PART II SURVEY RESULTS

CHAPTER 1 GENERALITIES OF THE SURVEY AREA

Airborne geophysical survey, soil geochemical survey and geological survey were carried out during the Phase II survey in San Jose and Arroyo Grande areas in the locations shown in Fig.II-1-1.

1-1 Location and Access

Uruguay is located at the eastern seashore of the South American Continent bordering the Atlantic Ocean and bordered by Brazil at the north, Argentine at the south and the La Plata River at the west. Uruguay has a land surface of 176,000 km^2, about half of the Japan archipelago and a population of about 3,160,000 (1996 census), half of them residing in the capital, Montevideo.

The project area is located at the northern part of Montevideo and it consists of two areas, named San Jose and Arroyo Grande. San Jose area is located 90Km northwest of Montevideo; it is elongated along the E-W direction measuring 220Km by 50Km. The city of San Jose de Mayo was used as base camp of the Project during the study of San Jose area. The city is located at northwest of Montevideo by the road No. 1 for 50Km and then by road No. 3 for 30Km. The time spent by car is approximately 1h and 30min.

Arroyo Grande area is located 140Km to northwest of Montevideo. The survey area has elongated form to E-W and measuring 50Km by 20Km. From Montevideo it takes around 2 hours by car. All main roads are paved and the secondary roads are so well maintained that facilitate the accessibility during the survey.

The area covered by the aerogeophysical survey was 12,000Km^2 and the area for geological and geochemical survey area was 400 Km^2 that comprised the San Jose and Arroyo Grande areas.

1-2 Topography and Drainage

The maximum altitude in Uruguay is 514m and most of the country has a flat to gently hills. Due to the weathering, the outcrops are rare but the existence of some hills and rock outcrops reflect a more resistant geological unit. Main drainage system in the San Jose area consists of Santa Lucia river at east, Rosario river at west, San Juan river at South and the San Jose river at central part. The most important rivers in the Arroyo Grande area is the Neguro river that is a branch of the Uruguay river that runs in the western part of the area.

1-3 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℃. Even in the winter season from June to September, the mean temperature seldom falls below 10℃. The mean temperature in the summer season from December to March is 23℃. The annual mean precipitation in Montevideo is around 1000mm.

The survey area has a very flat topography with slight inclined hills with many trees along the rivers side. The land have been used for pasture since the western immigration arrived in Uruguay.

CHAPTER 2 GENERAL GEOLOGY OF THE SURROUNDING AREA

Four survey areas were selected within San Jose belt and one survey area within Arroyo Grande belt were selected for geological and geochemical survey.

2-1 Geology

The geology of this area consists mainly of basement complex (pCCcb, pCCanf), greenstone units (pCCsjo, pCCsj, pCCps and pCCag), ancient granite (pCCG), younger granite (pCC), Cretaceous, Neogene and Quaternary sedimentary sequence that overlays the above units. The stratigraphic column of the area is shown in the Fig. II-2-2.

(1) Basement complex

The basement complex is distributed in the western edge and at the eastern part of the San Jose belt. It is also present in the northwestern part of the San Jose belt and along the southern edge of the Arroyo Grande belt. Frequent faults are separating the basement complex units with younger units. The basement complex is mainly composed of gneiss, schists, silicified rocks, amphibolite and granites, and locally by migmatite and hornfels. Granites shows weak foliation related to metamorphism.

(2) Greenstone units

As recommended by Mason, 1990 and other authors, the denomination greenstone was adopted in this report to the rocks composing the San Jose belt and Arroyo Grande belt.

The greenstone rocks of the San Jose formation (pCCsjo) was subjected to a medium grade metamorphism while the Paso Severino (pCCps), the Cerros de San Juan (pCCsj) and the Arroyo Grande (pCCag) formations were subjected to a weak metamorphism.

Preciozzi et al. (1991) proposed the name San Jose belt to designate a southward increase in the metamorphic grade. Also, this denomination was proposed to put together several metamorphic units as Paso Severino formation, San Juan formation and Cerros de San Juan formation. Mica schist and quartz schist, metavolcanic rocks and metasedimentary rocks compose the common lithofacies of these four formations.

The San Jose formation mainly consists of mica schist, quartz schist, gneiss, meta-rhyolite, meta-basalt, quartzite, meta-sandstone, green rock, slate, phyllite and amphibolite. The quartz schist shows porphyroclastic texture, where quartz and plagioclase are imbedded as relict mineral in the matrix, which has a developed schistosity and consists of plagioclase, muscovite and quartz. The amphibolite is composed of quartz, plagioclase, epidote, amphibolite and actinolite. Green rock is a massive rock consisted of fine-grained epidote, titanite, chlorite, quartz, albite, carbonate minerals and magnetite. The mineral assemblage is an indication of low-grade metamorphic rocks.

The Paso Severino formation consists of greenschist, mica schist, quartz schist, meta-basalt, meta-gabbro, meta-sandstone, slate, phyllite and amphibolite. The greenschist is composed of a mineral assemblage characteristic of greenschist facies, as quartz, albite, chlorite, actinolite and epidote. The quartz schist consists of fine-grained minerals of quartz, plagioclase, calcite, chlorite and muscovite, and shows a massive structure. The metabasalt was recrystallized showing a new metamorphic mineral assemblage formed by albite, actinolite, chlorite and epidote, although the former basalt porphyritic structure with phenocryst of peridotite is relict. The meta-gabbro is completely replaced with a metamorphic mineral assemblage of chlorite, calcite, epidote, titanite, prehnite and actinolite. The amphibolite consists of such metamorphic minerals as hornblende, quartz, plagioclase and magnetite. The original igneous texture is not preserved and a weak foliation attributed to the orientation of hornblende is recognized.

The Cerros de San Juan formation consists of green-schist, mica-schist, quartz-schist, talc, dolomite, meta-basalt, meta-gabbro, meta-sandstone, slate, phyllite, amphibolite and dolerite. Microscopic examination of dolerite showed that phenocryst of peridotite is imbedded in the matrix consisted of fine-grained plagioclase and augite. It includes alteration minerals such as serpentinite, chlorite, actinolite, talc and magnetite.

The Arroyo Grande formation consists of green-schist, mica-schist, quartz-schist, gneiss, meta-basalt, meta-gabbro, meta-sandstone, slate, phyllite and amphibolite. The meta-sandstone consists of metamorphic minerals such as quartz, plagioclase, potassium feldspar and muscovite. Locally, it shows porphyroclastic texture, where quartz and potassium feldspar are imbedded as relict mineral in the matrix of fine-grained metamorphic minerals. A weak foliation is recognized.

(3) Upper units

Cretaceous rocks overlays the Arroyo Grande belt and it consists mainly of siliceous rock, agate and fine-grained sandstone.

Neogene rocks are present in the eastern part of the San Jose belt and at the central portion of the western part of the San Jose belt. It consists mainly of mudstone, fine-grained sandstone, conglomerate and breccias.

Quaternary unit consists mainly of recently deposited sand, gravel and clay.

(4) Instrusive rocks

Ancient granite (pCCG), younger granite (pCC), dolerite (dd) and gabbro (gb) are present in the survey area.

Ancient granite outcrops in many areas, as at the west and Middle Eastern part of the San Jose area, at western part of the San Jose area and the central and northern parts of the Arroyo Grande area. Ancient granite consists mainly of middle to coarse-grained equigranular or porphyritic biotite granite, muscovite granite, granodiorite, diorite and quartz diorite, and they were subjected to metamorphism. Locally, it is observed strong shearing, foliation and mylonitization at the proximity of a fault zone along E-W and NW-SE directions in the Middle Western part of the San Jose area. Microscopic examination of biotite granite showed blastoporphyritic texture with quartz, potassic feldspar and plagioclase as well as biotite phenocryst. Muscovite granite shows phenocryst of quartz, potassium feldspar, plagioclase and muscovite. Granodiorite presented quartz, plagioclase and amphibolite's phenocryst.

Younger granitic rocks outcrop as stock in the whole survey area of the San Jose area and Arroyo Grande area. They are composed of coarse-grained equigranular or porphyritic biotite granite, muscovite granite, two mica granite, hornblende granite, leucogranite, granodiorite, diorite and tonalite. By microscopic examination, the younger granite showed phenocrysts of quartz, potassic feldspar and plagioclase and mafic minerals as biotite, muscovite, hornblende and minor constituents of apatite, zircon, titanite and magnetite.

Dolerite fills NE-SW fracturing structure in the central part and western part of the San Jose area and also it intrudes the younger granite (pCC). On the microscopic examination, the dolerite presented minerals as hornblende, plagioclase, epidote and magnetite.

Gabbro is present as small intrusions in the San Jose and Paso Severino formations in the western part of the San Jose area. The rock is dark-greenish gray. On the microscopic examination, gabbros are composed of peridotite, augite, plagioclase and magnetite and include also metamorphic minerals as talc, chlorite, epidote, carbonate minerals and serpentinite.

Datation performed on biotite granite that hosts the Mahoma mine, showed an age of 1960±140Ma by K-Ar method. The biotite granite has been classified in the bibliography as ancient granite intrusive (pCCG). Existing data showed an age of 2200Ma for the same biotite granite. Geological map of Uruguay on a scale of 1:500,000 classify the amphibolite with age of 2000±280Ma as part of the basement Complex.

Innumerous datation was performed for younger granite (pCC). In the San Jose area, the ages obtained were as follows. Two mica granite showed an age of 1690±120Ma, muscovite granite an age of 1240±10Ma and a biotite granite an age of 1750±120Ma. In Arroyo Grande area, leucogranite indicated an age of 1980±130Ma. Existing information classifies the age of younger granite (pCC) between 1800 and 2000Ma and correlates these granites with the igneous activity of the Transamazonian orogenesis.

2-2 Mineralization

During the field survey, a total of 13 quartz showings areas were found (Fig.I-3-1). Detailed descriptions of these quartz veins showing are presented in the Table I-3-1.

The host rocks of the quartz vein are the basement complex (pCCcb and pCCanf), ancient granite (pCCG) and greenstone units (pCCps, pCCsj, pCCag and pCCsjo).

The wall rock alterations are silicification, chloritization and epidotization. Result of X-ray diffractive analysis showed a mineral assemblage consisting of quartz–sericite–(pyrite) and chlorite– epidote–(albite).

The width of the quartz veins ranges from decimeters to several dozens meters within basement rocks and ancient granite but it declines abruptly to several centimeters in younger granite rocks (pCC).

Two preferential directions of the quartz veins along NE-SW and NW-SE directions were observed. The former is approximately concordant with the geological structure as typified by faults and schistosity plane directions.

Results of the polished sections in quartz vein and wall rock samples did not indicate any specific association mineral with ore, except a little limonite and a very rare pyrite. A small amount of pyrite– (chalcopyrite) dissemination was recognized in green rocks and in some of the quartz vein. The quartz vein was classified in three types: milky sugar-like semi-transparent quartz, colorless to white transparent quartz and opaque quartz.

Fluid inclusion results from 14 samples showed a maximum homogenization temperature of 447.7℃ and minimum of 85.6℃. The histogram indicated three peaks at around 300℃, 250℃ and 200 to 150℃, which can be considered to correspond to milky semi-transparent quartz, colorless to white transparent quartz and opaque quartz, respectively. Based on the analytical results, the salinity was 4.2 to 35% (NaCl % equivalent).

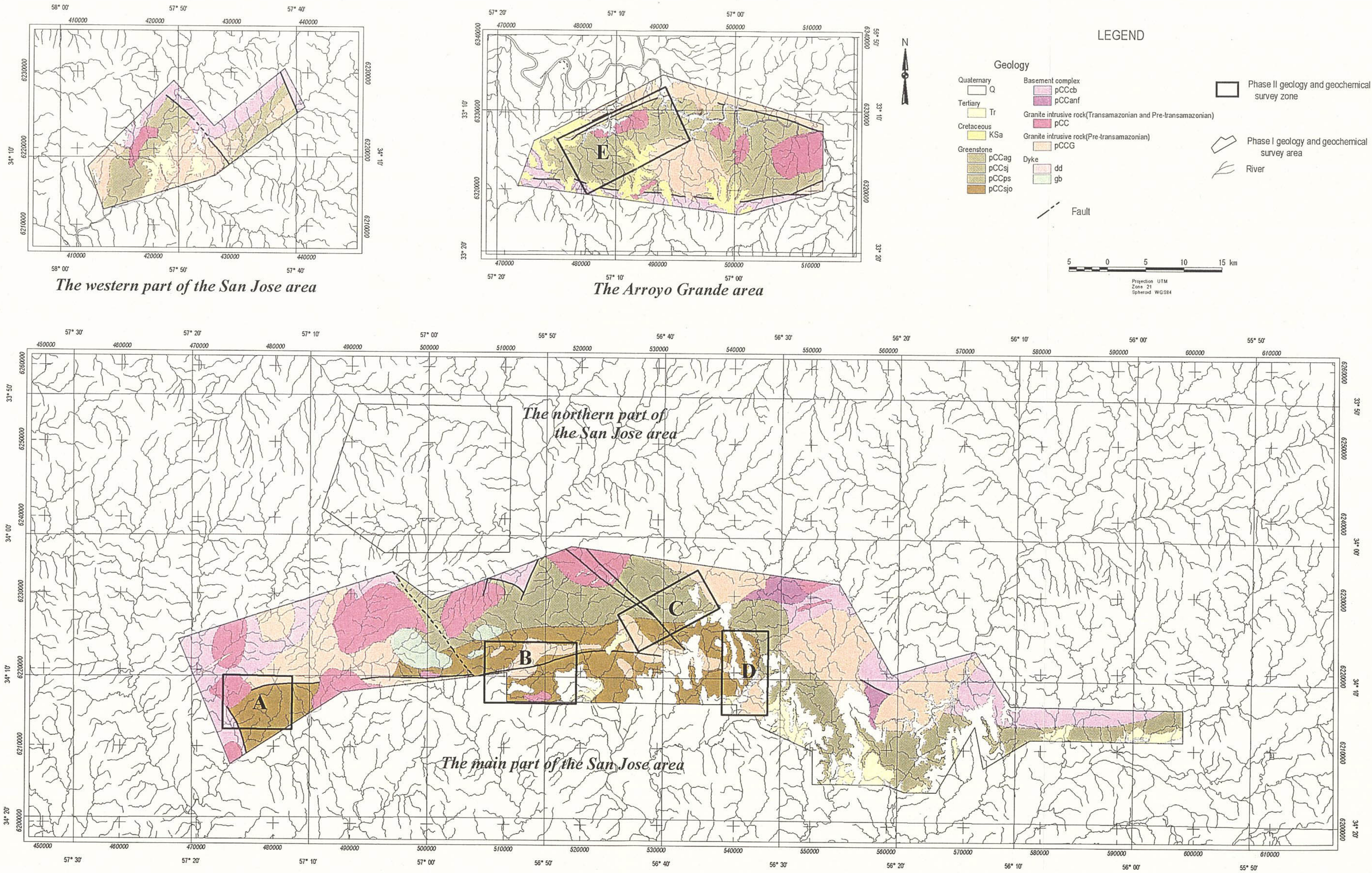

Fig. II-1-1 Location map of geology and geochemical survey zones

Age (Ma)	Units	Events	Domain
1,400-1,800	Doleritic dykes	Distensive enviroments	
1,845 1,900	Pintos granite	*CRATONIZATION*	
1,900-1,970	Aplites and granitic dykes Leucogranite dykes		TRANSAMAZONIAN OROGENESIS
2,000-2,070	Granite-gneissic complex Granitic dyke Isla Mala Gabbroic Complex Mahoma-Guaycuru		
2,070-2,100		Metamorphism, migmatization, granitization and folding	
2,100	Leucogranite	3rd deformation phase	
2,180 2,225	Southern granite A. Virgen leucogranite	Syncolisional Paso Lugo fault Late orogenic	PRE TRANSAMAZONIAN
2,270-2,290	A. Grande granodiorite Hornblendites Isla Mala leucogranite	Distensive, 2nd deformation phase *MYLONITIZATION*	
2,291-2,386	Marincho main granodiorite		
2,450	Isla Mala granodiorite		
2,500-2,544	*San Jose metamorphic belt* Alkaline granite	Metamorphism+1st deformation phase	
	Arrojo Grande metamorphic belt Complejo Basal	Metamorphism+1st deformation phase	ARCHEAN

Stratigraphy in accordance with PRECIOZZI et al.(1999). Modified.

Fig. II-2-1 Schematic stratigraphic column around the survey areas

CHAPTER 3 RESULTS OF LABORATORY ANALYSIS

As shown on Table I-1-2, thin section, polished section, X-ray, Fluid Inclusion and Ore analysis were carried out during this phase. Datation, residual magnetism measurement and chemical analysis for soil geochemical samples were also carried out.

A total of 638 ore samples were collected during the field survey as shown in the Fig. II-3-1. Ore samples were analyzed for 8 elements: Au, As, Sb, Hg, Ag, Cu, Pb and Zn, and the analysis results are shown in the Appendix 1.

Analysis results indicated 2 samples with ore grade above 100 ppm, 3 samples above 30 ppm, 11 samples with grades above 1ppm, 30 samples above 100 ppb and 64 samples above 10 ppb.

A total of 30 samples were analyzed for X-ray, and a total of 28 polished samples were analyzed.

A total of 34 fluid inclusions samples indicated a minimum homogenization temperature of 156.1℃ and a maximum of 307.6℃. The average results were as follows: 21 samples between 150℃ and 200℃ and 8 samples between 200℃ and 250℃. The salinity results were between 0.5% and 32.9% and 12 samples showing salinity between 0% and 10%, 10 samples between 10% and 20% and 8 samples between 20% and 32.9%.

Datation results showed a similar rock age as in the Phase 1.

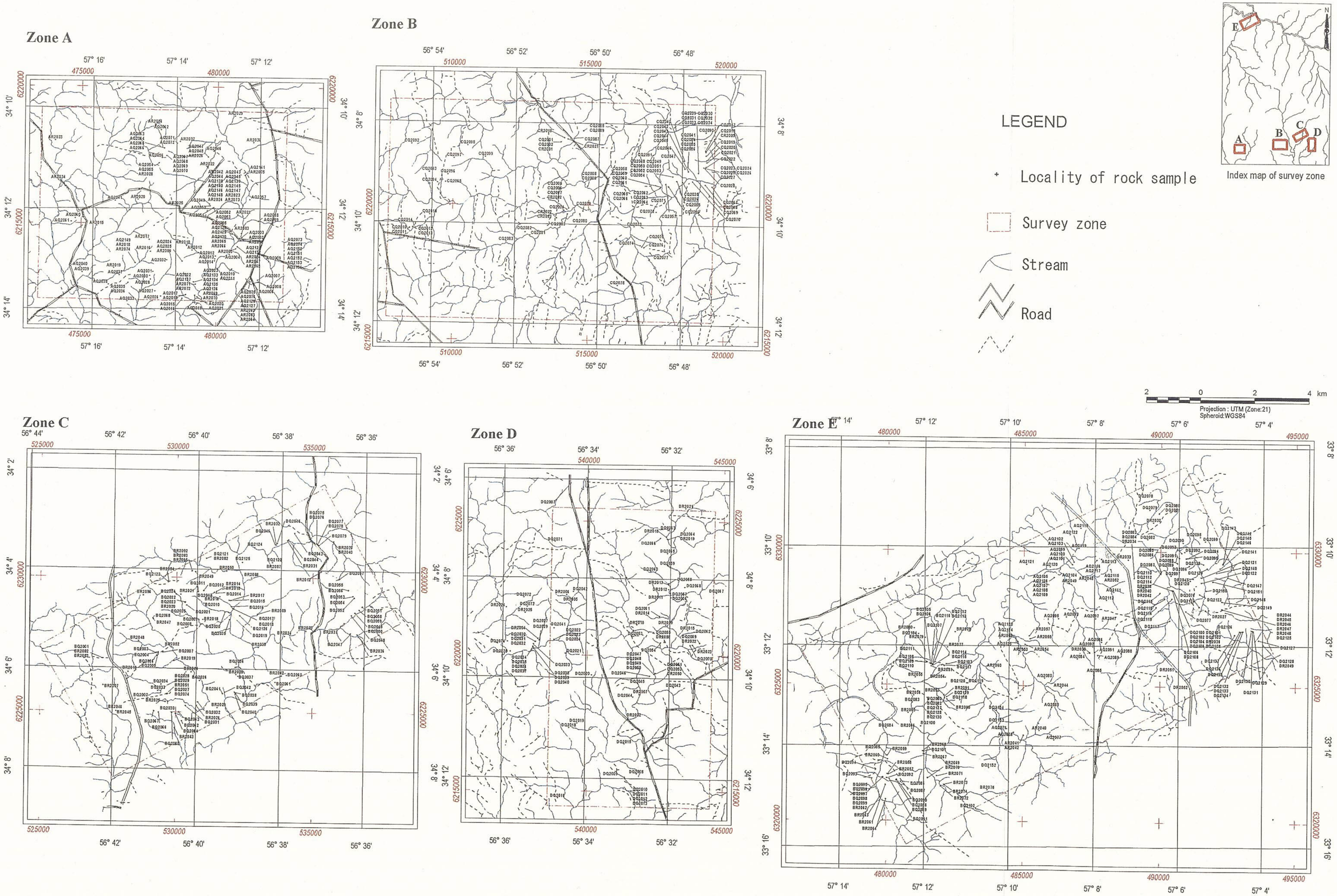

Fig. II-3-1 Location map of results of the Phase II survey

CHAPTER 4　GEOPHYSICAL SURVEY RESULTS

4-1 Purpose

The purpose of this survey was to assist in the clarification of the overall structural and lithological mapping of the San Jose and Arroyo Grande areas by using aeromagnetic and radiometric data. The integration of the results of these two methods with the knowledge of the existing geological data will improve the mapping of sub-outcropping lithological units, delineating fault zones and other structural features.

The survey results are discussed in Chapter 5 within the geological survey results.

4-2　Location, Survey Area and Specifications

4-2-1 Survey area

The Project area covered by this survey consists of 3 blocks: Block1, Block 2 and Block 3. As seen in the Fig.II-4-1, the Blocks 2 and 3 are located within the San Jose area, while the Block 1 is located within Arroyo Grande area. The following corners define the location of each of the 3 blocks:

Table II-4-1 Coordinate location of the survey area

Block	Longitude West			Latitude Sur			UTM-X (m)	UTM-Y (m)
	Deg.	Min.	Sec.	Deg.	Min.	Sec.		
1	56	52	26.55	33	7	26.79	511749.88	6334947.35
	56	52	25.69	33	17	27.46	511750.05	6316449.12
	57	18	23.23	33	17	26.34	471466.52	6316449.04
	57	18	21.77	33	7	25.66	471450.40	6334947.33
2	57	38	44.50	34	3	45.86	440414.87	6230699.44
	57	38	49.34	34	14	20.09	440414.78	6211163.89
	57	58	16.98	34	14	12.38	410543.05	6211164.15
	57	58	7.67	34	3	38.22	410595.79	6230699.65
3	57	21	32.16	33	59	35.76	466850.71	6238532.51
	55	53	22.16	33	59	19.60	602569.29	6238532.69
	55	53	6.57	34	19	8.40	602569.08	6201910.37
	57	21	37.34	34	19	24.76	466847.14	6201910.37

(1) San Jose Area

This area that comprises the Blocks 2 and 3 is relatively flat with elevations from about 50m to about 240m. Maximum dimensions of the survey area are 35 km north - south and 132 km east– west in the Block 3 and 20km north-south and 30km east-west in the Block 2.

The survey area in the 2 blocks is centered at approximately 57.2° West, 34. 10 ° South. At this location and for an elevation of 80 m and a 2001.12 date, the geomagnetic field has the following characteristics.

Nominal total field: 23315 check nT

Inclination: -36.7°

Declination: magnetic north is 7.9 ° west of geographic north

(2) Arroyo Grande Area

This area corresponds to the Block 1, which is relatively flat with elevations from about 50m to about 150m. Maximum dimensions of the survey area are about 20 km north - south and 40 km east – west. The survey area in this block is approximately –57.1° West, 33.5 ° South. At this location and for an elevation of 80 m and a 2001.12 date, the geomagnetic field has the following characteristics.

Nominal total field: 23232 nT

Inclination: -36.2°

Declination: magnetic north is 8.3 ° west of geographic north

4-2-2 Survey quantities

The survey area covers about 2980km^2. Traverse and tie lines were spaced 250m and 5000m, respectively. The traverse lines were flown NS and the control lines in an EWt direction every 5000 meters resulting in an estimated total line km. count as follows:

Total coverage within the survey boundary was according to the table shown below.

Tab.II-4-2 Total line coverage

Block	Survey Lines		Control Lines		Total Distance
	No. Lines	Distance	No. Lines	Distance	
1	164	3114.8	5	332.2	3447.0
2	121	2576.3	5	152.9	2729.2
3	547	20229	8	1090.3	21319.5
Total		25920.3		1575.4	27495.7

4-2-3 Survey period

The survey was flown in the period between November 12th and January 16th, 2002.

The survey ran smoothly without any serious problems. Only two events delayed the survey activities: problems in the base station delayed the survey one week and a left engine problem delayed again the survey for about 3 weeks.

The area has a moderate climate. During the survey the maximum temperatures were usually in the range 25° C to 30° C and the daily temperature range was modest. The period between November and January was suitable for field survey because the rainfall was light and the climate stable. Most of the time it was sunny and relatively warm, but in few occasions it was rainy and windy. The south part of the country including the project area generally presents hilly topography that is nearly flat.

4-3 Survey Instrumentation

Fugro Sial Airborne Surveys Inc. from Canada was entrusted by MMAJ to carry out an aeromagnetic and radiometric survey. Aircraft used during the survey was a Piper Navajo C-GKMW equipped with a 3m stinger.

Table II-4-3 shows the specifications of the airborne instrumentation used during the survey.

Tab. II-4-3 Specification of the survey instruments

Name	Model	Manufacturer (Country)	Specifications
Aircraft	Piper Navajo C-GKMW		Equiped with a 10-foot stinger
Magnetometer optically pumped cesium sensor	G-822A	Geometrics(Canada)	Dynamic range:20,000-95,000nT Sensitivity:±0.001nT, Sampling interval 3.0 sec Noise Level:Less than 0.01nT Cesium Vapor split beam in a tail stinger
Data adcquision/ recording system	High-Sense MiniMag-II		
Base Station Magnetometer	GSM-19 Overhauser	GEM Systems	Dynamic range:20,000-95,000nT Sensitivity:±0.001nT, Sampling Rate:3Hz Noise Level:0.1nT
Spectrometer	GR-820, 256 channels		EXPORANIUM multi-channel gamma-ray spectrometer with 256 channels analysers for upward and downward looking cristals, crystal: GPX-1024(16.7L downward, 4.2L upward)x2 pairs
GPS	OMNI-STAR 3000 LR8		Used in conjuction with a remote station NOVATEL 3151R GPS Receiver
Radar Altimeter	Terra TRA-3500A		Range: 0 to 800m Accuracy: 1%
Barometric Altimeter		Rosemount(U.S.A)	

4-4 Methodology and Data Acquisition

4-4-1 Methods used

(1) Aeromagnetic method

Due to the geographic location of the survey area the magnetic inclination and declination values (See Sec 4.2) are such that the magnetic dipole is inclined at approximately – 37° from the horizontal with a declination of about 8° West. As a consequence of this, the anomalies found in the total magnetic intensity (TMI) map do not perfectly reflect the position, geometries, and trends of the anomalous sources. A numerical procedure called reduction to the magnetic north pole (RTP) is necessary to get a more interpretable map. For this reason, the aeromagnetic grids were reduced to the north magnetic pole (RTP), a process that causes magnetic anomaly highs to be centered over the causative bodies with gradients to occur over boundaries between magnetically different units. The process assumes that all magnetization is induced parallel to the Earth's magnetic field, with an inclination of about -37 ° degrees and a declination of about 8.5 ° degrees, and calculates a new grid with a vertical inclination.

The color magnetic maps indicate red color as magnetic high and blue color as magnetic lows.

To correlate the magnetic anomalies with geology, it is generally understood that the sedimentary rocks are not magnetic, whereas igneous rocks, such as mafic or ultamafic, tends to be very magnetic. In most cases faults and/or fractured zones are not magnetic due to the demagnetization that produces a magnetic contrast with the surrounding rocks.

(2) Radiometric method

It is now a standard practice to fly high resolution aeromagnetic (HRA) together with aerial gamma-ray surveys (AGRS) with a crystal that can be easily accommodated in the aircraft.
Aerial gamma-ray surveys involve the measurement of gamma-ray radiation from low flying aircraft, emitted by the radioactive decay of the radioelements potassium (K), uranium (U) and thorium (Th) which are present in varying amounts in all natural materials. These surveys may be useful to provide better geological and superficial information.

Airborne gamma spectrometry (AGS) measures geochemistry, i.e. the spatial distribution of elements potassium (K), thorium (Th) and uranium (U), in the top 30-45 cm of the surface layer. The abundances of K, Th and U in near-surface materials are measured by detecting the gamma-rays produced during the natural radioactive decay of isotopes of these elements. The measurement of particular wavelengths makes it possible to determine the quantities of various isotopes. Since gamma-rays are strongly attenuated in rocks as well as in soil and air, most of the radiation emanates from shallow ground depth. While the gamma-ray counts are attenuated by soil moisture and vegetation, these effects are generally minor. To obtain enough signals, an aircraft must fly at low altitude, in our case at a maximum of only 120 meters. The measured gamma spectra are then analyzed to obtain the abundances of the three above mentioned elements together with a total count. The measured values are interpolated to form a grid of values that can be displayed as an image of the surveyed region.

Just as indicated for the magnetic maps, the color radiometric maps indicate, red color as high; blue color as lows. The three elements are also combined into a single image called ternary plots where potassium is displayed as red, uranium as blue and thorium as green.

As it was mentioned above, the moisture content in the soil or air decreases the variation in the gamma ray readings. Standing water gives lows due to absorption. In the north part of the area E, the lows detected are due to a branch of the artificial lake and all the blue lines correspond to rivers.

In the radiometer maps, the granite bodies show high values of K, separated by areas of low values that are characteristic of the basement.

4-4-2 Data Acquisition

Following installation and system checkout, the aircraft was mobilized to the survey area. Initial flights were used to set up the automatic digital compensator. Magnetic compensation was done using pitch, roll and yaw maneuvers while flying well outside of ground affects.

Survey parameters were 250m flight-line spacing, 120m mean terrain clearance, a magnetometer average sampling interval of about 7m and spectrometer sampling interval of 60 m.

The survey was flown during the period November 12 to January 16, 2001. Navigation was assisted by a GPS system that provided guidance to the pilot over the survey grid.
Fig II-4-2 shows the flight map of the survey lines.

A summary log detailing the production in the survey data acquisition is given in Appendix.

4-4-3 Data Processing

(1) Aeromagnetic survey

Final processing consisted of the following operations:

- -Complete verification of the different field (X-Y-Z-GPS, GPS time, radar altimeter)
- -Complete visual verification of the magnetic profile (de-spike, filtering of the low noise, residual calculation

-Lag removed (-0.9 sec)
-Diurnal correction
-Intersection leveling of the total field
-Reduction to the pole calculation

After long wavelength diurnals were removed, the final leveling of the total magnetic field was done by intersection analysis. First, all the intersection differences were calculated and examined. A statistical leveling was done on each control line by subtracting a second order curve. Secondly, any residual difference between control line/traverse-line was applied on each traverse-line to produce identical values for the intersections.

The magnetic values were then reduced to a regular 50 meters X-Y grid. The gridded data was reduced to the pole using standard FFT techniques.

(2) Radiometric survey

The raw data was further processed to reduce raw counts/second into equivalent concentrations of Potassium, Thorium and Uranium. Factors such as altitude influence, gridding data and leveling were considered to process the final data. The data were gridded using the same procedure used for the aeromagnetic data. The cell size used was 50 meters

Corrections applied involved: live-time corrections, filtering, cosmic and aircraft background for each spectral window, radon background, stripping ratios, attenuation corrections and conversion to apparent radioelement concentrations.

Further details related to the magnetic and radiometric data acquisition and processing are provided in Fugro Report: "Combined Magnetic and Radiometric Airborne Surveys" February 2002.

4-4-4 Susceptibility of rocks

Depending on the kind of rock, the magnetic response is due to several factors such as the magnetic susceptibility of the type of rock, the amount of metamorphism, the amount of alteration. Rocks that are magnetic in one area may not present magnetism in another area due to alteration.

An important term is used to describe how magnetized an object may become under the influence of a magnetic field. This is called the magnetic susceptibility (k), for which the defining equations are M =kH. In some cases, depending on the history of the host rock, the rock may present also a permanent or remanent magnetization.

Remanent magnetization measurements were made on 8 samples collected from several zones of the survey area by using a paleomagnetic processor that consists of a demagnetization unit and a remnant magnetism unit. This system belongs to Institute of Geosciences, Shizuoka University. Alternative magnetic fields of 5mT, between 10mT~40mT were applied during the demagnetization process, and then remanent magnetization was measured by using declination and inclination angles.

The results of measurement are summarized as follows:

Green schist, sample number AR2038 gave the highest magnetic susceptibility of 7x10E-3, and the other green schist gave also high values.

Meta-sandstone was the next highest with 4x10E-3.

Granitic samples with 0.48x10-3 indicated one-order smaller values than green schist samples.

Meta-basalt showed the lowest value of 0.003x10E-3.

Based on the magnetic map, low magnetic anomaly corresponds with granite rocks, while high magnetic anomaly with schist, which can be explained by these results.

Meta-basalt sample was taken from San Jose Formation, which reflect high magnetic anomaly, so that collected the meta-basalt sample could indicate small susceptibility value.

It is generally said that magnetic susceptibility of granite range between 10E-3 to 10E-5, basalt between 10E-2 to 10E-4 and schist between 10E-4 to 10E-5. Compared with the results of this area, characteristics of this area is that granite shows an average value, while meta-basalt shows far smaller value than the average. Furthermore, schist and meta-sandstone show high values that are within the upper limit.

The following table shows a summary of the results of the magnetic studies on the above mentioned 8 samples.

Tab. II-4-4 Magnetic measurements on rock samples

Sample No	Rock Name	Zone	UTM-x	UTM-y	Mag. Suscept	From RTP map
AR2034	Granite	A	474234	6216591	0.48 E-03	Low
AR2038	Green schist	A	480967	6214414	7.7 E-03	High
AR2039	Meta basalt	A	481410	6218006	0.0029 E-03	Medium
AR2048	Granite	E	487274	6328910	0.003 E-03	Low
BR2010	Granodiorite	C	528253	6226467	0.0028 E-03	Low
BR2052	Green schist	C	529834	6227390	5.2 E-03	High
CR2022	Green schist	B	513836	6219526	4.9 E-03	Very high
DR2027	Meta sandstone	E	491678	6327821	3.6 E-03	Very high

4-5 Survey Results

The Fig. II-4-1 shows the location of the 3 blocks where the airborne survey was carried out. The block 2 contains the zone E while the block No. 3 contains the zones A, B, C and D.

Fig. II-4-2 shows the flight survey and tie lines map. The gray lines on this map indicate the aircraft flight path. The flight lines were oriented NS and spaced 250m apart. Flight altitude was about 120m.

4-5-1 Aeromagnetic survey

The original magnetic field (TMI) is indicated in the Fig. II-4-3, whereas the Fig. II-4-4 and II-4-5 show the result of reducing these data to the pole (RTP). Figs II-4-6 and II-4-7 show the results of the vertical gradient procedure (VG). The RTP maps give a picture of the magnetization properties of the rocks and emphasize mainly in geological structures and intrusive rocks in the area, while the VG defines better the limit of areas with different magnetization which can be associated with structural trends or lineaments identifying shallow crustal faults that separate rocks of contrasting magnetic properties.

On the other hand, the color magnetic maps indicate, red color as magnetic high; blue color as magnetic lows.

To correlate the magnetic anomalies with geology, we recall that the sedimentary rocks are generally low magnetism, whereas igneous rocks, such as mafic or ultamafic, tends to present high magnetism.

The mineralizations in the project area of San Jose and Arroyo Grande do not seem to present clear magnetic signatures. But by the aeromagnetic survey it would be possible to map stratigraphy, intrusions and structure in the area. Faults and shear zones may be characterized by alteration that causes destruction of magnetite that produces a magnetic contrast with the surrounding rock

Based on the analysis of the total magnetic field reduced to the pole, on the magnetic vertical gradient and on the geology of the area, the following results can be extracted:

(1) Block 1

Dominant high magnetic N60E-trendings are seen distributed in the area as illustrated by lineaments with localized zones of higher magnetic response in the VG map. In the central part of this block, especially within the zone E, several high magnetic lineaments run along approximate EW trendings are seen crossing diagonally the zone and appearing to interrupt the more prominent N60E trendings.

Several high magnetic distributions running along N60E are distributed in the SE edge of the block as well as in the NW edge. These high magnetic anomalies are considered to be due to basaltic intrusives.

In the SW of zone E, the high magnetic anomaly corresponds probably to meta-basaltic lava, while the NE of this zone corresponds to metagabro.

Low magnetic values are widely seen in this block suggesting the influence of basement rocks, granitic rocks or meta-sedimentary rocks. Trans-Amazonian granite is inferred in the north part of zone E

(2) Block 2

This block is located in what was called the western part of the San Jose area in Phase I of this project. This block does not present clear linear magnetic trends, excepting one N60E distributed from the central part to about the northeast part of the block.

Most of the high magnetic relief is observed in the southwest part of the area, with conspicuous non magnetic structures. Low magnetic distributions are detected in the north part of zone E due probably to the Trans-Amazonian granite.

(3) Block 3

Total magnetic intensity values (Fig. II-4-3) within this block vary from about 23000nT to over 23350nT. Intensities of less than 23230nT are typical in most of this area.

Three main magnetic lineament trends associated with faults and/or contacts are observed in the block:

a) Approximately N60E trending systems are detected in the entire block. The analysis of the high magnetic N60E structures suggests that they are probably tied to a geological event at regional level with high magnetic values due to magnetized formation such as ultra-mafic intrusives along the structural trend. Especially the conspicuous high magnetic trending seen in zone B are due to limonitized meta-sediments with sulphide minerals. However, in zone D the high magnetic values are probably due to basaltic intrusives.

b) A second group of lineaments includes trends oriented approximately EW in the middle part of the block and appears to interrupt and possibly offset the more prominent N60E trends in the southeast part of the block. This trend cannot be clearly defined due to a change either in the geological structure or weathering effects of the rocks. These trends of high magnetic values may also be due to ultramafic intrusives along the structural zone. In the eastern part of zone B, granodiorite veins are seen along the fault.

c) Other high magnetic trends are seen along NW-SE. This trend is seen in the northeast part of zone A, in both zone C and D, but it cannot be clearly clarified because they are widely covered by sediments.

The high magnetic anomalies seen in the RTP map along NE direction in zone A and in the surrounding areas of zones C correspond to meta-basalts.

Regarding the low magnetic distributions within the zones surveyed this year in block 3, it can be inferred that Trans-Amazonian granite is inferred in the northwest part of zone A, Pre-Trans-Amazonian granite in the southwest of zone B, Tran-Amazonian granite to Pre-Trans-Amazonian granite in the southwest part of zone C and D. Sedimentary formations contributes also to the detection of low magnetic within the survey area.

On the other hand, the granite intrusives can be often recognized by their high amplitudes. The magnetic signature of the gabro-granodioritic complex in Guaycuru (Mal Abrigo and Mahoma granites), though probably masked by stratified bodies of gabro, gabronorites and norite (Oyhantcabal, Medina and Spoturno, 1990) has resulted in intermediate magnetic values. To the north of Mahoma granite it is seen a high anomaly assumed to be gabro, same as the high anomaly to the south of Mal Abrigo granodiorite.

4-5-2 Radiometric Survey

The radiometric survey can be useful to classify different types of felsic rocks and to map sedimentary or metasedimentary rocks, particularly when they posses no diagnostic magnetic signature. The more basic rocks generally have a low radiometric response.

Fig. II-4-8 and II-4-9 show the Potassium results. Other radiometric maps such as Uranium, Thorium, total count and ternary maps are shown in the appendices of this report. In this report the radiometric map of potassium are mainly considered because high potassium alteration zones coincident with magnetic structures may indicate shear zones that may open the possibility to find occurrences of hydrothermal minerals. Polymetallic mineralization occurs where potassium anomaly is coincident with conspicuous magnetic anomalies.

The zone B in block 3 where Mahoma mine is located, shows that close to a N60E trend, the magnetic contact coincides very well with a potassium lineament trending along same direction.

(1) Block 1

The bright red area distributed in the north west of the image (Fig.II-4-7) shows the so-called granitized belt of Florida. Several distributions with high K values are also detected from the center to the west edge of this block. These distributions show all low to medium magnetic values. They are inferred to be intrusive plutonics. These distributions are only weakly detected by the uranium and thorium concentration.

Coincidence of potassium lineaments with a relatively strong anomaly structure is detected in the west side of zone E; while a coincidence is also detected along an EW direction high magnetic that passes through the center of the zone E.

(2) Block 2

Granite plutonic of relatively high K values with no magnetic signature is detected in the east part of the block. However in the same area, low to intermediate concentrations of Uranium and Thorium are detected. The other half, shows opposite behavior. More investigation is needed to understand this behavior.

(3) Block 3

In this block it is quite remarkable the strong potassium signature coming from the gabro-granodiorite complex in Guaycaru (Mal Abrigo and Mahoma granites). To the south of the Mal Abrigo granite it is seen a zone of relatively low potassium assumed to be gabro. Low potassium values are also detected around the zone to the north and between the two granites Mahoma and Mal Abrigo. This zone is assumed to be gabro due to the high magnetic values detected.

About 10 km to the north of zone A, an anomaly of potassium represented by a trending along SW direction seems to coincide with an outstanding magnetic trend along the same direction. Investigation is needed to clarify the reason of this coincidence.

A large distribution of high to medium values is detected around the northwest and southwest edges of the block. They also show some coincidence with relatively high values as indicated by the RTP distribution map.

In the southwest part of the zone A, metabasalt formation is assumed due to the high magnetic signatures presented and by the low potassium values. Granites intrusive are assumed in the northwest part of the area due to the medium-high potassium values and the low magnetic signature. In the south part of this zone, metasedimentary rocks are assumed because of the intermediate potassium values and the intermediate magnetic values detected in this part.

In the Zone B, the potassium map detected only 2 prominent portions, the most important is the strong N60E trending detected also in the RTP map which shows the same tendency, but it is interesting to comment here that the high potassium values are located in the zone of low magnetic values of the magnetic anomaly, i.e., it means that the potassium anomaly is related to an alteration zone. Although not clear, the potassium map shows also a N60E trending of intermediate potassium values in approximate coincidence of a trend high-intermediate magnetic values in the north of this zone. A distribution of high potassium values is seen to the south of zone B in coincidence with a zone of low magnetic values, indicating an intrusive granite body.

The Thorium and Uranium concentration values do not show distinctive features in this zone.

The zone C does not present remarkable values, except for the northeast edge of the zone which shows relatively high potassium values presumably due to be granite.

The zone D does not either show remarkable values, however a not clear potassium trending is detected along NS direction in relative coincidence with a medium magnetic distribution along same direction.

In both zones C and D, the Uranium and Thorium distributions do not present any remarkable distribution.

4-6 Further Considerations

An airborne survey was flown over 3 blocks located in San Jose and Arroyo Grande areas, Uruguay. Total coverage of the survey amounted to 6400Km^2 consisting of 27497m-lines at about 120m above sea level. The survey was flown from November 12^{th}, 2001 to January 16^{th}, 2002.

1) Aeromagnetic maps have provided good complementary information for use in geological interpretations. This information has permitted interpretation of contact/faults and underlying lithologies that will provide new insights on the geological framework to decide future exploration works in the area.

2) The application of enhancement techniques, such as the vertical gradient probed to be useful in the determination of magnetic lineaments related to fault and contacts. On this regards, the aeromagnetic survey was able to detect several trends and features characteristic of the structural setting of the area such as three main trends associated with faults and/or contacts observed in the survey area.

3) The approximate N60E trend is by far the most recognizable trending system. One of these trends crosses the zone B where Mahoma mine is located. The intersection of these systems by structures and faults along the second EW trend are thought of particular interest for the existence of gold mineralizations.

4) Low magnetic values widely seen in the survey area suggest the influence of basement rocks, granitic rocks or meta-sedimentary rocks. Ganite plutonics are well detected by the radiometric survey as distributions with high potassium concentrations with no magnetic signature.

5) Using the radiometric data, it was possible to observe that some anomalous potassium revealed lineaments that coincide with magnetic lineaments. This may indicate that the lineaments found in the potassium maps and associated to magnetic lineaments may indicate shear zones related to the possibility of hydrothermal minerals. More study is needed to verify this result in the field, stressing the importance of combining geophysical/geochemical information provided by the regional airborne survey with good geological control to identify

and delimit mineralization. On this regards, several places were recognized in the potassium radiometric map where the potassium trend is coincident with remarkable magnetic trends. This result may probe to be useful for future surveys within the project area.

6) It may be desirable to carry out more detailed geophysical interpretations, spectral analysis and modeling to characterize the sources of the magnetic field.

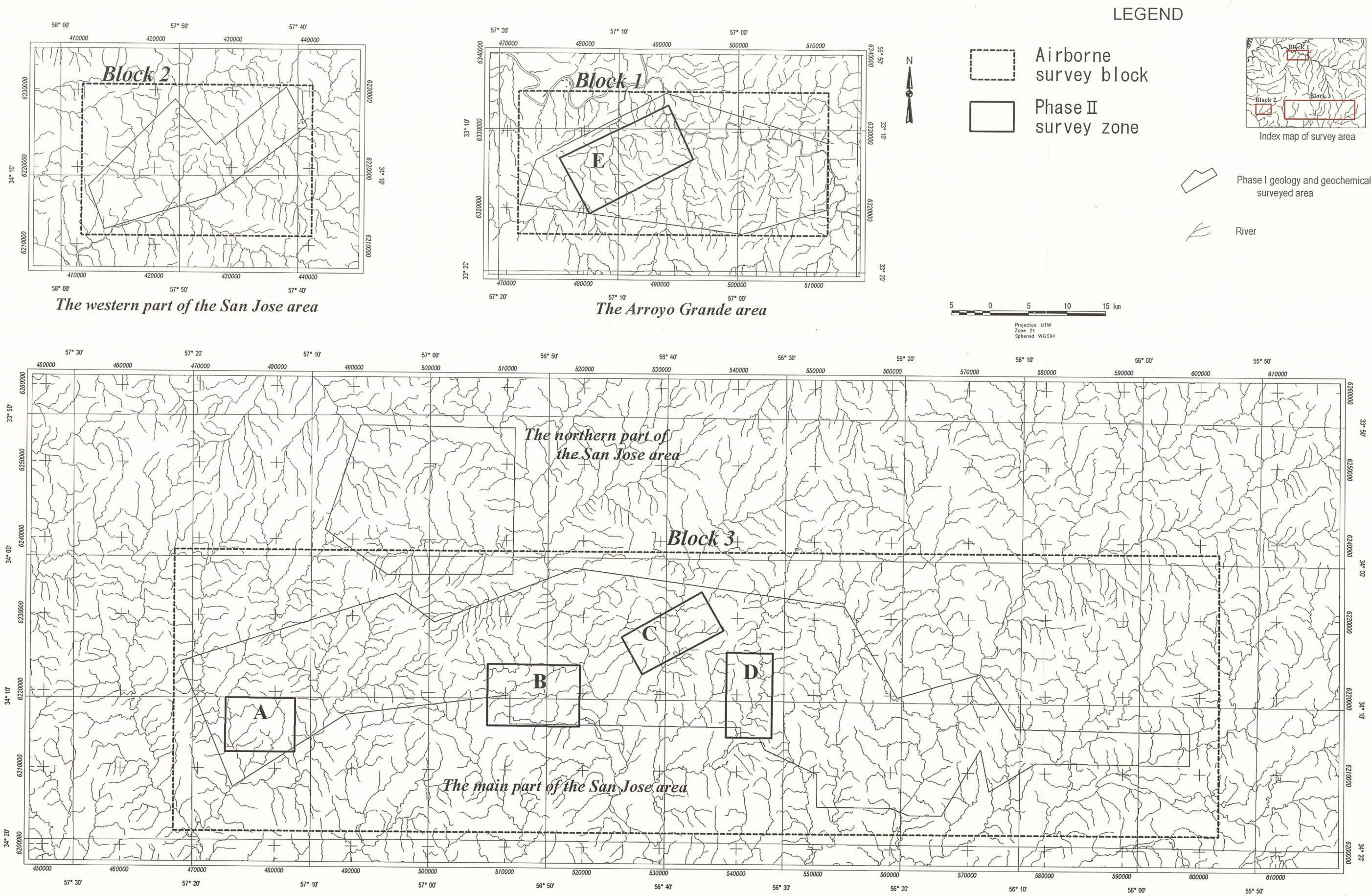

Fig. II-4-1 Location map of the airborne survey area

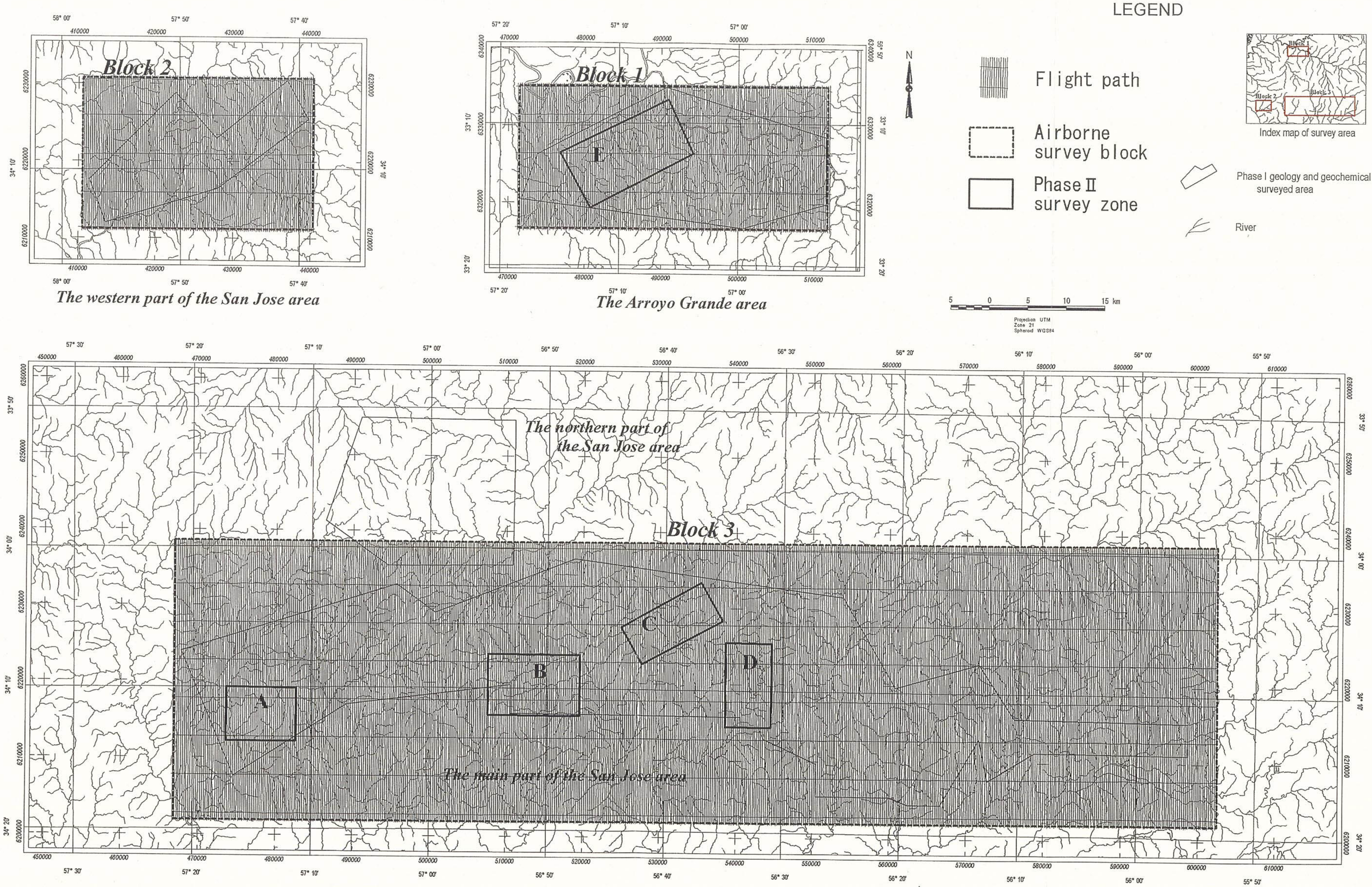

Fig. II-4-2 Flight path map

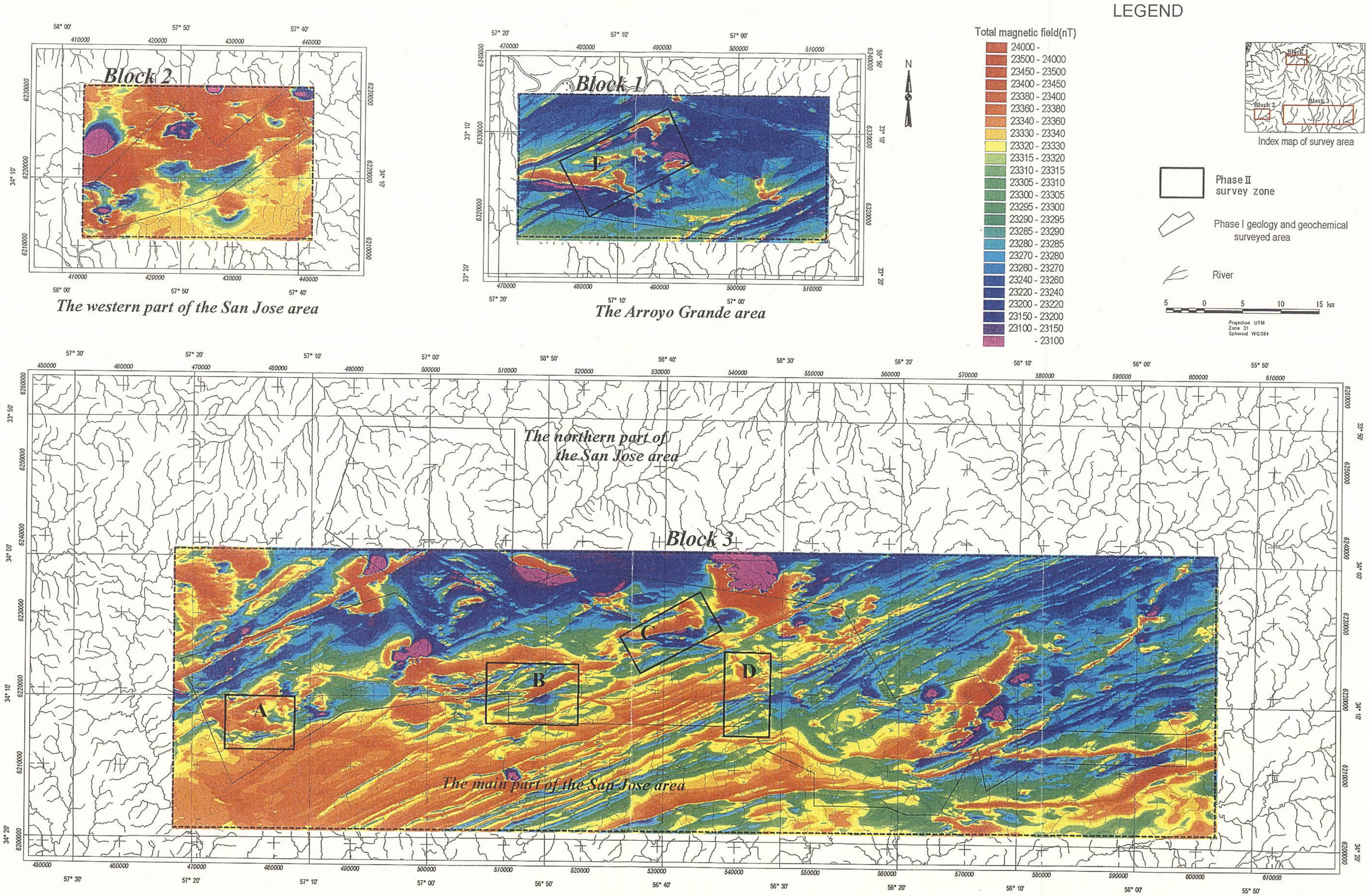

Fig. II-4-3 Total magnetic intensity of the survey area

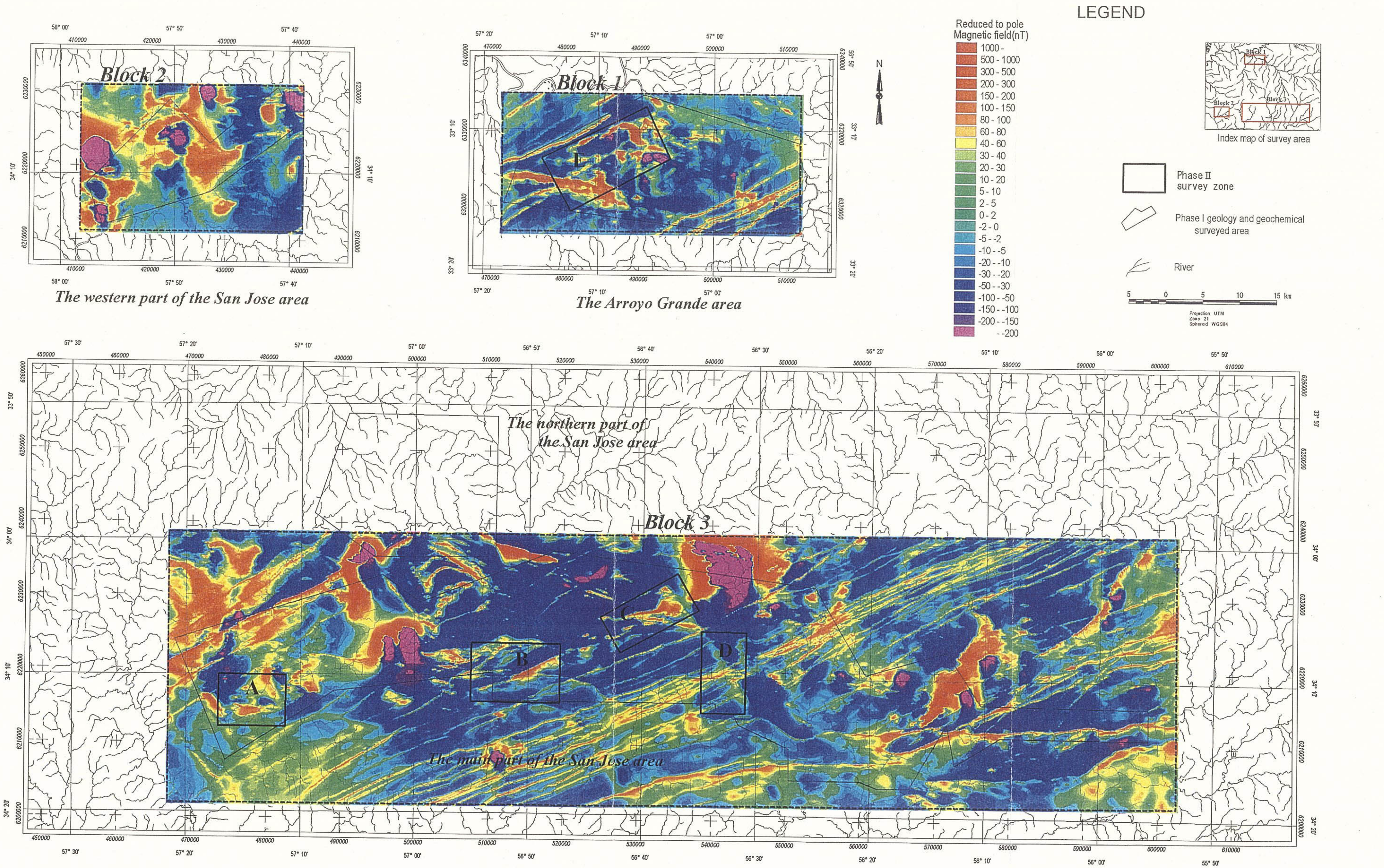

Fig. II-4-4 TMI reduced to the pole of the survey area