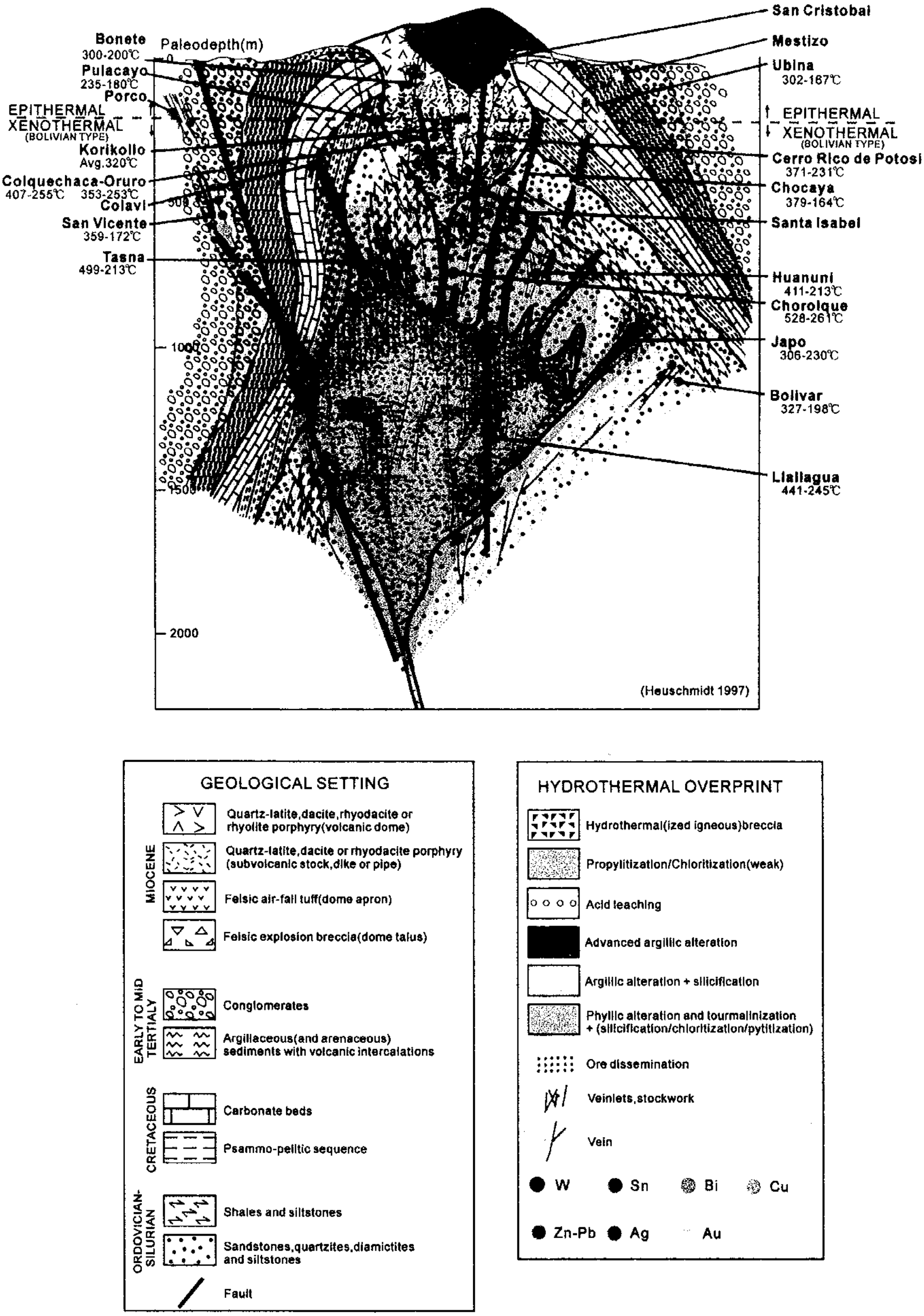


Fig. II-1-6 Idealized Model of Bolivia Type Deposit

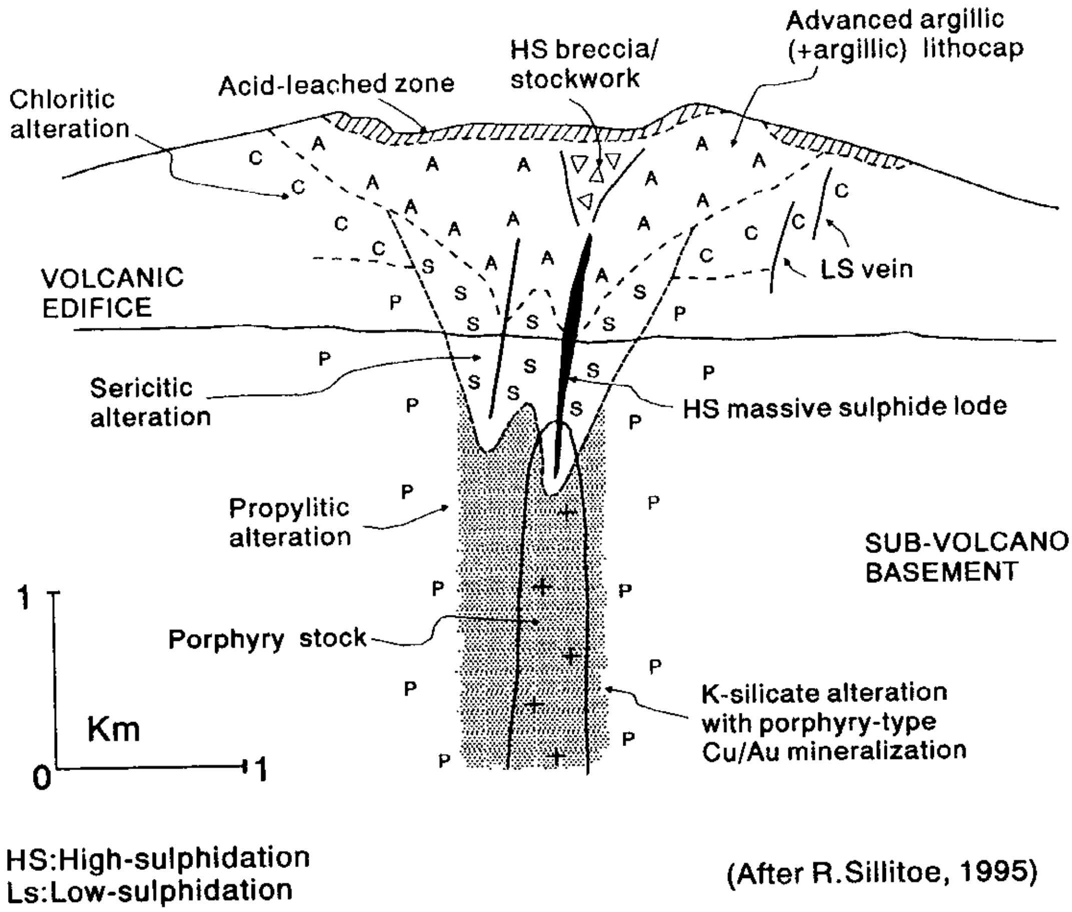


Fig. II -1-7　　Idealized Lithocap and Underlying Porphyry Cu/Au Deposit kaolin are secondarily generated whereas pyrophylite is a primary mineral whose presence suggests the possible occurrence of high-sulfidation epithermal vein-type deposits.

The Choquelimpic deposit lies in a hydrothermal alteration zone near the center of a stratovolcanic body exposed by erosion. Some of the alteration zones extending from here to the Calorno district in the south is likely to have their near-central portions exposed by erosion; occurrence of epithermal ore deposits similar to those of Choquelimpic can be anticipated.

In a low-sulfidation epithermal vein-type deposit, quartz-adularia veins are accompanied by argentite, tetrahedrite, galena and sphalerite. Hydrothermal alteration accompanied by the mineralization is characterized by sericitization accompanied by adularia and carbonate minerals by argillization, but alunite is lacking.

The Turaquiri deposit has the possibility of being a low-sulfidation epithermal vein deposit.

Low-sulfidation epithermal vein-type deposits are likely to occur on the outer side of a caldera.

Chapter 2　　Satellite Image Analysis

2-1 Purpose of Analysis

In order to obtain the basic data for assessing mineral potential of the survey area, an analysis of satellite image has been conducted. Based on the spectrum data and texture data of satellite image, a distribution map of geological units and a lineament map were prepared to recognize the regional geological structure and to detect spectral anomalous area, which suggests the presence of, mineralized alteration zones.

2-2 Data Used for Analysis

As shown in Table II-2-1 and Fig. II-2-1, seven scenes of Landsat TM data were used for the analysis. Among them, the images of three scenes (Scenes 1-3) were newly processed this year, and the rest of four scenes were processed in the "Mineral Exploration in the Republic of Bolivia in 1999" as shown Table II-2-1.

Table II-2-1 List of LANDSAT TM data

Scene No.	Path	Row	Date
1	1	72	1987.05.30
2	2	72	1986.11.10
3	233	75	1986.05.30
4	1	73	1987.05.30
5	1	74	1986.10.02
6	233	73	1986.08.08
7	233	74	1989.07.23

2-3 Image Processing

Color synthetic images and ratioing images were prepared by the following procedure for the newly processed three scenes. In data processing, the software of PCI EASI/PACE ver. 6.3 and Adobe Photoshop were used.

2-3-1 Preparatory Work

The following work has been conducted as preparatory work.

(1) Data input

All file data of the supplied CD-ROM were transmitted to HDD connected with EWS.

(2) Separation of header information from the image data

Header information same including the location of satellite image were separated from the transmitted file and report in a text file.

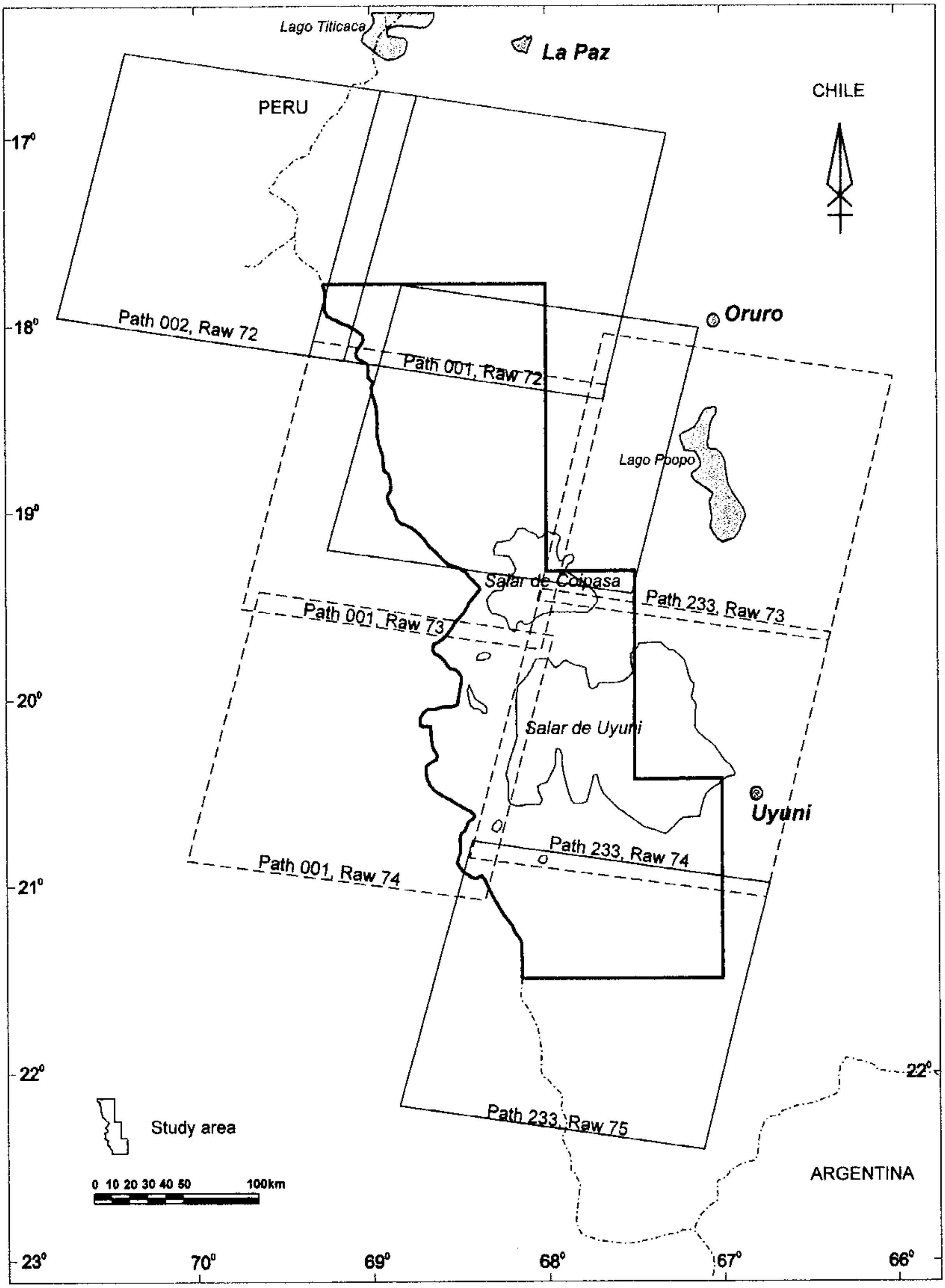


Fig. II -2-1 Area of Satellite Image

(3) Checking of additional data

Every longitude and latitude of the four corners of the images, date of observation and file size of the image (number of pixels and number of lines) were checked.

(4) Data conversion

Image data were put into the standard image database format of the software PCI EASI/PACE, prepared by PCI Co., of Canada.

2-3-2 Geometric Adjustment

Geometric correlation between satellite images and topographic map with scale of 1:500,000 (TPC P-26A, B, C and D) were carried out at more than ten selected sites. They were geometrically adjusted by a quadratic equation and GCP was properly selected so the error after adjustment is less than one pixel. After geometric adjustment, projection to the map was based on UTM (Zone-19, Row-K), and WGS1984 was used for the earth ellipsoid model.

2-3-3 Preparation of Color Composite Image

Color synthetic images were separated by the following procedure.

(1) Enhancement of contrast: In order to prepare the most adequate image for the interpretation of geological structure, enhancement of contrast was conducted on bands 1, 4, and 7.

(2) Enhancement of edge: Edge of images was enhanced using 3x3 filter

(3) Applying blue, green and red to the bands 1, 4, and 7, respectively, a color synthetic image was prepared.

(4) Then, scale, title, subtitle, longitude and latitude, and UTM coordinates were added on to the image. Two kinds of data, one for making a hard copy on a scale of 1:250,000 and the other for film output were prepared. The size of characters was properly adjusted for each case.

(5) Form of image was converted into TIFF form.

(6) Number of pixel of the image data and accuracy of analysis were modified to coincide with the specifications of the output device.

(7) A hard copy on the scale of 1:250,000 (laser graphic output) and positive film (8 in. x 10 in.) were prepared.

2-3-4 Preparation of Ratioing Image

Ratioing images, which are thought to be effective in detecting the alteration zone, were prepared by the following procedure.

(1) Preparation of masking area

In conducting a spectral analysis of satellite image data to detect alteration zones in the survey area, the satellite image data were filtrated with proper threshold to eliminate the pixels of surface material, which interfere with the spectral analysis. The values of the threshold for each scene are shown in Table II-2-2.

Table II-2-2 Threshold for Ratioing Analysis

LANDSAT TM Path/Row	Blank, Water body (Band 5)	Cloud, Snow, Playa (Band1)	Vegetation (*NDVI)
P001/R072	< 5	90 <	0.10 <
P002/R072	< 11	135 <	0.07 <
P233/R075	< 3	100 <	0.10 <

*NDVI = (band4 − band3) / (band4 + band3)

The spectral analysis was conducted excluding the pixels listed in the above table.

(2) Ratioing analysis

To distinguish alteration zones more adequately, two ways of calculation, described below have been conducted.

R1 = (band 2 - band 1)/(band 2+ band 1)

R2= (band 5 - band 7)/(band 5 + band 7)

R1 is considered to be effective in detecting iron oxide minerals, while R2 is effective in detecting carbonate minerals.

(3) Determination of anomalous value

Statistic values of the ratioing analysis were calculated in all scenes. Then, threshold value to distinguish spectral anomaly was determined. Table II-2-3 shows the statistic and threshold values.

(4) Preparation of image showing anomaly area

Pixels exceeding the threshold value are collected and illustrated on the monochromatic image of band 4 as a spectral anomaly of R1, suggesting the presence of iron oxide minerals was shown in red, while the anomaly of R2 suggesting the presence of clay/carbonate minerals was shown in green. The area overlapped with R1 and R2 was shown in yellow.

Table II-2-3 Statistic Value for Ratioing Analysis

Path/Row	Ratioing type*	Mean value (M)	Standard deviation (σ)	Threshold value (M+2σ)
P001/R072	R1	-0.319	0.050	-0.219
	R2	0.299	0.045	0.389
P002/R072	R1	-0.303	0.027	-0.249
	R2	0.253	0.034	0.321
P233/R075	R1	-0.296	0.031	-0.234
	R2	0.215	0.030	0.275

Ratioing Type*: R1= (band 2−band 1) ／ (band 2+band 1)
R2= (band 5−band 7) ／ (band 5+band 7)

(5) Scale, title, subtitle, longitude and latitude, and UTM coordinates were added on to the image. Two kinds of data, one for making a hard copy on a scale of 1:250,000 and the other for film output were prepared. The size of characters was properly adjusted for each case.

(6) Form of the image was converted into TIFF form.

(7) Number of pixels of the image data and accuracy of analysis were modified to coincide with the specifications of the output device.

(8) A hard copy on the scale of 1:250,000 (laser graphic output) and positive film (8 in. x 10 in.) were prepared.

2-4 Geological Interpretation of Image

Based on the color synthetic image and the image showing anomaly area were made by ratioing analysis in seven scenes in total, geological units, geological structure and alteration are interpreted and mapped on a scale of 1:250,000 in every scene. Figs. II-2-2 and II-2-3 show a mosaic of color synthetic images of seven LANDSAT TM scenes and a mosaic of images showing spectral anomaly area, which have been provided for interpretation.

The interpretation was conducted in the following procedure.

(1) Classification of geological units: Based on the surface texture and topographic character of the image, the area was classified into several geological units. Their photogeological characteristics were correlated with correspondent formations of the existing geological map.

(2) Interpretation of lineament and geological structure: Geological structures such as fault, lineament and folding structure were detected from minor topographic features.

(3) Interpretation of alteration zone: Considering photogeological unit described in item (1), the

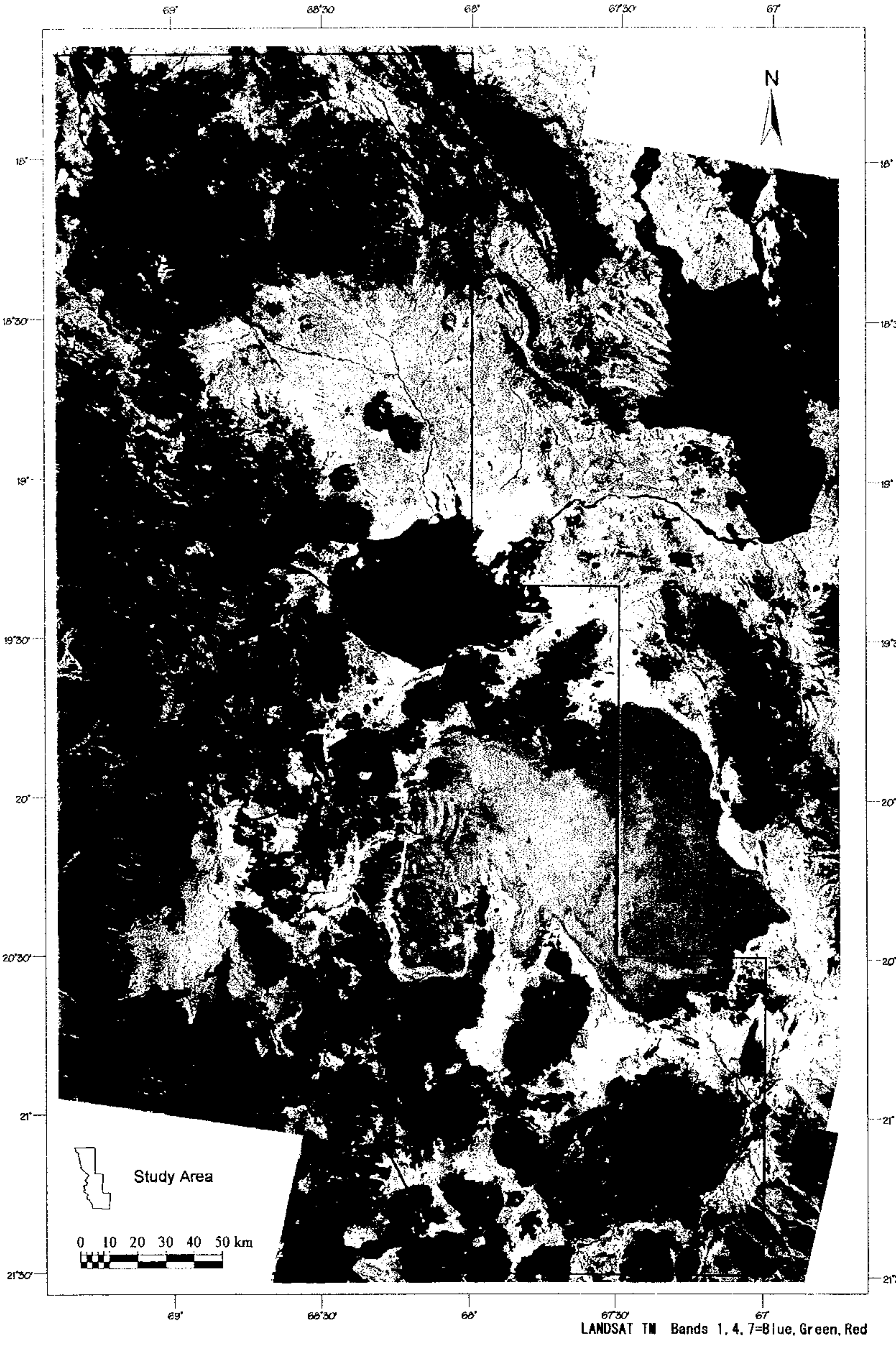
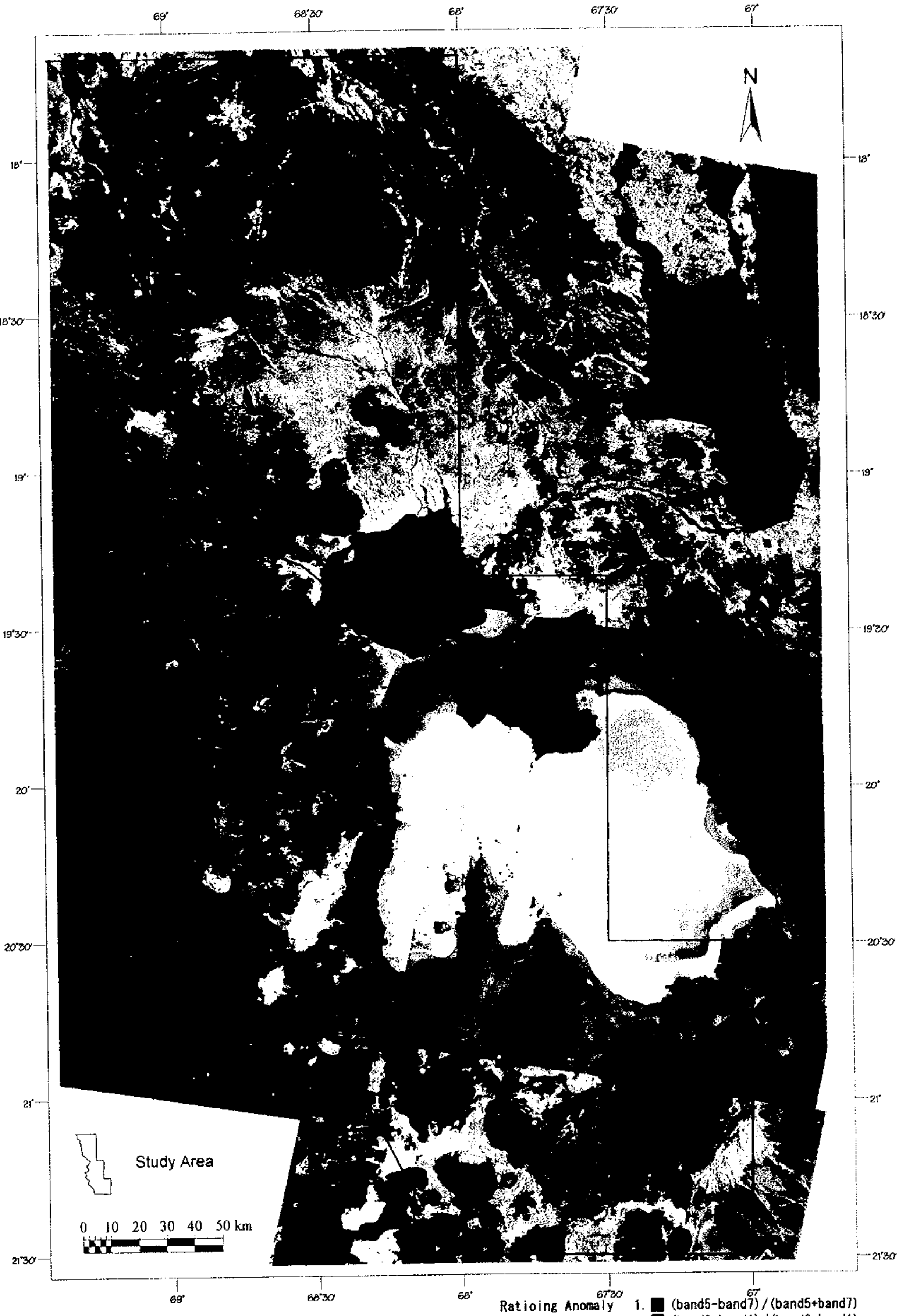


Fig. II-2-2 LANDSAT TM Color Composite Image



Ratioing Anomaly
1. ■ (band5-band7)/(band5+band7)
2. ■ (band2-band1)/(band2+band1)
3. □ Anomaly of both 1 & 2

Fig. II-2-3 LANDSAT TM Ratio Anomaly Image

area of possible alteration zone was selected from the areas of spectral anomaly, obtained by ratioing analysis of the images.

(4) Result of the above interpretation was compiled into one map.

2-5 Result of Geological Interpretation

2-5-1 Geological Units

Interpretation of geological units was conducted in reference to the existing geological map on a scale of 1:500,000. Geological information obtained from the satellite image was described as much as possible. The geological units thus classified were numbered with serial numbers from the lower horizon with reference to the classification of the existing geological map. Summary of geological units obtained from the above-described procedure in seven scenes was shown in Fig. II-2-4, and correlation with the correspondent formation of the existing geological map is shown in Table II-2-4.

Major characteristics of each geological unit in the color synthetic images are described as follows.

(1) Unit Qc

This unit is widely spread over the flatland of the Altiplano, particularly north of the Salar de Coipasa. They are also distributed in a number of places from the slope to the river in the Altiplano and Cordillera Occidental.

The unit shows a smooth texture and its color varies from gray to pale brown in image. This unit is correlated with Quaternary surface sediments consisting of alluvium and talus.

(2) Unit Qb2

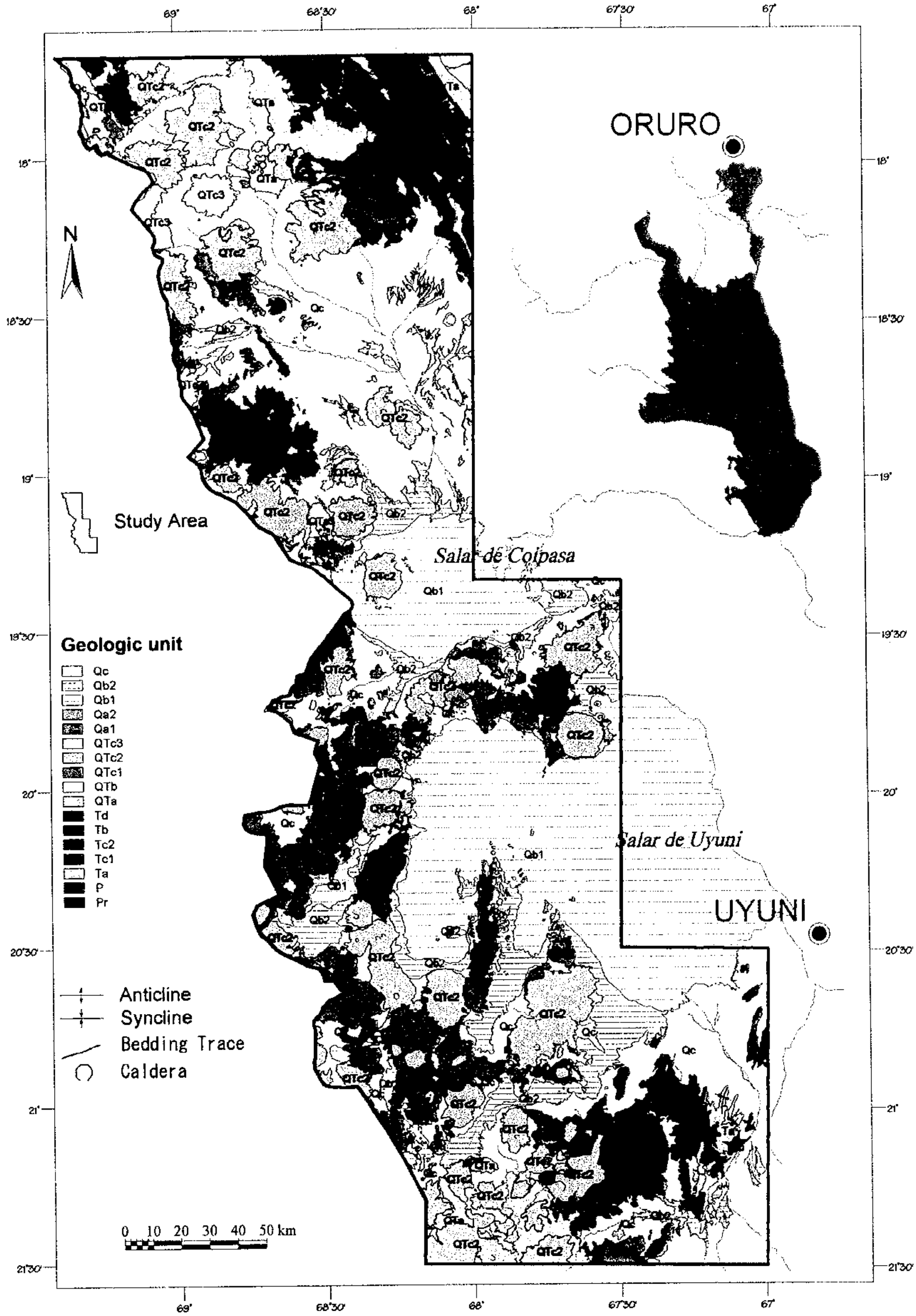
This unit is widely spread over the flatland of the Altiplano ,particularly around the Salar de Coipasa and Salar de Uyuni. It appears smooth in texture in image and a drainage pattern was recognized. This unit is correlated with lacustrine sediments of Pleistocene to Holocene in age.

(3) Unit Qb1

This unit is spread over the area of the Salar de Coipasa and Salar de Uyuni. It appears blue to sky blue and smooth texture in image. As any drainage pattern was recognized, the unit probably has been covered by lake water during the rainy season. This unit is correlated with lacustrine sediments of Pleistocene to Holocene in age.

(4) Unit Qa2

This unit is scattered in the area of west and north of Salar de Uyuni. It appears yellowish gray and



Fug. II-2-4 Geologic Interpretation Map of LANDSAT TM Image

Table II-2-4 List of geologic unit

GEOLOGIC UNIT	COLOR on LANDSAT TM Color Composite Image	TEXTURE	DRAINAGE		ROCK RESISTANCE	BEDDING	LINEAMENT DENSITY	LITHOLOGY	GEOLOGICAL CORRELATION (U. S. Geological survey Bulletin, 1975)	
			PATTERN	DENSITY						
Qc	brownish gray, dark gray ~ light gray, pale brown	fine	dichotomic, dendritic	low - middle	low	-	rare	alluvium, talus deposit	Qsu	Surficial deposits (Holocene and Pleistocene)
Qb2	white, bluish white, dark ~ pale brown	fine	dichotomic	low	low	-	-	salt	Qs	Salt deposits (Holocene and Pleistocene)
Qb1	blue, light blue	fine	-	-	low	-	-			
Qa2	grayish brown, brownish gray	medium	parallel, dendritic	middle - high	high	poor bedded	-	limestone	Ql	Lacustrine deposits (Qa2: Minchin Limestone) (Holocene and Pleistocene)
Qa1	yellowish gray	fine	parallel, dendritic	middle - high	low	poor bedded	-	lake deposite		
QTc3	dark bluish gray, dark green	coarse - medium	radial, sub-dendritic	low	high	-	low	andesite, dacite	QTev	Stratovolcano deposits (Holocene to Miocene)
QTc2	dark brown ~ brown, dark gray	fine - medium	radial	low	high	-	low	andesite, dacite		
QTc1	dark gray ~ gray, brown	coarse - medium	sub-dendritic	middle - high	high	-	low	andesite, dacite		
QTb	brownish gray ~ light gray, yellowish gray	medium	pinnate	high	middle	-	-	conglomerate, sandstone, shale	QTs	Sedimentary rocks (Pleistocene and Pliocene)
Qta	pale brown, grayish brown	fine	parallel, dendritic, sub-dendritic	high	middle	-	-	ignimbrite	QTig	Ignimbrite (Perez tuff) (Pleistocene to Miocene)
Td	brownish gray, dark ~ light gray, reddish brown	medium	sub-dendritic	middle	high	-	-	dacite	TI	Intrusive rocks (Pliocene to Oligocene)
Tc2	dark ~ pale brown, dark ~ light gray, grayish green	medium	parallel, dendritic, sub-dendritic, pinnate, radial	middle - high	high - middle	poor bedded - well bedded	low	volcanic rocks, pyrocrastic rocks	Tvnd Tig	Volcanic rocks, Pyroclastic rocks (Tc2: Tagus Formation, Mauri Formation, Caranges Formation, Mumuntani Formation) (Tc1: Quemez Formation) (Miocene and Oligocene)
Tc1	pale brown	fine	colinear, dendritic	high	middle	poor bedded	low	ignimbrite		
Tb	dark gray, brown, yellowish brown	medium	parallel, dendritic	high	middle	poor bedded - well bedded	low	conglomerate, sandstone, shale	Ts2	Sedimentary rocks (Pliocene to Oligocene)
Ta	dark brown ~ brown, brownish gray	fine	parallel, dendritic	low - middle	middle	bedded - well bedded	low	conglomerate, sandstone, shale	Ts1	Sedimentary rocks (Oligocene to Paleocene)
P	brawn, yellowish brown	medium	traillis	middle	high	bedded - well bedded	low	sandstone, shale	Pzs	Sedimentary rocks (Paleozoic)
Pr	light brawn ~ brown, dark gray	coarse - medium	sub-dendritic	middle	high	-	low	gneiss	QTig	Gneiss (Proterozoic)

fine smooth texture in image. This unit is correlated with lacustrine sediments of Pleistocene to Holocene age.

(5) Unit Qal

This unit is scattered south of Salar de Uyuni. It is grayish brown to brownish gray and has a somewhat rough texture. This unit is correlated with Quaternary Minchin Limestone.

(6) Unit QTc3

This unit is distributed in Cordillera Occidental near the border of Chile. It appears dark brown to brown, sometimes dark blue and has a medium to rough texture in image. Structures of stratovolcano, crater and lava flow are clearly recognized. This unit is correlated with the lava and pyroclastics of Pleistocene and Holocene age.

(7) Unit QTc2

This unit is widely spread over the Cordillera Occidental and Altiplano. In the Altiplano, this unit is widely distributed in the north and south ends of the study area, and the area between Salar de Coipasa and Salar de Uyuni. It appears dark brown to brown and has a medium to fine texture in image. Stratovolcano, lava flow and radial drainage pattern are recognized. This unit is correlated with lava and pyroclastics of the Miocene to Pleistocene age.

(8) Unit QTc1

This unit is widely distributed in the Cordillera Occidental and west to southwest of the Salar de Uyuni in the Altiplano. It appears dark gray to gray and brown and has a medium to rough texture in image. Structure of stratovolcano is not clearly observed as in the case of Unit QTc2. This unit is correlated with lava and pyroclastics of Miocene to Pleistocene age.

(9) Unit QTb

This unit is distributed in the northwestern and northeastern corners of the study area. In the northwestern corner of the study area, the unit is scattered and overlain by units of QTc1, QTc2 and Qc. In the northeastern corner of the study area, this unit overlies the unit Ta. It appears brownish gray to bright gray or yellowish gray and medium grade rough texture, and have a dendritic drainage pattern. This unit is correlated with conglomerate, sandstone and shale of Pliocene to Pleistocene. No bedding plane was recognized in the image.

(10)Unit Qta

This unit is widely distributed over the areas of southern and northern ends of the study area in the Altiplano, which is overlain by units QTc1 and QTc2, and overlies Unit Tc2. It appears pale brown to grayish brown showing a characteristic parallel drainage pattern in image. This unit is correlated with ignimbrite of Miocene to Pliocene age.

(11)Unit Tol

This unit occurs in a round small area with diameters of 2-3 km in Altiplano. It appears reddish brown, sometimes brownish gray or dark to bright gray, and has a rough texture in image. The unit intrudes into unit Tb and Tc2. This unit is correlated wit a stock, plug or dyke of Oligocene to Pleistocene intrusives.

(12)Unit Tc2

This unit is distributed in the area of south and north of Salar de Uyuni, southwest of Salar de Coipasa and northeast corner of the study area. Appearance of this unit is variable according to the location probably due to the difference of rock facies in different areas. South of the Salar de Uyuni, it appears dark brown to brown with a number of parallel or sub-dendritic drainage patterns in image. Clear bedding, a number of folding with axes of NNE, and a caldera of 7km in diameter were recognized.

North of the Salar de Coipasa, it appears dark to brownish gray with a few sub-dendritic drainage patterns. No clear bedding was recognized. It is intruded by unit Td. A caldera structure was observed.

In the northwest of the Salar de Coipasa, it appears pale brown to bright gray. A dome structure and flat iron are recognized, and radial drainage pattern is characteristic in the western area. The unit is correlated with Tertiary Carangas Volcanics.

In the northeast corner of the study area, it appears pale brown to brown. Dendritic and pine leaf shaped drainage patterns were observed. Clear bedding and many folds in the NNW direction are recognized. This unit is correlated with Tertiary Mauri Formation. In addition to the above, this unit occurs in the northwestern corner of the study area and northwest of the Salar de Uyuni. Northwest of the Salar de Uyuni, the unit is exposed in a window, overlain by units QTc1 and QTc2. This unit is correlated with Tertiary Murmuntani Formation.

(13)Unit Tc1

This unit is distributed in the south and west of the Salar de Uyuni. It is overlain by units QTc1, QTc2 and Tc2 and exposed on the surface in small windows except for the west coast of the Salar de Uyuni where somewhat wide area is covered by this unit. It appears pale brown with fine texture. Colinear or dendritic drainage patterns are observed. Character in the image is similar to that of unit Qta. This unit is correlated with volcanics or pyroclastics of Oligocene to

Miocene age.

(14)Unit Tb

This unit is distributed widely in the northeast corner of the survey area and locally southeast of the Salar de Uyuni. This unit is correlated with Oligocene to Pleistocene sedimentary rocks consisting of conglomerate, sandstone and shale, which is overlain by unit TC2. It appears dark gray in the area surrounding the Salar de Uyuni and southeast of the lake, and brown or yellowish brown in the northeast corner of the study area. Parallel or dendritic drainage pattern was recognized. Clear bedding and folding can be observed.

(15)Unit Ta

This unit is distributed in the northeast and southeast corners of the study area, overlain by unit Tc2. The unit is correlated with sedimentary rocks of Oligocene to Pliocene age consisting of conglomerate, sandstone and shale. It appears brown to dark brown, and a parallel or dendritic drainage pattern is recognized. Bedding is clearly observed which trends NW in the northeast corner of the study area and NNE in the southeast corner of the study area.

(16)Unit P

This unit, distributed in the southeast corner of the study area, is correlated with sedimentary rocks of Devonian to Ordovician age. It appears brown or yellowish brown and has a rough texture. Latticework drainage pattern is recognized. Bedding is clear which strikes NNE and dips W. The unit Tb is distributed on the east side of this unit probably with fault contact, while unit Ta overlies this unit on the west side. Lineament is observed not only north of the area but also south of the area.

(17)Unit Pr

This unit is distributed in the flatland 100 km NNE from the Salar de Coipasa over an area of 6 km in diameter. The unit is correlated with pre-Cambrian gneiss. It appears bright brown to brown and occasionally dark brown and medium to rough texture in image. Sub-dendritic drainage pattern is observed.

2-5-2 Geological Structure

Result of interpretation on geological structure is shown in Fig. II-2-5, that is summarized as follows:

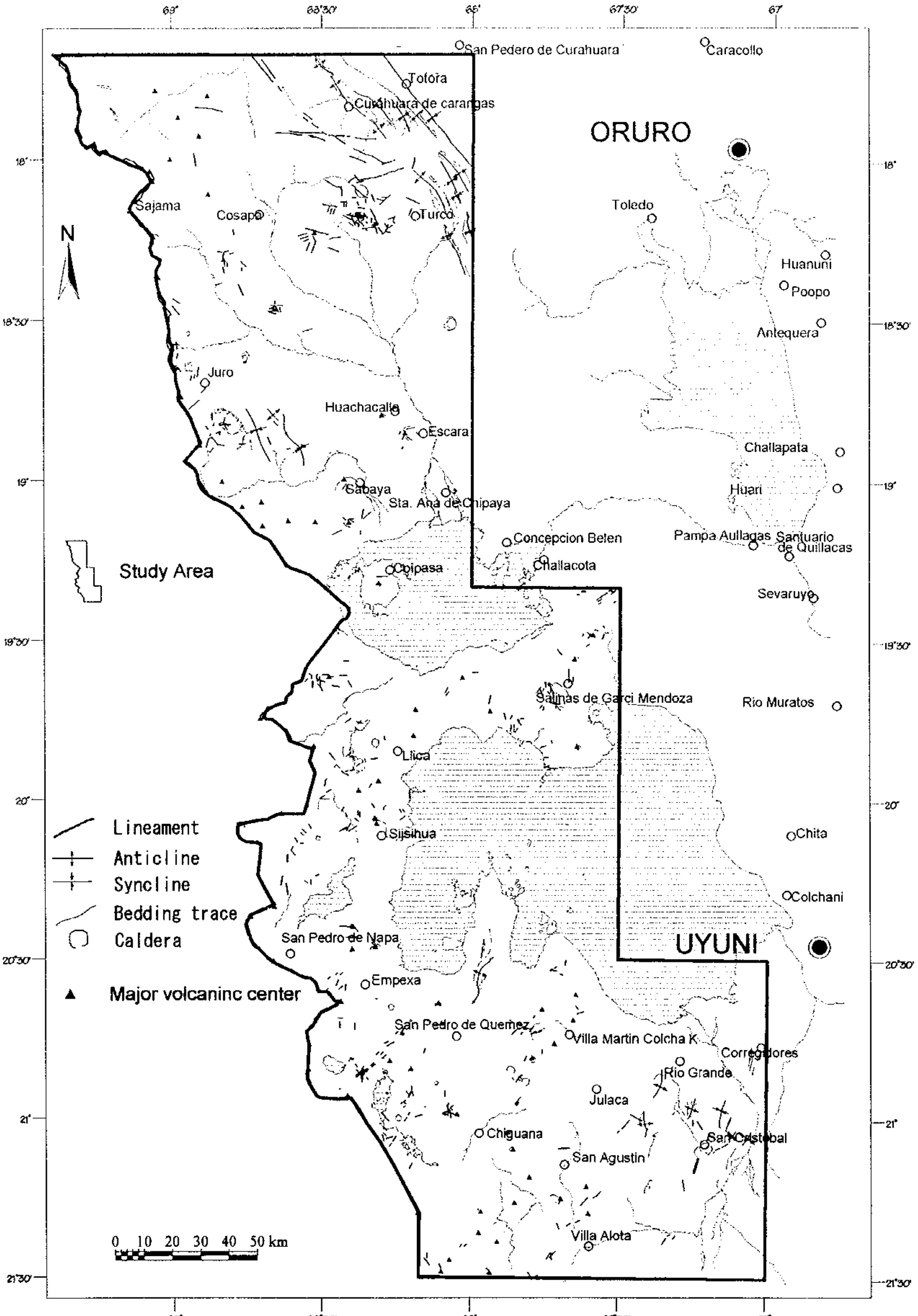


Fig. II-2-5 Extracted Lineament Map of LANDSAT TM Image

(1) Folding

Folding was observed in the units of Ta, Tb and Tc2 in the southeast and northeast corners of the study area, and south of the Salar de Uyuni and northwest of the Salar de Coipasa. No folding was observed in the geological units later than the above units.

Anticline and syncline with axes of NNE were recognized in the place occupied by units Ta, Tb and Tc2 in the southeast corner of the study area and south of the Salar de Uyuni. The folding in the southeast corner of the area is almost symmetrical while folding south of the Salar de Uyuni is asymmetrical as the west wing of the folding is steeply dipping.

In the northeast corner of the study area, a number of anticline and syncline with axes of NW were recognized. They seem to be symmetrical folding.

A dome structure was recognized west of the Salar de Coipasa, where unit Tc2 is widely distributed. East of the dome, a pair of anticline and syncline was observed.

(2) Fault and lineament

The number of lineaments observed in the area is not large, and most of them are located in the area of unit QTc1. The direction of lineaments is variable according to the district within the study area. The study area is subdivided into three districts: south, west and north or northwest. A major trend of lineament is conformable to the folding axes.

In the south district, lineaments are recognized in units Ta, Tb, Tc2, QTc1 and QTc2 in the area south of the Salar de Uyuni. Most of them strike NNE to NE. A thrust fault striking NNE and dipping east penetrating unit Tb was recognized south of the Salar de Uyuni.

In the west district, lineaments are observed in units Tc2, Tc1 and QTc2 in the area west of the Salar de Uyuni to the west of the Salar de Coipasa. Their strike is variable to the NE, NW, NS and EW, although the number of lineaments is not large.

In the north-northwest district, lineaments were observed in units Tb, Tc2, Qta, QTc1 and QTc2 in the area north of the Salar de Coipasa. Two kinds of lineament strike NW and EW-ENE are predominant and both lineaments are interconnected in the north end of the district. A thrust fault strikes NW and dips E was also recognized. A ring structure was found east of Cosapa, and south of a number of E-W lineaments was observed.

2-5-3 Alteration Zones

Fig. II-2-6 shows a possible alteration zone, detected from the spectral anomalies as shown in Fig. II-2-3. In the study detecting an alteration zone, the spectral anomalies in alluvium and shadow area in the steep slope-facing southwest were excluded. The following is a summary of alteration zones worthy of being prospected.

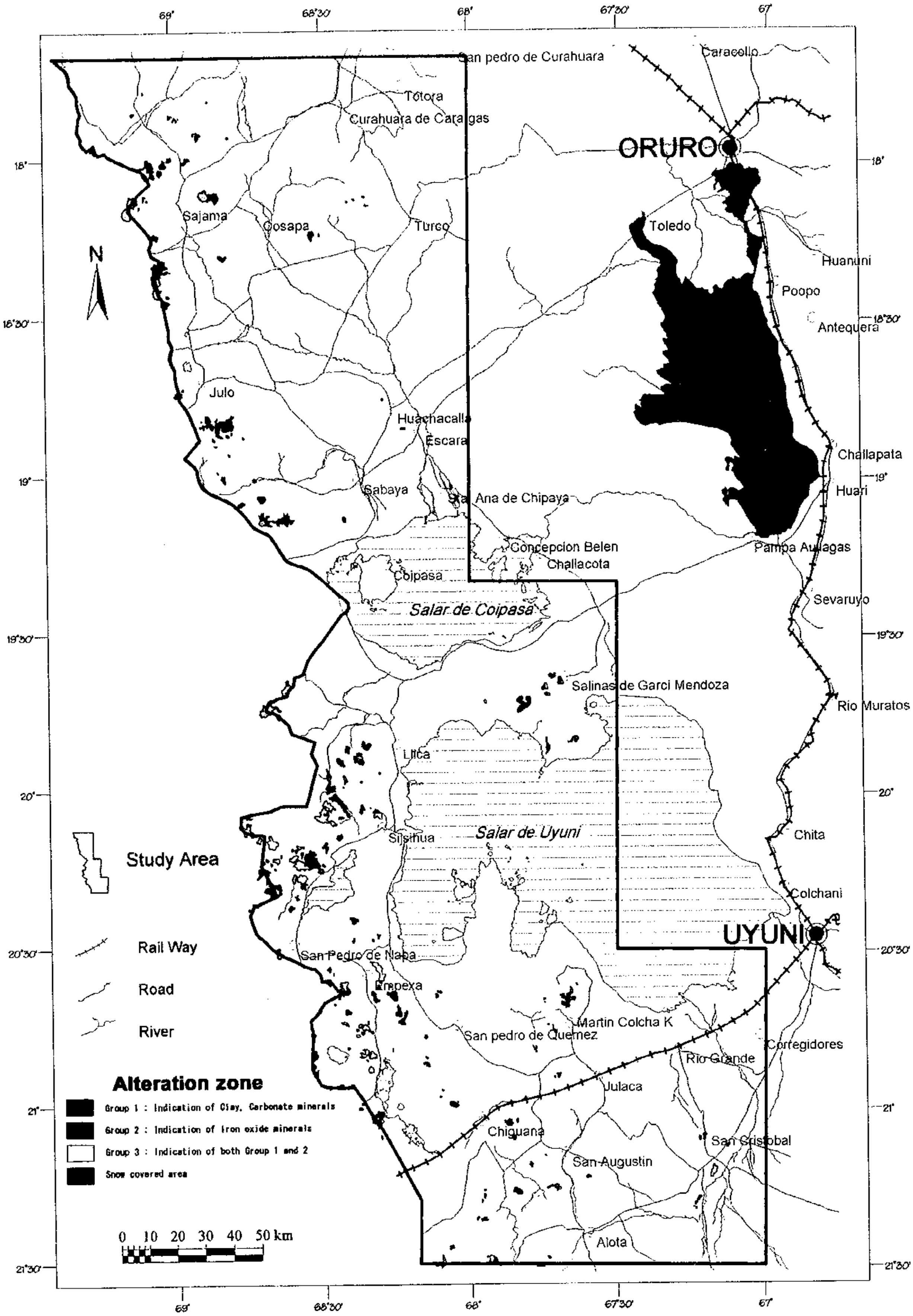


Fig. II-2-6 Extracted Alteration Map of LANDSAT TM Image

(1) Spectral anomalies suggesting the presence of argillic carbonate alteration zone: (green parts in Fig. II-2-b)

The anomalies are recognized in unit TC2 north and west of the Salar de Uyuni and in units QTc1 and QTc2 west and south of the Salar de Uyuni. Among them, the alteration zones in Tc2 and QTc1 are extensive.

(2) Spectral anomalies suggesting the presence of iron oxide alteration zone: (red parts in Fig. II-2-b).

The anomalies are observed in units Tc2, QTc1, QTc2 and QTc3 in the area north of the Salar de Coipasa and south of Salar de Uyuni. Most anomalies in QTc2 and QTc3 are located near the top of statovolcano.

(3) Spectral anomalies suggesting the presence of both argillic-carbonate alteration zone and iron oxide alteration zone: (yellow part in Fig. II-2-6).
The anomalies are observed in the units QTc1 and QTc2 in the area west and southwest of the Salar de Uyuni. Among them, the anomaly in QTc1 is extensive.

2-6 Summary and consideration

Result of analysis is summarized as follows:

(1) As the result of color synthetic image analysis, it was revealed that the lava and pyroclastics of Miocene to Holocene age related to mineralization are units of QTc1, QTc2 and QTc3 in this analysis. Among them, QTc2 and QTc3 clearly form stratovolcano, while the feature of stratovolcano is not clearly seen in QTc1 due to advanced erosion. In QTc3, explosion craters and lava flow are clearly recognized.

(2) Spectral anomalies suggesting the presence of alteration zones were recognized in the geologic units, Tc2, QTc1, QTc2 and QTc3. In units Tc2 and QTc1, the alteration zones were recognized in well-eroded volcanics and pyroclastics. On the other hand, alteration zones in QTc2 and QTc3 were recognized only in and around the crater of stratovolcano. Alteration zones in the unit QTc3 were excluded from prospective area as the unit is considered to be Holocene age that is too young for mineralization.

(3) Tectonic history of the area is reflected in the result of lineament analysis. Folding and thrust faulting were recognized in the formation of pre-Andes orogenesis such as units, P, Ta, Tb and Tc2. On the other hand, lineament is very few and short in units of the post Andes orogenesis.

Relation between lineaments and alteration zones is not clear.

(4) Alteration zone located near the top of stratovolcano associated with exhalation sulphur deposits in the geologic unit QTc2 was excluded from the prospective area.

(5) Alteration zone near the top of the stratovolcano within geologic unit QTc2, which crosses the border of Chile, was also excluded from the prospective area.

(6) Independent small alteration zone of less than 2 km^2 was excluded from the prospective area.
Summary of the analytical result is shown in Fig. II-2-7. In the figure, prospective alteration zones, Tertiary volcanics that related with alteration, lineament, known mineral deposits and showings and sedimentary sulphur deposits are illustrated.
The prospective alteration zones are classified into three categories according to the size, small for 2-10 km^2, medium for 10-20 km^2 and large for over 20 km^2. The following is a brief explanation on the prospective areas, which are shown in Fig. II-2-7.

- Blanca Nieves District
  Located in the eastern slope of stratovolcano near the border, hosted in geological unit QTc2, iron oxide alteration, small size (9.5 km^2).
- Chullcani District
  Located near the top of stratovolcano, hosted in geological unit QTc2, iron oxide alteration, small size (3 km^2).
- Asu Asuni District
  Located near the top of a well-eroded stratovolcano, hosted in geological unit QTc2, iron oxide alteration, small size (4 km^2).
- Sonia Susana District
  Located in a well-eroded dome structure, hosted in geological unit Tc2, iron oxide alteration, large size (28 km^2).
- Cerro Culebra District
  Located near the top of a well-eroded stratovolcano, hosted in geological unit QTc2, iron oxide alteration, small size (5 km^2).
- Salinas de Garci Mendoza District,Iñexa District,Año Nuevo District
  Located in the well-eroded geological unit TC2, argillic alteration, large size (26 km^2).
- Cerro Picacho District
  Located in the well-eroded geological unit QTc1, argillic alteration, large size (22 km^2).
- Cerro Panizo District,Cerro Puquisa District
  Located in the well-eroded geological unit QTc1, argillic and iron oxide alterations, large

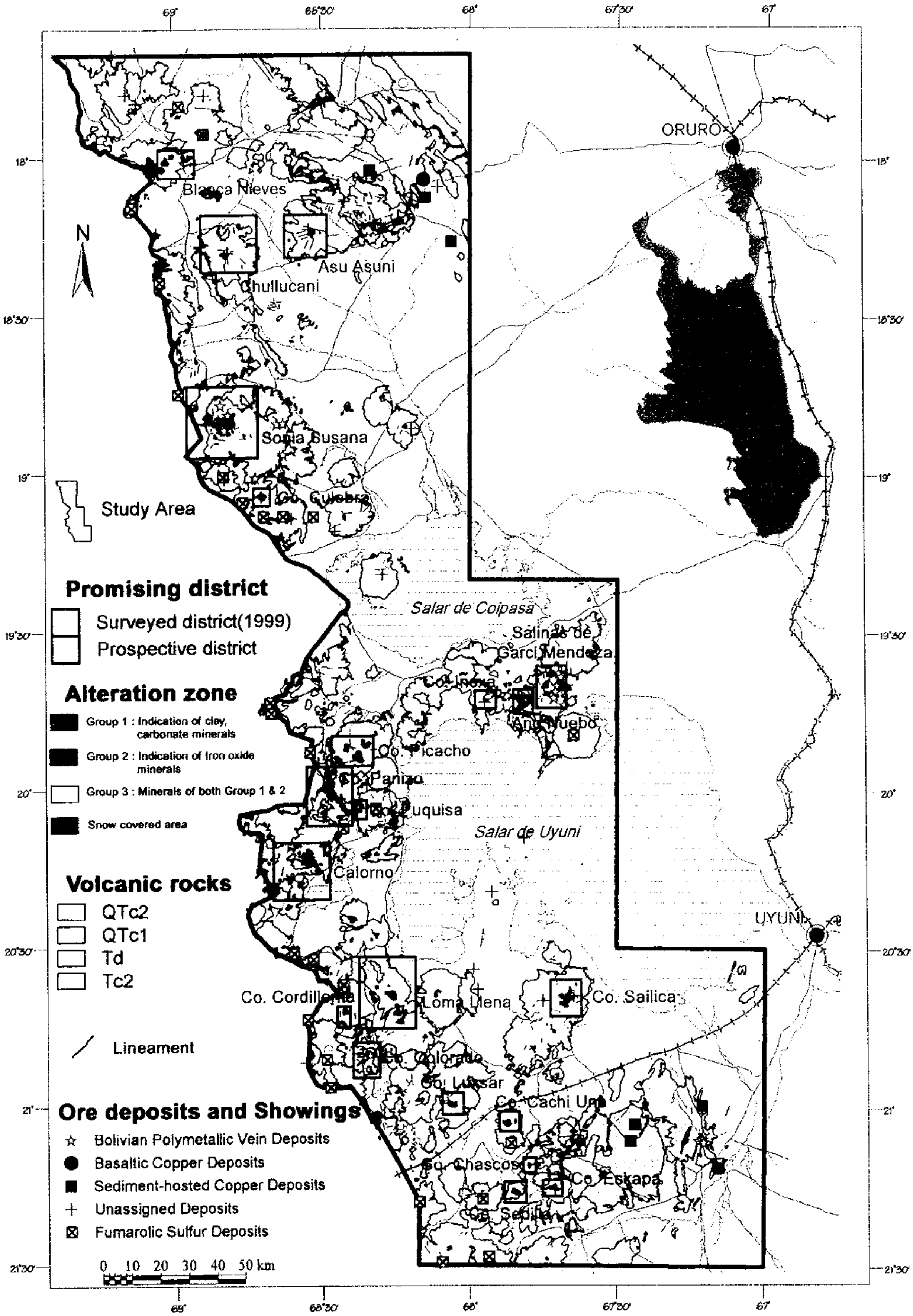


Fig. II-2-7 Integrated Map of Satellite Image Analysis

size (40 km^2).

- Calorno District

  Located in the well-eroded geological unit QTc1, argillic and iron oxide alterations, large size (30 km^2).

- Loma Llena District

  Located in the well-eroded geological unit QTc1, argillic and iron oxide alterations, large size (27 km^2).

- Cerro Cordillerita District

  Located in the well-eroded geological unit QTc1, argillic and iron oxide alterations, small size (4 km^2).

- Cerro Colorado District

  Located in the well-eroded geological unit QTc1, argillic and iron oxide alterations, medium size (12 km^2).

- Cerro Sailica District

  Located in the well-eroded geological unit QTc2, argillic and iron oxide alterations, medium size (10 km^2).

- Cerro Luxar District

  Located in the well-eroded geological unit QTc2 (near the top of stratovolcano), argillic and iron oxide alterations, small size (4 km^2).

- Cerro Cachi Unu District

  Located in the well-eroded geological unit QTc2 (near the top of stratovolcano), argillic alteration, small size (4 km^2).

- Cerro Sedilla District,Cerro Chascos District

  Located in the well-eroded geological unit QTc2 (near the top of stratovolcano), argillic and iron oxide alterations, small size (4 km^2).

- Cerro Eskapa District

  Located in the well-eroded geological unit QTc2 (in the crater of stratovolcano), argillic alteration, small size (2 km^2).

Table II-2-5 Summary of Prospective District

District	Location of alteration zone	Geologic unit of alteration zone	Indicated mineral	Scale of alteration zone (km^2)
Blanca Nieves	Slope	QTc2	Iron oxide	9
Chullcani	Top of the Mt.	QTc2	Iron oxide	3
Asu Asuni	Top of the Mt.	QTc2	Iron oxide	4
Sonia Susana	Centre of Dome Struct.	Tc2	Iron oxide	28
Cerro Culebra	Top of the Mt.	QTc2	Iron oxide	5
Salinas de Garci Mendoza, Año Nuevo, Iñexa	Top of the Mt.	Tc2	Clay, Carbonate	26
Cerro Picacho	Widely distr.	QTc1	Clay, Carbonate	22
Cerro Panizo Cerro Puquisa	Widely distr.	QTc1	Iron oxide, Clay, Carbonate	40
Calorno	Widely distr.	QTc1	Iron oxide, Clay, Carbonate	30
Loma Llena	Widely distr.	QTc1	Iron oxide, Clay, Carbonate	27
Cerro Cordillerita	Slope	QTc1	Iron oxide, Clay, Carbonate	4
Cerro Colorado	Top of the Mt.	QTc1	Iron oxide, Clay, Carbonate	12
Cerro Sailica	Top of the Mt.	QTc2	Iron oxide, Clay, Carbonate	10
Cerro Luxsar	Top of the Mt.	QTc2	Iron oxide, Clay, Carbonate	4
Cerro Cachi Unu	Top of the Mt	QTc2	Clay, Carbonate	4
Cerro Sedilla Cerro Chascos	Top of the Mt	QTc2	Iron oxide, Clay, Carbonate	4
Cerro Eskapa	Slope	QTc2	Clay, Carbonate	2

Chapter 3 Geological and Geochemical Surveys

3-1 Method of Survey

The geological and geochemical surveys at the quantities indicated in Table I-1-1 were executed in the promising areas selected as the result of the analysis of existing data and interpretation of satellite images.

For the field survey, route maps were prepared by enlarging a 1:50,000-scale topographic map. The survey route was determined in a way that the results of existing data analysis and satellite image interpretation may be reflected.

The GPS was utilized for confirming geographic positions, while positions of outcrops in mineralization zones were determined by the simple surveying when necessary.

Observation findings were recorded in the route map as accurately as possible, and outcrops of particular importance were sketched at 1:100 to 1:200 scales and photographed in color.

Rocks collected at sites as the geochemical sample media were sent to the laboratory of ASA (Alex Stewart Assayers) in Oruro for crushing, grinding and sample preparation. The prepared samples were sent to ASA, UK for assay.

Statistical processing was applied to the assay values of 803 pieces of geochemical samples collected during the survey, so that accumulation frequency curves were drawn on logarithmic graph paper. The inflection points of the frequency curves were found, which are to serve as the thresholds for discriminating abnormal values from the backgrounds.

The geological survey findings were incorporated in a 1:100,000-scale geologic map. (Figs. II-3-1(1)~(6))

3-2 Turaquiri District (Figs. II-3-1(1), II-3-2(1) and II-3-3(1))

3-2-1 Geology

The area is underlain by tuff, lapilli tuff, tuff breccia (volcanic breccia) and dacite.

Tuff is light gray, and weakly welded in part. (2112). It is dacitic and includes fragments of dacite, andesite and tuff, as well as quartz, biotite and hoenblendee. The K-Ar dating of a non-altered rock sample (No. 2112) indicated 5.51 ± 0.11 Ma.

The lapilli tuff is grayish white to grayish green and includes subrounded to subangular rock fragments of andesite, which have maximum diameters of 1-20 cm and account for 10% to 30%.

The tuff breccia is grayish white to grayish green, including mainly subangular rock fragments which with maximum diameters of 5-30 cm and account for 25% to 75%.

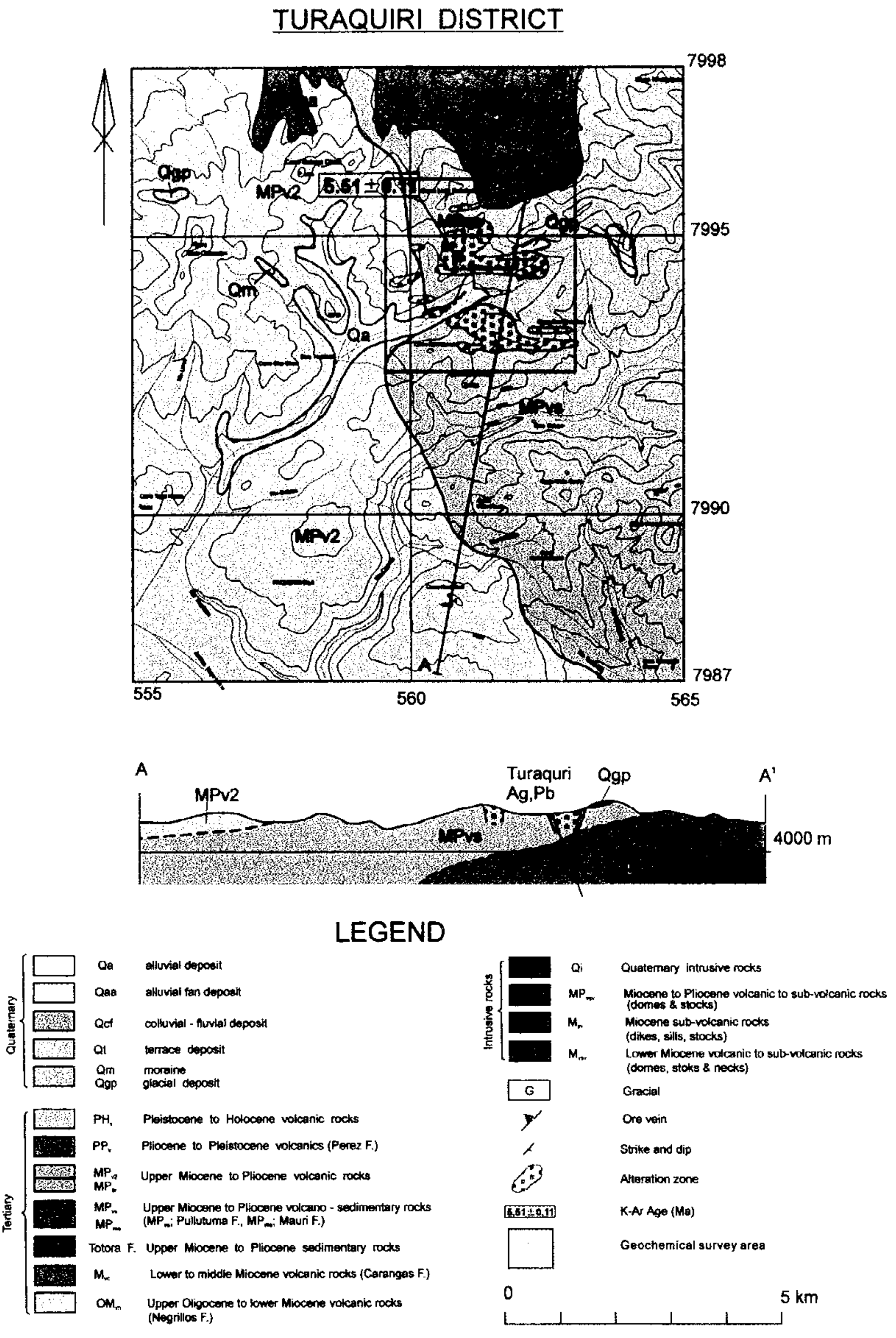


Fig. II -3-1 (1) Geological Map of the Turaquiri District

The dacite is subjected to white to green alteration. Small quantities of biotite and hoenblendee are observable, and under the microscope, altered minerals such as sericite and smectite are seen.

The dominant trend of the faults, veins and fractures in the area is E-W, while those with the N-S trend are partially observed.

3-2-2 Alteration

Hydrothermal alteration zones, though small in scale, are spotted within a 3 km x 3 km area.

Silicification, argillization and propylitization are observed.

Silicification is observed in various parts within a narrow area, extending along the veins and fractures in the E-W direction.

Argillization is seen encircling the silicification zones. Altered minerals such as quartz, kaolin, chlorite, sericite, smectite and alunite are observed.

Propylitization is partially observable; dacite, lapilli tuff and tuff breccia are subjected to carbonation and chloritization.

3-2-3 Mineralization

The Turaquiri deposit is said to have been mined since the colonial times. The ore deposit is mainly composed of silver-bearing galena-barite-quartz veins in lapilli tuff and tuff breccia.

The veins are generally in the E-W direction. The southern vein dips approximately 75°N while the northern vein dips approx. 75°S. The two veins are connected by a vein trending N70°E and dipping 70°N.

A vein, 30 cm to 3 m wide, is observed on a remaining wall rock of the old surface exploitation site. The largest exploitation site is 20 m in width and 140 m in extension. (Sketch 1)

The ore minerals such as galena, pyrite, chalcopyrite, goethite and marcasite are observed under the microscope, while the gangue minerals are generally quartz and barite, partially accompanied by siderite (Nos.1795 and 1800), chlorite (Nos.1484, 1797 and 1798), alunite (No.1796) and garnet (No.1800).

The old drift of the colonial times that extends from the valley west of Loma Churicollo eastward is built with block stones of some 40 cm in size and is driven over 150 m. A vein changes into a clay vein hardly discriminable from argillized host rocks. (Sketch 2) The average content of 17 samples collected in the drift are 5 ppb Au, 27 ppm Ag, 80 ppm Cu, 4.147 ppm Pb and 3.641 ppm Zn. The ore minerals are indiscernible with the naked eye.

The maximum assay values of 37 samples collected from the vein (except ores in the

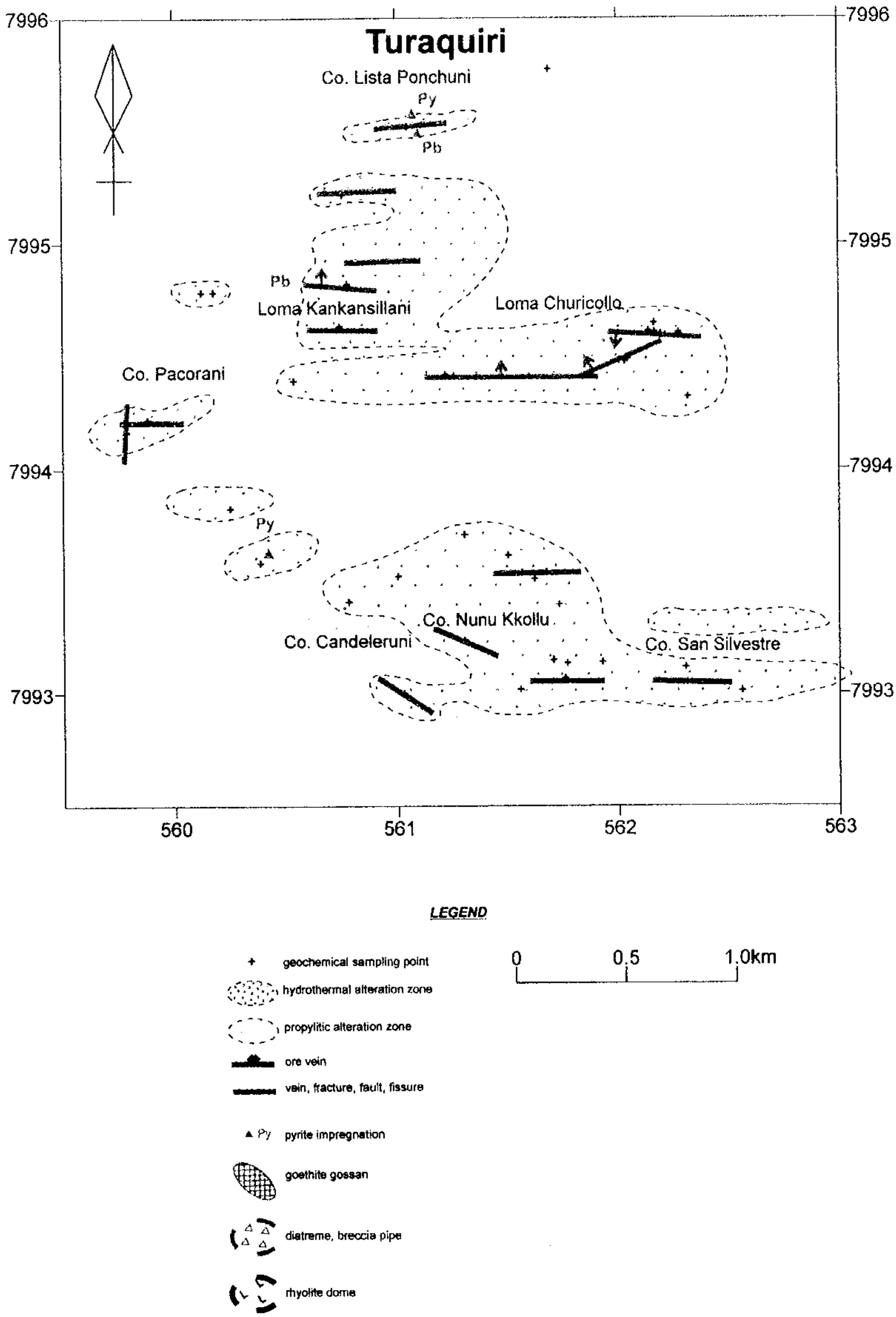


Fig. II -3-2 (1) Alteration Map of the Turaquiri District

stockyard) were Au: 31 ppb (No.1965); Ag: 877 ppm (No.1396); Cu: 535 ppm (No.1299); Pb: 25,000 ppm (No.1492); and, Zn: 15,639 ppm (No.1965), whilst the average values were Au: 5 ppb; Ag: 136 ppm; Cu: 83 ppm; Pb: 4,067 ppm; and, Zn: 2,626 ppm.

To examine thermal properties of the mineralization and chemical properties of the ore-forming fluid, homogenization and melting temperatures (freezing temperature) of fluid inclusions were measured of seven samples. The measurements are shown in Table II-3-2.

All seven samples measured are quartz, whose homogenization temperatures ranged from 140°C to 280°C while the average temperatures of respective samples ranged from 168°C to 227°C.

The melting temperatures were distributed between -15°C and -0.4°C, and average temperatures of respective samples were from -14.0°C to -1.9°C. The salinity (NaCl equivalent) obtained from the temperature values are 3.1 wt% to 17.9 wt%.

Table II-3-1 Homogenization Temperature and Melting Temperature

		Homogenization Temperature			Melting Temperature			
Sample No.	Mineral	Inc. No.	Range (°C)	Ave. (°C)	Inc. No.	Range (°C)	Ave. (°C)	Salinity (wt%)
1299	Qz	26	173 ~ 247	200	19	-6.9 ~ -5.0	-5.8	8.9
1396	Qz	36	178 ~ 280	227	24	-10.8 ~ -4.8	-7.9	11.5
1487	Qz	24	149 ~ 215	168	19	-2.4 ~ -0.4	-1.9	3.1
1488	Qz	37	161 ~ 227	197	21	-8.0 ~ -5.5	-6.8	10.3
1489	Qz	24	146 ~ 227	190	22	-12.6 ~ -4.3	-9.0	12.8
1576	Qz	14	181 ~ 230	213	16	-9.9 ~ -7.0	-7.6	11.3
1623	Qz	16	163 ~ 232	203	16	-15.0 ~ -13.4	-14.0	17.9
Average			146 ~ 280	200			-7.6	10.8

In the old drift of the Turaquiri mine, there remain sampling sites where stone structures are partially removed at intervals of several meters. In the vicinity of the upper reaches of the river near the portal, some vestiges of drilling survey presumably conducted in recent years are left.

In addition to the ore deposit, there are old mining sites on the northern slope of Cerro Candeleruni-Cerro San Silvestre in the south. In the west, a lead and zinc-bearing barite-quartz vein trending E-W is present on the ridge of Loma Kankansillani.

Pyrite dissemination is observed at Cerro Llista Ponchuni in the north and on the right bank of the Rio Virgen de Penas while, Cerro Llista Ponchuni, galena and marcasite dissemination is observed.

3-2-4 Assay of geochemical samples

Forty-six pieces of rock samples were collected at the area.

The minimum, maximum and average assay values by elements (in the order of appearance) are as follows:

Au: <2 ppb, 20 ppb and <2 ppb; Ag: <0.5 ppm, 583 ppm and 34 ppm; Cu: <2 ppm, 790 ppm and 41 ppm; Pb: <3 ppm, 5,534 ppm and 701 ppm; Zn: 16 ppm, 3,801 ppm and 596 ppm; As: <5 ppm, 650 ppm and 36 ppm; Sb: <5 ppm, 6 ppm and <5 pm; Hg: 10 ppm, 770 ppm and 178 ppm; Mo: <1 ppm, 8 ppm and 2 ppm; Ba: 40 ppm, 5,260 ppm and 1,064 ppm; and, Sn: <5 ppm, <5 ppm and <5 ppm.

The geochemical anomalies of the respective elements are shown in Fig. II-3-3(1).

Au: Although the maximum assay value is 20 ppb, most samples are under the detection limit, showing neither anomalies nor concentration.

Ag: The maximum assay value is 583 ppm, and portions of 10 ppm or more concentration at the known vein portion of the Turaquiri deposit at Loma Churicollo. Besides, anomalous values of 30 ppm or more are locally obtained at the ore showings on the north slope of Cerro Nuñu Kkollu in the south.

Cu: Anomalous portions of 90 ppm or higher are located on the surface of the Turaquiri vein portion and at the ore showings on the north slope of Cerro Nuñu Kkollu in the south, but these are localized and not concentrated.

Pb: From the surface to the underground Turaquiri vein portion, anomalous zones of 400 ppm or more are seen. Besides, anomalous portions are observed locally at the ore showings on the north slope of Cerro Nuñu Kkollu in the south.

Zn: From the surface to the underground of the Turaquiri vein portion, anomalous zones of 230 ppm or higher exist. Besides, there are anomalous zones at the ore showings on the north slope of Cerro Nuñu Kkollu in the south. Another anomalous zone is located at the western extension of the Turaquiri veins, where the presence of barite veins trending WNW is known.

As: From the surface to the underground portion of the Turaquiri vein, somewhat high values are indicated. Also at the ore showings on the north slope of Cerro Nuñu Kkollu and east slope of Cerro Llista Ponchuni northwest of the Turaquiri deposit, there is one spot each that indicates anomalies of 140 ppm or higher.

Sb: Except a spot that shows 6 ppm, all the samples are under the detection limit.

Hg: From the surface to the underground Turaquiri vein portion, there is an anomalous zone of 200 ppm or higher. Anomalous zones are located also at the ore showings on the north slope of Cerro Nuñu Kkollu in the south.

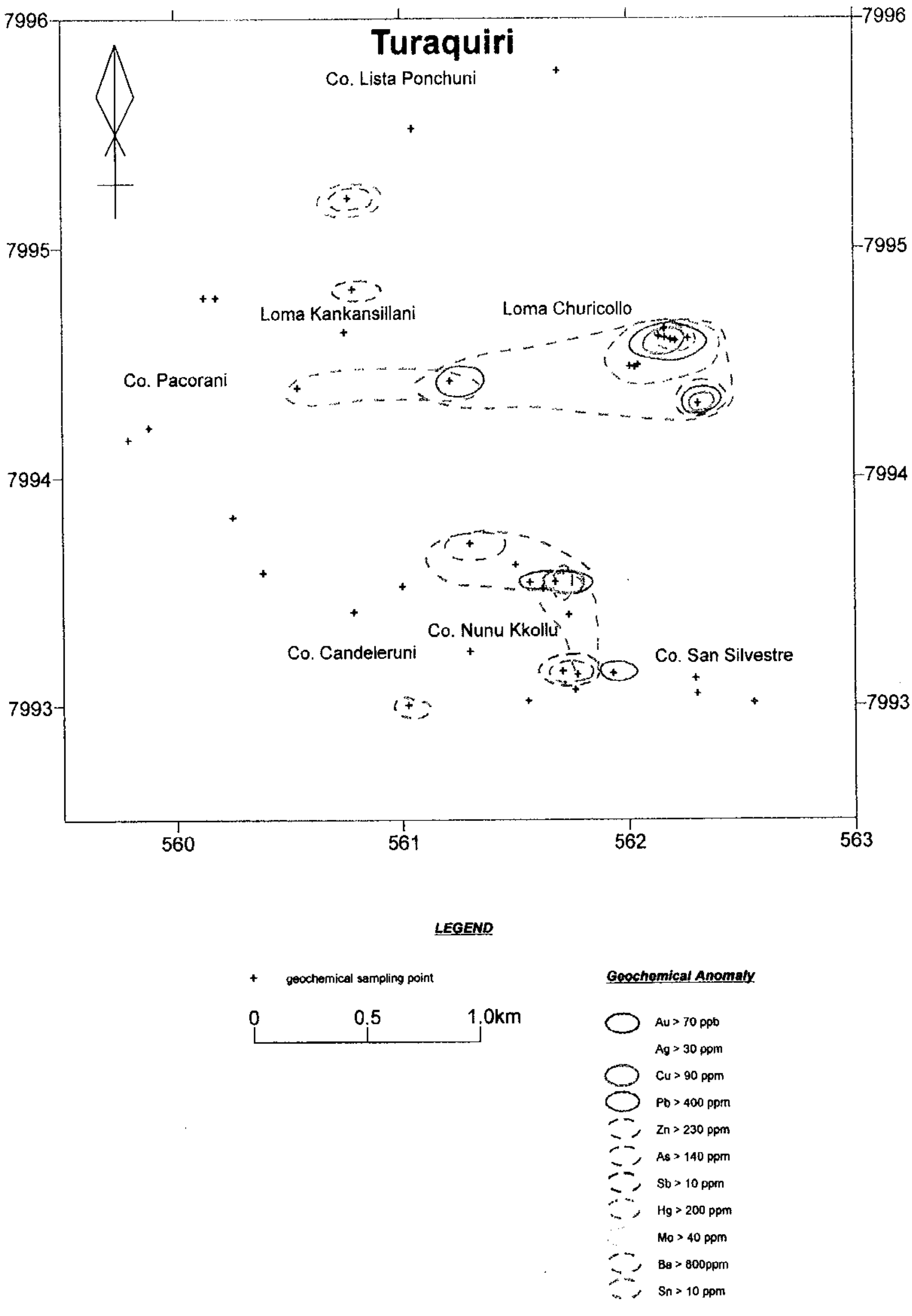


Fig. II-3-3 (1) Geochemical Anomaly Map of the Turaquiri District

Mo: On the surface of the Turaquiri vein portion, 8 ppm is detected while there is no anomalous value of 40 ppm or higher.

Ba: Anomaly zones of 800 ppm or more are from the surface portion of the veins of the Turaquiri deposit to the north slope of Co. Nuñu Kkollu.

Sn: All the samples are under the detection limit.

3-3 Asu Asuni District (Figs. II-3-1(2), II-3-2(2) and II-3-3(2))

3-3-1 Geology

The area is underlain by lapilli tuff, tuff breccia (volcanic breccia), andesite and dacite.

Lapilli tuff and tuff breccia include andesite fragments and are subjected to alteration.

Andesite is composed of two-pyroxene andesite, hoenblendee andesite and pyroxene-hoenblendee andesite. On the ridges, there remain fresh rocks saved from alteration.

In the area, faults, veins and fractures with the E-W trend prevail.

3-3-2 Alteration

The hydrothermal alteration zone is almost in a square shape of 2.5 km x 2.5 km.

Silicification, argillization and propylitization are observed.

Altered ores are quartz, alunite, halotrichite, smectite and epidote.

3-3-3 Mineralization

Only minor dissemination with pyrite and marcasite is observable in some andesite.

Under the microscope, ore minerals such as pyrite, marcasite and goethite are observed.

3-3-4 Assay of geochemical samples

Twenty-seven pieces of samples were collected in this area.

The minimum, maximum and average assay values by elements (in the order of appearance) are as follows:

Au: <2 ppb, 3 ppb and <2 ppb; Ag: <0.5 ppm, 1 ppm and<0.5 ppm; Cu: <2 ppm, 51 ppm and 12 ppm; Pb: <3 ppm, 28 ppm and 5 ppm; Zn: <2 ppm, 433 ppm and 31 ppm; As: <5 ppm, 39 ppm and 4 ppm; Sb: <5 ppm, <5 ppm and <5 ppm; Hg: <10 ppm, 100 ppm and 27 ppm; Mo: <1 ppm, 12 ppm and 2 ppm; Ba: 114 ppm, 1,191 ppm and 300 ppm; and, Sn: <5 ppm, <5 ppm and <5 ppm.

Geochemical anomalies of the respective elements are indicated in Fig. II-3-3(2).

ASU ASUNI DISTRICT

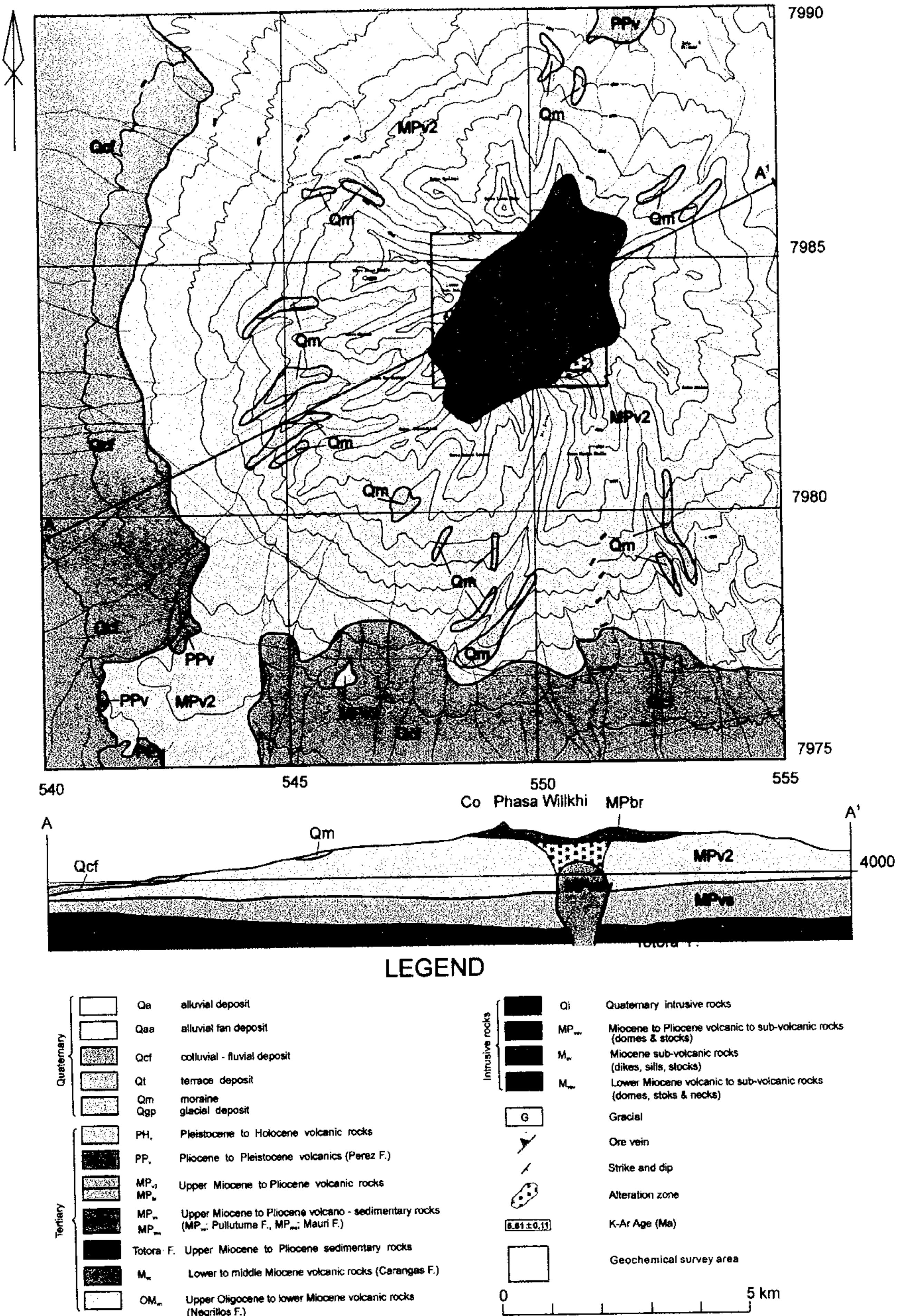


Fig. Ⅱ-3-1 (2) Geological Map of the Asu Asuni District

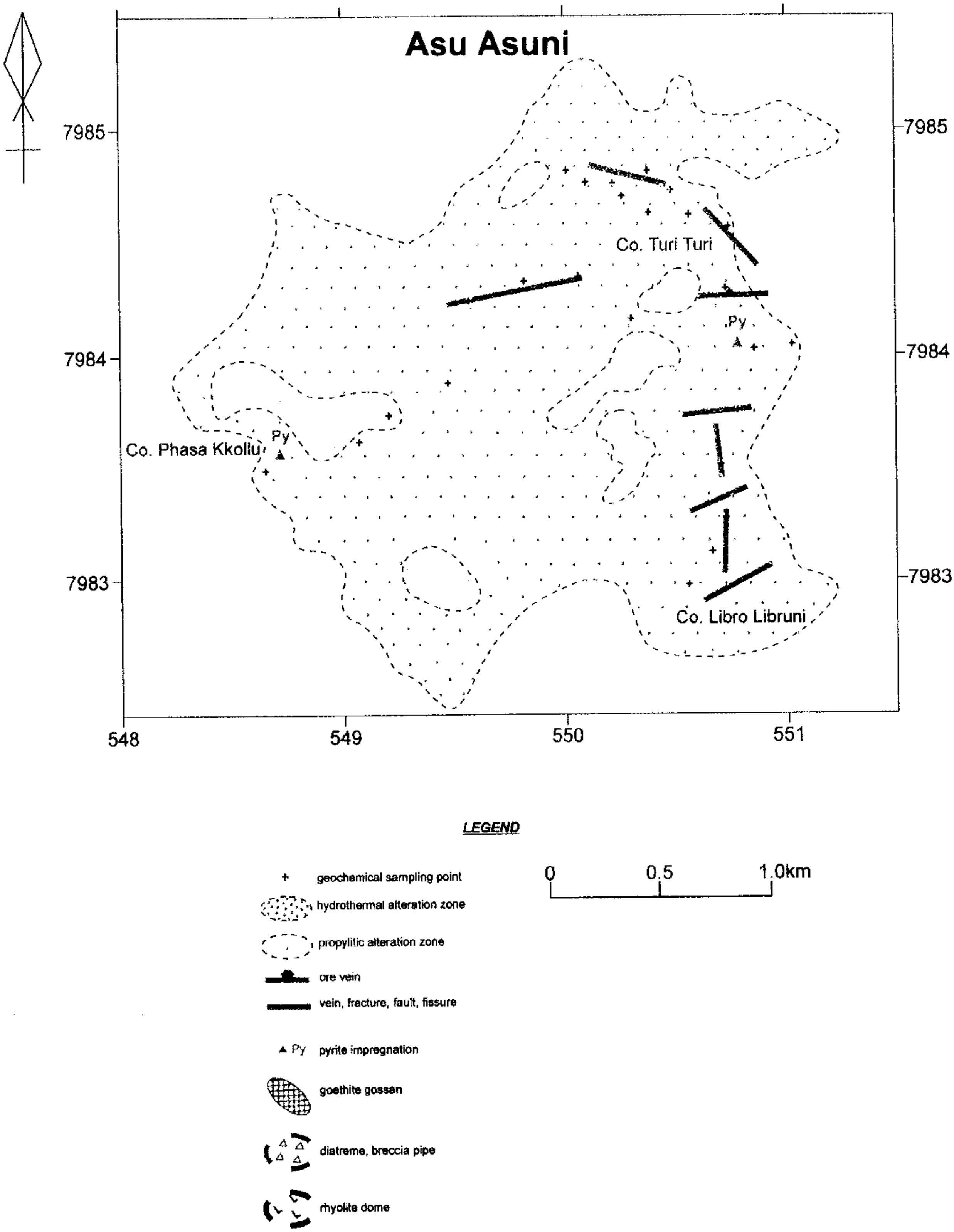


Fig. II -3-2 (2) Alteration I Map of the Asu Asuni District

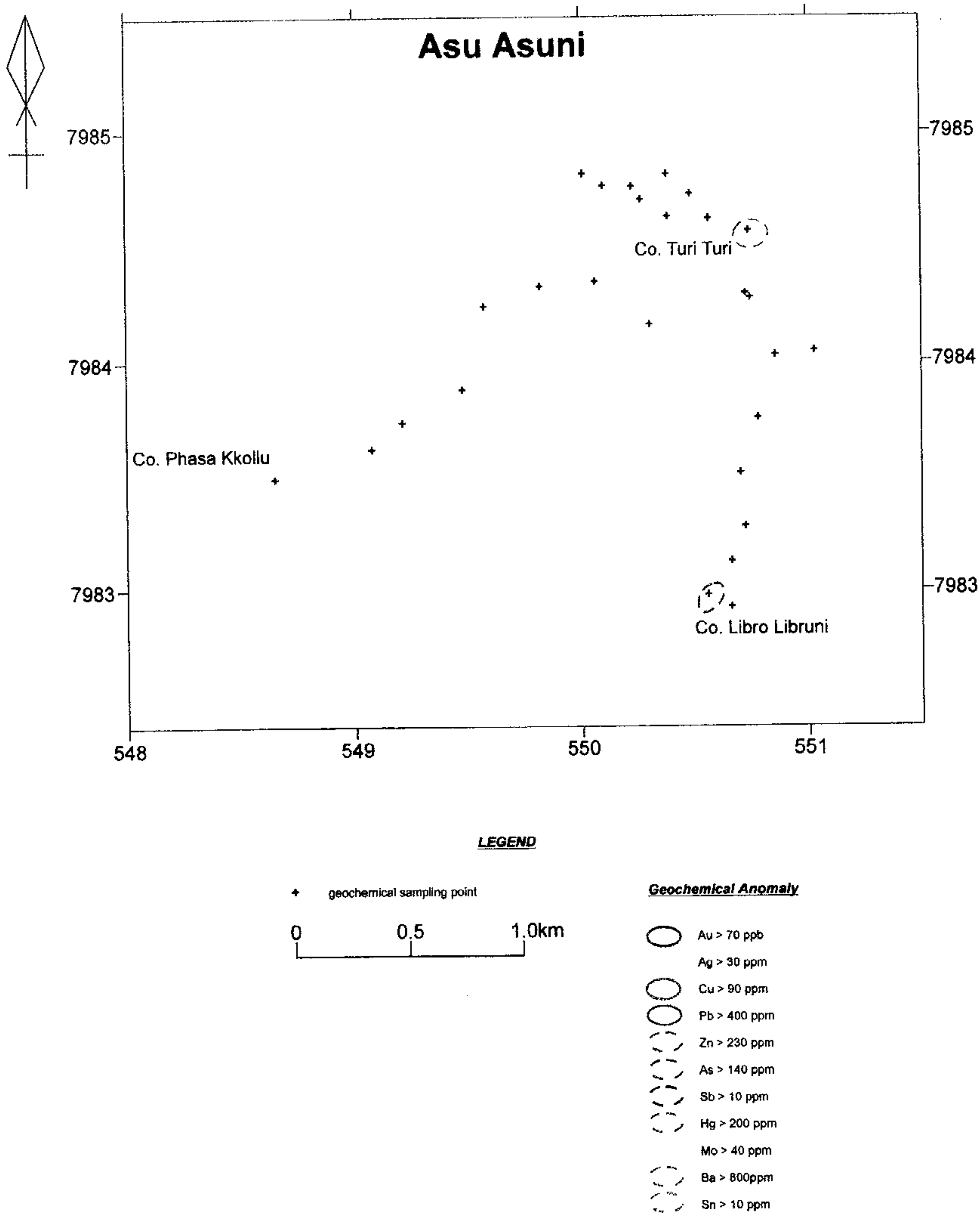


Fig. II -3-3 (2) Geochemical Anomaly Map of the Asu Asuni District

Au: Except a spot indicating 3 ppb, all the samples were under the detection limit.

Ag: Except a spot indicating 1 ppb, all the samples were under the detection limit.

Cu: No marked concentration was found nor anomalies of 90 ppm or higher.

Pb: Assay values are generally low; no marked concentration was observed.

Zn: Although an anomalous value of 433 ppm was indicated at a spot on Co. Libro Libruni, no marked concentration was observed.

As: Except a spot indicating 39 ppm, all the samples were under the detection limit.

Sb: All the samples were under the detection limit.

Hg: Except a spot indicating 100 ppm, all the samples were 60 ppm or less.

Mo: Except a spot indicating 12 ppm, all the samples were 7 ppm or less, and there is no anomalous value of 40 ppm or higher.

Ba: An anomalous value of 1,191 ppm was indicated at a spot on Co. Turi Turi. From there toward Co. Phasa Kkollu, somewhat high values were detected.

Sn: All the samples were under the detection limit.

3-4 Chulcani District (Figs. II-3-1(3), II-3-2(3) and II-3-3(3))

3-4-1 Geology

The area is underlain by lapilli tuff, tuff breccia (volcanic breccia) and andesite.

Lapilli tuff and/or tuff breccia are dacitic and subjected to alteration.

Andesite is partially subjected to alteration. Fresh andesite (No.2113) is hoenblende andesite consisting of two-pyroxene and biotite, the K-AR dating of which indicated 6.13 ± 0.12 Ma (No.2113).

A diatreme, presumably about 300 m in diameter, lies in the area.

Faults, veins and fractures with the NE-SW to ENE-WSW trend are predominant in the area, followed by those with the N-S trend.

3-4-2 Alteration

The hydrothermal alteration zone is in somewhat irregular shape of approx. 4 km x 4 km.

Silicification and argillization are observed.

Altered minerals such as quartz, alunite, halotrichite, smectite, kaolinite and siderite are observed.

3-4-3 Mineralization

Andesite and dacitic lapilli tuff are disseminated with pyrite.

Ore minerals such as pyrite and goethite, partly accompanied by barite, are observed under the

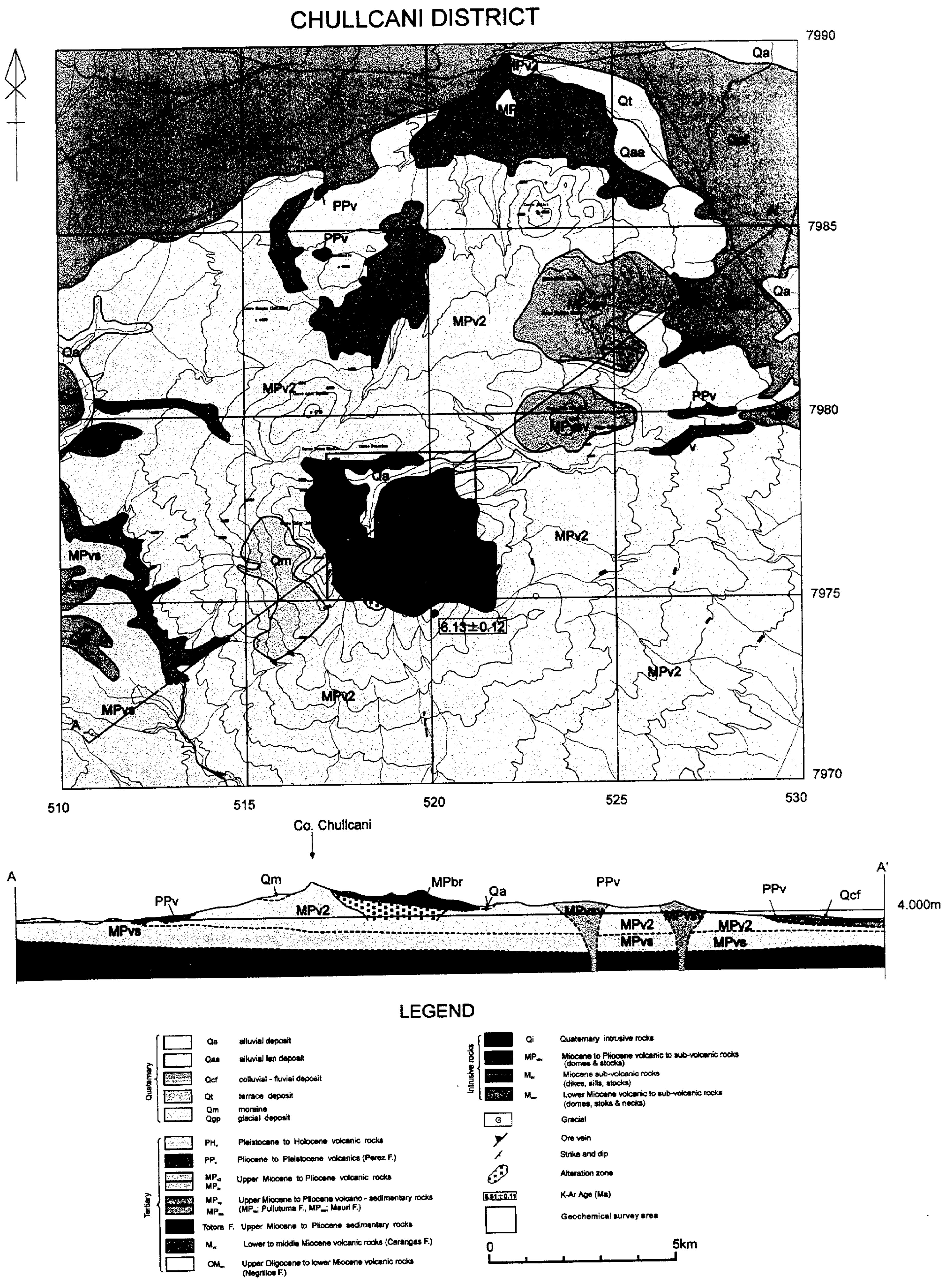


Fig. II-3-1 (3) Geological Map of the Chullcani District

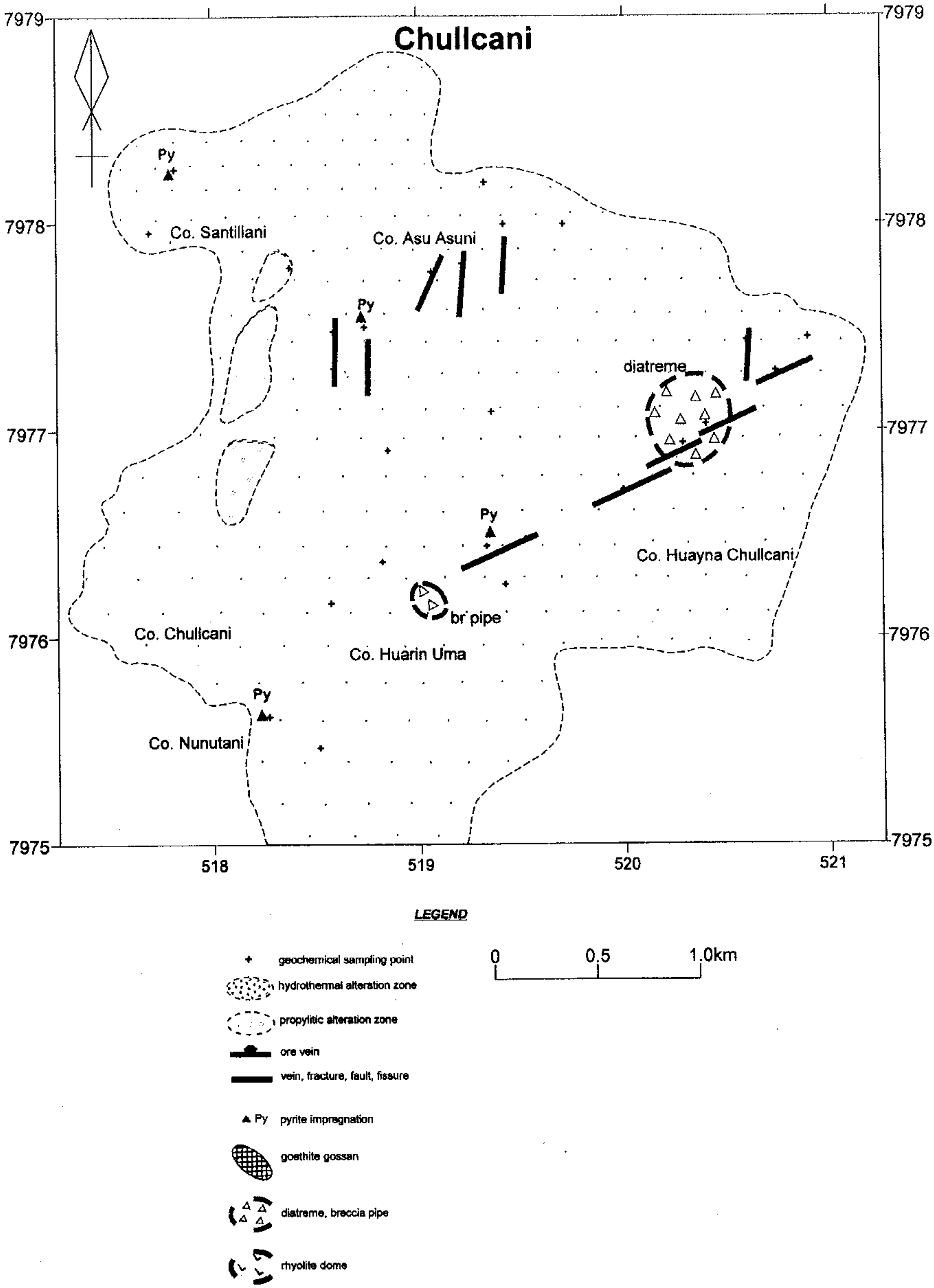


Fig. II -3-2 (3) Alteration Map of the Chullcani District

microscope.

3-4-4 Assay of geochemical samples

Twenty-eight pieces of rock samples were collected in this area.

The minimum, maximum and average assay values by elements (in the order of appearance) are as follows:

Au: <2 ppb, 408 ppb and 38 ppb; Ag: <0.5 ppm, 4 ppm and 1 ppm; Cu: <2 ppm, 124 ppm and 21 ppm; Pb: <3 ppm, 2,569 ppm and 121 ppm; Zn: <2 ppm, 75 ppm and 20 ppm; As: <5 ppm, 373 ppm and 29 ppm; Sb: <5 ppm, 10 ppm and <5 ppm; Hg: 10 ppm, 860 ppm and 143 ppm; Mo: <1 ppm, 58 ppm and 6 ppm; Ba: 108 ppm, 3,165 ppm and 715 ppm; and, Sn: <5 ppm, <5 ppm and <5 ppm.

Geochemical anomalies by the elements are indicated in Fig. II-3-3(3).

Au: The maximum assay value reached 408 ppb, while anomaly zones of 100 ppb or higher exist at two locations on Co. Asu Asuni and Co. Huarin Uma.

Ag: Most of the assay samples were under the detection limit.

Cu: An anomalous value of 124 ppm was found at a location northwest of Co. Huayna Chukani. In the gold anomaly zones, the values are 13 ppm to 69 ppm.

Pb: Somewhat high values, including the maximum value of 2,569 ppm, overlap the gold anomalies on Co. Asu Asuni, whereas the values are low in the gold anomaly zone on Co. Huarin Uma.

Zn: The values are low except a value of 52 ppm to 75 ppm was detected in the intensive argillization portion north of Co. Santillani.

As: An anomalous value of 373 ppm overlaps the gold anomaly of 344 ppb on Co. Asu Asuni. Anomalous values of 140 ppm or more are detected at the ore showings on the north slope of Co. Nuñu Kkollu and east slope of Co. Llista Ponchuni northwest of the Turaquiri deposit.

Sb: Except a spot indicating 6 ppm, all the samples were under the detection limit.

Hg: An anomaly zone that indicates 200 ppm or higher extends NE-SW to the northwest of Co. Huayna Chukani. Besides, an anomalous value of 380 ppm was detected in the north slope of Co. Asu Asuni.

Mo: At a spot indicating 58 ppb Au on Co. Huarin Uma, an anomalous value of 58 ppm was taken and, to the north of the spot, a value of 26 ppm was obtained but all the others were 10 ppm or less.

Sn: All the samples were under the detection limit.

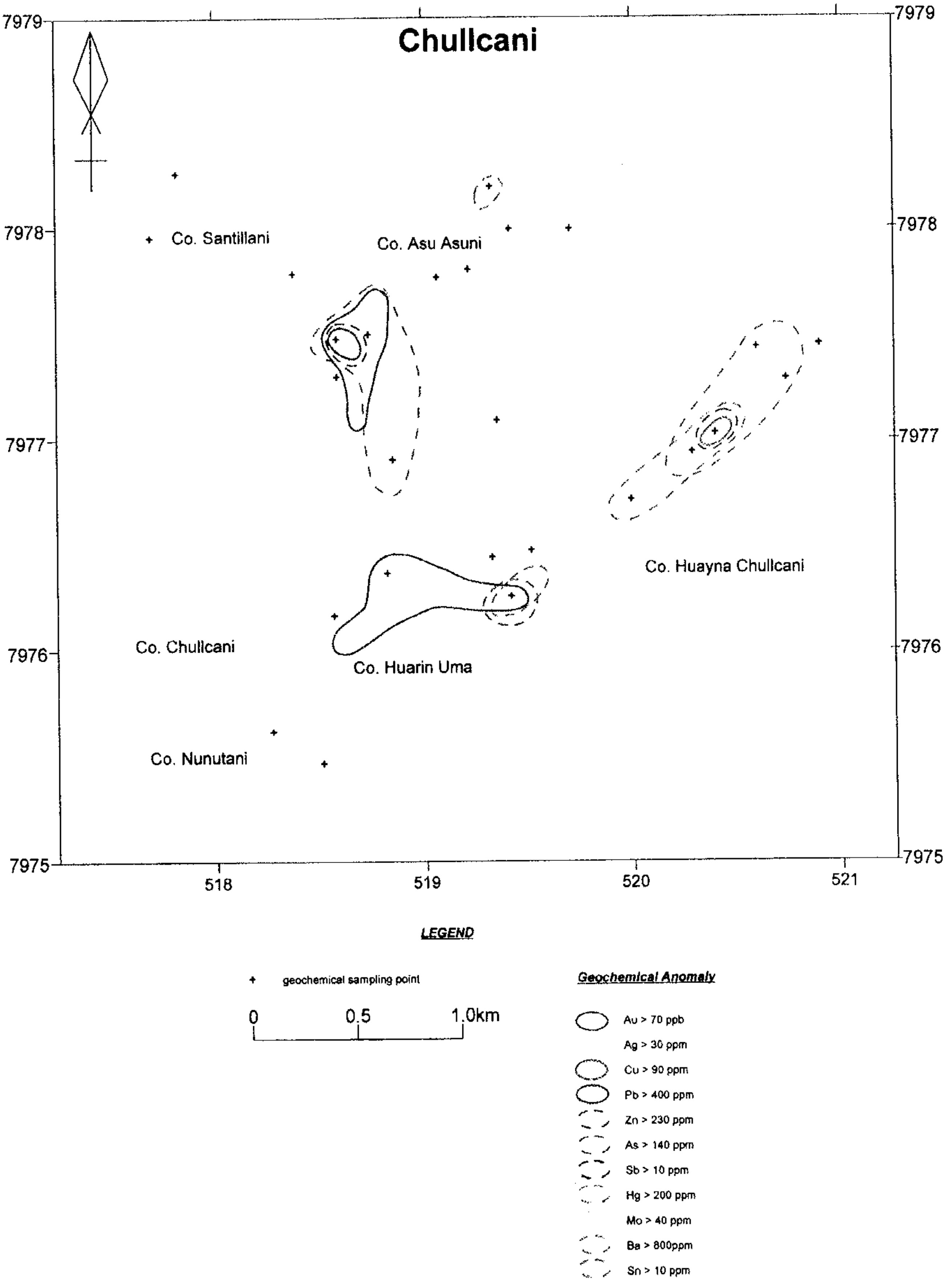


Fig. II -3-3 (3) Geochemical Anomaly Map of the Chullcani District

3-5 Sonia - Susana District (Figs. II-3-1(4), II-3-2(4) and II-3-3(4))

3-5-1 Geology

The district is underlain by pyroclastic rocks such as tuff, lapilli tuff and tuff breccia (volcanic breccia), and lavas such as andesite, dacite, rhyolite and basalt, as well as dolerite as an intrusive rock.

Tuff is andesitic, dacitic and rhyolitic, widespread from the central part of the district westward, (Nos.1370 and 2107). Rhyolitic tuff (No.2107) lies in a circle and is partially welded. The K-Ar dating indicated 17.70± 0.35 Ma (No.2107).

Lapilli tuff and tuff breccia are greenish white to brownish gray, including subrounded to subangular rock fragments. The rock fragments are andesite and rhyolite, having maximum diameters of 1 cm to 20 cm, accounting for 10% to 20%.

Andesite is mainly (Hoenblendee)-Pyroxene andesite and partially, non-porphyritic andesite (No.1923), which is very hard, gray and bedded.

Rhyolite is gray, having the flow structure, presumably present in a dome-like shape, approximately 1 km in diameter, centering on Cerro Entre Campanini in the north-central part of the district. Under the microscope, quartz, potassium feldspar and plagioclase are observed, as well as very small amounts of biotite, magnetite, goethite and marcasite (No.1949). Rhyolite is seen covering rhyolitic tuff that assumes a ring structure, in the north central to the north part of the district. Rhyolite has a spherulitic shape, the K-Ar dating of which indicated 1.73 ± 0.03 Ma (No.2108).

Non-altered dacite lies around the national border in the west, whose K-Ar dating indicated 1.52 ± 0.03 Ma (No.2109).

Basalt is observed at a locality in the central part of the district, subjected to alteration and accompanied by pyrite dissemination (No.1958). Under the microscope, chlorite, sericite, epidote and calcite are seen.

Dolerite was confirmed at five locations in the whole district. On the south slope of Cerro Jankho Kkollu and north slope of its southern ridge, dolerite intrudes in the E-W direction. Under the microscope, plagioclase, pyroxene and olivine (No.1794) are observed; besides, altered minerals such as chlorite and calcite are generated.

Faults, veins and fractures trending E-W are predominant in the eastern part of the district. In Santa Catalina Loma to the west, those trending NW-SE are somewhat dominant whilst, in the central part, the NE-SW trend is dominant. In the west, the main trend is E-W but the N-S and NW-SE trends are also observable.

SONIA SUSANA DISTRICT

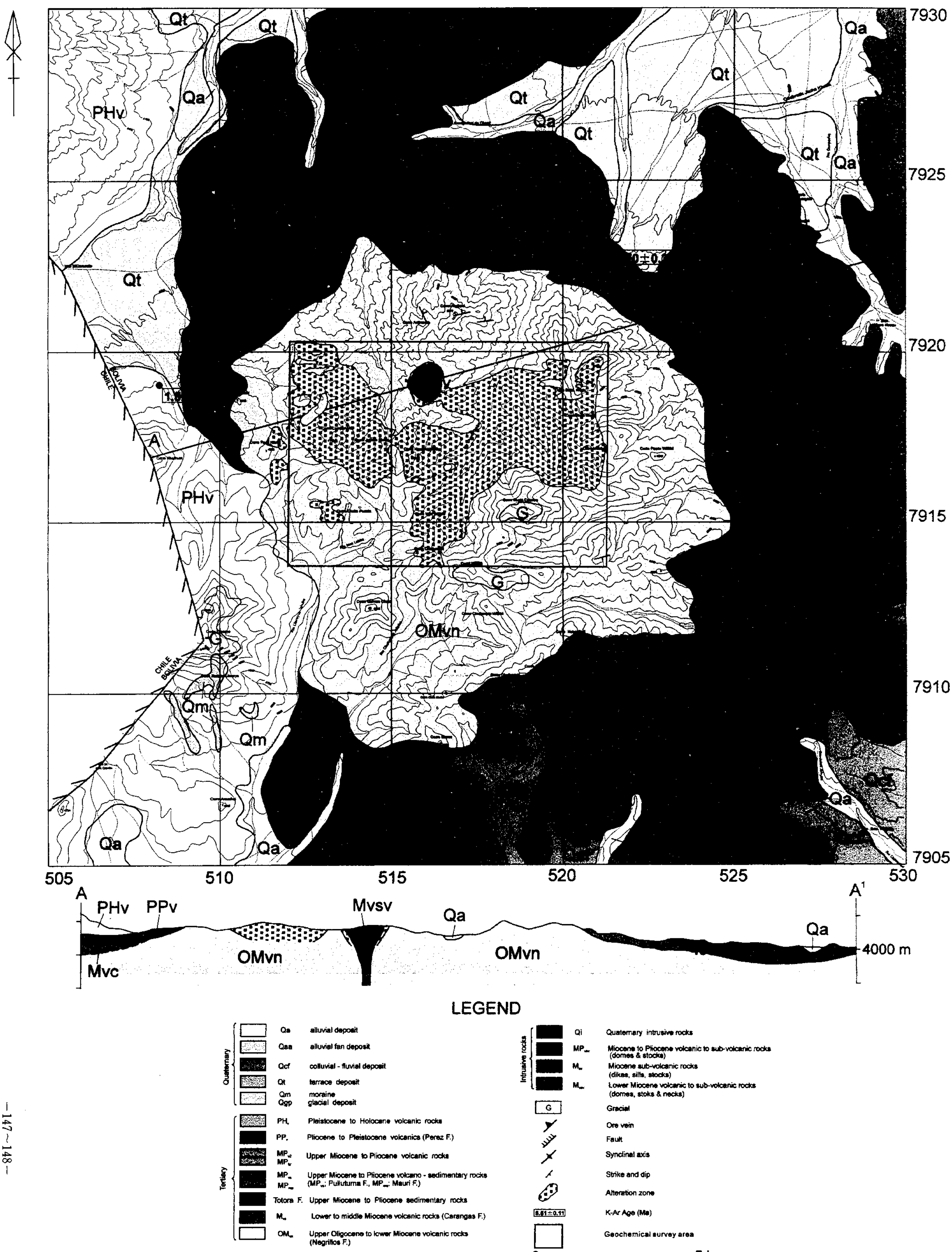


Fig. II -3-1 (4) Geological Map of the Sonia-Susana District

3-5-2 Alteration

A hydrothermal zone assumes a shape of an irregular rectangle of approximately 4 km x 9 km.

Silicification, argillization and propylitization are observed

The argillization zone is widespread in the alteration zone, in which silicification is seen like veins. A propylitization zone is insulated in the argillization zone, while silicification is seen extending rather broadly outside of the argillization zone, as well.

Altered minerals such as quartz, alunite, halotrichite, sericite, smectite, kaolinite, sericite-smectite mixed-layer minerals, calcite, chlorite and epidote are observed.

3-5-3 Mineralization

Pyrite dissemination is observed at various locations, as well as vein-type mineralization accompanied by base and precious metals.

A gold-bearing quartz vein is observed in argillized lapilli tuff on the north slope of Cerro Llica Khaua. The vein is 30 cm wide, striking N45°W and dipping 75°SW (No.1933). The quartz vein grades at 2.97 g/t Au and 24 g/t Ag but is low in base metals content. In the surrounding areas, there remain drilling sites and an old stope which is driven down with an inclination of 30° toward the lower part of the quartz vein and is collapsed at a depth of 7 m.

At the footwall side of the quartz vein, green copper dissemination, 40 cm wide, is seen, which grades 1.38% Cu, 0.12% Pb and 0.55% Zn (No.1931). Under the microscope, pyrite, goethite and small amounts of marcasite, azurite and sphalerite are observed.

Quartz veins and barite veins extend from the mountain slope to the ridge south of Cerro Jankho Kkollu. The veins have widths that vary up to 30 cm, repeating sharp swells and pinches, and have poor continuity. A vein that strikes N-S and dips 75°E contains lead, and has grades of 18 g/t Ag, 4.24% Pb and 0.97% Zn (No. 1611). A quartz vein that strikes N30°W, dipping 83°SW contains 1.21% Zn (No.1609). All the veins are low in the gold grade.

In order to study thermal properties of mineralization and chemical properties of ore-forming fluid, homogenization temperature and melting temperature (freezing temperature) of fluid inclusions of three samples were measured. The measurements are shown in Table II-3-3.

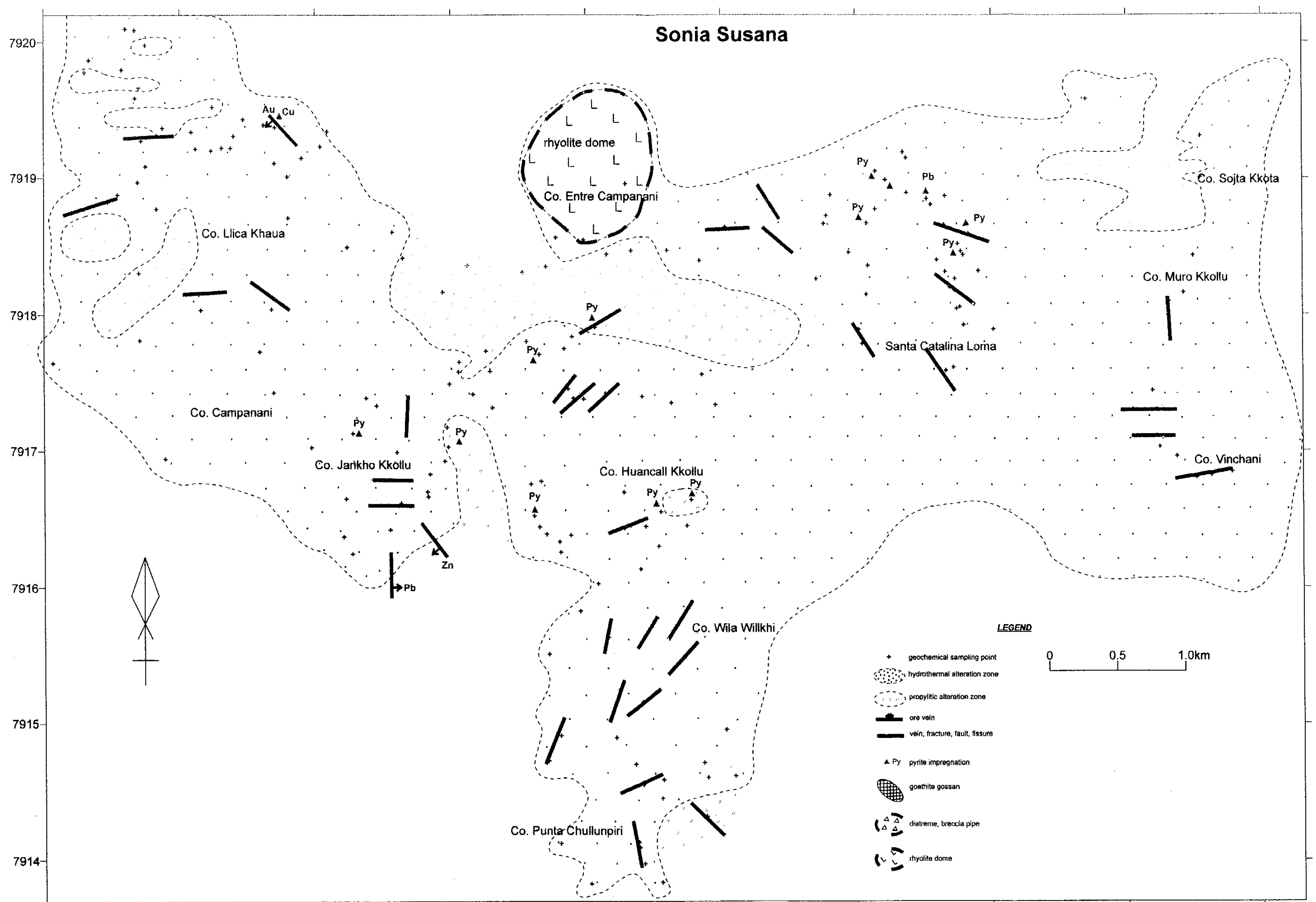


Fig. II-3-2 (4) Alteration Map of the Sonia-Susana District

Table II-3-2 Homogenization Temperature and Melting Temperature

Sample No.	Mineral	Homogenization Temperature			Melting Temperature			
		Inc. No.	Range (°C)	Ave (°C)	Inc. No.	Range (°C)	Ave (°C)	Salinity (wt%)
1609	Qz	14	149 ～ 249	201	15	-4.8 ～ -3.3	-4.1	6.6
1617	Qz	18	151 ～ 258	179	12	-3.5 ～ -1.1	-2.2	3.7
1920	Qz	15	139 ～ 249	205	17	-4.2 ～ -1.3	-2.3	3.9
Average			139 ～ 258	195		-4.8 ～ -1.1	-2.9	4.7

All the three samples measured are quartz, whose homogenization temperatures ranged from 139°C to158°C, and average temperatures were 179°C, 201°C and 205°C.

The melting temperatures ranged from -4.8°C to -1.1°C, and average temperatures were -4.1°C, -2.3°C and -2.2°C. The salinity (NaCl equivalent) that was calculated from these values are 6.6 wt.%, 3.9 wt.% and 3.7 wt.%.

In this district, COMINCO Bolivia has carried out a drilling survey of 10 boreholes, geochemical and IP surveys, leaving the drill sites, access roads, channel sampling sites and survey points at various places.

3-5-4 Assay of geochemical samples

One hundred ninety-four pieces of rock samples were collected in the district.

The minimum, maximum and average assay values by elements (in the order of appearance) are as follows:

Au: <2 ppb, 504 ppb and 12 ppb; Ag: <0.5 ppm, 57 ppm and 1 ppm; Cu: <2 ppm, 700 ppm and 43 ppm; Pb: <3 ppm, 1,672 ppm and 121 ppm; Zn: <2 ppm, 4,660 ppm and 141 ppm; As: <5 ppm, 3,210 ppm and 40 ppm; Sb: <5 ppm, 93 ppm and <5 ppm; Hg: <10 ppm, 22,230 ppm and 170 ppm; Mo: <1 ppm, 238 ppm and 7 ppm; Ba: 15 ppm, 2,690 ppm and 272 ppm; and, Sn: <5 ppm, 44 ppm and <5 ppm.

Geochemical anomalies of the respective elements are indicated in Fig. II-3-3(4).

Au: The maximum assay value of gold reached 504 ppb, while each anomaly zone indicated 100 ppb or higher exist at Santa Catalina Loma and Co. Campanini. In the former, an anomaly zone of 10 ppb or more spreads broadly.

Ag: A spot at Santa Catalina Loma indicated an anomalous value of 57 ppm, in the surroundings values less than 27 ppm are widespread. Around Co. Vinchani, there are portions indicating somewhat high values up to 18 ppm.

Cu: At Santa Catalina Loma, anomalous zones of 90 ppm or higher are widespread.

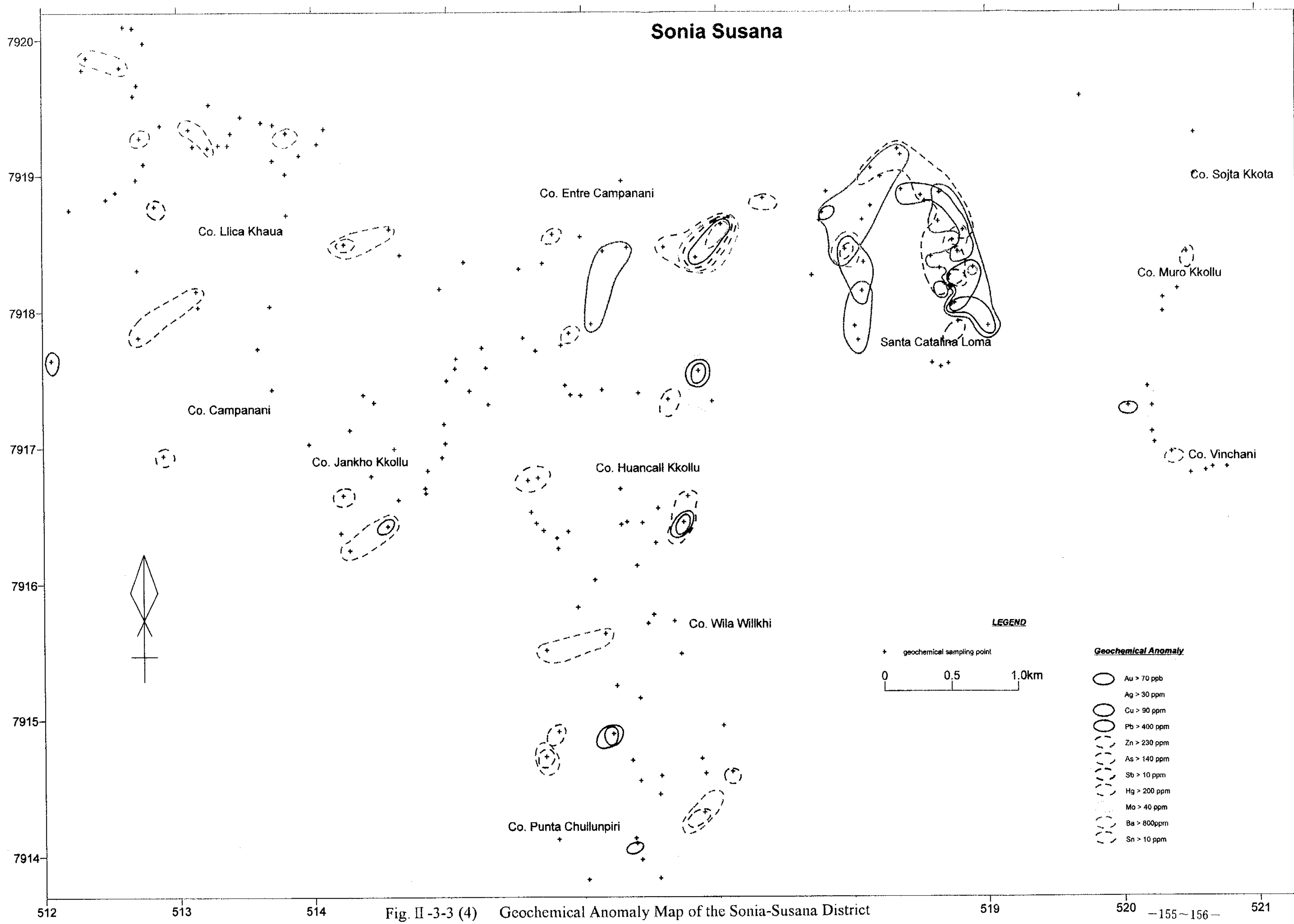


Fig. II -3-3 (4) Geochemical Anomaly Map of the Sonia-Susana District

Anomalous zones are found to the south of Co. Entre Campanini, while anomalous values of 90 ppm or higher were ascertained at five locations but they are scattered.

Pb: While anomaly zones of 400 ppm or more are at Santa Catalina Loma, anomalous values of 90 ppm or more were ascertained at five locations, though scattered.

Zn: Anomaly zones of 230 ppm or higher are at Santa Catalina Loma. Small anomaly zones are found also at Co. Huancall Kkollu. Besides, anomalous values of 230 ppm or more were detected at five scattered locations.

As: Anomaly zones of 140 ppm or higher overlap the gold anomaly zone at Co. Entre Campanini. Besides, anomalous values were seized at two separate spots in Santa Catalina Loma.

Sb: While the samples are mostly under the detection limit, an anomaly zone that indicates 26 ppm to 93 ppm overlaps the gold anomaly zone at Co. Entre Campanini. Besides, a spot at the Llica Khaua indicated 14 ppm.

Hg: Small anomaly zones of 200 ppm or higher are scattered at Co. Llica Khaua. Also at Co, Punta Chullunpiri and Co. Entre Campanini, anomalous values of 200 ppm or higher are locally observable.

Mo: Small anomaly zones of 800 ppm or higher are scattered all over the district.

Sn: While most of the samples were under the detection limit, anomaly zones of 10 ppm or more overlap the gold anomaly zones at Co. Entre Campanini and Santa Catalina Loma.

3-6 Calorno District (Figs. II-3-1(5), II-3-2(5) and II-3-3(5))

3-6-1 Geology

The district is underlain by tuff, lapilli tuff, tuff breccia (volcanic breccia), andesite and dacite. Generally, the mountaintops are covered by lavas while pyroclastic rocks overlie the lower parts.

Tuff is light gray to grayish white and <u>includes</u> subrounded to subangular rock fragments with maximum diameters of 1 cm to 20 cm and account for 10% to 20%.

Tuff breccia is light gray to grayish white and <u>includes</u> mainly subangular rock fragments with maximum diameters of 5 cm to 30 cm and account for 20% to 70%.

Andesite is very hard and gray to greenish gray. In the phenocrysts, observed are biotite and/or hoenblendee, partially accompanied by pyroxenes and olivine (Nos. 1863 and 2101). The K-Ar dating indicated 11.69 ± 0.23 Ma (No.1863) and 9.01 ± 0.18 Ma (No.2101).

At Cerro Sancarata in the north part of the district, faults, veins and fractures with the N-S trend are predominant, followed by those with the E-W trend. In the central part of the district, the NW-SE trend is conspicuous while the N-S and E-W trends are also observable. In the south, the

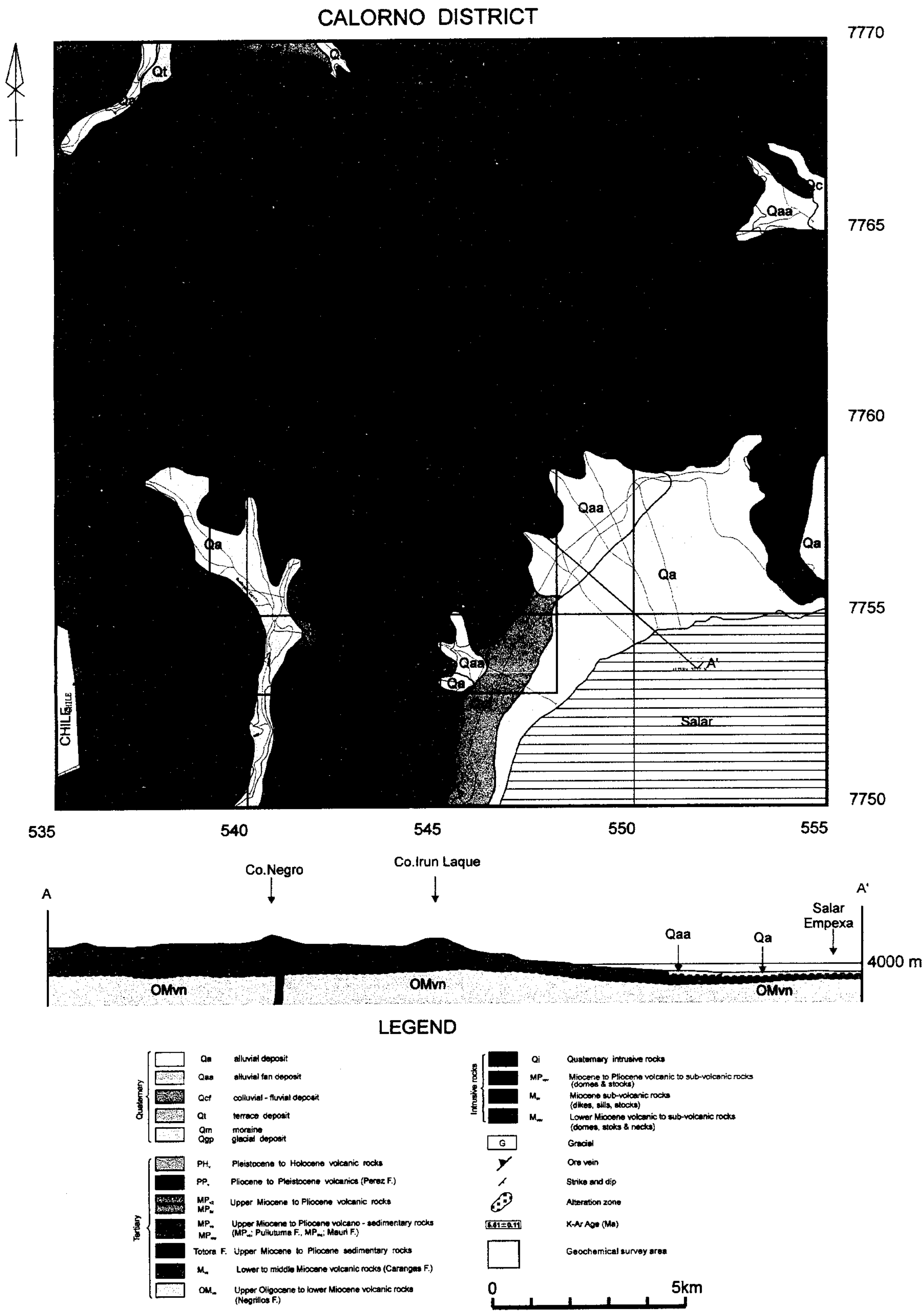


Fig. II -3-1 (5) Geological Map of the Calorno District

dominant trend is ENE-WSW or WNW-ESE.

3-6-2 Alteration

Hydrothermal alteration zones lie roughly in the four areas: Northeastern part (I), northwestern-central part (II), southern part (III) and southernmost part (IV) of the district and are of irregular shapes with their approximate sizes are 2.5 km x 2.5 km, 3 km x 11 km, 3 km x 4 km and 1 km x 3 km, respectively.

Silicification and argillization are observed; in the broad argillization zone, vein-like silicification portions are seen.

Fresh rocks are left on the mountaintops.

Vuggy silica is observed to the north of Cerro Irun Laque in the alteration zone (II).

Altered minerals such as quartz, alunite, kaolinite, halloysite, potassium feldspar and sericite are observed, in addition to chlorite, sericite-smectite mixed-layer minerals (No.1748) and propylite, which are partially present.

3-6-3 Mineralization

Silicified veins and quartz veins are existent but no indications of metallic ores are found.

In the alteration zone (II), pyrite is seen disseminating.

Gossans of goethite are exposed over about 800 m along the riverbed of the Rio Agua Milagro in the southeast of the alteration zone II. Its southern tip contacts lapilli tuff, and the contact plane striking N45°E and dipping 22°S. An old stope of 11 m in depth remains on the right bank, in which lapilli tuff is strongly limonitized. Assay of samples collected from the old stope and outcrops on the riverbank indicated maximum 245 ppm of lead (No.1903) and maximum 201 ppm of zinc (No.1913), but gold and silver were not detected. Arsenic was rather high, showing an anomalous value of 7,810 ppm at the uppermost part of the gossans (No.1777), where antimony was also as high as 357 ppm.

3-6-4 Assay of geochemical samples

Three hundred forty-three pieces of rock samples were collected in the district.

The minimum, maximum and average assay values by elements are (in the order of appearance) as follows:

Au: <2 ppb, 12 ppb and <2 ppb; Ag: <0.5 ppm, 2 ppm and <0.5 ppm;
Cu: <2 ppm, 190 ppm and 18 ppm; Pb: <3 ppm, 289 ppm and 10 ppm;
Zn: <2 ppm, 224 ppm and 10 ppm; As: <5 ppm, 11,388 ppm and 135 ppm;

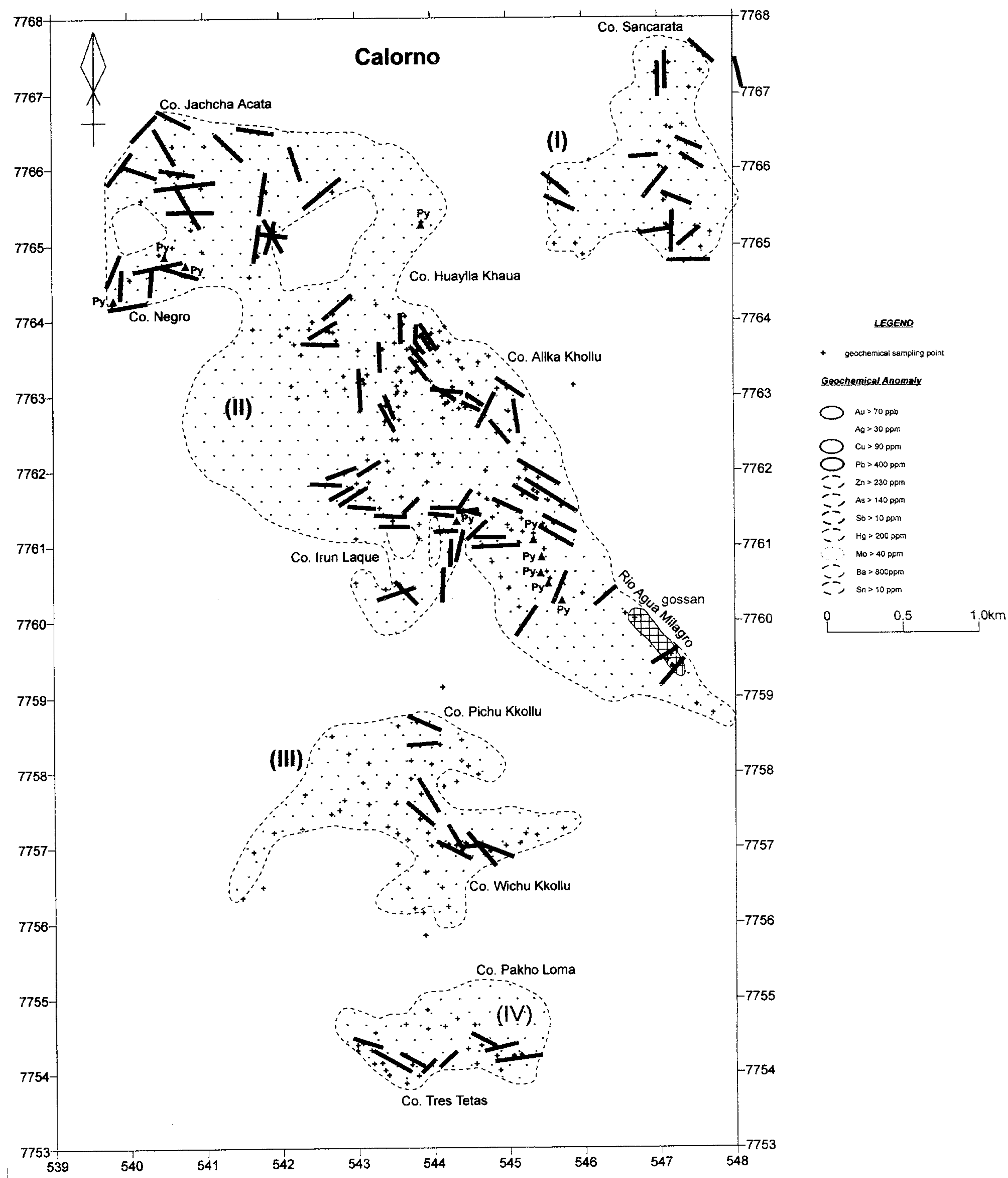


Fig. II -3-2 (5) Alteration Map of the Calorno District

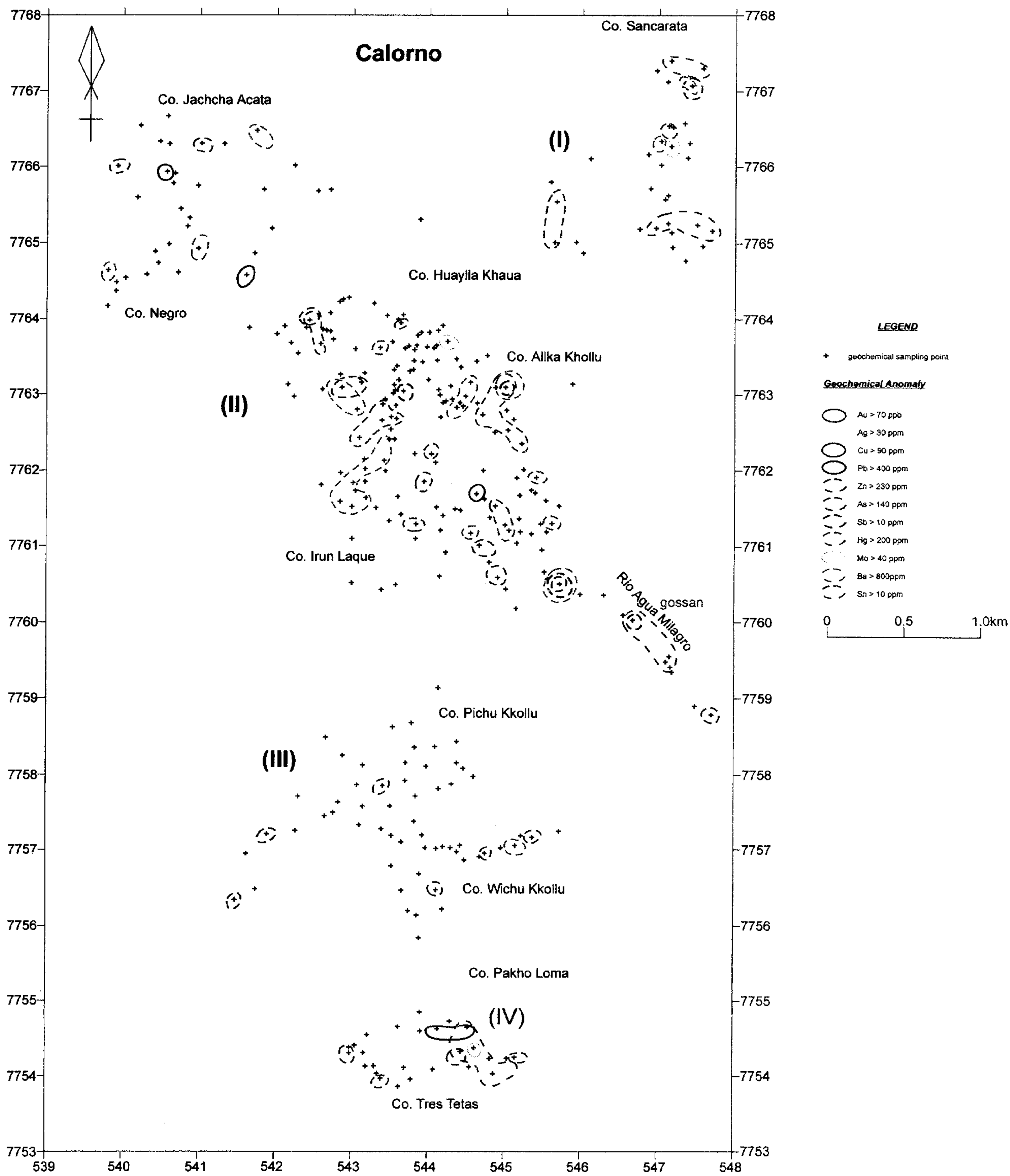


Fig. II -3-3 (5) Geochemical Anomaly Map of the Calorno District

Sb: <5 ppm, 357 ppm and <5 ppm; Hg: <10 ppm, 5,260 ppm and 154 ppm;
Mo: <1 ppm, 191 ppm and 5 ppm; Ba: 11 ppm, 1,678 ppm and 288 ppm; and, Sn: <5 ppm, 7 ppm, <5 ppm.

Geochemical anomalies of the respective elements are shown in Fig. II-3-3(5).

Au: No marked concentration or assay values of 300 ppb or more were obtained, but portions of 1 ppb to 12 ppb are locally spotted.

Ag: Except a spot indicating 2 ppm, all the samples were under the detection limit.

Cu: Anomalous portions indicating 90 ppm or higher were found at four scattered locations.

Pb: Four portions that indicate 100 ppm or more were found but there is no anomalous portion indicating 400 ppm or higher.

Zn: No marked concentration nor anomalous values of 230 ppm or higher were ascertained. Except two locations showing 201 ppm and 224 ppm, all the samples were 89 ppm or less.

As: Anomalous zones of 140 ppm or higher lie in the south of Co. Sancarata in the alteration zone (I), the Rio Agua Milagro in the alteration zone (II) and at Co. Tres Tetas. The anomalous zone at the Rio Agua Milagro corresponds to the zone of gossans mainly of goethite while, at Co. Tres Tetas, the assay reached 11,388 ppm. Anomalous portions are scattered at several other locations.

Sb: While most of the samples were under the detection limit, four localities indicated 10 ppm or more. The gossan showing the highest value of 357 ppm was also high in the As value, which was 7,810 ppm.

Hg: Small-scale anomaly zones of 200 ppm or higher are spotted, many of which were found at Co. Allka Khollu - Co. Irun Laque in the alteration zone (II).

Mo: Anomalous portions of 400 ppm or higher exist at three locations.

Ba: Small anomalous portions of 800 ppm or higher exist at Co. Allka Khollu - Co. Irun Laque in the alteration zone (II) and several other locations.

Sn: Except a locality showing 7 ppm, all the samples were under the detection limit.

3-7 Loma Llena district (Figs. II-3-1(6), II-3-2(6) and (7), and II-3-3(6) and (7))

3-7-1 Geology

The district is divided into the three areas, from north to south: Loma Llena (I), (II) and (III).

The district is underlain by pyroclastic rocks such as tuff, lapilli tuff and tuff breccia (volcanic breccia), as well as andesite, dacite and basalt.

Tuff is locally existent.

Lapilli tuff and tuff breccia include andesite fragments and are subjected to alteration.

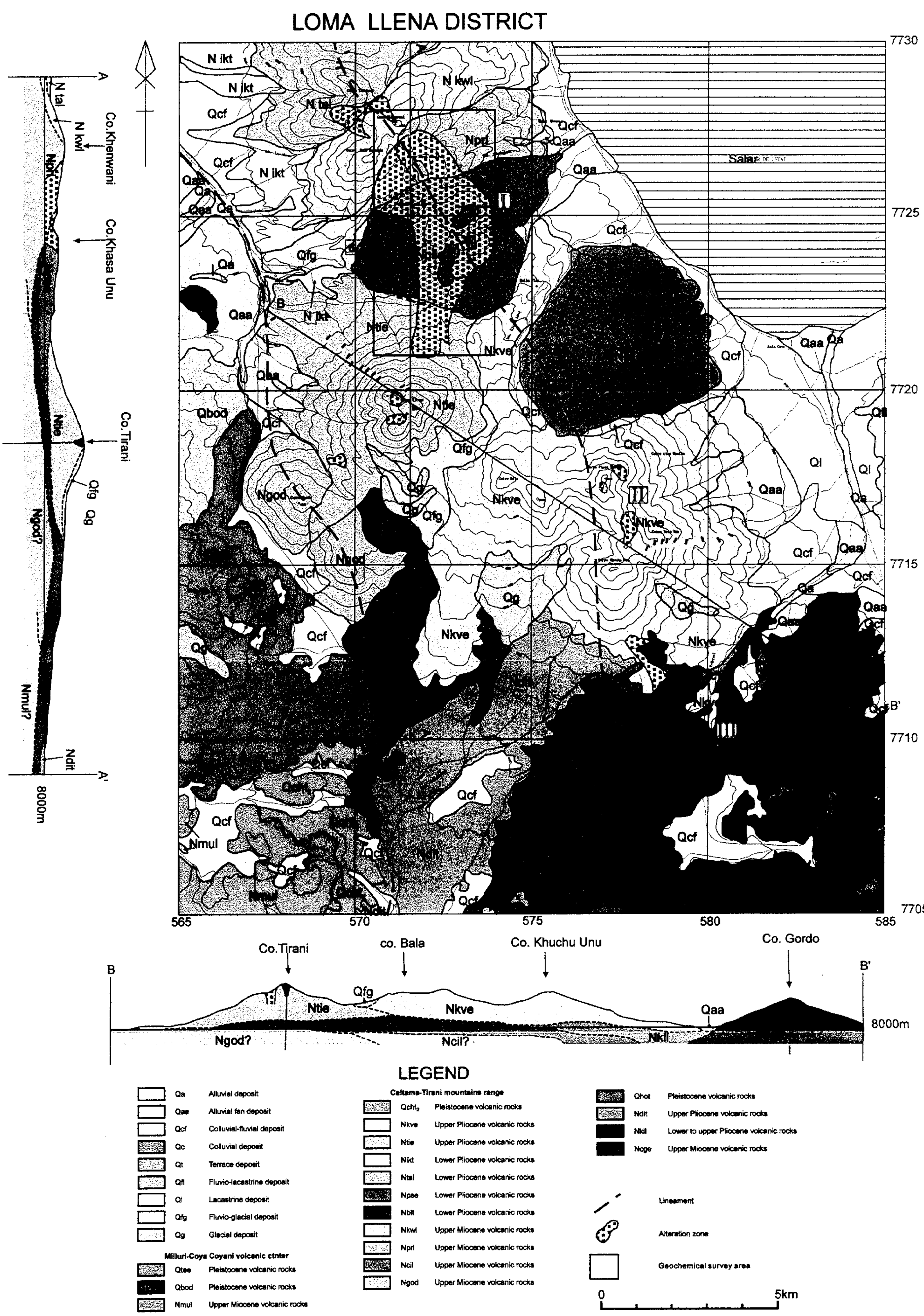


Fig. II-3-1 (6) Geological Map of the Loma Llena District

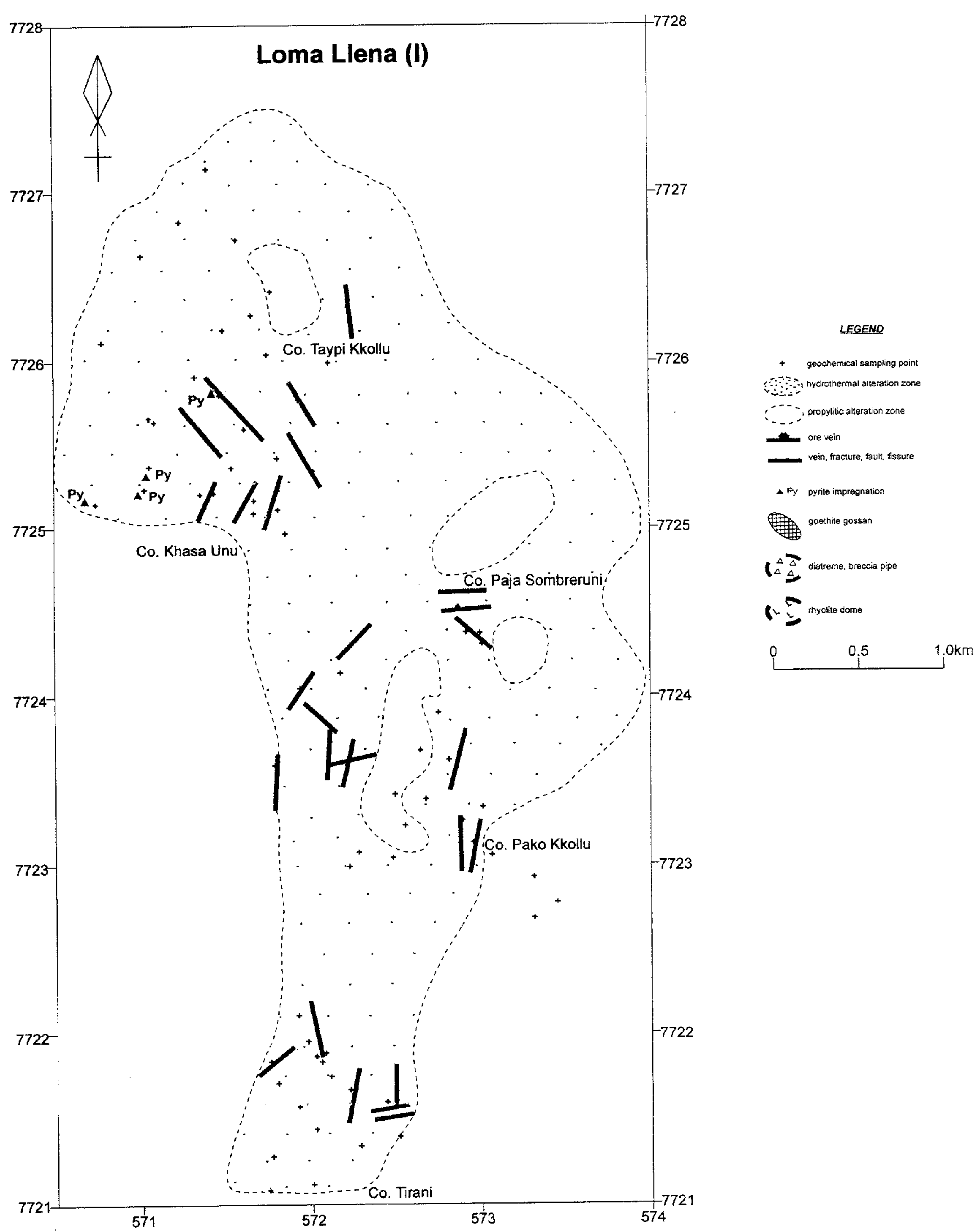


Fig. II -3-2 (6) Alteration Map of the Loma Llena District (I)

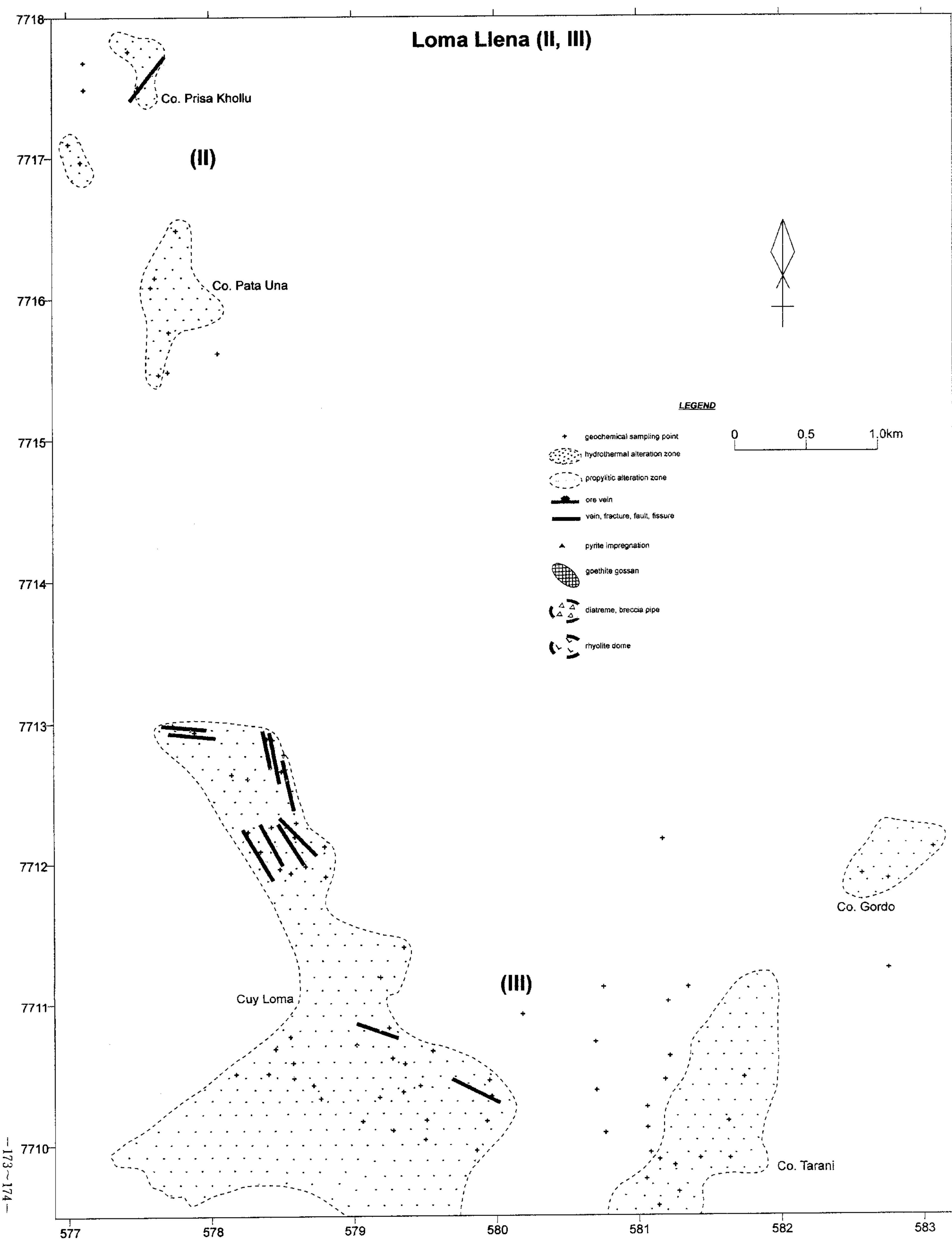


Fig. II -3-2 (7) Alteration Map of the Loma Llena District(II)(III)

Dacite is found in the area (I). Under the microscope, phenocrysts of quartz, hoenblendee and biotite -- in addition to plagioclase -- are observed, subjected to kaolinization (No.1719).

It was ascertained that andesite is composed of hypersthene andesite, two-pyroxene andesite, hoenblendee two-pyroxene andesite, biotite two-pyroxene andesite, hoenblendee-augite andesite and hornblende andesite. The K-Ar dating indicated 6.24 ± 0.12 Ma (No.1043), 4.07 ± 0.08 Ma (No.1042), and 3.75 ± 0.08 Ma (No.1142).

Basalt constitutes the bodies of Cerro Tirani, altitude 5,216 m, in the area (I) and Cerro Gordo, altitude 4,784 m, in the area (III). Under the microscope, olivine two-pyroxene basalt (No.1791) and augite olivine basalt (No.1802) are observed.

The faults, veins and fractures with NW-SE and N-S trends are dominant in the area (I) whereas, in the area (II), the NW-SE trend is predominant.

3-7-2 Alteration

A hydrothermal alteration zone of 1 km ~ 3 km x 6.5 km is situated in the area (I), while three zones smaller than 0.5 km x 1 km are found in the area (II). In the area (III), there are three zones, 0.5 km ~ 3 km x 4 km, 0.5 km x 1.5 km and 0.5 km x 0.8 km.

Silicification and argillization are observed. Vein-like silicification portions are included in a broad argillization zone.

Altered minerals such as quartz, alunite, kaolinite, potassium feldspar and sericite are observed.

3-7-3 Mineralization

No marked indications of metallic minerals are found, except pyrite dissemination and veinlets observed on the northwest slope of Cerro Khasa Unu in the north of the area (I).

3-7-4 Assay of Geochemical samples

One hundred sixty-five pieces of rock samples were collected in the district.

The minimum, maximum and average assay values by elements (in the order of appearance) are as follows:

Au: <2 ppb, 11 ppb and <2 ppb; Ag: <05 ppm, 1 ppm and <0.5 ppm;
Cu: <2 ppm, 96 ppm and 18 ppm; Pb: <3 ppm, 98 ppm and 6 ppm;
Zn: <2 ppm, 164 ppm and 18 ppm; As: <5 ppm, 152 ppm and 12 ppm;
Sb: <5 ppm, <5 ppm and <5 ppm; Hg: <10 ppm, 5,750 ppm and 139 ppm;
Mo: <1 ppm, 86 ppm and 4 ppm; Ba: 12 ppm, 1,494 ppm and 296 ppm; and,

Sn: <5 ppm, 16 ppm and <5 ppm.

Geochemical anomalies of the respective elements are indicated in Figs II-3-3 (6) and (7).

Au: No marked concentration nor anomalous values of 30 ppb or higher were found. Portions that indicate 1 ppb to 11 ppb are spotted at nine locations.

Ag: Except a locality that showed 1 ppm, all the samples were under the detection limit.

Cu: Anomalous portions showing 90 ppm or higher were found at two separate locations at the Taypi Kkollu in the area (I). In the southwest of Co. Gordo, portions showing 17 ppm to 50 ppm are widespread, which correspond to the distribution of fresh lavas of basalt and andesite. In the district, the area (I) in the north has a higher concentration of anomalies than the area (III) in the south.

Pb: While the maximum assay value was 98 ppm, no marked concentration or anomalous portions of 400 ppm or higher were found. At Co. Taypi Kkollu in the north part of the area (I), there are small portions showing 30 ppm or higher.

Zn: Assay values of 100 ppm or more were obtained at four locations only. No marked concentration or anomalous values of 230 ppm or higher were obtained. In the southwest of Co. Gordo in the area (III), portions showing 37 ppm to 109 ppm are broadly distributed, which correspond to the distribution of fresh lavas of basalt and andesite.

As: Except an anomalous value of 152 ppm detected at Co. Taypi Kkollu in the area (I), all the samples showed 91 ppm or lower. No marked concentration was seen. The north part of the district shows a higher concentration than the south.

Sb: All the samples were under the detection limit.

Hg: Small anomalous zones showing 200 ppm or higher are spotted at Cuy Loma in the area (III). Besides, anomalous portions were found at 10 locations.

Mo: Anomalous portions showing 40 ppm or higher locally exist at three locations.

Ba: Small anomalous zones showing 800 ppm or higher are distributed at Co. Taypi Kkollu and Co. Khasa Unu. Besides, anomalous portions are locally spotted at four locations.

Sn: Two locations at Cuy Loma in the area (III) showed 5 ppm and 16 ppm; all the others were under the detection limit.

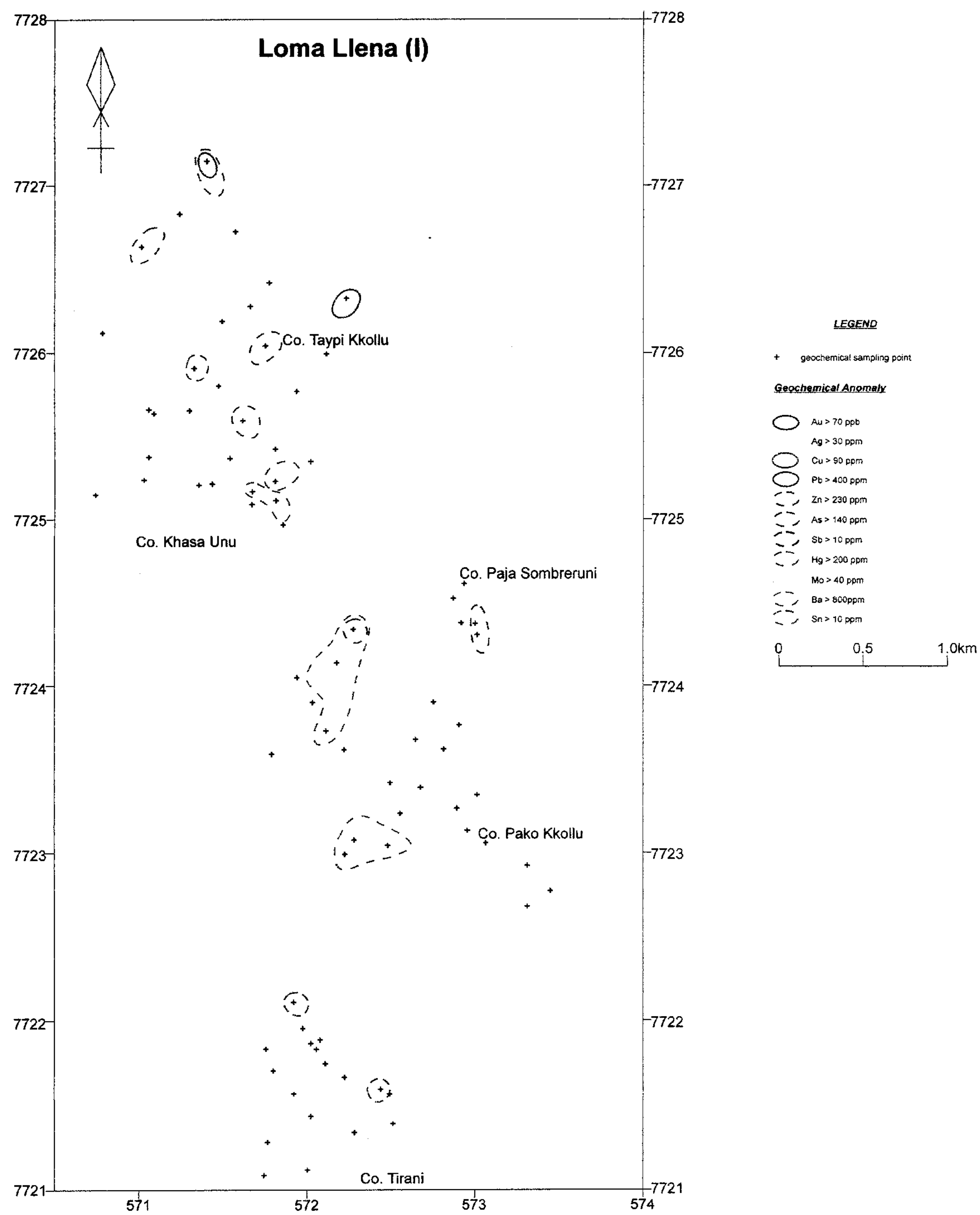


Fig. II-3-3 (6) Geochemical Anomaly Map of the Loma Llena District (I)

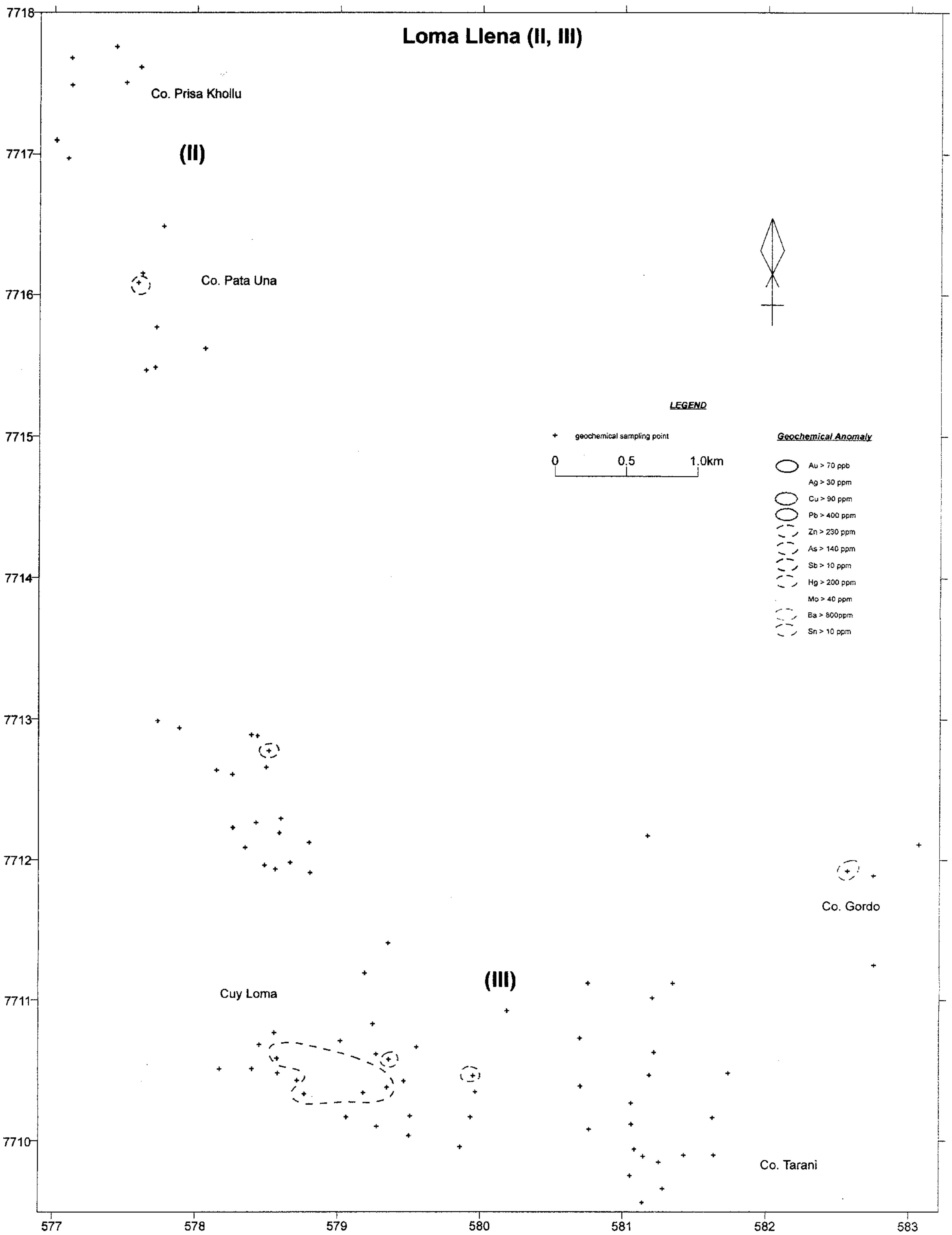


Fig. Ⅱ-3-3 (7) Geochemical Anomaly Map of the Loma Llena District (II)(III)

3-8 Summary

The survey findings of the districts as selected in Phase I are summarized as follows:

Turaquiri District

The area is underlain by pyroclastic rocks and dacite lava.

The K-Ar dating of non-altered dacitic tuff indicated 5.51 ± 0.11 Ma, which corresponds to the late Miocene time.

The predominant trend of faults, veins and fractures is E-W in the area.

Silicification and argillization zones develop closely along the veins, though small in size; chloritization (propylitization) portions are partially present.

The Turaquiri ore deposit is composed of dacitic lapilli tuff and galena-barite-quartz veins in dacite.

The ore deposit strikes nearly E-W, and the northern vein dips 75°S while the southern vein dips 75°N. The Turaquiri vein is 2 m wide and extends over 2 km in the strike direction and continues over 100 m in the vertical direction. The largest mining site is 20 m wide and 140 m long. The microscopic observation indicated that ore minerals are mainly galena accompanied by chalcocite, pyrite, goethite and marcasite. Gangue minerals are mostly barite and quartz, partly accompanied by siderite, chlorite, alunite and garnet.

The homogenization temperature of fluid inclusions of seven vein quartz samples is 200° C on the average, while the salinity is 10.8 wt%.

Pyrite and galena dissemination is partly observed.

At the known vein portions, geochemical anomalies of silver, copper, lead and zinc are present; copper, lead, silver and zinc anomalies are seen at the ore showings in the south.

Asu Asuni District

The area is underlain by pyroclastic rocks, andesite and dacite lava.

Veins and fractures with the E-W trend are dominant.

Medium-scale silicification and argillization zones spread, and propylitization portions are observable.

Pyrite dissemination is partly observed.

No marked geochemical anomalies were detected.

Chulcani District

The area is underlain by pyroclastic rocks and andesite lava.

The K-Ar dating of fresh andesite indicated 6.13 ± 0.12 Ma, which corresponds to the late Miocene time.

A diatreme presumably of about 1 km in diameter exists.

Veins and fractures with NE-SW to ENE-WSW trends are dominant, while those with the N-S trend are also seen.

Medium-scale silicification and argillization zones lie with some propylitization.

Pyrite dissemination is spotted and barite is generated in parts.

The geochemical survey ascertained anomalous portions accompanied by gold at the two localities, which showed maximum 4,008 ppb, partially overlapping lead, mercury and arsenic anomalies, and also an anomalous portion unaccompanied by gold but accompanied by copper, arsenic and mercury.

Sonia - Susana District

The district is underlain by pyroclastic rocks, andesite, dacite, rhyolite, basalt lavas and intrusive dolerite.

The K-Ar dating indicated that rhyolitic tuff lying in a circle is 17.70 ± 0.35 Ma, biotite rhyolite is 1.73 ± 0.03 Ma and dacite close to the Chilean border is 1.52 ± 0.03 Ma.

As for the trends of fractures and veins, the E-W trend is dominant in the east, the NW-SW is somewhat dominant in the Santa Catalina Loma to the west, the NE-SW is dominant in the central part while, in the west, the E-W is the main trend but the N-S and NW-SE are also observable.

Silicification, argillization and propylitization zones are widespread, and rhyolite subjected to alteration forms a dome of about 1 km in diameter.

Pyrite dissemination is observed at many locations while quartz and barite veins accompanied by base metals such as copper, lead, zinc and precious metals were ascertained. A quartz vein at Cerro Llica Khaua, which is 30 cm wide, striking N45°W and dipping 70°SW, contains 2.97 g/t Au and 24 g/t Ag. In the argillization portion adjoining the vein, dissemination with green copper oxide and azurite is seen, which grades 1.38% Cu, 0.12% Pb and 0.55% Zn. A base metal-bearing barite vein showed 4.24% Pb and 0.97% Zn, whilst a quartz vein showed 1.21% Zn.

The average homogenization temperature of fluid inclusions of vein quartz samples taken at three spots is 195°C, and salinity is 4.7 wt%.

Geochemical anomalies of gold, copper, lead, zinc and tin are seen overlapping at Santa Catalina Loma and Cerro Entre Campanini.

Calorno District

The district is underlain by pyroclastic rocks, andesite and dacite lava.

The K-Ar dating indicated 11.69 ± 0.23 Ma and 9.01 ± 0.18 Ma, which correspond to the middle and late Miocene time, respectively.

Silicification and argillization zones are widespread, while fresh rocks are left on the mountaintops.

Vuggy silica is seen in the north of Cerro Irun Laque.

The X-ray diffractive analysis confirmed the presence of pyrophyllite at Cerro Kachacha Acata.

The dominant trends of fracture and veins in the area are N-S at Cerro Sancarata in the north, NW-SE at Cerro Irun Laque in the central part and E-W in the south.

A geothite zone extends over 800 m along the Rio Agua Milagro, which includes an old stope. Pyrite dissemination is seen in a silicification zone along the river and several locations at Cerro Jachacha Acata in the north.

The geochemical survey indicated that although there is no concentration of anomalies of gold, silver, copper, lead and zinc, anomalous portions of mercury, barium, arsenic and antimony are spotted from Cerro Irun Laque to Cerro Huaylla Khaua.

Loma Llena District

The district is underlain by pyroclastic rocks, andesite, dacite and basalt lava.

The K-Ar dating of andesite indicated 6.24 ± 0.12 Ma, 4.07 ± 0.08 Ma and 3.75 ± 0.08 Ma, which correspond to the late Miocene to the early Pliocene time.

Silicification and argillization zones are widespread, whilst fresh rocks are left on the mountaintops.

The dominant trends of fractures and veins in the district are the NW-SE and N-E at Cerro Taypi Kkollu - Cerro Tirani in the area (I), while the NW-SE at Cuy Loma - Cerro Tarani in the area (III).

Pyrite dissemination and veinlets are observable at Cerro Taypi Kkollu in the north of the area (I).

Geochemical anomalies are generally scarce. An anomalous zone of barium lies at Cerro Paja Sombreruni in the area (I), while that of mercury lies at Cuy Loma in the area (III).