Chapter 4 Geochemical Survey of Sstream Sediments

4-1 Analysis Method

The assay values of 48 elements of the stream sediment samples were analyzed by means of the descriptive statistics, correlation matrix calculation and factor analysis using the SPSS statistical analysis package application. 2,003 data were used for the statistical analysis. In case an assay value of an element was less than detection limit, it was replaced by a value equivalent to 1/2 of the detection limit of the element concerned. Se and W were excluded from the statistical analysis because these elements in all the samples are lower than the detection limits and, therefore, the variance comes to zero.

4-2 Results of Analysis and Considerations

Elements whose loadings for each factor are 0.4 or higher are as follows:

First Factor: Ca, Co, Cr, Fe, Ga. Mg, Ni, P, Sc, Ti, V and Zn
Second factor: Al, Ba, Be, Ca, Ga, K, Mg, Na, Rb, Sc, Sr, Y and Zr
Third factor: Ag, Cd, Mn, Pb, Sb and Zn
Fourth factor: Ge, Nb, Sn and Y
Fifth factor: Ce, La, Th, Ti and Y
Sixth factor: As, B and S
Seventh factor: In, Mn and Mo
Eighth factor: Li and U
Ninth factor: P and Te
Tenth factor: Cu
Eleventh factor: Au and Te
Twelfth factor: Bi

In the light of the above combinations of factors, the third factor is considered to be the one related to the mineralization in the area.

The third factor's score distribution is demonstrated in Figs. II-4-1 (1) and (2). The high score zones of the third factor are found in the Sonia Susana District and in the Chinchilhuma prospect of the Panizo District.

Northern Part

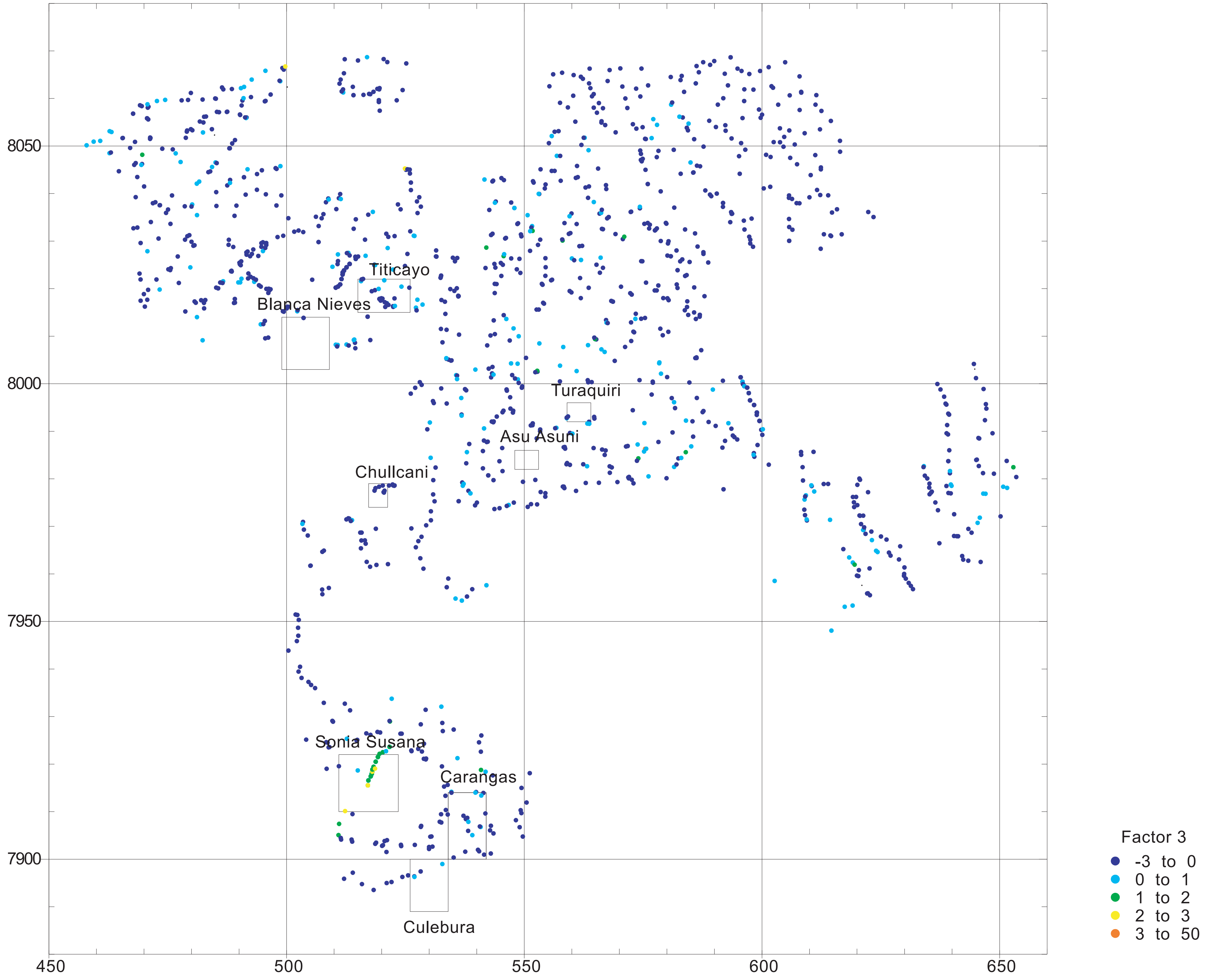

Fig.II-4-1(1) Geochemical Anomaly Map of the Stream Sediments (Northern Part)

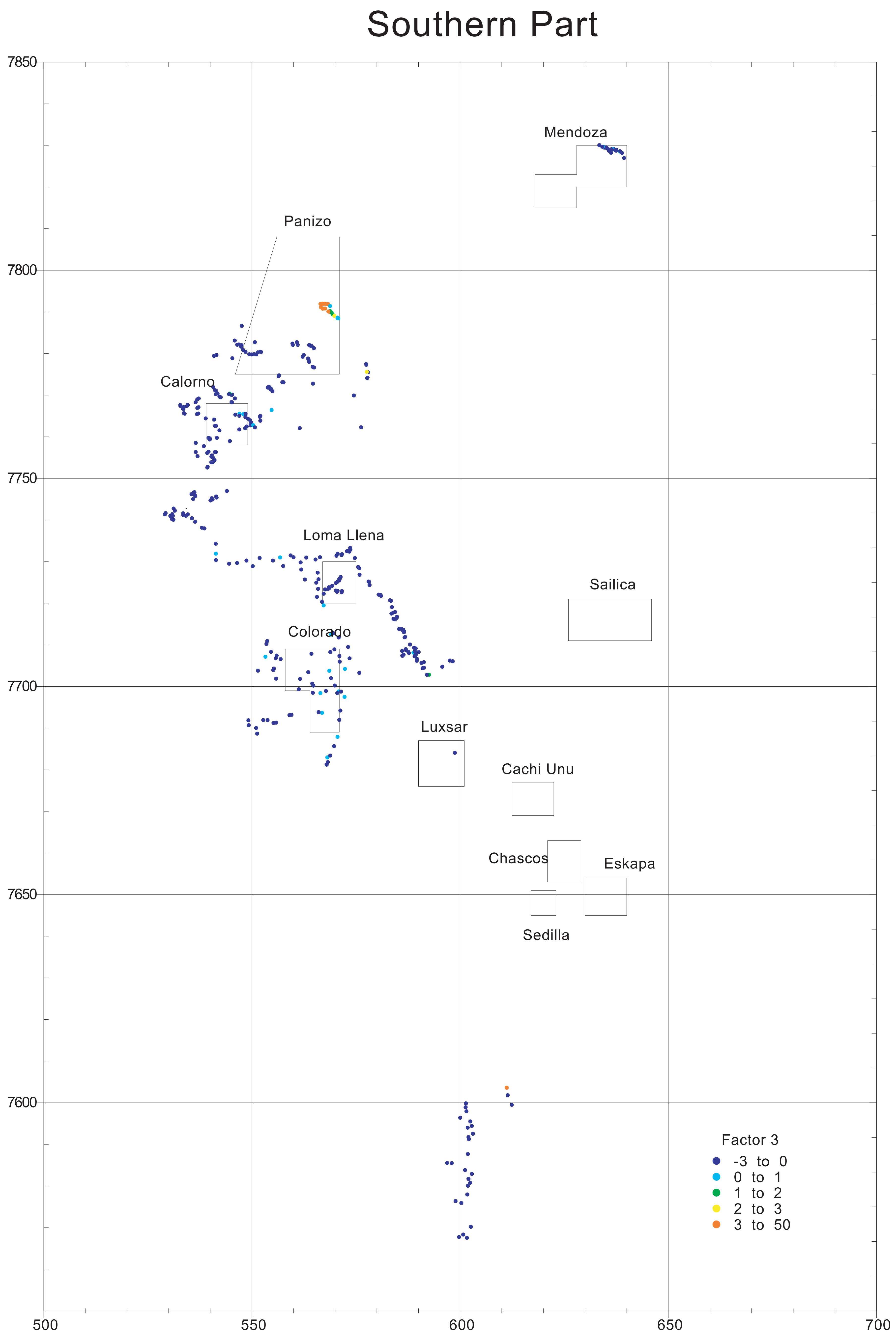

Fig.II-4-1(2) Geochemical Anomaly Map of the Stream Sediments (Southern Part)

Chapter 5 Comprehensive Analysis

5-1 Result of Satellite Image Analysis and Ground Truth

Except Chascos prospect in the Sedilla district, alteration zones selected by satellite image analysis well coincide with the results of the ground truth. However the difference between argillic-carbonate alteration zone and iron oxide alteration zone by spectral anomalies is not clearly observed in the survey.

Hydrothermal anomalies by satellite image in the Chascos are interpreted as shadows of spectral anomalies.

Satellite image analysis is useful for selection of alteration zones, although no coincides perfectly.

5-2 Characteristics of Volcanic Age

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

Based on the dating of the volcanic rocks in the survey area, early Miocene and Pleistcene rocks are distributed (Table II-3-1).

Along the national border volcanic rocks of Late Pliocene to Pleistocene are observed, nevertheless, there are no regular tendency of age distributions that volcanic rocks become younger toward west (Fig. II- 5- 1). Somewhere in the western area the older volcanic rocks may exist like as Sonia-Susana district.

5-3 Relationship between Structure and Mineralization

The lineament is not well developed in volcanic rocks and indicates no tendency of its direction and intensity by the result of satellite image analysis.

The lineament is scarce and cort. It is not sure that the lineament in volcanic rocks is dificult to be analized or developed.

The relation between alterations and lineaments is not clear.

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

The fractures with the E-W trend might have fulfilled an essential function for mineralization.

5-4 Characteristics of Alteration Zone

The hydrothermal alterations in the Western Andes are wide showing maximun area of 30

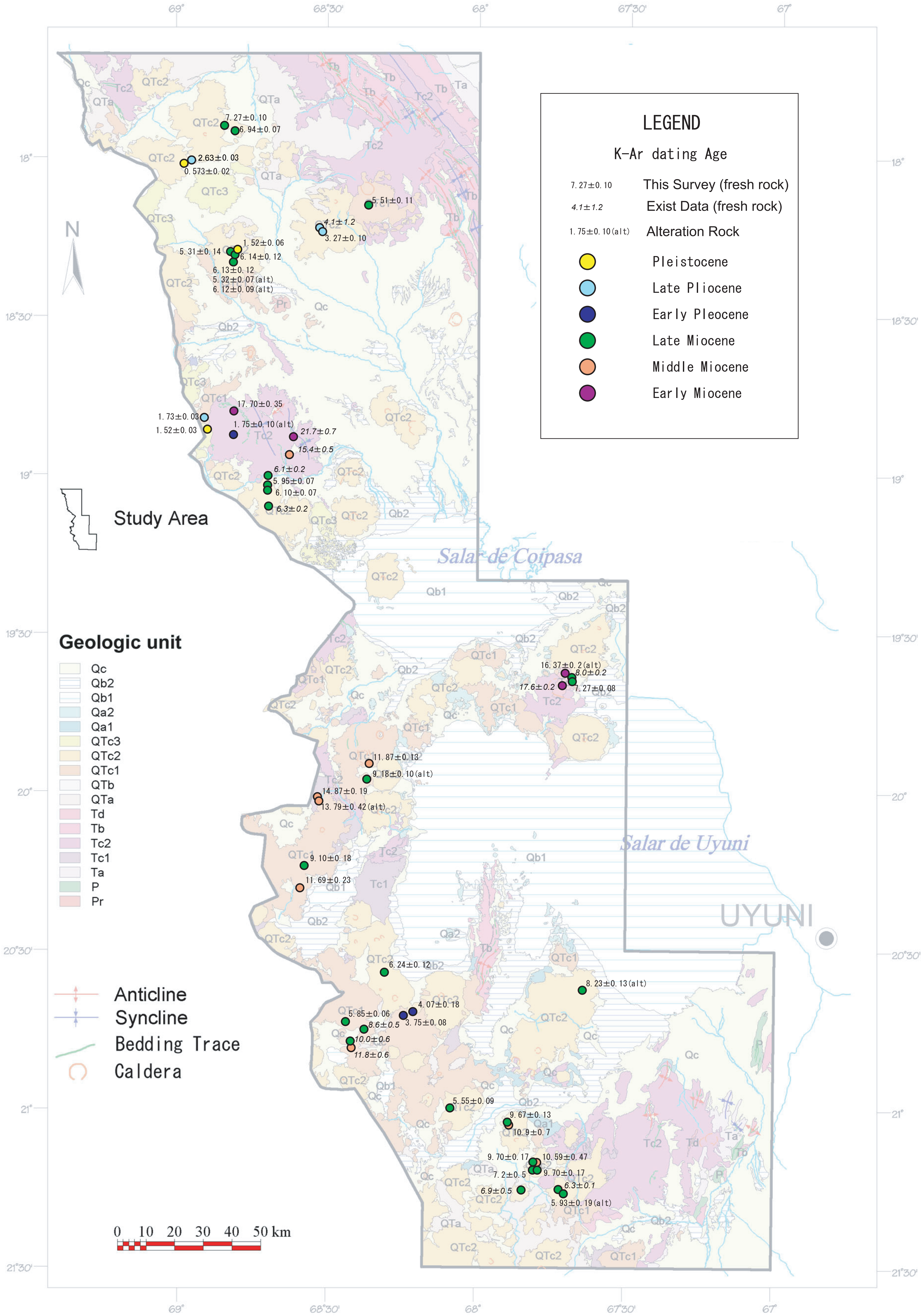

Fig. II-5-1 K-Ar Age in the Survey Area

km^2 in Calorno district and silicification zones distribute in a shape of vein and island in vast argillized zones,

Based on the analysis of alteration minerals in Chullcani District (Fig. II-5-2), it is surmised that the quartz-sericite, quartz and cristobalite zones distribute in order from the centre of the alteration zone to the outer. There is a possibility of lack of them by degrees of erosion.

A sericite zone appears in a place where intrusive rock exposes by erosion

An alunite zone has tendency to distribute mainly near the border between the quartz and cristobalite zones, overlapping on them.

The age of alterations is in harmony with that of volcanic rock surround.

In general, the distribution of quartz-sericite zones is small or nothing in younger volcanic rocks (Late Miocene to Pleistocene), while large in older volcanic rocks (older than Middle Miocene).

5-5 Characteristics of Vein Qualyty

The La Deseada vein exposes from the centre to the outermost portions by erosion. The result of geochemical analysis and variety of veins are applicable to another prospects and can consider position of mineralized zone.

Materials in the vein of the uppermost part of the mineralization are shown as lenticular silicification in the argillized zone or argillized-silicified vein form remaining a texture of volcanic rocks. Toward the centre the vein shape becomes clearer and increase silica acompanied by pyrite dissemination and the texture of original rocks are obscure or no. At farther centre part quarts appear in veins increasing its contents with sulfides of lead and zinc (Fig. II-5- 3).

5-6 Characteristics between Geochemical Aanomalies and Mineralization

Chemical analysis values of (gold), (copper), lead, arsenic and antimony are higher in the upper part of the mineralization, and those of gold, silver, copper, lead, zinc and antimony increase in the lower part of mineralization. Taking the above factors and vein character into consideration, the location of a mineralized zone can be presumed.

A place where chemical anomalies of Au, Cu, Pb, As and Sb exist an ore deposit like La Deseada vein is expected underneath (Fig.II- 3- 7 (2) .

5-7 Characteristics between Homogenization Temperature and Salinity (Fig. II-5- 4)

The average homogenization temperatures in this survey area are 168 °C to 297°C and average salinities are 0.2 % to 17.9 % equivalent to NaCl (Table II-5-1).

The salinities of the Turaquiri vein are rather high and those of the Iranuta veins and Maria Luisa veins in the Mendoza District are low. This fact suggests that the ore solutions are different

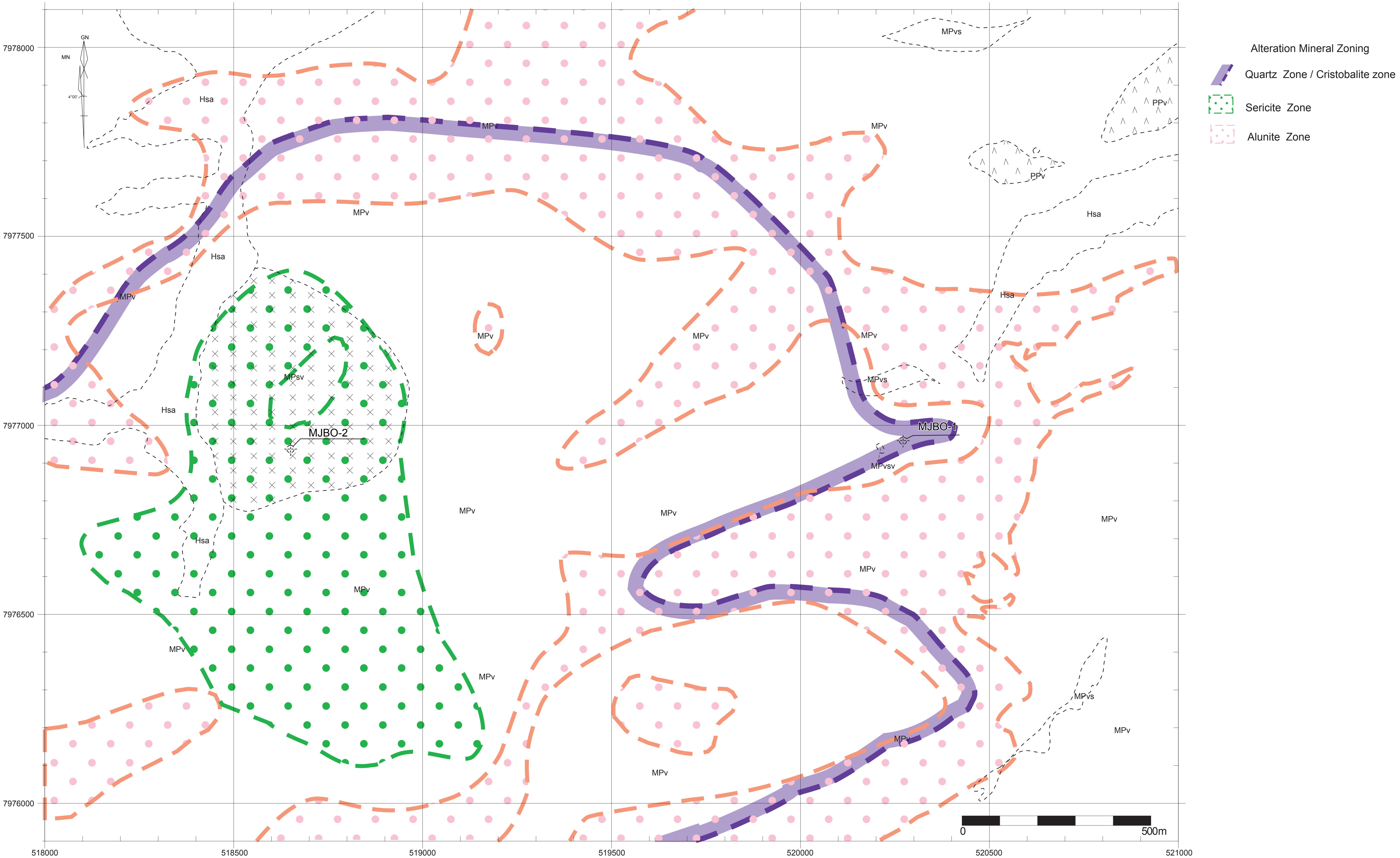

Fig.II-5-2 Distribution Map of the Alteration Minerals in the Chullcani District

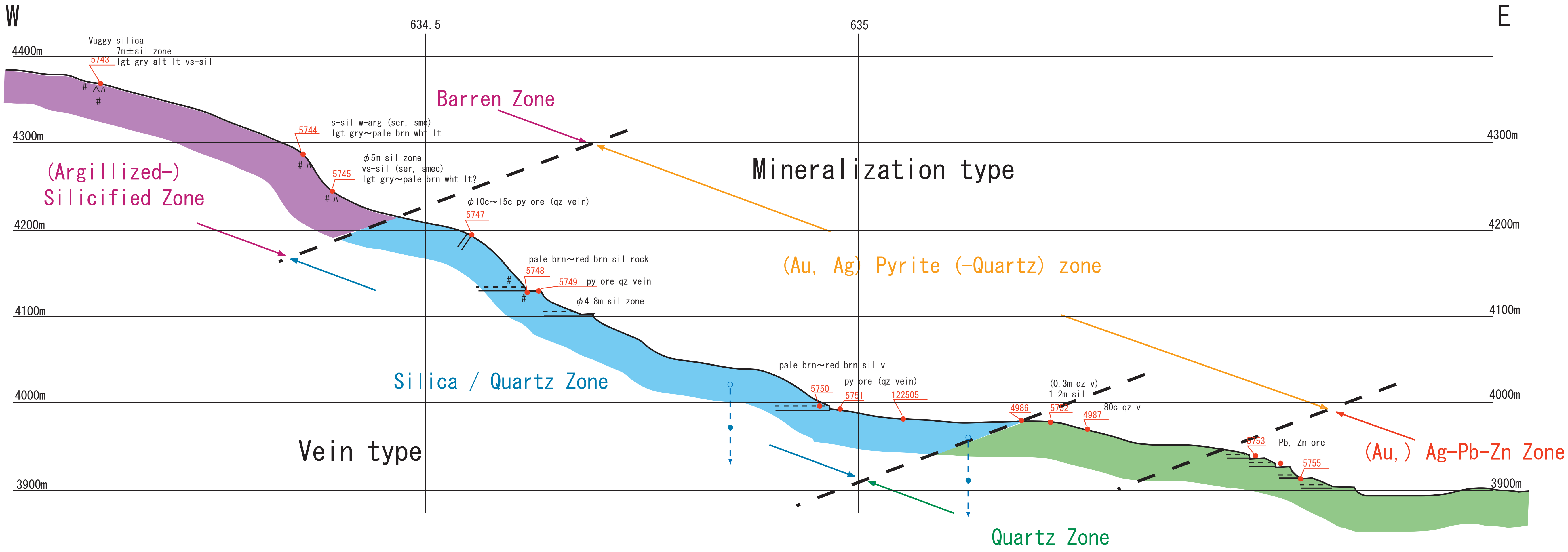

Fig. II-5-3 Schematic section of mineralization at the La Deseada Mine

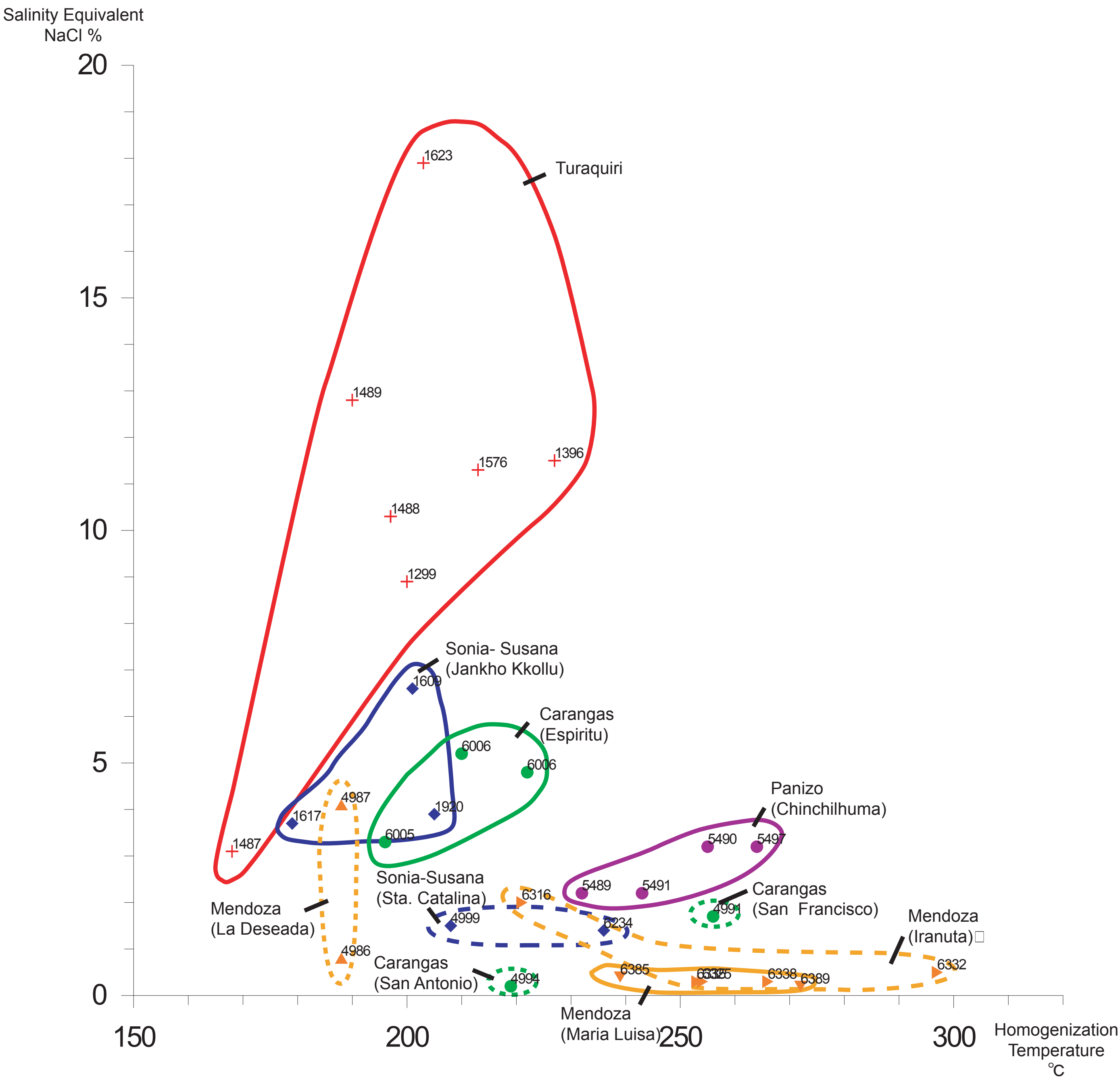

Fig.II-5-4 Temperature and Salinity of F.I. in the Area and in the Turaquiri the magma solution concerned and in the Mendoza district meteoric water concerned.　If so, a porphyry stock may be exist just underneath of the Turaquiri vein.

More data are necessary, but based on the data from this survey La Deseada veins (Mendoza District), Jankho Kkollu veins (Sonia-Susana District), Espiritu veins (Carangas District), and San Antonio veins (Carangas District) are expected the possibility of existence of ore deposit.

Table II-5-1 Homogenization Temperature and Salinity of the Fluid Inclusions

District		Sample No	Host Min.	Ave.Temp.℃	Nacl (wt%)
Turaquiri		1299	quartz	200	8.9
		1396	quartz	227	11.5
		1487	quartz	168	3.1
		1488	quartz	197	10.3
		1489	quartz	190	12.8
		1576	quartz	213	11.3
		1623	quartz	203	17.9
Sonia-Susana	Jankho Kkollu	1609	quartz	201	6.6
		1617	quartz	179	3.7
		1920	quartz	205	3.9
	Sta.Catalina	4999	quartz	208	1.5
		6234	quartz	236	1.4
Carangas	San Antonio	4994	quartz	219	0.2
	Espiritu	6005	quartz	196	3.3
		6006	sphalerite	210	5.2
		6006	quartz	222	4.8
	San Francisco	4991	quartz	256	1.7
Mendoza	La Deseada	4986	quartz	188	0.8
		4987	quartz	188	4.1
	Maria Luisa	6385	quartz	239	0.4
		6389	quartz	272	0.2
	Iranuta	6316	quartz	221	2.0
		6325	quartz	254	0.3
		6332	calcite	297	0.5
		6335	quartz	253	0.3
		6338	quartz	266	0.3
Panizo	Chinchilhuma San Salvador	5489	sphalerite	232	2.2
		5490	sphalerite	255	3.2
		5491	sphalerite	243	2.2
	Aguilani	5497	sphalerite	264	3.2

5-8　Characteristics of Mineralization

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

[1] Copper deposits accompanying alkali basalt

[2] Bedded copper deposits embedded in Paleogene red sedimentary rocks (The Corocoro-type)

[3] Epithermal deposits

[4] Bolivian-type polymetallic vein deposits

[5] Porphyry-type copper-gold deposits

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

The porphyry type deposit is now in progress under Holocene volcanic rocks. And also it is considered to be situated deeper part under the younger volcanic rocks, the exploration is difficult.

Rather old volcanic rocks are needed to expose at surface for the exploration.

The main turget in the area are epithermal deposits and Bolivian-type polymetallic vein deposits.

Bolivian-type polymetallic vein deposits have a general tendency that sulfide mineral veins in the lower part change into barite-quartz or barite-chalcedony veins in the upper part (Fig.II- 5- 5).

Therefore, the forrowing classification of II and III epithermal deposits is possible to correspond to upper parts of Bolivian-type deposits.

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

I Bolivian-type polymetallic deposits

(A) Ore deposits rich in silver-tin (mainly at Cordillera Oriental)

Mineral assemblage: silver-tin-lead-zinc-tungsten-bismuth-gold

Vein : sulfide vein

Example: Potosí deposit, Pulacayo deposit, Huanuni deposit

(B) Ore deposits rich in silver-gold-copper (mainly at Cordillera Oriental)

Mineral assemblage: silver-gold –small amount of copper (lead-zinc-antimony-tin)

Vein: sulfide vein

Example: Kori Kollo deposit

II Epithermal gold-silver-lead-zinc deposits related to shallow volcanic activity

Mineral assemblage: (gold)-silver- small amount of lead-zinc-tin

Vein: barite-quartz vein

Example: San Cristóbal deposit

III Epithermal precious metal deposits related to shallow hypabyssal intrusive activity

Mineral assemblage: gold-silver- lead- zinc- (copper)

Vein: alunite-kaolin-quartz vein, barite-quartz vein with neutral alteration zone

Example: Choquelimpie deposit, La Española deposit

IV High sulfidation type deposits (quartz-alunite vein type deposit)

Epithermal gold-silver-copper deposit

Mineral assemblage: (gold)-silver- copper (enargite)

Vein: alunite- barite- quartz vein

Example: Laurani deposit, Choquelimpie deposit, La Española deposit

V Low sulfidation type deposits (quartz-adularia vein type deposit)

Sericitized zone with adularia, carbonate minerals

Neutral argillic alteration zone (lack of alunite)

Vein: quartz-adularia vein

Example: peripheral part in the La Española mine

Figs. II-5-5 and II-5-6 indicate schematic models of hydrothermal ore deposits including the Bolivian-type polymetallic vein deposits and porphyry copper-gold deposits accompanied by epithermal alteration, respectively.

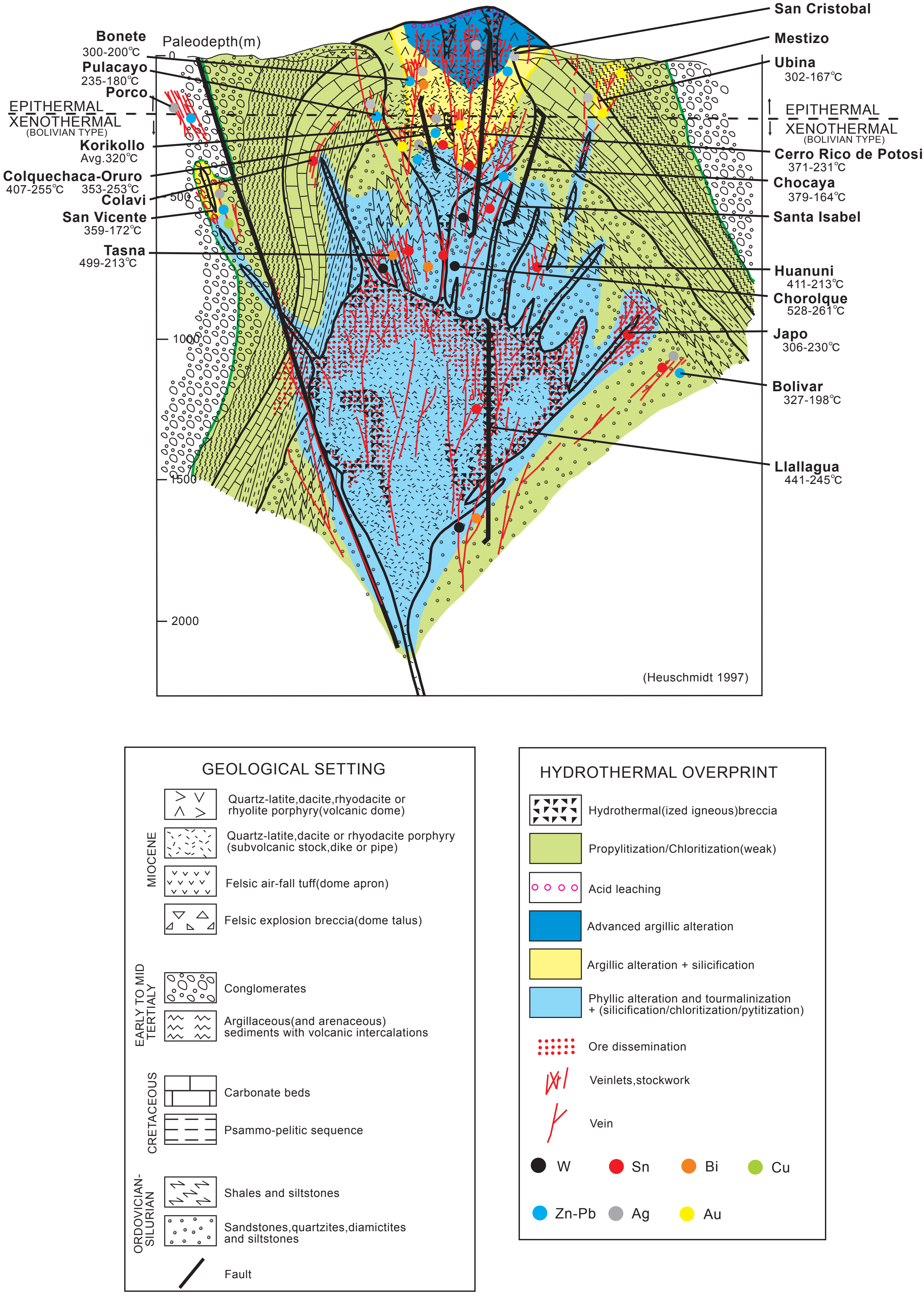

Fig. II-5-5 Idealized Bolivia Type deposit

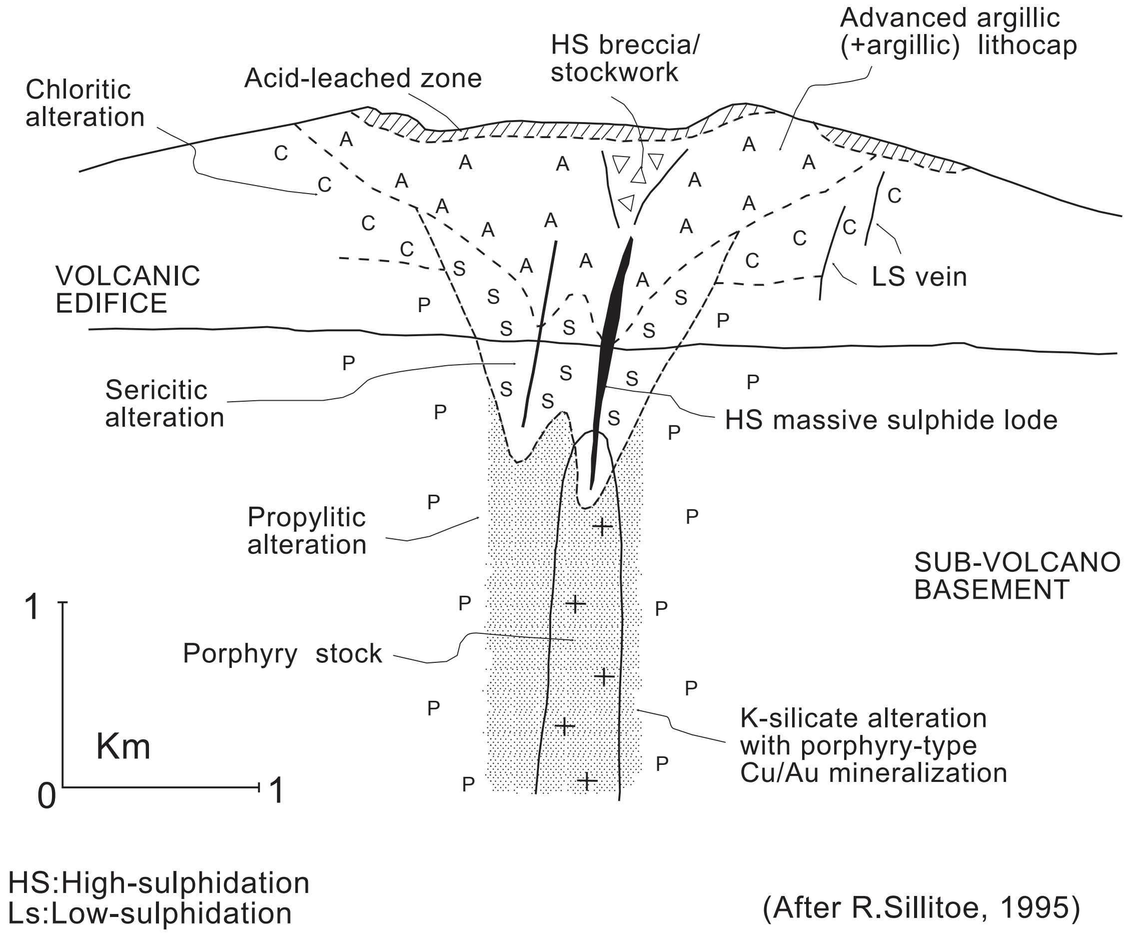

Fig. II-5-6 Idealized Lithocap and Underlying Porphyry Cu/Au deposit