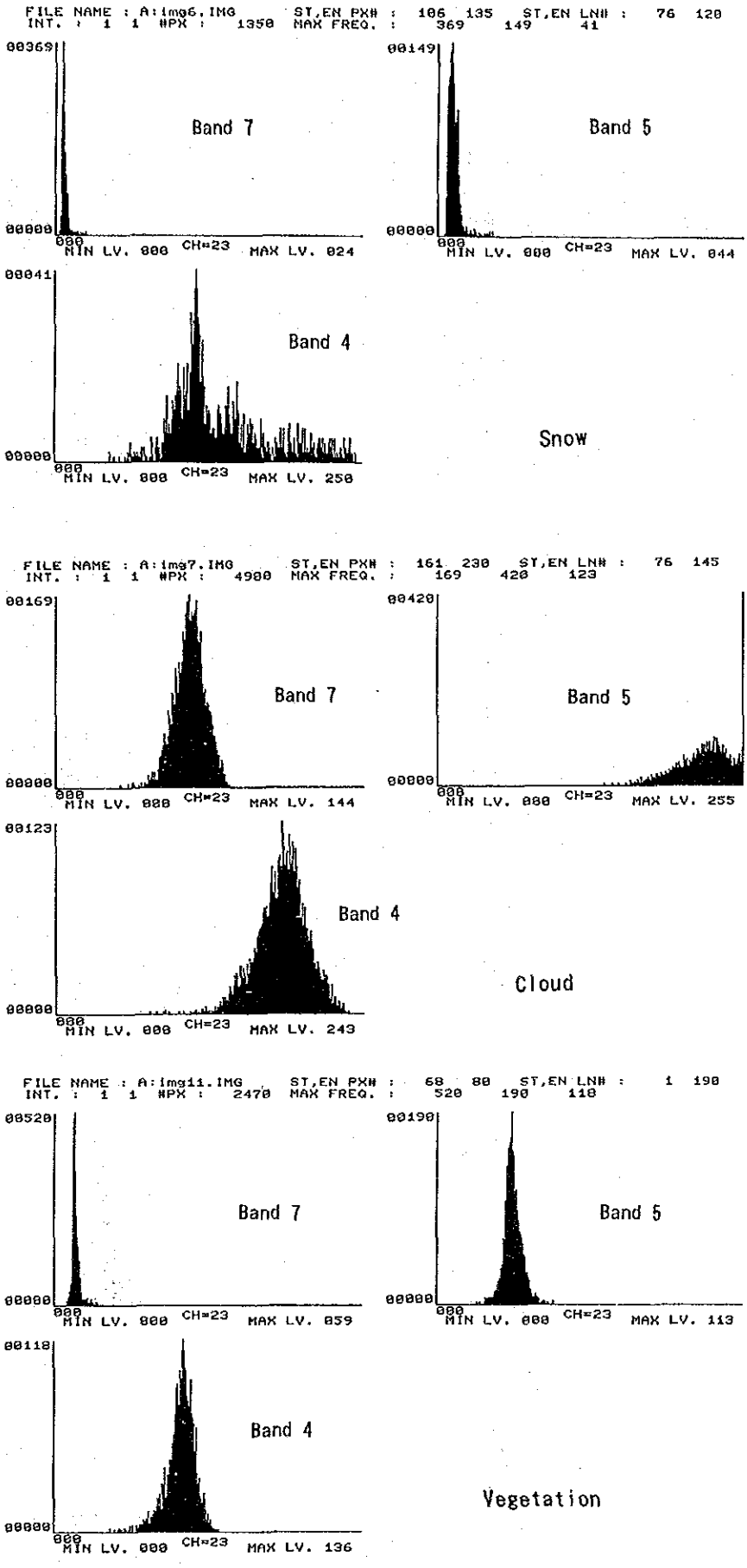


Figure II-1-6 Radiance Histograms of Cloud, Snow and Vegetation at Images

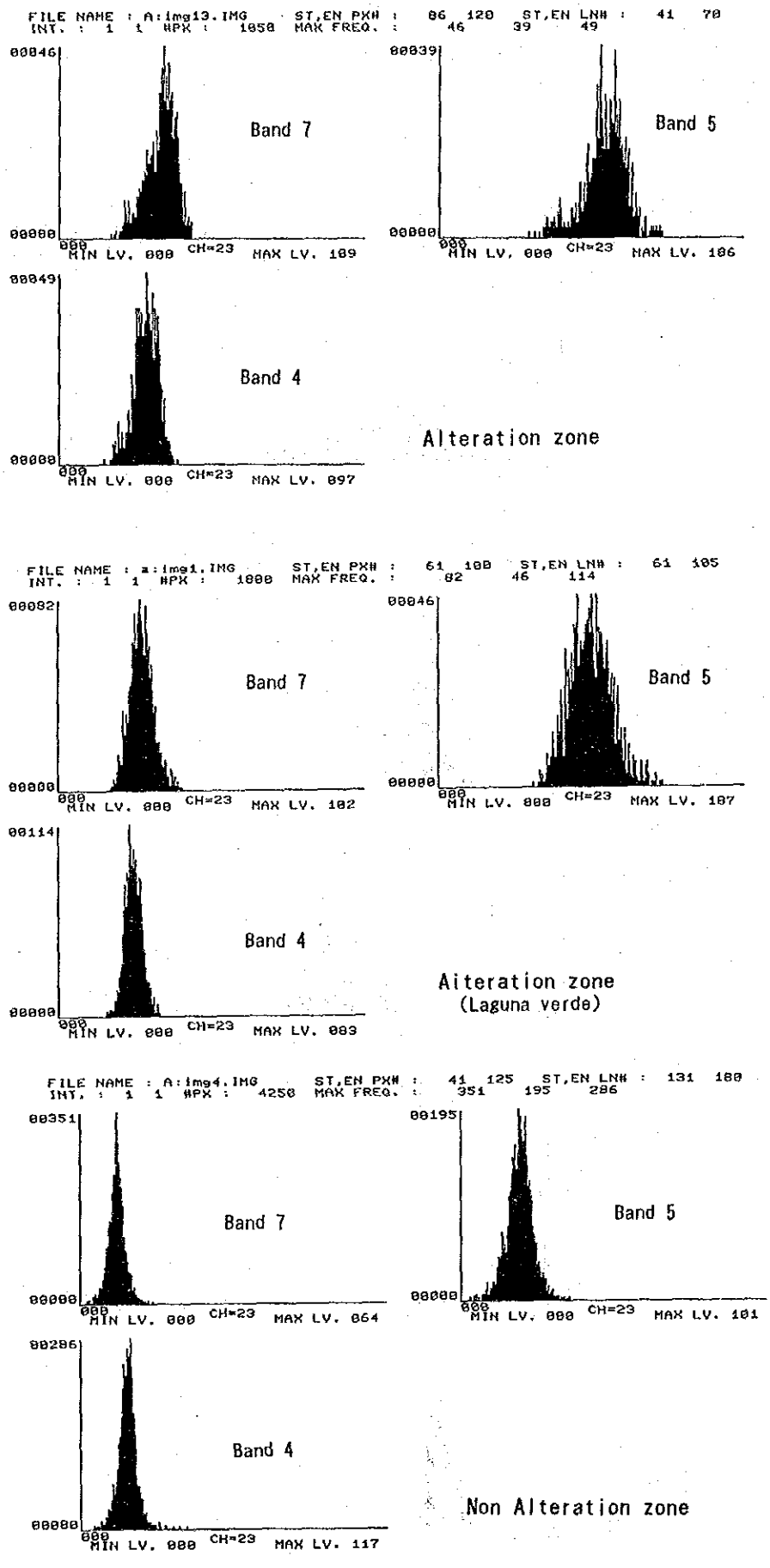


Figure II-1-7 Radiance Histograms of Alteration Zone and Unaltered Zone

resistance and existence of bedding and so on.

Lineamenta are the topographic linear features which suggest the existence of fault, and the main basis of interpretation are as follows:-

(a) Existence of fault scarps
(b) Existence of linear valleys (fault valleys)
(c) Rivers with very linear flow pattern
(d) Existence of kerncols and kernbuts
(e) Linear arrangement of break points of mountain slopes

These topographic features are affected by geology, geologic structure, and the age of the rocks. Thus there are some exceptional features, but the most of lineaments can be understood by empirical interpretation of these topographic features.

1.5. Results of Interpretation

1.5.1. Photogeologic units

A total of eight photogeologic units were delineated as illustrated in Figure Ⅱ-1-8. Unit classification of the Phase Ⅰ was followed in this analysis. The areal extension of this analysis is reduced from that of the Phase Ⅰ as mentioned in the section 1.1. and therefore some of the units outside of the area of this analysis are not included in this description. Their photogeologic characteristics are summarized on Table Ⅱ-1-3 and below:-

a. Unit A

This unit is distributed in the southern part of the area.

Its tone varies, namely pale blue, blue and locally ochre colors. The parts with blue color lie in high altitudes corresponding to the densely vegetated areas. Pale blue color parts are recognized mainly in the plain, mostly meadow. Whereas the ochre parts are correlated to the barren mountains.

Topographic ruggedness of this unit is gentle, and topographic features suggesting bedding or schistosity are developed. This unit locally shows fine crinkle-shaped features.

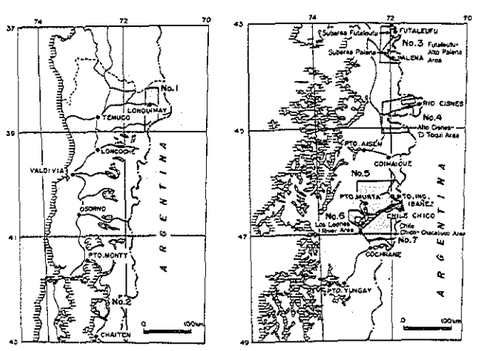
b. Unit B

This unit is distributed from the central to the southern part of the area.

PL. 1

THE INVESTIGATION OF MINERAL POTENTIAL IN THE LOQUIMAY AREA AND REGIONS LOS LAGOS AND AYSEN PHASE II

PHOTOGEOLOGICAL INTERPRETATION MAP OF LANDSAT THEMATIC MAPPER IMAGES



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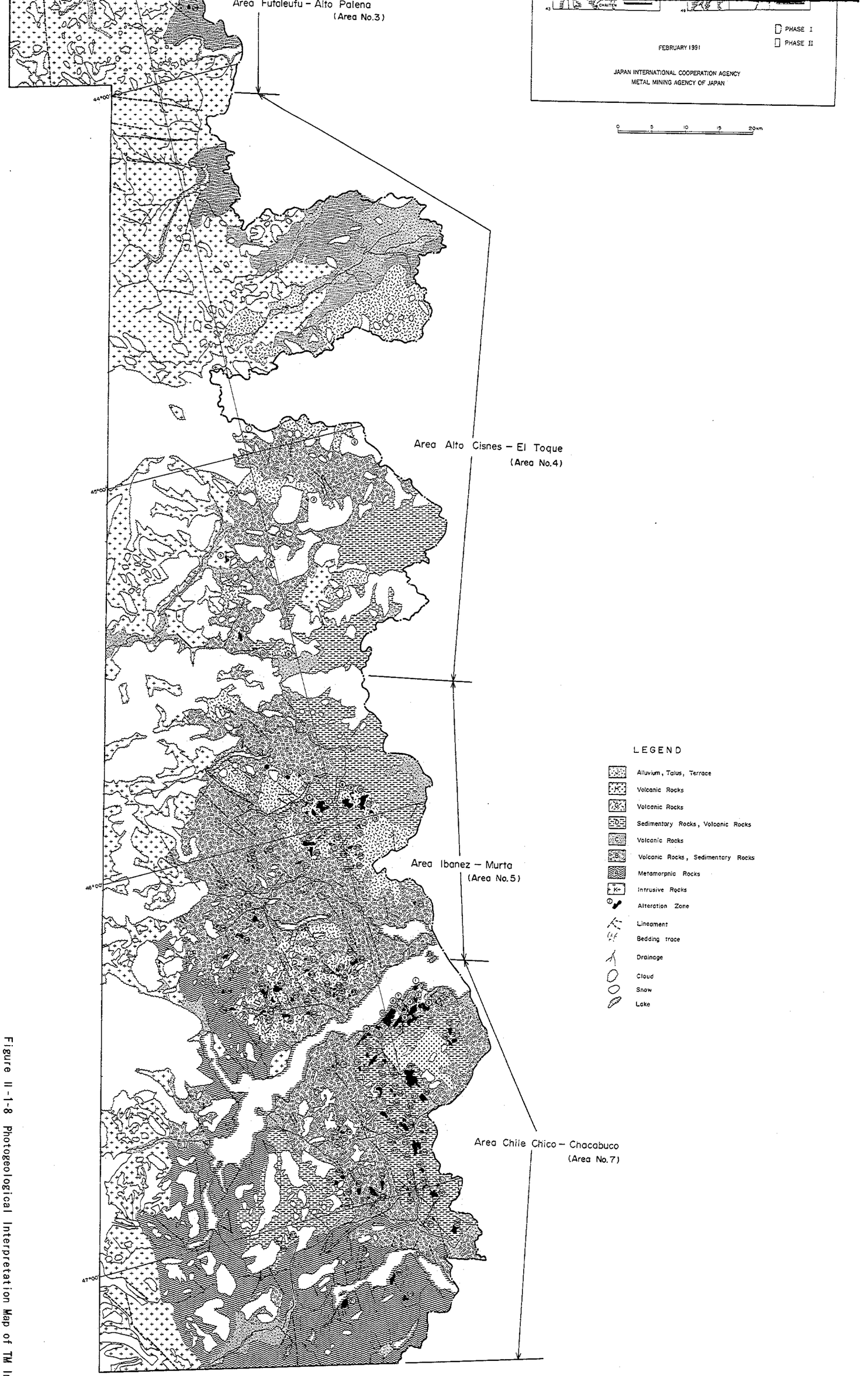
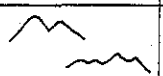


Figure II-1-8 Photogeological Interpretation Map of TM Images

Table II-1-3 Result of Photogeological Interpretation of Landsat TM Images

Unit	Photo-Characteristics		Mophological-Expression					Cover	Conclosion	
			Drainage		Rock Properties					Existing
	Tone	Texture	Pattern	Density	Registance	Cross Section	Bedding	Vegetation	Probable Lithology	Geological data
A	light blue ~ blue	coarse	dendritic	high medium	high low		well bedded	very dense	metamorphic rocks	metamorphic rocks (Paleozoic)
B	red partly whitish gray	fine	dendritic	medium	medium		well bedded	dense~sparse	volcanic rocks sedimentary rocks	volcanic rocks (Jurassic)
C	light blue ~ blue	coarse	dendritic	low	low		partly bedded	dense	volcanic rocks	volcanic rocks, sedimentary rocks (Cretaceous)
D	light blue	fine	dendritic parallel	low	medium~low		very well bedded	dense	sedimentary rocks	sedimentary rocks (Cretaceous)
G	light yellow	fine	dendritic parallel	medium	high		massive	moderate	volcanic rocks	volcanic rocks (Pliocene)
H	dark brown	fine	parallel	very low	medium		very massive	moderate	volcanic rocks	basic volcanic rocks (Quaternary, Terciary)
J	yellowish brown	fine	dendritic meandring	low	very low		none	dense	sediments	alluviam, talus terrace (Quaternary)
K	blue, yellowish gray~gray	coarse	dendritic	high	very high		massive	very dense	intrusive rocks	granitic rocks

Its tone is blue and pale brown. It is considered that the blue parts represent vegetation and the pale brown parts represent the bare mountains.

Gentle topography is featured in the north of the Lake General Carrera and the basin of Ibañez River, while the central area shows rugged topography. Other than this, topography suggesting beddings is recognized around the Port of Ibañez, but topography in the central part is massive.

c. Unit C

This unit lies the area extending from the central to the northern part of the survey area.

Its tones are blue and pale blue. Pale blue part is distributed in the high altitude and the blue part is in low altitude. The topography of this unit features gentle low mountains.

d. Unit D

This unit lies in the area from the central to the northern part of the survey area around the Chile-Argentina border.

Its tone is pale yellow.

Topography of this unit is rugged due to its high rock resistance. The distribution areas of this unit are covered by cloud in many cases, and therefore it was not possible to grasp the whole distribution of this unit.

e. Unit H

Small distribution of this unit is recognized only to the south of the Lake Generral Carrera.

Its tone varies from brown to dark brown. The topography of this unit consists of gentle mountains.

f. Unit J

This unit crops out in many places on small scale. Most are developed along rivers. Its tone shows many varieties such as blue, pale blue and pale brown. The distribution is confined to along rivers, and the rock resistance is low featuring plain topography.

g. Unit K

This unit is broadly scattered from the northern part to the southern part of the area, although the southern half of this distribution is blinded by broad cloud cover.

The tones is mostly blue, although the high mountains in the north show pale blue and pale yellow colors.

The topography is characterized by rugged features due to its high rock resistance.

1.5.2. Extraction of alteration zones

TM images used for this analysis are dominated by whitish and bluish tone throughout the area because of the effects of broad cloud-snow cover and vegetation up to 1,500m in altitude, even in the clearest images available.

As mentioned, the standard for identification was the alteration zone accompanying the Laguna Verde gold deposit and ferruginous alteration zone developed in the north of Chacabuco River which were identified by the surface survey conducted during Phase I.

The Laguna Verde Deposit is an epithermal gold deposit located in the southern coast of the Lake Generral Carrera. Dacitic rocks hosting the deposit are extensively affected by intensive silicification and weak kaolinitization suggesting interaction with acidic (or low K^+/H^+ ratio) solution. This alteration zone extends for 3x5km, generally colored pale yellow. Stockwork of hematite-pyrite-quartz occur in the zone.

As to the climate and vegetation, this area belongs to cold climate zone with much rain and the part up to around 1,500m in altitude are covered by conifer forests. Above this level, surface is bare with sporadic bushes. In the level below 1,500m, surface is covered by thick soil and the plain terrain is grassland. Although the Laguna Verde Alteration Zone lies at the level of 200m in altitude, this is a bare area with merely sporadic bush.

This zone showed pale yellow color on the false color TM composite image.

During the study of MMAJ-ERSDAC, false color TM images of several bands composite for two deposits in areas of arid climate and no vegetation were prepared, the Goldfield Deposit, Nevada, U.S.A. and the Escondida Deposit,

northern Chile. The alteration zones associated with those deposits were expressed as pale green on the same band composite false color images as that of the present analysis.

The alteration zone of Goldfield Deposit carries abundant iron oxide minerals and kaoline group minerals. Spectral patterns of the iron oxides and clays consisting of several clay minerals are illustrated in Figure Ⅱ-1-9 and Ⅱ-1-10 respectively. That study concluded that the rock with these alteration assemblage has reflectance peak at the range of band 5 and absorption peak at band 7 so that green assigned to band 5 was emphasized to indicate greenish color.

The alteration zone of the Laguna Verde Deposit, however, shows different tone, pale yellow. This analysis used this pale yellow color as the standard for determination because this deposit is an important gold deposit in the area and the similarity to this is considered to have significance for exploration.

A total of 173 alteration zones were extracted from the area covered by the images; 26 for Futaleufu-Alto Palena Area, eight for Alto Cisnes-El Toqui Area, 63 for Ibañez-Murta area and 76 for Chile Chico-Chacabuco area. Their distribution is plotted in Figure Ⅱ-1-8, and their characteristics are outlined in Table 2 in Appendix.

As shown in the figure, they are concentrated in the area ranging from Ibañez-Murta area to the eastern part of Chile Chico-Chacabuco area, and they are largely arranged in the N-S direction. The average size is 1x1km with the maximum of 2x5km. These zones occur in the photogeologic units, A, B, C, D and K, and the units B and D host the largest number of these zones. According to the existing geological material, the unit B is correlated to Late Jurassic dacitic and andesitic rocks of Ibañez Formation and the unit D to Early Cretaceous sedimentary rocks and intermediate volcanic rocks of Coyhaique Formation. Also the unit K is correlated to dikes and are distributed in the northern part of the analyseds area.

The central part of the analyzed area is noted the relative lack of these zones. This is not only due to the poor development of the units B and D, but also due to the impossibility of extraction caused by thick and broad cloud cover. Elsewhere very scarce zones are also recognized in the unit A which is correlated to metamorphic rocks.

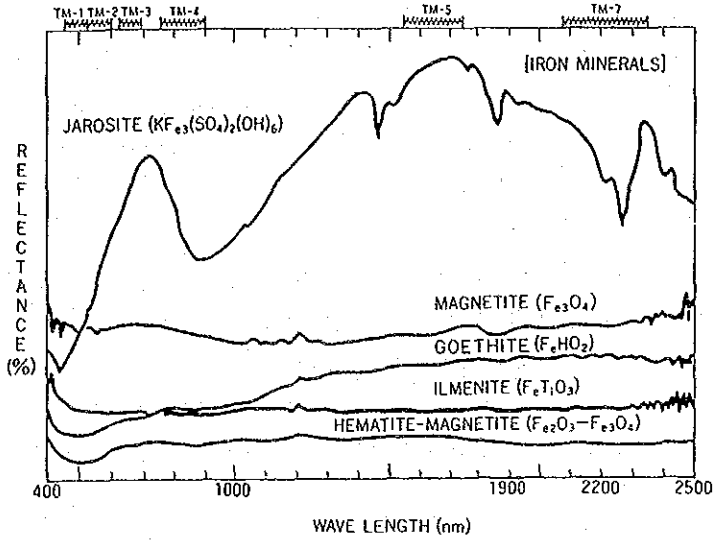


Figure II-1-9 Spectral Reflection Pattern of Iron Oxide Minerals

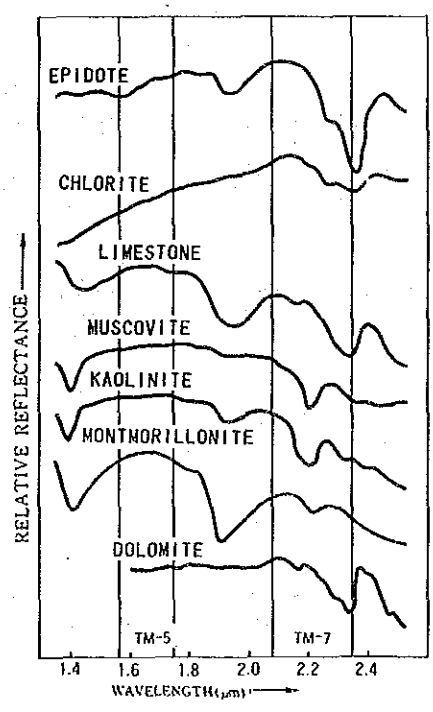


Figure II-1-10 Spectral Reflection Pattern of Intermixed Sample of Clay Minerals and Carbonate Minerals at Short Wave Infrared Range

This distribution pattern shows that the alteration zones are mainly developed in volcanic rocks ranging from intermediate to felsic in composition and partly in sedimentary rocks, and are distributed mainly from Coyhaique to the south of Chile Chico located in the southern part of area. Also it is pointed out that they are arranged in N-S direction under the tectonic control and also the elongation of rock units.

1.6. Comparison with the Results of Surface Survey

Sixteen zones of which occur densely in one sub-area were selected for ground verification survey from total of 173 zones extracted. These 16 zones lie arranged in the N-S direction between about 17km south of the Laguna Verde Deposit in the north and Chacabuco River located in the southern end of the analyzed area. Locality numbers are as follows:-

7-29, 7-30, 7-38, 7-41, 7-42, 7-43, 7-39, 7-40, 7-49, 7-50, 7-52, 7-53, 7-54, 7-55, 7-56 and 7-58

Details of the survey results are described in Chapter 7. Outline is as follows.

Zone 7-29

The whole extracted extension of this zone was not identified, but its locality and shape largely agreed.

Zone 7-30

Locality agreed, but its size was revealed to be twice of that interpreted.

Zone 7-38

Not found.

Zone 7-39

Locality agreed, the whole of this zone was not confirmed due to snow cover.

Zone 7-40

This does not exist at the locality extracted, it consisted of a conifer forest.

Zone 7-42

Alteration zone was found to be about 500m off to the west from the analyzed locality, it turned out to be exposed zone of pale green tuff.

Zone 7-43

Locality identified on surface is about 2km off to the north from the results of the image analysis. This zone consists of many small scattered alteration zones.

Zone 7-49

This was exposed rock zone greyish white color without alteration zone.

Zone 7-50

Locality agreed with the image analysis, but its actual size was about half of the onterpreted result.

Zone 7-52

Locality agreed with the image analysis with two subsidiary small alteration zones.

Zones 7-53, 7-54, 7-55 and 7-56

Alteration zones were found within 1km radius from the localities determined by image analysis, but all were small.

Zone 7-58

Locality agreed with the image analysis and the size was about three times of the interpreted result.

Among the above zones, gold-lead mineralization with a maximum of 6.7ppm Au and 1.1% Pb was found in the Zone 7-39. Details are described in Chapter 7. In many cases, the small zones of 1km or less in diameter were revealed to be in different locality and shape. Meanwhile the pale green tuff turns out to be pale yellow in the false color images and is confused as alteration zone.

CHAPTER 2. PHOTOGEOLOGICAL INTERPRETATION OF AERIAL PHOTOGRAPHS

2.1. Area for Interpretation

The areas investigated by photogeology are the Alto Palena sub-area included in the Futaleufu-Alto Palena area, and the Alto Cisnes-El Toqui area. Their areal extension is shown in Figure Ⅱ-2-1.

2.2. Methods

2.2.1. Data used

Aerial photographs used for the work are black and white photographs of 1:70,000 scale published by the Instituto Geografico Militar de Chile. Total of 89 copies were used for analysis. List of photograph numbers are laid out in Table Ⅱ-2-1.

Table Ⅱ-2-1 List of Aerial Photographs

AREA	PHOTO-NUMBER SERIES	NUMBERS OF COPIES
Alto Palena Sub-area	11604 to 11609	6
	11659 to 11662	4
Alto Cisnes-El Toqui	11622 to 11628	7
Area (Northern Half)	11640 to 11647	8
	11703 to 11709	7
	12402 to 12409	8
	12435 to 12440	6
	12449 to 12455	7
	12466 to 12474	9
	12488 to 12491	4
Alto Cisnes-El Toqui	18516 to 18518	3
Area (Southern Half)	18593 to 18596	4
	12928 to 12933	6
	13008 to 13012	5
	13019 to 13023	6
Total		89

2.1.2. Procedure of analysis

Photogeological interpretation is generally completed through the procedure described below.

① Preparation: Purchase of materials, orientation of the principal points of photographs and collection of the existing geologic data and so on.

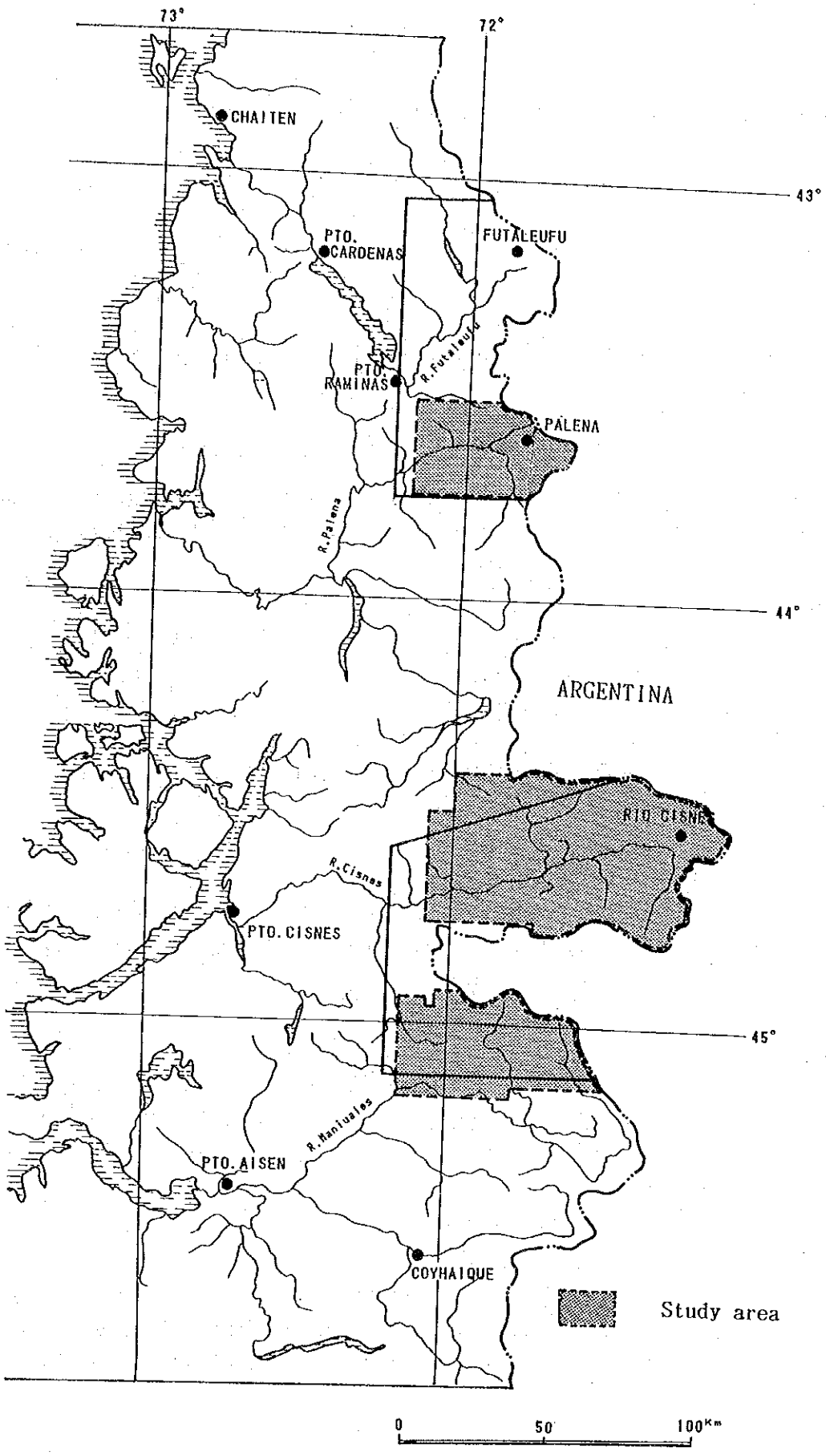


Figure II-2-1 Map showing Aerial Extension of Photogeological Interpetation of Aerial Photographs

② Interpretation and preparation of analysis maps

③ Ground verification

④ Re-interpretation referring to results of the ground verification and collective interpretation.

Emphasis was placed on the following photogeological factors.

a. Tone and texture

b. Geomorphological features; drainage pattern and density, resistance of rock, ruggedness, shape of ridges, existence and density of bedding, and direction and length of lineament.

c. Characteristics of the surface materials, such as vegetation

2.3. Result of Interpretation

2.3.1. Classification of photogeologic units

Photogeological and geomorphological features of each unit are outlined below.

(1) Alto Palena sub-area

Photogeological map is shown in PLATE 2. Six units were defined in this sub-area. Their photogeological and geomorphological features are summarized in Table Ⅱ-2-2.

a. Unit A

This is distributed on a small scale in the north of Palena. This unit occurs enclosed by Unit B. Unit A is distinguished from the Unit B by geomorphological features, such as Unit A forms gentle hills, while the Unit B forms very steep and rugged topography.

b. Unit B

This is distributed from the northern part to near the Chile-Argentina border, the easternmost part of the sub-area. This unit lies mainly on the mountain slopes which are very steep topography. Rock resistance is high.

c. Unit C

Table II-2-2 Result of Photogeological Interpretation of Aerial Photographs in Futaleufu-Alto Palena Area

Unit	Photo-Characteristics		Mophological-Expression					Cover	Conclosion	
			Drainage		Rock Properties					Existing
	Tone	Texture	Pattern	Density	Registance	Cross Section	Bedding	Vegetation	Probable Lithology	Geological data
E	dark	fine	meandering	low	low		none	sparse.	Alluvium	Alluvium
D	dark	fine	subparallel	low	low		low	sparse	Terrace	Terrace
C	dark~ dark gray	fine	dendritic parallel	medium	high		medium	moderate~ sparse	Volcanic rocks Sedimentary rocks	Volcanic rocks
B	medium gray	fine~ coarse	dendritic parallel	medium	high		medium	moderate~ dense	Volcanic rocks	Sedimentary rocks
A	dark	coarse	parallel	low	medium		low	moderate	Volcanic rocks	—
F	medium gray ~light gray	rough	dendritic parallel	high	very high		high	sparse~ moderate	Intrusive rocks	Granitic rocks

This unit is recognized mainly atop mountains distributed from the northern part to the eastern part of the sub-area. The mountain ridges of this unit are narrow and jagged, while the ridges of Unit B are featured wide. Interpretation factors suggesting the existence of beddings are partly observed.

d. Unit D

This unit is distributed on a small scale around the outskirts of mountains. Steep mountain slope usually breaks to turn into gentle slope at this unit showing discordant distribution with the units which overlie on Unit D.

e. Unit E

This is distributed along main rivers. This apparently consists of the recent sediments because of plain topography and its distribution to along the rivers.

f. Unit F

This is broadly distributed from the northeastern part to the southern part of this sub-area. Topography of the unit is steep and ridges are very rugged.

Development of lineaments are most significant in Unit F.

(2) Alto Cisnes-El Toqui area

This area is separated into the northern half and the southern half by the Argentine territory extending into Chile. PLATE 4 is a photogeological map of the northern half of this area and PLATE 5 of the southern half. Eleven photogeologic units were delineated. Schematic photogeological and geomorphological features are summarized in Table Ⅱ-2-3.

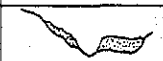
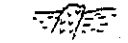
a. Unit A

This delineated in the central part of the both northern and southern halves of the area. This unit in the north is massive, but in the south bedding structure is very significant. Lineaments occur abundantly in this unit.

b. Unit B

This is distributed on a small scale around El Toqui mine located in the southern half of the area. Medium rock resistance is inferred from slightly

Table II-2-3 Result of Photogeological Interpretation of Aerial Photographs in Alto Cisnes-El Toqui Area

Unit	Photo-Characteristics		Mophological-Expression					Cover	Conclosion	
			Drainage		Rock Properties					Existing
	Tone	Texture	Pattern	Density	Registance	Cross Section	Bedding	Vegetation	Probable Lithology	Geological data
G	medium gray light gray	fine, smooth	meandering	—	very low		none	sparse.	Alluvium	Alluvium, fluviam
F	light gray	fine, smooth	meandering parallel	low	low		none	sparse.	Terrace	Terrace
E	medium gray	smooth	dendritic	low	low		none	sparse.	Sedimentary rocks	Volcanic rocks
D	medium gray	fine	dendritic parallel	medium	high		bedded	moderate	Sedimentary rocks	Volcanic rocks Sedimentary rocks
C	dark grey	coarse	parallel	medium	high		massive	moderate	Volcanic rocks	Volcanic rocks Sedimentary rocks
B	dark	rough	dendritic	low	medium		partly bedded	moderate dense.	Sedimentary rocks	Sedimentary rocks
A	dense	rough	dendritic partly angular	high	medium		very well bedded	moderate~ dense	Sedimentary rough	Volcanic rocks Sedimentary rocks
H	light gray	fine	—	—	medium		none	none	Dyke	—
I	light gray	rough	radial	low	high		massive	sparse	Intrusive rocks	Granitic rocks
J	dark	coarse	annular	medium	high		massive	dense	Intrusive rocks	Granitic rocks
K	dark gray	coarse	dendritic parallel	high	very high		massive	moderate	Intrusive rocks	Granitic rocks

rugged hill topography. Gently inclined bedding structure is partly recognized.

c. Unit C

This unit is elongated in the NE-SW direction in the northern half, but in the NW-SE direction in the central part of the southern half. This unit lies over mainly steep mountain slopes. Bedding is rarely observed, and is mainly massive.

d. Unit D

This unit occurs over the high altitude of mountains throughout the area. The topography of this unit is very steep and this is easily distinguished from the underlying units by the change of the slopes. Banded patterns suggesting bedding are observed in many places.

e. Unit E

Distribution is confined to the summits of mountains located in the eastern part of the northern half, and the central part of the both northern and southern halves and around the Chile-Argentina border. Topography is gentle and the texture is very smooth.

f. Unit F

This unit is distributed sporadically in the eastern part of the northern half and scattered in the southern half of the area. This unit is distributed mostly on the mountain slopes, the base of mountains and along rivers. The mountain slopes of this unit is gentle compared with other units on the same mountain. This unit developed along rivers lies on the river banks forming terrace-shaped topography. This unit is distinguished from the other units by these geomorphological features.

g. Unit G

This unit is distributed along rivers throughout the area and underlies the Unit F. This is believed to be recent sediments.

h. Unit H

Small distribution of this unit is recognized in the eastern part of the northern half of the area. This unit is elongated in the E-W direction. The tone of this unit is very and the boundary of this unit is very clear. These elongated distribution pattern suggests it to be dikes.

i. Unit I

This unit occurs scattered in small patches in the eastern and the central part of the northern half of the area. This unit shows somewhat protuding features with rugged topography and light tone. This discordance to other units suggests that these occurrences may be dikes.

j. Unit J

This is broadly distributed in the western part of the northern half of this area. Although the rock resistance is high, this does not form steep high mountains. It occurs in relatively low mountain terrains. Bedding is rarely observed, and is essentially a massive unit.

k. Unit K

This unit in the northern half occurs from the southwestern to the central part of the area elongated in the NE-SW direction, while in the southern half, this unit is broadly distributed in the western part. Rock resistance is very high featuring steep topography. Mountain ridges are jagged. On the other hand, lineaments are well developed.

2.3.2. Geologic structure

(1) Lineaments

i. Futaleufu-Alto Palena Area

Lineaments of this area selectively occur in the Unit F, while few lineaments occur in other photogeologic units as shown in Figure PLATE 2. Their directional trend is dominated by NW-SE and E-W systems.

ii. Alto Cisnes-El Toqui area

Lineaments in this area tend to occur very densely in the units A, J and K. NE-SW lineaments are dominant and continuous in the unit A which are distributed in the northern half of the area, while particular directional trend of lineaments are not recognized in Units J and K and they are usually short. On the contrary, different features are noted in the southern half of the area. That is, no particular direction of lineaments is observed in the Unit A, but the NW-SE lineaments among them have tendency to be relatively continuous. In the Unit K, the NW-SE lineaments are dominant and continuous and also faint lineaments suggesting joints are observed. Unit J distributed in the southern half, lineaments are distributed sparsely.

(2) Fold structure

i. Futaleufu-Alto Palena area

Only few bedding is observed and therefore fold structure cannot be interpreted.

ii. Alto Cisnes-El Toqui area

Only few bedding is observed and therefore fold structure cannot be interpreted in the northern half of the area. On the other hand, an anticlinal structure with the E-W direction is inferred along Cisness River on the basis of the distribution pattern of photogeologic units, younging north and southward.

Although the beddings in the unit A are not traced due to thick vegetation, the development of small fold structures are inferred from the distribution of dipslopes and cuestaslopes. In the unit C, both dipslopes and cuestaslopes are observed in the high altitude and from their distribution, synclinal structure is inferred to exist.

2.4. Comparison with the Results of Surface Survey

2.4.1. Futaleufu-Alto Palena area

The unit A was at first interpreted as volcanic rocks, but it turned out to be alternating beds of sandstone and shale. Distribution of the units interpreted frpm aerial photographs largely agreed with the results of surface survey. Although the rock unit classification for units B and C was basically correct, consisting of andesitic volcanic rocks, but a part of this units in the western part was granite.

The survey on Units D and F agreed well with interpretation. Unit F, interpreted as granitoids, turned out to extended larger than interpretation. Meanwhile granitoids with good development of joints were very difficult to distinguish from the stratified rocks. Re-compiled photogeological map corrected after the results of the ground verification is shown in PLATE 3.

2.4.2. Alto Cisnes-El Toqui area

Surface survey was carried out only in the northern half of the area. The major differences from the interpretation are the following points.

i. The units B, C and D were interpreted as volcanic rocks lying around Moro River and Pedregoso River which are southern tributaries of Cisnes River. However, it was revealed that they are granitoids. Topographic differences are

usually recognized between granitoids and volcanic rocks because of the difference of rock resistances. However extensive development of glaciers eliminated the manifestation of the difference in the resistance of both rocks and thus it was difficult to interpret the lithology accurately.

ii. The Units J and K, were both interpreted as intrusive granitic bodies. Their ages were originally distinguished as younger body (Unit J) and older body (Unit K) with the assumption that the more fractured unit K would be older. But the surface survey revealed that the both units belong to the same quartz monzonite body.

On the basis of the results of the surface survey, photogeological map was re-compiled as shown in PLATE 6.

CHAPTER 3. THE FUTALEUFU-ALTO PALENA AREA (FUTALEUFU SUB-AREA)

3.1. Geology

Figure Ⅱ-3-1 is geological map of this sub-area. This area is geologically characterized by intermediate volcanic rocks intruded by granitic rocks.

3.1.1. Stratigraphy

The geological sequences in the area consist of Upper Jurassic, Upper Cretaceous and Quaternary sequences in ascending order. No basement unit crops out in the area. Schematic stratigraphic succession is illustrated in Figure Ⅱ-3-2.

(1) Upper Jurassic

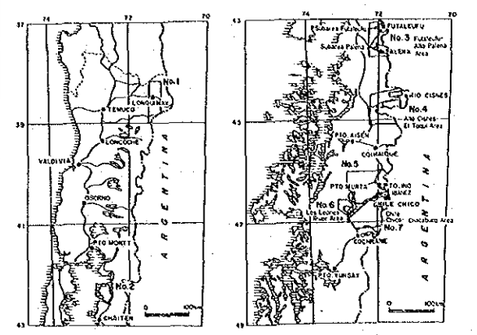
This sequence consists mainly of andesitic ejecta. They are divided into two members, namely the lower member composed mainly of pyroclastic rocks and the upper member of lava.

The lower member crops out around the Futaleufu and its vicinity to the south of the town. The upper member is distributed broadly throughout the survey area. The base of the lower member is not exposed, therefore although at least 1,000m are estimated, the total thickness is not known. Thickness of the upper member is estimated to be at least 1,700m, although its upper limit is not confirmed.

PL. 7

THE INVESTIGATION OF MINERAL POTENTIAL
IN THE LOQUIMAY AREA AND REGIONS LOS LAGOS AND AYSEN
PHASE II

GEOLOGICAL MAP OF FUTALEUFU-ALTO PALENA AREA
(SUB-AREA FUTALEUFU)



FEBRUARY 1991

JAPAN INTERNATIONAL COOPERATION AGENCY
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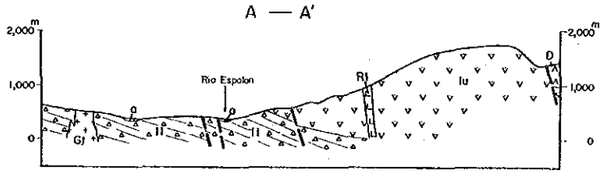
0 4km

LEGEND

Quaternary	Alluvium, Terrace and Moraine		a
Late Cretaceous	Divisadero Formation		D
Late Jurassic	Ibañez F. Upper member		Iu
	Ibañez F. Lower member		Il

Intrusive Rocks

Rhyolite		Rl	
Loncopan Stock		Tl	
Futaleufu-Palena Batholith		Gt	
Fault			
Bedding			
Vein			
Hydrothermal Alteration			
Mineralization			



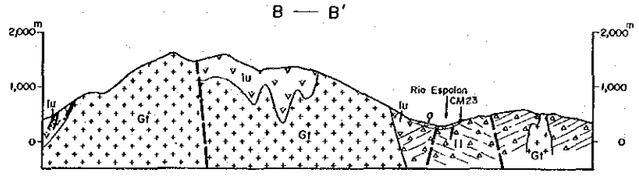


Figure II-3-1 Geological Map of Futaleufu Sub-Area

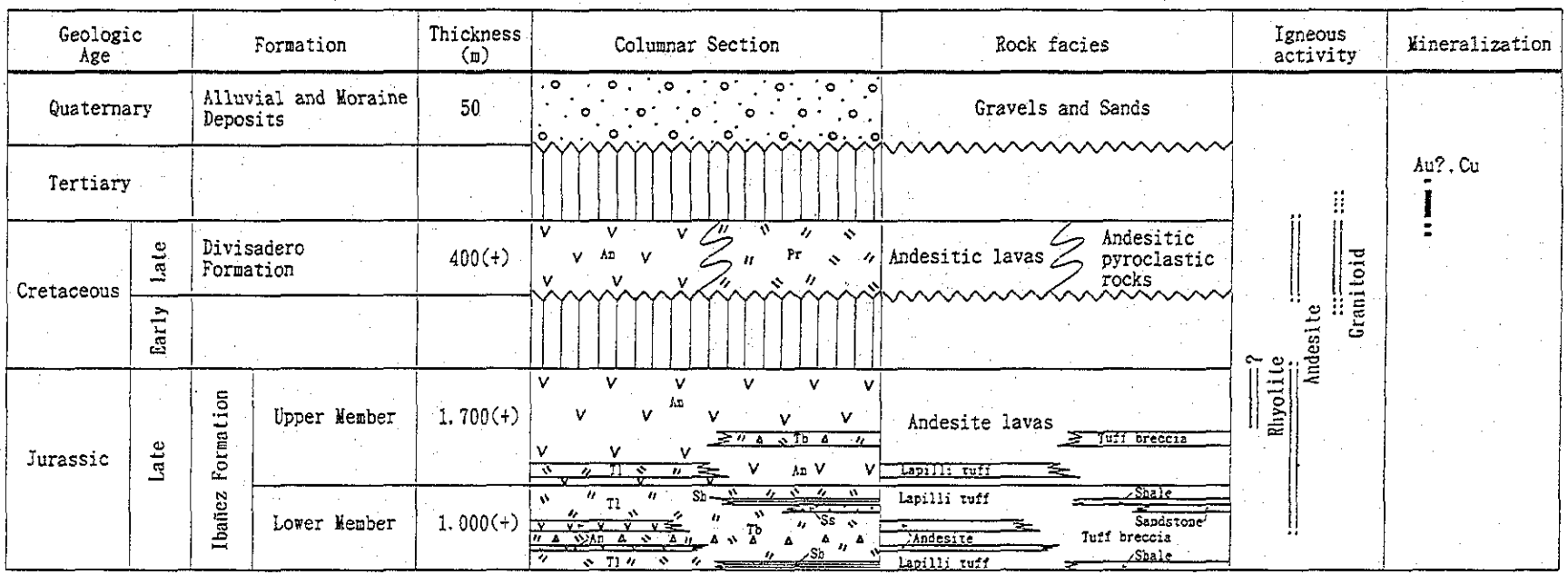


Figure II-3-2 Schematic Diagram of Stratigraphy in Futaleufu Sub-Area

The lower member is composed mainly of lapilli tuff, tuff breccia and interbeded thin beds of andesite lava, fine tuff, tufaceous sandstone and tuffaceous shale. Lapilli tuff and tuff breccia are generally hard with green, yellowish green and greenish brown color. They contain andesitic angular and sub-angular volcaniclastic materials of 2 to 5cm in diameter. Andesite lava is hard and aphanitic with pale green color.

Sandstone is fine to medium-grained and tuffaceous with yellowish green color. Shale is tuffaceous with grey or greenish grey color. Distribution of these sedimentary rocks is confined to the zone located about 700m northwest of Futaleufu. These sedimentary rocks are interbedded in lapilli tuff.

The upper member consists dominantly of andesite lava, while andesitic pyroclastic rocks (mainly lapilli tuff) are interbedded in the lower portion. Lithological features of andesite in this member are the same as those of andesite in lower member. The rocks of this member are extensively affected by chloritization throughout the area, whereas more extensive chloritization and epidotization are recognized near the contact of andesite and granitic rocks.

Field evidences regarding the age of sedimentation could not be found by this survey. Thiele et al.,(1978) however, concluded that this sequence is of the Late Jurassic and correlated it to the Ibañez Formation. Most of the upper member is believed to be of terrestial origin, but the lower member is assumed to have deposited under continental environment.

(2) Upper Cretaceous

The rocks of this sequence are distributed around the Chile-Argentina border. The distribution extends across the border and is larger in Argentina than in Chile where it is confined to the area in the east of the Paso Arroyo Huemul. Thickness of this sequence is estimated to be at least 400m, but the total thickness is unknown because the top is not confirmed.

This sequence consists of alternating beds of lavas and pyroclastic rocks. Lava is hard and compact with greenish grey color. Pyroclastic rocks are generally alternating thin beds of greenish yellow rocks grading from fine tuff to tuff breccia. Stratification is well developed and nearly flat. This sequence unconformably overlies the Upper Jurassic sequence.

The age of this sequence is not clearly identified by field data. However, it is pointed out that the rocks of this sequence resembles the