PART Ⅰ GENERALITIES

CHAPTER 1 INTRODUCTION

1-1 Purpose and Prehistory of the survey

The industry of the Oriental Republic of Uruguay (hereafter "Uruguay") had centered around agriculture and cattle breeding. However, it can be seen that the country made positive efforts to collaborate and participate in the inauguration Mercosur in 1995, at that time, Uruguay set out to outgrow the industrial structure dependent on agriculture and diversify industry oriented toward developing mining and manufacturing. In the 1980s, some prospecting companies from Canada and the U.S.A. turned their attention to the greenstone belt with it's potential to yield the last remaining promising gold ore field in the world. In the aftermath of their prospecting in this country, such gold mines as Mahoma and San Carlos in the south, and San Gregorio in the north had consecutively been discovered and exploited. Taking advantage of the exploitation of these mines, the country set out to evolve and modernize the backward mining industry. Consequently the request for an exploitation survey for mineral resources was made to the Japanese government on 10 February, 2000.

The Metal Mining Agency of Japan had already recognized the potentiality of the mineral deposits in Uruguay, and concluded the scope of the work with Dirección Nacional de Minería Geología (DINAMIGE) of Uruguay on 24 November, 2000 by request.

The purpose of this survey is to clarify the picture of the ore fields of mineral deposits in the San Jose and the Arroyo Grande Areas (Fig.1) through various geological surveys, with the aim of discovering new ore deposits. Another purpose is to transfer our advanced technology to the involved organizations of the object country throughout this survey.

1-2 Survey area, contents and coverage of the first phase survey

The project area is the San Jose and the Arroyo Grande Areas, located in the southern part of Uruguay. The project area covers about 12,000km^2. The project area is indicated in Figure 1. The main contents of the survey of the first phase include the existing data analysis, the geologic interpretation of satellite image data, the geological survey, and soil and rock geochemical prospecting (Tab. I-1-1). The contents and coverage of the laboratorial studies are shown in Tab. I-1-2.

For the existing data analysis, such existing data as geological literatures, geological maps, topographical maps and aerial photographs were collected, arranged and analyzed. To be conclusive, the existing information and data concerning the geological features, geological structure, mineral deposit and the result of geochemical prospecting of the project area was compiled and analyzed to grasp the outline of geological feature, geological structure, mineral deposit and potential ore fields.

For the geologic interpretation of satellite image data, photo-geological interpretation of the satellite image was carried out to grasp the regional geologic structure of the project area and to prepare the basic map for regional evaluation of the potential of the project area with the result of the existing data analysis.

Based on the results of the existing data analysis and the geologic interpretation of satellite image data, the survey area of 2,500km^2, where the greenstone belt was distributed and the field survey would be implemented, was extracted from the project area of 12,000km^2

For the geological survey, geological and geologic structural surveys were implemented on the survey area to prepare a geological map and a rout map. The survey was carried out paying attention to the lithologic character of greenstone, the relation between greenstone and intrusive rock, distribution and mode of occurrence of quartz, and the relation between mineralization and fault, in order to understand the relation between the mineralization and the geological feature and structure. Especially at a mineral showing (potential ore field), detailed survey including geological sketch and observation and sampling of the ore was performed in order to evaluate the ore potential.

For the soil geochemical prospecting, the sampling point and sampling measures were determined by examining such local situation as topographic features, drainage system, weathering and alteration of the site. Moreover, considering the experience of the presence of the counterpart DINAMIGE, riverside weathered soil was determined as the sample.

For rock geochemical prospecting, the following points were kept in mind; 1) all rock samples consisting the greenstone belt should be sampled, 2) sampling should be closely and densely carried out at the mineral showings, and 3) the sampling should be carried out with attention to igneous rocks. In particularly quartz was sampled in large amounts, to be able to assess the mineral showing.
Prospective areas which had potential for many mineral deposits and the potential ore fields were extracted by assembling and analyzing the results of the geological survey, soil and rock geochemical prospecting.

1-3 Investigation team

The persons in charge of the design of the survey plan and negotiation in advance and the work management on the site and, the executants participated in the field investigation team were as follow.

1-3-1 Design of the survey plan and negotiation in advance

Japanese side	Uruguayan side
Keisuke Mihira (JICA)	Dr. Carlos Soares de Lima (DINAMIGE)
Akira Chiba (MMAJ)	Ing. Jorge Spoturno (DINAMIGE)
Tetsuo Suzuki (MMAJ)	Ing. Humberto Pirelli (DINAMIGE)
Tetsuya Honjo (MMAJ)	Ing. Richard Arrighetti (DINAMIGE)
Yoshiaki Igarashi (MMAJ)	Ing. Javier Techera (DINAMIGE)

DINAMIGE : Dirección Nacional de Minería Geología

1-3-2 Work management on the site

Tadashi Itoh	(MMAJ)

1-3-3 Field investigation team

Japanese side	Uruguayan side
Norio Ikeda (Leader, geological and geochemical survey)	Dr. Carlos Soares de Lima (DINAMIGE)
Yoshio Takeda (Geological and geochemical survey)	Ing. Jorge Spoturno (DINAMIGE)
Nobuhiro Goto(Geological and geochemical survey)	Ing. Humberto Pirelli (DINAMIGE)
Susumu Takeda(Geological and geochemical survey)	Ing. Richard Arrighetti (DINAMIGE)
Masami Otake(Geological and geochemical survey)	Ing. Eduardo Medina (DINAMIGE)
	Ing. Javier Techera (DINAMIGE)

1-4 Survey Period

The survey period was as follows:

Field survey

Geological survey and geochemical prospecting: from 1 January to 5 March, 2001

Table Ⅰ-1-1 Summary of work amounts

Contents of Survey	Coverage
Existing data analysis	Surveyed area 12,000 km^2
Geological interpretation of Satellite image data	Surveyed area 12,000 km^2
Geological survey and Geochemical prospecting	Surveyed area 2,580 km^2 Route length 649 km

Table Ⅰ-1-2 Work amounts of laboratorial studies

Survey	Laboratory work	sample
Geological survey and Geochemical prospecting	Thin section of rock	67
	Thin section of mineral ore	38
	X-ray diffraction analysis	31
	Whole rock analysis (Al_2O_3, CaO, Cr_2O_3, Fe_2O_3, MgO, MnO, P_2O_5, K_2O, SiO_2, Na_2O, TiO_2, LOI)	61
	Chemical analysis (rock) (Au, Ag, Cu, Pb, Zn, As, Sb, Hg)	607
	Chemical analysis (soil) (Al, Sb, As, Ba, Be, Bi, B, Cd, Ca, Co, Cu, Ga, Fe, La, Pb, Mg, Mn, Hg, Mo, Ni, P, K, Sc, Ag, Na, Sr, S, Tl, Ti, W, U, V, Zn, Au)	2,021
	Fluid inclusion (homogenization temperatur +salt concentration)	14
	Radiometric dating (K-Ar)	6

CHAPTER 2 TOPOGRAPHY OF THE PROJECT AREA

2-1 Location and Traffic

Uruguay is located on the eastern seashore of the South American Continent and faces the Atlantic Ocean. The country abuts on Brazil in the north, and the La Plata River and Uruguay River forms the Argentine border in the south and the west. The nations land area is 176,000 km^2, which is about half the size of Japan. The population is about 3,160,000 (in 1996) and a little less than half of the all population reside in the capital, Montevideo.

The project area covered by this survey consists of two areas, the San Jose and the Arroyo Grande Areas. These areas are located to the north of Montevideo and lie in the south of the country.

The San Jose Area is a centrally located long rectangular shape which extends east and west, 220km from east to west and about 50km from south to north, and is placed about 90km northwest of the capital Montevideo. In this area, National Roads No. 5, 3, 23 and 54 from the east side to the west, that run in the direction of south and north. There are also seats of the Department offices including Trinidad City in the eastern part and Cardona City in the western part. Abutting on this area in the south, San Jose de Mayo City is located. This city, which was selected as a base camp for this year's field survey, is located by travelling 50 km on National Road No. 1 towards the northwest and then 30km on National Road No. 3 towards the north, requiring a total time of about one and a half hours.

The Arroyo Grande Area is also a centrally located rectangular shape, which extends east and west, 50km from east to west and about 20km from south to north, and is about 140km northwest of the capital, Montevideo. This area can be reached by travelling 90km on the same road, National Road No. 3 towards the north-northwest of San Jose de Mayo City. It takes around two and a half hours from Montevideo City by car. All national roads are paved. In the survey area, the transportation network is well developed including department, farm and national roads that make access and movement very convenient.

2-2 Topography and the Drainage system

The area rises 514m above sea level, the highest altitude in Uruguay. The whole country forms a gently inclined hill, particularly the south part of the country including the project area generally presents hilly topography which is nearly flat, while the east part of the project area is gently inclined to the south side and the west part to the southwest side respectively. Primary soil is widely distributed, and rocks rarely crop out. In some cases, however, topography reflects the geological features and intrusive rock of granitic rock locally forms a hill.

In the San Jose area, the Santa Lucia river flows southward in the eastern part of the area and the San Jose river also does the same in the central part, while the Rosario and San Juan rivers flow in a southwesterly direction in the west. These rivers form the framework of the drainage system and all of them flow into the La Plata river. In the Arroyo Grande Area, the Neguro river flows westward and contributes to the principal drainage system in this area. In both areas, confluents of these rivers are developed dendritically and homogeneously, and show a meshy distribution. Annual precipitation is much less than Japan. Once it rains, the land often becomes like wetlands around the confluence of tributaries because inclination is gentle and the water permeability is bad due to the clay soil.

2-3 Climate and Vegetation

According to the world climatic division, Uruguay belongs to the temperate rainy climate. The climate is mild and the annual mean temperature is about 16°C. Even in the winter season from June to September, the mean temperature seldom falls below 10°C. The mean temperature in the summer season from December to March is 23°C. The annual mean precipitation in Montevideo is around 1000mm. This precipitation is low for the rainy climate region and it is considered that the precipitation in the project area is similar to this amount. The period between September and December is suitable for field survey because the rainfall is light and the climate is stable.

The survey area is pasture land making good use of the slightly inclined hilly topography and is dotted with broadleaf trees along its rivers. This area has been a rich grassland since days before Westerns immigrated. Imported eucalypti and palm are planted as windbreaks and roadside trees around private houses. Eucalypti are partly planted for use as raw pulp material.

CHAPTER 3 FOREGONE GEOLOGICAL IMFORMATION OF THE SURVER AREA

3-1 Foregone information concerning natural resources

The research in foregone information was carried out concerning natural resources of the survey area, specifically the San Jose Area and the Arroyo Grande Area. The result is resumed below.

In the San Jose Area, such resources as talc and stones were borne as well as gold. The gold ore deposits were found in the greenstone belt, and were mined at the Mahoma and San Carlos mines. It was well known that the area had gold bearing ore deposits, as described by Maeso in 1882. However, it was from the 1980's onward, that the greenstone belt of Uruguay was targeted as a promising area of gold ore deposit and foreign resource development companies vied to do prospecting. As a result of these prospection, the Mahoma and the San Carlos gold mines were discovered. Although even now a number of mine lots are set and the prospection continues to be carried out, the details are unknown. Moreover the San Gregorio mine was discovered in the greenstone belt of north Uruguay, which is now being worked.

3-2 General geology of the survey area and its surroundings

The South American Continent was formed by the break up of the Pangaea super-continent, due to concurrent expansion of the Atlantic Ocean from the Jurassic period onward. Accordingly the geology and mineral resources of the eastern part of the South American Continent facing to the Atlantic Coast, including Brazil and Uruguay, are very close to that of the western part of the African Continent (Fig. I-3-1). Restoring the Pangaea super-continent to its original state, Brazil can be parallelized with the region from central Africa to Namibia, and also Uruguay with the region from Namibia to the northern part of Southern Africa correspondingly. With regard to this theory, respective studies have been conducted in such fields as geological structure from the standpoints of craton and mobile belt, plate tectonics and historical geology. It also occurs in the fields of geologic deposit and resource prospecting. Consequently, it is often the case that the prospecting for gold, uranium, platinum, nickel and diamonds in Brazil and Uruguay as well as the geology and the ore deposits of the countries are discussed by contrast with that of the western part of Africa.

The geological formation of Uruguay is underlain by the basement rocks of the pre-Cambrian group, sedimentary rocks of post-Mesozoic and the basalt lava plateau layered over them from the bottom up. The pre-Cambrian basement rocks, i.e. the Rio de la Plata Craton in a broad sense, is widely predominant in the south of the country and accounts for 40% of the land of Uruguay. The Permian sedimentary rocks and the Cretaceous basalt lava plateau on and after the Devonian period, which cover the Rio de la Plata Craton, crop out from the central part and the northern part of Uruguay to the frontier with Brazil. The Cenozoic system distributes in a region from east of the country to the Atlantic Coast and in the western and southern part of the country as well (Fig. I-3-2).

The Main constituents of the Rio de la Plata Craton exposed to the ground surface are mylonitized and migmatized metamorphic rocks. The source rock was a complex system of aggregated diversified effusive rocks, intrusive rocks and sedimentary rocks. The supracrustral rocks were intensely deformed by metamorphism. The Rio de la Plata Craton is developed with the E-W trend. The western wing is older, which has rocks of Archaean to Lower to Middle Proterozoic. The eastern wing is relatively newer where the rocks of Upper Proterozoic to Cambrian crop out. Considering the rock constituent, it is very similar to the geology of Western Australia, Canada and Ontario. It has basalts, basic intrusive rocks, siliceous volcanic rocksand volcaniclastic rocks as the igneous rock, and chert, shale, greywacke and quartzite as the sedimentary rock.

The pre-Cambrian system is broadly classified into three Terranes (Fig. I-3-2). These are the Pieda Alta Terrane in the south of the country, the S-N trending Nico Perez Terrane in the east and the Cuchilla Dionisio Terrane at the southeast of the country. These tarranes border each other by mylonitized and migmatized tectonic lines. The geological age of the Tarranes is estimated as Proterozoic to Cambrian. Since then the tarranes were metamorphosed and subjected to tectonic movements several times over.

An E-W trending complex rock belt of Archaean to Lower Proterozoic in age, called "greenstone belt", is developed around the north and south boundaries of Pieda Alta Terrane, which is mainly composed of basalt rocks, volcaniclastic rocks and sedimentary rocks with some granite intrusive rocks. The belt at the north boundary is called Arroyo Grande Belt and that of the south boundary is San Jose Belt.

Moreover both the Isla Cristallina de Rivera belonging to the Nico Perez Terrane and cropping out around the northern part of the country, and the Valentines Formation at the central part of the country are also considered as greenstone belt. These greenstone belts are supposed to be promising prospecting areas which bear nonferrous metal ore deposits in Uruguay.

3-3 Geological significance and mineralization of the survey area

(1) Geological significance

As mentioned above, the characteristic of geology of Uruguay is that 40 % of the land is covered by pre-Cambrian rocks, i.e. Archaean (2.5Gy) to Proterozoic (2.5Gy-550My). Among them, in the region called "greenstone belt" where the source rock was volcanic sediments and igneous rocks, the mineralization of nonferrous metal ore deposit including gold, copper lead and zinc is recognized abundantly. The main promising areas are the following 5 (Fig. I-3-3 and Tab. I-3-1).

①Isla Cristallina de Rivera (Rivera Belt)

②Trienta y Tres

③Arroyo Grande Belt

④San Jose Belt

⑤Southern part of Minas

Out of these, areas ③ and ④, which are distributed in the north and south part of the Pieda Alta Terrane and involve the greenstone belt, are targeted in this survey.

(2) Mineralization

(i) San Jose Belt

Gold ore deposits such as the Mahoma and the San Carlos mines are distributed in the greenstone belt of the San Jose Area. Reports about the ore deposits describing their geological structure, ore deposit type and metallogenies are not found. This perhaps is because that the mining period was short. The both mines are situated in the greenstone belt, considered to be closely associated with granodiorites, and an ore deposit accompanying quartz, but further information is unknown.

(a) Mahoma mine

The Mahoma mine is now dormant because digging of the main ore deposits has finished. The mining right holder is Rea Gold Co., Ltd. of Canada. The Mahoma ore deposit is located in San Jose Province, about 130 km northwest of Montevideo, and approximately in the center of the Arroyo Grande greenstone belt. This mine was discovered through modern investigation carried out by Lac Mineral Co., Ltd from 1986 to 1990. The method of prospecting was mainly geochemical type (valley sand and successively soil), where preparation of a presumed geological structural map was combined with an airborne electromagnetic survey. After the ore reserve was evaluated by a drilling survey and the F/S was prepared, mining was begun by American Resources Corp. (ARC), a subsidiary company of Rea Gold, in 1992. The quantity of production at that time was 330 tons/day. In 1993, digging was discontinued for a time because of floods and the change of construction firm. Although it was resumed in 1994, operation has ceased since December 1995 because of exhaustion of the ore reserve. Gold was found accompanying quartz veins and was mined by open-pit mining. The open cut had a long slot shape which was 20 to 50m wide and several hundred meters in length and is now submerged. In JMEC (2000), it is found the following description about this mine: "The type of this ore deposit is auriferous quartz vein. It consists of three metalliferous veins which extend along the E-W trending fracture zone. The veins cut the granodiorite host rock, in the strike of N70E and with the dip of 75N. It is estimated that the potential mining amount is 169,000 to 330,000 tons and the ore grade is 8.9 to 11.8 g/t. Mining ore minerals are electrum and others, sulfide minerals such as pyrite, chalcopyrite, galenite and zincblende, and secondary minerals including covelline and chalcocite. Sulfide minerals occur in the form of stringers and dissemination accompanying quartz, while galenite sometimes occurs in the form of irregularly shaped coagulation (bringing with it an extremely small quantity of zincblende)."

(b) San Carlos mine

The San Carlos mine is located near the western extremity of the San Jose belt. It was also surveyed and discovered by Lac Mineral Co., Ltd as was the case with the Mahoma mine. This is a small scale ore deposit accompanying quartz vein or dissemination, and mined by open-pit mining. The open cut is back-filled after digging.

(c) Narangio mine

At the Narangio mine, talc is mined. Granites are mined for such building materials as floor and walling, and granodiorites for aggregate.

(ii) Minas

Minas city is located to the east of the San Jose area. This city was the center base of many mines which were mined from the end of 18th to early 19th century, as it is imaginable from the name "Minas". This area is located around the Minas city, and the geology is characterized by the rocks of middle Proterozoic to Cambrian. Although there is no working mine now in this area, many mines were operated by the British and the Spanish until the early 20th century. The principal ore deposits of copper, lead, silver and zinc are Apolonia, Chape, Euritina, Rues, Oriental and Valencia, and also known are many more mineral showings.

(iii) Arroyo Grande

In the Arroyo Grande Area, gold ore deposit had not been discovered until now. Ultrabasic rock and gabbro crop out along National Road No. 3. Regarding this ultrabasic rock, the Geological Survey Institution of the U.S.A. made a short-term field survey for the prospecting of platinum ore deposits but the details are unknown.

3-4 Extraction of the object area for the geological survey and geochemical prospecting

In the survey area, gold ore deposits were recognized in greenstone and these deposits were mined as the Mahoma and the San Carlos mines. It is considered that the ore deposit is closely associated with granodioraites. It is the ore deposit accompanying quartz. Fig. I-3-4 shows the geological map of the survey area. In the legend, greenstone belt is represented as pCCsjo, pCCsj and pCCps, and granodiorites as pCCG and pCC.

Based on this information, the field survey area (about 2,500km^2), where the greenstone belt had been distributed and many intrusions of granodiorites rock body had been recognized, was extracted from the project area (12,000 km^2), according to the result of the existing data analysis and the geologic interpretation of satellite image data (Fig. I-3-4).

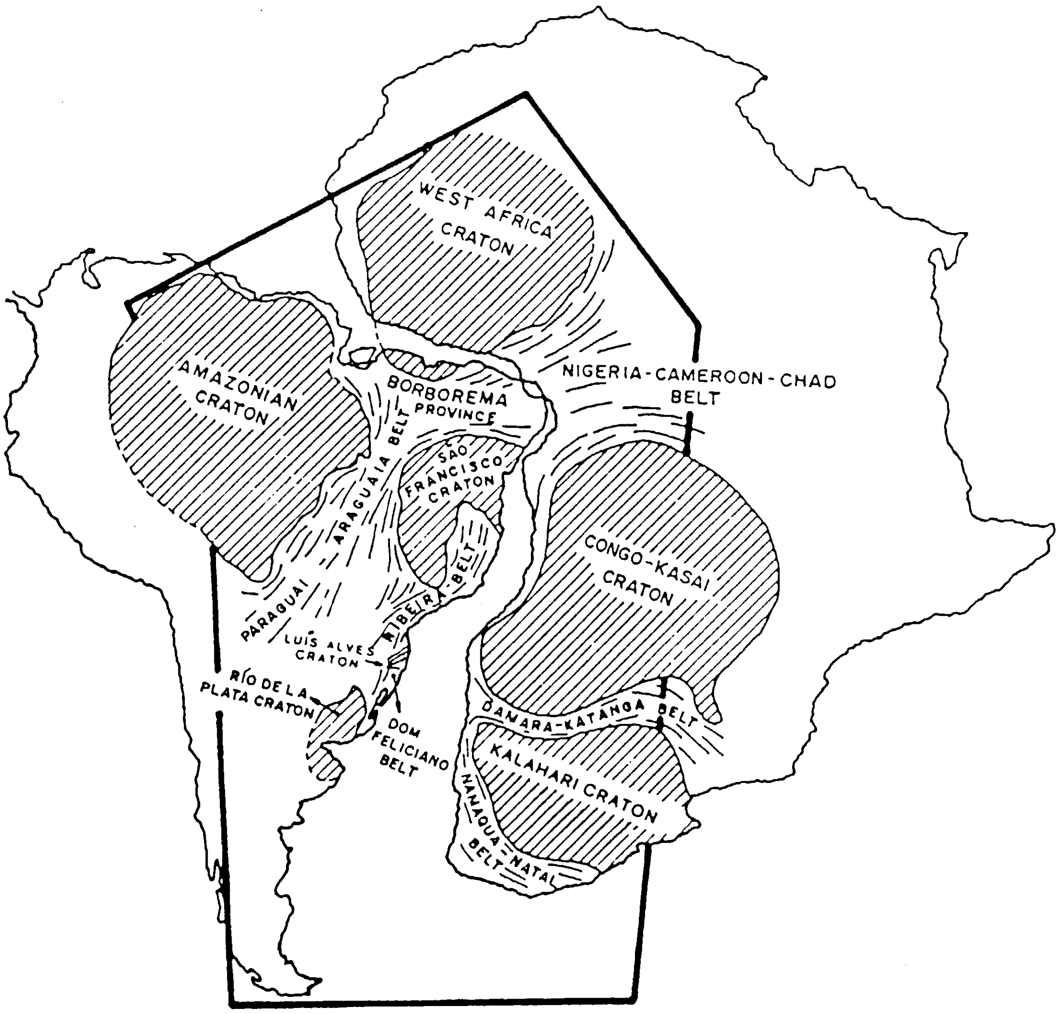

Fig.I-3-1 Major tectonic features of South America and Africa

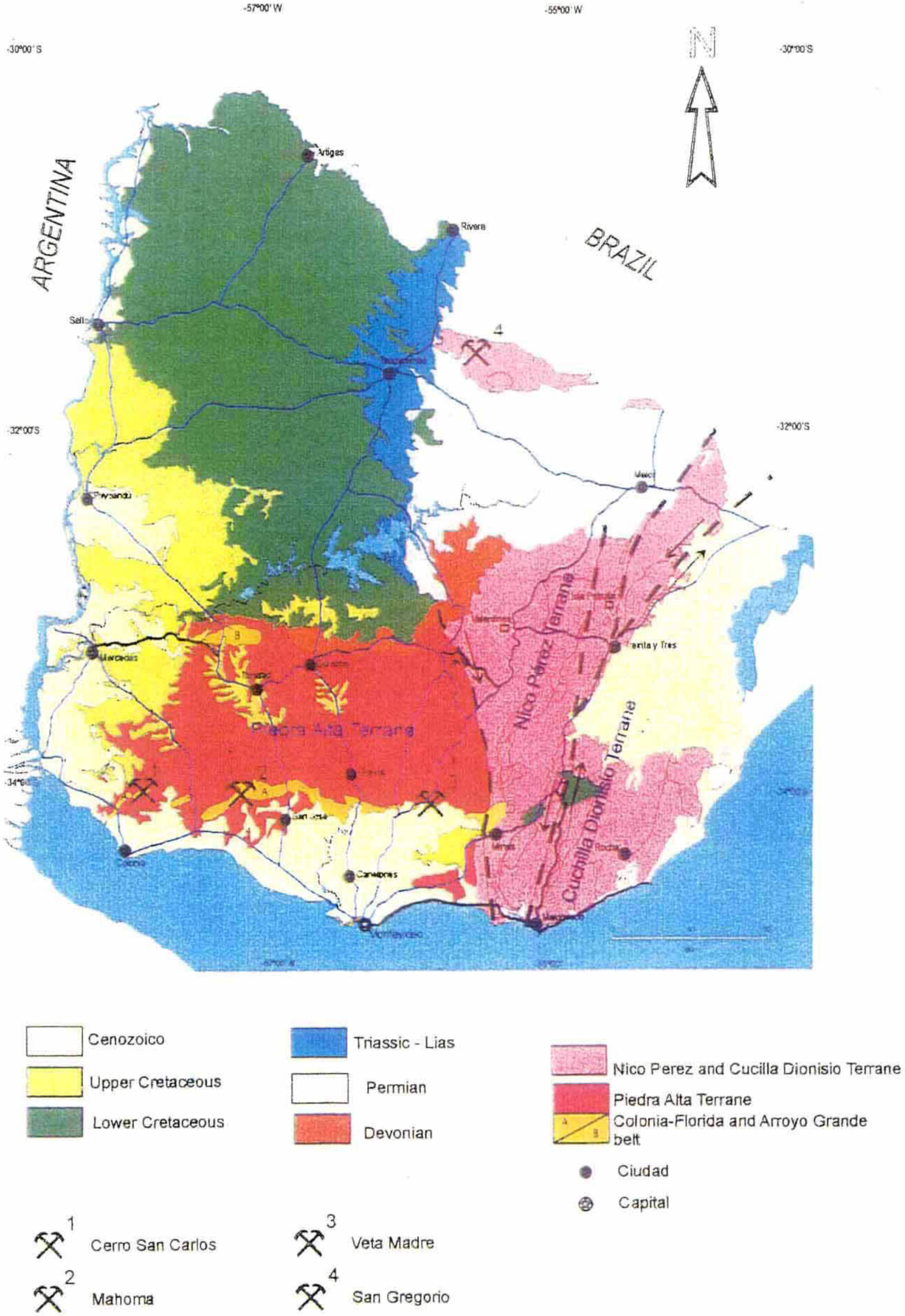

Fig.I-3-2 Geological map of Uruguay

① Isla Cristallina de Rivera(Rivera Belt)地域
(San Gregorio 鉱山、Mina de Corrales 地区)

② Trienta y Tres 地域 (Isla Patrulla 地区、Valentines 地区)

③ Arroyo Grande Belt 地域

④ San Jose Belt 地域 (Mahoma 鉱山)

⑤ Minas 南部地域 (Oriental 鉱山)

Fig.I-3-3 Main promising areas

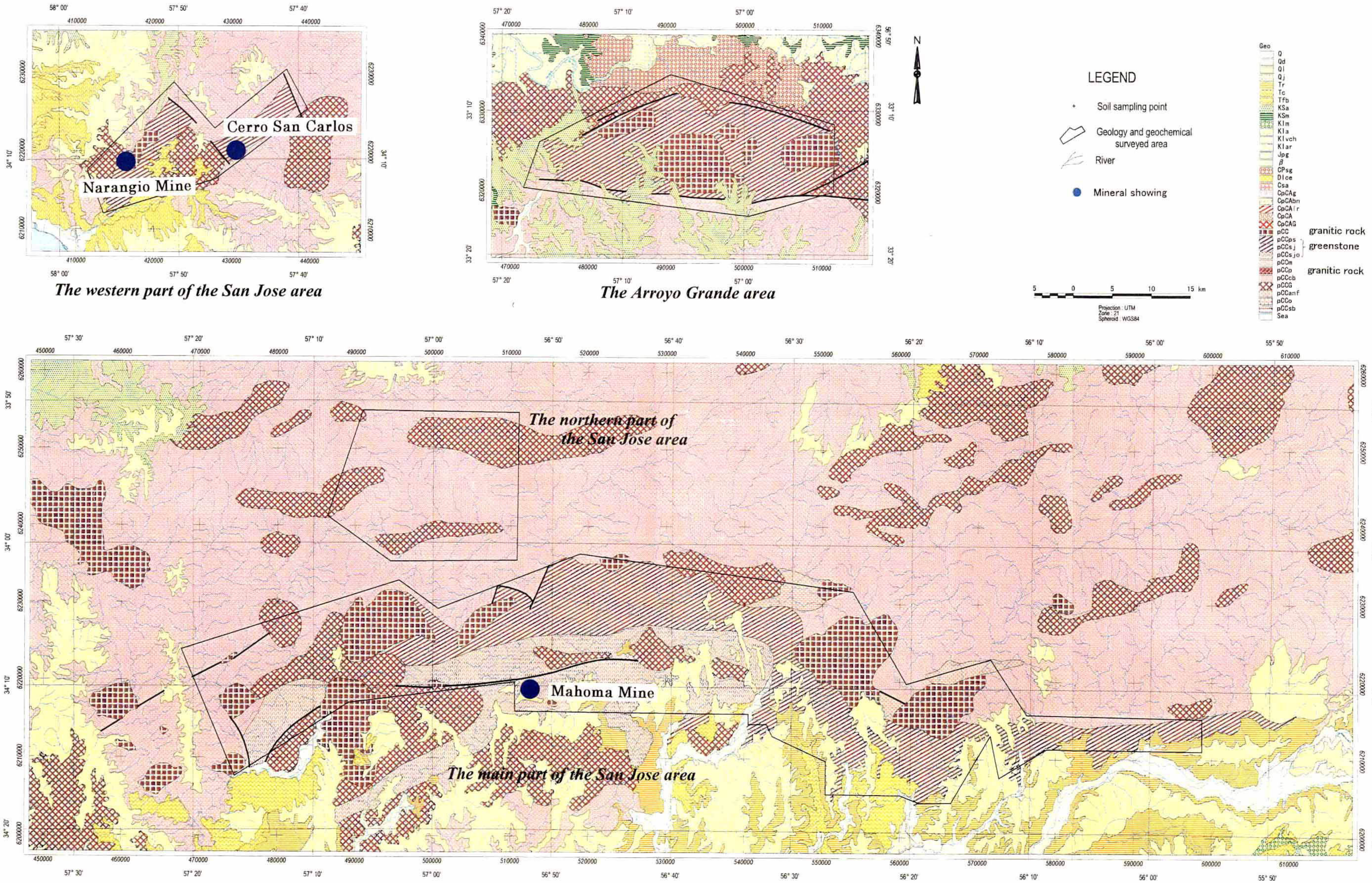

Fig.I-3-4 Location map of geology and geochemical survey areas

Tab.I-3-1 List of mineral showings

Name of ore deposit	Minerals	Location	Mineraliztion	Present Status
Mahoma	Gold	In the centralsouth of the Main Part of San Jose area.	Quartz vein in the granodiorite intruded greenstones.	Main ore deposit was mined out. (Suspending)
Cerro San Carlos	Gold	In the west of the Western Part of San Jose area.	Quartz vein and/or quartz network in the granodiorite intruded greenstones	Mined out.
Narangio	Talc	In the east of the Western Part of San Jose area.	Vein type mineralization in white dolomite in mafic rock.	Operating: 50ton/mon of production.

* Listed ore deposits are already mined out or operating ones, while there are many mineralized zones in the San Jose greenstone belt : Colla , Mal Abligo, Amanda zone etc, and Arroyo Grande greenstone belt : Palacios zone.

CHAPTER 4 COMPREHENSIVE DISCUSSION ABOUT THE RESULT OF THE SURVEY

4-1 Geological structure, characteristic feature of mineralization and mineralizing control

The ore deposit type of this area is a gold-bearing quartz vein deposit impregnated with basement complex (pCCcb), older granite intrusive rocks (pCCG) and greenstone (pCCps, pCCsj, pCCag and pCCsjo).

Regarding the wall rock alteration, it is estimated that from the edge of the quartz vein outwards, the mineral assemblages consist of quartz – sericite – (pyrite) and chlorite – epidote – (albite).

As for the occurring appearance of quartz veins, the vein width comes to several to dozens of meters in basement rocks, greenstone and ancient granitic rocks, while it declines extremely to several millimeters to centimeters in younger granitic rocks (pCC). It is considered that pCC had some bearing on the gold mineralization. In the wall rock around the pCC body, quartz veins are well developed. However the geological information of pCC as directly associated with igneous rocks was not obtained. Assuming a series of ore-forming processes, the following causes are estimated as reasons for diminution of quartz vein width in pCC.

The lithologic character of pCC is inhomogeneous, when compared with pCCG. Large fissures were not formed because creeping deformation occurred due to its high ductility. Conversely, fractures with a moderate width could not be formed because brittle deformation occurred due to its low ductility.

As for the disposition pattern of the quartz vein, two preferred directions of the veins were observed; the NE-SW to E-W and the NW-SE. The former is approximately concordant with the large-scale fracture zone displaying left lateral slip, while the latter displays right lateral slip sense owing to the left echelon disposition. Faults with the same sense are developed along with the latter veins. It is considered that the NW-SE faults can be a conjugate set with the NE-SW to E-W veins.

According to the result of the polished section observation of both quartz vein and the wall rock of the deposit, ore mineral was hardly found in the quartz vein except a little limonite and partially an infinitesimal amount of pyrite. A small amount of pyrite – (chalcopyrite) dissemination was recognized in green rocks and some of quartz vein.

From the lithologic character of the quartz vein, it was classified into three types, milky sugar-like translucent quartz, colorless to white transparent quartz and dark gray transparent quartz. Considering the zonal distribution, which is locally recognized, and their appearance of interpenetration, it is estimated that these different stages of each quartz type become recent in this order in a chronological relationship.

As the result of the fluid inclusions analysis, the homogenization temperature was estimated to be 447.7°C at the highest and 85.6°C at the lowest, and the histogram usually had three peaks at around 300°C, 250°C and 200 to 150°C, which could be considered to correspond to milky sugar-like quartz, colorless to white transparent quartz and transparent quartz, respectively. According to the result of measurement, the salinity was 4.2 to 35% (NaCl % equivalent), which indicates a coexistence of quartz formed under high and low pressure.

Considering which type of quartz is accompanied by Au, no characteristic depending on the mineral showing is recognized. It seems that Au is apt to accompany colorless to white transparent quartz and dark gray transparent quartz. In addition to these types, black quartz also occurs which contains clay minerals (phyllosilicate) difficult to identify. Consequently it is necessary to analyze more carefully in detail to be able to discuss the ore-forming stage of quartz accompanied by Au.

4-2 Relevance of geochemical anormaly and mineralization

As the result of a bivariate analysis of data obtained by soil geochemical prospecting, the Au anormaly zone was extracted from the mineral showings H and L, while the As anormaly zone was extracted from the B, E, G, northern part of G, H, I, the eastern part of K, L and M. As the result of a multivariate analysis (factor analysis), factors which could be associated with the Au mineralization (Factor4: Au, As, K, V) were extracted.

When examining the relation between the soil geochemical anormalies and the mineralized zone, the mineral showings A, B, E, G, H and L stood out as the place which the anormalies of Au and As, and high score zone of Factor4 had been duplicated.

As the result of a bivariate analysis of data obtained by rock geochemical prospecting, the Au anormaly zone was extracted from the mineral showings B, E, G, J, K, L and M as well as the mineral showing A around the Mahoma mine. As the result of a multivariate analysis (factor analysis), factors associated with the Au mineralization (Factor2: Au, Ag) were extracted.

Examining the relation between the rock geochemical anormalies and the mineralized zone, the mineral showings A, E, G, H, K and L loomed up as the place which the anormalies of Au and As, and high score zone of Factor 2 had been duplicated.

4-3 The ore-bearing potential

In this area, a gold-bearing quartz vein deposit associated with fracture zone is expected because of such aspects as many quartz veins containing Au are distributed, the structural control are recognized in the ore deposit, several ore-forming stages are estimated, the Au content is not partialized in a specific rock, and related igneous rock is hardly determined. Basically it can be considered that the ore-forming fluid containing Au (it is difficult to determine the origin of Au) had ascended along the NE-SW to E-W trending fracture zone and the NW-SE trending fracture zone as a conjugate sets, and then Au had precipitated on an oxidation-reduction condition.

According to the result of rock geochemical prospecting, some samples, which the Au content was particularly high in the quartz vein, were obtained in the mineral showing A involving the Mahoma mine. Geochemical anormalies were extracted at the mineral showings B, E, G, J, K, L and M. According to the result of soil analysis, there were many samples which indicated the Au and As anormalies, in mineral showings A, B, E, H and L.

Geological descriptions including mode of occurrence and scale of each mineralized zone, the result of laboratory experiments and analyses and, a comprehensive evaluation are summarized in Tab. I-5-1. The location of each mineral showing is plotted on the geological map along with the Au anormalies (Fig. I-5-1).

As a result, geochemical anormalies of Au were extracted along the shear zone in the mineral showing A, while they were also extracted near the shear zone in the mineral showings B, E, K and L. Consequently, the possibility that gold ore deposit would exist along the shear zone is high.

CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS

5-1 Conclusions

5-1-1 Gelology and ore deposit

The geological formation of this area mainly consists of basement complex (pCCcb and pCCanf), greenstone (pCCps, pCCsj, pCCag and pCCsjo), older granite intrusive rocks (pCCG) and younger granite intrusive rocks (pCC) (Fig. II-3-2, Plate II-3-1～Plate II-3-4).

The basement complex is mainly composed of gneiss, schists, migmatite and amphibolite. The granite intrusive rocks of pCCG and pCC, are composed of granite, granodiorite, leucogranodiorite and diorite. The latter is rather heterogeneous. Each of them partially comes under mylonitization and the foliation is recognized.

According to the result of age determination, pCC shows the age around 1.7 to 2.0Gy, except granite of Mal Abrigo (1.2Gy). This is consistent with the description in the existing information that the pCC is related in the Transamazonian orogenesis. On the other hand, wall rock (diorite to granodiorite) of the Mahoma mine, as a representative of pCCG, shows the age of 2.0Gy and a rejuvenation is presumed alongside that of the age before 2.2Gy found in existing information. It can be considered that the rejuvenation is caused by a mineralized alteration.

As for greenstone, the main part of the San Jose Area, which is the principal part of the survey area, is composed of the central to eastern part of the Paso Severino formation (pCCps) and the western to southern part of the San Jose formation (pCCsjo). The former was subjected to a weak metamorphism, while the latter to a relatively high-grade metamorphism. The Cerros de San Juan formation (pCCsj) in the western part of the San Jose Area was subjected to a weak metamorphism. The Arroyo Grande formation (pCCag) in the Arroyo Grande Area to the north, was subjected to a weak to moderate metamorphism.

The greenstone is mainly composed of greenschist, basic to acidic volcanic rocks (metabasalt to metarhyolite), amphibolite, quartz schist, quartzite, metasandstone and slate to phyllite.. Adding to this, the San Jose and the Arroyo Grande formations are slightly intercalated with thin gneiss beds and the Cerros de San Juan formation with limestone and dolomite beds.

As a result of the field survey, the following 13 mineral showings were found as a zone where the quartz vein had been developed (Fig. II-3-7). Descriptions about each mineral showing are resumed in Tab. I-5-1.

The main part of the San Jose area (10 mineral showings)

A: surrounding area of the Mahoma mine (20km EW × 15km NS)

B: Nueva Helvecia (the western extremity of the area : 10km × 18km)

C: Arroyo del Medio (6km × 15km)

D: Canada de Cabrera (8km × 4km)

E: Arroyo charruzo (10km × 12km)

F: Tala I (3km × 4km)

G: Tla II (9km × 14km)

H: West of 25 de Mayo (6km × 8km)

I: South of 25 de Mayo (10km × 10km)

J: San Ramon (the eastern extremity of the area : 10km × 5km)

The western part of the San Jose area (1 mineral showing)

K: San Carlos (21km × 13km)

The Arroyo Grande area (2 mineral showings)

L: Rio Negro I (10km × 15km)

M: Rio Negro II (25km × 10km)

The gold-bearing quartz vein is impregnated with basement complex (pCCcb), ancient granite intrusive rocks (pCCG) and greenstone (pCCps, pCCsj, pCCag and pCCsjo). Regarding the wall rock alteration, it is megascopically recognized that both granites and greenstone of the wall rock have been subjected to silicification, chloritization and epidotization at the edge of the quartz vein. According to the result of X-ray diffractive analysis, it is estimated that from the edge of the quartz vein outwards, the mineral assemblages consist of quartz – sericite – (pyrite) and chlorite – epidote – (albite).

As for the occurring appearance of quartz veins, the vein width comes to several to dozens of meters in basement rocks, greenstone and ancient granitic rocks, while it declines extremely to several millimeters to centimeters in younger granite intrusive rocks (pCC). It is considered that pCC had some bearing on the gold mineralization. In the wall rock around the pCC body, quartz veins are well developed. However the geological information of pCC as directly associated igneous rocks was not obtained. Assuming a series of ore-forming processes, the following causes are estimated as reasons for diminution of quartz vein width in pCC.

The lithologic character of pCC is inhomogeneous, when compared with pCCG. Large fissures were hardly formed because creeping deformation occurred due to its high ductility. Conversely, fractures with a moderate width could not be formed because brittle deformation occurred due to its low ductility.

As for the disposition pattern of the quartz vein, two preferred directions of the veins are observed; the NE-SW to E-W and the NW-SE. The former is approximately concordant with the large-scale fracture zone displaying left lateral slip, while the latter displays right lateral slip sense owing to the left echelon disposition. Faults with the same sense are developed along with the latter veins. It is considered that the NW-SE faults can be a conjugate set with the NE-SW to E-W veins.

According to the result of the polished section observation of both quartz vein and the wall rock of the deposit, ore mineral was hardly found in the quartz vein except a little limonite and partially an infinitesimal amount of pyrite. A small amount of pyrite – (chalcopyrite) dissemination was recognized in green rocks and some of quartz veins.

According to the assay result, the maximum assay value was 19,890ppb.

From the lithologic character of the quartz vein, it was classified into three types, milky sugar-like translucent quartz, colorless to white transparent quartz and dark gray transparent quartz. Considering the zonal distribution, which is locally recognized, and their appearance of interpenetration, it is estimated that these different stages of each quartz type become recent in this order in a chronological relationship.

As the result of the fluid inclusions analysis, the homogenization temperature was estimated to be 447.7°C at the highest and 85.6°C at the lowest, and the histogram usually had three peaks at around 300°C, 250°C and 200 to 150°C, which could be considered to correspond to milky translucent quartz, colorless to white transparent quartz and dark gray transparent quartz, respectively. According to the result of measurement, the salinity was 4.2 to 35% (NaCl % equivalent), which indicates a coexistence of both quartz formed under high and low pressure.

Considering which type of quartz is accompanied by Au, no characteristic depending on the mineral showing is recognized. It seems that Au is apt to accompany colorless to white transparent quartz and gun metal transparent quartz. In addition to these types, black quartz also occurs which contains clay minerals (phyllosilicate) difficult to identify. Consequently it is necessary to analyze more carefully in detail to be able to discuss the ore-forming stage of quartz accompanied by Au.

5-1-2 Soil geochemical prospecting

2,021 soil samples of weathered soil of riverside , were chemically analyzed for 34 elements (Al, Sb, As, Ba, Be, Bi, B, Cd, Ca, Co, Cu, Ga, Fe, La, Pb, Mg, Mn, Hg, Mo, Ni, P, K, Sc, Ag, Na, Sr, S, Tl, Ti, W, U, V, Zn and Au). Based on the result, bivariate and multivariate analyses were implemented, after statistically processing the data to obtain the key statistics.

As the result of a bivariate analysis, the Au anormaly zone was extracted from the mineral showings H and L, while the As anormaly zone was extracted from the B, E, G, northern part of G, H, I and the eastern part of K, L and M.. As the result of a multivariate analysis (factor analysis), factors were extracted which could be associated with the Au mineralization and with the rock properties of mafic rock and granites.

Factor1 : Co, Cr, Cu, Fe, Mg and Ni

Factor2 : Ga, Al, Fe, K, Li, Pb, Y and Zn

Factor3 : Ca, Na and Sr

Factor4 : Au, As, K and V

When examining the relation between the soil geochemical anormalies and the mineralized zone, the mineral showings A, B, E, G, H and L stood out as the place which the anormalies of Au and As, and high score zone of Factor4 had been duplicated. According to the result of soil geochemical prospecting, and as a result of this fiscal year's survey, the possibility of bearing a potential gold ore deposit is sufficiently recognized.

5-1-3 Rock geochemical prospecting

607 rock samples of quartz vein, wall rock and rock were chemically analyzed for 8 elements (Au, Ag, Cu, Pb, Zn, As, Sb and Hg). According to the result of the assay, the following samples were extracted as

Au anormary; 23 samples taken from quartz vein which contains relatively high grade ore with the maximum assay value of 19,890ppb, and 18 samples taken from green rocks and granites which contains relative low grade ore. The assay value of quartz veins impregnated with green rocks was in a range of 5ppb to 19.890ppb, and that of granites was 5,370ppb to 37ppm, while that of other rocks was 14ppb to 562ppb. Regarding the assay result of the wall rock, the assay value of green rocks was 5ppb to 37ppb, and that of granites was 9ppb to 291ppb, while that of other rocks was 9ppb to 354ppb.

As the result of a bivariate analysis, the Au anormaly zone was extracted from the mineral showings B, E, G, J, K, L and M as well as the mineral showing A around the Mahoma mine. As the result of a factor analysis, factors associated with the Au mineralization and rock properties were extracted.

Factor1 : Cu, Zn and As

Factor2 : Au and Ag

Factor3 : Pb and Zn

Examining the relation between the rock geochemical anormalies and the mineralized zone, the mineral showings A, E, G, H, K and L loomed up as the place which the anormalies of Au and As, and high score zone of Factor 2 had been duplicated.

5-1-4 The ore-bearing potential

A gold-bearing quartz vein deposit associated with fracture zone is expected because of such aspects as the structural control recognized in the ore deposit, several ore-forming stages exist, the Au content is not partialized in a specific rock, and related igneous rock is hardly determined. Basically it can be considered that the ore-forming fluid containing Au (the origin of Au is unknown) had ascended along the NE-SW to E-W trending fracture zone and the NW-SE trending fracture zone as a conjugate sets, and then Au had precipitated on an oxidation-reduction condition.

According to the result of rock geochemical prospecting, the particularly high Au content was obtained in the quartz vein of the mineral showing A involving the Mahoma mine. Geochemical anormalies were extracted at the mineral showings B, E, G, J, K, L and M. According to the result of soil analysis, there were many samples which indicated the Au and As anormalies, in mineral showings A, B, E, H and L.

Geological descriptions including mode of occurrence and scale of each mineral showing, the result of laboratory experiments and analyses and, a comprehensive evaluation are summarized in Tab. I-5-1. The location of each mineral showing is plotted on the geological map along with the Au anormalies (Fig. I-5-1).

As a result, geochemical anormalies of Au were extracted along the shear zone in the mineral showing A, while they were also extracted near the shear zone in the mineral showings B, E, K and L. Consequently, the possibility that gold ore deposit would exist along the shear zone is high.

5-2 Recommendations for the second phase

Among the above-mentioned object survey area, the most promising areas expected to bear ore deposit were conclusively extracted and marked as the recommendation area with lines in red on the map (Fig.

I-5-1), after the geochemical anormaly area was extracted by soil and rock geochemical analysis, and data obtained through various analyses was comprehensively analyzed. It is considered that the following prospecting methods are effective for these promising areas. Comprehensive evaluation in ranks from A to D to define priority and an effective prospecting method are indicated in Tab. I-5-1.

①Mineral showing A, including surrounding area of Mahoma mine : detail geological survey and rock geochemical prospecting, complete soil geochemical prospecting, and

②Mineral showings H to G : detail geological survey and rock geochemical prospecting and, complete soil geochemical prospecting.

③Mineral showings L to partial M: detail geological survey and rock geochemical prospecting and, complete soil geochemical prospecting

④Mineral showing B : detail geological survey and detail complete geochemical prospecting

⑤Mineral showing E : detail geological survey and detail complete geochemical prospecting

The detail of the prospecting methods are discribed as follows.

①Detail geological survey and rock geochemical prospecting (including trenching for quartz vein prospection at inappropriate outcrop)

②Complete soil geochemical prospecting (10 samples/km^2: randam sampling is effective being compared with grid sampling, because the vegetation is relatively luxuriant near a river.).

The result of Phase I was obtained from limited amount of outcrops, so it necessary to implement the airborn geophysical for prospect a wide area.

From the field prospecting of this year the high potential zone was recognized extending widely to the southwestern field of Mahoma Mine, consequently it is recommended that geochemical prospecting of riverside weathered soil should be implemented over a 100km^2 area.

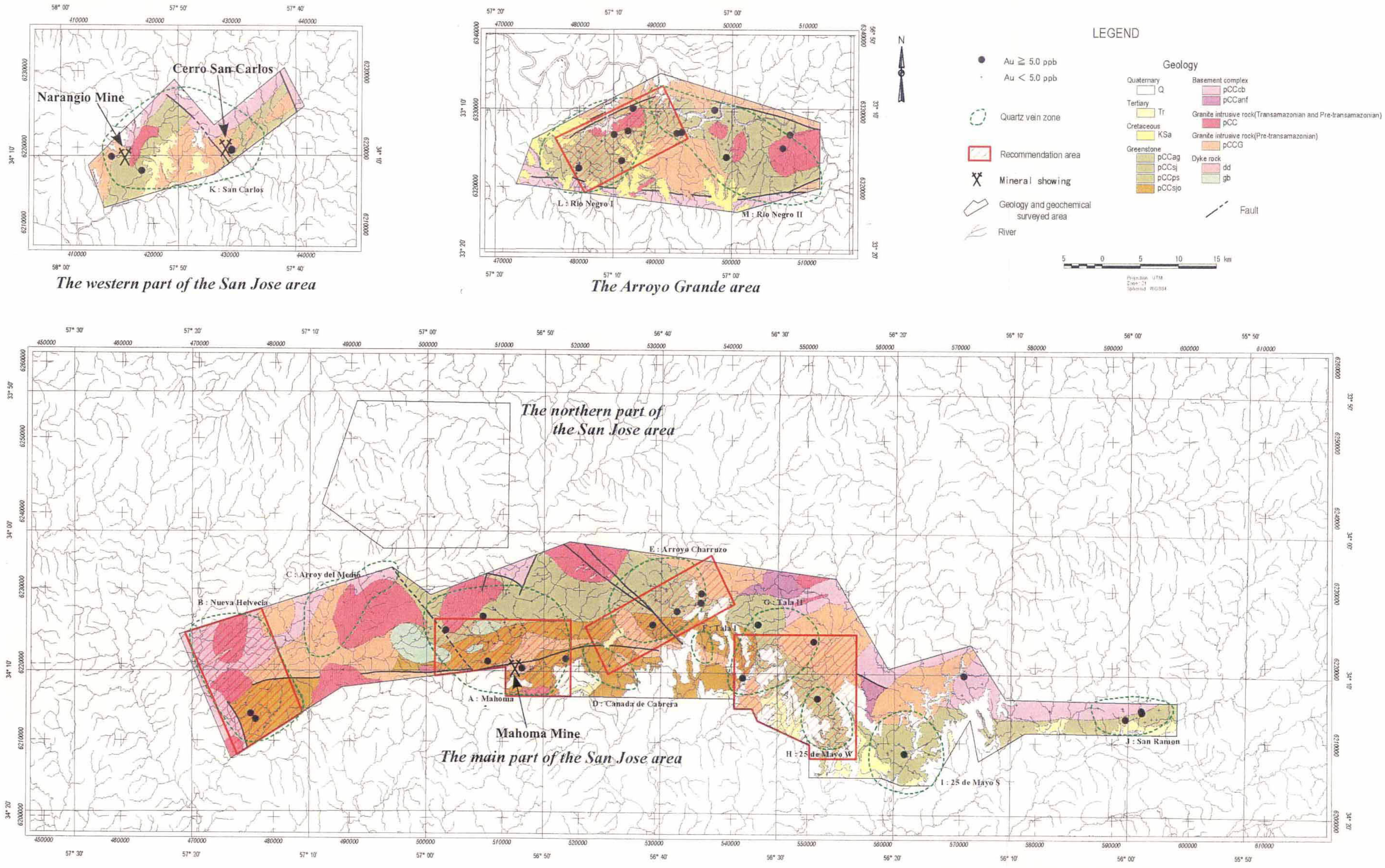

Fig. I -5-1 Survey results and recommendation for future survey

Tab.I-5-1 Survey results and evaluation of mineral showings

Mineral showings		Lcation	Occurrence	Length, width	Host rock	Alterarion minerals	Ore minerals	Gangue minerals	Soil results	Assay results	Evaluation
A	Mahoma	Paso del Rey	quartz vein (NW,E-W,NE) >> floats of quartz	20km × 15km	green schist, metabasalt, quartz schist, granodiorite (pCCG)	quartz-(sericite)-(pyrite), chlorite-(epidote)-(albite)	pyrite, limonite	quartz,clay	Au:23-79ppb, Cu,Pb,Zn, Factor2,Factor3, Factor4	quartz:1520-19890, rock:5-354	A (rock and soil geochem.)
B	Nueva Helvecia	Colla-Nueva Helvecia	floats of quartz	10km × 18km	green schist> quartz schist,	quartz-(sericite)-(pyrite), chlorite-(epidote)-(albite)	limonite, (pyrite)	quartz	Au:14-23ppb, As,Cu,Pb,Zn, Factor1,Factor4	rock:32-37	B (soil geochem.)
C	Arroy del Medio	Mal Abrigo	quartz vein (NE,E-W) = floats of quartz	6km × 15km	granodiorite (pCCG)	quartz-(sericite)-(pyrite), chlorite-(epidote)-(albite)	limonite	quartz	Cu,Pb,Zn, Factor2,Factor3	-	D
D	Canada de Cabrera	Paso del Rey	floats of quartz	8km × 4km	green schist,	quartz-(sericite)-(pyrite), chlorite-(epidote)-(albite)	limonite	quartz	Au:6ppb,Pb,Zn, Factor2	-	C
E	Arroyo Charruzo	Paso del Rey	quartz vein (E-W,N-S) = floats of quartz	10km × 12km	green schist> metabasalt, quartz schist,	quartz-(sericite)-(pyrite), chlorite-(epidote)-(albite)	limonite	quartz,clay	Au:14-51ppb, As,Cu,Pb, Factor4	quartz:37-1680, rock:5-23	B (soil geochem.)
F	Tala I	Paso del Rey	quartz vein (NE,NW)	3km × 4km	green schist,	quartz-(sericite)-(pyrite), chlorite-(epidote)-(albite)	limonite	quartz	Au:32ppb	-	D
G	Tala II	Florida	quartz vein (NE) = floats of quartz	9km × 14km	green schist, granodiorite (pCC-V)	quartz-(sericite)-(pyrite), chlorite-(epidote)-(albite)	limonite, (pyrite)	quartz	As,Factor2, Factor3,Factor4	quartz:18-125	B (soil geochem.)
H	West of 25 de Mayo	Florida-Cardal	floats of quartz	6km × 8km	green schist,	quartz-(sericite)-(pyrite), chlorite-(epidote)-(albite)	limonite	quartz	Au:9-111ppb, As,Cu, Factor4	quartz:32	A (rock and soil geochem.)
I	South of 25 de Mayo	Cardal	floats of quartz >> quartz vein (NW)	10km × 10km	green schist> quartz schist	quartz-(sericite)-(pyrite), chlorite-(epidote)-(albite)	limonite	quartz	As, Factor4	quartz:23	C
J	San Ramon	San Ramon	floats of quartz	10km × 5km	green schist,	quartz-(sericite)-(pyrite), chlorite-(epidote)-(albite)	limonite	quartz	Cu,Pb,Factor3	quartz:5, rock:9-41	C
K	San Carlos	Miguelete	quartz vein (NE) > floats of quartz	21km × 13km	green schist> quartz schist	quartz-(sericite)-(pyrite), chlorite-(epidote)-(albite)	limonite	quartz	Au:9-37ppb, Cu,Pb,Zn	quartz:37-1548, rock:115	C
L	Rio Negro I	Paso del Puerto	quartz vein (NW,E-W)	10km × 15km	green schist, quartz schist,	quartz-(sericite)-(pyrite), chlorite-(epidote)-(albite)	limonite, (pyrite)	quartz,sericite	Au:14-97ppb, As,Cu,Pb,Zn, Factor3,Factor4	quartz:245-5370, rock:19	A (rock and soil geochem.)
M	Rio Negro II	Paso del Puerto	quartz vein (NW) = floats of quartz	25km × 10km	green schist, metabasalt, granodiorite (pCCG)	quartz-(sericite)-(pyrite), chlorite-(epidote)-(albite)	limonite	quartz	Au:9-97ppb, As,Cu,Pb,Zn, Factor1, Factor2,Factor3	quartz:32-826, rock:9-562	C

Evaluation: A > B > C > D