Divisadero Formation of Late Cretaceous distributed around Coyhaique city in both lithological features and geologic structure. Therefore, Late Cretaceous time is assumed for the age of this sequence in this report and a correlation between this sequence and the Divisadero Formation is assumed.

(3) Quaternary

Quaternary sequences consist of alluvium, alluvial fan sediments and river terrace deposits distributed along rivers. They consist of unconsolidated sand and gravel, and are about 50m thick.

3.1.2 Intrusive rocks

Intrusive rocks distributed in this area are mainly felsic rocks. Three rock types are recognized, namely granite, tonalite and rhyolite. Granite intrusive body occupies particularly large areas, about 60% of the whole area. Thiele et al.(1978) named this intrusive body the Futaleufu-Palena Batholith and also named tonalite intrusive body the Lonconao Stock. Rhyolite are dikes and distributed sporadically.

(1) Futaleufu-Palena Batholith

The rocks are generally hard with greyish white and greenish grey color. Major rock-forming minerals are coarse-grained and subhedral quartz, plagioclase, biotite and amphibole. The rock types range from granite to quartz monzonite. Chemical composition of the typical rock of this batholith is listed below:-

Chemical Composition of the Typical Rock Sample (YR311) in the Batholith

SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	BaO
64.60	0.62	15.26	1.85	1.92	0.03	1.44	2.42	3.49	3.47	0.17	0.04

expressed as weight percents

Ratios of several elements are as follows:-

FeO/MgO; 2.48, Na_2O/CaO; 1.44, (K_2O+Na_2O+CaO)/Al_2O_3; 0.93

Differentiation Index calculated from normative composition is 73.7 showing advanced differentiation stage.

Upper Jurassic sequence is intruded by this batholith and affected by the intensive thermal alteration which generated veinlets and disseminations of epidote.

The radiometric dating work was carried out during this second phase. Radiometric age determined by K-Ar technique is 109±4Ma suggesting Middle Cretaceous for the consolidation age of the rock.

(2) Lonconao Stock

Only several small stock bodies are distributed in the southern part of the area. Thiele et al.,(1978) named the stock at the south end of the Lake Espolon the Lonconao Stock. The rocks are hard and compact with dark green and green color consisting of fine-grained minerals. These rocks are identified as tonalite.

Typical chemical composition is as follows:-

Chemical Composition of the Typical Rock Sample (YR306) in the Lonconao Stock

SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	BaO
57.51	0.96	17.88	4.22	3.43	0.19	3.33	5.03	4.99	2.02	0.25	0.06

expressed as weight percents

Ratios of several elements are as follows:-

FeO/MgO; 2.17, Na_2O/CaO; 0.99, $(K_2O+Na_2O+CaO)/Al_2O_3$; 1.06

Differentiation Index calculated from normative composition is 59.8.

The radiometric dating work was carried out during this Phase as well. Radiometric age determined by K-Ar technique is 112±3Ma suggesting Aptian Series of Early Cretaceous for the consolidation age of the rock.

3.1.3. Geologic structure

Structure of the lower member of the Upper Jurassic sequence is clearly identified from well developed bedding. Its attitude is generally N60°W,30-50°N, though many minor faults disturb the attitude in the southern part of the area. Structure of the upper member is not clear because it consists mainly of massive andesite, while the attitude of the lower member is largely parallel to the general attitude of pyroclastic rocks interbedded into andesite lava at lower portion of the upper member.

Lineaments are extensively developed in the area. The E-W and N-S systems are developed dominantly in the lower member of the Upper Jurassic sequence. Some of the lineaments have dislocated beds and are considered to be faults.

On the other hand, there are two lakes side by side elongated in the NW-SE direction, namely the Lake Espólon and the Lake Noroeste, in the western part of the area. Their topographic features suggest they are tectonic valleys.

3.2. Mineralization

Mining and exploration activity are hitherto unknown in the area. Twenty indications of mineralization, however, are observed as shown in Table 6 in Aeendix. Their localities of them are illustrated in PLATE 16. These indications were discovered during the work of both phases and have not been explored by either drilling or adits.

There are many varieties of mineralization in this area such as vein, dissemination and network. Principal ore mineral assemblage is hematite(rarely specularite)-pyrite-chalcopyrite-galena-sphalerite. In many cases, pyrite is transformed into limonite. Gangue minerals are mainly quartz, but calcite and chlorite occur in rare cases.

Veins occur mainly along the coast of the Lake Noroeste and are 0.2 to 0.5m wide. Major mineral assemblage is pyrite and rare amount of chalcopyrite and copper oxide minerals. Most of the country rocks are andesite of Ibañez Formation. Veins, in the most cases, fill the weak fissures related to joints of rocks. Assays on ore outcrops show low grades with exceptions in two outcrops showing notable grades of gold and copper as listed below. All assay results are shown on Table 7 attached in Appendix.

FM327	(0.3m wide)	200ppb Au	4.30% Cu
KM311	(0.05m wide)	2.4ppm Au	1.26% Cu

The locality FM327 is located on the coast of the Lake Noroeste and the locality KM311 crops out beside the main road located at 4km southwest of Futaleufu. The veins strike mainly N-S.

Stockwork and dissemination mineralization are developed in the granitic rocks and their periphery. Width of these mineralized zones range from 0.5 to 20m. The principal minerals are mostly pyrite, and sometimes accompanied by quartz, calcite and monor amount of chalcopyrite. Those mineralization is often associated with faint silicification and argilization. The mineralized zones extend to a maximum of 200-300mx200-300m including the peripheral alteration zones. Degrees of alteration is generally weak, and alteration minerals are mainly sericite rarely accompanied with small amounts of kaoline group minerals and chlorite.

The trend of stockwork and disseminated mineralization is not very clear. Assays on these indications shows low grades as indicated on Table 6 attached in Appendix.

3.3. Geochemical exploration

Panning geochemistry was employed for this phase survey targetting gold and silver.

(1) Sampling and assay

Samples were basically collected from immediately above the bedrock or clay bed where heavy detrital minerals, especially gold grains are concentrated. About 20grams of samples were concentrated by panning from about 8kg of stream sediments. Total of 131 samples were collected. Localities of samples are illustrated in PLATE 24.

Samples were assayed for seven elements (Au, Ag, Cu, Pb, Zn, Mo and As) at the SERNAGEOMIN Laboratory. The detection limits and analytical methods used are compiled in the following Table.

Analytical Methods and Detection Limits

Elements	Methods	Detection Limits	
		Lower Limit	Upper Limit
Au	AAS-MIBK extraction	20ppb	20ppm
Ag	AAS	0.1ppm	100ppm
Cu	AAS	1ppm	10,000ppm
Pb	AAS	1ppm	5,000ppm
Zn	AAS	1ppm	10,000ppm
As	AAS	2ppm	10,000ppm
Mo	AAS	1ppm	10,000ppm

NOTES: AAS;Atomic Absorption Spectrometry, MIBK; Methyl isobutyle keton.

(2) Statistical data-processing

i. Caluculation

Considering the geologic similarity of the source areas, all data from this area were treated as a single population. In cases when the contents were below the limits of detection, half of the detection limit values were used.

ii. Elemental statistics

Analytical values are listed in Table 9, Appendix. Elemental statistical parameters are indicated on Table 3. They are expressed as real numbers converted from logarithmic values. Characteristic features are as follows:-

Au

The maximum value is 27,000ppb and the minimum is 10ppb. Mean value is 20ppb. The content of 76% of 131 samples are below the detection limit.

Ag

The maximum value is 15ppm and the minimum is 0.05ppm. Mean value is 0.3ppm. Although the number of samples with content the below detection limit is only four, the content is generally very low level.

Cu

The maximum value is 766ppm and the minimum is 3.3ppm. Mean value is 24.5ppm. Very low level values were obtained for the paned concentrate samples.

Pb

The maximum value is 404ppm and the minimum is 0.5ppm. Mean value is 5.1ppm. Very low values were obtained for the paned concentrate samples.

Zn

The maximum value is 290ppm and the minimum is 20ppm. Mean value is 79ppm. No sample contained the metal below the detection limit, but all values are generally low level.

Mo

The maximum value is 34ppm and the minimum is 0.5ppm. Mean value is 1ppm. The content of about 50% of samples are below the detection limit.

As

The maximum value is 100ppm and the minimum is 1ppm. Mean value is 1.6ppm. The content of about 80% of samples are below the detection limit.

iii. Frequency distribution

Figure Ⅱ-3-3 illustrates the frequency distribution pattern for each element. X-axis is expressed as logarithm scale. A group of elements Zn, Cu and Ag seem to follow a log-normal distribution. As to Au, its pattern is considered to be log-normal with low-peak at around 200ppb other than the high-peak below the detection limit. The frequency distribution pattern of Pb has no peak. The peak of the frequency of Mo is below detection limit and its frequency tends to decrease toward higher values. Arsenic has a peak below detection limit as well, but the frequency at detectable level show very flat distribution with small frequencies.

iv. Correlations

Correlation coefficients of element pairs are shown in Table 4 in Appendix. Pairs with coefficients of 0.5 or more are as follows:-

Pb-As: 0.61984 Cu-Pb: 0.61733 Cu-As: 0.60639 Cu-Ag: 0.51176

It is noted that the pair Pb-Zn shows very low correlation coefficient, 0.18431, although this pair is generally believed to be well correlated. This leads to an assumption that the mineralization in the area is not characterized by Pb-Zn combination. This assumption is also suggested by Principal Component Analysis mentioned below.

v. Principal Component Analysis

Principal Components were interpreted in order to examine the interactions between various geochemical constituents and find the most efficient linear combination. The calculated eigen vectors and eigen values are shown on Table 5 in Appendix. Principal components are interpreted with eigen vectors as follows:-

First principal component

All eigen vectors are 0.5 or less, but are relatively high for four elements, Ag, Cu, Pb and As. Thus, this component is believed to express the variance of these elements.

Second and third principal component

Eigen vectors of Au and Zn are relatively high. These principal components express the variance of Au and Zn.

This does not express the variance caused by mineralization, but the metal content of the source area.

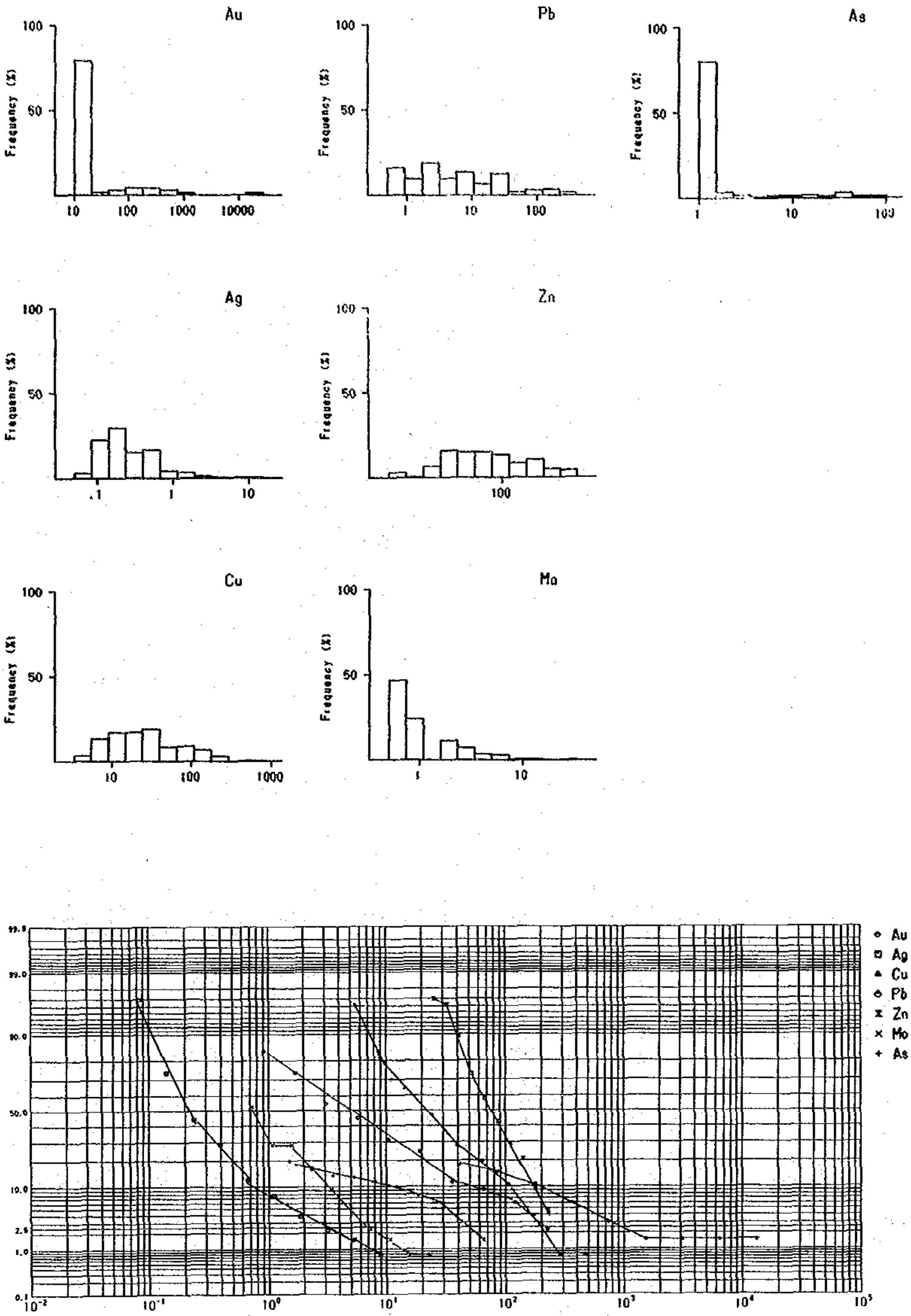


Figure Ⅱ-3-3 Histograms and Cumulative Frequency Curves showing Frequency Distribution Patterns of Assays on Pan Concentrate Geochemical Samples Collected in Futaleufu Sub-Area

(3) Geochemical anomalies and anomalous zones

i. Threshold

The value $m+2\sigma$ was used for threshold value, where m is mean value and σ is standard deviation. Threshold values for each element are listed below.

Threshold Values

Elements	Threshold Values
Au	389ppb
Ag	1.7ppm
Cu	191.1ppm
Pb	151ppm
Zn	252ppm
Mo	5ppm
As	14ppm

ii. Anomalous zones

The numbers of sample points with geochemically anomalous values is as follows:-

Number of Geochemically Anomalous Points

Elements	Numbers
Au	8
Ag	6
Cu	3
Pb	6
Zn	2
Mo	7
As	12

NOTE: Total number of sample points are 131.

Localities of their anomalous points are illustrated in PLATE 20. Major features concerning their distributions are summarized as follows:-

Au

Gold anomalies are distributed sporadically in the zone of granitic rocks.

Ag

Distribution behavior is the same as that of gold.

Cu

Copper anomalies are very sporadically scattered throughout the area.

Pb

Lead anomalies are sporadically distributed from central to northern part of the area.

Zn

There are only two anomalies. They are solely distributed in the up-stream of Bella Vista River and down-stream of Noroeste River.

Mo

Molybdenum anomalies are somewhat densely distributed in the basin of Bella Vista River.

As

Arsenic anomalies are detected in El Craudio River, Bernardo River and Corrido Grande River with small distribution of a few anomalies.

3.4. Evaluation

Figure II-3-4 is collective interpretation map summarizing the geology, tectonics, mineralization and results of geochemical survey. From this map, the features of mineralization in this area are outlined as follows:-

No clear structural control is recognized in either ore outcrops or alteration zones. Major mineral indications and alteration zones occur in the rocks near intrusion of the Futaleufu-Palena Batholith. Those country rocks accompanied epidote, chlorite, calcite and rarely small amount of actinolite and albite which were generated by thermal metamorphism caused by intrusion. This thermal event may have been favorable for convection of hydrothermal ore solution. However, evidences indicating the occurrence of economic mineralization was not found.

The elements examined by the geochemical survey are grouped into two groups, namely Ag-Cu-Pb-Zn-As group and Au-Mo group based on the correlation. As shown in Figure II-3-4, the high Au-Mo anomaly zones are largely overlapped with the Futaleufu-Palena Batholith which is broadly distributed in the

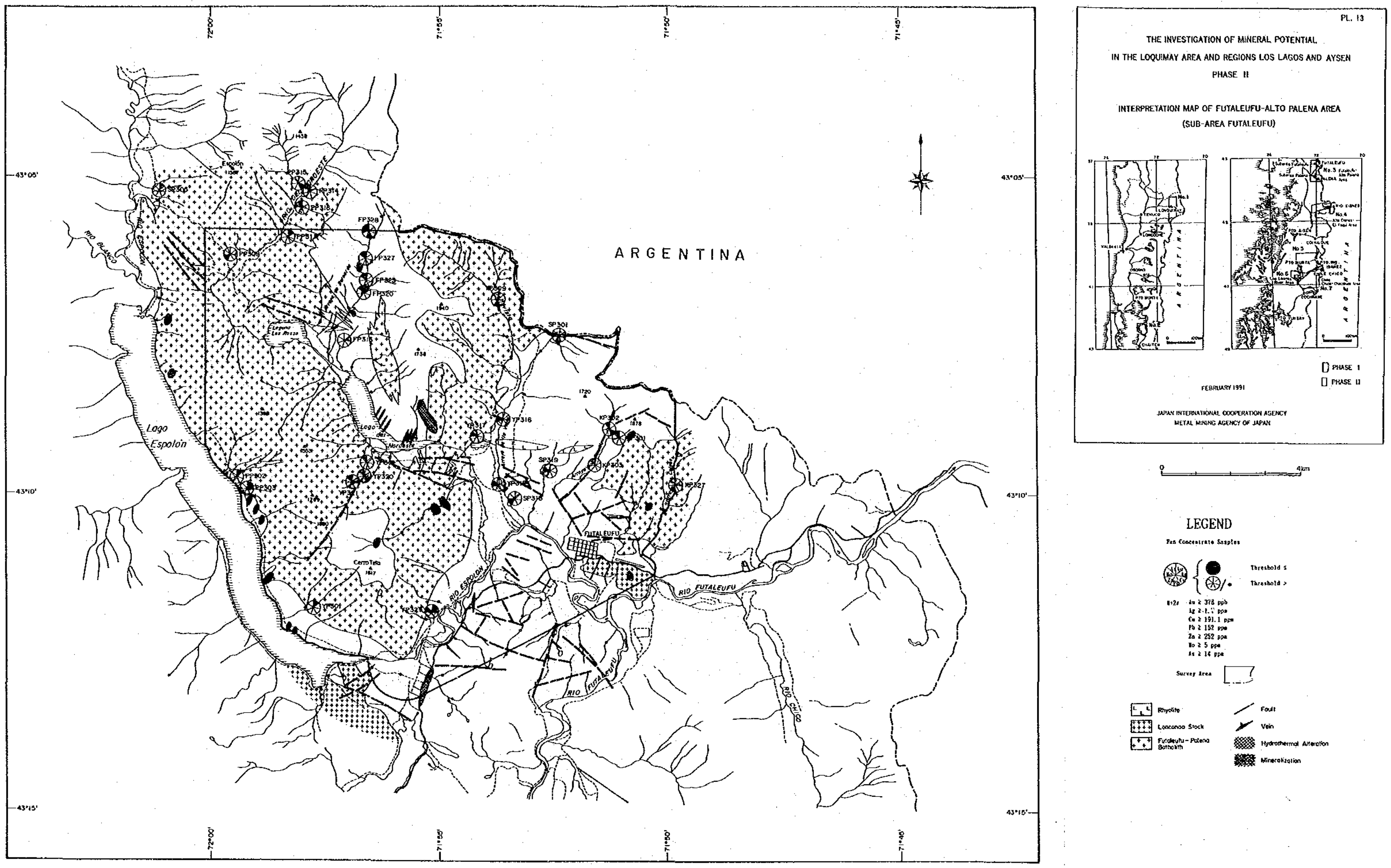


Figure Ⅱ-3-4 Collective Interpretation Map of Futaleufu Sub-Area

western half of the area. This suggests that the Au and Mo mineralization are confined to the inside of the Batholith.

Whereas the high-anomalies of Ag-Cu-Pb-As is distributed at periphery out of the Batholith overlapping with the distributions of mineral indications. As mentioned, the chlorite-epidote zone is generated at periphery out of the Batholith.

CHAPTER 4. THE FUTALEUFU-ALTO PALENA AREA (ALTO PALENA SUB-AREA)

4.1. Geology

This area is underlain by Cretaceous sequence consisting of sedimentary rocks, lavas and pyroclastic rocks, and Quaternary sequence (Figure Ⅱ-4-1). The Cretaceous sequences are intruded by intrusive rocks.

4.1.1. Stratigraphy

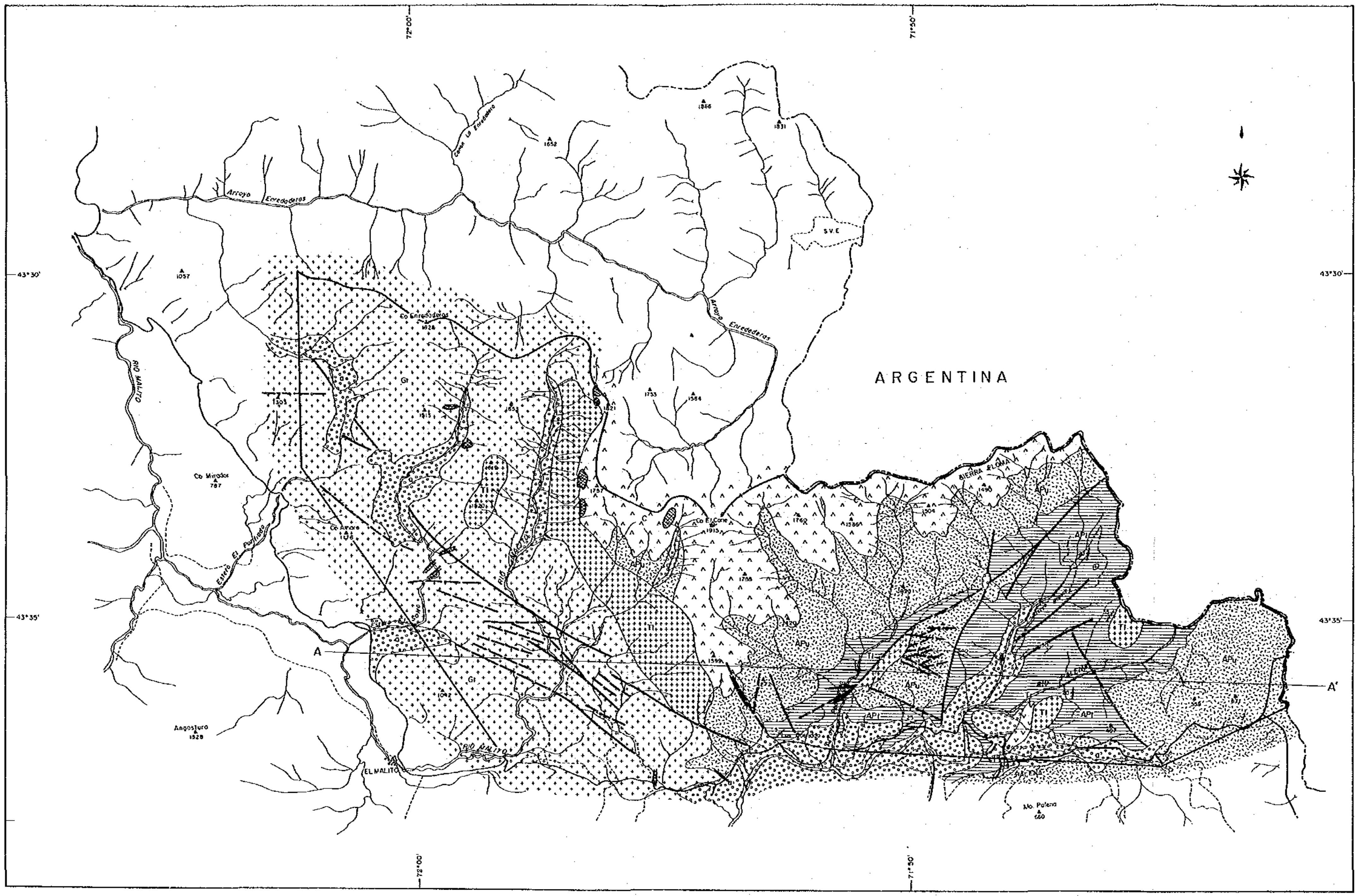
Schematic stratigraphic succession is shown in Figure Ⅱ-4-2. The Cretaceous sequences are divided into two members, the Alto Palena Formation of Early Cretaceous and the Cordon de Las Tobas Formation of Late Cretaceous. The Alto Palena Formation consists of two members, namely the lower member and the upper member.

(1) Alto Palena Formation

i. Lower Member

This member crops out from the north of Palena town located near the eastern edge of the area to the border of Chile and Argentina. Total thickness of this member is not certain due to no outcrop of its base, but at least 1,750m are estimated. The member consists mainly of alternating beds of calcareous shale and sandstone, though andesitic pyroclastic rocks are locally interbedded into the sedimentary sequence.

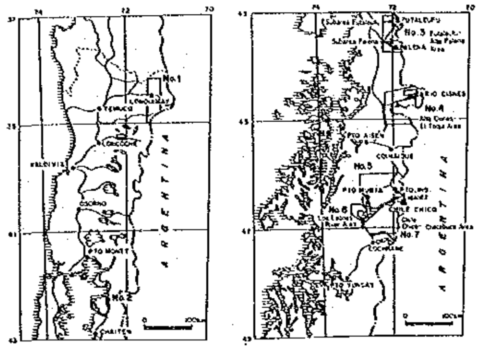
Shale is moderately hard with dark grey or black color and its fractures usually show cubic-shaped. This rock foams up with dilute hydrochloric acid indicating large constituent of calecareous matters. Bedding is not well developed.



PL. 8

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 ALTO PALENA)



PHASE I
PHASE II

FEBRUARY 1991

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

0 — 4km

LEGEND

- Quaternary — Alluvium, Terrace and Moraine — a
- Late Cretaceous — Cordón de Las Tobas Formation — C
- Early Cretaceous — Alto Palena F. — Upper member — APu
- Early Cretaceous — Alto Palena F. — Lower member — APl

Intrusive Rocks

- Trachyte — Tr
- Futaleufu-Palena Batholith — Gt
- Tonalite — Tl

- Fault
- Bedding
- Vein
- Hydrothermal Alteration
- Mineralization

A — A'

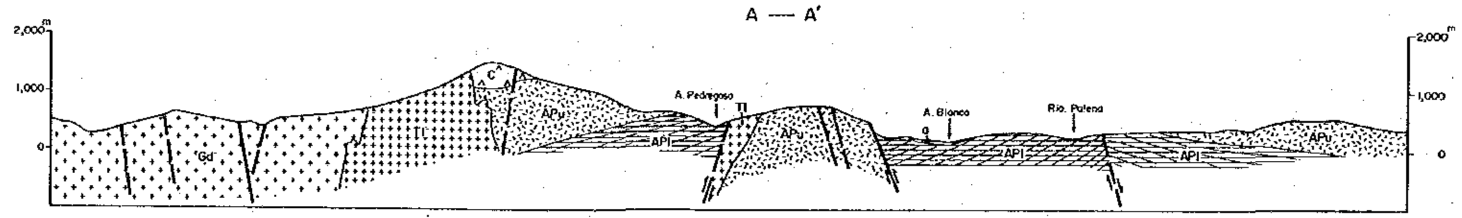


Figure II-4-1 Geological Map of Alto Palena Sub-Area

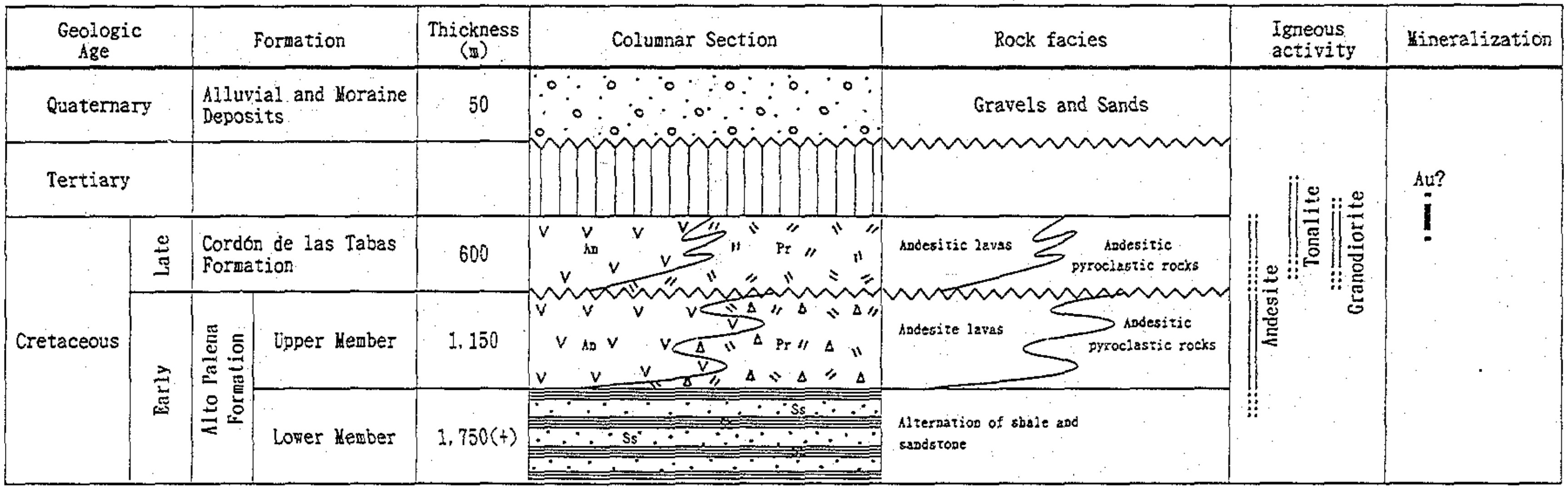


Figure II-4-2 Schematic Diagram of Stratigraphy in Alto Palena Sub-Area

Sandstone is moderately hard and medium-grained with grey or yellowish grey color. Beddings is poorly developed, but grains are well sorted and rounded.

Abundant ammonite and bivalve fossils occur in this member. Fuenzalida(1962) studied the fossils in this area and identified the following fossils of cephalopoda and pelecypoda. This member is biostratigraphically correlated to Valanginian stage in Lower Cretaceous.

Cephalopoda: Favrella wilckensi
Blanfordiceras australis
Frenguelliceras cf. magister Leanza
Neocomites pseudoregalis
Lyticoceras palenensis sp.nov.
Ammonites sp.
Belemnopsis patagoniensis
Nautilus sp. ind.

Pelecypoda: Gryphaea sp.
Monotis sp.
Lamellibranchiata

Other than the above, drift wood were also reported by Fuenzalida(1962).

A genus of Ammonite, Favrella, characteristically occurs in Coyhaique Formation. Therefore, this member is correlated to Coyhaique Formation.

ii. Upper Member

This member is distributed in the eastern half of the area and is 1,150m thick. This member is composed of alternating beds of andesitic pyroclastic rocks and andesite lavas. Pyroclastic rocks vary in grain size from fine tuff to tuff breccia, and lapilli tuff is the main constituent among them. All of them are hard and massive with green color. Andesite lava is hard with dark green color and many have fairly large phenocrysts showing porphyritic texture. They are totally affected by chloritization. Very extensive chloritization and epidotization are observed near the contact with granitic rocks.

This member conformably covers the lower member and is correlated to the Lower Cretaceous as well as the lower member.

(2) Cordon de Las Tobas Formation

This formation lies atop ridges ranging from Cordon de Las Tobas Mountains to Ploma Mountains around the Chile-Argentina border. Thickness of the formation is estimated at least 600m, though total thickness is not known because the upper level has been eroded.

The formation consists of alternating beds of andesite lava and andesitic pyroclastic rocks. Andesite lava is hard and compact with dark green color. Pyroclastic rocks are generally green and consist of fine tuff, lapilli tuff and tuff breccia, of which lapilli tuff is the dominant rock type.

Chemical composition of a typical andesite sample is shown in Table 8 attached in the Appendix. Ratios of oxides are shown in this Table as well.

This formation horizontally covers Alto Palena Formation unconformably. No geologic data suggests the time of the eruption event. However this formation is estimated to be of Late Cretaceous, judging from the lithological and structural similarities to Late Cretaceous Divisadero Formation.

(3) Quaternary

Quaternary sequences consist of river terrace deposits, alluvium, alluvium fan sediments and drifts. All sediments are unconsolidated sand and gravels. Thickness is about 50m.

4.1.2. Intrusive rocks

Intrusive rocks occupy broad areas in the western half of the area. Rock types are granitic rocks, trachyte and basalt. Granitoids intrusive body is the south extension of the Futaleufu-Palena Batholith mentioned in the previous section.

(1) Futaleufu-Palena Batholith

The rocks of this rock type occupy large areas in the western half of the area.

The rocks are generally hard and greyish white or greenish grey. Rock-forming minerals are quartz, plagioclase, potassium feldspars and biotite. They are coarse-grained subhedral minerals. Most of rocks in this intrusive body are granite, but some are diorite.

Chemical composition of three rock samples, KR331, FR335 and FR343, are shown on Table 8 in the Appendix. MgO and CaO contents are less compared to the general composition of granitic rocks. Other costituents are in the normal level of granitic rocks. Fe_2O_3/FeO ratios are less than 0.5 showing less Fe^{3+} content than the intrusive body in Futaleufu.

This intrusive body intrude into the Cordon Las Tobas Formation. At the contact zones, the intruded rocks are extensively affected by heat from the intrusive body, and resulted in the dissemination of pyrite, epidote and chlorite.

101±5Ma was determined for this intrusive by K-Ar method.

(2) Tonalite

Several stocks of this rock are distributed in the northern half of the central part and the eastern part of this area. Lithology of this intrusive rock resembles the Lomconao Stock in the Futaleufu Sub-area. They are hard and compact with dark green, green and grey color. They are identified to be tonalite by microscopy.

Chemical composition of one rock sample is shown in Table 8, Appendix. Major constituents are 63.23% SiO_2, 2.8% MgO and 1.48% CaO, and the ratio Na_2O/CaO is 0.75. This composition is relatively rich in the mafic constituents as compared with the chemical compositions of the Futaleufu-Palena Batholith.

These bodies intrude into the Alto Palena Formation, but the relationship with the batholith is not known.

(3) Undifferentiated dykes

Few volcanic rocks are distributed in the area, and they are tarachyte dike and basalt dike intruded into the Alto Palena Formation. Their area of distribution is confined to the east of the aerodrome in Palena town.

4.1.3. Geologic structure

The lower member of the Alto Palena Formation is gently folded with the axis of the NE-SW direction which is parallel to Blanco River. Whereas the Codon Las Tobas Formation is nearly flat.

Faults with several kilometers length are well developed in the area. Among them, N60°W system and NE-SW system are dominant. The former lies mainly in the granitic rocks distributed in the western part of the area. Many parallel faults are densely developed. This dense fault zone is characterized by a graben-shaped depression with 2km width at its central part.

The faults of the latter system are well developed in the zone lying between the north slope of the Blanco River and the Pedregoso River lying the north of the Blanco River. Anticline axis lies on southern side of this faulted scarp.

4.2. Mineralization

Mining activity is hitherto unknown in this area, while a few outcrops indicating mineralization are known. Neither drilling nor underground exploration activities have been conducted in these prospects so far. This survey newly discovered some ferruginous alteration zones. Their locations are plotted on Plate 17.

The mineralization of this area consists mainly of veins and partly stockwork. Principle metal mineral constituents are hematite(rarely specularite), pyrite, chalcopyrite, galena and sphalerite. In many cases, iron minerals are altered to limonite. Gangue minerals are mainly quartz, but also calcite occurs in some cases.

The characteristics of significant mineralized zones are summarized as follows:-

(1) KM-350

Mineralization in this locality occurs at the down-stream area of the Pedregoso River. A few clay veins of 10 to 20cm width occur in the fractured zone 7m wide striking N65°E and dipping 72°N(Fig.Ⅱ-4-3). These clay veins contain veinlets of quartz, calcite and pyrite. A rich ore float of 10 to 15cm in size was found on the foot of this outcrop. Assay on this sample showed high grade lead-zinc, namely 80ppb Au, 692ppm Ag, 0.36% Cu, 24% Pb and 36% Zn. However, no outcrops similar to this ore sample was found.

Alteration is mainly silicification and argillization. The alteration zone broadly extends around the fractured zone outcrop with about 200m width.

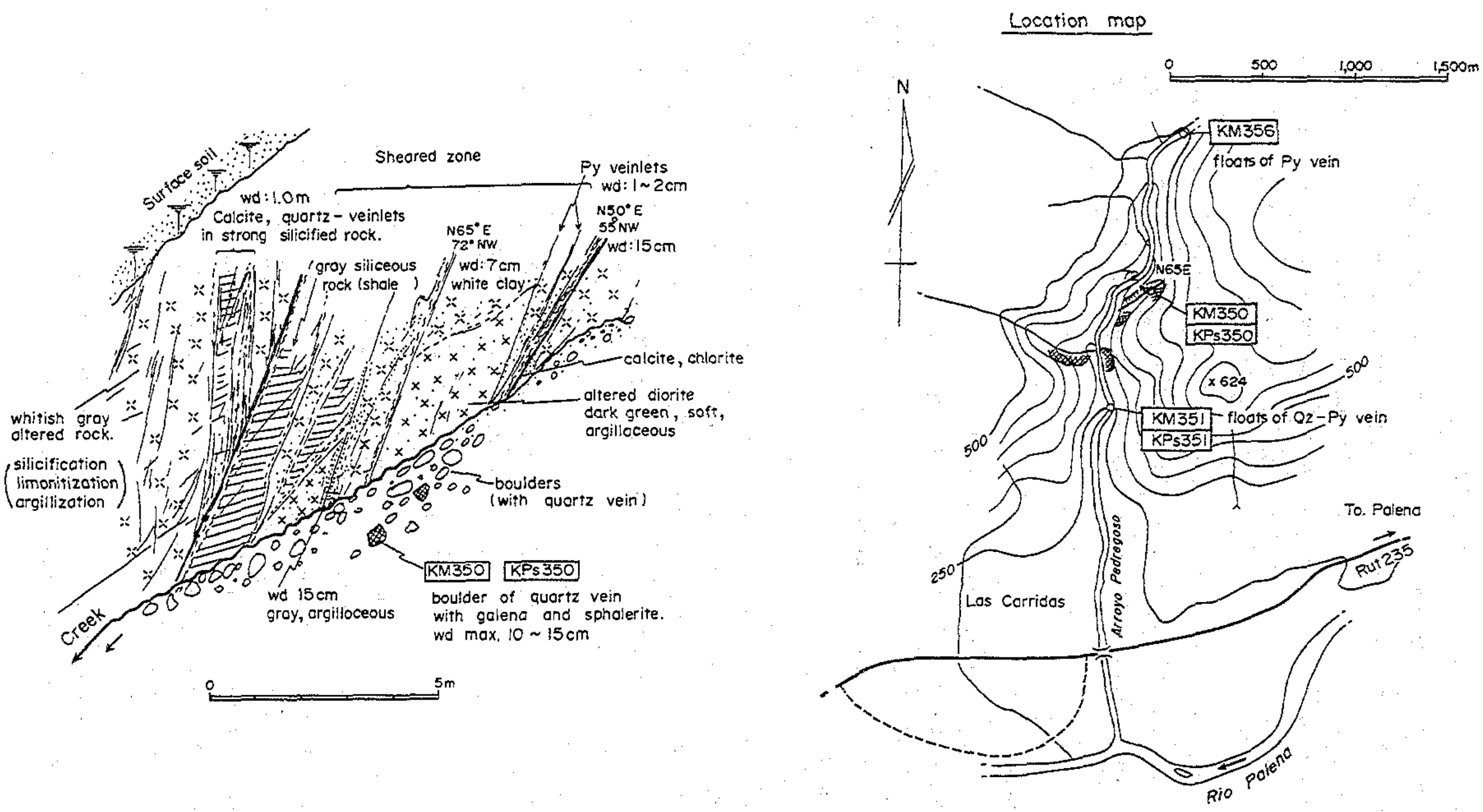


Figure II-4-3 A sketch of Mineralized Outcrop at Pedregoso River

(2) KM-342

This locality lies about 4km west-southwest of the locality KM-350. The mode of occurrence is illustrated in Figure Ⅱ-4-4. In also this locality, fractured zone of 7m width is developed. Barren calcite veins and weakly argillized cracks occur parallel in this zone. Country rocks are andesite of the Alto Palena Formation and granitic rocks. No ore mineral is found on the outcrop, but floats of vein ore are scattered on the foot of the outcrop. They contain bornite, chalcopyrite, covelline and copper oxide minerals. The maximum size of those floats is 50x100x50cm. The significant ore-grades of assays on these samples are 600ppb Au and 3.32% Cu.

Other than the above, a few floats of quartz network were found, which are of very low grade(Table 7 in Appendix). Ferruginous alteration zones are developed mainly around the dikes and in the batholith. Those alteration zones are composed of joint-filling limonite and hematite accompanied by weak silicification and argillization.

4.3. Geochemical Exploration

Stream sediment geochemistry was carried out targeting lead-zinc mineralization.

(1) Sampling and assay

About 100g of stream sediments were collected and sent to assay laboratory. The mesh fraction is -30 mesh. Total of 104 stream sediment samples were collected from this area. Their localities are plotted on PLATE 25.

Samples were assayed for six elements, Au, Ag, Cu, Pb, Zn and As by Chemex Labs. Inc., Canada after pulverizing to -200 mesh at the laboratory of SERNAGEOMIN. The detection limits and analytical methods are as follows:-

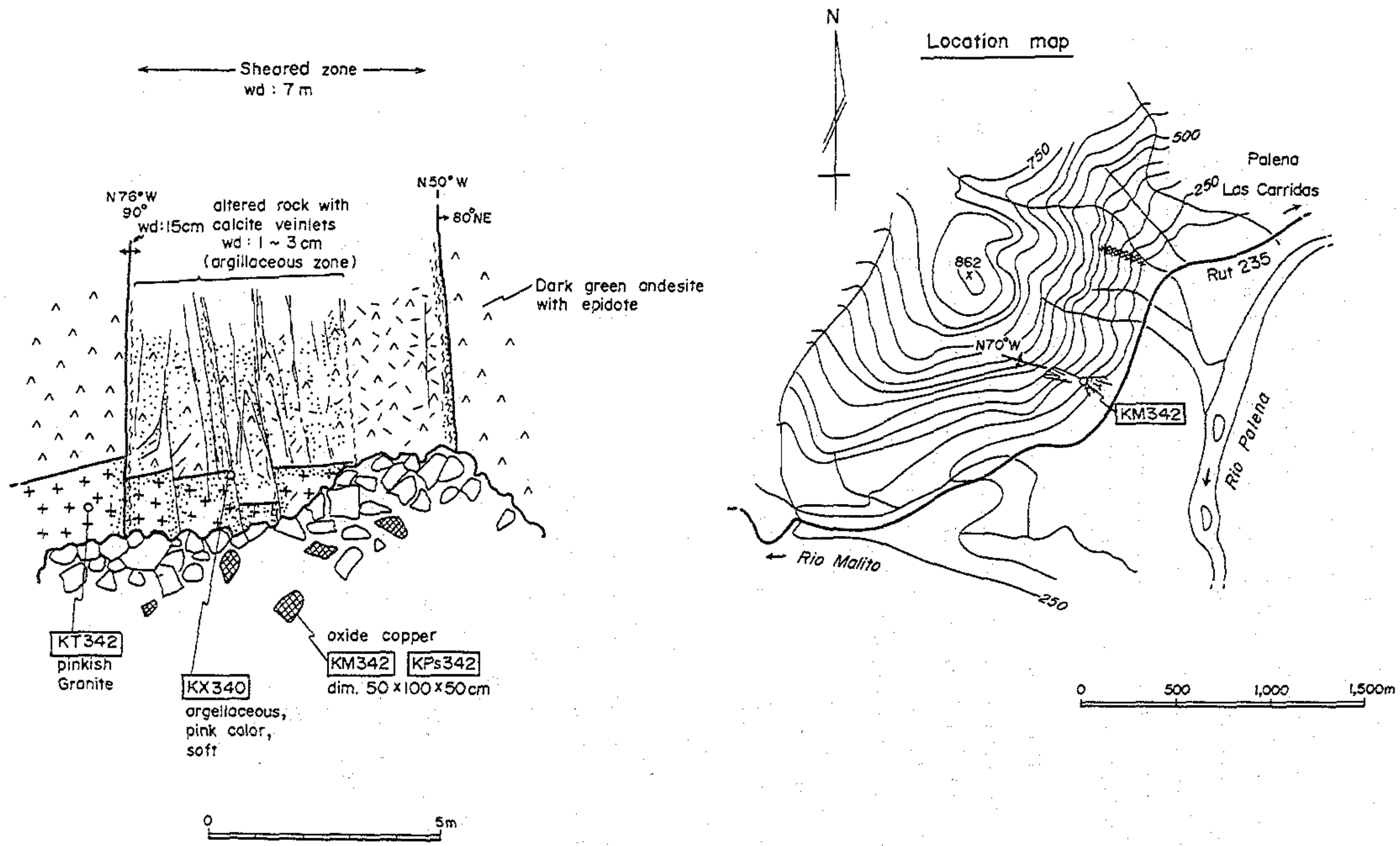


Figure II-4-4 A sketch of Mineralized Outcrop at West of Palena

Detection Limits and Analytical Methods Used

Element	Method	Detection Limits	
		Lower Limit	Upper Limit
Au	FA-NAA	1ppb	10,000ppb
Ag	AAS	0.2ppm	100ppm
Cu	AAS	1ppm	10,000ppb
Pb	AAS	1ppm	10,000ppm
Zn	AAS	1ppm	10,000ppm
As	AAS	1ppm	10,000ppm

NOTES: FA; Fire Assay, NAA; Neutron Activation Analysis, AAS; Atomic Absorption Spectrometry

(2) Statistical data-processing

i. Calculation

Data of 25 samples collected during the work of the first phase were added in the calculation altogether with the data of 104 samples of this year. However, the previous data for Au and As were excluded from calculation because of the different assay technique and detection limit. Therefore the total number of samples for calculation are 104 for Au and As, and 129 for the other four elements. The calculation was carried out in the same manner as in the Futaleufu sub-area.

ii. Elemental statistics

Assay results are listed on Table 10 in Appendix. Elemental statistic parameters are listed in Table 3 in Appendix. Their characteristics are summarized as follows:-

Au

The maximum value is 23ppb and the minimum value is 0.5ppb. Mean value is 1.2ppb. Fifty four percent of the total are below the detection limit.

Ag

The maximum value is 0.3ppm and the minimum value is 0.05ppm. Mean value is 0.09ppm. Only one sample contained Ag above the detection limit.

Cu

The maximum value is 70ppm and the minimum value is 1ppm. Mean value is 15.2ppm. These values are similar to the background level observed in many places.

Pb

The maximum value is 95ppm and the minimum value is 0.5ppm. Mean value is 3.9ppm. These values are similar to the background level observed in many places.

Zn

The maximum value is 230ppm and the minimum value is 14ppm. Mean value is 48ppm. All assay data are detectable values and 14 data are over 100ppm. Zinc assay results are on higher level than those of the other elements.

As

The maximum value is 52ppm and the minimum value is 1ppm. Mean value is 2.3ppm. All assay data are detectable values, but about 90% of data are in the range of one digit, totally very low level.

iii. Frequency distribution pattern

Figure II-4-5 shows the frequency distribution patterns. Elements Zn, Cu and Pb behave following log-normal law. Frequency peaks of Au and Ag are at the field below detection limits. Whereas As shows a pattern decreasing monotonously from low value toward high value.

iv. Correlation

Correlation coefficients of elements-pairs are listed on Table 4 in Appendix. The following pairs showed correlation coefficients of 0.5 or more

Pb-Zn: 0.79777 Zn-As: 0.70270 Cu-Zn: 0.63402 Pb-As: 0.58972

v. Principal component analysis

Calculated eigen vectors are listed on Table 5, Appendix.

Geochemical characteristics in view of PCA is summarized as follows:-

First principal component

Pb, Zn, Cu and As behave in the same manner with negative values. Assay of Pb, Zn and Cu take relatively higher values than Au and Ag, and some ore outcrops carry these three elements. Thus the first principal component is

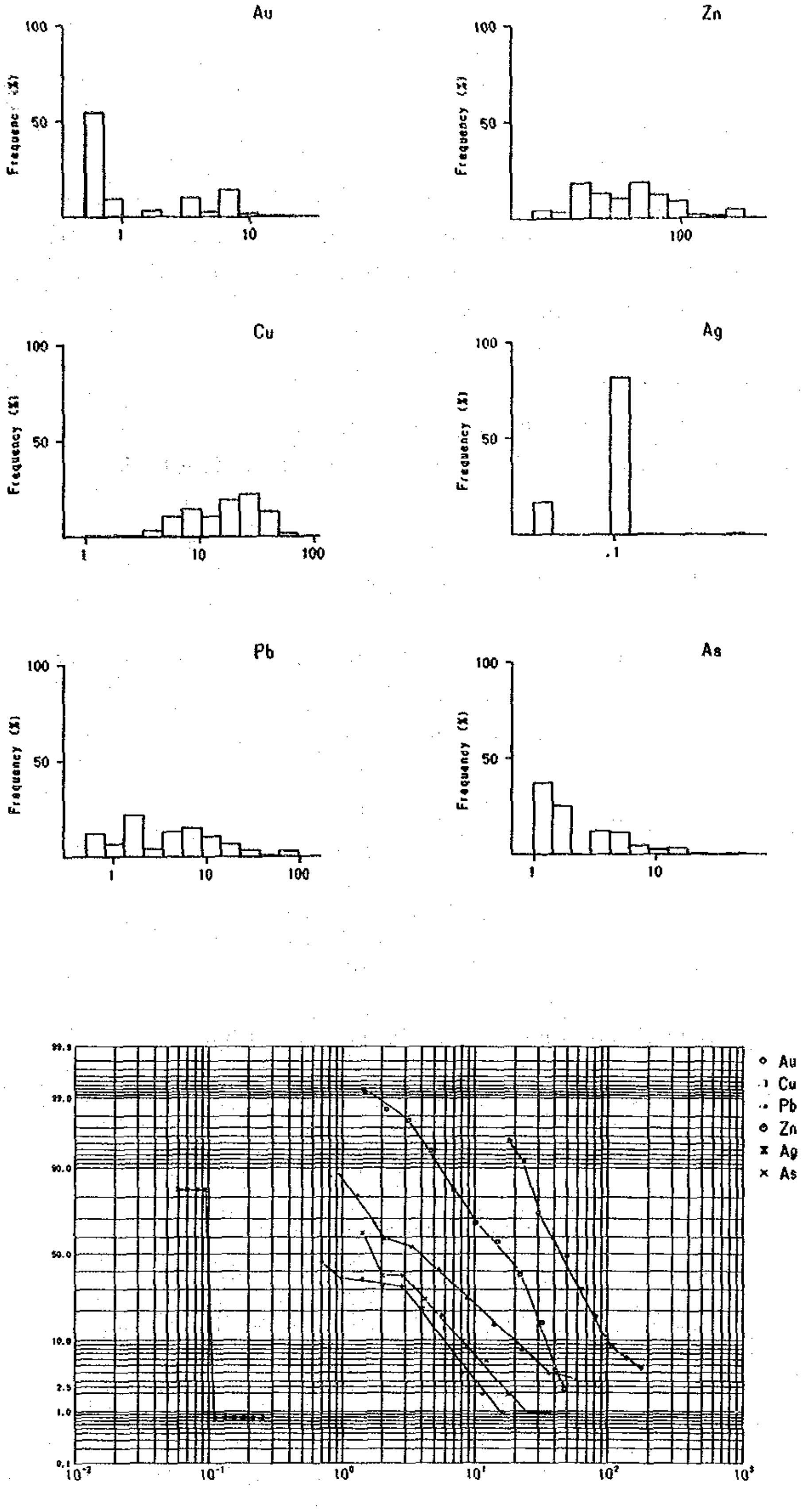


Figure II-4-5 Histograms and Cumulative Frequency Curves showing Frequency Distribution Patterns of Assays on Stream Sediment Geochemical Samples Collected in Alto Palena Sub-Area believed to reflect the variance of the mineralization in this area.

Second principal component

Large negative value is assigned to Au, and large positive value to Ag. Both assay values are not above the background values thus this principal component is believed to express the variance of metal contents in the host rocks and not reflect the mineralization.

Third principal component

Two sets of behavior are observed for the pairs Au-Ag and Cu-As, and therefore this principal component is believed to reflect the variance of the mineralization.

(3) Geochemical anomalies and anomalous zones

i. Threshold values

The values m+2σ were used for threshold. These values are shown below.

Threshold Values

Au	11ppb
Ag	0.16ppm
Cu	70ppm
Pb	47ppm
Zn	165ppm
As	13ppm

ii. Geochemically anomalous zones

The number of geochemically anomalies picked up are as follows:-

Number of Geochemically Anomalies

Element	Numbers of Points
Au	2
Ag	1
Cu	1
Pb	4
Zn	7
As	6

Localities of these anomalies are illustrated in PLATE 21 and their distribution are summarized below.

Au

Two anomalies were detected, one 2.5km west of the Palena Town and the other along a tributary south of the Enderaderas River. The former overlaps with Zn and As anomalies and found in the area of Alto Palena Formation. The latter occurs solely with no other elements and is situated in the granitic rocks.

Ag

Ag anomalies are detected in the streams on the western slope of El Cono Mountain. Pb and Zn anomalies are detected in the same as well.

Cu

There is only one Cu anomaly in the tributary south of the Enderaderas River. This value, however, is considered to be on the upper level of the background.

Pb and Zn

The distributions of the Pb anomalies and Zn anomalies overlap in two localities. One lies to the west of Las Corridas village and the other at the western slope of El Cono Mountain.

As

Arsenic anomalies are concentrated around the Pedregoso River.

4.4. Evaluation

Figure Ⅱ-4-6 is the collective interpretation map compiled from geologic data in order to examine the relationships of the mineralization with the geologic, tectonic and geochemical features.

Indications of mineralization and alteration zones are selectively distributed around the periphery out of granitic rocks. This suggests a close relationship between mineralization and magmatism of granitic rocks.

The vein systems do not show any particular directions. The mineralization at KM342 and KM350 are veins, but no dominant direction is recognized. Neither mineralization nor hydrothermal alteration occur in the NW-SE fissures which are parallel to the major fault system.

The mineralization of El Toqui Deposit type, large lead-zinc replacement

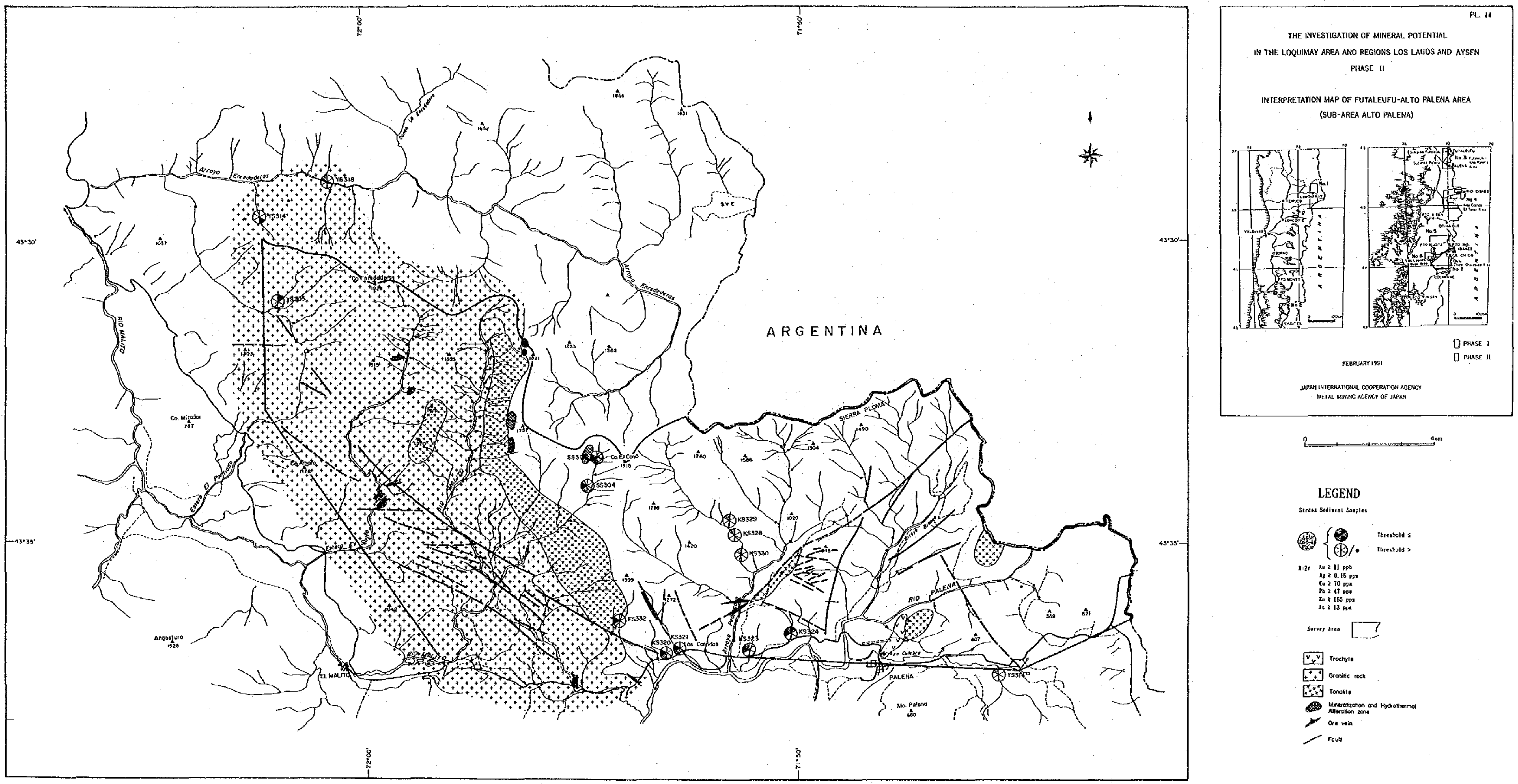


Figure Ⅱ-4-6 Collective Interpretation Map of Alto Palena Sub-Area

deposit, was expected at first, because the marine calcareous beds were found by the first phase survey, but this second phase survey found only small vein mineralization. It was found that the calcareous beds in the area consists of calcareous shale, and not limestone, while the large replacement mineralization including El Toqui Deposit occur mainly in limestone and tuff beds associated with close spacing fissures of NW-SE direction. The shale beds of this area is compact and therefore believed to be less permeable. Considering that and less development of fissures in the area, the geologic circumstances of this area might not be favorable for the formation of replacement deposit.

Good mutual correlations of Pb, Zn and Cu are recognized. As shown in Figure Ⅱ-4-6, their high anomalies zones are distributed around the margin of the granitic rocks batholith. This suggests the mineralization in this area is related to the batholith as well as in the Futaleufu sub-area.

CHAPTER 5. ALTO CISNES-EL TOQUI AREA

5.1. Geology

The geology of this area consists of Late Jurassic ejecta, Early Cretaceous marine sedimentary rocks, Late Jurassic ejecta, Quaternary sequences and granitic rocks. Geological map is indicated in Figure Ⅱ-5-1 and geologic section is shown in Figure Ⅱ-5-2. No basement rock crops out in this area.

5.1.1. Stratigraphy

Figure Ⅱ-5-3 is a schematic stratigraphic columun of this area. Stratigraphic succession consists of Ibañez Formation of Late Jurassic, Coyhaique Formation of Lower Cretaceous and Divisadero Formation of Upper Cretaceous in the ascending order.

(1) Ibañez Formation

This formation is distributed at the upstream basins of the Buitrera River and the Pedregoso River, and the southern part of the upstream basin of the Mallin Chileno River. Thickness is estimated to be at least 15,000m.

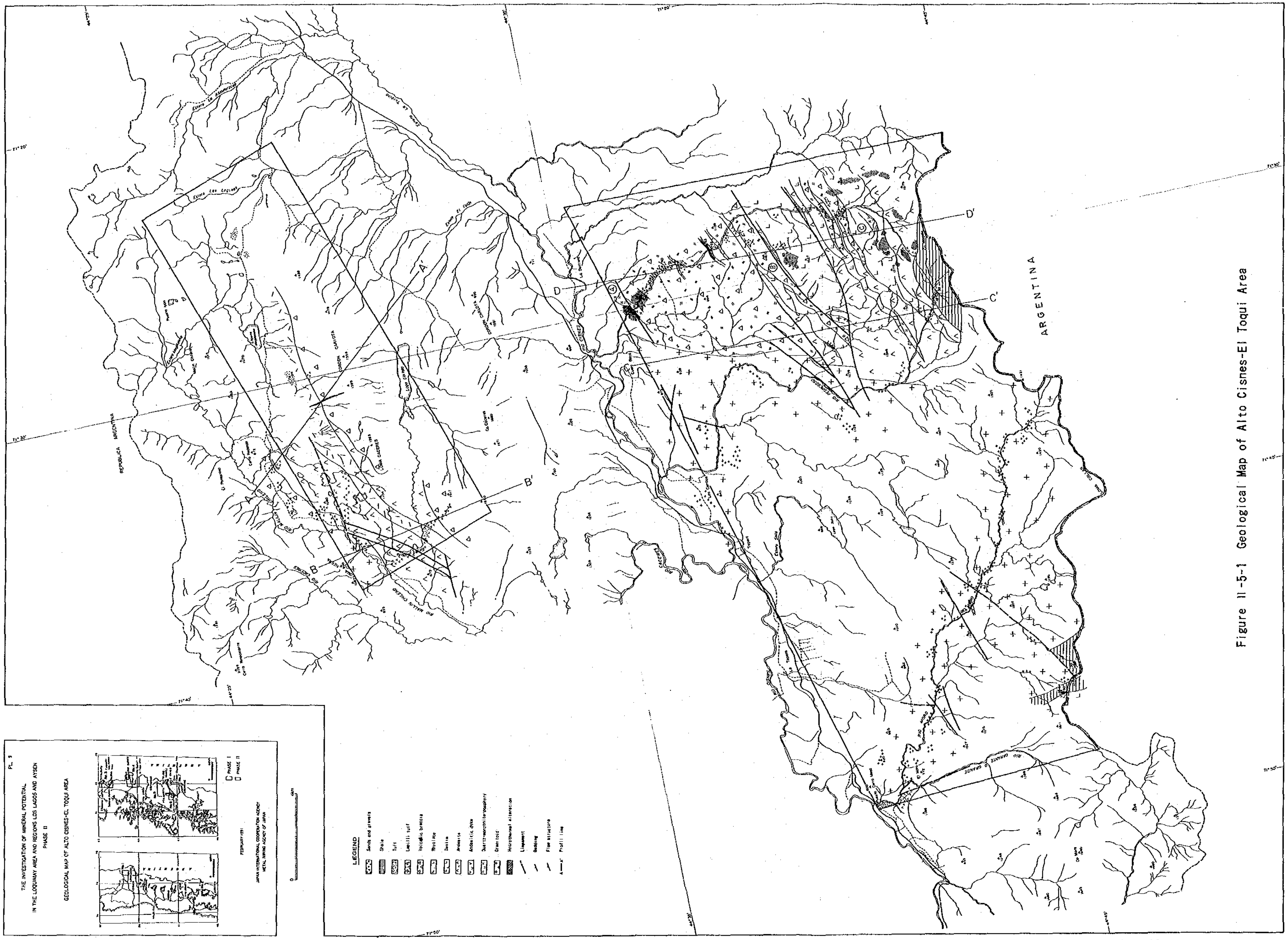
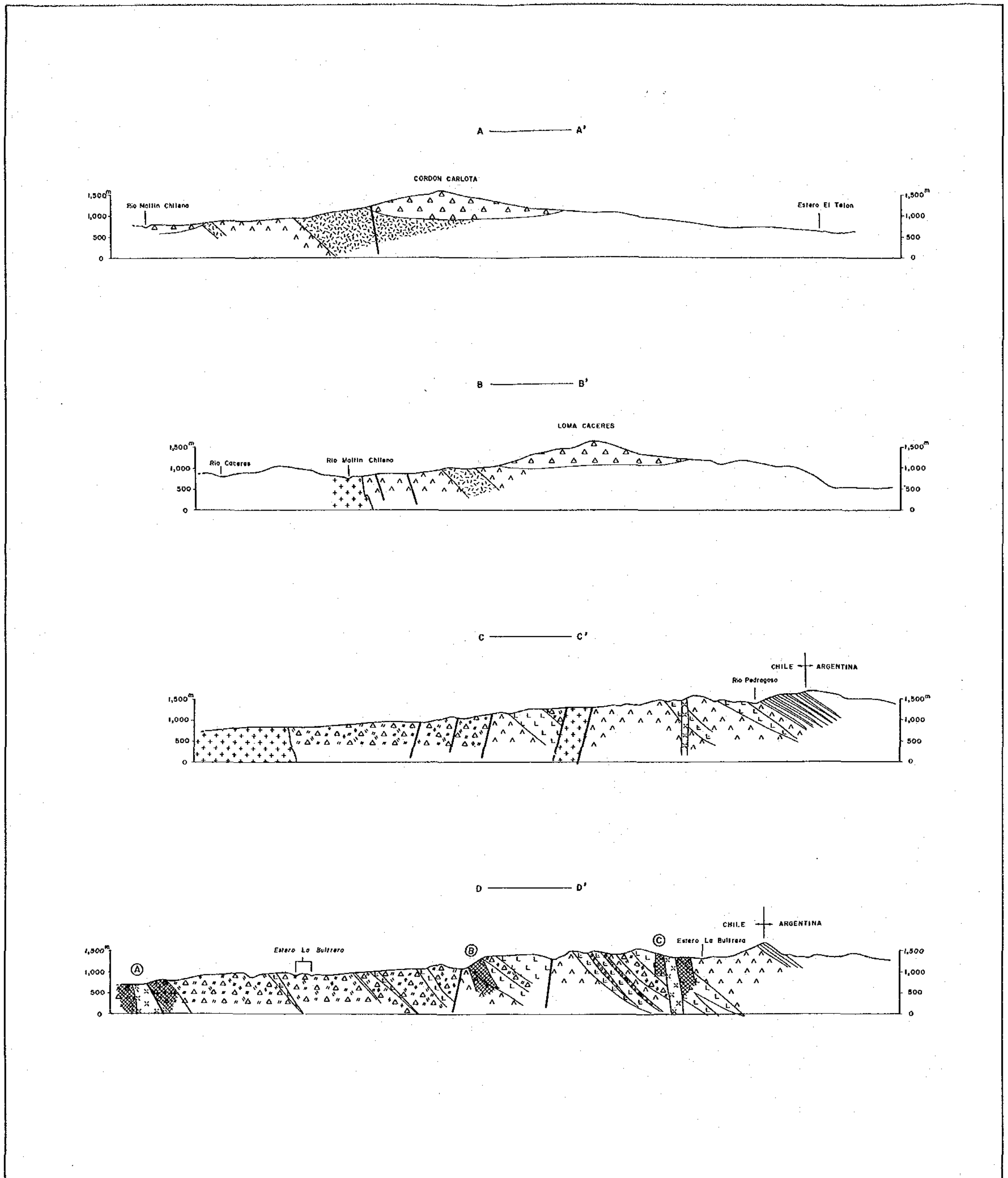


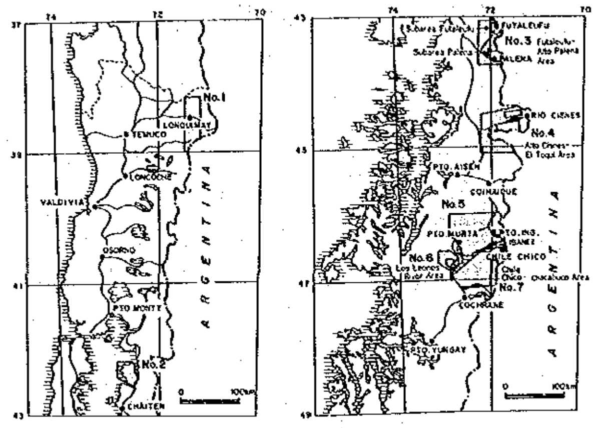
Figure II-5-1 Geological Map of Alto Cisnes-El Toqui Area



PL. 10

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

GEOLOGIC PROFILE OF ALTO CISNES-EL TOQUI AREA



☐ PHASE I
☐ PHASE II

FEBRUARY 1991

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0 4km

LEGEND

- Sands and gravels
- Shale
- Tuff
- Lapilli tuff
- Volcanic breccia
- Rhyolite
- Dacite
- Andesite
- Andesitic dyke
- Quartz-monzonite porphyry
- Granitoid
- Hydrothermal alteration
- Lineament

Figure II-5-2 Gelogical Section of Alto Cisnes-El Toqui Area

Geologic Age	Formation	Thickness (m)	Rock facies	Igneous activity	Mineralization
Quaternary	Alluvial and Moraine Deposits	100	Gravels and Sands		
Tertiary					
Cretaceous	Divisadero Formation	700(+)	Pr:pyroclastics	Dacite, Rhyolite; Andesite; Granitoid	Au?
	Coyhaique Formation	500(+)	Sh:shale Ch:chert Ss:sandstone Ad:andesite dyke		
Jurassic	Ibañez Formation	15.000	An:andesite lavas Da:dacite lavas Tf:tuff Tl:lapilli tuff Tb:tuff breccia Sh:shale Ss:sandstone Rh:rhyolite dyke Po:porphyry dyke Gr:granitoid		

Columnar Section

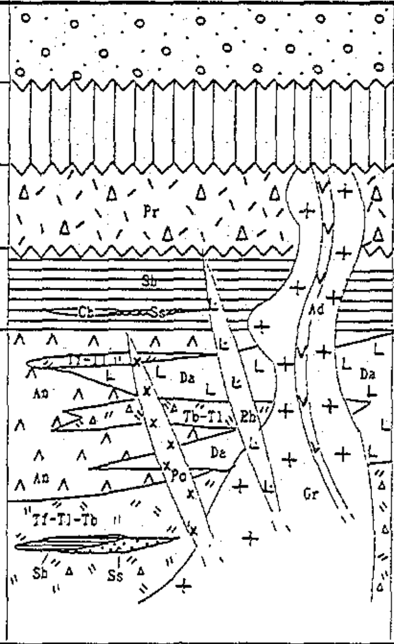


Figure II-5-3 Schematic Diagram of Stratigraphy in Alto Cisnes-El Toqui Area

This formation consists of dacite and andesite lavas, and dacitic pyroclastic rocks. The pyroclastic rocks are dominant in the lower portion and the lavas in the upper portion. The pyroclastic rocks are mainly distributed in the downstream side of the distribution at the Buitrera River. They consists mainly of lapilli tuff. The pyroclastic rocks are compact and dacitic with green and pale green colors containing a large amount of quartz crystals. Thin beds of tuffaceous sandstone and black shale are intercalated into the pyroclastic rocks in rare cases.

Dacite lava is hard and compact with grey, dark green and greyish green color. Lithology of this rock changes to rhyolitic facies with spherulitic and flow structures. Chemical composition of this rhyolitic rock shows the border composition of dacite and rhyolite. MgO content is extremely low so that FeO/MgO ratio is very high at 343.8. Differentiation Index of this rock is 93.8 indicating highly advanced stage of the differentiation.

Andesite lavas occur alternating with the dacite mentioned above. They are aphanitic with green color. Chemical composition of one sample shows a border composition of andesite and dacite. MgO content of this rock is very low as well as that of the dacite sample bringing the ratio FeO/MgO to 1,035.

No field evidence indicating the age of eruption which produced this formation was obtained, but this is correlated to the Ibañez Formation in this report based on their lithological similarities, namely dominant constituent of acidic volcanic rocks and the existence of overlying bed of the sedimentary rocks is considered correlated to the Coyhaique Formation mentioned below.

(2) Coyhaique Formation

This formation is distributed on a small scale from the upstream basin area to near the drainage divide of the Moro River and Pedregoso River. Thickness of at least 500m are estimated with an uncertainty caused by the lack of the top sequence. This formation consists mainly of siliceous shale intercalating thin beds of fine-grained sandstone and chert. Shale is hard with grey and dark grey color, and contains very fine-grained quartz grains. Chert is very hard with fine bands repeated rhythmically.

This formation is partly in contact with granitic rocks through a fault, but also with a rhyolite dike(?) in the Moro River area. This conformably overlies the andesite unit of the Ibañez Formation in the Pedregoso River area. The observation on this formation is very restricted due to its small distribution, the correlation to Coyhaique Formation is not certain. That is, shale of this formation is siliceous in the contrast to the fact that the pelitic rocks of the Coyhaique Formation near Coyhaique city are generally calcareous. On the other hand, no calcareous sedimentary rocks are occur in the standard regime of Ibañez Formation established near the Lake General Carrera located in the southern end of the survey areas in second phase. This suggests that there is a possibility that this formation may be correlated to the Ibañez Formation. Therefore more geologic data are necessary for the exact correlation.

(3) Divisadero Formation

This formation is distributed around the north slopes of the Caceres Mountain and the Carlota Mountain, and the southern part of the basin of the Mallin Chileno River. Thickness is estimsted at least 700m, but the top sequence is not confirmed. Dacitic tuff breccia and lapilli tuff are constituents of this formation.

The rocks of this formation lithologically resemble the rocks of Ibañez Formation mentioned above. But this covers the Ibañez Formation with structural discordance as shown in the geologic sections C-C' and D-D' on Figure II-5-2. It is, therefore, treated as correlated to Divisadero Formation in this report regardless of the insufficient geologic data.

(4) Quaternary

Quaternary sequences are composed of alluvium, river terrace deposits, alluvial fan sediments and drifts. All are unconsolidated gravels and sand, and about 100m thick.

5.1.2. Intrusive rocks

The area is intruded by granitic rocks, quartz monzonite and rhyolite.

(1) Granitic rocks

Granitic rocks broadly intrude the west of the Pedregoso River which forms a batholith in the deeper parts. Rocks are generally hard with greyish white and greenish grey color. Minerals are coarse-grained and subhedral. Rock types range from granite to diorite, but consist mainly of granite and monzogranite.

These bodies intrude Coyhaique Formation. Late Cretaceous K-Ar radioactive ages are 75±2 Ma and 93±2 Ma determined during the work of PhaseI.

(2) Quartz monzonite porphyry

This intrusive rock occur in the upper reaches of the Pedregoso River and the lower reaches of the Butrera River as dikes elongated in the N60°E direction. The rock carries large phenocrysts of quartz, alkaline feldspars and amphiboles with pinkish grey color. These bodiy intrudes into Ibañez Formation and alteration zone mentioned later.

5.1.3. Geologic structure

Ibañez Formation shows a monoclinal structure striking N60°E and dipping 30-50°S. Coyhaique Formation developed along the Pedregoso River is parallel to Ibañez Formation, although the structure of Coyhaique Formation is disturbed to some extent by faults. Structure of Divisadero Formation is almost horizontal.

5.2. Mineralization

There are several deposits mined and explored so far, and El Toqui Deposit is still in operation. Most of them are distributed in the southern half of the area, but merely one deposit, Santa Teresa Deposit, was operated for gold and copper in the northern half of the area surveyed this year. The surface geological work of this second phase discovered many gossaneous alteration zones.

The localities of those alteration zones are illustrated in Figure Ⅱ-5-1 and Plate 18. They are distributed mainly in the eastern half of the survey area. These alteration zones are distributed largely in three groups. These groups are named Group A, Group B and Group C in this report.

(1) Alteration group A

This group is developed around 3km upstream along the Buitrera River from the converging point with the Cisnes River. The size and elongated directions are unknown, but 1km continuity is recognized along the river.

The host rock in this zone is pyroclastic rocks of Ibañez Formation. The grains of the pyroclastics are argillized and the matrix is silicified. Very fine-grained pyrite is disseminated in the rock and many of the pyrites are altered to limonite. Many shear zones are developed in the zone with N45°E direction and about 10m of width. Alteration minerals determined by X-ray diffraction are mainly quartz and minor kaoline group minerals.

Assays on outcrops show low grade as indicated in the following table.

Assay on Group A

Sample	Au(ppb)	Ag(ppm)	Cu(ppm)	Pb(ppm)	Zn(ppm)
FM402	<20	0.9	28	300	264
FM404	<20	0.3	20	28	50

(2) Alteration group B

This group lies about 7km south of the Group A, ranging from the western slope up to the top of the mountain located in the mid-stream of Buitrera River. The rocks in this zone are dacite and rhyolite of Ibañez Formation. This zone extends to at least 500x600m in size, though limit of the group are not quite identified.

Quartz stockwork with limonite and hematite occur in moderately silicified rocks. The rock surfaces generally exhibit yellowish color. Only quartz is determined by X-ray diffraction.

Assay on this group show very low grade as listed below.

Assay on Group B

Sample	Au(ppb)	Ag(ppm)	Cu(ppm)	Pb(ppm)	Zn(ppm)
FM417	<20	0.2	38	5	48
FM418	20	0.2	10	18	32
FM419	<20	0.6	18	20	24
FM420	<20	0.3	12	21	26

(3) Alteration group C

Altered portions belonging to this group are found sporadically on the ridges of the upper reaches of the Buitrera River. This group seems to extend at least 5km along the strike. Pyrite is disseminated in the andesite of Ibañez Formation ,but no other types of mineralization are observed. The degree of alteration is very low and the original rock textures are recognizable.

Assay on this group show very low grade as shown in below Table.

Assay on Group C

Sample	Au(ppb)	Ag(ppm)	Cu(ppm)	Pb(ppm)	Zn(ppm)
FM409	<20	0.2	10	27	82

5.3. Geochemical Exploration

This work was stream sediment geochemistry with the target on lead-zinc mineralization represented by El Toqui lead-zinc replacement deposit.

(1) Sampling and assay

One hundred and seven stream sediment samples were collected. Their mesh fraction is -30 mesh and amount is about 100g. Localities of sampling points are illustrated in PLATE 26.

All the samples were pulverized to -200 mesh and sent to Chemex Labs., Inc. to be analyzed for six elements, Au, Ag, Pb, Zn and As. General matters concerning chemical analysis technique are the same as in Chapter 4.

(2) Statistical data-processing

ⅰ. Calculation

Assay on 46 samples collected during the work of Phase Ⅰ were included in the calculation. But, Au and As assays of the Phase Ⅰ were excluded because they were analyzed with different detection limits from those in the Phase Ⅱ. Therefore, the numbers of samples treated in statistics are 107 for Au and As, and 153 for every other elements.

ⅱ. Elemental statistics

Assay results are listed on Table 10 attached in Appendix. Elemental statistical parameters are shown on Table 10, Appendix. Those statistical features are outlined as follows:-

Au

Maximum value is 19ppb, minimum value is 1.0ppb and mean value is 0.5ppb. About 62% of samples were below detection limit.

Ag

Maximum value is 0.4ppm, minimum value is 0.05ppm and mean value is 0.1ppb. All are very low.

Cu

Maximum value is 68ppm, minimum value is 1ppm and mean value is 7ppm.

Pb

Maximum value is 50ppm, minimum value is 0.5ppm and mean value is 3ppm.

Zn

Maximum value is 140ppm, minimum value is 19ppm and mean value is 45ppm. No sample was below the detection limit and seven samples copntained over 100ppm.

As

Maximum value is 40ppm, minimum value is 0.5ppm and mean value is 2ppm. Eleven samples were below the detection limit and 93% of samples had less than 10ppm.

iii. Frequency distribution pattern

Figure II-5-4 is frequency distribution diagram. Zn, Cu and Pb are likely follow log normal law. Au and Ag have their peaks below the detection limits. Distribution pattern of As is nearly flat.

iv. Correlation

Correlation coefficients are listed on Table 4, Appendix. The pairs listed below are considered to have good correlation with coefficients of 0.5 or higher.

Pb-Zn: 0.74510 Zn-Cu: 0.72739 Pb-As: 0.65286 Zn-As: 0.65000 Cu-Pb: 0.61994

v. Principal component analysis

Eigen vectors are listed on Table 5 in Appendix.

First principal component

Pb and Zn take the highest values followed by Cu and As. Taking account of the assay and the numbers of anomalies, this principal component is believed to reflect the variance of mineralization.

Second principal component

This reflects the variance of silver. This is considered to express the variance of the silver contents in rocks.

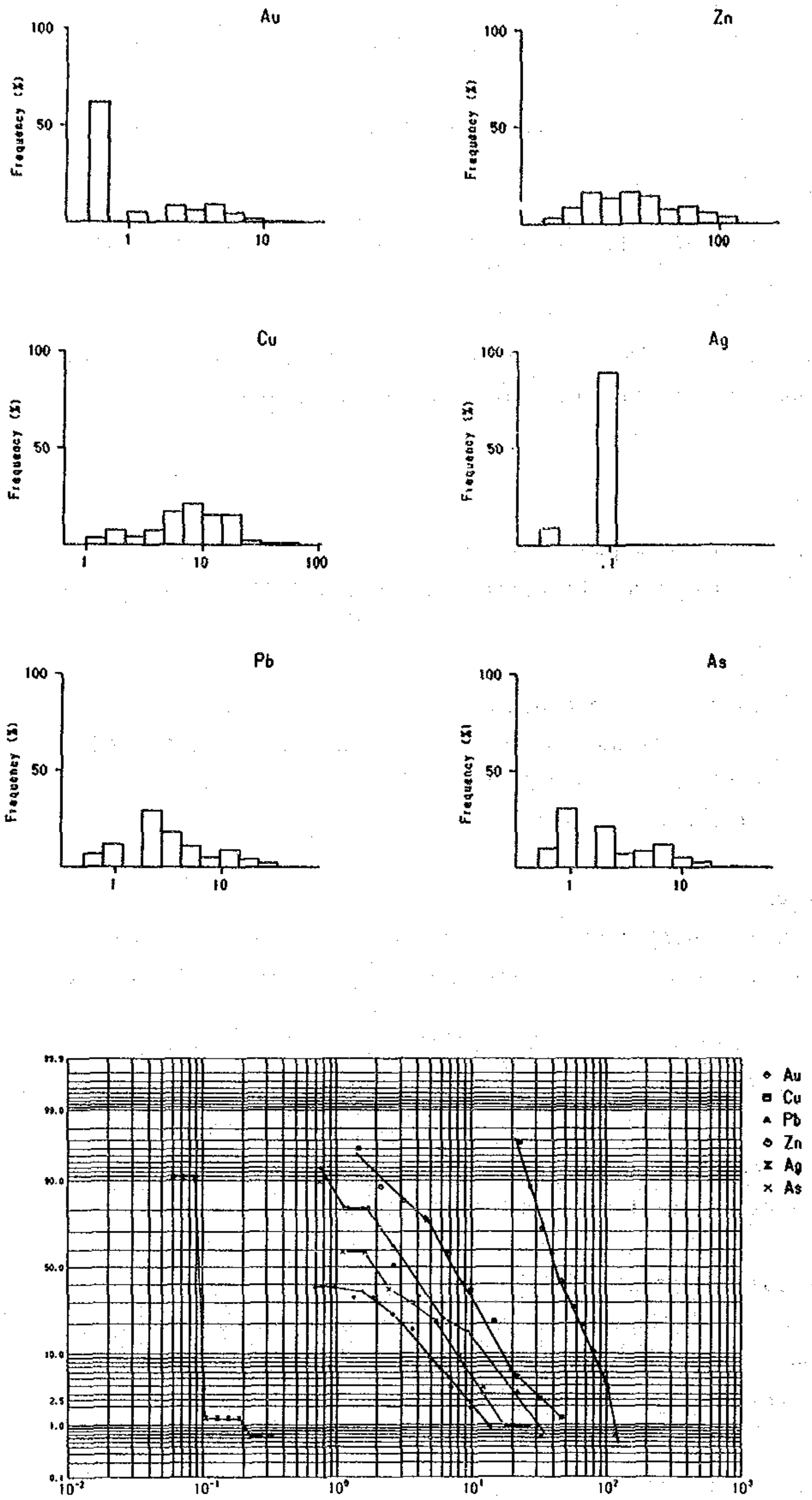


Figure Ⅱ-5-4 Histograms and Cumulative Frequency Curves showing Frequency Distribution Patterns of Assays on Stream Sediment Geochemical Samples Collected in Alto Cisnes-El Toqui Area

Third principal component

This reflects the variance of the gold contents in rocks.

(3) Geochemical anomalies and anomalous zones

i. Threshold values

Threshold values used were m+2σ, where m is mean value and σ is standard deviation. These values are as listed below.

Threshold Values Used

Element	Threshold Values
Au	7.6ppb
Ag	0.15ppm
Cu	36ppm
Pb	23ppm
Zn	105ppm
As	16ppm

ii. Geochemically anomalous zones

Numbers of anomalies with contents higher than the above thresholIds is counted as follows:-

Number of Anomalies

Element	Numbers of Anomalies
Au	4
Ag	2
Cu	3
Pb	3
Zn	5
As	3

Localities are plotted on Plate 22. The nature of their distribution are as follows:-

Au

No dense distribution was recognized other than two anomalies in the basin of the Buitrera River.

Ag

Two anomalies were detected. One lies near the Alteration Group A in the Buitrera River and another is in the upper reaches of the Pedregoso River. Those localities also carry Cu and Zn anomalies.

Cu

Copper anomalies are detected around the alteration Group A and C sometimes accompanied by Ag, Pb and Zn anomalies.

Pb and Zn

These anomalies occur densely around the Group C.

As

Arsenic anomalies also densely occur around the Group C.

5.4. Evaluation

The following two points were considered from the results of the surface survey. However not enough geologic data were acquired because the main objective for this area was to verify the result of photogeological interpretation of aerial photographs and therefore the density of traverse lines is rather rough.

(1) Major alteration zones occur in the Ibañez Formation at the outskirts of the granitic intrusions. Some mineralization are indicated in the granitic rocks as well, but they are only narrow veinlets of Mo. Mineralized zones in this area are almost always associated with acidic porphyritic rocks; i.e. quartz porphyry occurs in the Santa Teresa Deposit studied in the Phase 1 and quartz monzonite porphyry occurs in the alteration groups A, B and C developed along the Buitrera River.

The radiometric age for the quartz porphry in Santa Teresa Deposit is 84Ma and that of the granitoids batholith ranges between 75 and 93Ma. Those rocks seem to have been formed about the same time, Late Cretaceous. Probably they were generated from the same igneous activity and the porphyritic rocks are regarded as the hypabyssal facies of the batholith. There may be some prospectivity in the areas intruded by small dikes of porphyritic rocks near the batholith.

(2) Major geochemical anomalies of Au, Pb and Zn are distributed from the basins of the Buitrera River to the upstream area of the Pedregoso River, and their distribution is in very good accordance with the alteration zones mentioned above, while assays on these alteration zones show low grades. In this work, not many samples were collected and very intensive silicification was recognized in some places. This and the good spatial coincidence of geochemical anomalies and the alteration zones lead to a conclusion that there is prospectivity in those alteration zones for locating largerconcentration of metals.

Stockworks of limonite and locally quartz are developed over all alteration zones. It might be allowed that these stockwork would represent to the leached zones and that primary sulfide ore underlies these leached zones.

CHAPTER 6. LOS LEONES RIVER AREA

6.1. Geology and Geologic Structure

6.1.1. Geology

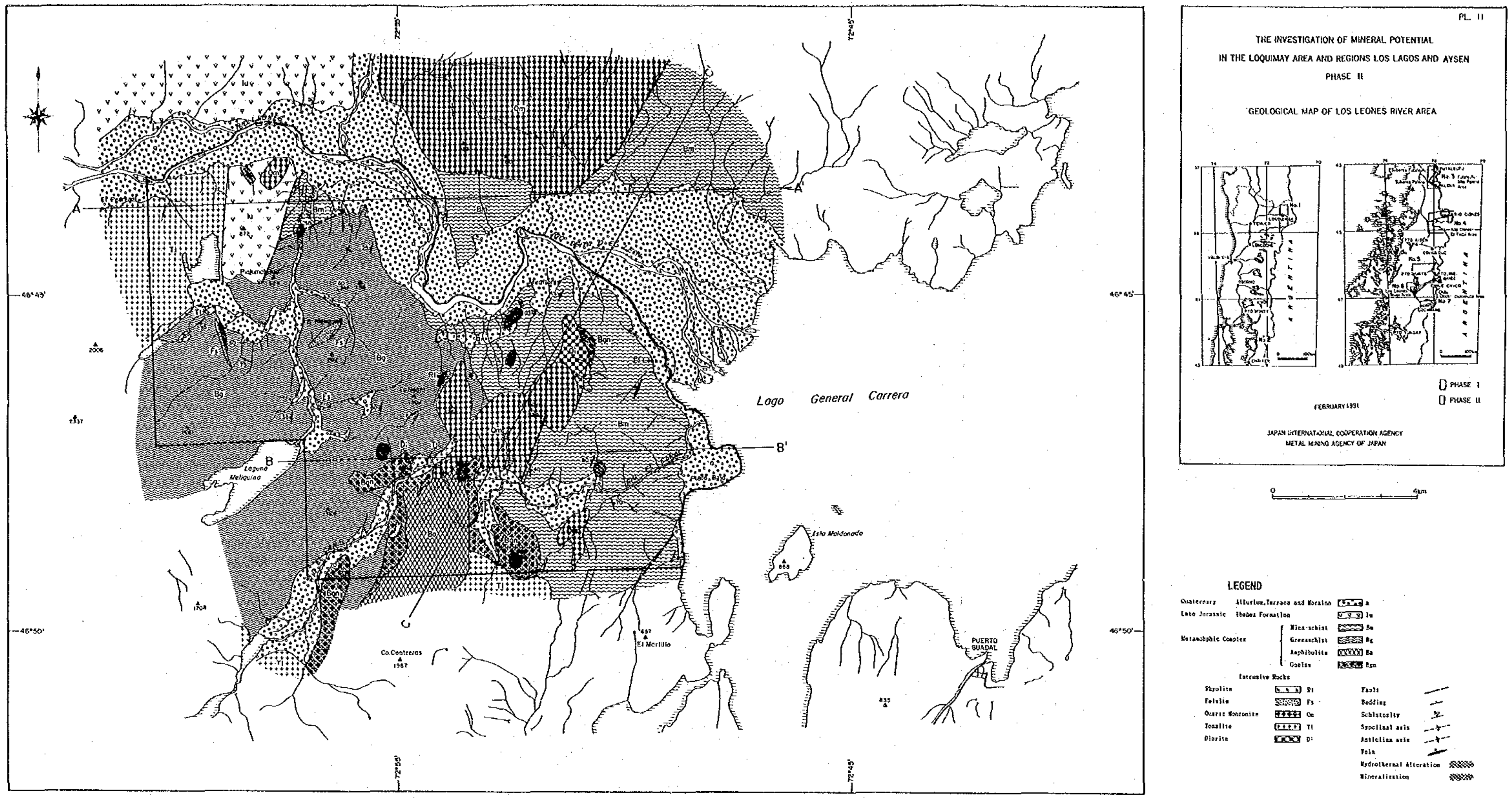
The area is underlain by the metamorphic complex believed to be the basement unit of the Aysen region and it is covered unconformably by the Ibañez Formation. The above units are intruded by several intrusive rock bodies ranging from intermediate to felsic in their composition.

The metamorphic complex occupies a large area in this area (see Figure Ⅱ-6-1). It is largely classified into two rock types, namely the metasediments and metabasites. The metamorphism is generally not of high-grade. However, rather high-grade metamorphic rocks such as amphibolite and gneiss are also developed near the intrusive bodies.

Schematic stratigraphy is illustrated in Figure Ⅱ-6-2.

(1)Basement metamorphic complex

The metamorphic rocks developed in the survey area consist mainly of low-grade crystalline schists. They can be divided into two members, namely mica-schist and phyllite distributed in the eastern part, and greenschist in the western part of the area. It is believed that the former is the metasediments derived from the pelitic rocks and the latter is derived from mafic rocks.



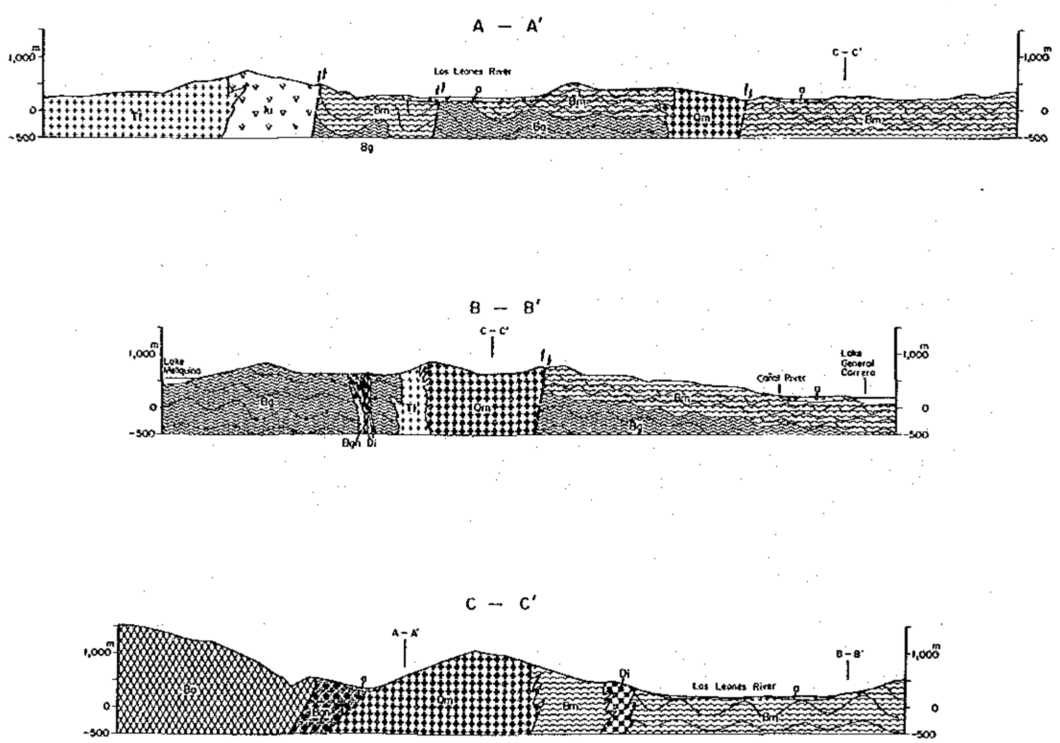


Figure II-6-1 Geological Map of Los Leones River Area

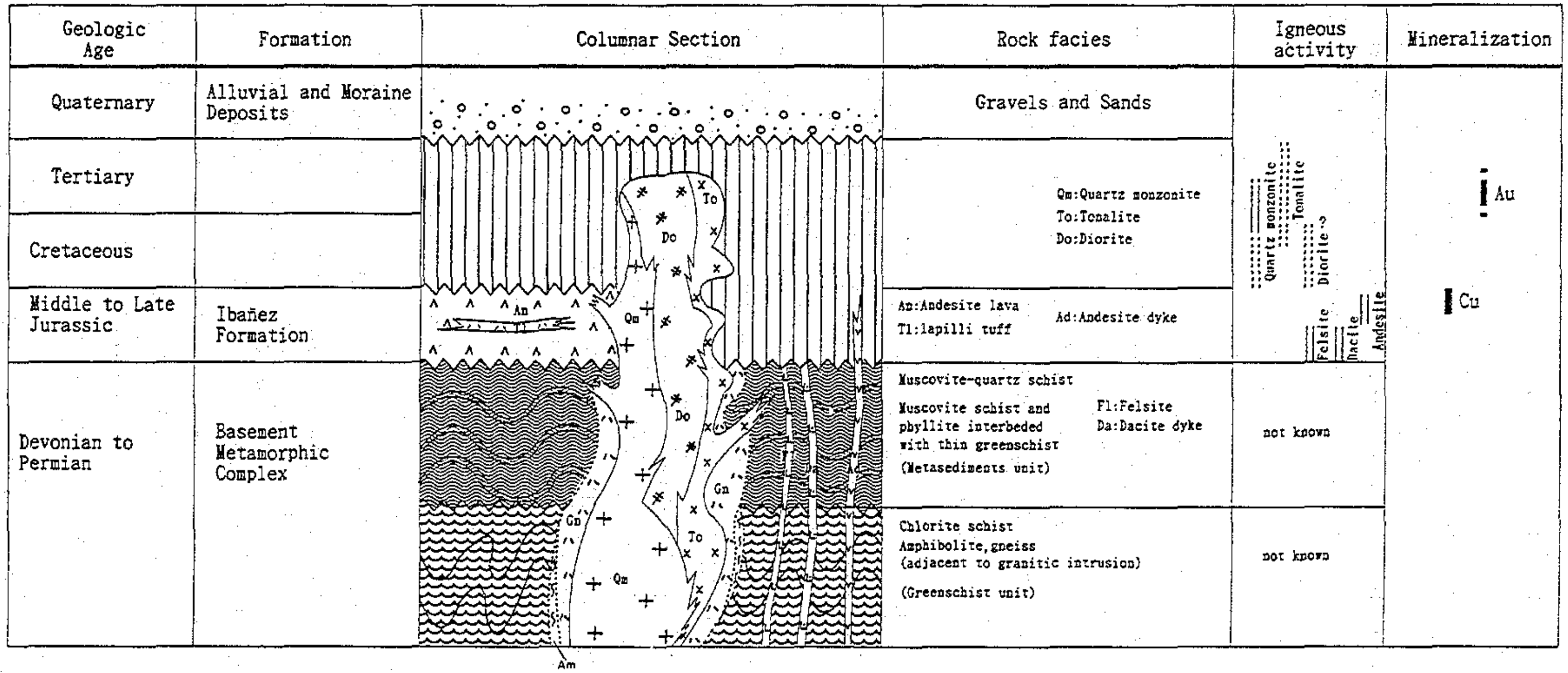


Figure Ⅱ-6-2 Schematic Diagram of Stratigraphy in Los Leones River Area

The original stratigraphic relationship of the both members could not be established because of strong deformation. Judging from the regional geology, however, a monoclinal regional geologic structure striking NNW-SSE and dipping E is recognized because the Ibañez Formation which overlies the basement unconformably crops out adjacent to the east of the basement. Therefore, the metasediments member is assumed to overlie the greenschist member. Their geologic features are as follows:-

i. Greenschist member

The distribution of this member is limited to the western half of this area. The rocks are mainly in the greenschist facies such as chlorite schist and chlorite-epidote schist. These rocks are generally hard and compact with dark to pale green color. Schistosity is visible despite consisting of very fine bands, but the rocks themselves are not very well exfoliated along schistosity. Their orientation varies widely from N-S to E-W. Whereas the microfolding is not recognized.

The metasediment member overlying this greenschist carry well developed microfolds. The schistosity in the unfolded part of the member strikes approximately N-S. This leads to an assumption that two kinds of structural layers exist in the basement complex. Thus, an unconformity is inferred between those two members. Whereas, it also can be pointed out that the difference of the development of microfolds might be caused by the difference of the physical characteristics of rocks(especially ductility), therefore, this hypothesis must be investigated and discussed further.

ii. Metasediment member

This member lies in the eastern half of the survey area. It consists mainly of muscovite schist, muscovite-quartz schist and phyllite which are believed to have been metamorphosed from pelitic rocks. No limestone beds is distributed in the area which are intercalated into this member around Puerto Crystal and host the Silva lead zinc replacement deposits. Many segregated quartz veinlets occur along the schistosity planes of muscovite-quartz schist. The rocks of this member is generally black and the weathered surface is black with reddish tint. All the rocks of this member are easily exfoliated along the schistosity. Microfolds are well developed as mentioned above. Direction of their axes range widely and they plunge in general, while the schistosity in the unfolded part consistently strike approximately N-S.

Other than those two members, gneiss and amphibolite crop out in the vicinity of the intrusive bodies of granitic rocks. They occur intimately with these intrusive bodies so that the close genetic relationship is assumed. Their modes of occurrences are as follows:-

iii. Gneiss

This rock unit is distributed in the southern part of the area. Amphiboles form bands of several millimeters width in quartz matrix. Grains of both minerals are subeuhedral and 1 to 2 mm in diameter. Quartz veinlets assumed as segregation origin sometimes occur along with the banded structures. Some of them cross cut those structures.

iv. Amphibolite

This massive rock unit consists of subhedral mineral grains of 1 to 2mm in diameter. The rock forming minerals are mainly hornblend and plagioclase. Quartz is contained to some extent as well and therefore there seems to be phase transition to hornblend-plagioclase gneiss. It is distributed in the southern part of the area and occurs intimately with gneiss.

(2) Radiometric ages of the metamorphic rocks

Radiometric dating was carried out for the metamorphic rocks developed in the survey area during the work of Phases I and II. The method used is K-Ar method. These work revealed that metamorphic events took place 228±7 Ma (Middle to Late Triassic) for muscovite-quartz schist and 389±28 Ma (Middle Devonian) for amphibolite in the southwestern part of the area. The amphibolite provided for dating is considered to be intruded in its west by tonalite, though the contact is not identified. On the other hand, the radiometric age of tonalite mentioned below shows 341±15 Ma. It is pointed out that the radiometric ages of the both rocks nearly overlap taking the measurement errors into consideration. On this hypothesis, this amphibolite is believed to have been metamorphosed after the original rock (mafic rocks ?) under the condition of rather high-temperatures and low to medium pressures caused by the tonalite intrusion. Whereas muscovite-quartz schist is about 160 Ma younger than amphibolite. This suggests that there were at least two metamorphic event in the area, the local contact metamorphism and the regional metamorphism. As to the age of the original rocks, Skarmeta et al.,(1984) presumed Devonian to Carboniferous time.

(3)Ibañez Formation

This sequence is distributed along Los Leones river in the north-western part of the area. The stratigraphy of the Ibañez Formation is generally simplified as follows. The lower portion consists mainly of acidic pyroclastic rocks and the upper portion is the sequence of andesite lava and andesitic pyroclastic rocks. The formation recognized in this area is composed of andesite lava and interbedded andesitic lapilli tuff.

Both rock units are silicified extensively.

This sequence unconformably overlies the basement metamorphic rocks complex, but the contact seems to be partly fault.

(4) Quaternary

Quaternary sequences consist of river terrace deposits, alluvium and drift. They are expressed as one unit on the geological map. The river terrace deposits are distributed chiefly along Los Leones River and El Cañal River, and partly along their tributaries. The river terrace deposits are treated in this report as one without classifying them by level. The level difference of the terrace surfaces and the present river bed exceeds 100m. The terrace surfaces are strongly dissected.

Alluvial deposits are distributed broadly along each river and in the rivermouth of Los Leones River. On the contrary, in the part of El Cañal River, the rocks crop out on the river bed and form the box-shaped valley with thin alluvial deposits distributed at the rivermouth of the branches.

Drift lies along the parts of the branch streams. This deposit consists of poorly sorted sediments neither containing round nor sub-round gravel.

(5) Intrusive rocks

Composition of intrusive rocks in the survey area range between intermediate and felsic composition. Their rock types are tonalite, quartz monzonite and diorite. Petrology is described below:-

Tonalite is distributed in the northwestern, southwestern part and a small portion of the central part of the area. Mineral grains are subhedral and medium-grained. Hornblende and biotite are the major mafic constituents. This rock sometimes transforms in the margin of the rock bodies to a rock facies like pegmatite with large hornblend crystals of 2cmx0.5cm in size. K-Ar dating shows 341±15 Ma (Table 15 in Appendix). Quartz monzonite is distributed in the central part of the area elongated in the NE-SW direction. The radiometric age for this rock type was determined to be 14 Ma during the work of the first Phase. Diorite intrudes into muscovite-quartz schist in the northeastern part of the area.

Also small dikes of dacite, felsite and andesite intrude the basement metamorphic complex sporadically, while it is not confirmed whether they intrude the Ibañez Formation or not.

6.1.2. Geologic structure

The schistosity of the metasediment member principally strikes N-S, but their dip azimuth is not very consistent. The elongation of the intrusive bodies are generally oblique to the direction of the their schistosity with low angles. The schistosity direction of greenschist facies sub-unit vary widely from N-S to E-W.

Anticline and syncline are inferred in the northwestern part of the area on the basis of the pattern of strike-dip direction of schistosity, and the strike of the inferred faults, namely NNE-SSW to NE-SW. It is noted that three structural features; the principal directions of the elongation of intrusive bodies and folds and faults are approximately in the same direction. This suggests the presence of the rupture-deformation structure with the NNE-SSW to NE-SW direction which existed prior to the intrusion event of the granitic rocks.

The Ibañez Formation shows different structural features from that of the basement rocks. The attitudes of units layers of the andesite lava flow are believed to be nearly parallel to one of the dominant two joints which are parallel to the lapilli tuff beds. The structure of the formation is a monocline structure striking N65-80°E and dipping 50°N.

6.2. Mineralization

Mining activity is hitherto unknown in this area and neither of mining nor exploration concession was marked out as of October, 1989. Thus this is a virgin area regarding exploration and exploitation of mineral resources. Several small indications of mineralization are recognized in the area and notable ore outcrop among them are at VM-606, VM-607 and VM-610. These mineralization occurs at the edge of diorite stock, near the contact with muscovite-quartz schist featuring stockwork of quartz-pyrite(-chalcopyrite-hematite). Mineral assemblage is simple and no other mineral is observed even under the microscope. This stockwork zone is 3 to 5m wide and strike NNE-SSW to NE-SW which is parallel to the trend of the contact between diorite intrusive body and mica schist. The wall rock alteration is merely weak silicification and confined within the stockwork zone. Assay on these outcrops show very low grade, though ore grades at the point VM-607 are a little remarked for Au, Ag and Cu. Assay results are listed up on the following Table.

Assay on Stockworks occurring at Contact Zone

Sample	Width*	Au(ppb)	Ag(ppm)	Cu(ppm)	Pb(ppm)	Zn(ppm)
VM606	5m	20	0.1	9	20	25
VM607	3m	0.5ppm	3.1	0.12%	450	14
VM610	4m	60	0.5	9	26	12

*: Width is denoted as the width of stockwork zone.

Other than that, single veins and disseminated stockwork of quartz-pyrite associated with felsite and andesite dikes are recognized. Single veins are 40cm wide at maximum and occur in granitic rocks. Mineral assemblage is mainly quartz-pyrite-hematite and sometimes is accompanied by galena-sphalerite-chalcopyrite showing 0.7% Pb and 0.21% Zn. Stockwork mineralization associated with dikes (usually some 10cm wide) are 2m wide at maximum and country rocks, usually greenschist, are affected by silicification and pyrite dissemination within the stockwork zones. Stockwork consists of very simple assemblage, quartz and pyrite.

Notable assay results on some outcrops are shown on the following table.

Assays on Some Disseminated or Stockwork Associating Dikes

Sample	Width*	Au(ppb)	Ag(ppm)	Cu(ppm)	Pb(ppm)	Zn(ppm)
KM685(stockwork[1])	1m	60	6.7	97	250	730
KM686(disseminated[2])	5m	20	6.3	451	270	960
YM616(disseminated[3])	2m	20	1.6	0.16%	14	139
YM633(stockwork[4])	1m	<20	0.3	0.28%	5	32

*: Expressed as the width of zones.

Dikes related to mineralization are as follows:-

1) Andesite 2) Andesite 3) Felsite 4) Felsite

Low grade silver and copper are noted, but they never occur in large scale.

As a fact of matter, it is concluded from the surface geological survey that no promising mineralized zone with economic possibility has yet been defined in the area.

6.3 Geochemical Exploration

(1) Sampling and assays

Paned concentrate geochemical exploration was conducted throughout this area. Care was taken to cover even very small streams because it was expected that the mineralization in this area might be very small. Two hundred and sixteen geochemical samples were collected in this area.

General matters regarding sampling and chemical analysis were common with the case of the Futaleufu area. Samples were assayed by the Laboratory of SERNAGEOMIN for seven elements; Au,Ag,Cu,Pb,Zn,Mo and As.

(2) Statistical data-processing

i. Elemental statistic

Table 9 attached in Appendix shows the results of assay and the elemental statistical parameters are listed on Table 3 in Appendix. Raw values were calculated after converting to logarithmic values and the statistical parameters were denoted by real numbers. All the elements, except for As, show very low mean values, compared the other areas where paned concentrate geochemistry was carried out, namely Futaleufu sub-area and Chile Chico-Chacabuco area. On the other hand, the ratios of samples with contents below the detection limits in this area are as follows.

Au:79% Ag:2% Cu:0.4%
Pb:40% Zn:0% Mo:69% As:45%

Based on these ratios, all the elements can be classified into three categories; element group of most samples existing in amounts above the detection limits (Ag,Cu and Zn), about half of the samples existing in amounts below detection limits (Pb and As) and 70% of samples existing in amounts below detection limits (Au and Mo).

ii. Frequency distribution pattern

Figure II-6-3 illustrates the frequency histogram for each element and the cumulative frequency distribution curves. The lateral axes of both diagrams are calibrated by logarithm. On cumulative frequency distribution diagrams,

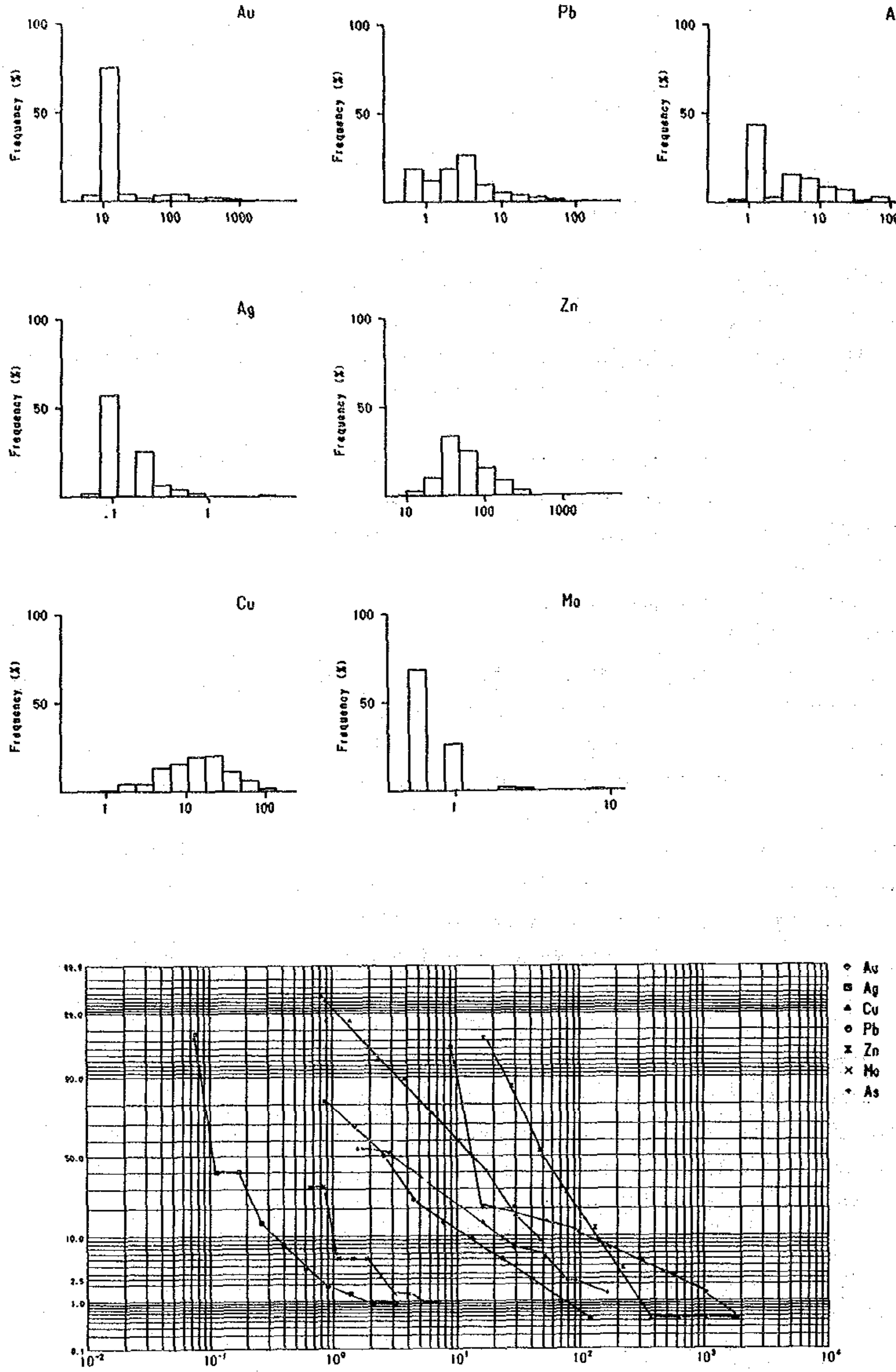


Figure II-6-3 Histograms and Cumulative Frequency Curves showing Frequency Distribution Patterns of Assays on Pan Concentrate Geochemical Samples Collected in Los Leones River Area behavior patterns of each element are grouped into two types; one group is Au-Ag-As-Mo and another is Cu-Pb-Zn. Of these curves, those of the Cu-Pb-Zn group are interpreted as not defining the ore and background populations separately, but only one population following the log-normal law; possibly this reflects the metal contents in rock fragments remained in the container after the panning concentration. On the other hand, the frequency distribution patterns of the group Au-Ag-As-Mo can be divided into two populations. Those two populations are believed to follow the log-normal law. The transitional borders of those populations are set up approximately around 20ppb for Au, 0.2ppm for Ag, 3ppm for As and 2ppm for Mo. These figures are on fairly low level, considering that the samples were concentrated by panning.

ⅲ. Correlation

Correlation coefficients are listed on Table 4 in Appendix. Generally they are small, and the correlate relationss are acknowledged for only the pairs Pb-Zn and Cu-As which show coefficients of 0.5 or higher.

ⅳ. Principal component analysis

Table 5 in Appendix shows the eigen vectors. On the basis of the conventional technique, the principal components carrying the eigen values of 1.0 and higher were used to examine up to the third principal component. First to third components explain 73% of variance caused by geology and mineralization in the area. The result is summarized as follows:-

First principal component

This expresses the variance of pair Cu-As

Second principal component

This expresses the variance of pair Pb-Zn

Third principal component

This express the variance of pair Au-Ag

In the previous section, correlation coefficients were examined. Considering these coefficients together with the results of this analysis, the second principal component is considered to reflect the variance of background values. This may be caused by contamination of rock fragments which could not be excluded by panning. As mentioned on the section 6.2., some of the indications of mineralization in this area show low grade gold, silver and copper. They might have influenced the first and third principal components.

(3) Geochemical anomalies and anomalous zone

i. Threshold values

Each of the population of the four elements, Au, Ag, As and Mo, is composed of two populations as mentioned above. Values at the transitions of each populations, however, are at very low level so that all the threshold values were set to m+2σ not following the frequency distribution curve method. Threshold values used are as indicated below.

Threshold Values Used

Au 170ppb	Cu 93ppm	Zn 230ppm	As 58ppm
Ag 0.5ppm	Pb 27ppm	Mo 2ppm	

ii. Geochemically anomalous zones

Geochemically anomalous zones are summarized as follows:-

Au

Small numbers of anomalies are situated in the mouth of El Cañal River and scattered in the area from the central to the western part of this area. These areas lie in the downstream zones of the quartz monzonite and diorite intrusive bodies are distributed.

Ag

A few anomalies are sporadically distributed in the up-stream area of the Meliqui River in the western part, mid-stream and downstream areas of the El Cañal River in the southern part.

Cu

Anomalies are very sporadically distributed along El Cañal River and the upper reaches of the Meliquina River.

Pb

Anomalies are distributed in the mid-stream and down-stream areas of El Cañal River, and ar the eastern rim of the area. They are especially concentrated on the rim area. These anomalous zones are in the of muscovite-quartz schist zone.

Zn

The distribution patterns are similar to those of Pb.

Mo

Many anomalies occur in the Mirasal area located in the north eastern part of the area. This zone is situated in the lower reaches of the area of quartz monzonite and diorite intrusive bodies.

As

A part of anomalies overlap with those of Mo. Also other anomalies occur densely in the mid-stream of El Cañal River. These areas lie in the lower reaches of the area of quartz monzonite and diorite intrusive bodies distributed.

6.4. Evaluation

(1) Result of the geological survey

The mineralization in the area are grouped into two types, namely the stockwork developed in the diorite stocks which intruded into the muscovite-quartz schist, and the stockwork-dissemination associated with the dikes of felsite and andesite. The former mineralization occurs in the rim of the diorite body and its strike agrees well with the direction of the contact of diorite and schist. This suggests that the mineralization took place in the fissures which were selectively formed at sites where large contrast exist in the competence of the rocks.

The fractures of the latter might have been formed by the intrusion of the dikes, or the already existing fractures could have opened as the result of the intrusion.

This area is considered geologically favorable for the formation of fractures since the hard and competent intrusive bodies intruded the incompetent crystalline schist. As mentioned in 6.1.2., the NNE-SSW to NE-SW trending rupture-deformation structure could have existed prior to the intrusion and this also was favorable for expecting high mineral potential. However, this survey revealed that the grades of the ore outcrops are at very low levels and their size is also very small.

There may be a possibility that the grades and size improve in the deeper parts, even though they are disappointing on the surface. But this possibility is believed to be very small because all the alteration zones observed on the surface are small, and therefore it is pointed out that the intensive hydrothermal activity never took place in this area. This lead to the conclusion that the mineral potential in this area is ranked very low.

(2) Result of geochemical exploration

At first, some gold anomalies were detected through the paned concentrate geochemical work of Phase I. This led to the further exploration work of this phase. Panned concentrate geochemistry was also carried out this year with the target on gold mineralization. However this work ended in very disappointing results. Especially the assay for gold, the primary target at the start of this programme, was very disappointing with 80% of samples showing contents below 20ppb.

It is pointed out that the deposit containing very fine-grained gold may be hardly detected by the panned concentrate geochemistry, since panning will probably not collect the very finr graines. In fact, it was difficult to exclude rock fragments from the samples for chemical analysis, and therefore the heavy mineral contents could have been diluted. However, it would not be that most of assay results for gold are below the detection limit, if samples contained even a very tiny gold grain. Thus, it is concluded that no further advanced stages of the exploration on this area is necessary.

As to base metals, geochemical features are the same as those of gold. The following table compares the assay results of this year to the standard metal content for some rock types.

Assays on Panned Concentrates and Standard Metal Contents in Some Rock Types

Element	Assays on Pan Concentrates		Standard Metal Contents in Rocks			
	Mean	Threshold(m+2σ)	Basaltic rocks	Granodiorite	Granite	Shale
Au	16ppb	170ppb	4ppb	40ppb	40ppb	n ppb
Ag	0.1ppm	0.5ppm	0.11ppm	0.05ppm	0.04ppm	0.07ppm
Cu	13ppm	93ppm	87ppm	30ppm	10ppm	45ppm
Pb	3ppm	27ppm	6ppm	15ppm	19ppm	20ppm
Zn	56ppm	230ppm	105ppm	60ppm	39ppm	95ppm
Mo	0.7ppm	2ppm	1.5ppm	1.0ppm	1.3ppm	2.6ppm
As	4ppm	58ppm	2ppm	1.9ppm	1.5ppm	13ppm

NOTE: The data for the standard metal contents in rocks were adopted after Turekian and Wedepohle(1961).

Metasedimentary rocks are believed to have been originally pelitic rocks and the original chemical constituents might not have changed very much because they are low-grade metamorphic rocks. Therefore, they are correlated to shale in the table. The metal contents of basaltic rocks are listed for the greenschist in this report.

As shown on the table, all the mean values of the assay data on this work are in the same level as the standard metal contents in the rocks. Even regarding the threshold values, they, except for gold and zinc, are in the same levels. These facts strongly suggest that the geochemical exploration data obtained through this work reflect merely the background.

Figure Ⅱ-6-4 is a map with plots geochemical anomalies of panned concentrates on the geologic map. Localities of the mineral indications are also shown on the map. This discussion is proceeded by mainly using this map with elements Au, Pb and Cu which show characteristic distribution patterns.

Gold anomalous zones lie from the central to the western part of the area. They are in the greenschist and quartz monzonite areas, and it is also noted that these zones sit at the base of the high mountains of quartz monzonite.

Lead anomalies are concentrated in the metasediment area.

On the other hand, very sporadic anomaly distribution occurs in the river basin in the greenschist area. Dikes of andesite and felsite accompanied by small mineralization intrude around this zone. The maximum Pb assay on ore outcrops is 270ppm. It is believed that this anomalous zone is attributed to this kind of small mineralization.

Geochemical values of copper shows no particular tendency, but a small anomalous zone is recognized near that of Pb mentioned above. The maximum copper content of outcrops of mineralized zones occurring with dikes mentioned above is 0.28% Cu.

As mentioned, this survey revealed that two types of mineralization are recognized in this area, namely the quartz-pyrite stockwork occurring in the marginal parts of diorite stocks, and quartz-pyrite stockwork and pyrite dissemination related to dikes. Aside from this, gold mineralization is presumed to occur also in quartz monzonite, considering the result of geochemical exploration. However, no indication of the mineralization was

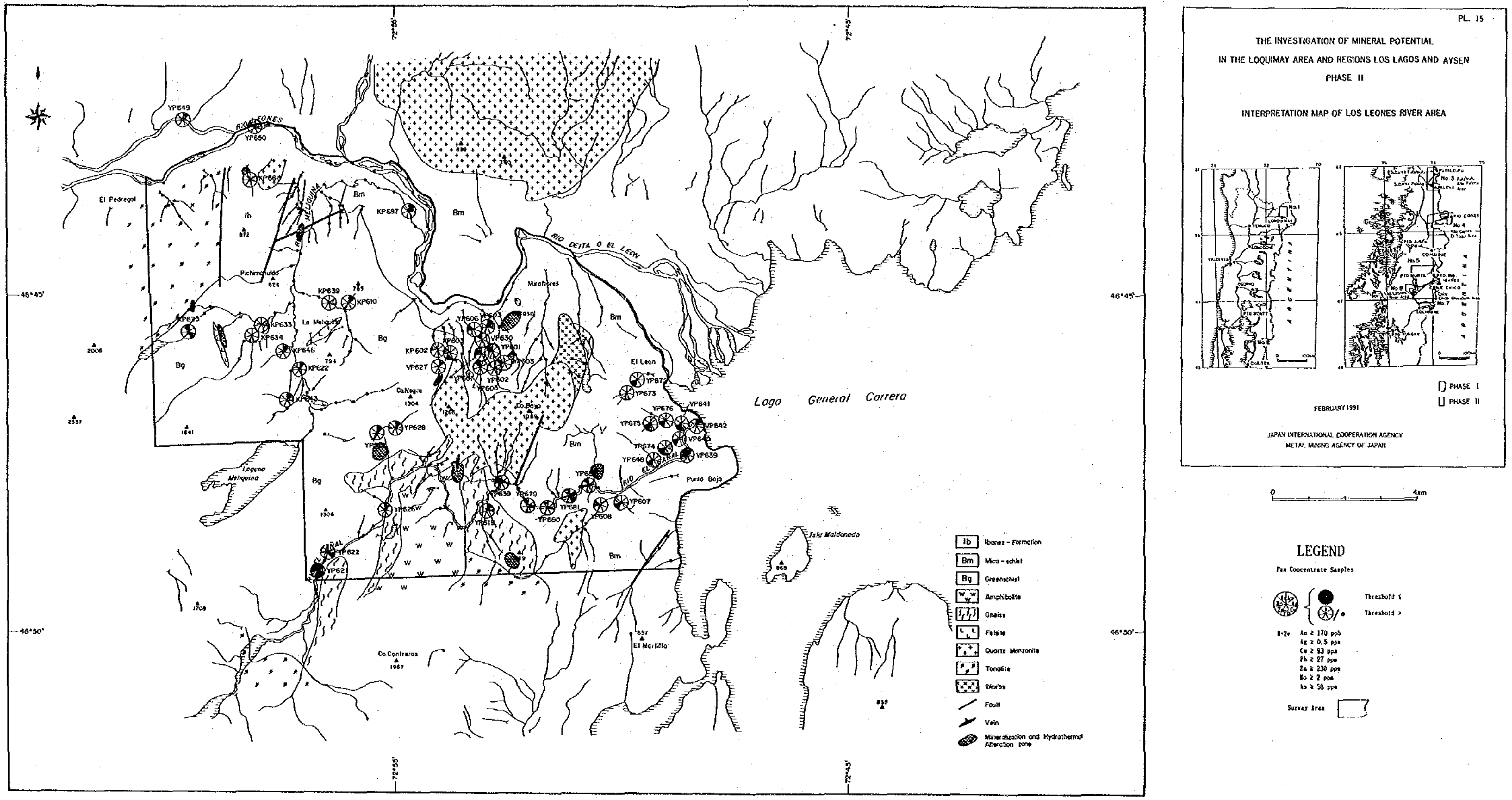


Figure Ⅱ-6-4 Collective Interpretation Map of Los Leones River Area

found in quartz monzonite despite the extensive surface survey. Furthermore, the rock is very hard and massive with rare fractures and also is not affected by strong alteration. These facts suggest that the occurrence of gold mineralization in quartz monzonite is very confined even if it does exist. Taking the very low level geochemical Au anomalies into account, this gold mineralization is probably small and weak which might not be more than geochemical anomaly.

As mentioned above, the exploration work in this area was ended in very disappointing results, which indicate low mineral potential of this area.

CHAPTER 7. THE CHILE CHICO-CHACABUCO AREA

7.1. Survey of the Alteration Zones

A total of 16 alteration zones were delineated by photogeological interpretation of this area and were surveyed geologically on surface.

The surface survey revealed that localities and shapes of the alteration zones extracted by TM images are largely correct, but sometimes they do not coincide in detail, particularly with small alteration zones with areas of less than $1km^2$. On the other hand, the photogeological interpretation overlapped alteration zones and picked up false zones in some cases. Total of 21 alteration zones are observed by the surface survey. These localities are illustrated in Figure Ⅱ-7-1.

Those alteration zones are divided into nine groups on the basis of their location. Symboles, A to I, are assigned to them in this report (Figure Ⅱ-7-1). Their features of geology and mineralization are described below.

(1) Alteration group A

This group corresponds to the alteration zone "7-27" assigned by TM Image analysis. This zone lies about 17km south of the Laguna Verde Deposit and is extended around the Colorado Alto Mountain located in the mid-stream of Las Nieves River. Extension of 5.5x3km is identified. No mining and exploration activities are hitherto recorded.

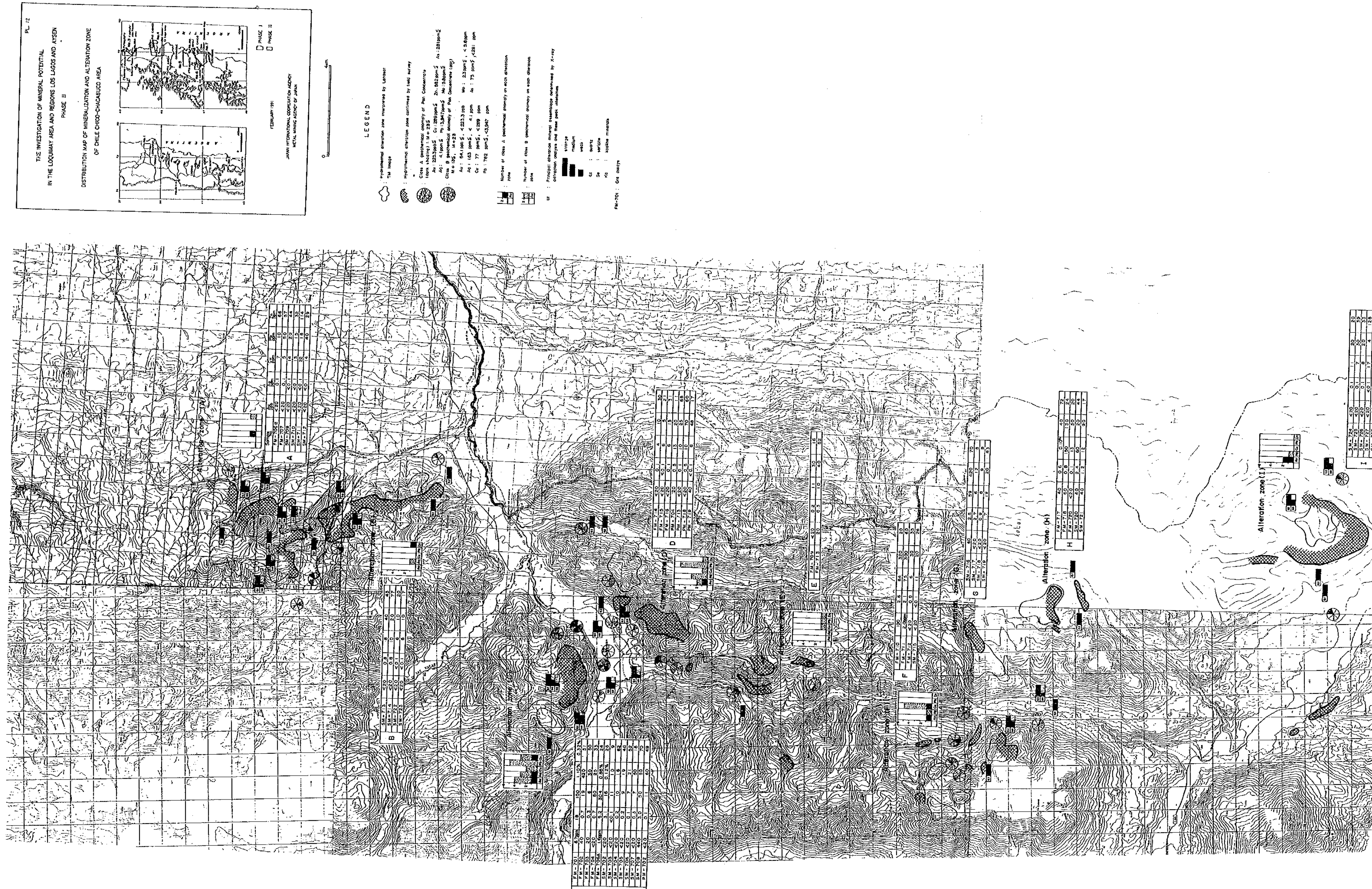


Figure II-7-1 A Plan Map Illustrating the Results of th

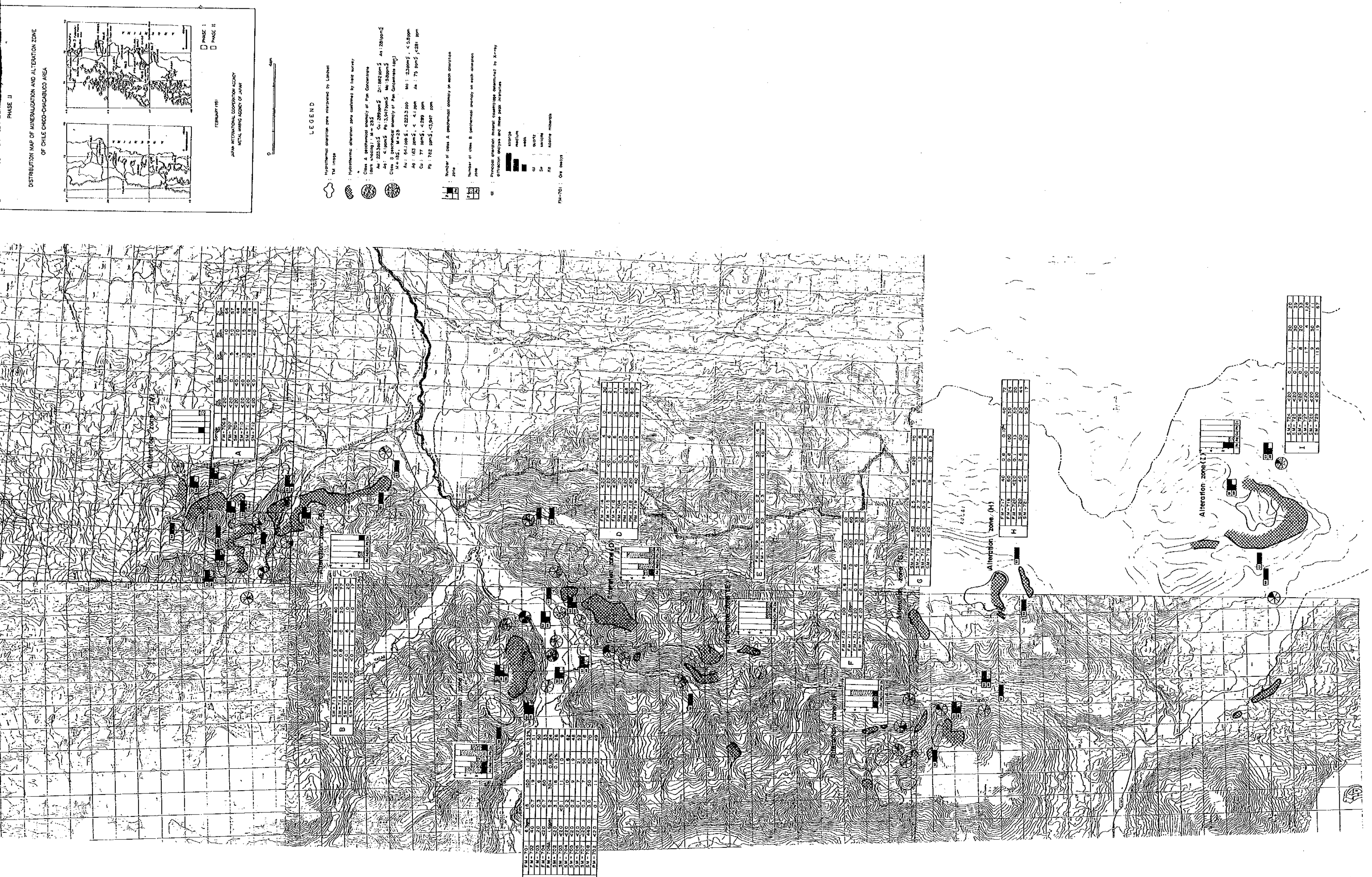


Figure II-7-1 A Plan Map Illustrating the Results of the Surface Survey

The alteration occurs in dacitic tuff and dacitic lava. Limonitic veinlets and pyrite dissemination are scarcely observed in the zone. The alteration is weak, but rocks are affected by bleaching and weak silicification caused by the weathering. Alteration minerals determined by X-ray diffraction are listed on Table 14 in Appendix. This detected only weak peaks of quartz, sericite and kaolinite.

Assay on the rock chip samples and floats show very low grades as shown on below Table.

Assay on Alteration Group A

Sample	Au(ppb)	Ag(ppm)	Cu(ppm)	Pb(ppm)	Zn(ppm)
FM706b	<20	0.1	7	10	66
FM707	<20	0.1	5	50	37
SM709	<20	<0.1	14	20	44
SM710	<20	<0.1	13	15	32
SM711	<20	<0.1	22	18	114
SM712	<20	<0.1	14	40	29

(2) Alteration group B

This is the alteration zone "7-30" assigned by TM Image analysis. The size identified in the field were as large as twice of that estimated by TM Image analysis. This zone lies about 1km south of the Group A extending in the N-S direction over the Las Lajas Mountain. An areal extension of 5.5x1km are identified. Mining and exploration activities are hitherto unknown.

This group is developed along the sheared anticlinal zone with axial-plane standing vertically. This anticlinal zone strike N-S and is about 700m wide extending to the south along the border ridge of Chile-Argentina. Alteration occur in dacitic tuff and lapilli tuff of Divisadero Formation. Ferruginous alteration is developed with veinlets and dissemination of limonite. Other than this, faint breaching and silicification are recognized. Alteration minerals determined by X-ray diffraction are listed on Table 14 attached in Appendix. Rocks are composed mainly of quartz, but small amounts of kaolinite are detected.

Assay on this alteration zone show very low grades.

Assay on the Group B

Sample	Au(ppb)	Ag(ppm)	Cu(ppm)	Pb(ppm)	Zn(ppm)
SM713	<20	0.8	8	40	43
SM714	<20	0.8	10	20	77
SM722	<20	<0.1	6	10	27
SM723	<20	<0.1	6	10	17

(3) Alteration group C

This is the alteration zone "7-39" of TM Image Analysis. Although originally two other alteration zones, "7-38" and "7-41", were also extracted around this locality by TM Image Analysis, the "7-41" was a false zone, while the "7-38" was not observed due to snow cover.

This group is at distance of about 65km from Chie Chico town along a car road and is accessible up to its outskirts by vehicle. Also this area lies about 10km southwest of the group B and ranges from the north coast of the Lake Jeinemeni to Mountain Ridge. The whole area around this lake is a National Park and is administrated by the Jeinemeni Forest Office located by the lake. The rocks of this zone crop out along the side walls of the glacier valley and it is very difficult to reach the outcrops in many cases. Therefore, observation and sampling were based on float samples which are likely to be derived from this zone.

The areal extension is at least 1x3km, but it is not certain due to snow cover. No mining activity was hitherto known, but according to local people, a company carried out the surface geological survey some years ago.

The rock in this group are dacite and dacitic tuff of Divisadero Formation. Stockwork of quartz, limonite and hematite is densely developed in the zone. Each veinlets of the stockwork are 0.1 to 2cm wide and sometimes accompanied by small amount of galena, sphalerite and pyrite. The alteration is composed of rather intensive silicification and faint sericitization. Quartz, sericite and kaoline are detected by X-ray diffraction(Table 14 in Appendix).

Assay on the group are as follows. A couple of them show fairly high grade of gold and minor content of lead.

Assay on the Alteration Group C

Sample	Au(ppb)	Ag(ppm)	Cu(ppm)	Pb(ppm)	Zn(ppm)
FM701(F)	6.7ppm	18	100	1.10%	0.32%
FM702(F)	40	0.7	19	420	51
FM703	20	0.3	6	30	50
FM704	<20	0.7	60	25	33
FM706a	1.6ppm	5.2	304	0.88%	24
SM702(F)	<20	3.1	16	0.12%	28
SM703(F)	<20	<0.1	11	10	9
SM704(F)	<20	0.2	10	16	62
SM705(F)	<20	0.2	9	19	48
SM706(F)	<20	0.1	7	21	52
SM707(F)	<20	0.3	7	50	18
SM708(F)	440	3.0	50	50	70
PM702(F)	<20	0.1	11	60	49

NOTE: "(F)" indicates float samples derived from the alteration zones.

(4) **Alteration group D**

This alteration group includes the zones "7-42" and "7-43" of TM image analysis, but both the location and shape is a little different from it as shown in Figure Ⅱ-7-1. This group lies at the opposite side across the Lake Jeinemeni from the Group C. No mining and exploration activities are hitherto known.

This group consists of two zones arranged N-S. The zone in the north extends to the size of 1kmx0.4km and the south sub-zone extends to the size of 2.5x1km. The rock is dacite of Divisadero Formation. Stockwork of limonite is extensively developed throughout the two zones. Dissemination of pyrite is recognized as well. Types of alteration are moderate silicification and faint sericitization.

The area of this group has very rugged topography, and especially the south zone is accessible only up to the margin. Assay on this zone are listed below and all are of low grade.

Assay on the Alteration Group D

Sample	Au(ppb)	Ag(ppm)	Cu(ppm)	Pb(ppm)	Zn(ppm)
FM714	<20	0.1	4	10	30
FM715	<20	<0.1	6	5	21
FM716	<20	0.1	6	15	31
PM704	20	0.5	13	20	11
PM713	<20	0.1	10	25	68
PM718(F)	<20	0.5	10	70	60
PM719(F)	40	<0.1	8	48	17

(5) Alteration group E

This group is believed to coincide to the alteration zone "7-43" of TM Image Analysis, but its locality and shape are to some extent different from that identified by the surface survey. This is not as large as interpreted by TM image analysis. But consists of small three zones distributed about 4km south-southwest of the Group D. Mining and exploration activities are hitherto unknown.

The topography of this group is very rugged and only one zone nearest to the Antonio River could be closely surveyed, while other two zones were nothing more than observed from a distance with binoculars. Those zones extend to approximately 0.5x1km each in size. Rock is dacite of Divisadero Formation. Stockworks of quartz and limonite occur in this group with small pyrite dissemination. Type of alteration is moderate silicification other than ferruginous alteration.

Assay on this group is low grades as follows:-

Assay on the Alteration Group E

Sample	Au(ppb)	Ag(ppm)	Cu(ppm)	Pb(ppm)	Zn(ppm)
FM709	<20	0.2	11	30	166
FM713(F)	20	0.2	10	40	82

(6) Alteration group F

This group corresponds to a group of the alteration zones "7-53", "7-54", "7-55" and "7-56" of TM image analysis. As to the zones "7-54" and "7-56", they are recognized in the place indicated by TM image analysis. Except for these two zones, the localities and shapes are to some extent different from result of TM image analysis. This group lies in the basin of a western tributary of La Leona River at its mid-river. No mining and exploration activities are known so far. This group is divided into five zones.

Only one zone at the southernmost past was accessible, while access to the other zones was obstructed by very steep topography. Size of these zones range from 0.2x0.7km at minimum to 1.2x1km at maximum. Rock is dacite of Divisadero Formation.

The surface is most likely a ferruginous alteration zone, and limonite stockwork and small amount of quartz veinlets are developed in the rock. The rocks are also disseminated by small amount of pyrite. Other type of alteration in this zone is faint silicification.

Assay on this zone are as listed below. Weak Au and Pb mineralizations are recognized. The sample FM711 showing 2.0ppm Au is a float of quartz-limonite-pyrite vein with 5cm width derived from veins occured in greenschist of Paleozoic basement unit, and this is of a different mineralization.

Assay on the Alteration Group F

Sample	Au(ppb)	Ag(ppm)	Cu(ppm)	Pb(ppm)	Zn(ppm)
FM710(F)	100	2.6	64	320	20
FM711(F)	2.0ppm	2.1	75	300	60
FM712	<20	0.9	6	30	33
SM715	<20	<0.1	11	20	26

(7) Alteration group G

This group corresponds to the zone "7-50" extracted by TM image analysis, and lies about 8km south of the Zone E or the basin of an eastern tributary of Las Leona River. Neither mining nor exploration activities are hiotherto known. Access to this zone was not completed due to rugged topography. Size from a distance is approximately 1.5x0.4km, and is smaller than interpreted by the TM image analysis. The rock is considered to be dacite of Divisadero Formation judging from float rocks.

Bleached rocks with limonite impregnation are often found in float rocks at the outskirts of this group. This group is likely a pseudo-hydrothermal alteration zone formed by weathering. Assay on these rocks are as follows:-

Assay on Float Rocks Collected at Outskirts of the Group G

Sample	Au(ppb)	Ag(ppm)	Cu(ppm)	Pb(ppm)	Zn(ppm)
SM716(F)	40	2.5	59	420	70
SM717(F)	<20	2.7	6	12	8
SM718(F)	<20	0.9	8	9	8
SM719(F)	<20	1.7	19	20	83

(8) Alteration group H

This group corresponds to the zone "7-52" of TM image analysis and lies about 4km south of the Group G or the western slope at the mid-river basin of El Halcon River. Mining and exploration activities for this group are unknown so far. Rugged mountains obstruct access to this group very much.

This alteration group consists of two zones, the north and the south. The north zone is atop mountain and it was impossible to reach. Whereas the south zone is rather easy of access because it is developed in the vicinity of a river. Areal extention of the north zone is estimated to be approximately 1.4x0.7km, though the whole area is unknown. The south zone is elongated in the E-W direction covering 1.5x0.3km.

Geology of this group is composed of aphanitic andesite of the Divisadero Formation and dacite dikes. In the south zone, stockwork of limonite-quartz and minor chalcopyrite-pyrite dissemination occur in the dacite dikes. Rocks in this zone show brown color as a whole. Alteration types are faint silicification and chloritization.

Observation for the north zone was done by from a distance and collecting float rocks. This zone is concluded to be possibly dacitic oxidized by weathering.

Assay on this group are as indicated on below table.

Assay on Alteration Group H

Sample	Au(ppb)	Ag(ppm)	Cu(ppm)	Pb(ppm)	Zn(ppm)
FM717(outcrop)	40	0.6	0.10%	40	72
FM718(outcrop)	60	0.8	150	130	24
FM720(float)	<20	0.1	13	30	20
SM720(float)	40	2.4	60	20	44
SM721(float)	40	1.2	12	90	17

(9) Alteration group I

This group corresponds to the zone "7-58" of TM image analysis. The Luas Briget Mountain lying about 12km south of the Group H is at the central part of this group. This mountain is very jagged and not accessible so that the survey was limited to the base of the mountain. Mining and exploration activities are hitherto unknown.

This group occupies a large area, at least 3.0x3.5km. The part behind the mountain is not observed and, therefore , this group may be larger than observed from a distance. The rocks are dacite and dacitic tuff of Divisadero Formation. Mineralization in this group is limonite stockwork and pyrite dissemination and the rocks are colored brown or yellowish brown. Alteration types other than ferruginous alteration are faint silicification and sericitization.

Assay on this group are as follows:-

Assay on Alteration Group I

Sample	Au(ppb)	Ag(ppm)	Cu(ppm)	Pb(ppm)	Zn(ppm)
SM724(float)	<20	0.1	11	20	20
SM725(outcrop)	<20	0.1	7	30	39
SM726(outcrop)	<20	0.1	8	20	33
SM727(float)	<20	<0.1	17	4	128
SM728(float)	<20	0.1	9	30	11
SM729(float)	<20	0.1	113	19	67

7.2. Geochemical Prospecting

Panned concentrate geochemical samples were collected in order to examine the prospectivity of some alteration zones which could not sampled due to difficult access.

(1) Sampling and assays

A total of 57 samples were collected from this area. Localities of the sampling points are illustrated in PLATE 28.

Samples were assayed for seven elements, Au, Ag, Cu, Pb, Zn, Mo and As, in the laboratory of SERNAGEOMIN. This work employed the same detection limits and assay techniques as for the other areas prospected by panned concentrate geochemistry.

(2) Statistical data-processing

i. Calculation

Calculation was done in the same manner as that for Los Leones Area (refer to Section 6.3.).

ii. Elemental statistics

Assay data are listed on Table 9 attached in Appendix. Table 3 in Appendix indicates elemental statics parameters. They are summarized as follows:-

Au

The maximum value is 1,100ppb and the minimum value is less than 20ppb. Mean value is 18.4ppb. Values of 100ppb or more are concentrated in the Alteration Group C. Whereas the maximum value comes from the sample (SP725) at Alteration Group I.

Ag

The maximum value is 11ppm and the minimum value is 0.1ppm. Mean value is 0.6ppm. All are very low grade.

Cu

The maximum value is 343ppm and the minimum value is 1ppm. Mean value is 20.7ppm. Values of 100ppm or more including the maximum are concentrated in the Alteration Group F.

Pb

The maximum value is 3,176ppm and the minimum value is 4ppm. Mean value is 155.2ppm. Rather high values, 500ppm or more in this case, are characteristically occur in the Alteration Groups C and D.

Zn

The maximum value is 1,550ppm and the minimum value is 62ppm. Mean value is 233.8ppm. There is no concentrated distribution of higher values, 500 ppm or more.

Mo

The maximum value is 27ppm and the minimum value is 0.5ppm. Mean value is 0.9ppm. All are low grade.

As

The maximum value is 439ppm and the minimum value is 1ppm. Mean value is 19.9ppm. The values of 50ppm or more including the maximum are characteristically occurred in the Alteration Group C.

iii. Frequency distribution

Frequency histogram and cumulative frequency curve are indicated in Figure Ⅱ-7-2. As shown, the mother populations of Ag, Cu, Zn and As can not be separated into ore populations and background populations. Whereas the mother populations of Au, Pb and Mo are interpreted to consist of two sort of populations. Their transitional border are placed on around 60ppb, 300ppm and 2ppm respectively, very low level values for pan concentrate samples.

iv. Correlation

Correlation coefficients are indicated on Table 4 in Appendix. Pairs shown the coefficients of 0.5 or more are lined up as follows:-

Pb-Ag, Pb-As, Ag-As, Pb-Mo, Ag-Mo, Au-Ag, Pb-Cu and Ag-Cu

As shown, many pairs are in good correlation, and it is also noted that silver and lead correlate to all the elements with some exceptions, zinc for silver and gold-zinc for lead.

v. Principal component analysis

First principal component

This explains the variance of Ag and Pb. Taking account of the Pb assays, this is considered to express the variance caused by mineralization.

Second principal component

Eigen vector of Zn takes the highest value, while the vectors of the other elements behave opposingly against that of Zn.

Third principal component

This expresses the variance of Au and Cu. This is believed to express the variance caused by mineralization.

(3) Geochemical anomalies and anomalous zones

i. Threshold values

Values $m+2\sigma$ were used for threshold. These values were dealt as the Class A anomalies and the values between $m+\sigma$ and $m+2\sigma$ were treated as the Class B anomalies. Those values are as listed below.

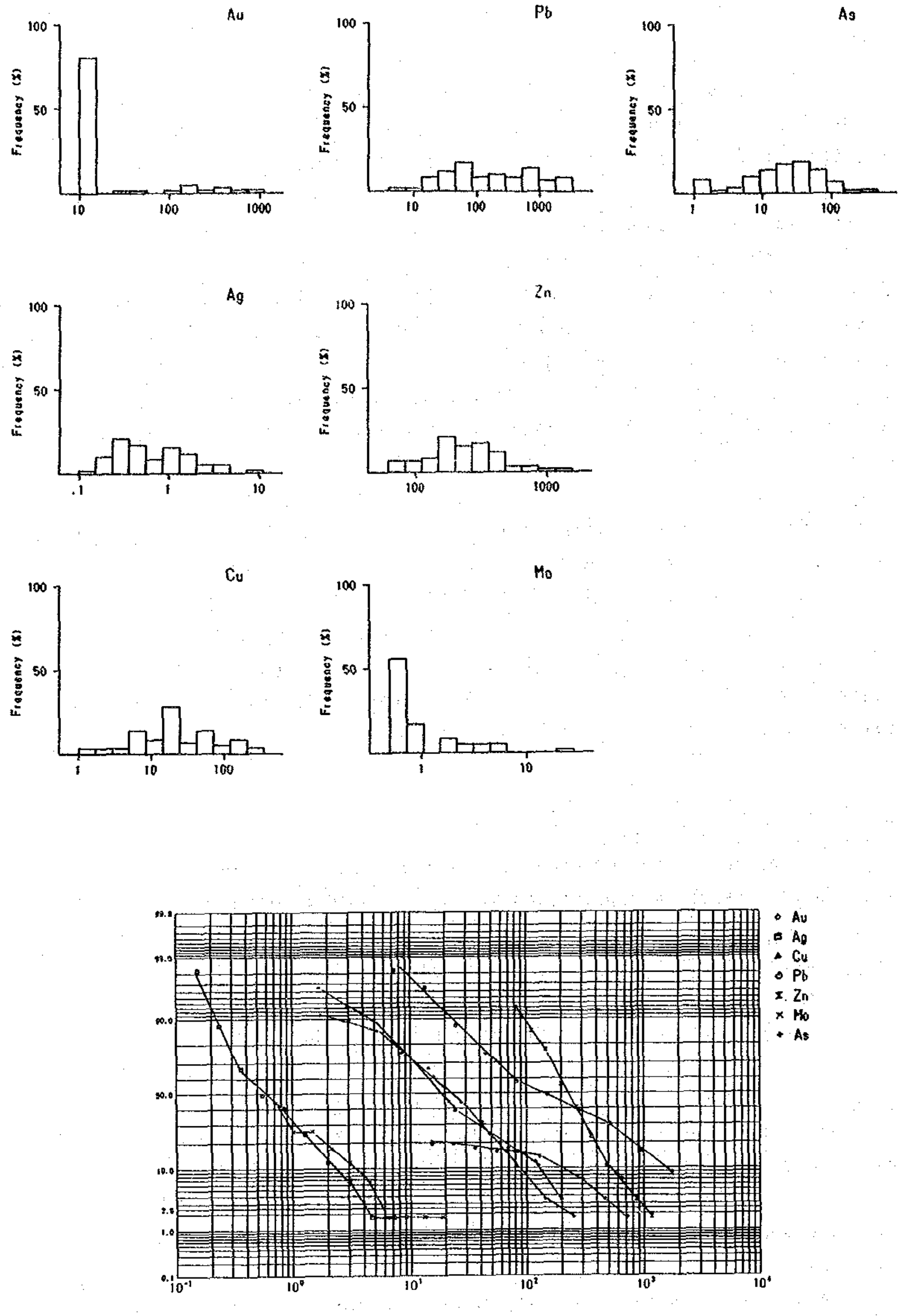


Figure II-7-2 Histograms and Cumulative Frequency Curves showing Frequency Distribution Patterns of Assays on Pan Concentrate Geochemical Samples Collected in Chile Chico-Chacabuco Area

Thresholds to Class A and Class B

Element	Value to Class A	Value to Class B
Au	223ppb	64ppb
Ag	4ppm	2ppm
Cu	289ppm	77ppm
Pb	3,947ppm	782ppm
Zn	882ppm	454ppm
Mo	6ppm	2ppm
As	281ppm	75ppm

ii. Geochemically anomalous zones

Numbers of anomalies detected are summarized for each alteration zones as follows:-

Number of Anomalies

Alteration Group	Class A Anomalies							Class B Anomalies						
	Au	Ag	Cu	Pb	Zn	Mo	As	Au	Ag	Cu	Pb	Zn	Mo	As
A		1				1						1	1	1
B					1				1					
C	1	1			1	1	1	2	2	2	3	2	3	1
D	1							1	3	1	5	1	1	1
E										1	1	1	1	
F	1		1						1	4				1
G	no anomalous values													
H	no anomalous values													
I	2								1				1	1

As shown, the Group C is ranked first regarding the number of anomalies and their elements ascribed to this group. In alteration group D, Au, Ag and Pb anomalies occur. The Groups G and I are characterized by Cu and Au anomalies respectively.

7.3. Evaluation

The alteration groups mentioned are arranged in the N-S direction. There is the Laguna Verde Deposit, prospective gold mineralization, at the northern extension of this arrangement. On the other hand, major lineaments extracted from TM images also trend in the N-S direction. It is believed from these that the alteration zones are structurally controlled in the N-S direction, while the groups except for the Group B show no trend, but massive. Stockwork and dissemination are typical modes of occurrence for oxide minerals and sulfide minerals occurring in these zones, and they occur mainly in dacite. Therefore, it is concluded that joints of country rocks is the mineralization controlling factor on small scale. Whereas the Group B is clearly controlled by fracture zone formed by tectonic movement.

This survey did not reveal igneous rock relatrd to the alteration and cannot explain the formation mechanism of those broad alteration zones. However, country rocks are mainly dacitic rocks of Divisadero Formation and thus, it is largely considered that the mineralization occurred in close relation to Late Cretaceous igneous activity.

Alteration mineral assemblages are principally quartz-sericite, while acidic alteration assemblages such as alunite-kaoline group minerals scarcely occur. Considering this and other features, such as the lack of low-temperature alteration minerals and poor correlation between gold and arsenic, it is unlikely that this mineralization is of the hot spring type. Probably this is epithermal mineralization, but not very shallow deposit like hot spring type deposit.

The Alteration Group C carries the largest number of anomalies and anomalous elements, and some of the ore assay on this group showed high grade gold. This suggests that this group may be mineralized by gold mineralization similar to the Laguna Verde Deposit. It is also noted that erosion might be more advanced than that in the Laguna Verde Deposit judging from presence of Pb-Zn minerals and alteration mineral assemblage.

Assay on the Alteration Group D show nothing more than low grade, but this group is noted by close distance from the Group C, the number of geochemical anomalies is second after Group C and it has high degree of silicification. Thus, the presence of the same mineralization as that of the Group C is possible.

Cu geochemical anomalies occur densely in the Alteration F, and a sample of outcrop of the Group F shows moderate grade gold. This sample is a float of quartz-limonite-pyrite vein with 5cm width derived from veins occurred in Paleozoic greenschist. Consequently Au-Cu vein type mineralization is expected.

Although high Au anomalies are detected from the Alteration Group I, all ore assay results on rock chips show low grades. There are not much prospectivity in this group.

No other significant indication of mineralization was obtained.

PART Ⅲ
CONCLUSIONS AND RECOMMENDATIONS

PART Ⅲ
CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 1. CONCLUSIONS

1.1. Satellite Image Analysis

Landsat TM image analysis was carried out in order to extract hydrothermal alteration zones similar to those associated with the Laguna Verde Deposit.

One hundred and seventy alteration zones were extracted by using bands 4-5-7 composite TM images. Sixteen of them distributed in the south of the Laguna Verde Deposit were selected and surveyed on surface.

The detailed localities and shapes were not always in good accordance with the survey results, but 90% of zones largely occurred in localities interpreted from TM image analysis. Total of 21 hydrothermal alteration zones were found by the surface survey. Some indications of gold mineralization with content in the order of ppm were recognized in three zones. The maximum gold content of the samples from these alteration groups is 6.7ppm Au. One of these three zones carry 1.1% Pb as well.

Other than the above, TM image analysis extracted a group of alteration zones (5-4 to 5-13) densely developed at about 65km north of the Laguna Verde Deposit. This lies on the extension of the N-S tectonic line which is considered to structurally control the arrangement of the hydrothermal alteration zones in the south. This leads to a conclusion that gold mineralization similar to the Laguna Verde Deposit can be anticipated in this locality, considering the result of TM image analysis.

1.2. Photogeological Interpretation of Aerial Photographs

This work covers Alto Palena sub-area and Alto Cisnes-El Toqui area, and the surface verification survey was carried out for these two areas.

The surface survey revealed that structural features, especially lineaments were correctly interpreted by photogeological work, but the rock unit classification did not bring perfect coincidences with the surface survey results. Photogeological rock unit classification is rather difficult in the glacier areas such as these two areas because of the eradication of surface manifestation of rock resistance and other factors caused by glaciation.

Distinction of volcanic rocks and granitic rocks with tabular joints was especially difficult.

1.3. Geological Survey and Geochemical Exploration

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

The survey of the first phase revealed that this area is broadly underlain by Ibañez Formation which hosts many major ore deposits in the Aysen Region and some gold geochemical anomalies occur in the area. Based on those results, geological and geochemical surveys were introduced into this sub-area.

It is revealed by this survey that the geology of this area consists of Upper Jurassic Ibañez Formation of andesitic volcanic units and Upper Cretaceous granitic intrusive rocks. There are many indications of gold and copper mineralization in andesite of Ibañez Formation. This 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.

These results lead to the conclusion that the prospectivity for significant mineralization is small in this area and that it does not warrant further exploration.

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

The first phase survey revealed the wide distribution of Coyhaique Formation which hosts El Toqui Deposit and detected many anomalies of lead and zinc. These results led to the introdution of geological and geochemical survey onto this sub-area.

Shale and andesitic volcanic rocks of Coyhaique Formation host several vein and disseminated mineralization caused by contact metamorphism due to the intrusion of granitic rocks. Although bonanzas are partly 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 rocks of Divisadero Formation at the eastern periphery of granitic intrusion. 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, cannot be expected to occur in these zones because of the lack of calcareous rocks in the vicinity.

It is concluded that the necessity for further exploration works 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 intrusive bodies. Broad hydrothermal alteration zones accompanied by limonite-quartz stockwork are found developed at the periphery of the granitic bodies. Major alteration is silicification.

Ore assay on these alteration zones resulted in low grade. However, geochemical anomalies of gold, lead and zinc occur in the alteration zones. The mineralization of Laguna Verde type is expected in this area, considering 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 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 earlier, TM image analysis extracted 16 alteration zones and the surface survey found 21 alteration zones. Those 21 zones are grouped locality-wise into nine alteration groups, Group A to 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 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 those features of Groups D and I, they are assessed to be very important for gold exploration, second after the Group C, although all assay results were low. Whereas detailed survey might be nearly impossible for the zone I due to its topographical difficulty.

Other alteration groups are concluded to be less prospective because no significant results of ore assay and geochemistry were obtained and also because of their small size and low degree of alteration.

CHAPTER 2. RECOMMENDATIONS FOR THE PHASE III

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

(1) Geological and geochemical survey of 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 Groups 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) Geophysical exploration using SIP of the important alteration zones selected by the work listed above.

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